fNIRS publications on PubMed: January 1, 2022 - April 30, 2022

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Methodology. Searches were made in PubMed constraining the search period between January 1, 2022 and April 30, 2022. 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

Identification of ?9-tetrahydrocannabinol (THC) impairment using functional brain imaging.

Gilman JM, Schmitt WA, Potter K, Kendzior B, Pachas GN, Hickey S, Makary M, Huestis MA, Evins AE.

Neuropsychopharmacology. 2022 Mar;47(4):944-952.
doi: 10.1038/s41386-021-01259-0. Epub 2022 Jan 8.

Erratum in Neuropsychopharmacology. 2022 Feb 28;:

Characterizing reproducibility of cerebral hemodynamic responses when applying short-channel regression in functional near-infrared spectroscopy.

Wyser DG, Kanzler CM, Salzmann L, Lambercy O, Wolf M, Scholkmann F, Gassert R.

Neurophotonics. 2022 Jan;9(1):015004.
doi: 10.1117/1.NPh.9.1.015004. Epub 2022 Mar 7.

Significance: Functional near-infrared spectroscopy (fNIRS) enables the measurement of brain activity noninvasively. Optical neuroimaging with fNIRS has been shown to be reproducible on the group level and hence is an excellent research tool, but the reproducibility on the single-subject level is still insufficient, challenging the use for clinical applications. Aim: We investigated the effect of short-channel regression (SCR) as an approach to obtain fNIRS measurements with higher reproducibility on a single-subject level. SCR simultaneously considers contributions from long- and short-separation channels and removes confounding physiological changes through the regression of the short-separation channel information. Approach: We performed a test-retest study with a hand grasping task in 15 healthy subjects using a wearable fNIRS device, optoHIVE. Relevant brain regions were localized with transcranial magnetic stimulation to ensure correct placement of the optodes. Reproducibility was assessed by intraclass correlation, correlation analysis, mixed effects modeling, and classification accuracy of the hand grasping task. Further, we characterized the influence of SCR on reproducibility. Results: We found a high reproducibility of fNIRS measurements on a single-subject level (ICCsingle =0.81 and correlation r =0.81). SCR increased the reproducibility from 0.64 to 0.81 (ICCsingle) but did not affect classification (85% overall accuracy). Significant intersubject variability in the reproducibility was observed and was explained by Mayer wave oscillations and low raw signal strength. The raw signal-to-noise ratio (threshold at 40dB) allowed for distinguishing between persons with weak and strong activations. Conclusions: We report, for the first time, that fNIRS measurements are reproducible on a single-subject level using our optoHIVE fNIRS system

and that SCR improves reproducibility. In addition, we give a benchmark to easily assess the ability of a subject to elicit sufficiently strong hemodynamic responses. With these insights, we pave the way for the reliable use of fNIRS neuroimaging in single subjects for neuroscientific research and clinical applications.

Cerebrovascular Function, Vascular Risk, and Lifestyle Patterns in Resistant Hypertension.

Smith PJ, Sherwood A, Hinderliter AL, Mabe S, Tyson C, Avorgbedor F, Watkins LL, Lin PH, Kraus WE, Blumenthal JA.

J Alzheimers Dis. 2022;87(1):345-357.
doi: 10.3233/JAD-215522.

BACKGROUND: Impaired cerebrovascular reactivity (CVR) and blunted cerebral hemodynamic recruitment are thought to be important mechanisms linking hypertension to cerebrovascular and cognitive outcomes. Few studies have examined cardiovascular or dietary correlates of CVR among hypertensives. OBJECTIVE: To delineate associations between cardiometabolic risk, diet, and cerebrovascular functioning among individuals with resistant hypertension from the TRIUMPH trial (n = 140). METHODS: CVR was assessed by examining changes in tissue oxygenation (tissue oxygenation index [TOI] and oxygenated hemoglobin [HBO2]) using functional near-infrared spectroscopy (fNIRS) during a breath holding test, a standardized CVR assessment to elicit a hypercapnic response. Participants also underwent fNIRS during three cognitive challenge tasks. Vascular function was assessed by measurement of brachial artery flow-mediated dilation and hyperemic flow response. Cardiometabolic fitness was assessed from peak VO2 on an exercise treadmill test and body mass index. Dietary patterns were quantified using the DASH eating score. Cognitive function was assessed using a 45-minute test battery assessing Executive Function, Processing Speed, and Memory. RESULTS: Greater levels fitness (B = 0.30, p = 0.011), DASH compliance (B = 0.19, p = 0.045), and lower obesity (B = -0.30, p = 0.004), associated with greater changes in TOI, whereas greater flow-mediated dilation (B = 0.19, p = 0.031) and lower stroke risk (B = -0.19, p = 0.049) associated with greater HBO2. Similar associations were found for cerebral hemodynamic recruitment, and associations between CVR and cognition were moderated by duration of hypertension. CONCLUSION: Impaired CVR elevated cardiometabolic risk, obesity, vascular function, and fitness among hypertensives.

FGANet: fNIRS-Guided Attention Network for Hybrid EEG-fNIRS Brain-Computer Interfaces.

Kwak Y, Song WJ, Kim SE.

IEEE Trans Neural Syst Rehabil Eng. 2022;30:329-339.
doi: 10.1109/TNSRE.2022.3149899. Epub 2022 Feb 16.

Non-invasive brain-computer interfaces (BCIs) have been widely used for neural decoding, linking neural signals to control devices. Hybrid BCI systems using electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) have received significant attention for overcoming the limitations of EEG- and fNIRS-standalone BCI systems. However, most hybrid EEG-fNIRS BCI studies have focused on late fusion because of discrepancies in their temporal resolutions and recording locations. Despite the enhanced performance of hybrid BCIs, late fusion methods have difficulty in extracting correlated features in both EEG and fNIRS signals. Therefore, in this study, we proposed a deep learning-based early fusion structure, which combines two signals before the fully-connected layer, called the fNIRS-guided attention network (FGANet). First, 1D EEG and fNIRS signals were converted into 3D EEG and fNIRS tensors to spatially align EEG and fNIRS signals at the same time point. The proposed fNIRS-guided attention layer extracted a joint representation of EEG and fNIRS tensors based on neurovascular coupling, in which the spatially important regions were identified from fNIRS signals, and detailed neural patterns were extracted from EEG signals. Finally, the final prediction was obtained by weighting the sum of the

prediction scores of the EEG and fNIRS-guided attention features to alleviate performance degradation owing to delayed fNIRS response. In the experimental results, the FGANet significantly outperformed the EEG-standalone network. Furthermore, the FGANet has 4.0% and 2.7% higher accuracy than the state-of-the-art algorithms in mental arithmetic and motor imagery tasks, respectively.

Functional near-infrared spectroscopy to assess pain in neonatal circumcisions.

Yuan I, Nelson O, Barr GA, Zhang B, Topjian AA, DiMaggio TJ, Lang SS, Christ LA, Izzetoglu K, Greco CC, Kurth CD, Ganesh A.

Paediatr Anaesth. 2022 Mar;32(3):404-412.
doi: 10.1111/pan.14326. Epub 2021 Nov 14.

Comment in Paediatr Anaesth. 2022 Mar;32(3):394-395.

Development of a miniaturized and modular probe for fNIRS instrument.

Liu G, Cui W, Hu X, Xiao R, Zhang S, Cai J, Qiu J, Qi Y.

Lasers Med Sci. 2022 Jan 14.
doi: 10.1007/s10103-021-03493-w. Online ahead of print.

Functional near-infrared spectroscopy (fNIRS) is a non-invasive and promising method for continuously monitoring hemodynamic and metabolic changes in tissues. However, the existing fNIRS equipment uses optical fiber, which is bulky, expensive, and time-consuming. We present a miniaturized, modular, novel silicon photomultiplier (SiPM) detector and develop a fNIRS instrument aimed at investigating the cerebral hemodynamic response for patients with epilepsy. Light emitting probe is a circle with a diameter of 5mm. Independent and modular light source and detector are more flexible in placement. The system can be expanded to high-density measurement with 16 light sources, 16 detectors, and 52 channels. The sampling rate of each channel is 25Hz. Instrument performance was evaluated using brain tissue phantom and in vivo experiments. High signal-to-noise ratio (60dB) in source detector separation (SDS) of 30mm, good stability (0.1%), noise equivalent power (0.89 pW), and system drift (0.56%) were achieved in the phantom experiment. Forearm blood-flow occlusion experiments were performed on the forearm of three healthy volunteers to demonstrate the ability to track rapid hemodynamic changes. Breath holding experiments on the forehead of healthy volunteers demonstrated the system can well detect brain function activity. The computer software was developed to display the original light signal intensity and the concentration changes of oxygenated hemoglobin (HbO2) and deoxygenated hemoglobin (HbR) in real time. This system paves the way for our further diagnosis of epilepsy.

Transformer Model for Functional Near-Infrared Spectroscopy Classification.

Wang Z, Zhang J, Zhang X, Chen P, Wang B.

IEEE J Biomed Health Inform. 2022 Jan 5;PP.
doi: 10.1109/JBHI.2022.3140531. Online ahead of print.

Functional near-infrared spectroscopy (fNIRS) is a promising neuroimaging technology. The fNIRS classification problem has always been the focus of the brain-computer interface (BCI). Inspired by the success of Transformer based on self-attention mechanism in the fields of natural language processing and computer vision, we propose an fNIRS classification network based on Transformer, named fNIRS-T. We explore the spatial-level and channel-level representation of fNIRS signals to improve data utilization and network representation capacity. Besides, a preprocessing module, which consists of one-dimensional average pooling and layer normalization, is designed to replace filtering and baseline correction of data preprocessing. It makes fNIRS-T an end-to-end network, called fNIRS-PreT. Compared with traditional

machine learning classifiers, convolutional neural network (CNN), and long short-term memory (LSTM), the proposed models obtain the best accuracy on three open-access datasets. Specifically, in the most extensive ternary classification task (30 subjects) that includes three types of overt movements, fNIRS-T, CNN, and LSTM obtain 75.49%, 72.89%, and 61.94% on test sets, respectively. Compared to traditional classifiers, fNIRS-T is at least 27.41% higher than statistical features and 6.79% higher than well-designed features. In the individual subject experiment of the ternary classification task, fNIRS-T achieves an average subject accuracy of 78.22% and surpasses CNN and LSTM by a large margin of +4.75% and +11.33%. fNIRS-PreT using raw data also achieves competitive performance to fNIRS-T. Therefore, the proposed models improve the performance of fNIRS-based BCI significantly.

Oscillator decomposition of infant fNIRS data.

Matsuda T, Homae F, Watanabe H, Taga G, Komaki F.

PLoS Comput Biol. 2022 Mar 24;18(3):e1009985.
doi: 10.1371/journal.pcbi.1009985. eCollection 2022 Mar.

The functional near-infrared spectroscopy (fNIRS) can detect hemodynamic responses in the brain and the data consist of bivariate time series of oxygenated hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb) on each channel. In this study, we investigate oscillatory changes in infant fNIRS signals by using the oscillator decompisition method (OSC-DECOMP), which is a statistical method for extracting oscillators from time series data based on Gaussian linear state space models. OSC-DECOMP provides a natural decomposition of fNIRS data into oscillation components in a data-driven manner and does not require the arbitrary selection of band-pass filters. We analyzed 18-ch fNIRS data (3 minutes) acquired from 21 sleeping 3-month-old infants. Five to seven oscillators were extracted on most channels, and their frequency distribution had three peaks in the vicinity of 0.01-0.1 Hz, 1.6-2.4 Hz and 3.6-4.4 Hz. The first peak was considered to reflect hemodynamic changes in response to the brain activity, and the phase difference between oxy-Hb and deoxy-Hb for the associated oscillators was at approximately 230 degrees. The second peak was attributed to cardiac pulse waves and mirroring noise. Although these oscillators have close frequencies, OSC-DECOMP can separate them through estimating their different projection patterns on oxy-Hb and deoxy-Hb. The third peak was regarded as the harmonic of the second peak. By comparing the Akaike Information Criterion (AIC) of two state space models, we determined that the time series of oxy-Hb and deoxy-Hb on each channel originate from common oscillatory activity. We also utilized the result of OSC-DECOMP to investigate the frequency-specific functional connectivity. Whereas the brain oscillator exhibited functional connectivity, the pulse waves and mirroring noise oscillators showed spatially homogeneous and independent changes. OSC-DECOMP is a promising tool for data-driven extraction of oscillation components from biological time series data.

Evaluating mental workload during multitasking in simulated flight.

Li W, Li R, Xie X, Chang Y.

Brain Behav. 2022 Apr;12(4):e2489.
doi: 10.1002/brb3.2489. Epub 2022 Mar 15.

BACKGROUND: Pilots must process multiple streams of information simultaneously. Mental workload is one of the main issues in man-machine interactive mode when dealing with multiple tasks. This study aimed to combine functional near-infrared spectroscopy (fNIRS) and electrocardiogram (ECG) to detect changes in mental workload during multitasking in a simulated flight. METHODS: Twenty-six participants performed three multitasking tasks at different mental workload levels. These mental workload levels were set by varying the number of subtasks. fNIRS and ECG signals were recorded during tasks. Participants filled in the national aeronautics and space administration task load index (NASA-TLX) scale after each task. The effects of mental workload on scores of NASA-TLX, performance of tasks, heart rate (HR), heart

rate variability (HRV), and the prefrontal cortex (PFC) activation were analyzed. RESULTS: Compared to multitasking in lower mental workload conditions, participants exhibited higher scores of NASA-TLX, HR, and PFC activation when multitasking in high mental workload conditions. Their performance was worse during the high mental workload multitasking condition, as evidenced by the higher average tracking distance, smaller number of response times, and longer response time of the meter. The standard deviation of the RR intervals (SDNN) was negatively correlated with subjective mental workload in the low task load condition and PFC activation was positively correlated with HR and subjective mental workload in the medium task load condition. CONCLUSION: HR and PFC activation can be used to detect changes in mental workload during simulated flight multitasking tasks.

Modulation of dorsolateral prefrontal cortex functional connectivity after intermittent theta-burst stimulation in depression: Combining findings from fNIRS and fMRI.

Struckmann W, Bodn R, Gingnell M, Fllmar D, Persson J.

Neuroimage Clin. 2022;34:103028.
doi: 10.1016/j.nicl.2022.103028. Epub 2022 May 2.

BACKGROUND: Resting-state functional magnetic resonance imaging (fMRI) can assess modulation of functional connectivity networks following repetitive transcranial magnetic stimulation (rTMS) in the treatment of depression. Functional near-infrared spectroscopy (fNIRS) is well suited for the concurrent application during rTMS treatment sessions to capture immediate blood oxygenation (oxy-Hb) effects, however limited in spatial resolution. OBJECTIVE: To understand the network effects behind such a prefrontal fNIRS response during rTMS, and to test whether the fNIRS signal may be predictive of treatment response, we linked data from fNIRS and fMRI within a clinical intervention study. METHODS: 42 patients with ongoing depression were recruited and randomized to receive active or sham intermittent theta-burst stimulation (iTBS) over the dorsomedial prefrontal cortex (dmPFC) twice daily for ten days at target intensity. Oxy-Hb was recorded with fNIRS during the first, fifth, and final day of iTBS, with the probe holders located laterally to the TMS coil over regions corresponding to the left and right dorsolateral prefrontal cortex (dlPFC). Resting-state fMRI scanning was performed before and after the whole iTBS treatment course. Functional connectivity analyses were then performed using dlPFC seeds from parcels of a brain atlas showing most overlap with the fNIRS probe locations during treatment. RESULTS: After active iTBS, left dlPFC-connectivity to the right insula/operculum was reduced compared to sham. The left insula showed a connectivity reduction to the left dlPFC that correlated with an improvement in symptoms. In addition, the posterior parietal cortex showed a connectivity reduction to the left dlPFC that correlated with the fNIRS signal following active iTBS. Finally, the fNIRS oxy-Hb signal from the left dlPFC-seed during the first treatment day was predictive of dlPFC-connectivity change to precentral and temporal cortex regions. CONCLUSION: By linking findings from these two different methods, this study suggests that changes within both the salience network and the central executive network affect the fNIRS response to iTBS.

Infants' brain activity to cartoon face using functional near-infrared spectroscopy.

Yamanaka N, Kanazawa S, Yamaguchi MK.

PLoS One. 2022 Feb 16;17(2):e0262679.
doi: 10.1371/journal.pone.0262679. eCollection 2022.

In this study, to investigate whether infants showed face-specific brain activity to a cartoon human face, we conducted a functional near-infrared spectroscopy (fNIRS) experiment and a behavioral experiment. In the fNIRS experiment, we measured the hemodynamic responses of 5- and 6-month-old infants to cartoon female and cartoon character faces using fNIRS. The results showed that the concentration of oxy-Hb increased for cartoon female faces but not for cartoon character faces. This indicates that face-specific

brain activity occurred for cartoon female faces but not cartoon character faces, despite the fact that both are faces. In the behavioral experiment, we examined whether the 5- and 6-month-old infants preferred cartoon female faces to cartoon character faces in the upright and inverted conditions. The results showed a preference for cartoon female faces in the upright but not in the inverted condition. This indicates that 5- and 6-month-old infants can perceive cartoon female faces, but not cartoon character faces, as faces. The results of the two experiments indicated that face-specific brain activity occurred for cartoon female faces. This indicates that infants can perceive cartoon female faces as faces.

Effects of pharmacological treatments on neuroimaging findings in borderline personality disorder: A review of FDG-PET and fNIRS studies.

Cattarinussi G, Delvecchio G, Moltrasio C, Ferro A, Sambataro F, Brambilla P.

J Affect Disord. 2022 Jul 1;308:314-321.
doi: 10.1016/j.jad.2022.04.050. Epub 2022 Apr 13.

BACKGROUND: Borderline personality disorder (BPD) is a serious mental condition characterized by instability in identity, interpersonal relationships, emotion regulation and impulsivity. These symptoms seem to be associated to specific brain alterations, which have been largely investigated. In particular, positron emission tomography (PET) and functional near-infrared spectroscopy (fNIRS) have demonstrated abnormalities in brain metabolism and hemodynamics in BPD, specifically in the fronto-limbic system. However, the role of medications on brain metabolism and hemodynamics in BPD is still largely unknown. METHODS: We conducted a search on PubMed, Scopus and Web of Science of PET and fNIRS studies exploring the effect of medications on brain metabolism and hemodynamics in BPD. A total of 10 studies met the inclusion criteria. RESULTS: Overall, PET studies showed an effect of psychotropic agents on brain metabolism, especially in frontal and temporal areas. Also, higher metabolic rates in frontal areas were found to correlate with clinical improvements. In contrast, fNIRS investigations reported an inconclusive or absent effects on brain hemodynamics in BPD patients. LIMITATIONS: The small sample size, the elevated percentage of women, the heterogeneity in pharmacological agents and the presence of comorbidities limit the conclusions of the present review. CONCLUSIONS: Serotoninergic agents and second-generation antipsychotics produce changes in frontal and temporal metabolism in BPD, which appear to correlate with clinical improvements. Differently, brain hemodynamics do not seem to be significantly affected by the most commonly prescribed drugs in BPD, suggesting that the therapeutic actions of medications are not mediated by changes in neural hemodynamics.

Analyzing Classification Performance of fNIRS-BCI for Gait Rehabilitation Using Deep Neural Networks.

Hamid H, Naseer N, Nazeer H, Khan MJ, Khan RA, Shahbaz Khan U.

Sensors (Basel). 2022 Mar 1;22(5):1932.
doi: 10.3390/s22051932.

This research presents a brain-computer interface (BCI) framework for brain signal classification using deep learning (DL) and machine learning (ML) approaches on functional near-infrared spectroscopy (fNIRS) signals. fNIRS signals of motor execution for walking and rest tasks are acquired from the primary motor cortex in the brain's left hemisphere for nine subjects. DL algorithms, including convolutional neural networks (CNNs), long short-term memory (LSTM), and bidirectional LSTM (Bi-LSTM) are used to achieve average classification accuracies of 88.50%, 84.24%, and 85.13%, respectively. For comparison purposes, three conventional ML algorithms, support vector machine (SVM), k-nearest neighbor (k-NN), and linear discriminant analysis (LDA) are also used for classification, resulting in average classification accuracies of 73.91%, 74.24%, and 65.85%, respectively. This study successfully demonstrates that the enhanced performance of fNIRS-BCI can be achieved in terms of classification accuracy using DL approaches com-

pared to conventional ML approaches. Furthermore, the control commands generated by these classifiers can be used to initiate and stop the gait cycle of the lower limb exoskeleton for gait rehabilitation.

Brain Connectivity and Network Analysis in Amyotrophic Lateral Sclerosis.

Renga V.

Neurol Res Int. 2022 Feb 7;2022:1838682.
doi: 10.1155/2022/1838682. eCollection 2022.

Amyotrophic lateral sclerosis (ALS) is a fatal neurodegenerative disease with no effective treatment or cure. ALS is characterized by the death of lower motor neurons (LMNs) in the spinal cord and upper motor neurons (UMNs) in the brain and their networks. Since the lower motor neurons are under the control of UMN and the networks, cortical degeneration may play a vital role in the pathophysiology of ALS. These changes that are not apparent on routine imaging with CT scans or MRI brain can be identified using modalities such as diffusion tensor imaging, functional MRI, arterial spin labelling (ASL), electroencephalogram (EEG), magnetoencephalogram (MEG), functional near-infrared spectroscopy (fNIRS), and positron emission tomography (PET) scan. They can help us generate a representation of brain networks and connectivity that can be visualized and parsed out to characterize and quantify the underlying pathophysiology in ALS. In addition, network analysis using graph measures provides a novel way of understanding the complex network changes occurring in the brain. These have the potential to become biomarker for the diagnosis and treatment of ALS. This article is a systematic review and overview of the various connectivity and network-based studies in ALS.

Effective brain network analysis in unilateral and bilateral upper limb exercise training in subjects with stroke.

Xu G, Huo C, Yin J, Li W, Xie H, Li X, Li Z, Wang Y, Wang D.

Med Phys. 2022 May;49(5):3333-3346.
doi: 10.1002/mp.15570. Epub 2022 Apr 11.

PURPOSE: Knowing the patterns of brain activation that occur and networks involved under different interventions is important for motor recovery in subjects with stroke. This study aimed to study the patterns of brain activation and networks in two interventions, affected upper limb side and bilateral exercise training, using concurrent functional near-infrared spectroscopy (fNIRS) imaging. METHODS: Thirty-two patients in the early subacute stage were randomly divided into two groups: unilateral and bilateral groups. The patients in the unilateral group underwent isokinetic muscle strength training on the affected upper limb side and patients in the bilateral group underwent bilateral upper limb training. Oxyhemoglobin and deoxyhemoglobin concentration changes (?HbO2 and ?HbR, respectively) were recorded in the ipsilateral and contralateral prefrontal cortex (IPFC and CPFC, respectively) and ipsilateral and contralateral motor cortex (IMC and CMC, respectively) by fNIRS equipment in the resting state and training conditions. The phase information of a 0.01-0.08Hz fNIRS signal was extracted by the wavelet transform method. Dynamic Bayesian inference was adopted to calculate the coupling strength and direction of effective connectivity. The network threshold was determined by surrogate signal method, the global (weighted clustering coefficient, global efficiency, and small-worldness) and local (degree, betweenness centrality, and local efficiency) network metrics were calculated. The degree of cerebral lateralization was also compared between the two groups. RESULTS: The results of covariance analysis showed that, compared with bilateral training, the coupling effect of CMC?IMC was significantly enhanced ($p=0.03$); also, the local efficiency of the IMC ($p=0.01$), IPFC ($p<0.001$), and CPFC ($p=0.006$) and the hemispheric autonomy index of IPFC ($p=0.007$) were significantly increased in unilateral training. In addition, there was a significant positive correlation between the coupling intensity of the inter-hemispheric motor area and the shifted local efficiency. CONCLUSIONS: The results indicated that unilateral upper limb training could more effectively promote

the interaction and balance of bilateral motor hemispheres and help brain reorganization in the IMC and prefrontal cortex in stroke patients. The method provided in this study could be used to evaluate dynamic brain activation and network reorganization under different interventions, thus improving the strategy of rehabilitation intervention in a timely manner and resulting in better motor recovery.

Cortical activation during gait adaptability in people with Parkinson's disease.

Pelicioni PHS, Lord SR, Okubo Y, Menant JC.

Gait Posture. 2022 Jan;91:247-253.
doi: 10.1016/j.gaitpost.2021.10.038. Epub 2021 Oct 30.

BACKGROUND: People with Parkinson's disease (PD) have difficulties adapting their gait. While underlying neural mechanisms involving the prefrontal cortex (PFC) have been studied across various complex walking tasks, less is known about the premotor cortex (PMC) and supplementary motor area (SMA), key cortical regions for motor planning. This study compared frontal cortical regions activation patterns using functional near-infrared spectroscopy (fNIRS), between people with PD and healthy controls (HC) during gait adaptability tasks. METHODS: Forty-nine people with PD (mean (SD) age: 69.5 (7.9) years) and 21 HC (69.0 (5.9) years) completed a simple walk and three randomly presented gait adaptability tasks: (i) stepping on targets, (ii) avoiding obstacles and (iii) negotiating both targets and obstacles. Cortical activity in the dorsolateral PFC (DLPFC), SMA and PMC were recorded using fNIRS. Step length, velocity and accuracy and cortical activity were contrasted between the groups and walking conditions. RESULTS: Compared with the HC, the PD group exhibited greater PMC activation and walked significantly slower and took shorter steps in all conditions. A statistically significant group by condition interaction indicated an increase in DLPFC cortical activation in the HC participants when undertaking the obstacle avoidance task compared with the simple walk but no increase in cortical activation in the PD group when undergoing this more challenging gait task. CONCLUSIONS: Our findings suggest people with PD have little or no DLPFC, SMA and PMC capacity beyond what they need for simple walking and in consequence need to slow their gait velocity to meet the demands of target stepping and obstacle avoidance tasks. Such behavioral and neural patterns appear consistent with concepts of compensatory over-activation and capacity limitation.

Identifying Individuals by fNIRS-Based Brain Functional Network Fingerprints.

Ren H, Zhou S, Zhang L, Zhao F, Qiao L.

Front Neurosci. 2022 Feb 11;16:813293.
doi: 10.3389/fnins.2022.813293. eCollection 2022.

Individual identification based on brain functional network (BFN) has attracted a lot of research interest in recent years, since it provides a novel biometric for identity authentication, as well as a feasible way of exploring the brain at an individual level. Previous studies have shown that an individual can be identified by its BFN fingerprint estimated from functional magnetic resonance imaging, electroencephalogram, or magnetoencephalography data. Functional near-infrared spectroscopy (fNIRS) is an emerging imaging technique that, by measuring the changes in blood oxygen concentration, can respond to cerebral activities; in this paper, we investigate whether fNIRS-based BFN could be used as a "fingerprint" to identify individuals. In particular, Pearson's correlation is first used to calculate BFN based on the preprocessed fNIRS signals, and then the nearest neighbor scheme is used to match the estimated BFNs between different individuals. Through the experiments on an open-access fNIRS dataset, we have two main findings: (1) under the cases of cross-task (i.e., resting, right-handed, left-handed finger tapping, and foot tapping), the BFN fingerprints generally work well for the individual identification, and, more interestingly, (2) the accuracy under cross-task is well above the accuracy under cross-view (i.e., oxyhemoglobin and de-oxyhemoglobin). These findings indicate that fNIRS-based BFN fingerprint is a potential biometric

for identifying individual.

LIONirs: flexible Matlab toolbox for fNIRS data analysis.

Tremblay J, Martnez-Montes E, Hsser A, Caron-Desrochers L, Lepage C, Pouliot P, Vannasing P, Gallagher A.

J Neurosci Methods. 2022 Mar 15;370:109487.
doi: 10.1016/j.jneumeth.2022.109487. Epub 2022 Jan 25.

BACKGROUND: Functional near-infrared spectroscopy (fNIRS) is a suitable tool for recording brain function in pediatric or challenging populations. As with other neuroimaging techniques, the scientific community is engaged in an evolving debate regarding the most adequate methods for performing fNIRS data analyses. NEW METHOD: We introduce LIONirs, a neuroinformatics toolbox for fNIRS data analysis, designed to follow two main goals: (1) flexibility, to explore several methods in parallel and verify results using 3D visualization; (2) simplicity, to apply a defined processing pipeline to a large dataset of subjects by using the MATLAB Batch System and available on GitHub. RESULTS: Within the graphical user interfaces (DisplayGUI), the user can reject noisy intervals and correct artifacts, while visualizing the topographical projection of the data onto the 3D head representation. Data decomposition methods are available for the identification of relevant signatures, such as brain responses or artifacts. Multimodal data recorded simultaneously to fNIRS, such as physiology, electroencephalography or audio-video, can be visualized using the DisplayGUI. The toolbox includes several functions that allow one to read, preprocess, and analyze fNIRS data, including task-based and functional connectivity measures. COMPARISON WITH EXISTING METHODS: Several good neuroinformatics tools for fNIRS data analysis are currently available. None of them emphasize multimodal visualization of the data throughout the preprocessing steps and multidimensional decomposition, which are essential for understanding challenging data. Furthermore, LIONirs provides compatibility and complementarity with other existing tools by supporting common data format. CONCLUSIONS: LIONirs offers a flexible platform for basic and advanced fNIRS data analysis, shown through real experimental examples.

Volitional control of walking in aging.

Holtzer R.

Aging (Albany NY). 2022 Mar 28;14(6):2440-2441.
doi: 10.18632/aging.203986. Epub 2022 Mar 28.

DOI: 10.18632/aging.203986 PMCID: PMC9004554 PMID: 35344509 [Indexed for MEDLINE]

Preventing pediatric chronic postsurgical pain: Time for increased rigor.

Sieberg CB, Karunakaran KD, Kussman B, Borsook D.

Can J Pain. 2022 Apr 28;6(2):73-84.
doi: 10.1080/24740527.2021.2019576. eCollection 2022.

Chronic postsurgical pain (CPSP) results from a cascade of events in the peripheral and central nervous systems following surgery. Several clinical predictors, including the prior pain state, premorbid psychological state (e.g., anxiety, catastrophizing), intraoperative surgical load (establishment of peripheral and central sensitization), and acute postoperative pain management, may contribute to the patient's risk of developing CPSP. However, research on the neurobiological and biobehavioral mechanisms contributing to pediatric CPSP and effective preemptive/treatment strategies are still lacking. Here we evaluate the perisurgical process by identifying key problems and propose potential solutions for the pre-, intra-, and postoperative pain states to both prevent and manage the transition of acute to chronic pain. We propose

an eight-step process involving preemptive and preventative analgesia, behavioral interventions, and the use of biomarkers (brain-based, inflammatory, or genetic) to facilitate timely evaluation and treatment of premorbid psychological factors, ongoing surgical pain, and postoperative pain to provide an overall improved outcome. By achieving this, we can begin to establish personalized precision medicine for children and adolescents presenting to surgery and subsequent treatment selection.

Deep learning-based motion artifact removal in functional near-infrared spectroscopy.

Gao Y, Chao H, Cavuoto L, Yan P, Kruger U, Norfleet JE, Makled BA, Schwaitzberg S, De S, Intes X.
Neurophotonics. 2022 Oct;9(4):041406.
doi: 10.1117/1.NPh.9.4.041406. Epub 2022 Apr 23.

Significance: Functional near-infrared spectroscopy (fNIRS), a well-established neuroimaging technique, enables monitoring cortical activation while subjects are unconstrained. However, motion artifact is a common type of noise that can hamper the interpretation of fNIRS data. Current methods that have been proposed to mitigate motion artifacts in fNIRS data are still dependent on expert-based knowledge and the post hoc tuning of parameters. Aim: Here, we report a deep learning method that aims at motion artifact removal from fNIRS data while being assumption free. To the best of our knowledge, this is the first investigation to report on the use of a denoising autoencoder (DAE) architecture for motion artifact removal. Approach: To facilitate the training of this deep learning architecture, we (i)designed a specific loss function and (ii)generated data to mimic the properties of recorded fNIRS sequences. Results: The DAE model outperformed conventional methods in lowering residual motion artifacts, decreasing mean squared error, and increasing computational efficiency. Conclusion: Overall, this work demonstrates the potential of deep learning models for accurate and fast motion artifact removal in fNIRS data.

Notched Sound Alleviates Tinnitus by Reorganization Emotional Center.

Huang B, Wang X, Wei F, Sun Q, Sun J, Liang Y, Chen H, Zhuang H, Xiong G.
Front Hum Neurosci. 2022 Jan 28;15:762492.
doi: 10.3389/fnhum.2021.762492. eCollection 2021.

BACKGROUND: Tinnitus is a common disease, and sound therapy is an effective method to alleviate it. Previous studies have shown that notched sound not only changes levels of cortical blood oxygen, but affects blood oxygen in specific cerebral cortical areas, such as Brodmann area 46 (BA46), which is associated with emotion. Extensive evidence has confirmed that tinnitus is closely related to emotion. Whether notched sound plays a role in regulating the emotional center is still unclear. METHODS: This study included 29 patients with newly diagnosed chronic tinnitus who were treated with notched sound. Functional near-infrared spectroscopy (fNIRS) was conducted before and after treatment to observe bilateral changes in cortical blood oxygen in the cerebral hemispheres. We compared the changes in connectivity between the two regions of interest (the superior temporal gyrus and BA46), as wells as other cortical regions before and after treatment. RESULTS: The results showed (1) That global connectivity between the bilateral auditory cortex of the superior temporal sulcus and the ipsilateral cortex did not change significantly between baseline and the completion of treatment, and (2) That the connectivity between channel 14 and the right superior temporal sulcus decreased after treatment. The overall connectivity between the right BA46 region and the right cortex decreased after treatment, and decreases in connectivity after treatment were specifically found for channels 10 and 14 in the right parietal lobe and channels 16, 20, 21, and 22 in the frontal lobe, while there was no significant change on the left side. There were no significant changes in the questionnaire measures of tinnitus, anxiety, or depression before and after treatment. CONCLUSION: The results of the study indicate that cerebral cortex reorganization occurs in tinnitus patients after submitted to treatment with notched sound for 1 month, and that notched sound decreases the connectivity between the auditory cortex and specific brain regions. SIGNIFICANCE: Notched sound not only regulates the

auditory center through lateral inhibition, but also alleviates tinnitus by reorganizing the emotional control center.

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fNIRS brain measures of ongoing nociception during surgical incisions under anesthesia.

Green S, Karunakaran KD, Labadie R, Kussman B, Mizrahi-Arnaud A, Morad AG, Berry D, Zurakowski D, Micheli L, Peng K, Borsook D.

Neurophotonics. 2022 Jan;9(1):015002.
doi: 10.1117/1.NPh.9.1.015002. Epub 2022 Jan 27.

Significance: Functional near-infrared spectroscopy (fNIRS) has evaluated pain in awake and anesthetized states. Aim: We evaluated fNIRS signals under general anesthesia in patients undergoing knee surgery for anterior cruciate ligament repair. Approach: Patients were split into groups: those with regional nerve block (NB) and those without (non-NB). Continuous fNIRS measures came from three regions: the primary somatosensory cortex (S1), known to be involved in evaluation of nociception, the lateral prefrontal cortex (BA9), and the polar frontal cortex (BA10), both involved in higher cortical functions (such as cognition and emotion). Results: Our results show three significant differences in fNIRS signals to incision procedures between groups: (1)NB compared with non-NB was associated with a greater net positive hemodynamic response to pain procedures in S1; (2)dynamic correlation between the prefrontal cortex (PreFC) and S1 within 1min of painful procedures are anticorrelated in NB while positively correlated in non-NB; and (3)hemodynamic measures of activation were similar at two separate time points during surgery (i.e., first and last incisions) in PreFC and S1 but showed significant differences in their overlap. Comparing pain levels immediately after surgery and during discharge from postoperative care revealed no significant differences in the pain levels between NB and non-NB. Conclusion: Our data suggest multiple pain events that occur during surgery using devised algorithms could potentially give a measure of "pain load." This may allow for evaluation of central sensitization (i.e., a heightened state of the nervous system where noxious and non-noxious stimuli is perceived as painful) to postoperative pain levels and the resulting analgesic consumption. This evaluation could potentially predict postsurgical chronic neuropathic pain.

LASSO Homotopy-Based Sparse Representation Classification for fNIRS-BCI.

Gulraiz A, Naseer N, Nazeer H, Khan MJ, Khan RA, Shahbaz Khan U.

Sensors (Basel). 2022 Mar 28;22(7):2575.
doi: 10.3390/s22072575.

Brain-computer interface (BCI) systems based on functional near-infrared spectroscopy (fNIRS) have been used as a way of facilitating communication between the brain and peripheral devices. The BCI provides an option to improve the walking pattern of people with poor walking dysfunction, by applying a rehabilitation process. A state-of-the-art step-wise BCI system includes data acquisition, pre-processing, channel selection, feature extraction, and classification. In fNIRS-based BCI (fNIRS-BCI), channel selection plays a vital role in enhancing the classification accuracy of the BCI problem. In this study, the concentration of blood oxygenation (HbO) in a resting state and in a walking state was used to decode the walking activity and the resting state of the subject, using channel selection by Least Absolute Shrinkage and Selection Operator (LASSO) homotopy-based sparse representation classification. The fNIRS signals of nine subjects were collected from the left hemisphere of the primary motor cortex. The subjects performed the task of walking on a treadmill for 10 s, followed by a 20 s rest. Appropriate filters were applied to the collected signals to remove motion artifacts and physiological noises. LASSO homotopy-based sparse representation was used to select the most significant channels, and then classification was performed to identify walking and resting states. For comparison, the statistical spatial features of mean, peak, variance,

and skewness, and their combination, were used for classification. The classification results after channel selection were then compared with the classification based on the extracted features. The classifiers used for both methods were linear discrimination analysis (LDA), support vector machine (SVM), and logistic regression (LR). The study found that LASSO homotopy-based sparse representation classification successfully discriminated between the walking and resting states, with a better average classification accuracy (p < 0.016) of 91.32%. This research provides a step forward in improving the classification accuracy of fNIRS-BCI systems. The proposed methodology may also be used for rehabilitation purposes, such as controlling wheelchairs and prostheses, as well as an active rehabilitation training technique for patients with motor dysfunction.

Inhibitory Control in Children 4-10 Years of Age: Evidence From Functional Near-Infrared Spectroscopy Task-Based Observations.

Zhou X, Planalp EM, Heinrich L, Pletcher C, DiPiero M, Alexander AL, Litovsky RY, Dean DC 3rd.
Front Hum Neurosci. 2022 Jan 3;15:798358.
doi: 10.3389/fnhum.2021.798358. eCollection 2021.

Executive function (EF) is essential to child development, with associated skills beginning to emerge in the first few years of life and continuing to develop into adolescence and adulthood. The prefrontal cortex (PFC), which follows a neurodevelopmental timeline similar to EF, plays an important role in the development of EF. However, limited research has examined prefrontal function in young children due to limitations of currently available neuroimaging techniques such as functional resonance magnetic imaging (fMRI). The current study developed and applied a multimodal Go/NoGo task to examine the EF component of inhibitory control in children 4-10 years of age. Cortical activity was measured using a non-invasive and child-friendly neuroimaging technique - functional near-infrared spectroscopy (fNIRS). Children's response accuracy and reaction times were captured during the fNIRS session and compared with responses obtained using the standardized assessments from NIH Toolbox cognition battery. Results showed significant correlations between the behavioral measures during the fNIRS session and the standardized EF assessments, in line with our expectations. Results from fNIRS measures demonstrated a significant, age-independent effect of inhibitory control (IC) in the right PFC (rPFC), and an age-dependent effect in the left orbitofrontal cortex (lOFC), consistent with results in previous studies using fNIRS and fMRI. Thus, the new task designed for fNIRS was suitable for examining IC in young children, and results showed that fNIRS measures can reveal prefrontal IC function.

Optimized electroencephalogram and functional near-infrared spectroscopy-based mental workload detection method for practical applications.

Chu H(#), Cao Y(#), Jiang J, Yang J, Huang M, Li Q, Jiang C, Jiao X.
Biomed Eng Online. 2022 Feb 2;21(1):9.
doi: 10.1186/s12938-022-00980-1.

BACKGROUND: Mental workload is a critical consideration in complex man-machine systems design. Among various mental workload detection techniques, multimodal detection techniques integrating electroencephalogram (EEG) and functional near-infrared spectroscopy (fNIRS) signals have attracted considerable attention. However, existing EEG-fNIRS-based mental workload detection methods have certain defects, such as complex signal acquisition channels and low detection accuracy, which restrict their practical application. METHODS: The signal acquisition configuration was optimized by analyzing the feature importance in mental workload recognition model and a more accurate and convenient EEG-fNIRS-based mental workload detection method was constructed. A classical Multi-Task Attribute Battery (MATB) task was conducted with 20 participating volunteers. Subjective scale data, 64-channel EEG data, and two-channel fNIRS data were collected. RESULTS: A higher number of EEG channels correspond to

higher detection accuracy. However, there is no obvious improvement in accuracy once the number of EEG channels reaches 26, with a four-level mental workload detection accuracy of 76.25 5.21%. Partial results of physiological analysis verify the results of previous studies, such as that the ? power of EEG and concentration of O2Hb in the prefrontal region increase while the concentration of HHb decreases with task difficulty. It was further observed, for the first time, that the energy of each band of EEG signals was significantly different in the occipital lobe region, and the power of [Formula: see text] and [Formula: see text] bands in the occipital region increased significantly with task difficulty. The changing range and the mean amplitude of O2Hb in high-difficulty tasks were significantly higher compared with those in low-difficulty tasks. CONCLUSIONS: The channel configuration of EEG-fNIRS-based mental workload detection was optimized to 26 EEG channels and two frontal fNIRS channels. A four-level mental workload detection accuracy of 76.25 5.21% was obtained, which is higher than previously reported results. The proposed configuration can promote the application of mental workload detection technology in military, driving, and other complex human-computer interaction systems.

Widespread nociceptive maps in the human neonatal somatosensory cortex.

Jones L, Verriotis M, Cooper RJ, Laudiano-Dray MP, Rupawala M, Meek J, Fabrizi L, Fitzgerald M.
Elife. 2022 Apr 22;11:e71655.
doi: 10.7554/eLife.71655.

Topographic cortical maps are essential for spatial localisation of sensory stimulation and generation of appropriate task-related motor responses. Somatosensation and nociception are finely mapped and aligned in the adult somatosensory (S1) cortex, but in infancy, when pain behaviour is disorganised and poorly directed, nociceptive maps may be less refined. We compared the topographic pattern of S1 activation following noxious (clinically required heel lance) and innocuous (touch) mechanical stimulation of the same skin region in newborn infants (n = 32) using multioptode functional near-infrared spectroscopy (fNIRS). Within S1 cortex, touch and lance of the heel elicit localised, partially overlapping increases in oxygenated haemoglobin concentration (?[HbO]), but while touch activation was restricted to the heel area, lance activation extended into cortical hand regions. The data reveals a widespread cortical nociceptive map in infant S1, consistent with their poorly directed pain behaviour.

Frequency-domain analysis of fNIRS fluctuations induced by rhythmic mental arithmetic.

Molina-Rodrguez S, Mirete-Fructuoso M, Martnez LM, Ibaez-Ballesteros J.
Psychophysiology. 2022 Apr 8:e14063.
doi: 10.1111/psyp.14063. Online ahead of print.

Functional near-infrared spectroscopy (fNIRS) is an increasingly used technology for imaging neural correlates of cognitive processes. However, fNIRS signals are commonly impaired by task-evoked and spontaneous hemodynamic oscillations of non-cerebral origin, a major challenge in fNIRS research. In an attempt to isolate the task-evoked cortical response, we investigated the coupling between hemodynamic changes arising from superficial and deep layers during mental effort. For this aim, we applied a rhythmic mental arithmetic task to induce cyclic hemodynamic fluctuations suitable for effective frequency-resolved measurements. Twenty university students aged 18-25years (eight males) underwent the task while hemodynamic changes were monitored in the forehead using a newly developed NIRS device, capable of multi-channel and multi-distance recordings. We found significant task-related fluctuations for oxy- and deoxy-hemoglobin, highly coherent across shallow and deep tissue layers, corroborating the strong influence of surface hemodynamics on deep fNIRS signals. Importantly, after removing such surface contamination by linear regression, we show that the frontopolar cortex response to a mental math task follows an unusual inverse oxygenation pattern. We confirm this finding by applying for the first time an alternative method

to estimate the neural signal, based on transfer function analysis and phasor algebra. Altogether, our results demonstrate the feasibility of using a rhythmic mental task to impose an oscillatory state useful to separate true brain functional responses from those of non-cerebral origin. This separation appears to be essential for a better understanding of fNIRS data and to assess more precisely the dynamics of the neuro-visceral link.

Neural decoding of semantic concepts: a systematic literature review.

Rybr M, Daly I.

J Neural Eng. 2022 Apr 13;19(2).
doi: 10.1088/1741-2552/ac619a.

Objective.Semantic concepts are coherent entities within our minds. They underpin our thought processes and are a part of the basis for our understanding of the world. Modern neuroscience research is increasingly exploring how individual semantic concepts are encoded within our brains and a number of studies are beginning to reveal key patterns of neural activity that underpin specific concepts. Building upon this basic understanding of the process of semantic neural encoding, neural engineers are beginning to explore tools and methods for semantic decoding: identifying which semantic concepts an individual is focused on at a given moment in time from recordings of their neural activity. In this paper we review the current literature on semantic neural decoding.Approach.We conducted this review according to the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines. Specifically, we assess the eligibility of published peer-reviewed reports via a search of PubMed and Google Scholar. We identify a total of 74 studies in which semantic neural decoding is used to attempt to identify individual semantic concepts from neural activity.Main results.Our review reveals how modern neuroscientific tools have been developed to allow decoding of individual concepts from a range of neuroimaging modalities. We discuss specific neuroimaging methods, experimental designs, and machine learning pipelines that are employed to aid the decoding of semantic concepts. We quantify the efficacy of semantic decoders by measuring information transfer rates. We also discuss current challenges presented by this research area and present some possible solutions. Finally, we discuss some possible emerging and speculative future directions for this research area.Significance.Semantic decoding is a rapidly growing area of research. However, despite its increasingly widespread popularity and use in neuroscientific research this is the first literature review focusing on this topic across neuroimaging modalities and with a focus on quantifying the efficacy of semantic decoders.

Regional Haemodynamic and Metabolic Coupling in Infants.

Siddiqui MF, Pinti P, Lloyd-Fox S, Jones EJH, Brigadoi S, Collins-Jones L, Tachtsidis I, Johnson MH, Elwell CE.

Front Hum Neurosci. 2022 Feb 4;15:780076.
doi: 10.3389/fnhum.2021.780076. eCollection 2021.

Metabolic pathways underlying brain function remain largely unexplored during neurodevelopment, predominantly due to the lack of feasible techniques for use with awake infants. Broadband near-infrared spectroscopy (bNIRS) provides the opportunity to explore the relationship between cerebral energy metabolism and blood oxygenation/haemodynamics through the measurement of changes in the oxidation state of mitochondrial respiratory chain enzyme cytochrome-c-oxidase (?oxCCO) alongside haemodynamic changes. We used a bNIRS system to measure ?oxCCO and haemodynamics during functional activation in a group of 42 typically developing infants aged between 4 and 7 months. bNIRS measurements were made over the right hemisphere over temporal, parietal and central cortical regions, in response to social and non-social visual and auditory stimuli. Both ?oxCCO and ?[HbO2] displayed larger activation for the social condition in comparison to the non-social condition. Integration of haemodynamic and metabolic signals revealed

networks of stimulus-selective cortical regions that were not apparent from analysis of the individual bNIRS signals. These results provide the first spatially resolved measures of cerebral metabolic activity alongside haemodynamics during functional activation in infants. Measuring synchronised changes in metabolism and haemodynamics have the potential for uncovering the development of cortical specialisation in early infancy.

Hybrid motion artifact detection and correction approach for functional near-infrared spectroscopy measurements.

Gao L, Wei Y, Wang Y, Wang G, Zhang Q, Zhang J, Chen X, Yan X.
J Biomed Opt. 2022 Feb;27(2):025003.
doi: 10.1117/1.JBO.27.2.025003.

SIGNIFICANCE: Functional near-infrared spectroscopy (fNIRS) is a promising optical neuroimaging technique, measuring the hemodynamic signals from the cortex. However, improving signal quality and reducing artifacts arising from oscillation and baseline shift (BS) are still challenging up to now for fNIRS applications. AIM: Considering the advantages and weaknesses of the different algorithms to reduce the artifact effect in fNIRS signals, we propose a hybrid artifact detection and correction approach. APPROACH: First, distinct artifact detection was realized through an fNIRS detection strategy. Then the artifacts were divided into three categories: BS, slight oscillation, and severe oscillation. A comprehensive correction was applied through three main steps: severe artifact correction by cubic spline interpolation, BS removal by spline interpolation, and slight oscillation reduction by dual-threshold wavelet-based method. RESULTS: Using fNIRS data acquired during whole night sleep monitoring, we compared the performance of our approach with existing algorithms in signal-to-noise ratio (SNR) and Pearson's correlation coefficient (R). We found that the proposed method showed improvements in performance in SNR and R with strong stability. CONCLUSIONS: These results suggest that the new hybrid artifact detection and correction method enhances the viability of fNIRS as a functional neuroimaging modality.

Viewing neurovascular coupling through the lens of combined EEG-fNIRS: A systematic review of current methods.

Yeung MK, Chu VW.
Psychophysiology. 2022 Jun;59(6):e14054.
doi: 10.1111/psyp.14054. Epub 2022 Mar 31.

Neurovascular coupling is a key physiological mechanism that occurs in the healthy human brain, and understanding this process has implications for understanding the aging and neuropsychiatric populations. Combined electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) has emerged as a promising, noninvasive tool for probing neurovascular interactions in humans. However, the utility of this approach critically depends on the methodological quality used for multimodal integration. Despite a growing number of combined EEG-fNIRS applications reported in recent years, the methodological rigor of past studies remains unclear, limiting the accurate interpretation of reported findings and hindering the translational application of this multimodal approach. To fill this knowledge gap, we critically evaluated various methodological aspects of previous combined EEG-fNIRS studies performed in healthy individuals. A literature search was conducted using PubMed and PsycINFO on June 28, 2021. Studies involving concurrent EEG and fNIRS measurements in awake and healthy individuals were selected. After screening and eligibility assessment, 96 studies were included in the methodological evaluation. Specifically, we critically reviewed various aspects of participant sampling, experimental design, signal acquisition, data preprocessing, outcome selection, data analysis, and results presentation reported in these studies. Altogether, we identified several notable strengths and limitations of the existing EEG-fNIRS literature. In light of these limitations and the features of combined EEG-fNIRS, recommendations are made to improve

and standardize research practices to facilitate the use of combined EEG-fNIRS when studying healthy neurovascular coupling processes and alterations in neurovascular coupling among various populations.

Multi-Modal Integration of EEG-fNIRS for Characterization of Brain Activity Evoked by Preferred Music.

Qiu L, Zhong Y, Xie Q, He Z, Wang X, Chen Y, Zhan CA, Pan J.
Front Neurorobot. 2022 Jan 31;16:823435.
doi: 10.3389/fnbot.2022.823435. eCollection 2022.

Music can effectively improve people's emotions, and has now become an effective auxiliary treatment method in modern medicine. With the rapid development of neuroimaging, the relationship between music and brain function has attracted much attention. In this study, we proposed an integrated framework of multi-modal electroencephalogram (EEG) and functional near infrared spectroscopy (fNIRS) from data collection to data analysis to explore the effects of music (especially personal preferred music) on brain activity. During the experiment, each subject was listening to two different kinds of music, namely personal preferred music and neutral music. In analyzing the synchronization signals of EEG and fNIRS, we found that music promotes the activity of the brain (especially the prefrontal lobe), and the activation induced by preferred music is stronger than that of neutral music. For the multi-modal features of EEG and fNIRS, we proposed an improved Normalized-ReliefF method to fuse and optimize them and found that it can effectively improve the accuracy of distinguishing between the brain activity evoked by preferred music and neutral music (up to 98.38%). Our work provides an objective reference based on neuroimaging for the research and application of personalized music therapy.

Kernel Flow: a high channel count scalable time-domain functional near-infrared spectroscopy system.

Ban HY, Barrett GM, Borisevich A, Chaturvedi A, Dahle JL, Dehghani H, Dubois J, Field RM, Gopalakrishnan V, Gundran A, Henninger M, Ho WC, Hughes HD, Jin R, Kates-Harbeck J, Landy T, Leggiero M, Lerner G, Aghajan ZM, Moon M, Olvera I, Park S, Patel MJ, Perdue KL, Siepser B, Sorgenfrei S, Sun N, Szczepanski V, Zhang M, Zhu Z.
J Biomed Opt. 2022 Jan;27(7):074710.
doi: 10.1117/1.JBO.27.7.074710.

SIGNIFICANCE: Time-domain functional near-infrared spectroscopy (TD-fNIRS) has been considered as the gold standard of noninvasive optical brain imaging devices. However, due to the high cost, complexity, and large form factor, it has not been as widely adopted as continuous wave NIRS systems. AIM: Kernel Flow is a TD-fNIRS system that has been designed to break through these limitations by maintaining the performance of a research grade TD-fNIRS system while integrating all of the components into a small modular device. APPROACH: The Kernel Flow modules are built around miniaturized laser drivers, custom integrated circuits, and specialized detectors. The modules can be assembled into a system with dense channel coverage over the entire head. RESULTS: We show performance similar to benchtop systems with our miniaturized device as characterized by standardized tissue and optical phantom protocols for TD-fNIRS and human neuroscience results. CONCLUSIONS: The miniaturized design of the Kernel Flow system allows for broader applications of TD-fNIRS.

Time-resolved multivariate pattern analysis of infant EEG data: A practical tutorial.

Ashton K, Zinszer BD, Cichy RM, Nelson CA 3rd, Aslin RN, Bayet L.
Dev Cogn Neurosci. 2022 Apr;54:101094.

doi: 10.1016/j.dcn.2022.101094. Epub 2022 Feb 25.

Time-resolved multivariate pattern analysis (MVPA), a popular technique for analyzing magneto- and electro-encephalography (M/EEG) neuroimaging data, quantifies the extent and time-course by which neural representations support the discrimination of relevant stimuli dimensions. As EEG is widely used for infant neuroimaging, time-resolved MVPA of infant EEG data is a particularly promising tool for infant cognitive neuroscience. MVPA has recently been applied to common infant imaging methods such as EEG and fNIRS. In this tutorial, we provide and describe code to implement time-resolved, within-subject MVPA with infant EEG data. An example implementation of time-resolved MVPA based on linear SVM classification is described, with accompanying code in Matlab and Python. Results from a test dataset indicated that in both infants and adults this method reliably produced above-chance accuracy for classifying stimuli images. Extensions of the classification analysis are presented including both geometric- and accuracy-based representational similarity analysis, implemented in Python. Common choices of implementation are presented and discussed. As the amount of artifact-free EEG data contributed by each participant is lower in studies of infants than in studies of children and adults, we also explore and discuss the impact of varying participant-level inclusion thresholds on resulting MVPA findings in these datasets.

Observation and motor imagery balance tasks evaluation: An fNIRS feasibility study.

Almulla L, Al-Naib I, Ateeq IS, Althobaiti M.

PLoS One. 2022 Mar 23;17(3):e0265898.
doi: 10.1371/journal.pone.0265898. eCollection 2022.

In this study, we aimed at exploring the feasibility of functional near-infrared spectroscopy (fNIRS) for studying the observation and/or motor imagination of various postural tasks. Thirteen healthy adult subjects followed five trials of static and dynamic standing balance tasks, throughout three different experimental setups of action observation (AO), a combination of action observation and motor imagery (AO+MI), and motor imagery (MI). During static and dynamic standing tasks, both the AO+MI and MI experiments revealed that many channels in prefrontal or motor regions are significantly activated while the AO experiment showed almost no significant increase in activations in most of the channels. The contrast between static and dynamic standing tasks showed that with more demanding balance tasks, relative higher activation patterns were observed, particularly during AO and in AO+MI experiments in the frontopolar area. Moreover, the AO+MI experiment revealed a significant difference in premotor and supplementary motor cortices that are related to balance control. Furthermore, it has been observed that the AO+MI experiment induced relatively higher activation patterns in comparison to AO or MI alone. Remarkably, the results of this work match its counterpart from previous functional magnetic resonance imaging studies. Therefore, they may pave the way for using the fNIRS as a diagnostic tool for evaluating the performance of the non-physical balance training during the rehabilitation period of temporally immobilized patients.

Immediate acupuncture with GB34 for biliary colic: protocol for a randomised controlled neuroimaging trial.

Sun N, He DM, Ye X, Bin L, Zhou Y, Deng X, Qu Y, Li Z, Cheng S, Shao S, Zhao FJ, Zhang TH, Cai J, Sun R, Liang FR.

BMJ Open. 2022 Jan 13;12(1):e050413.
doi: 10.1136/bmjopen-2021-050413.

INTRODUCTION: As the main manifestation of gallstone disease, biliary colic (BC) is an episodic attack that brings patients severe pain in the right upper abdominal quadrant. Although acupuncture has been documented with significance to lead to pain relief, the immediate analgesia of acupuncture for BC still needs to be verified, and the underlying mechanism has yet to be covered. Therefore, this trial aims first to verify the immediate pain-alleviation characteristic of acupuncture for BC, then to explore its

influence on the peripheral sensitised acupoint and central brain activity. METHODS AND ANALYSIS: This is a randomised controlled, paralleled clinical trial, with patients and outcome assessors blinded. Seventy-two patients with gallbladder stone disease presenting with BC will be randomised into a verum acupuncture group and the sham acupuncture group. Both groups will receive one session of immediate acupuncture treatment. Improvements in patients' BC will be evaluated by the Numeric Rating Scale, and the pain threshold of acupoints will also be detected before and after treatment. During treatment, brain neural activity will be monitored with functional near-infrared spectroscopy (fNIRS), and the needle sensation will be rated. Clinical and fNIRS data will be analysed, respectively, to validate the acupuncture effect, and correlation analysis will be conducted to investigate the relationship between pain relief and peripheral-cerebral functional changes. ETHICS AND DISSEMINATION: This trial has been approved by the institutional review boards and ethics committees of the First Teaching Hospital of Chengdu University of Traditional Chinese Medicine, with the ethical approval identifier 2019 KL-029, and the institutional review boards and ethics committees of the First People's Hospital of Longquanyi District, with the ethical approval identifier AF-KY-2020071. The results of this trial will be disseminated through peer-reviewed publications and conference abstracts or posters. TRIAL REGISTRATION NUMBER: CTR2000034432.

Functional near-infrared spectroscopy in the neuropsychological assessment of spatial memory: A systematic review.

Llana T, Fernandez-Baizan C, Mendez-Lopez M, Fidalgo C, Mendez M.

Acta Psychol (Amst). 2022 Apr;224:103525.
doi: 10.1016/j.actpsy.2022.103525. Epub 2022 Feb 3.

Functional near-infrared spectroscopy (fNIRS) is a non-invasive optical imaging technique that employs near-infrared light to measure cortical brain oxygenation. The use of fNIRS has increased exponentially in recent years. Spatial memory is defined as the ability to learn and use spatial information. This neuropsychological process is constantly used in our daily lives and can be measured by fNIRS but no research has reviewed whether this technique can be useful in the neuropsychological assessment of spatial memory. This study aimed to review empirical work on the use of fNIRS in the neuropsychological assessment of human spatial memory. We used four databases: PubMed, PsycINFO, Scopus and Web of Science, and a total of 18 articles were found to be eligible. Most of the articles assessed spatial or visuospatial working memory with a predominance in computer-based tasks, used fNIRS equipment of 16 channels and mainly measured the prefrontal cortex (PFC). The studies analysed found linear or quadratic relationships between working memory load and PFC activity, greater activation of PFC activity and worse behavioural results in healthy older people in comparison with healthy adults, and hyperactivation of PFC as a form of compensation in clinical samples. We conclude that fNIRS is compatible with the standard neuropsychological assessment of spatial memory, making it possible to complement behavioural results with data of cortical functional activity.

Comparison of Functional Connectivity during Visual-Motor Illusion, Observation, and Motor Execution.

Sakai K, Tanabe J, Goto K, Kumai K, Ikeda Y.

J Mot Behav. 2022;54(3):354-362.
doi: 10.1080/00222895.2021.1976717. Epub 2021 Sep 13.

This study investigated the functional connectivity during visual-motor illusion and compared it with observation and motor execution using functional near-infrared spectroscopy (fNIRS). Thirty subjects were randomly assigned to: illusion, observation, and motor execution group. Illusion group watched own finger joint movement video image and induced kinesthetic illusion, while the other group only performed observation or motor execution. Continuous brain activity was measured using fNIRS and functional

connectivity was analyzed. The illusion group perceived (using 7-point Likert scale) a higher degree of kinesthetic illusion and sense of body ownership than the observation group. Visual-motor illusion was associated with stronger functional connectivity between the left premotor cortex and the left parietal area compared with observation and motor execution only, suggesting that these areas respond to visual-motor illusion.

Interpersonal Neural Synchronization Predicting Learning Outcomes From Teaching-Learning Interaction: A Meta-Analysis.

Zhang L, Xu X, Li Z, Chen L, Feng L.
Front Psychol. 2022 Feb 28;13:835147.
doi: 10.3389/fpsyg.2022.835147. eCollection 2022.

In school education, teaching-learning interaction is deemed as a core process in the classroom. The fundamental neural basis underlying teaching-learning interaction is proposed to be essential for tuning learning outcomes. However, the neural basis of this process as well as the relationship between the neural dynamics and the learning outcomes are largely unclear. With non-invasive technologies such as fNIRS (functional near-infrared spectroscopy), hyperscanning techniques have been developed since the last decade and been applied to the field of educational neuroscience for simultaneous multi-brain scanning. Hyperscanning studies suggest that the interpersonal neural synchronization (INS) during teaching-learning interaction might be an ideal neural biomarker for predicting learning outcomes. To systematically evaluate such a relationship, this meta-analysis ran on a random-effects model on 16 studies with 23 independent samples (effect sizes). Further moderator analyses were also performed to examine the potential influences of the style, mode, content, and the assessment method of learning outcomes. The random-effects modeling results confirmed a robust positive correlation between INS and learning outcomes. Subsequent analyses revealed that such relationship was mainly affected by both interaction style and mode. Therefore, the present meta-analysis provided a confirmatory neurocognitive foundation for teaching-learning interaction, as well as its relation to the learning outcomes, consolidated future learning and teaching studies in various disciplines including second language education with a firm methodological reference.

Characterization of Bimanual Cyclical Tasks From Single-Trial EEG-fNIRS Measurements.

Jiang YC, Ma R, Qi S, Ge S, Sun Z, Li Y, Song J, Zhang M.
IEEE Trans Neural Syst Rehabil Eng. 2022;30:146-156.
doi: 10.1109/TNSRE.2022.3144216. Epub 2022 Jan 28.

Robot-assisted bimanual training is promising to improve motor function and cortical reorganization for hemiparetic stroke patients. Closing the rehabilitation training loop with neurofeedback can help refine training protocols in time for better engagements and outcomes. However, due to the low signal-to-noise ratio (SNR) and non-stationary properties of neural signals, reliable characterization of bimanual training-induced neural activities from single-trial measurement is challenging. In this study, ten human participants were recruited conducting robot-assisted bimanual cyclical tasks (in-phase, 90 out-of-phase, and anti-phase) when concurrent electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) were recorded. A unified EEG-fNIRS bimodal signal processing framework was proposed to characterize neural activities induced by three types of bimanual cyclical tasks. In this framework, novel artifact removal methods were used to improve the SNR and the task-related component analysis (TRCA) was introduced to increase the reproducibility of EEG-fNIRS bimodal features. The optimized features were transformed into low-dimensional indicators to reliably characterize bimanual training-induced neural activation. The SVM classification results of three bimanual cyclical tasks revealed a good discrimination ability of EEG-fNIRS bimodal indicators (90.1%), which was higher than that using EEG (74.8%) or fNIRS

(82.2%) alone, supporting the proposed method as a feasible technique to characterize neural activities during robot-assisted bimanual training.

Cognitive and linguistic dysfunction after thalamic stroke and recovery process: possible mechanism.

Obayashi S.

AIMS Neurosci. 2021 Dec 20;9(1):1-11.
doi: 10.3934/Neuroscience.2022001. eCollection 2022.

Thalamic stroke may result in cognitive and linguistic problems, but the underlying mechanism remains unknown. Especially, it is still a matter of debate why thalamic aphasia occasionally occurs and then mostly recovers to some degree. We begin with a brief overview of the cognitive dysfunction and aphasia, and then review previous hypotheses of the underlying mechanism. We introduced a unique characteristic of relatively transient "word retrieval difficulty" of patients in acute phase of thalamic stroke. Word retrieval ability involves both executive function and speech production. Furthermore, SMA aphasia and thalamic aphasia may resemble in terms of the rapid recovery, thus suggesting a shared neural system. This ability is attributable to the supplementary motor area (SMA) and inferior frontal cortex (IFG) via the frontal aslant tract (FAT). To explore the possible mechanism, we applied unique hybrid neuroimaging techniques: single-photon emission computed tomography (SPECT) and functional near-infrared spectroscopy (f-NIRS). SPECT can visualize the brain distribution associated with word retrieval difficulty, cognitive disability or aphasia after thalamic stroke, and f-NIRS focuses on SMA and monitors long-term changes in hemodynamic SMA responses during phonemic verbal task. SPECT yielded common perfusion abnormalities not only in the fronto-parieto-cerebellar-thalamic loop, but also in bilateral brain regions such as SMA, IFG and language-relevant regions. f-NIRS demonstrated that thalamic stroke developed significant word retrieval decline, which was intimately linked to posterior SMA responses. Word retrieval difficulty was rapidly recovered with increased bilateral SMA responses at follow-up NIRS. Together, we propose that the cognitive domain affected by thalamic stroke may be related to the fronto-parieto-cerebellar-thalamic loop, while the linguistic region may be attributable to SMA, IFG and language-related brain areas. Especially, bilateral SMA may play a crucial role in the recovery of word retrieval, and right language-related region, including IFG, angular gyrus and supramarginal gyrus may determine recovery from thalamic aphasia.

A Multimodal Data Driven Rehabilitation Strategy Auxiliary Feedback Method: A Case Study.

Zhao L, Sun H, Yang F, Wang Z, Zhao Y, Tang W, Bu L.

IEEE Trans Neural Syst Rehabil Eng. 2022;30:1181-1190.
doi: 10.1109/TNSRE.2022.3170943. Epub 2022 May 9.

In Industry 4.0, medical data present a trend of multisource development. However, in complex information networks, an information gap often exists in data exchange between doctors and patients. In the case of diseases with complex manifestations, doctors often perform qualitative analysis, which is macroscopic and fuzzy, to present treatment recommendations for patients. Improving the reliability of data acquisition and maximizing the potential of data, require attention. To solve these problems, a multimodal data-driven rehabilitation strategy auxiliary feedback method is proposed. In this study, depth sensor and functional near-infrared spectroscopy (fNIRS) were used to obtain ethology and brain function data, and skeleton tracking analysis and ethology discrete statistics were performed to assist the diagnostic feedback of rehabilitation strategies. This study takes rhythm rehabilitation training of autistic children as a case, and results show that the multimodal data-driven rehabilitation strategy auxiliary feedback method can provide effective feedback for individuals or groups. The proposed auxiliary decision method increases the dimension of data analysis and improves the reliability of analysis. Through discrete statistical results, the

potential of data are maximized, thereby assisting the proposed rehabilitation strategy diagnostic feedback.

[Neurovascular coupling analysis of working memory based on electroencephalography and functional near-infrared spectroscopy].

[Article in Chinese; Abstract available in Chinese from the publisher]

Sheng Wu Yi Xue Gong Cheng Xue Za Zhi. 2022 Apr 25;39(2):228-236.
doi: 10.7507/1001-5515.202108048.

Liu W(1)(2), Zhang H(3), Yang L(1)(2), Gu Y(1)(2)(4).

Treatment of Persistent Postconcussion Syndrome With Repetitive Transcranial Magnetic Stimulation Using Functional Near-Infrared Spectroscopy as a Biomarker of Response: Protocol for a Randomized Controlled Clinical Trial.

du Plessis S, Oni IK, Lapointe AP, Campbell C, Dunn JF, Debert CT.

JMIR Res Protoc. 2022 Mar 22;11(3):e31308.
doi: 10.2196/31308.

BACKGROUND: Approximately one-third of all concussions lead to persistent postconcussion syndrome (PPCS). Repetitive transcranial magnetic stimulation (rTMS) is a form of noninvasive brain stimulation that has been extensively used to treat refractory major depressive disorder and has a strong potential to be used as a treatment for patients with PPCS. Functional near-infrared spectroscopy (fNIRS) has already been used as a tool to assess patients with PPCS and may provide insight into the pathophysiology of rTMS treatment in patients with PPCS. OBJECTIVE: The primary objective of this research is to determine whether rTMS treatment improves symptom burden in patients with PPCS compared to sham treatment using the Rivermead postconcussion symptom questionnaire. The secondary objective is to explore the neuropathophysiological changes that occur following rTMS in participants with PPCS using fNIRS. Exploratory objectives include determining whether rTMS treatment in participants with PPCS will also improve quality of life, anxiety, depressive symptoms, cognition, posttraumatic stress, and function secondary to headaches. METHODS: A total of 44 adults (18-65 years old) with PPCS (>3 months to 5 years) will participate in a double-blind, sham-controlled, concealed allocation, randomized clinical trial. The participants will engage in either a 4-week rTMS treatment protocol or sham rTMS protocol (20 treatments). The left dorsolateral prefrontal cortex will be located through Montreal Neurologic Institute coordinates. The intensity of the rTMS treatment over the left dorsolateral prefrontal cortex will be 120% of resting motor threshold, with a frequency of 10 Hz, 10 trains of 60 pulses per train (total of 600 pulses), and intertrain interval of 45 seconds. Prior to starting the rTMS treatment, participant and injury characteristics, questionnaires (symptom burden, quality of life, depression, anxiety, cognition, and headache), and fNIRS assessment will be collected. Repeat questionnaires and fNIRS will occur immediately after rTMS treatment and at 1 month and 3 months post rTMS. Outcome parameters will be analyzed by a 2-way (treatment time) mixed analysis of variance. RESULTS: As of May 6, 2021, 5 participants have been recruited for the study, and 3 have completed the rTMS protocol. The estimated completion date of the trial is May 2022. CONCLUSIONS: This trial will expand our knowledge of how rTMS can be used as a treatment option of PPCS and will explore the neuropathophysiological response of rTMS through fNIRS analysis. TRIAL REGISTRATION: ClinicalTrials.gov NCT04568369; https://clinicaltrials.gov/ct2/show/NCT04568369. INTERNATIONAL REGISTERED REPORT IDENTIFIER (IRRID): DERR1-10.2196/31308.

Looking for "fNIRS Signature" in Autism Spectrum: A Systematic Review Starting

From Preschoolers.

Conti E, Scaffei E, Bosetti C, Marchi V, Costanzo V, Dell'Oste V, Mazziotti R, Dell'Osso L, Carmassi C, Muratori F, Baroncelli L, Calderoni S, Battini R.

Front Neurosci. 2022 Mar 2;16:785993.
doi: 10.3389/fnins.2022.785993. eCollection 2022.

Accumulating evidence suggests that functional Near-Infrared Spectroscopy (fNIRS) can provide an essential bridge between our current understanding of neural circuit organization and cortical activity in the developing brain. Indeed, fNIRS allows studying brain functions through the measurement of neurovascular coupling that links neural activity to subsequent changes in cerebral blood flow and hemoglobin oxygenation levels. While the literature offers a multitude of fNIRS applications to typical development, only recently this tool has been extended to the study of neurodevelopmental disorders (NDDs). The exponential rise of scientific publications on this topic during the last years reflects the interest to identify a "fNIRS signature" as a biomarker of high translational value to support both early clinical diagnosis and treatment outcome. The purpose of this systematic review is to describe the updating clinical applications of fNIRS in NDDs, with a specific focus on preschool population. Starting from this rationale, a systematic search was conducted for relevant studies in different scientific databases (Pubmed, Scopus, and Web of Science) resulting in 13 published articles. In these studies, fNIRS was applied in individuals with Autism Spectrum Disorder (ASD) or infants at high risk of developing ASD. Both functional connectivity in resting-state conditions and task-evoked brain activation using multiple experimental paradigms were used in the selected investigations, suggesting that fNIRS might be considered a promising method for identifying early quantitative biomarkers in the autism field.

An fNIRS Study of Brain Lateralization During Observation and Execution of a Fine Motor Task.

Khaksari K, Smith EG, Miguel HO, Zeytinoglu S, Fox N, Gandjbakhche AH.

Front Hum Neurosci. 2022 Jan 26;15:798870.
doi: 10.3389/fnhum.2021.798870. eCollection 2021.

Brain activity in the action observation network (AON) is lateralized during action execution, with greater activation in the contralateral hemisphere to the side of the body used to perform the task. However, it is unknown whether the AON is also lateralized when watching another person perform an action. In this study, we use fNIRS to measure brain activity over the left and right cortex while participants completed actions with their left and right hands and watched an actor complete action with their left and right hands. We show that while activation is lateralized when the participants themselves are moving, brain lateralization is not affected by the side of the body when the participant is observing another person's action. In addition, we demonstrate that individual differences in hand preference and dexterity between the right and left hands are related to brain lateralization patterns.

Effects of Systemic Physiology on Mapping Resting-State Networks Using Functional Near-Infrared Spectroscopy.

Abdalmalak A, Novi SL, Kazazian K, Norton L, Benaglia T, Slessarev M, Debicki DB, Lawrence KS, Mesquita RC, Owen AM.

Front Neurosci. 2022 Mar 8;16:803297.
doi: 10.3389/fnins.2022.803297. eCollection 2022.

Resting-state functional connectivity (rsFC) has gained popularity mainly due to its simplicity and potential for providing insights into various brain disorders. In this vein, functional near-infrared spectroscopy (fNIRS) is an attractive choice due to its portability, flexibility, and low cost, allowing for bedside imaging of brain function. While promising, fNIRS suffers from non-neural signal contaminations (i.e.,

systemic physiological noise), which can increase correlation across fNIRS channels, leading to spurious rsFC networks. In the present work, we hypothesized that additional measurements with short channels, heart rate, mean arterial pressure, and end-tidal CO2 could provide a better understanding of the effects of systemic physiology on fNIRS-based resting-state networks. To test our hypothesis, we acquired 12 min of resting-state data from 10 healthy participants. Unlike previous studies, we investigated the efficacy of different pre-processing approaches in extracting resting-state networks. Our results are in agreement with previous studies and reinforce the fact that systemic physiology can overestimate rsFC. We expanded on previous work by showing that removal of systemic physiology decreases intra- and inter-subject variability, increasing the ability to detect neural changes in rsFC across groups and over longitudinal studies. Our results show that by removing systemic physiology, fNIRS can reproduce resting-state networks often reported with functional magnetic resonance imaging (fMRI). Finally, the present work details the effects of systemic physiology and outlines how to remove (or at least ameliorate) their contributions to fNIRS signals acquired at rest.

Effects of Cardiorespiratory Fitness on Cerebral Oxygenation in Healthy Adults: A Systematic Review.

Salzman T, Dupuy O, Fraser SA.

Front Physiol. 2022 Mar 4;13:838450.

doi: 10.3389/fphys.2022.838450. eCollection 2022.

INTRODUCTION: Exercise is known to improve cognitive functioning and the cardiorespiratory hypothesis suggests that this is due to the relationship between cardiorespiratory fitness (CRF) level and cerebral oxygenation. The purpose of this systematic review is to consolidate findings from functional near-infrared spectroscopy (fNIRS) studies that examined the effect of CRF level on cerebral oxygenation during exercise and cognitive tasks. METHODS: Medline, Embase, SPORTDiscus, and Web of Science were systematically searched. Studies categorizing CRF level using direct or estimated measures of V?O2max and studies measuring cerebral oxygenation using oxyhemoglobin ([HbO2]) and deoxyhemoglobin ([HHb]) were included. Healthy young, middle-aged, and older adults were included whereas patient populations and people with neurological disorders were excluded. RESULTS: Following PRISMA guidelines, 14 studies were retained following abstract and full-text screening. Cycle ergometer or treadmill tests were used as direct measures of CRF, and one study provided an estimated value using a questionnaire. Seven studies examined the effects of CRF on cerebral oxygenation during exercise and the remaining seven evaluated it during cognitive tasks. Increased [HbO2] in the prefrontal cortex (PFC) was observed during cognitive tasks in higher compared to lower fit individuals. Only one study demonstrated increased [HHb] in the higher fit group. Exercise at submaximal intensities revealed increased [HbO2] in the PFC in higher compared to lower fit groups. Greater PFC [HHb] was also observed in long- vs. short-term trained males but not in females. Primary motor cortex (M1) activation did not differ between groups during a static handgrip test but [HHb] increased beyond maximal intensity in a lower compared to higher fit group. CONCLUSION: Consistent with the cardiorespiratory hypothesis, higher fit young, middle-aged, and older adults demonstrated increased cerebral oxygenation compared to lower fit groups. Future research should implement randomized controlled trials to evaluate the effectiveness of interventions that improve CRF and cerebral oxygenation longitudinally.

Neurobiological effects of urban built and natural environment on mental health: systematic review.

Bolouki A.

Rev Environ Health. 2022 Jan 31.

doi: 10.1515/reveh-2021-0137. Online ahead of print.

Although rapid global urbanization improves people in many ways, it also increases the prevalence of major mental disorders in urban communities. Exposure to natural surroundings, whether real or virtual, on the other hand, has been found to reduce arousal and stress. The purpose of this study is to provide an overview of the existing literature on how brain function changes when exposed to natural and urban settings. As a highly effective technique for determining human brain activity, this review considers literature using neuroimaging techniques, i.e.,electroencephalography (EEG), functional magnetic resonance imaging (fMRI), and functional near-infrared spectroscopy (fNIRS). SCOPUS and PubMed were searched for peer-reviewed literature published prior to September 2021. Twenty-six sources were included, returning 263 papers; 18 empirical articles published from 1991 to 2021 were included in the final synthesis. EEG findings were generally consistent with those obtained from fMRI/NIRS data. Natural settings were linked to greater alpha EEG values and fewer demands on information processing and stronger functional connectivity in fMRI/NIRS studies, which indicate feelings of relaxation and restoration. These findings offer a better understanding of the functional activities during environmental exposures and also imply that nature exposure improves cognitive functions and mental health.

Diagnostic classification of schizophrenia and bipolar disorder by using dynamic functional connectivity: An fNIRS study.

Eken A, Akaslan DS, Baskak B, Mnir K.

J Neurosci Methods. 2022 Apr 14;376:109596.
doi: 10.1016/j.jneumeth.2022.109596. Online ahead of print.
DOI: 10.1016/j.jneumeth.2022.109596 PMID: 35429508

Motion Artifacts Correction from Single-Channel EEG and fNIRS Signals Using Novel Wavelet Packet Decomposition in Combination with Canonical Correlation Analysis.

Hossain MS, Chowdhury MEH, Reaz MBI, Ali SHM, Bakar AAA, Kiranyaz S, Khandakar A, Alhatou M, Habib R, Hossain MM.

Sensors (Basel). 2022 Apr 21;22(9):3169.
doi: 10.3390/s22093169.

The electroencephalogram (EEG) and functional near-infrared spectroscopy (fNIRS) signals, highly non-stationary in nature, greatly suffers from motion artifacts while recorded using wearable sensors. Since successful detection of various neurological and neuromuscular disorders is greatly dependent upon clean EEG and fNIRS signals, it is a matter of utmost importance to remove/reduce motion artifacts from EEG and fNIRS signals using reliable and robust methods. In this regard, this paper proposes two robust methods: (i) Wavelet packet decomposition (WPD) and (ii) WPD in combination with canonical correlation analysis (WPD-CCA), for motion artifact correction from single-channel EEG and fNIRS signals. The efficacy of these proposed techniques is tested using a benchmark dataset and the performance of the proposed methods is measured using two well-established performance matrices: (i) difference in the signal to noise ratio ( ) and (ii) percentage reduction in motion artifacts ( ). The proposed WPD-based single-stage motion artifacts correction technique produces the highest average (29.44 dB) when db2 wavelet packet is incorporated whereas the greatest average (53.48%) is obtained using db1 wavelet packet for all the available 23 EEG recordings. Our proposed two-stage motion artifacts correction technique, i.e., the WPD-CCA method utilizing db1 wavelet packet has shown the best denoising performance producing an average and values of 30.76 dB and 59.51%, respectively, for all the EEG recordings. On the other hand, for the available 16 fNIRS recordings, the two-stage motion artifacts removal technique, i.e., WPD-CCA has produced the best average (16.55 dB, utilizing db1 wavelet packet) and largest average (41.40%, using fk8 wavelet packet). The highest average and using single-stage artifacts removal techniques (WPD) are found as

16.11 dB and 26.40%, respectively, for all the fNIRS signals using fk4 wavelet packet. In both EEG and fNIRS modalities, the percentage reduction in motion artifacts increases by 11.28% and 56.82%, respectively when two-stage WPD-CCA techniques are employed in comparison with the single-stage WPD method. In addition, the average also increases when WPD-CCA techniques are used instead of single-stage WPD for both EEG and fNIRS signals. The increment in both and values is a clear indication that two-stage WPD-CCA performs relatively better compared to single-stage WPD. The results reported using the proposed methods outperform most of the existing state-of-the-art techniques.

Novel fNIRS study on homogeneous symmetric feature-based transfer learning for brain-computer interface.

Khalil K, Asgher U, Ayaz Y.

Sci Rep. 2022 Feb 24;12(1):3198.

doi: 10.1038/s41598-022-06805-4.

The brain-computer interface (BCI) provides an alternate means of communication between the brain and external devices by recognizing the brain activities and translating them into external commands. The functional Near-Infrared Spectroscopy (fNIRS) is becoming popular as a non-invasive modality for brain activity detection. The recent trends show that deep learning has significantly enhanced the performance of the BCI systems. But the inherent bottleneck for deep learning (in the domain of BCI) is the requirement of the vast amount of training data, lengthy recalibrating time, and expensive computational resources for training deep networks. Building a high-quality, large-scale annotated dataset for deep learning-based BCI systems is exceptionally tedious, complex, and expensive. This study investigates the novel application of transfer learning for fNIRS-based BCI to solve three objective functions (concerns), i.e., the problem of insufficient training data, reduced training time, and increased accuracy. We applied symmetric homogeneous feature-based transfer learning on convolutional neural network (CNN) designed explicitly for fNIRS data collected from twenty-six (26) participants performing the n-back task. The results suggested that the proposed method achieves the maximum saturated accuracy sooner and outperformed the traditional CNN model on averaged accuracy by 25.58% in the exact duration of training time, reducing the training time, recalibrating time, and computational resources.

Deep Learning-Based Multilevel Classification of Alzheimer's Disease Using Non-invasive Functional Near-Infrared Spectroscopy.

Ho TKK, Kim M, Jeon Y, Kim BC, Kim JG, Lee KH, Song JI, Gwak J.

Front Aging Neurosci. 2022 Apr 26;14:810125.

doi: 10.3389/fnagi.2022.810125. eCollection 2022.

The timely diagnosis of Alzheimer's disease (AD) and its prodromal stages is critically important for the patients, who manifest different neurodegenerative severity and progression risks, to take intervention and early symptomatic treatments before the brain damage is shaped. As one of the promising techniques, functional near-infrared spectroscopy (fNIRS) has been widely employed to support early-stage AD diagnosis. This study aims to validate the capability of fNIRS coupled with Deep Learning (DL) models for AD multi-class classification. First, a comprehensive experimental design, including the resting, cognitive, memory, and verbal tasks was conducted. Second, to precisely evaluate the AD progression, we thoroughly examined the change of hemodynamic responses measured in the prefrontal cortex among four subject groups and among genders. Then, we adopted a set of DL architectures on an extremely imbalanced fNIRS dataset. The results indicated that the statistical difference between subject groups did exist during memory and verbal tasks. This presented the correlation of the level of hemoglobin activation and the degree of AD severity. There was also a gender effect on the hemoglobin changes due to the functional stimulation in our study. Moreover, we demonstrated the potential of distinguished DL models, which

boosted the multi-class classification performance. The highest accuracy was achieved by Convolutional Neural Network-Long Short-Term Memory (CNN-LSTM) using the original dataset of three hemoglobin types (0.909 0.012 on average). Compared to conventional machine learning algorithms, DL models produced a better classification performance. These findings demonstrated the capability of DL frameworks on the imbalanced class distribution analysis and validated the great potential of fNIRS-based approaches to be further contributed to the development of AD diagnosis systems.

Effects of degraded speech processing and binaural unmasking investigated using functional near-infrared spectroscopy (fNIRS).

Zhou X, Sobczak GS, McKay CM, Litovsky RY.

PLoS One. 2022 Apr 25;17(4):e0267588.
doi: 10.1371/journal.pone.0267588. eCollection 2022.

The present study aimed to investigate the effects of degraded speech perception and binaural unmasking using functional near-infrared spectroscopy (fNIRS). Normal hearing listeners were tested when attending to unprocessed or vocoded speech, presented to the left ear at two speech-to-noise ratios (SNRs). Additionally, by comparing monaural versus diotic masker noise, we measured binaural unmasking. Our primary research question was whether the prefrontal cortex and temporal cortex responded differently to varying listening configurations. Our a priori regions of interest (ROIs) were located at the left dorsolateral prefrontal cortex (DLPFC) and auditory cortex (AC). The left DLPFC has been reported to be involved in attentional processes when listening to degraded speech and in spatial hearing processing, while the AC has been reported to be sensitive to speech intelligibility. Comparisons of cortical activity between these two ROIs revealed significantly different fNIRS response patterns. Further, we showed a significant and positive correlation between self-reported task difficulty levels and fNIRS responses in the DLPFC, with a negative but non-significant correlation for the left AC, suggesting that the two ROIs played different roles in effortful speech perception. Our secondary question was whether activity within three sub-regions of the lateral PFC (LPFC) including the DLPFC was differentially affected by varying speech-noise configurations. We found significant effects of spectral degradation and SNR, and significant differences in fNIRS response amplitudes between the three regions, but no significant interaction between ROI and speech type, or between ROI and SNR. When attending to speech with monaural and diotic noises, participants reported the latter conditions being easier; however, no significant main effect of masker condition on cortical activity was observed. For cortical responses in the LPFC, a significant interaction between SNR and masker condition was observed. These findings suggest that binaural unmasking affects cortical activity through improving speech reception threshold in noise, rather than by reducing effort exerted.

Integration of social status and trust through interpersonal brain synchronization.

Cheng X, Zhu Y, Hu Y, Zhou X, Pan Y, Hu Y.

Neuroimage. 2022 Feb 1;246:118777.
doi: 10.1016/j.neuroimage.2021.118777. Epub 2021 Dec 3.

Trust can be a dynamic social process, during which the social identity of the interacting agents (e.g., an investor and a trustee) can bias trust outcomes. Here, we investigated how social status modulates trust and the neural mechanisms underlying this process. An investor and a trustee performed a 10-round repeated trust game while their brain activity was being simultaneously recorded using functional near-infrared spectroscopy. The social status (either high or low) of both investors and trustees was manipulated via a math competition task. The behavioral results showed that in the initial round, individuals invested more in low-status partners. However, the investment ratio increased faster as the number of rounds increased during trust interaction when individuals were paired with a high-status partner. This increasing trend was particularly prominent in the low (investor)-high (trustee) status group. Moreover, the low-high

group showed increased investor-trustee brain synchronization in the right temporoparietal junction as the number of rounds increased, while brain activation in the right dorsolateral prefrontal cortex of the investor decreased as the number of rounds increased. Both interpersonal brain synchronization and brain activation predicted investment performance at the early stage; furthermore, two-brain data provided earlier predictions than did single-brain data. These effects were detectable in the investment phase in the low-high group only; no comparable effects were observed in the repayment phase or other groups. Overall, this study demonstrated a multi-brain mechanism for the integration of social status and trust.

Functional Network Changes After High-Frequency rTMS Over the Most Activated Speech-Related Area Combined With Speech Therapy in Chronic Stroke With Non-fluent Aphasia.

Chang WK, Park J, Lee JY, Cho S, Lee J, Kim WS, Paik NJ.

Front Neurol. 2022 Feb 10;13:690048.
doi: 10.3389/fneur.2022.690048. eCollection 2022.

OBJECTIVE: High-frequency repetitive transcranial magnetic stimulation (HF-rTMS) to the lesional hemisphere requires prudence in selecting the appropriate stimulation spot. Functional near-IR spectroscopy (fNIRS) can be used in both selecting the stimulation spot and assessing the changes of the brain network. This study aimed to evaluate the effect of HF-rTMS on the most activated spot identified with fNIRS and assess the changes of brain functional network in the patients with poststroke aphasia. METHODS: A total of five patients received HF-rTMS to the most activated area on the lesional hemisphere, followed by 30 min of speech therapy for 10 days. The Korean version of the Western aphasia battery (K-WAB) and fNIRS evaluation were done 1 day before the treatment, 1 day and 1 month after the last treatment session. Changes of K-WAB and paired cortical interaction and brain network analysis using graph theory were assessed. RESULTS: Aphasia quotient in K-WAB significantly increased after the treatment ($P = 0.043$). The correlation analysis of cortical interactions showed increased connectivity between language production and processing areas. Clustering coefficients of the left hemisphere were increased over a sparsity range between 0.45 and 0.58 ($0.015 < p < 0.031$), whereas the clustering coefficients of the right hemisphere, decreased over a sparsity range 0.15-0.87 ($0.063 < p < 0.095$). The global efficiency became lower over a network sparsity range between 0.47 and 0.75 ($0.015 < p < 0.063$). CONCLUSION: Improvement of language function and changes of corticocortical interaction between language-related cortical areas were observed after HF-rTMS on the most activated area identified by fNIRS with combined speech therapy in the patients with poststroke aphasia.

What has social neuroscience learned from hyperscanning studies of spoken communication? A systematic review.

Kelsen BA, Sumich A, Kasabov N, Liang SHY, Wang GY.

Neurosci Biobehav Rev. 2022 Jan;132:1249-1262.
doi: 10.1016/j.neubiorev.2020.09.008. Epub 2020 Oct 3.

A growing body of literature examining the neurocognitive processes of interpersonal linguistic interaction indicates the emergence of neural alignment as participants engage in oral communication. However, questions have arisen whether the study results can be interpreted beyond observations of cortical functionality and extended to the mutual understanding between communicators. This review presents evidence from electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) hyperscanning studies of interbrain synchrony (IBS) in which participants communicated via spoken language. The studies are classified into: knowledge sharing; turn-taking speech co-ordination; cooperation, problem-solving and creativity; and naturalistic discussion paradigms according to the type of interaction specified in each study. Alignment predominantly occurred in the frontal and temporo-parietal areas, which may

reflect activation of the mirror and mentalizing systems. We argue that the literature presents a significant contribution to advancing our understanding of IBS and mutual understanding between communicators. We end with suggestions for future research, including analytical approaches and experimental conditions and hypothesize that brain-inspired neural networks are promising techniques for better understanding of IBS through hyperscanning.

Altered prefrontal activation during the inhibition of eating responses in women with bulimia nervosa.

Berner LA, Winter SR, Ayaz H, Shewokis PA, Izzetoglu M, Marsh R, Nasser JA, Matteucci AJ, Lowe MR.
Psychol Med. 2022 Feb 25:1-11.
doi: 10.1017/S0033291722000198. Online ahead of print.

BACKGROUND: The sense of 'loss of control' (LOC), or a feeling of being unable to stop eating or control what or how much one is eating, is the most salient aspect of binge eating. However, the neural alterations that may contribute to this experience and eating behavior remain poorly understood. METHODS: We used functional near-infrared spectroscopy (fNIRS) to measure activation in the prefrontal cortices of 23 women with bulimia nervosa (BN) and 23 healthy controls (HC) during two tasks: a novel go/no-go task requiring inhibition of eating responses, and a standard go/no-go task requiring inhibition of button-pressing responses. RESULTS: Women with BN made more commission errors on both tasks. BN subgroups with the most severe LOC eating (n = 12) and those who felt most strongly that they binge ate during the task (n = 12) showed abnormally reduced bilateral ventromedial prefrontal cortex (vmPFC) and right ventrolateral prefrontal cortex (vlPFC) activation associated with eating-response inhibition. In the entire BN sample, lower eating-task activation in right vlPFC was related to more frequent and severe LOC eating, but no group differences in activation were detected on either task when this full sample was compared with HC. BN severity was unrelated to standard-task activation. CONCLUSIONS: Results provide initial evidence that diminished PFC activation may directly contribute to more severe eating-specific control deficits in BN. Our findings support vmPFC and vlPFC dysfunction as promising treatment targets, and indicate that eating-specific tasks and fNIRS may be useful tools for identifying neural mechanisms underlying dysregulated eating.

Vocal brain development in infants of mothers with serious mental illness (CAPRI-Voc): study protocol.

Stibbs-Eaton L, Hodgson C, Kolade A, Crowell J, Gemignani J, Hope H, Pierce M, Elmadih A, Zhao C, Downey D, Elliott R, Abel KM.
BMJ Open. 2022 Mar 17;12(3):e053598.
doi: 10.1136/bmjopen-2021-053598.

INTRODUCTION: Improving the lives of children and adolescents with parental mental illness (CAPRI) remains an urgent political and public health concern for the UK and European Union. Recurrent parental mental illness is believed to lead to fractures in the family, academic and social lives of these children, yet interventions are poorly targeted and non-specific. Part of an interdisciplinary programme of work (the CAPRI Programme; grant number: 682741), CAPRI-Voc aims to achieve two goals: first, to test the feasibility of our longitudinal imaging paradigm in mother-infant pairs where the mother has a diagnosis of severe mental illness. Second, to compare development of vocal processing in these infants with infants in the general population. METHODS AND ANALYSIS: Recruitment of 100 infants of mothers with mental illness, alongside 50 infants of healthy mothers. Both cohorts of infants will undergo functional near infrared spectroscopy (fNIRS) brain imaging at three time points: 9, 12 and 18 months to explore differences between cohorts in their neural responses to vocal stimuli in our language paradigm. Mothers will complete an interview and psychological questionnaires. We shall also complete an infant develop-

mental battery and mother-child interaction play session. Data on recruitment, retention and dropout will be recorded. ETHICS AND DISSEMINATION: It will be made clear that fNIRS is a safe, non-invasive technology widely used in infant clinical and psychological research. We shall reassure mothers that no definitive causal link exists between maternal mental illness and language development in infants, and that individual data will only exist as part of the wider dataset. As the study includes both children and vulnerable adults, all research staff will complete National Health Service (NHS) Safeguarding level 3 training. Dissemination will be via direct feedback to stakeholders, patient and advisory groups, and through presentations at conferences, journal publications and university/NHS trust communications. The study was approved through North West-Greater Manchester West Research Ethics Committee (17/NW/0074) and Health Research Authority (212715).

Novel Approaches and Cognitive Neuroscience Perspectives on False Memory and Deception.

Toglia MP, Schmuller J, Surprenant BG, Hooper KC, DeMeo NN, Wallace BL.

Front Psychol. 2022 Mar 21;13:721961.
doi: 10.3389/fpsyg.2022.721961. eCollection 2022.

The DRM (Deese-Roediger-McDermott) paradigm produces robust false memories of non-presented critical words. After studying a thematic word list (e.g., bed, rest, and pillow) participants falsely remember the critical item "sleep." We report two false memory experiments. Study One introduces a novel use of the lexical decision task (LDT) to prime critical words. Participants see two letter-strings and make timed responses indicating whether they are both words. The word pairs Night-Bed and Dream-Thweeb both prime "sleep" but only one pair contains two words. Our primary purpose is to introduce this new methodology via two pilot experiments. The results, considered preliminary, are promising as they indicate that participants were as likely to recognize critical words (false memories) and presented words (true memories) just as when studying thematic lists. Study Two actually employs the standard DRM lists so that semantic priming is in play there as well. The second study, however, uses functional near-infrared spectroscopy (fNIRS) to measure activity in the prefrontal cortex during a DRM task which includes a deception phase where participants intentionally lie about critical lures. False and true memories occurred at high levels and activated many of the same brain regions but, compared to true memories, cortical activity was higher for false memories and lies. Accuracy findings are accompanied by confidence and reaction time results. Both investigations suggest that it is difficult to distinguish accurate from inaccurate memories. We explain results in terms of activation-monitoring theory and Fuzzy Trace Theory. We provide real world implications and suggest extending the present research to varying age groups and special populations. A nagging question has not been satisfactorily answered: Could neural pathways exist that signal the presence of false memories and lies? Answering this question will require imaging experiments that focus on regions of distinction such as the anterior prefrontal cortex.

Functional near-infrared spectroscopy in developmental psychiatry: a review of attention deficit hyperactivity disorder.

Goss LK, Bell SW, Hosseini SMH.

Eur Arch Psychiatry Clin Neurosci. 2022 Mar;272(2):273-290.
doi: 10.1007/s00406-021-01288-2. Epub 2021 Jun 29.

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.

Neuromonitoring Correlates of Expertise Level in Surgical Performers: A Systematic Review.

Hannah TC, Turner D, Kellner R, Bederson J, Putrino D, Kellner CP.

Front Hum Neurosci. 2022 Feb 16;16:705238.
doi: 10.3389/fnhum.2022.705238. eCollection 2022.

Surgical expertise does not have a clear definition and is often culturally associated with power, authority, prestige, and case number rather than more objective proxies of excellence. Multiple models of expertise progression have been proposed including the Dreyfus model, however, they all currently require subjective evaluation of skill. Recently, efforts have been made to improve the ways in which surgical excellence is measured and expertise is defined using artificial intelligence, video recordings, and accelerometers. However, these aforementioned methods of assessment are still subjective or indirect proxies of expertise, thus uncovering the neural mechanisms that differentiate expert surgeons from trainees may enhance the objectivity of surgical expertise validation. In fact, some researchers have already suggested that their neural imaging-based expertise classification methods outperform currently used methods of surgical skill certification such as the Fundamentals of Laparoscopic Surgery (FLS) scores. Such imaging biomarkers would not only help better identify the highest performing surgeons, but could also improve residency programs by providing more objective, evidence-based feedback and developmental milestones for those in training and perhaps act as a marker of surgical potential in medical students. Despite the potential advantages of using neural imaging in the assessment of surgical expertise, this field of research remains in its infancy. This systematic review identifies studies that have applied neuromonitoring in assessing surgical skill across levels of expertise. The goals of this review are to identify (1) the strongest neural indicators of surgical expertise, (2) the limitations of the current literature on this subject, (3) the most sensible future directions for further study. We found substantial evidence that surgical expertise can be delineated by differential activation and connectivity in the prefrontal cortex (PFC) across multiple task and neuroimaging modalities. Specifically, novices tend to have greater PFC activation than experts under standard conditions in bimanual and decision-making tasks. However, under high temporal demand tasks, experts had increased PFC activation whereas novices had decreased PFC activation. Common limitations uncovered in this review were that task difficulty was often insufficient to delineate between residents and attending. Moreover, attending level involvement was also low in multiple studies which may also have contributed to this issue. Most studies did not analyze the ability of their neuromonitoring findings to accurately classify subjects by level of expertise. Finally, the predominance of fNIRS as the neuromonitoring modality limits our ability to uncover the neural correlates of surgical expertise in non-cortical brain regions. Future studies should first strive to address these limitations. In the longer term, longitudinal within-subjects design over the course of a residency or even a career will also advance the field. Although logistically arduous, such studies would likely be most beneficial in demonstrating effects of increasing surgical expertise on regional brain activation and inter-region connectivity.

Portable Neuroimaging-Guided Noninvasive Brain Stimulation of the Cortico-Cerebello-Thalamo-Cortical Loop-Hypothesis and Theory in Cannabis Use Disorder.

Walia P, Ghosh A, Singh S, Dutta A.

Brain Sci. 2022 Mar 26;12(4):445.
doi: 10.3390/brainsci12040445.

BACKGROUND: Maladaptive neuroplasticity-related learned response in substance use disorder (SUD) can be ameliorated using noninvasive brain stimulation (NIBS); however, inter-individual variability needs to be addressed for clinical translation. OBJECTIVE: Our first objective was to develop a hypothesis for NIBS for learned response in SUD based on a competing neurobehavioral decision systems model. The next objective was to develop the theory by conducting a computational simulation of NIBS of the cortico-cerebello-thalamo-cortical (CCTC) loop in cannabis use disorder (CUD)-related dysfunctional "cue-reactivity"-a construct closely related to "craving"-that is a core symptom. Our third objective was to test the feasibility of a neuroimaging-guided rational NIBS approach in healthy humans. METHODS: "Cue-reactivity" can be measured using behavioral paradigms and portable neuroimaging, including functional near-infrared spectroscopy (fNIRS) and electroencephalogram (EEG) metrics of sensorimotor gating. Therefore, we conducted a computational simulation of NIBS, including transcranial direct current stimulation (tDCS) and transcranial alternating current stimulation (tACS) of the cerebellar cortex and deep cerebellar nuclei (DCN) of the CCTC loop for its postulated effects on fNIRS and EEG metrics. We also developed a rational neuroimaging-guided NIBS approach for the cerebellar lobule (VII) and prefrontal cortex based on a healthy human study. RESULTS: Simulation of cerebellar tDCS induced gamma oscillations in the cerebral cortex, while transcranial temporal interference stimulation induced a gamma-to-beta frequency shift. A preliminary healthy human study (N = 10) found that 2 mA cerebellar tDCS evoked similar oxyhemoglobin (HbO) response in the range of 5 10-6 M across the cerebellum and PFC brain regions (a = 0.01); however, infra-slow (0.01-0.10 Hz) prefrontal cortex HbO-driven phase-amplitude-coupled (PAC; 4 Hz, 2 mA (max)) cerebellar tACS evoked HbO levels in the range of 10-7 M that were statistically different (a = 0.01) across these brain regions. CONCLUSION: Our healthy human study showed the feasibility of fNIRS of cerebellum and PFC and closed-loop fNIRS-driven ctACS at 4 Hz, which may facilitate cerebellar cognitive function via the frontoparietal network. Future work needs to combine fNIRS with EEG for multi-modal imaging for closed-loop NIBS during operant conditioning.

Relationship between cool and hot executive function in young children: A near-infrared spectroscopy study.

Moriguchi Y.

Dev Sci. 2022 Mar;25(2):e13165.
doi: 10.1111/desc.13165. Epub 2021 Aug 6.

A theoretical distinction exists between the cool and hot aspects of executive function (EF). At the neural level, cool EF may be associated with activation in the lateral prefrontal cortex and the anterior cingulate cortex, whereas the orbitofrontal cortex may play a key role in hot EF. However, some recent studies have shown that young children show activity in the lateral prefrontal regions during hot EF tasks, suggesting that the distinction between hot and cool EF may not be as marked. Nevertheless, few neuroimaging studies have directly examined the relationship between cool and hot EF. In this study, preschool children (N=46, mean age=66.1 months) were given both cool (Dimensional Change Card Sort (DCCS) and Stroop-like tasks) and hot (delay of gratification) EF tasks, and neural activation during these tasks was measured using functional near-infrared spectroscopy (fNIRS). Correlational analyses and analysis of variance (ANOVA) were conducted to assess the relationship between cool and hot EF. At the behavioral level, a moderate correlation was found between DCCS and Stroop-like tasks, but no correlation emerged between cool and hot EF tasks. At the neural level, prefrontal activations during the cool EF

tasks did not correlate with those during the hot EF task. Further, children showed stronger prefrontal activations during the DCCS tasks compared to the delay of gratification tasks. The results suggest that the neural basis of hot and cool EF may differ during early childhood.

Investigating mental workload-induced changes in cortical oxygenation and frontal theta activity during simulated flights.

Hamann A, Carstengerdes N.

Sci Rep. 2022 Apr 19;12(1):6449.
doi: 10.1038/s41598-022-10044-y.

Monitoring pilots' cognitive states becomes increasingly important in aviation. Physiological measurement can detect increased mental workload (MWL) even before performance declines. Yet, changes in MWL are rarely varied systematically and few studies control for confounding effects of other cognitive states. The present study targets these shortcomings by analysing the effects of stepwise increased MWL on cortical activation, while controlling for mental fatigue (MF). 35 participants conducted a simulated flight with an incorporated adapted n-back and monitoring task. We recorded cortical activation with concurrent EEG and fNIRS measurement, performance, self-reported MWL and MF. Our results show the successful manipulation of MWL without confounding effects of MF. Higher task difficulty elicited higher subjective MWL ratings, performance decline, higher frontal theta activity and reduced frontal deoxyhaemoglobin (Hbr) concentration. Using both EEG and fNIRS, we could discriminate all induced MWL levels. fNIRS was more sensitive to tasks with low difficulty, and EEG to tasks with high difficulty. Our findings further suggest a plateau effect for high MWL that could present an upper boundary to individual cognitive capacity. Our results highlight the benefits of physiological measurement in aviation, both for assessment of cognitive states and as a data source for adaptive assistance systems.

Cortical activity evoked by voice pitch changes: A combined fNIRS and EEG study.

Steinmetzger K, Megbel E, Shen Z, Andermann M, Rupp A.

Hear Res. 2022 Mar 11:108483.
doi: 10.1016/j.heares.2022.108483. Online ahead of print.

Functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG) data were simultaneously obtained from normal-hearing listeners presented with continuous natural vowel sequences to study the interrelation of the haemodynamic and electrophysiological cortical responses evoked by voice pitch changes. fNIRS topographies and distributed ERP source reconstructions both indicated additional activity in the right superior temporal cortex if the prosodic contours varied between successive vowels, rather than being the same throughout the sequences. The source-level ERPs furthermore revealed two temporally and spatially separable adaptation processes in superior temporal cortex: Firstly, the early P1 component was bilaterally attenuated when vowels with the same prosodic contours were presented repeatedly, reflecting sensory adaptation. Secondly, the later P2 and sustained potential components were smaller in the right hemisphere during sequences without prosodic changes, which is taken to represent an attention-based adaptation effect. The present results demonstrate the convergence of both methods and demonstrate which ERPs underlie the right-lateralised activity in superior temporal cortex evoked in response to pitch changes that has been observed in many neuroimaging studies.

Interpersonal neural synchronization could predict the outcome of mate choice.

Yuan D, Zhang R, Liu J, Feng D, Hu Y, Li X, Wang Y, Zhou X.

Neuropsychologia. 2022 Jan 28;165:108112.

doi: 10.1016/j.neuropsychologia.2021.108112. Epub 2021 Dec 7.

Although mate choice is crucial for adults, its neural basis remains elusive. In the current study, we combined the functional near-infrared spectroscopy (fNIRS)-based hyperscanning and speed-dating to investigate the inter-brain mechanism of mate choice. Each participant was paired with two opposite-sex partners (participants) in separate speed-dating sessions and was asked to decide whether to engage in a further relationship with the paired partner after each session. The physical attraction of the daters was rated by their partners at the beginning of the dating whereas the social attraction was rated after the dating. Interpersonal neural synchronization (INS) at the dorsolateral prefrontal cortex during speed-dating rather than reading task predicts the outcome of mate choice. Moreover, social attraction rather than physical attraction affects INS during speed-dating. These findings demonstrate for the first time that INS predicts the outcome of mate choice of interacting daters in ecologically valid settings during their initial romantic encounter.

Cortical Activation of Swallowing Using fNIRS: A Proof of Concept Study with Healthy Adults.

Knollhoff SM, Hancock AS, Barrett TS, Gillam RB.

Dysphagia. 2022 Feb 7.
doi: 10.1007/s00455-021-10403-3. Online ahead of print.

The purpose of this study was to determine whether functional near-infrared spectroscopy (fNIRS) could reliably identify cortical activation patterns as healthy adults engaged in single sip and continuous swallowing tasks. Thirty-three right-handed adults completed two functional swallowing tasks, one control jaw movement task, and one rest task while being imaged with fNIRS. Swallowing tasks included a single sip of 5mL of water via syringe and continuous straw drinking. fNIRS patches for acquisition of neuroimaging data were placed parallel over left and right hemispheres. Stimuli presentation was controlled with set time intervals and audio instructions. Using a series of linear mixed effect models, results demonstrated clear cortical activation patterns during swallowing. The continuous swallowing task demonstrated significant differences in blood oxygenation and deoxygenation concentration values across nearly all regions examined, but most notably M1 in both hemispheres. Of note is that there were areas of greater activation, particularly on the right hemisphere, when comparing the single sip swallow to the jaw movement control and rest tasks. Results from the current study support the use of fNIRS during investigation of swallowing. The utilization of healthy adults as a method for acquiring normative data is vital for comparison purposes when investigating individuals with disorders, but also in the development of rehabilitation techniques. Identifying activation areas that pertain to swallowing will have important implications for individuals requiring dysphagia therapy.

The Neurovascular Couplings Between Electrophysiological and Hemodynamic Activities in Anticipatory Selective Attention.

Zhao C, Li D, Guo J, Li B, Kong Y, Hu Y, Du B, Ding Y, Li X, Liu H, Song Y.

Cereb Cortex. 2022 Jan 24:bhab525.
doi: 10.1093/cercor/bhab525. Online ahead of print.

Selective attention is thought to involve target enhancement and distractor inhibition processes. Here, we recorded simultaneous electroencephalographic (EEG) and functional near-infrared spectroscopy (fNIRS) data from human adults when they were pre-cued by the visual field of coming target, distractor, or both of them. From the EEG data, we found alpha power relatively decreased contralaterally to the to-be-attended target, as reflected by the positive-going alpha modulation index. Late alpha power relatively increased contralaterally to the to-be-suppressed distractor, as reflected by the negative-going alpha modulation index. From the fNIRS data, we found enhancements of hemodynamic activity over the contralateral

hemisphere in response to both the target and the distractor anticipation but within nonoverlapping posterior brain regions. More importantly, we described the specific neurovascular modulation between alpha power and oxygenated hemoglobin signal, which showed a positive coupling effect during target anticipation and a negative coupling effect during distractor anticipation. Such flexible neurovascular couplings between EEG oscillation and hemodynamic activity seem to play an essential role in the final behavioral outcomes. These results provide unique neurovascular evidence for the dissociation of the mechanisms of target enhancement and distractor inhibition. Individual behavioral differences can be related to individual differences in neurovascular coupling.

Excess significance and power miscalculations in neurofeedback research.

Thibault RT, Pedder H.

Neuroimage Clin. 2022 Apr 26:103008.

doi: 10.1016/j.nicl.2022.103008. Online ahead of print.

DOI: 10.1016/j.nicl.2022.103008 PMID: 35525708

Novel diagnostic tools for identifying cognitive impairment using olfactory-stimulated functional near-infrared spectroscopy: patient-level, single-group, diagnostic trial.

Kim J(#), Yon DK(#), Choi KY, Lee JJ, Kim N, Lee KH(#), Kim JG(#).

Alzheimers Res Ther. 2022 Mar 8;14(1):39.

doi: 10.1186/s13195-022-00978-w.

INTRODUCTION: Basic studies suggest that olfactory dysfunction and functional near-infrared spectroscopy (fNIRS) can be used as tools for the diagnosis of mild cognitive impairment (MCI); however, real-world evidence is lacking. We investigated the potential diagnostic efficacy of olfactory-stimulated fNIRS for early detection of MCI and/or Alzheimer disease (AD). METHODS: We conducted a patient-level, single-group, diagnostic interventional trial involving elderly volunteers (age >60 years) suspected of declining cognitive function. Patients received open-label olfactory-stimulated fNIRS for measurement of oxygenation difference in the orbitofrontal cortex. All participants underwent amyloid PET, MRI, Mini-Mental State Examination (MMSE), and Seoul Neuropsychological Screening Battery (SNSB). RESULTS: Of 97 subjects, 28 (28.9%) were cognitively normal, 32 (33.0%) had preclinical AD, 21 (21.6%) had MCI, and 16 (16.5%) had AD. Olfactory-stimulated oxygenation differences in the orbitofrontal cortex were associated with cognitive impairment; the association was more pronounced with cognitive severity. Olfactory-stimulated oxygenation difference was associated with MMSE (adjusted [a] 1.001; 95% CI 0.540-1.463), SNSB language and related function (a, 1.218; 95% CI, 0.020-2.417), SNSB memory (a, 1.963; 95% CI, 0.841-3.084), SNSB frontal/executive function (a, 1.715; 95% CI, 0.401-3.029) scores, standard uptake value ratio from amyloid PET (a, -10.083; 95% CI, -19.063 to -1.103), and hippocampal volume from MRI (a, 0.002; 95% CI, 0.001-0.004). Olfactory-stimulated oxygenation difference in the orbitofrontal cortex was superior in diagnosing MCI and AD (AUC, 0.909; 95% CI, 0.848-0.971), compared to amyloid PET (AUC, 0.793; 95% CI, 0.694-0.893) or MRI (AUC, 0.758; 95% CI, 0.644-0.871). DISCUSSION: Our trial showed that olfactory-stimulated oxygenation differences in the orbitofrontal cortex detected by fNIRS were associated with cognitive impairment and cognitive-related objectives. This novel approach may be a potential diagnostic tool for patients with MCI and/or AD. TRIAL REGISTRATION: CRIS number, KCT0006197 .

Trait rumination and social anxiety separately influence stress-induced rumination and hemodynamic responses.

Laicher H(#), Int-Veen I(#), Torka F, Kroczek A, Bihlmaier I, Storchak H, Velten-Schurian K, Dresler T, Tglich R, Fallgatter AJ, Ehlis AC, Rosenbaum D.
Sci Rep. 2022 Apr 1;12(1):5512.
doi: 10.1038/s41598-022-08579-1.

We aimed to investigate stress-reactive rumination in response to social stress and its association with social anxiety and trait rumination. From previous investigations we know that people with a certain vulnerability to rumination show increased stress-reactive rumination. However, up to date the possible influence of social anxiety on this relationship is still unclear. Therefore, we reanalyzed the data of two of our previous studies assessing healthy low and high trait ruminators and depressed patients performing the Trier Social Stress Test (TSST). We measured cortical oxygenation using functional Near-Infrared Spectroscopy (fNIRS) as well as different behavioral outcome measures (subjective stress levels, negative affect, state rumination). On a behavioral level, we found an influence of both, social anxiety and trait rumination, on state rumination, even when correcting for the other factor, respectively, implying two potentially independent factors of influence. On a neural level, we observed reduced activation in brain regions of the cognitive control network (CCN) for higher social anxiety and trait rumination, which might be a result of reduced cognitive and attentional control. Results indicate a specific role of social anxiety, at least on a behavioral level, and therefore implicate a crucial factor to be considered in the treatment of depression.

Functional Reorganization of the Central Auditory System in Children with Single-Sided Deafness: A Protocol Using fNIRS.

Calmels MN, Gallois Y, Marx M, Deguine O, Taoui S, Arnaud E, Strelnikov K, Barone P.
Brain Sci. 2022 Mar 22;12(4):423.
doi: 10.3390/brainsci12040423.

In children, single-sided deafness (SSD) affects the development of linguistic and social skills and can impede educational progress. These difficulties may relate to cortical changes that occur following SSD, such as reduced inter-hemispheric functional asymmetry and maladaptive brain plasticity. To investigate these neuronal changes and their evolution in children, a non-invasive technique is required that is little affected by motion artifacts. Here, we present a research protocol that uses functional near-infrared spectroscopy (fNIRS) to evaluate the reorganization of cortical auditory asymmetry in children with SSD; it also examines how the cortical changes relate to auditory and language skills. The protocol is designed for children whose SSD has not been treated, because hearing restoration can alter both brain reorganization and behavioral performance. We propose a single-center, cross-sectional study that includes 30 children with SSD (congenital or acquired moderate-to-profound deafness) and 30 children with normal hearing (NH), all aged 5-16 years. The children undergo fNIRS during monaural and binaural stimulation, and the pattern of cortical activity is analyzed using measures of the peak amplitude and area under the curve for both oxy- and deoxyhemoglobin. These cortical measures can be compared between the two groups of children, and analyses can be run to determine whether they relate to binaural hearing (speech-in-noise and sound localization), speech perception and production, and quality of life (QoL). The results could be of relevance for developing individualized rehabilitation programs for SSD, which could reduce patients' difficulties and prevent long-term neurofunctional and clinical consequences.

Infants' Hemodynamic Modulation in the Temporal Region.

Tsuji Y, Kanazawa S, Yamaguchi MK.
Front Hum Neurosci. 2022 Mar 10;16:821539.
doi: 10.3389/fnhum.2022.821539. eCollection 2022.

This study examined whether 8-month-old infants' hemodynamic responses in the temporal region

were modulated by repeated presentation of "Peekaboo" by using functional near-infrared spectroscopy (fNIRS). Previous studies have shown that infants' temporal region responds to faces (e.g., Otsuka et al., 2007). A recent electroencephalography study showed that the neural activity of infants was modulated by repeated presentation of "Peekaboo." Some fNIRS studies also revealed that the movie of "Peekaboo" activated the hemodynamic response of the temporal region in infancy. However, no studies have shown the hemodynamic modulation of the temporal region according to the repeated presentation of "Peekaboo" in infants. In order to examine whether the hemodynamic responses of the temporal region were modulated by repeated presentation of "Peekaboo," we compared the activity of the temporal region between the early and late trials. We set long and short delays before face-presentation. The results showed that the concentration of oxy-hemoglobin in the right occipitotemporal region (Ch 21) in both conditions increased after the presentation of "Peekaboo" relative to the baseline. Moreover, in the long delay condition, the hemodynamic modulation of the right occipitotemporal region was induced according to the repeated presentation of "Peekaboo" in infants.

Cortical activation during cooperative joint actions and competition in children with and without an autism spectrum condition (ASC): an fNIRS study.

Su WC, Culotta M, Tsuzuki D, Bhat A.

Sci Rep. 2022 Mar 25;12(1):5177.

doi: 10.1038/s41598-022-08689-w.

Children with an Autism Spectrum Condition (ASC) have social communication and perceptuomotor difficulties that affect their ability to engage in dyadic play. In this study, we compared spatio-temporal errors and fNIRS-related cortical activation between children with and without an ASC during a Lincoln Log dyadic game requiring them to play leader or follower roles, move in synchrony or while taking turns, and move cooperatively or competitively with an adult partner. Children with an ASC had greater motor, planning, and spatial errors and took longer to complete the building tasks compared to typically developing (TD) children. Children with an ASC had lower superior temporal sulcus (STS) activation during Turn-take and Compete, and greater Inferior Parietal Lobe (IPL) activation during Lead and Turn-take compared to TD children. As dyadic play demands increased, TD children showed greater STS activation during Turn-take (vs. Synchrony) and Compete (vs. Cooperate) whereas children with an ASC showed greater IPL activation during Lead and Compete (vs. Cooperate). Our findings suggest that children with an ASC rely on self-generated action plans (i.e., increased IPL activation) more than relying on their partner's action cues (i.e., reduced STS activation) when engaging in dyadic play including joint actions and competition.

Morphological and phonological processing in English monolingual, Chinese-English bilingual, and Spanish-English bilingual children: An fNIRS neuroimaging dataset.

Sun X, Zhang K, Marks R, Karas Z, Eggleston R, Nickerson N, Yu CL, Wagley N, Hu X, Caruso V, Chou TL, Satterfield T, Tardif T, Kovelman I.

Data Brief. 2022 Mar 12;42:108048.

doi: 10.1016/j.dib.2022.108048. eCollection 2022 Jun.

This article documents a functional Near-Infrared Spectroscopy (fNIRS) neuroimaging dataset deposited in Deep Blue Data. The dataset included neuroimaging and behavioral data from N=343 children aged 5-11 with a diverse linguistic background, including children who are English monolingual, Chinese-English, and Spanish-English bilingual. Children completed phonological and morphological awareness tasks in each of their languages during fNIRS neuroimaging. They also completed a wide range of language and reading tasks. Parents filled in questionnaires to report children's demographic information as well as their home language and literacy backgrounds. The dataset is valuable for researchers in the field of developmental cognitive neuroscience to further investigate questions such as the effects of bilingualism

on children's neural basis for literacy development.

Neurobehavioral mechanisms underlying the effects of physical exercise break on episodic memory during prolonged sitting.

Yu Q, Herold F, Ludyga S, Cheval B, Zhang Z, Mcke M, Kramer AF, Li J, Kong Z, Zou L.
Complement Ther Clin Pract. 2022 Feb 21;48:101553.
doi: 10.1016/j.ctcp.2022.101553. Online ahead of print.

BACKGROUND AND OBJECTIVE: Episodic memory is the ability that enables individuals to recall and re-experience previous events and usually includes information concerning the spatial and temporal context. This study examined the effects of a physical exercise break during a period of prolonged sitting on episodic memory. Furthermore, we aimed to investigate whether alterations of functional connectivity patterns might contribute to the exercise-induced changes in episodic memory. METHODS: Sixty healthy male college students were randomly assigned (1:1 ratio) to a prolonged-sitting group (PS group) or a physical-exercise-break group (PE group). The face-name paired-associate learning task was used to probe episodic memory. During the task, cortical hemodynamics in the prefrontal cortex were recorded using functional near-infrared spectroscopy (fNIRS). Changes in cortical hemodynamics were used to determine functional connectivity using graph-theoretical network analysis. RESULTS: There was no between-group difference in neurobehavioral outcomes at the pretest assessment. During the posttest assessment, compared with the PS group, higher nodal efficiency in the anterior prefrontal cortex (orbitofrontal and frontopolar cortices) was observed during the encoding phase (FDR corrected p values=0.039), and higher nodal efficiency and degree centrality of orbitofrontal cortex were observed in the retrieval phase in the PE group (FDR corrected p values=0.035). Moreover, the PE group showed closer temporal correlational interactions between the dorsolateral prefrontal cortex and the anterior prefrontal cortex in the left hemisphere during the episodic memory encoding phase (FDR corrected p values=0.043), when compared to the PS group. Neither significant between-group difference in accuracy nor correlations between neural and behavioral outcomes were observed after the intervention. CONCLUSION: Our findings suggest that a physical exercise break during a prolonged sitting period has neither a beneficial nor a detrimental effect on behavioral performance concerning episodic memory. However, physical breaks do facilitate functional connectivity patterns of the prefrontal cortex while performing a episodic memory task.

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fMRI-based validation of continuous-wave fNIRS of supplementary motor area activation during motor execution and motor imagery.

Klein F, Debener S, Witt K, Kranczioch C.
Sci Rep. 2022 Mar 4;12(1):3570.
doi: 10.1038/s41598-022-06519-7.

Compared to functional magnetic resonance imaging (fMRI), functional near infrared spectroscopy (fNIRS) has several advantages that make it particularly interesting for neurofeedback (NFB). A prerequisite for NFB applications is that with fNIRS, signals from the brain region of interest can be measured. This study focused on the supplementary motor area (SMA). Healthy older participants (N = 16) completed separate continuous-wave (CW-) fNIRS and (f)MRI sessions. Data were collected for executed and imagined hand movements (motor imagery, MI), and for MI of whole body movements. Individual anatomical data were used to (i) define the regions of interest for fMRI analysis, to (ii) extract the fMRI BOLD response from the cortical regions corresponding to the fNIRS channels, and (iii) to select fNIRS channels. Concentration changes in oxygenated ([Formula: see text]) and deoxygenated ([Formula: see text]) hemoglobin were considered in the analyses. Results revealed subtle differences between the different MI tasks, indicating that for whole body MI movements as well as for MI of hand movements [Formula: see text] is the more specific signal. Selection of the fNIRS channel set based on individual anatomy did

not improve the results. Overall, the study indicates that in terms of spatial specificity and task sensitivity SMA activation can be reliably measured with CW-fNIRS.

Cross-Modal Transfer Learning From EEG to Functional Near-Infrared Spectroscopy for Classification Task in Brain-Computer Interface System.

Wang Y, Yang Z, Ji H, Li J, Liu L, Zhuang J.

Front Psychol. 2022 Apr 7;13:833007.
doi: 10.3389/fpsyg.2022.833007. eCollection 2022.

The brain-computer interface (BCI) based on functional near-infrared spectroscopy (fNIRS) has received more and more attention due to its vast application potential in emotion recognition. However, the relatively insufficient investigation of the feature extraction algorithms limits its use in practice. In this article, to improve the performance of fNIRS-based BCI, we proposed a method named R-CSP-E, which introduces EEG signals when computing fNIRS signals' features based on transfer learning and ensemble learning theory. In detail, we used the Independent Component Analysis (ICA) algorithm for the correspondence between the sources of the two signals. We then introduced the EEG signals when computing the spatial filter based on a modified Common Spatial Pattern (CSP) algorithm. Experimental results on public datasets show that the proposed method in this paper outperforms traditional methods without transfer. In general, the mean classification accuracy can be increased by up to 5%. To our knowledge, it is an innovation that we tried to apply transfer learning between EEG and fNIRS. Our study's findings not only prove the potential of the transfer learning algorithm in cross-model brain-computer interface, but also offer a new and innovative perspective to research the hybrid brain-computer interface.

The Value of Brain Imaging and Electrophysiological Testing for Early Screening of Autism Spectrum Disorder: A Systematic Review.

Clairmont C, Wang J, Tariq S, Sherman HT, Zhao M, Kong XJ.

Front Neurosci. 2022 Feb 3;15:812946.
doi: 10.3389/fnins.2021.812946. eCollection 2021.

Given the significance of validating reliable tests for the early detection of autism spectrum disorder (ASD), this systematic review aims to summarize available evidence of neuroimaging and neurophysiological changes in high-risk infants to improve ASD early diagnosis. We included peer-reviewed, primary research in English published before May 21, 2021, involving the use of magnetic resonance imaging (MRI), electroencephalogram (EEG), or functional near-infrared spectroscopy (fNIRS) in children with high risk for ASD under 24 months of age. The main exclusion criteria includes diagnosis of a genetic disorder and gestation age of less the 36 weeks. Online research was performed on PubMed, Web of Science, PsycINFO, and CINAHL. Article selection was conducted by two reviewers to minimize bias. This research was funded by Massachusetts General Hospital Sundry funding. IRB approval was not submitted as it was deemed unnecessary. We included 75 primary research articles. Studies showed that high-risk infants had divergent developmental trajectories for fractional anisotropy and regional brain volumes, increased CSF volume, and global connectivity abnormalities on MRI, decreased sensitivity for familiar faces, atypical lateralization during facial and auditory processing, and different spectral powers across multiple band frequencies on EEG, and distinct developmental trajectories in functional connectivity and regional oxyhemoglobin concentrations in fNIRS. These findings in infants were found to be correlated with the core ASD symptoms and diagnosis at toddler age. Despite the lack of quantitative analysis of the research database, neuroimaging and electrophysiological biomarkers have promising value for the screening of ASD as early as infancy with high accuracy, which warrants further investigation.

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. 2022 Apr;12(3):210-222.
doi: 10.1089/brain.2020.0790. Epub 2021 Jul 26.

Aim: This investigation aims to advance the understanding of neural dynamics that underlies 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 noninteractive 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 noninteractive 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 noninteractive 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 a two-person live interaction. Impact statement The neural dynamics that underlies real-life social interactions is an emergent topic of interest. Dynamically coupled cross-brain neural mechanisms between interacting partners during verbal dialogue have been shown within Wernicke's area. However, it is not known how within-brain long-range neural mechanisms operate during these live social functions. Using Granger causality analysis, we show bidirectional neural activity between Broca's and Wernicke's areas during interactive dialogue compared with a noninteractive control task showing only unidirectional activity. Findings are consistent with an Interactive Brain Model where long-range neural mechanisms process interactive processes associated with rapid and spontaneous spoken social cues.

Recognition of Attentional States in VR Environment: An fNIRS Study.

Zapala D, Augustynowicz P, Tokovarov M.

Sensors (Basel). 2022 Apr 20;22(9):3133.
doi: 10.3390/s22093133.

An improvement in ecological validity is one of the significant challenges for 21st-century neuroscience. At the same time, the study of neurocognitive processes in real-life situations requires good control of all variables relevant to the results. One possible solution that combines the capability of creating realistic experimental scenarios with adequate control of the test environment is virtual reality. Our goal was to develop an integrative research workspace involving a CW-fNIRS and head-mounted-display (HMD) technology dedicated to offline and online cognitive experiments. We designed an experimental study in a repeated-measures model on a group of BCI-nave participants to verify our assumptions. The procedure included a 3D environment-adapted variant of the classic n-back task (2-back version). Tasks were divided into offline (calibration) and online (feedback) sessions. In both sessions, the signal was recorded during the cognitive task for within-group comparisons of changes in oxy-Hb concentration in the regions of interest (the dorsolateral prefrontal cortex-DLPFC and middle frontal gyrus-MFG). In the online session,

the recorded signal changes were translated into real-time feedback. We hypothesized that it would be possible to obtain significantly higher than the level-of-chance threshold classification accuracy for the enhanced attention engagement (2-back task) vs. relaxed state in both conditions. Additionally, we measured participants' subjective experiences of the BCI control in terms of satisfaction. Our results confirmed hypotheses regarding the offline condition. In accordance with the hypotheses, combining fNIRS and HMD technologies enables the effective transfer of experimental cognitive procedures to a controlled VR environment. This opens the new possibility of creating more ecologically valid studies and training procedures.

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fNIRS-Based Upper Limb Motion Intention Recognition Using an Artificial Neural Network for Transhumeral Amputees.

Sattar NY, Kausar Z, Usama SA, Farooq U, Shah MF, Muhammad S, Khan R, Badran M.
Sensors (Basel). 2022 Jan 18;22(3):726.
doi: 10.3390/s22030726.

Prosthetic arms are designed to assist amputated individuals in the performance of the activities of daily life. Brain machine interfaces are currently employed to enhance the accuracy as well as number of control commands for upper limb prostheses. However, the motion prediction for prosthetic arms and the rehabilitation of amputees suffering from transhumeral amputations is limited. In this paper, functional near-infrared spectroscopy (fNIRS)-based approach for the recognition of human intention for six upper limb motions is proposed. The data were extracted from the study of fifteen healthy subjects and three transhumeral amputees for elbow extension, elbow flexion, wrist pronation, wrist supination, hand open, and hand close. The fNIRS signals were acquired from the motor cortex region of the brain by the commercial NIRSport device. The acquired data samples were filtered using finite impulse response (FIR) filter. Furthermore, signal mean, signal peak and minimum values were computed as feature set. An artificial neural network (ANN) was applied to these data samples. The results show the likelihood of classifying the six arm actions with an accuracy of 78%. The attained results have not yet been reported in any identical study. These achieved fNIRS results for intention detection are promising and suggest that they can be applied for the real-time control of the transhumeral prosthesis.

Structured sparse multiset canonical correlation analysis of simultaneous fNIRS and EEG provides new insights into the human action-observation network.

Dashtestani H, Miguel HO, Condy EE, Zeytinoglu S, Millerhagen JB, Debnath R, Smith E, Adali T, Fox NA, Gandjbakhche AH.
Sci Rep. 2022 Apr 27;12(1):6878.
doi: 10.1038/s41598-022-10942-1.

The action observation network (AON) is a network of brain regions involved in the execution and observation of a given action. The AON has been investigated in humans using mostly electroencephalogram (EEG) and functional magnetic resonance imaging (fMRI), but shared neural correlates of action observation and action execution are still unclear due to lack of ecologically valid neuroimaging measures. In this study, we used concurrent EEG and functional Near Infrared Spectroscopy (fNIRS) to examine the AON during a live-action observation and execution paradigm. We developed structured sparse multiset canonical correlation analysis (ssmCCA) to perform EEG-fNIRS data fusion. MCCA is a generalization of CCA to more than two sets of variables and is commonly used in medical multimodal data fusion. However, mCCA suffers from multi-collinearity, high dimensionality, unimodal feature selection, and loss of spatial information in interpreting the results. A limited number of participants (small sample size) is another problem in mCCA, which leads to overfitted models. Here, we adopted graph-guided (structured) fused least absolute shrinkage and selection operator (LASSO) penalty to mCCA to conduct feature selection, in-

corporating structural information amongst the variables (i.e., brain regions). Benefitting from concurrent recordings of brain hemodynamic and electrophysiological responses, the proposed ssmCCA finds linear transforms of each modality such that the correlation between their projections is maximized. Our analysis of 21 right-handed participants indicated that the left inferior parietal region was active during both action execution and action observation. Our findings provide new insights into the neural correlates of AON which are more fine-tuned than the results from each individual EEG or fNIRS analysis and validate the use of ssmCCA to fuse EEG and fNIRS datasets.

Changes in visual cortical function in moderately myopic patients: a functional near-infrared spectroscopy study.

Zhang Y, Lin X, Bi A, Cao N, Zhang T, Wang S, Wen Y, Bi H.
Ophthalmic Physiol Opt. 2022 Jan;42(1):36-47.
doi: 10.1111/opo.12921. Epub 2021 Nov 19.

PURPOSE: To investigate haemoglobin oxygenation in the visual cortexof myopic patients using functional near-infrared spectroscopy (fNIRS). METHODS: The experiment consisted of two parts. Part 1 examined functional changes in the visual cortex before and after refractive correction in myopic patients. Subjects were divided into normal controls, uncorrected and corrected myopes. Part 2 examined functional changes in the visual cortex caused by lens-induced myopia in normal subjects, and whether this activity recovered after a period of rest. Here, subjects were divided into three groups: emmetropes, lens-induced myopia and a rest group.The rest group completed a test with the uncorrected eye following lens removal and 5min of rest. The visual stimulus was a black and white checkerboard. fNIRS was used to detect changes in oxyhaemoglobin content within the visual cortex. The original fNIRS data were analysed using MATLAB to obtain the values (the visual cortical activity response caused by the task); these were used to calculate ?, which represents the degree of change in oxygenated haemoglobin caused by visual stimulation. RESULTS: The ? value measured in each single channel or only in the region of interest (ROI) was significantly higher in the emmetropic control group than the uncorrected myopic group. After optical correction, the responses of myopic subjects approached those of the emmetropes and were not significantly different. If myopia was induced in emmetropic subjects by imposing defocus with positive lenses, a decline in functional activity was observed similar that observed in uncorrected myopes. Activity recovered after the lenses were removed. CONCLUSIONS: Myopic defocus reduced the level of haemoglobin oxygenation in the visual cortex, but activity could be restored by optical correction.

The amplitude of fNIRS hemodynamic response in the visual cortex unmasks autistic traits in typically developing children.

Mazziotti R(#), Scaffei E(#), Conti E, Marchi V, Rizzi R, Cioni G, Battini R, Baroncelli L.
Transl Psychiatry. 2022 Feb 8;12(1):53.
doi: 10.1038/s41398-022-01820-5.

Autistic traits represent a continuum dimension across the population, with autism spectrum disorder (ASD) being the extreme end of the distribution. Accumulating evidence shows that neuroanatomical and neurofunctional profiles described in relatives of ASD individuals reflect an intermediate neurobiological pattern between the clinical population and healthy controls. This suggests that quantitative measures detecting autistic traits in the general population represent potential candidates for the development of biomarkers identifying early pathophysiological processes associated with ASD. Functional near-infrared spectroscopy (fNIRS) has been extensively employed to investigate neural development and function. In contrast, the potential of fNIRS to define reliable biomarkers of brain activity has been barely explored. Features of non-invasiveness, portability, ease of administration, and low-operating costs make fNIRS a suitable instrument to assess brain function for differential diagnosis, follow-up, analysis of treatment

outcomes, and personalized medicine in several neurological conditions. Here, we introduce a novel standardized procedure with high entertaining value to measure hemodynamic responses (HDR) in the occipital cortex of adult subjects and children. We found that the variability of evoked HDR correlates with the autistic traits of children, assessed by the Autism-Spectrum Quotient. Interestingly, HDR amplitude was especially linked to social and communication features, representing the core symptoms of ASD. These findings establish a quick and easy strategy for measuring visually-evoked cortical activity with fNIRS that optimize the compliance of young subjects, setting the background for testing the diagnostic value of fNIRS visual measurements in the ASD clinical population.

Assessment of the mental workload of trainee pilots of remotely operated aircraft using functional near-infrared spectroscopy.

Tang L(#), Si J(#), Sun L, Mao G, Yu S.
BMC Neurol. 2022 Apr 30;22(1):160.
doi: 10.1186/s12883-022-02683-5.

BACKGROUND: Operating an aircraft is associated with a large mental workload; however, knowledge of the mental workload of ROV operators is limited. The purpose of this study was to establish a digital system for assessing the mental workload of remotely operatedvehicle (ROV) operators using hemodynamic parameters, and compare results of different groups with different experience levels. METHOD: Forty-one trainee pilots performed flight tasks once daily for 5 consecutive days in a flight simulation. Forty-five pilots experienced pilots and 68 experienced drivers were also included. Hemodynamic responses were measured by functional near-infrared spectroscopy (fNIRS). RESULTS: The median duration of peak oxyhemoglobin was 147.13s (interquartile range [IQR] 21.97, 401.70s) in the left brain and 180.74s (IQR 34.37, 432.01s) in the right brain in the experienced pilot group, and 184.42s (IQR 3.41, 451.81s) on day 5 in the left brain and 160.30s (IQR 2.62, 528.20s) in the right brain in the trainee group. CONCLUSION: Navigation training reduces peak oxyhemoglobin duration, and may potentially be used as a surrogate marker for mental workload of ROV operators. Peak oxyhemoglobin concentration during s task may allow development of a simplified scheme for optimizing flight performance based on the mental workload of a pilot.

Prolonged Continuous Theta Burst Stimulation Can Regulate Sensitivity on A Fibers: An Functional Near-Infrared Spectroscopy Study.

Li C, Zhang N, Han Q, Zhang L, Xu S, Tu S, Xie Y, Wang Z.
Front Mol Neurosci. 2022 Apr 12;15:887426.
doi: 10.3389/fnmol.2022.887426. eCollection 2022.

OBJECTIVE: High-frequency repetitive transcranial magnetic stimulation (rTMS) induces analgesic effects in both experimental pain and clinical pain conditions. However, whether rTMS can modulate sensory and pain thresholds on sensory fibers is still unclear. Here, we compared the effects of three rTMS paradigms on sensory and pain thresholds conducted by different sensory fibers (A, Ad, and C fibers) with sham stimulation and investigate the potential brain activation using functional near-infrared spectroscopy (fNIRS). METHODS: Forty right-handed healthy subjects were randomly allocated into one of four groups. Each subject received one session rTMS [prolonged continuous theta-burst stimulation (pcTBS), intermittent theta-burst stimulation (iTBS), 10 Hz rTMS or sham]. Current perception threshold (CPT), pain tolerance threshold (PTT), and fNIRS were measured at baseline, immediately after stimulation, and 1 h after stimulation, respectively. RESULTS: Significant differences between treatments were observed for changes for CPT 2,000 Hz between baseline and 1 h after rTMS ($F = 6.551$, $P < 0.001$): pcTBS versus sham ($P = 0.004$) and pcTBS versus 10 Hz rTMS ($P = 0.007$). There were significant difference in average HbO m in the right frontopolar cortex (FPC) [channel 23: $P = 0.030$ (pcTBS versus sham: $P = 0.036$)], left dorsolateral prefrontal cortex (DLPFC) [channel 7: $P = 0.006$ (pcTBS versus sham: $P = 0.004$)], left FPC

[channel 17: P = 0.014 (pcTBS versus sham: P = 0.046), channel 22: P = 0.004 (pcTBS versus sham: P = 0.004)] comparing four group in 1 h after stimulation in PTT 2000 Hz (A-fiber). CONCLUSION: Prolonged continuous theta-burst stimulation can regulate sensitivity on A fibers. In addition, single-session pcTBS placed on left M1 can increase the excitability of DLPFC and FPC, indicating the interaction between M1 and prefrontal cortex may be a potential mechanism of analgesic effect of rTMS. Studies in patients with central post-stroke pain are required to confirm the potential clinical applications of pcTBS.

Prefrontal hyperactivation during dual-task walking related to apathy symptoms in older individuals.

Talamonti D, Dupuy EG, Boudaa S, Vincent T, Fraser S, Nigam A, Lesage F, Belleville S, Gagnon C, Bherer L.

PLoS One. 2022 Apr 25;17(4):e0266553.
doi: 10.1371/journal.pone.0266553. eCollection 2022.

Increasing evidence associates apathy with worsening in cognitive performance and greater risk of dementia, in both clinical and healthy older populations. In older adults with neurocognitive disorders, apathy has also been related to specific fronto-subcortical structural abnormalities, thus differentiating apathy and major depressive disorder. Yet, the neural mechanisms associated with apathy in healthy older adults are still unclear. In the present study, we investigated the frontal cortical response during a dual-task walking paradigm in forty-one healthy older adults with and without apathy symptoms, controlling for depressive symptoms. The dual-task walking paradigm included a single cognitive task (2-back), a single motor task (walking), and a dual-task condition (2-back whilst walking). The cortical response was measured by means of functional Near-Infrared Spectroscopy (fNIRS). The results revealed that participants with apathy symptoms showed greater activation of subregions of the prefrontal cortex and of the premotor cortex compared to healthy controls during the single cognitive component of the dual-task paradigm, whilst cognitive performance was equivalent between groups. Moreover, increased cortical response during the cognitive task was associated with higher odds of exhibiting apathy symptoms, independently of depressive symptoms. These findings suggest that apathy may be related to differential brain activation patterns in healthy older individuals and are in line with previous evidence of the distinctiveness between apathy and depression. Future research may explore the long-term effects of apathy on the cortical response in healthy older adults.

Functional Connectivity Signatures Underlying Simultaneous Language Translation in Interpreters and Non-Interpreters of Mandarin and English: An fNIRS Study.

He Y, Hu Y.

Brain Sci. 2022 Feb 16;12(2):273.
doi: 10.3390/brainsci12020273.

Recent neuroimaging research has suggested that interpreters and non-interpreters elicit different brain activation patterns during simultaneous language translation. However, whether these two groups have different functional connectivity during such a task, and how the neural coupling is among brain subregions, are still not well understood. In this study, we recruited Mandarin (L1)/English (L2) interpreters and non-interpreter bilinguals, whom we asked to perform simultaneous language translation and reading tasks. Functional near-infrared spectroscopy (fNIRS) was used to collect cortical brain data for participants during each task, using 68 channels that covered the prefrontal cortex and the bilateral perisylvian regions. Our findings revealed both interpreter and non-interpreter groups recruited the right dorsolateral prefrontal hub when completing the simultaneous language translation tasks. We also found different functional connectivity between the groups. The interpreter group was characterized by information exchange between the frontal cortex and Wernicke's area. In comparison, the non-interpreter group revealed neural

coupling between the frontal cortex and Broca's area. These findings indicate expertise modulates functional connectivity, possibly because of more developed cognitive skills associated with executive functions in interpreters.

Spatial complexity method for tracking brain development and degeneration using functional near-infrared spectroscopy.

Liang Z, Wang Y, Tian H, Gu Y, Arimitsu T, Takahashi T, Minagawa Y, Niu H, Tong Y.
Biomed Opt Express. 2022 Feb 25;13(3):1718-1736.
doi: 10.1364/BOE.449341. eCollection 2022 Mar 1.

Brain complexity analysis using functional near-infrared spectroscopy (fNIRS) has attracted attention as a biomarker for evaluating brain development and degeneration processes. However, most methods have focused on the temporal scale without capturing the spatial complexity. In this study, we propose a spatial time-delay entropy (STDE) method as the spatial complexity measure based on the time-delay measure between two oxy-hemoglobin (?[HbO]) or two deoxy-hemoglobin (?[Hb]) oscillations within the 0.01-0.1 Hz frequency band. To do this, we analyze fNIRS signals recorded from infants in their sleeping state, children, adults, and healthy seniors in their resting states. We also evaluate the effects of various noise to STDE calculations and STDE's performance in distinguishing various developmental age groups. Lastly, we compare the results with the normalized global spatial complexity (NGSC) and sample entropy (SampEn) measures. Among these measures, STDEHbO (STDE based on ?[HbO] oscillations) performs best. The STDE value increases with age throughout childhood ($p < 0.001$), and then decreases in adults and healthy seniors in the 0.01-0.1 Hz frequency band. This trajectory correlates with cerebrovascular development and degeneration. These findings demonstrate that STDE can be used as a new tool for tracking cerebrovascular development and degeneration across a lifespan based on the fNIRS resting-state measurements.

Effectiveness of the world anti-doping agency's e-learning programme for anti-doping education on knowledge of, explicit and implicit attitudes towards, and likelihood of doping among Chinese college athletes and non-athletes.

Deng Z, Guo J, Wang D, Huang T, Chen Z.
Subst Abuse Treat Prev Policy. 2022 Apr 26;17(1):31.
doi: 10.1186/s13011-022-00459-1.

BACKGROUND: This study aimed to evaluate the effects of the World Anti-Doping Agency's e-learning programme for anti-doping education on knowledge of, explicit and implicit attitudes towards, and likelihood of doping among Chinese college athletes and non-athletes. METHOD: Thirty-two young adults (including 16 college athletes) were recruited to receive the Athlete Learning Program about Health and Anti-Doping (ALPHA) intervention (Zh-hans version). Another 32 young adults were recruited for no-treatment control purposes. Before and immediately after the intervention, the ALPHA test, performance enhancement attitude scale, doping likelihood scale, and brief implicit association test (BIAT) were performed. Cortical activity during the BIAT test was monitored using a functional near-infrared spectroscopy instrument. RESULTS: Significant intervention effects were observed for knowledge ($p < 0.01$, $?2 = 0.21$) and explicit attitude ($p < 0.05$, $?2 = 0.12$) but not for doping likelihood ($p > 0.05$; benefit situation: $?2 = 0.04$; cost situation: $?2 = 0.02$). Compared with the non-athletes, the college athletes reported lower doping likelihood scores in benefit situations (e.g., financial gain, $p < 0.05$, $?2 = 0.10$). Regarding the BIAT task, the experimental effect was successfully induced by different semantic associations between the concepts and the attitude (doping + like vs. doping + dislike). The mean reaction times ($p < 0.01$, $?2 = 0.36$) and error rate ($p < 0.01$, $?2 = 0.34$) in the doping-like block were higher than those in the doping-dislike block. Moreover, oxygenated haemoglobin (oxy-Hb) in response to BIAT interference in

the temporoparietal junction-related channels was increased during the post-intervention test ($p < 0.05$, ?2 varied from 0.09 to 0.16). CONCLUSIONS: The findings suggest that the online anti-doping education programme is partially effective among Chinese college athletes and non-athletes. Furthermore, our findings reflect enhanced cognitive control after the education intervention to suppress a prepotent implicit attitude towards doping.

Inter-Brain Synchrony Levels According to Task Execution Modes and Difficulty Levels: An fNIRS/GSR Study.

Park J, Shin J, Jeong J.

IEEE Trans Neural Syst Rehabil Eng. 2022;30:194-204.
doi: 10.1109/TNSRE.2022.3144168. Epub 2022 Jan 31.

Hyperscanning is a brain imaging technique that measures brain synchrony caused by social interactions. Recent research on hyperscanning has revealed substantial inter-brain synchrony (IBS), but little is known about the link between IBS and mental workload. To study this link, we conducted an experiment consisting of button-pressing tasks of three different difficulty levels for the cooperation and competition modes with 56 participants aged 23.7 3.8 years (meanstandard deviation). We attempted to observe IBS using functional near-infrared spectroscopy (fNIRS) and galvanic skin response (GSR) to assess the activities of the human autonomic nervous system. We found that the IBS levels increased in a frequency band of 0.075-0.15 Hz, which was unrelated to the task repetition frequency in the cooperation mode according to the task difficulty level. Significant relative inter-brain synchrony (RIBS) increases were observed in three and 10 channels out of 15 for the hard tasks compared to the normal and easy tasks, respectively. We observed that the average GSR values increased with increasing task difficulty levels for the competition mode only. Thus, our results suggest that the IBS revealed by fNIRS and GSR is not related to the hemodynamic changes induced by mental workload, simple behavioral synchrony such as button-pressing timing, or autonomic nervous system activity. IBS is thus explicitly caused by social interactions such as cooperation.

Different types of physical exercise in brain activity of older adults: A systematic review.

Ferreira SA, Stein AM, Stavinski NGL, Teixeira DC, Queiroga MR, Bonini JS.

Exp Gerontol. 2022 Mar;159:111672.
doi: 10.1016/j.exger.2021.111672. Epub 2021 Dec 24.

BACKGROUND: To verify the effects of different modalities of physical exercise on brain activity of older adults. METHODS: Systematic searches were conducted according to the PICOS strategy and the following databases were searched: PubMed, Web of Science, PsycInfo and Scielo. Two independent evaluators performed the initial selection from reading the title and abstract based on the stipulated eligibility criteria. RESULTS: The searches resulted in 1935 titles, of which 97 were duplicated and 1793 were excluded based on reading the titles and abstracts. This phase resulted in 45 articles for detailed analysis. At this stage, 35 articles were excluded because they did not meet the eligibility criteria. The information for qualitative analysis was extracted from 10 articles that met the criteria. CONCLUSION: There was improvement in the brain activity of older adults regardless of the type of physical exercise performed (aerobic, neuromuscular, flexibility or neuromotor), but with a discrete advantage for balance and coordination exercises (neuromotor).

The Effects of Virtual Reality Nonphysical Mental Training on Balance Skills and Functional Near-Infrared Spectroscopy Activity in Healthy Adults.

Kyagasioglu O, zgrbz C, Bediz CS, Gdc , Aydinoglu R, Aksit T.
J Sport Rehabil. 2022 May 1;31(4):428-441.
doi: 10.1123/jsr.2021-0197. Epub 2022 Jan 31.

CONTEXT: Athletic skills such as balance are considered physical skills. However, these skills may not just improve by physical training, but also by mental training. The purpose of this study was to investigate the effects of mental training programs on balance skills and hemodynamic responses of the prefrontal cortex. DESIGN: Randomized controlled trial. METHODS: Fifty-seven healthy adults (28 females, 29 males), aged between 18-25 years, participated in this study. Participants were randomly assigned to 3 groups: virtual reality mental training (VRMT) group, conventional mental training (CMT) group, and control group. The training program included action observation and motor imagery practices with balance exercise videos. The VRMT group trained with a VR head-mounted display, while the CMT group trained with a non-immersive computer screen, for 30 minutes, 3 days per week for 4 weeks. At baseline and after 4 weeks of training, balance was investigated with stabilometry and Star Excursion Balance Test (SEBT). Balance tests were performed with simultaneous functional near-infrared spectroscopy (fNIRS) imaging to measure prefrontal cortex oxygenation. RESULTS: For the stabilometry test, at least 1 variable improved significantly in both VRMT and CMT groups but not in the control group. For SEBT, composite reach distance significantly increased in both VRMT and CMT groups but significantly decreased in the control group. For separate directional scores, reach distance was significantly increased in both mental training groups for nondominant leg posterolateral and posteromedial directions, and dominant leg posterolateral direction, while nondominant posteromedial score was significantly increased only in the VRMT group. Between-group comparisons showed that dominant leg posteromedial and posterolateral score improvements were significantly higher than control group for both mental training groups, while nondominant leg improvements were significantly higher than control group only for the VRMT group. The fNIRS oxyhemoglobin levels were not significantly changed during stabilometry tests. However, oxyhemoglobin levels significantly reduced only in the control group during SEBT. CONCLUSIONS: Our findings suggest that both mental training interventions can significantly improve balance test results. Additionally, VRMT may have some advantages over CMT. These findings are promising for the use of mental training in prevention and rehabilitation for special populations such as athletes and older adults.

Gaming behavior and brain activation using functional near-infrared spectroscopy, Iowa gambling task, and machine learning techniques.

Kornev D, Nwoji S, Sadeghian R, Esmaili Sardari S, Dashtestani H, He Q, Gandjbakhche A, Aram S.
Brain Behav. 2022 Apr;12(4):e2536.
doi: 10.1002/brb3.2536. Epub 2022 Mar 15.

INTRODUCTION: The current study investigates the utilization and performance of machine learning (ML) algorithms in the cognitive task of finding the correlation between numerical parameters of the human brain activation during gaming. We hypothesize that our integrated feature extraction platform is able to distinguish between different psychosomatic conditions in the gaming process as measured by the functional near-infrared brain imaging technique. METHODS: For demonstration, the decision-making process was constructed in the experiment environment that combined gaming simulator, such as the Iowa Gaming Task (IGT), with functional near-infrared spectroscopy (fNIRS) as the neuroimaging technique. Features of fNIRS levels were extracted, averaged, and synchronized by time with the IGT dataset to predict the task score inside ML algorithms, such as multiple regression, classification and regression trees, support vector machine, artificial neural network, and random forest. For findings validation, the experiment data were resampled by training and testing sets. Further, a training dataset was used to train the ML algorithms, and prediction accuracy was estimated by repeated cross-validation methods and compared by R squared and root mean square error (RMSE). The model with the best accuracy was used with the testing dataset and finalized the experiment. RESULTS: During the experiment, the highest correlation was identified in the fourth block between the oxy-hemoglobin signal and IGT score in average value (0.24)

and signal feature (0.57). Such relationship is due to block 4 characterization as "conceptual" period when participants task experience reaches the maximum, and rewards raise accordingly. Simultaneously, ML algorithms, constructed based on training data set, demonstrate acceptable performance, and RMSE as the primary performance metric dynamically increases from block 1 to block 5, from the state of uncertainty and unknown to the certainty and risky. In contrast, R squared decreases during the same transition. In most IGT blocks, the best fitted model was determined as support vector machine with radial bases function kernel, and predictions were made with the highest accuracy (lowest RMSE) than in training models. CONCLUSION: Obtained findings showed the applicability and capability of ML models as a powerful technique to evaluate the cognitive neuroimaging task result. Moreover, in terms of features it was identified that the hemodynamic response reacts to the acceleration decision-making process and raises more significance than it was observed before.

Effects of acute exercise on craving and cortical hemodynamics under drug-cue exposure in MA-dependent individuals.

Qi L, Tian ZH, Yue Y, Guan S, Tang L, Dong G.

Neurosci Lett. 2022 Apr 30;781:136672.
doi: 10.1016/j.neulet.2022.136672. Online ahead of print.

BACKGROUND: Methamphetamine (MA) dependent individuals who want to break free of their drug habit or guard against a relapse often find it hard to overcome cravings induced by drug-related cues they are bound to encounter. The purpose of this study was to investigate the effects of acute virtual reality (VR) enhanced physical exercise on cue-induced cravings in MA-dependent individuals. METHODS: Thirty MA-dependent individuals performed a drug-cue reactivity task both before and after a 10min VR-enhanced competitive cycling exercise. Functional near-infrared spectroscopy (fNIRS) was recorded during the pre- and post-exercise drug-cue reactivity tasks. RESULTS: MA dependent individuals show higher hemodynamic responses in prefrontal cortex (PFC) to drug-related cues than to neutral cues. After acute exercise, hemodynamic responses in PFC, including bilateral dorsolateral prefrontal cortex and orbitofrontal cortex, were attenuated under the same drug-related cues exposure. Acute exercise also affected the functional connectivity between PFC and motor cortex in response to drug-related cues versus neutral cues. CONCLUSIONS: These results suggest that a single session of VR-enhanced competitive cycling exercise facilitates MA-dependent individuals' self-control over their cue-induced cravings by modulating cortical activations and brain functional networks.

An Energy-Efficient Wearable Functional Near-infrared Spectroscopy System Employing Dual-level Adaptive Sampling Technique.

Chen C, Ma Z, Liu Z, Zhou L, Wang G, Li Y, Zhao J.

IEEE Trans Biomed Circuits Syst. 2022 Feb;16(1):119-128.
doi: 10.1109/TBCAS.2022.3149766. Epub 2022 May 9.

Functional near-infrared spectroscopy (fNIRS) is a powerful medical imaging tool in brain science and psychology, it can also be employed in brain-computer interface (BCI) due to its noninvasive and artifact-less-sensitive characteristics. Conventional ways to detect large-area brain activity using near-infrared (NIR) technology are based on Time-division or Frequency-division modulation technique, which traverses all physical sensory channels in a specific period. To achieve higher imaging resolution or brain-tasks classification accuracy, the NIRS system require higher density and more channels, which conflict with the limited battery capacity. Inspired by the functional atlas of the human brain, this paper proposes a spatial adaptive sampling (SAS) method. It can change the active channel pattern of the fNIRS system to match with the real-time brain activity, to increase the energy efficiency without significant reduction on the brain imaging quality or the accuracy of brain activity classification. Therefore, the number of the

averaging enabled channels will be dramatically reduced in practice. To verify the proposed SAS technique, a wearable and flexible NIRS system has been implemented, in which each channel of light-emitting diode (LED) drive circuits and photodiode (PD) detection circuits can be power gated independently. Brain task experiments have been conducted to validate the proposed method, the power consumption of the LED drive module is reduced by 46.58% compared to that without SAS technology while maintaining an average brain imaging PSNR (Peak Signal to Noise Ratio) of 35 dB. The brain-task classification accuracy is 80.47%, which has a 2.67% reduction compared to that without the SAS technique.

Person-specific connectivity mapping uncovers differences of bilingual language experience on brain bases of attention in children.

Arredondo MM, Kovelman I, Satterfield T, Hu X, Stojanov L, Beltz AM.

Brain Lang. 2022 Apr;227:105084.
doi: 10.1016/j.bandl.2022.105084. Epub 2022 Feb 14.

Bilingualism influences children's cognition, yet bilinguals vary greatly in their dual-language experiences. To uncover sources of variation in bilingual and monolingual brain function, the present study used standard analysis and innovative person-specific connectivity models combined with a data-driven grouping algorithm. Children (ages 7-9; N=52) completed a visuo-spatial attention task while undergoing functional near-infrared spectroscopy neuroimaging. Both bilingual and monolingual groups performed similarly, and engaged bilateral frontal and parietal regions. However, bilinguals showed greater brain activity than monolinguals in left frontal and parietal regions. Connectivity models revealed two empirically-derived subgroups. One subgroup was composed of monolinguals and bilinguals who were more English dominant, and showed left frontal-parietal connections. The other was composed of bilinguals who were balanced in their dual-language abilities and showed left frontal lobe connections. The findings inform how individual variation in early language experiences influences children's emerging cortical networks for executive function, and reveal efficacy of data-driven approaches.

Middle occipital area differentially associates with malevolent versus benevolent creativity: An fNIRS investigation.

Qiao X, Lu K, Teng J, Gao Z, Hao N.

Soc Neurosci. 2022 Apr;17(2):127-142.
doi: 10.1080/17470919.2022.2038261. Epub 2022 Feb 10.

This study aimed to explore the neural correlates underlying idea generation during malevolent creativity (MC) using functional near-infrared spectroscopy (fNIRS). Participants were asked to solve problems during three types of creativity tasks: malevolent creativity task (MCT), benevolent creativity task (BCT), and alternative uses task (AUT). fNIRS was used to record individual cerebral activity during the tasks. The results revealed that participants demonstrated weaker neural activation in the right middle occipital area (rMO) and lower neural coupling (NC) between the right frontopolar cortex (rFPC) and rMO during MCT than during BCT and AUT. These suggest that r-MO activity and NC between the rFPC and rMO may distinguish between malevolent and benevolent forms of creative ideation.

Hemodynamic changes in the right ventrolateral prefrontal cortex relate to the psychological mood profile.

Tsuchiya K, Shimoda K, Mitsui S, Yamaya N, Kikuchi S, Fujita T, Tozato F.

Neurosci Lett. 2022 May 29;780:136653.
doi: 10.1016/j.neulet.2022.136653. Epub 2022 Apr 22.

Previous reports indicate that the right ventrolateral prefrontal cortex (VLPFC) is involved in emotional regulation. However, most such studies were performed under unphysiological conditions, like the administration of transcranial direct current or repetitive transcranial magnetic stimulation. We have shown that the right VLPFC is stimulated by an acute bout of daily activity, such as cleaning. Here, we investigated the relationship between the right VLPFC and mood changes using this system. Fourteen young adults vacuumed a floor as a cleaning task and kept a standing position as a control task on separate days. The oxyhemoglobin (oxy-Hb) and deoxy-hemoglobin (deoxy-Hb) signals of the prefrontal cortex were measured during the tasks. The mood scale scores of Profile of Mood States 2nd edition (POMS) and Two-Dimensional Mood Scale (TDMS) were measured before and after both tasks. The differences in subscale scores between pre- and post-tasks in both scales were calculated as ?POMS and ?TDMS. The cleaning task significantly increased the oxy-Hb signal in the bilateral VLPFC and right frontopolar, but did not affect the deoxy-Hb signals. The control task significantly decreased the oxy-Hb signal in some brain regions. The Confusion-Bewilderment score in POMS changed after the cleaning task. Importantly, the oxy-Hb signal in the right VLPFC was negatively correlated with the ?POMS Confusion-Bewilderment score. The activity of the right VLPFC stimulated by the cleaning task might have a correlation with the Confusion-Bewilderment mood state.

Bilingualism alters infants' cortical organization for attentional orienting mechanisms.

Arredondo MM, Aslin RN, Werker JF.

Dev Sci. 2022 Mar;25(2):e13172.
doi: 10.1111/desc.13172. Epub 2021 Aug 30.

A bilingual environment is associated with changes in the brain's structure and function. Some suggest that bilingualism also improves higher-cognitive functions in infants as young as 6-months, yet whether this effect is associated with changes in the infant brain remains unknown. In the present study, we measured brain activity using functional near-infrared spectroscopy in monolingual- and bilingual-raised 6- and 10-month-old infants. Infants completed an orienting attention task, in which a cue was presented prior to an object appearing on the same (Valid) or opposite (Invalid) side of a display. Task performance did not differ between the groups but neural activity did. At 6-months, both groups showed greater activity for Valid (>Invalid) trials in frontal regions (left hemisphere for bilinguals, right hemisphere for monolinguals). At 10-months, bilinguals showed greater activity for Invalid (>Valid) trials in bilateral frontal regions, while monolinguals showed greater brain activity for Valid (>Invalid) trials in left frontal regions. Bilinguals' brain activity trended with their parents' reporting of dual-language mixing when speaking to their child. These findings are the first to indicate how early (dual) language experience can alter the cortical organization underlying broader, non-linguistic cognitive functions during the first year of life.

Individual differences in skill acquisition and transfer assessed by dual task training performance and brain activity.

Reddy P, Shewokis PA, Izzetoglu K.

Brain Inform. 2022 Apr 2;9(1):9.
doi: 10.1186/s40708-022-00157-5.

Assessment of expertise development during training program primarily consists of evaluating interactions between task characteristics, performance, and mental load. Such a traditional assessment framework may lack consideration of individual characteristics when evaluating training on complex tasks, such as driving and piloting, where operators are typically required to execute multiple tasks simultaneously. Studies have already identified individual characteristics arising from intrinsic, context, strategy, personality, and preference as common predictors of performance and mental load. Therefore, this study aims to

investigate the effect of individual difference in skill acquisition and transfer using an ecologically valid dual task, behavioral, and brain activity measures. Specifically, we implemented a search and surveillance task (scanning and identifying targets) using a high-fidelity training simulator for the unmanned aircraft sensor operator, acquired behavioral measures (scan, not scan, over scan, and adaptive target find scores) using simulator-based analysis module, and measured brain activity changes (oxyhemoglobin and deoxyhemoglobin) from the prefrontal cortex (PFC) using a portable functional near-infrared spectroscopy (fNIRS) sensor array. The experimental protocol recruited 13 novice participants and had them undergo three easy and two hard sessions to investigate skill acquisition and transfer, respectively. Our results from skill acquisition sessions indicated that performance on both tasks did not change when individual differences were not accounted for. However inclusion of individual differences indicated that some individuals improved only their scan performance (Attention-focused group), while others improved only their target find performance (Accuracy-focused group). Brain activity changes during skill acquisition sessions showed that mental load decreased in the right anterior medial PFC (RAMPFC) in both groups regardless of individual differences. However, mental load increased in the left anterior medial PFC (LAMPFC) of Attention-focused group and decreased in the Accuracy-focused group only when individual differences were included. Transfer results showed no changes in performance regardless of grouping based on individual differences; however, mental load increased in RAMPFC of Attention-focused group and left dorsolateral PFC (LDLPFC) of Accuracy-focused group. Efficiency and involvement results suggest that the Attention-focused group prioritized the scan task, while the Accuracy-focused group prioritized the target find task. In conclusion, training on multitasks results in individual differences. These differences may potentially be due to individual preference. Future studies should incorporate individual differences while assessing skill acquisition and transfer during multitask training.

Mind over body: A neuroergonomic approach to assessing motor performance under stress in older adults.

Tyagi O, Mehta RK.

Appl Ergon. 2022 May;101:103691.
doi: 10.1016/j.apergo.2022.103691. Epub 2022 Jan 25.

Stress impairs motor performance, which is exacerbated with age. Stress also impairs brain activity in the prefrontal cortex, which communicates with the motor areas of the brain to regulate exercise and motor performance. To develop ergogenic strategies for the aging workforce, mind (brain)-body mechanisms behind the effect of stress on neuromuscular performance need to be well understood. This study investigated the influence of social stress on motor performance and information flow between the frontal and motor regions of the brain during intermittent handgrip contractions among older adults. Thirty older adults, balanced by gender, performed intermittent handgrip contractions at 30% of maximum strength before and after being subjected to a social stressor. Force steadiness, strength loss, root mean square electromyogram (EMG) activity, activation of the brain regions, and functional and effective connectivity between the frontal and motor brain regions were computed for pre- and post-stressor handgrip contractions. Older men exhibited improved motor performance after the stressor and concomitant reduction in functional connectivity between the frontal-motor brain regions ipsilateral to the contracting hand. Additionally, while both sexes exhibited significant causal information flow, i.e., effective connectivity, from the frontal to the motor regions of the brain, irrespective of the stressor, older women exhibited a bidirectional effective connectivity between the frontal-motor brain regions after the stressor. Stress had a facilitative effect on the motor performance of older men through compensatory brain network reorganization. Older women exhibited comparable motor performance pre/post stress, despite showing an increase in bidirectional information flow between the frontal-motor areas. Employing brain hemodynamics can facilitate better understanding of the impact of stress on neuromuscular performance and its differential impacts on brain network reorganization between the sexes.

Prefrontal cortex hemodynamic response to acute high intensity intermittent exercise during executive function processing.

Khandekar P, Shenoy S, Sathe A.

J Gen Psychol. 2022 Mar 15:1-28.
doi: 10.1080/00221309.2022.2048785. Online ahead of print.

We investigated prefrontal cortex (PFC) hemodynamic response, through functional near infrared spectroscopy (fNIRS) during executive function (EF) processing in response to acute high intensity intermittent exercise (HIIE) in young adults. We also assessed the associated sex differences in the cognitive scores and related PFC hemodynamic functions in response to HIIE. 49 young healthy adult participants (32 women, 17 men) were randomly assigned to either control or HIIE intervention groups. HIIE group participants performed 4 4 minutes of HIIE on cycle ergometer with 3 minutes of active recovery between the bouts; control group relaxed for the time equivalent to intervention. fNIRS data was collected during the performance of the EF tests including Color Word Stroop Test (CWST) and Trail Making Test (TMT) in pre and post sessions in both the groups. Results indicated a significant change in the hemodynamic response in the form of increased oxygenated and decreased deoxygenated hemoglobin in the PFC areas specific to the EF tasks, with improved CWST and TMT scores in response to HIIE intervention. PFC activation was different in men and women in response to HIIE, however similar scores of task performance were observed in men and women during the performance of executive functions in response to HIIE. The study concludes that an acute HIIE session improves executive function which is associated with an increase activation of PFC. Sex differences exist in the activation of PFC in response to HIIE during EF processing. Our study adds to the current evidence regarding exercise and cognition.

Increased prefrontal activity during usual walking in aging.

Hoang I, Paire-Ficout L, Derollepot R, Perrey S, Devos H, Ranchet M.

Int J Psychophysiol. 2022 Apr;174:9-16.
doi: 10.1016/j.ijpsycho.2022.01.011. Epub 2022 Jan 29.

Executive functions are important for successful accomplishment of walking tasks, particularly during a dual task. Over the past few years, several studies investigated prefrontal cortex activity under different walking conditions in older adults with functional near infrared spectroscopy (fNIRS). However, little is known about changes in dorsolateral prefrontal cortex (DLPFC) activity during walking in the early stages of aging. The main objective of this study was to compare changes in DLPFC activity during simple and dual task walking across three different age groups. Twenty-five young (age range=18-37), twenty-five youngest-old (age range=55-65), and twenty-five older adults (age range=67-87) participated in this study. Main results showed that, during simple task walking, older adults had increased DLPFC activity with equivalent walking performance. This increased mainly concerned the right hemisphere. During dual task walking, older adults had increased right DLPFC activity but seemed to have enough resources to maintain their performance during DT walking. This result supports the idea that compensation mechanisms, due to loss of automaticity of walking in aging, appear already during simple task walking. Measuring cortical activity with fNIRS during a simple task walking might be used as valuable indicator for identifying individuals at risk of falling.

The brain state of motor imagery is reflected in the causal information of functional near-infrared spectroscopy.

Du Q, Luo J, Chu C, Wang Y, Cheng Q, Guo S.

Neuroreport. 2022 Feb 2;33(3):137-144.
doi: 10.1097/WNR.0000000000001765.

BACKGROUND: Brain-computer interface (BCI) is a promising neurorehabilitation strategy for ameliorating post-stroke function disorders. Physiological changes in the brain, such as functional near-infrared spectroscopy (fNIRS) dedicated to exploring cerebral circulatory responses during neurological rehabilitation tasks, are essential for gaining insights into neurorehabilitation mechanisms. However, the relationship between the neurovascular responses in different brain regions under rehabilitation tasks remains unknown. OBJECTIVE: The present study explores the fNIRS interactions between brain regions under different motor imagery (MI) tasks, emphasizing functional characteristics of brain network patterns and BCI motor task classification. METHODS: Granger causality analysis (GCA) is carried out for oxyhemoglobin data from 29 study participants in left- and right-hand MI tasks. RESULTS: According to research findings, homozygous and heterozygous states in the two brain connectivity modes reveal one and nine channel pairs, respectively, with significantly different ($P < 0.05$) GC values under the left- and right-hand MI tasks in the population. With reference to the total 10 channel pairs of causality differences between the two brain working states, a support vector machine is used to classify the two tasks with an overall accuracy of 83% for five-fold cross-validation. CONCLUSION: As demonstrated in the present study, fNIRS offers causality patterns in different brain states of MIBCI motor tasks. The research findings show that fNIRS causality can be used to assess different states of the brain, providing theoretical support for its application to neurorehabilitation assessment protocols to ultimately improve patients' quality of life.Video Abstract: http://links.lww.com/WNR/A653.

Aching face and hand: the interoceptive attentiveness and social context in relation to empathy for pain.

Balconi M, Angioletti L.

J Integr Neurosci. 2022 Jan 28;21(1):34.
doi: 10.31083/j.jin2101034.

This research explored how the manipulation of interoceptive attentiveness (IA) can influence the frontal (dorsolateral prefrontal cortex (DLPFC) and somatosensory cortices) activity associated with the emotional regulation and sensory response of observing pain in others. 20 individuals were asked to observe face versus hand, painful/non-painful stimuli in an individual versus social condition while brain hemodynamic response (oxygenated (O2Hb) and deoxygenated hemoglobin (HHb) components) was measured via functional Near-Infrared Spectroscopy (fNIRS). Images represented either a single person (individual condition) or two persons in social interaction (social condition) both for the pain and body part set of stimuli. The participants were split into experimental (EXP) and control (CNT) groups, with the EXP explicitly required to concentrate on its interoceptive correlates while observing the stimuli. Quantitative statistical analyses were applied to both oxy- and deoxy-Hb data. Firstly, significantly higher brain responsiveness was detected for pain in comparison to no-pain stimuli in the individual condition. Secondly, a left/right hemispheric lateralization was found for the individual and social condition, respectively, in both groups. Besides, both groups showed higher DLPFC activation for face stimuli presented in the individual condition compared to hand stimuli in the social condition. However, face stimuli activation prevailed for the EXP group, suggesting the IA phenomenon has certain features, namely it manifests itself in the individual condition and for pain stimuli. We can conclude that IA promoted the recruitment of internal adaptive regulatory strategies by engaging both DLPFC and somatosensory regions towards emotionally relevant stimuli.

Differential age-dependent development of inter-area brain connectivity in term and preterm neonates.

Arimitsu T(#), Shinohara N(#), Minagawa Y, Hoshino E, Hata M, Takahashi T.

Pediatr Res. 2022 Jan 29.

doi: 10.1038/s41390-022-01939-7. Online ahead of print.

BACKGROUND: Among preterm infants, higher morbidities of neurological disturbances and developmental delays are critical issues. Resting-state networks (RSNs) in the brain are suitable measures for assessing higher-level neurocognition. Since investigating task-related brain activity is difficult in neonates, assessment of RSNs provides invaluable insight into their neurocognitive development. METHODS: The participants, 32 term and 71 preterm neonates, were divided into three groups based on gestational age (GA) at birth. Cerebral hemodynamic activity of RSNs was measured using functional near-infrared spectroscopy in the temporal, frontal, and parietal regions. RESULTS: High-GA preterm infants (GA = 30 weeks) had a significantly stronger RSN than low-GA preterm infants and term infants. Regression analyses of RSNs as a function of postnatal age (PNA) revealed a steeper regression line in the high-GA preterm and term infants than in the low-GA infants, particularly for inter-area brain connectivity between the frontal and left temporal areas. CONCLUSIONS: Slower PNA-dependent development of the frontal-temporal network found only in the low-GA group suggests that significant brain growth optimal in the intrauterine environment takes place before 30 weeks of gestation. The present study suggests a likely reason for the high incidence of neurodevelopmental impairment in early preterm infants. IMPACT: Resting-state fNIRS measurements in three neonate groups differing in gestational age (GA) showed stronger networks in the high-GA preterm infants than in the term and low-GA infants, which was partly explained by postnatal age (PNA). Regression analyses revealed a similar PNA-dependence in the development of the inter-area networks in the frontal and temporal lobes in the high-GA and term infants, and significantly slower development in the low-GA infants. These results suggest that optimal intrauterine brain growth takes place before 30 weeks of gestation. This explains one of the reasons for the high incidence of neurodevelopmental impairment in early preterm infants.

[The function of auditory cortex in the elderly using functional near-infrared spectroscopy technology].

[Article in Chinese; Abstract available in Chinese from the publisher]

Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2022 Apr 7;57(4):458-466.
doi: 10.3760/cma.j.cn115330-20210818-00558.

Yang L(1), Chen YN(1), Wang SJ(1), Wang Y(1), Chen T(2), Liang Y(2), Wang S(1).

Diffuse Optical Tomography Using fNIRS Signals Measured from the Skull Surface of the Macaque Monkey.

Hayashi R, Yamashita O, Yamada T, Kawaguchi H, Higo N.

Cereb Cortex Commun. 2021 Nov 10;3(1):tgab064.
doi: 10.1093/texcom/tgab064. eCollection 2022.

Diffuse optical tomography (DOT), as a functional near-infrared spectroscopy (fNIRS) technique, can estimate three-dimensional (3D) images of the functional hemodynamic response in brain volume from measured optical signals. In this study, we applied DOT algorithms to the fNIRS data recorded from the surface of macaque monkeys' skulls when the animals performed food retrieval tasks using either the left- or right-hand under head-free conditions. The hemodynamic response images, reconstructed by DOT with a high sampling rate and fine voxel size, demonstrated significant activations at the upper limb regions of the primary motor area in the central sulcus and premotor, and parietal areas contralateral to the hands used in the tasks. The results were also reliable in terms of consistency across different recording dates. Time-series analyses of each brain area revealed preceding activity of premotor area to primary motor area consistent with previous physiological studies. Therefore, the fNIRS-DOT protocol demonstrated in this study provides reliable 3D functional brain images over a period of days under head-free conditions for region-of-interest-based time-series analysis.

Effect of Audiovisual Cross-Modal Conflict during Working Memory Tasks: A Near-Infrared Spectroscopy Study.

Cui J, Sawamura D, Sakuraba S, Saito R, Tanabe Y, Miura H, Sugi M, Yoshida K, Watanabe A, Tokikuni Y, Yoshida S, Sakai S.

Brain Sci. 2022 Mar 3;12(3):349.
doi: 10.3390/brainsci12030349.

Cognitive conflict effects are well characterized within unimodality. However, little is known about cross-modal conflicts and their neural bases. This study characterizes the two types of visual and auditory cross-modal conflicts through working memory tasks and brain activities. The participants consisted of 31 healthy, right-handed, young male adults. The Paced Auditory Serial Addition Test (PASAT) and the Paced Visual Serial Addition Test (PVSAT) were performed under distractor and no distractor conditions. Distractor conditions comprised two conditions in which either the PASAT or PVSAT was the target task, and the other was used as a distractor stimulus. Additionally, oxygenated hemoglobin (Oxy-Hb) concentration changes in the frontoparietal regions were measured during tasks. The results showed significantly lower PASAT performance under distractor conditions than under no distractor conditions, but not in the PVSAT. Oxy-Hb changes in the bilateral ventrolateral prefrontal cortex (VLPFC) and inferior parietal cortex (IPC) significantly increased in the PASAT with distractor compared with no distractor conditions, but not in the PVSAT. Furthermore, there were significant positive correlations between ?task performance accuracy and ?Oxy-Hb in the bilateral IPC only in the PASAT. Visual cross-modal conflict significantly impairs auditory task performance, and bilateral VLPFC and IPC are key regions in inhibiting visual cross-modal distractors.

Therapeutic Garden With Contemplative Features Induces Desirable Changes in Mood and Brain Activity in Depressed Adults.

Olszewska-Guizzo A, Fogel A, Escoffier N, Sia A, Nakazawa K, Kumagai A, Dan I, Ho R.

Front Psychiatry. 2022 Apr 7;13:757056.
doi: 10.3389/fpsyt.2022.757056. eCollection 2022.

The therapeutic values of contact with nature have been increasingly recognized. A growing body of evidence suggests that a unique subcategory of "contemplative landscapes" is particularly therapeutic. Previous studies predominantly focused on observational designs in non-clinical populations. It is not known if these effects can be extrapolated to populations suffering from depression, and experimental designs need to be utilized to establish causality. We examined the effects of in-situ passive exposure to three urban spaces on brain activity, namely a Therapeutic Garden with high Contemplative Landscape scores (TG), Residential Green (RG) and Busy Downtown (BD), and self-reported momentary mood in adults aged 21-74 (n = 92), including 24 clinically depressed and 68 healthy participants. Portable, multimodal electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) systems were used to record brain activity, and a Profile of Mood States (POMS) questionnaire was used to record mood before and after exposure. We tested the interactions between the site, time and group for the mood, and between site and group for the neuroelectric oscillations and brain hemodynamics. Self-reported pre-post-mood was significant only at the TG ($p = 0.032$) in both groups. The lowest Total Mood Disturbance (TMD) was reported at TG and the highest in BD ($p = 0.026$). Results from fNIRS indicated marginally significant lower oxy-Hb in the frontal region at TG as compared to BD ($p = 0.054$) across both groups. The marginally significant effect of site and group was also observed ($p = 0.062$), with the Clinical group showing much lower oxy-Hb at TG than Healthy. The opposite pattern was observed at BD. EEG results showed differences between Healthy and Clinical groups in the Frontal Alpha Asymmetry (FAA) pattern across the sites ($p = 0.04$), with more frontal alpha right in the Clinical sample and more left lateralization in the Healthy sample at TG. Temporal Beta Asymmetry (TBA) analyses suggested that patients displayed lower

bottom-up attention than Healthy participants across all sites (p = 0.039). The results suggest that both healthy and depressed adults benefitted from exposure to TG, with possibly different pathways of mood improvement. Visiting therapeutic nature with contemplative features may provide valuable support for the treatment of depression in clinical populations and a self-care intervention in non-clinical populations.

Doll play prompts social thinking and social talking: Representations of internal state language in the brain.

Hashmi S, Vanderwert RE, Paine AL, Gerson SA.

Dev Sci. 2022 Mar;25(2):e13163.
doi: 10.1111/desc.13163. Epub 2021 Aug 6.

Doll play provides opportunities for children to practice social skills by creating imaginary worlds, taking others' perspectives, and talking about others' internal states. Previous research using functional near-infrared spectroscopy (fNIRS) found a region over the posterior superior temporal sulcus (pSTS) was more active during solo doll play than solo tablet play, implying that doll play might present opportunities for rehearsing theory of mind and empathy skills, even when playing alone. In this research, we addressed this more directly by investigating 4-8-year-old children's (N=33) use of internal state language (ISL; i.e., references to emotions, desires, and cognitions) when playing with dolls and on tablets, both by themselves and with a social partner, and their associated brain activity in the pSTS using fNIRS. We found that children used more ISL about others when playing with dolls than when playing on tablets, particularly when they were playing alone. This mirrored the patterns seen in pSTS activity in previous research. When individual variability in ISL about others was considered, more ISL about others was linked to stronger pSTS activation. Thus, variability in pSTS activity during play is not about the perceptual or physical differences between toys (e.g., dolls are more human-like) but about what children think about when they engage in different kinds of play. This is the first research to investigate brain activity during spontaneously occurring ISL and indicates that children have a tendency to take and discuss others' perspectives during doll play, with implications for social processing in the brain. A video abstract of this article can be viewed at https://youtu.be/58HgxbuhBzU.

Effects of Ordered Grasping Movement on Brain Function in the Performance Virtual Reality Task: A Near-Infrared Spectroscopy Study.

Li X, Yin J, Li H, Xu G, Huo C, Xie H, Li W, Liu J, Li Z.

Front Hum Neurosci. 2022 Mar 31;16:798416.
doi: 10.3389/fnhum.2022.798416. eCollection 2022.

OBJECTIVE: Virtual reality (VR) grasping exercise training helps patients participate actively in their recovery and is a critical approach to the rehabilitation of hand dysfunction. This study aimed to explore the effects of active participation and VR grasping on brain function combined with the kinematic information obtained during VR exercises. METHODS: The cerebral oxygenation signals of the prefrontal cortex (LPFC/RPFC), the motor cortex (LMC/RMC), and the occipital cortex (LOC/ROC) were measured by functional near-infrared spectroscopy (fNIRS) in 18 young people during the resting state, grasping movements, and VR grasping movements. The EPPlus plug-in was used to collect the hand motion data during simulated interactive grasping. The wavelet amplitude (WA) of each cerebral cortex and the wavelet phase coherence (WPCO) of each pair of channels were calculated by wavelet analysis. The total difference in acceleration difference of the hand in the VR grasping movements was calculated to acquire kinematic characteristics (KCs). The cortical activation and brain functional connectivity (FC) of each brain region were compared and analyzed, and a significant correlation was found between VR grasping movements and brain region activation. RESULTS: Compared with the resting state, the WA values of LPFC, RPFC, LMC, RMC, and ROC increased during the grasping movements and the VR grasping movements, these

changes were significant in LPFC ($p = 0.0093$) and LMC ($p = 0.0007$). The WA values of LMC ($p = 0.0057$) in the VR grasping movements were significantly higher than those in the grasping movements. The WPCO of the cerebral cortex increased during grasping exercise compared with the resting state. Nevertheless, the number of significant functional connections during VR grasping decreased significantly, and only the WPCO strength between the LPFC and LMC was enhanced. The increased WA of the LPFC, RPFC, LMC, and RMC during VR grasping movements compared with the resting state showed a significant negative correlation with KCs ($p < 0.001$). CONCLUSION: The VR grasping movements can improve the activation and FC intensity of the ipsilateral brain region, inhibit the FC of the contralateral brain region, and reduce the quantity of brain resources allocated to the task. Thus, ordered grasping exercises can enhance active participation in rehabilitation and help to improve brain function.

Cooperative Behavior Evokes Interbrain Synchrony in the Prefrontal and Temporoparietal Cortex: A Systematic Review and Meta-Analysis of fNIRS Hyperscanning Studies.

Czeszumski A, Liang SH, Dikker S, Knig P, Lee CP, Koole SL, Kelsen B.

eNeuro. 2022 Apr 13;9(2):ENEURO.0268-21.2022.
doi: 10.1523/ENEURO.0268-21.2022. Print 2022 Mar-Apr.

Single-brain neuroimaging studies have shown that human cooperation is associated with neural activity in frontal and temporoparietal regions. However, it remains unclear whether single-brain studies are informative about cooperation in real life, where people interact dynamically. Such dynamic interactions have become the focus of interbrain studies. An advantageous technique in this regard is functional near-infrared spectroscopy (fNIRS) because it is less susceptible to movement artifacts than more conventional techniques like electroencephalography (EEG) or functional magnetic resonance imaging (fMRI). We conducted a systematic review and the first quantitative meta-analysis of fNIRS hyperscanning of cooperation, based on thirteen studies with 890 human participants. Overall, the meta-analysis revealed evidence of statistically significant interbrain synchrony while people were cooperating, with large overall effect sizes in both frontal and temporoparietal areas. All thirteen studies observed significant interbrain synchrony in the prefrontal cortex (PFC), suggesting that this region is particularly relevant for cooperative behavior. The consistency in these findings is unlikely to be because of task-related activations, given that the relevant studies used diverse cooperation tasks. Together, the present findings support the importance of interbrain synchronization of frontal and temporoparietal regions in interpersonal cooperation. Moreover, the present article highlights the usefulness of meta-analyses as a tool for discerning patterns in interbrain dynamics.

ABBaH teens: Activity Breaks for Brain Health in adolescents: study protocol for a randomized crossover trial.

Heiland EG, Kjellenberg K, Tarassova O, Fernstrm M, Nyberg G, Ekblom MM, Helgadottir B, Ekblom .

Trials. 2022 Jan 6;23(1):22.
doi: 10.1186/s13063-021-05972-5.

BACKGROUND: Physical activity breaks are widely being implemented in school settings as a solution to increase academic performance and reduce sitting time. However, the underlying physiological mechanisms suggested to improve cognitive function from physical activity and the frequency, intensity, and duration of the breaks remain unknown. This study will investigate the effects of frequent, short physical activity breaks during prolonged sitting on task-related prefrontal cerebral blood flow, cognitive performance, and psychological factors. Additionally, the moderating and mediating effects of arterial stiffness on changes in cerebral blood flow will be tested. METHODS: This is a protocol for a randomized crossover study that will recruit 16 adolescents (13-14 years old). Participants will undergo three different conditions in a randomized order, on three separate days, involvingsitting 80 min with a different type of

break every 17 min for 3 min. The breaks will consist of (1) seated social breaks, (2) simple resistance activities, and (3) step-up activities. Before and after the 80-min conditions, prefrontal cerebral blood flow changes will be measured using functional near-infrared spectroscopy (primary outcome), while performing working memory tasks (1-, 2-, and 3-back tests). Arterial stiffness (augmentation index and pulse wave velocity) and psychological factors will also be assessed pre and post the 80-min interventions. DISCUSSION: Publication of this protocol will help to increase rigor in science. The results will inform regarding the underlying mechanisms driving the association between physical activity breaks and cognitive performance. This information can be used for designing effective and feasible interventions to be implemented in schools. TRIAL REGISTRATION: www.ClinicalTrials.gov , NCT04552626 . Retrospectively registered on September 21, 2020.

Neural mechanisms underlying the influence of retrieval ability on creating and recalling creative ideas.

Li X, Li Y, Wang X, Bai H, Deng W, Cai N, Hu W.

Neuropsychologia. 2022 Jul 4;171:108239.
doi: 10.1016/j.neuropsychologia.2022.108239. Epub 2022 Apr 12.

Previous studies revealed a close relationship between retrieval ability and creative thinking; however, it is still unclear what processes of creative thinking are influenced by retrieval ability. This study applied a novel task paradigm to distinguish between different processes of creative thinking. We used functional near-infrared spectroscopy (fNIRS) to explore the differences of cortical activation and functional connectivity in the prefrontal cortex (PFC), temporoparietal junction (TPJ) and temporal cortex between high (HRA) and low (LRA) retrieval ability groups during creating original ideas (CO) and recalling original ideas (RO) tasks. The behaviour results revealed that in the CO task, the HRA group performed better than the LRA group on fluency, flexibility, and originality. Importantly, the fNIRS results further indicated that the HRA group exhibited higher activation of the l-TPJ, l-STG, l-MTG, r-FPC, r-DLPFC than the LRA group during the CO task. Moreover, the HRA group exhibited higher activation of the bilateral TPJ, l-STG, l-MTG, r-DLPFC, and r-FPC in the CO task than in the RO task, and the LRA group exhibited higher activation of the l-STG in the CO task than in the RO task. The functional connectivity between the PFC and IFG, TPJ, and MTG of the HRA group was significantly stronger than that of the LRA group in both the CO and RO tasks. The findings suggest that high retrieval ability could facilitate the generation of creative ideas by facilitating the retrieval of novel information and suppression of common information compared to low retrieval ability. This study provides neural evidence for the effect of different levels of retrieval ability on creative thinking.

Causal connectivity from right DLPFC to IPL in schizophrenia patients: a pilot study.

Curcic-Blake B, Kos C, Aleman A.

NPJ Schizophr. 2022 Mar 7;8(1):16.
doi: 10.1038/s41537-022-00216-0.

Abnormal function and connectivity of the fronto-parietal network (FPN) have been documented in patients with schizophrenia, but studies are correlational. We applied repetitive transcranial magnetic stimulation (rTMS) to the dorso-lateral prefrontal cortex (DLPFC) and observed causal connectivity to the inferior parietal lobe (IPL). We hypothesized that patients with schizophrenia would have lower activation and slower reaction in the IPL following DLPFC stimulation. Thirteen patients with schizophrenia (SZ) and fourteen healthy controls subjects (HC) underwent rTMS at 10 Hz to the right DLPFC. Simultaneously, we measured brain activation in the IPL, represented as oxygenized hemoglobin (HbO) levels, using functional near-infrared spectroscopy (fNIRS). rTMS consisted of 20 trains of impulses at 10 Hz for 3 seconds, and 60 seconds waiting time. Using NIRSLab software, GLM was applied to estimate both hemodynamic response

function (HRF) and its derivative. Following TMS to the DLPFC, SZ showed a smaller decrease in HbO levels in the bilateral IPL than HC ($p = 0.05$). Timecourse analysis revealed an immediate decrease in parietal HbO levels in HC, but not in SZ. This difference was significant (at a threshold level of $p = 0.05$, with Bonferroni correction) for several time segments and channels in both rights and left IPL. Our findings suggest abnormal fronto-temporal connectivity in patients with schizophrenia, beyond a mere decrease or slowing of information processing. This is in line with the hypothesis of reduced fronto-parietal inhibition in schizophrenia.

Coupling between prefrontal brain activity and respiratory sinus arrhythmia in infants and adults.

Nguyen T, Hoehl S, Bertenthal BI, Abney DH.
Dev Cogn Neurosci. 2022 Feb;53:101047.
doi: 10.1016/j.dcn.2021.101047. Epub 2021 Dec 13.
Erratum in Dev Cogn Neurosci. 2022 Jan 18;:101062.

Brain Activation During Active Balancing and Its Behavioral Relevance in Younger and Older Adults: A Functional Near-Infrared Spectroscopy (fNIRS) Study.

Lehmann N, Kuhn YA, Keller M, Aye N, Herold F, Draganski B, Taube W, Taubert M.
Front Aging Neurosci. 2022 Mar 25;14:828474.
doi: 10.3389/fnagi.2022.828474. eCollection 2022.

Age-related deterioration of balance control is widely regarded as an important phenomenon influencing quality of life and longevity, such that a more comprehensive understanding of the neural mechanisms underlying this process is warranted. Specifically, previous studies have reported that older adults typically show higher neural activity during balancing as compared to younger counterparts, but the implications of this finding on balance performance remain largely unclear. Using functional near-infrared spectroscopy (fNIRS), differences in the cortical control of balance between healthy younger ($n = 27$) and older ($n = 35$) adults were explored. More specifically, the association between cortical functional activity and balance performance across and within age groups was investigated. To this end, we measured hemodynamic responses (i.e., changes in oxygenated and deoxygenated hemoglobin) while participants balanced on an unstable device. As criterion variables for brain-behavior-correlations, we also assessed postural sway while standing on a free-swinging platform and while balancing on wobble boards with different levels of difficulty. We found that older compared to younger participants had higher activity in prefrontal and lower activity in postcentral regions. Subsequent robust regression analyses revealed that lower prefrontal brain activity was related to improved balance performance across age groups, indicating that higher activity of the prefrontal cortex during balancing reflects neural inefficiency. We also present evidence supporting that age serves as a moderator in the relationship between brain activity and balance, i.e., cortical hemodynamics generally appears to be a more important predictor of balance performance in the older than in the younger. Strikingly, we found that age differences in balance performance are mediated by balancing-induced activation of the superior frontal gyrus, thus suggesting that differential activation of this region reflects a mechanism involved in the aging process of the neural control of balance. Our study suggests that differences in functional brain activity between age groups are not a mere by-product of aging, but instead of direct behavioral relevance for balance performance. Potential implications of these findings in terms of early detection of fall-prone individuals and intervention strategies targeting balance and healthy aging are discussed.

Cortical activation and functional connectivity during the verbal fluency task for adolescent-onset depression: A multi-channel NIRS study.

Liu X, Cheng F, Hu S, Wang B, Hu C, Zhu Z, Zhuang W, Mei X, Li X, Zhou Q, Zhang W, Tang Y, Zhou D.

J Psychiatr Res. 2022 Mar;147:254-261.
doi: 10.1016/j.jpsychires.2022.01.040. Epub 2022 Jan 19.

OBJECTIVE: Depression disorder is accompanied by cognitive impairments. However, there is limited research focused on cognitive impairments and their neurological mechanism in adolescents with depression. The purpose of the current study is to illustrate the differences in brain activity patterns between depressed adolescents and healthy controls (HCs). METHOD: A total of 72 adolescents with depression, as well as 74HCs, were recruited. We utilized functional near-infrared spectroscopy (fNIRS) to monitor the concentrations of oxyhemoglobin (Oxy-Hb) in the brains of participants while they performed the verbal fluency task (VFT) to examine cognitive impairment in adolescents with depression. RESULTS: Our study demonstrated that adolescents with depression had significantly less cortical activation in the hemodynamic responses of Oxy-Hb at channels mainly located in the prefrontal cortex (PFC) than HCs during the 60-s task period (false discovery rate (FDR)-corrected $p<0.05$). The mean channel-to-channel connectivity was 0.400 for HCs (SD=0.149) and 0.303 (SD=0.138) for adolescents with depression, and the HC group had a higher mean channel-to-channel connectivity strength than the depression group ($t=-15.586$, $p<0.001$). For the patient group, we found significant negative correlations between HAMD scores and mean Oxy-Hb changes in Channel 38 ($r=-0.33$, $p<0.01$), Channel 39 ($r=-0.34$, $p<0.01$), Channel 41 ($r=-0.25$, $p<0.05$), Channel 42 ($r=-0.28$, $p<0.05$), and Channel 44 ($r=-0.27$, $p<0.05$), and these channels were mainly located in areas with little difference between groups. CONCLUSIONS: Our study provides neurological evidence about the executive function (EF) in depressed adolescents. Adolescents with depression exhibited an abnormal activation pattern and decreased task-related functional connectivity compared to HCs. The changed Oxy-Hb concentration of PFC during VFT was not sensitive to depression symptoms.

Functional Near-Infrared Spectroscopy as a Target Navigator for rTMS Modulation in Patients with Hemiplegia: A Randomized Control Study.

Chang PW, Lu CF, Chang ST, Tsai PY.

Neurol Ther. 2022 Mar;11(1):103-121.
doi: 10.1007/s40120-021-00300-0. Epub 2021 Nov 13.

INTRODUCTION: Although repetitive transcranial magnetic stimulation (rTMS) is efficacious for motor neuromodulation in stroke survivors, high interindividual variability for responsiveness remains a concern. Target probing on the skull using a proper brain-mapping technique may help overcome this challenge. This study assessed the feasibility of functional near-infrared spectroscopy (fNIRS) as a target navigator in rTMS treatment for motor facilitation in patients with stroke. METHODS: Fifty-one patients with stroke were enrolled in this randomized controlled study. The patients were assigned to three groups: fNIRS-guided rTMS treatment (fNIRS group, $n = 20$), motor evoked potential (MEP)-guided rTMS treatment (MEP group, $n = 16$), and sham ($n = 15$) group. Motor assessments, including Fugl-Meyer Assessment (FMA), Wolf Motor Function Test (WMFT), and muscle strength, were conducted at baseline and after the 10-session rTMS treatment. RESULTS: The fNIRS-guided hotspot (fNIRS-HS) was obtained for each patient, even those for whom the MEP-guided hotspot was undetectable. Both intervention groups exhibited significant improvements in muscle strength, FMA, and WMFT scores ($P < 0.001$) compared with the sham group. The fNIRS group achieved significantly greater improvement in elbow function ($P = 0.001$) than the MEP group. CONCLUSION: fNIRS can be a reliable tool for hotspot navigation for motor neuromodulation in patients with stroke. With high sensitivity to cortical oxygenation changes, this navigation system achieved a superior outcome to the traditional MEP-based method in patients with stroke. fNIRS-based systems may also facilitate the integration of machine learning, thus enabling precision medicine for neuromodulation. TRIAL REGISTRATION: https://clinicaltrials.gov ;

Unique identifier: NCT02006615.

Attention Control in Children With ADHD: An Investigation Using Functional Near Infrared Spectroscopy (fNIRS).

Calub CA, Rapport MD, Irurita C, Eckrich SJ, Bohil C.

Child Neuropsychol. 2022 Mar 13:1-25.
doi: 10.1080/09297049.2022.2047913. Online ahead of print.

Attention problems are a predominant contributor to near- and far-term functional outcomes in attention-deficit/hyperactivity disorder (ADHD); however, most interventions focus on improving the alerting attentional network, which has failed to translate into improved learning for a majority of children with ADHD. Comparatively less is known regarding the executive attentional network and its overarching attention control process, which governs the ability to maintain relevant information in a highly active, interference-free state, and is intrinsic to a broad range of cognitive functions. This is the first study to compare attention control abilities in children with ADHD and typically developing (TD) children using the Visual Array Task (VAT) and to simultaneously measure hemodynamic functioning (oxyHb) using functional Near-Infrared Spectroscopy (fNIRS). Nineteen children with ADHD Combined type and 18 typically developing (TD) children aged 8 to 12years were administered the VAT task while prefrontal activity was monitored using fNIRS. Results revealed that children with ADHD evinced large magnitude deficits in attention control and that oxyHb levels in the left dorsal lateral prefrontal cortex (dlPFC) were significantly greater in children with ADHD relative to TD children. These findings suggest that poor attention control abilities in children with ADHD may be related to increased left dlPFC activation in response to an underdeveloped and/or inefficient right dlPFC. The need to design interventions that target and strengthen attention control and its corresponding neural network is discussed based on the likelihood that attention control serves as the potential quaesitum for understanding a wide array of ADHD-related deficits.

The newborn brain is sensitive to the communicative function of language.

Forgcs B, Tauzin T, Gergely G, Gervain J.

Sci Rep. 2022 Jan 24;12(1):1220.
doi: 10.1038/s41598-022-05122-0.

Recent studies demonstrated neural systems in bilateral fronto-temporal brain areas in newborns specialized to extract linguistic structure from speech. We hypothesized that these mechanisms show additional sensitivity when identically structured different pseudowords are used communicatively in a turn-taking exchange by two speakers. In an fNIRS experiment newborns heard pseudowords sharing ABB repetition structure in three conditions: two voices turn-takingly exchanged different pseudowords (Communicative); the different pseudowords were produced by a (Single Speaker); two voices turn-takingly repeated identical pseudowords (Echoing). Here we show that left fronto-temporal regions (including Broca's area) responded more to the Communicative than the other conditions. The results demonstrate that newborns' left hemisphere brain areas show additional activation when various pseudowords sharing identical structure are exchanged in turn-taking alternation by two speakers. This indicates that language processing brain areas at birth are not only sensitive to the structure but to the functional use of language: communicative information transmission. Newborns appear to be equipped not only with innate systems to identify the structural properties of language but to identify its use, communication itself, that is, information exchange between third party social agents-even outside of the mother-infant dyad.

Training causes activation increase in temporo-parietal and parietal regions in children

with mathematical disabilities.

Soltanlou M, Dresler T, Artemenko C, Rosenbaum D, Ehlis AC, Nuerk HC.
Brain Struct Funct. 2022 Jun;227(5):1757-1771.
doi: 10.1007/s00429-022-02470-5. Epub 2022 Mar 7.

While arithmetic training reduces fronto-temporo-parietal activation related to domain-general processes in typically developing (TD) children, we know very little about the training-related neurocognitive changes in children with mathematical disabilities (MD), who seek evidenced-based educational interventions. In a within-participant design, a group of 20 children (age range = 10-15years old) with MD underwent 2 weeks of arithmetic training. Brain activation was measured using functional near-infrared spectroscopy (fNIRS) before and after training to assess training-related changes. Two weeks of training led to both behavioral and brain changes. Training-specific change for trained versus untrained (control) simple multiplication solving was observed as activation increase in the bilateral temporo-parietal region including angular gyrus and middle temporal gyrus. Training-specific change for trained versus untrained (control) complex multiplication solving was observed as activation increase in the bilateral parietal region including intraparietal sulcus, superior parietal lobule, and supramarginal gyrus. Unlike the findings of a similar study in TD children, 2 weeks of multiplication training led to brain activation increase in the fronto-parietal network in children with MD. Interestingly, these brain activation differences between the current findings and a recent similar study in TD children underlie a rather similar behavioral improvement as regards response time and accuracy after 2 weeks of training. This finding provides valuable insights into underlying mechanisms of mathematics learning in special samples and suggests that the findings in TD children may not be readily generalized to children with MD.

Brain-based measures of nociception during general anesthesia with remifentanil: A randomized controlled trial.

Karunakaran KD, Kussman BD, Peng K, Becerra L, Labadie R, Bernier R, Berry D, Green S, Zurakowski D, Alexander ME, Borsook D.
PLoS Med. 2022 Apr 22;19(4):e1003965.
doi: 10.1371/journal.pmed.1003965. eCollection 2022 Apr.

BACKGROUND: Catheter radiofrequency (RF) ablation for cardiac arrhythmias is a painful procedure. Prior work using functional near-infrared spectroscopy (fNIRS) in patients under general anesthesia has indicated that ablation results in activity in pain-related cortical regions, presumably due to inadequate blockade of afferent nociceptors originating within the cardiac system. Having an objective brain-based measure for nociception and analgesia may in the future allow for enhanced analgesic control during surgical procedures. Hence, the primary aim of this study is to demonstrate that the administration of remifentanil, an opioid widely used during surgery, can attenuate the fNIRS cortical responses to cardiac ablation. METHODS AND FINDINGS: We investigated the effects of continuous remifentanil on cortical hemodynamics during cardiac ablation under anesthesia. In a randomized, double-blinded, placebo (PL)-controlled trial, we examined 32 pediatric patients (mean age of 15.8 years,16 females) undergoing catheter ablation for cardiac arrhythmias at the Cardiology Department of Boston Children's Hospital from October 2016 to March 2020; 9 received 0.9% NaCl, 12 received low-dose (LD) remifentanil (0.25 mcg/kg/min), and 11 received high-dose (HD) remifentanil (0.5 mcg/kg/min). The hemodynamic changes of primary somatosensory and prefrontal cortices were recorded during surgery using a continuous wave fNIRS system. The primary outcome measures were the changes in oxyhemoglobin concentration (NadirHbO, i.e., lowest oxyhemoglobin concentration and PeakHbO, i.e., peak change and area under the curve) of medial frontopolar cortex (mFPC), lateral prefrontal cortex (lPFC) and primary somatosensory cortex (S1) to ablation in PL versus remifentanil groups. Secondary measures included the fNIRS response to an auditory control condition. The data analysis was performed on an intention-to-treat (ITT) basis. Remifentanil group (dosage subgroups combined) was compared with PL, and a post hoc analysis was performed to identify dose effects. There were no adverse events. The groups were comparable in age, sex, and number

of ablations. Results comparing remifentanil versus PL show that PL group exhibit greater NadirHbO in inferior mFPC (mean difference (MD) = 1.229, 95% confidence interval [CI] = 0.334, 2.124, p < 0.001) and superior mFPC (MD = 1.206, 95% CI = 0.303, 2.109, p = 0.001) and greater PeakHbO in inferior mFPC (MD = -1.138, 95% CI = -2.062, -0.214, p = 0.002) and superior mFPC (MD = -0.999, 95% CI = -1.961, -0.036, p = 0.008) in response to ablation. S1 activation from ablation was greatest in PL, then LD, and HD groups, but failed to reach significance, whereas lPFC activation to ablation was similar in all groups. Ablation versus auditory stimuli resulted in higher PeakHbO in inferior mFPC (MD = 0.053, 95% CI = 0.004, 0.101, p = 0.004) and superior mFPC (MD = 0.052, 95% CI = 0.013, 0.091, p < 0.001) and higher NadirHbO in posterior superior S1 (Pos. SS1; MD = -0.342, 95% CI = -0.680, -0.004, p = 0.007) during ablation of all patients. Remifentanil group had smaller NadirHbO in inferior mFPC (MD = 0.098, 95% CI = 0.009, 0.130, p = 0.003) and superior mFPC (MD = 0.096, 95% CI = 0.008, 0.116, p = 0.003) and smaller PeakHbO in superior mFPC (MD = -0.092, 95% CI = -0.680, -0.004, p = 0.007) during both the stimuli. Study limitations were small sample size, motion from surgery, indirect measure of nociception, and shallow penetration depth of fNIRS only allowing access to superficial cortical layers. CONCLUSIONS: We observed cortical activity related to nociception during cardiac ablation under general anesthesia with remifentanil. It highlights the potential of fNIRS to provide an objective pain measure in unconscious patients, where cortical-based measures may be more accurate than current evaluation methods. Future research may expand on this application to produce a real-time indication of pain that will aid clinicians in providing immediate and adequate pain treatment. TRIAL REGISTRATION: ClinicalTrials.gov NCT02703090.

Real-time recognition of different imagined actions on the same side of a single limb based on the fNIRS correlation coefficient.

Fu Y, Wang F, Li Y, Gong A, Qian Q, Su L, Zhao L.

Biomed Tech (Berl). 2022 Apr 14.
doi: 10.1515/bmt-2021-0422. Online ahead of print.

Functional near-infrared spectroscopy (fNIRS) is a type of functional brain imaging. Brain-computer interfaces (BCIs) based on fNIRS have recently been implemented. Most existing fNIRS-BCI studies have involved off-line analyses, but few studies used online performance testing. Furthermore, existing online fNIRS-BCI experimental paradigms have not yet carried out studies using different imagined movements of the same side of a single limb. In the present study, a real-time fNIRS-BCI system was constructed to identify two imagined movements of the same side of a single limb (right forearm and right hand). Ten healthy subjects were recruited and fNIRS signal was collected and real-time analyzed with two imagined movements (leftward movement involving the right forearm and right-hand clenching). In addition to the mean and slope features of fNIRS signals, the correlation coefficient between fNIRS signals induced by different imagined actions was extracted. A support vector machine (SVM) was used to classify the imagined actions. The average accuracy of real-time classification of the two imagined movements was 72.250.004%. The findings suggest that different imagined movements on the same side of a single limb can be recognized real-time based on fNIRS, which may help to further guide the practical application of online fNIRS-BCIs.

Reduced parietal activation in participants with mild cognitive impairments during visual-spatial processing measured with functional near-infrared spectroscopy.

Haberstumpf S, Seidel A, Lauer M, Polak T, Deckert J, Herrmann MJ.

J Psychiatr Res. 2022 Feb;146:31-42.
doi: 10.1016/j.jpsychires.2021.12.021. Epub 2021 Dec 15.

Functional Near Infrared Spectroscopy (fNIRS) may be a suitable, simple, and cost-effective brain imag-

ing technique for detecting divergent neuronal patterns at an early stage of neurodegeneration. In course of Mild Cognitive Impairment (MCI) or Alzheimer's disease (AD), a deficit in visual-spatial processing, located in the parietal cortex, is a reliable risk factor. Earlier, we established the application of the clock-hand-angle-discrimination task (ADT) during fNIRS to identify neuronal correlates of the visual-spatial processing in a healthy elderly sample. In this analysis, we aimed to measure and find out differences in the hemodynamic response in MCI participants compared to matched healthy controls. As expected, MCI participants showed more errors over all conditions of pointer length and a higher reaction time in the long and middle pointer length condition. Moreover, results revealed a significant reduction of cortical activation in MCI patients. There was a generally increased activity in both the right as compared to the left hemisphere and the superior parietal brain region as compared to the inferior parietal brain region in both groups. In summary, fNIRS can be implemented in the measurement of visual-spatial processing in MCI patients and healthy elderly based on ADT. MCI participants had difficulties to cope with the ADT. Since neuronal hypoactivity occurs with concomitant behavioral deficits, an additional analysis was performed on a subgroup of MCI patients who performed as well as the control group in behavior. This subgroup analysis also showed a hypoactivation of the parietal cortex, without evidence of a compensatory activation. Therefore, we assume that MCI patients are characterized by a deficit in the parietal cortex. Overall, these findings confirm our hypothesis that hemodynamic deficits in visual-spatial processing, localized in the parietal cortex, are reliable and early diagnostic markers for cognitive decline in risk groups for the development of AD.

To snack or not to snack: Using fNIRS to link inhibitory control to functional connectivity in the toddler brain.

Kerr-German A, Namuth A, Santosa H, Buss AT, White S.

Dev Sci. 2022 Jan 10:e13229.
doi: 10.1111/desc.13229. Online ahead of print.

Inhibitory control (IC) emerges in infancy, continues to develop throughout childhood and is linked to later life outcomes such as school achievement, prosocial behavior, and psychopathology. Little, however, is known about the neural processes underpinning IC, especially in 2-year-olds. In this study, we examine functional connectivity (FC) in 2.5-year-olds while recording hemodynamic responses via functional infrared spectroscopy (fNIRS) during a traditional snack delay task. We found that functional connectivity strength between left frontal and parietal cortex and bilateral parietal cortex were positively associated with performance on this task. The current findings present the first neural data for toddlers during this IC task. Further, these data are the first to link this self-regulatory process to differences in brain development within this population. Implications for future directions and work with clinical populations are discussed.

Neural mechanisms of the mood effects on third-party responses to injustice after unfair experiences.

Xie E, Liu M, Liu J, Gao X, Li X.

Hum Brain Mapp. 2022 Apr 15.
doi: 10.1002/hbm.25874. Online ahead of print.

Behavioral decision theory argues that humans can adjust their third-party responses (e.g., punishment and compensation) to injustice by integrating unfair experiences. Typically, the mood plays an important role in such a decision-making process. However, the underlying neurocognitive bases remain largely unclear. We first employ a modified third-party justice game in which an allocator split an amount of money between oneself and a receiver. The participants can reapportion the money as observers by choosing from the following three costly options: compensate the receiver, accept the current allocation, or punish the allocator. Then, a second-party pseudo interaction is conducted where participants receive

more (i.e., advantageous unfair experience) or less (i.e., disadvantageous unfair experience) than others. Finally, participants perform the third-party justice game again after unfair experiences. Here, we use functional near-infrared spectroscopy (fNIRS) to measure participants' brain activities during third-party responses to injustice. We find participants compensate more to the receiver after advantageous unfair experience, which involved enhanced positive emotion, weakened sense of unfairness, and is linked with increased activity in the right dorsolateral prefrontal cortex (rDLPFC). In contrast, participants punish more on the allocator after disadvantageous unfair experience, which might primarily stem from their negative emotional responses, strong sense of unfairness, and is associated with significantly decreased activity in the rDLPFC. Our results suggest that third-party compensation and punishment involved differential psychological and neural bases. Our findings highlight the crucial roles of second-party unfair experiences and the corresponding mood responses in third-party responses to unfairness, and unravel the intermediate neural architecture.

Acute Aerobic Exercise-Induced Motor Priming Improves Piano Performance and Alters Motor Cortex Activation.

Moriarty T, Johnson A, Thomas M, Evers C, Auten A, Cavey K, Dorman K, Bourbeau K.
Front Psychol. 2022 Mar 18;13:825322.
doi: 10.3389/fpsyg.2022.825322. eCollection 2022.

Acute aerobic exercise has been shown to improve fine motor skills and alter activation of the motor cortex (M1). The intensity of exercise may influence M1 activation, and further impact whole-body motor skill performance. The aims of the current study were to compare a whole-body motor skill via a piano task following moderate-intensity training (MIT) and high-intensity interval training (HIIT), and to determine if M1 activation is linked to any such changes in performance. Nine subjects (seven females and two males), aged 18 1 years completed a control, MIT, and HIIT trial followed by administration of a piano performance task. M1 activation was evaluated by measuring oxyhemoglobin (O2Hb) and hemoglobin difference (Hbdiff) changes during post-exercise piano performance using functional near-infrared spectroscopy (fNIRS). The results indicate that piano performance scores were higher after the MIT trial, but not HIIT trial, compared to the control trial. A negative relationship was detected between heart rate during HIIT and post-HIIT piano scores. M1 activation (as measured by Hbdiff) was significantly increased after the HIIT trial. M1 activation was also positively associated with piano performance when exercise trials (HIIT + MIT) and all trials (HIIT + MIT + Control) were combined. We found that acute moderate-intensity exercise led to an improvement in complex motor skill performance while higher-intensity exercise increased M1 activation. These results demonstrate that moderate-intensity exercise can prime the nervous system for the acquisition of whole-body motor skills, suggesting that similar exercise protocols may be effective in improving the outcomes of other motor tasks performed during regular routines of daily life (e.g., sporting tasks, activities of daily living or rehabilitation). In addition, it appears that improvements in motor task performance may be driven by M1 activation. Our findings provide new mechanistic insight into the complex relationship between exercise intensity, M1 activation, and whole-body motor skill performance.

An intensive exercise-based training program reduces prefrontal activity during usual walking in patients with Parkinson's disease.

Hoang I, Ranchet M, Cheminon M, Derollepot R, Devos H, Perrey S, Luaut J, Danaila T, Paire-Ficout L.
Clin Park Relat Disord. 2021 Dec 16;6:100128.
doi: 10.1016/j.prdoa.2021.100128. eCollection 2022.

INTRODUCTION: Parkinson's disease (PD) leads to a progressive loss of locomotor automaticity. Consequently, PD patients rely more on executive resources for the control of gait, resulting in increased prefrontal activity while walking. Exercise-based training programs may improve automaticity of walking

and reduce prefrontal activity in this population. This study aimed to assess the effect of an intensive multidisciplinary exercise-based training program on prefrontal activity and gait performance during usual walking in PD patients. METHOD: Fourteen patients (mean age: 679; disease duration: 65years; Hoehn and Yahr score: 1.90.6) were included in this study. They were assessed in ON stage at three different times at 5-week intervals: two times before the training program (T0 and T1) and once after the training program (T2). Gait performance (stride time, speed, stride length, cadence, and their respective coefficient of variation) and cortical activity in the dorsolateral prefrontal cortex (DLPFC) using functional near infrared spectroscopy (fNIRS) were measured during usual walking. RESULTS: Patients had reduced cortical activity of the DLPFC at T2 compared to T1 (p=0.003). Patients had shorter stride time at T2 compared to T1 (p=0.025) and tended to have longer stride length at T2 than at T1 (p=0.056). CONCLUSION: The training program led to positive effects on prefrontal activity and gait performance. Reduced prefrontal activity during usual walking after training program suggests that patients may have a greater reserve capacity to face more challenging walking conditions. Further studies will investigate the effect of this training on cortical activity during dual-task walking..

Neurophysiological and behavioral effects of multisession prefrontal tDCS and concurrent cognitive remediation training in patients with autism spectrum disorder (ASD): A double-blind, randomized controlled fNIRS study.

Han YMY, Chan MMY, Shea CKS, Lai OL, Krishnamurthy K, Cheung MC, Chan AS.

Brain Stimul. 2022 Mar-Apr;15(2):414-425.
doi: 10.1016/j.brs.2022.02.004. Epub 2022 Feb 15.

BACKGROUND: The clinical effects and neurophysiological mechanisms of prefrontal tDCS and concurrent cognitive remediation training in individuals with autism spectrum disorder (ASD) remain unclear. OBJECTIVE: This two-armed, double-blind, randomized, sham-controlled trial aimed to investigate the beneficial effects of tDCS combined with concurrent cognitive remediation training on adolescents and young adults with ASD. METHODS: Participants were randomly assigned to either active or sham tDCS groups and received 1.5mA prefrontal tDCS with left dorsolateral prefrontal cortex (dlPFC) cathode placement and right supraorbital region anode placement for 20minutes over two consecutive weeks. tDCS was delivered concurrently with a computerized cognitive remediation training program. Social functioning and its underlying cognitive processes, as well as prefrontal resting-state functional connectivity (rsFC), were measured. RESULTS: The results from 41 participants indicated that multisession prefrontal tDCS, compared to sham tDCS, significantly enhanced the social functioning of ASD individuals [F(1,39)=4.75, p=.035, ?p2=0.11]. This improvement was associated with enhanced emotion recognition [F(1,39)=8.34, p=.006, ?p2=0.18] and cognitive flexibility [F(1,39)=4.91, p=.033, ?p2=0.11]. Specifically, this tDCS protocol optimized information processing efficiency [F(1,39)=4.43, p=.042, ?p2=0.10], and the optimization showed a trend to be associated with enhanced rsFC in the right medial prefrontal cortex (?=0.339, pFDR=.083). CONCLUSION: Multisession tDCS with left dlPFC cathode placement and right supraorbital region anode placement paired with concurrent cognitive remediation training promoted social functioning in individuals with ASD. This appeared to be associated with the enhancement of the functional connectivity of the right medial PFC, a major hub for flexible social information processing, allowing these individuals to process information more efficiently in response to different social situations. TRIAL REGISTRATION: ClinicalTrials.gov (ID: NCT03814083).

Brain-Computer Interface-Robot Training Enhances Upper Extremity Performance and Changes the Cortical Activation in Stroke Patients: A Functional Near-Infrared Spectroscopy Study.

Liu L, Jin M, Zhang L, Zhang Q, Hu D, Jin L, Nie Z.

Front Neurosci. 2022 Apr 8;16:809657.
doi: 10.3389/fnins.2022.809657. eCollection 2022.

INTRODUCTION: We evaluated the efficacy of brain-computer interface (BCI) training to explore the hypothesized beneficial effects of physiotherapy alone in chronic stroke patients with moderate or severe paresis. We also focused on the neuroplastic changes in the primary motor cortex (M1) after BCI training. METHODS: In this study, 18 hospitalized chronic stroke patients with moderate or severe motor deficits participated. Patients were operated on for 20 sessions and followed up after 1 month. Functional assessments were performed at five points, namely, pre1-, pre2-, mid-, post-training, and 1-month follow-up. Wolf Motor Function Test (WMFT) was used as the primary outcome measure, while Fugl-Meyer Assessment (FMA), its wrist and hand (FMA-WH) sub-score and its shoulder and elbow (FMA-SE) sub-score served as secondary outcome measures. Neuroplastic changes were measured by functional near-infrared spectroscopy (fNIRS) at baseline and after 20 sessions of BCI training. Pearson correlation analysis was used to evaluate functional connectivity (FC) across time points. RESULTS: Compared to the baseline, better functional outcome was observed after BCI training and 1-month follow-up, including a significantly higher probability of achieving a clinically relevant increase in the WMFT full score (?WMFT score = 12.39 points, $F = 30.28$, and $P < 0.001$), WMFT completion time (?WMFT time = 248.39 s, $F = 16.83$, and $P < 0.001$), and FMA full score (?FMA-UE = 12.72 points, $F = 106.07$, and $P < 0.001$), FMA-WH sub-score (?FMA-WH = 5.6 points, $F = 35.53$, and $P < 0.001$), and FMA-SE sub-score (?FMA-SE = 8.06 points, $F = 22.38$, and $P < 0.001$). Compared to the baseline, after BCI training the FC between the ipsilateral M1 and the contralateral M1 was increased ($P < 0.05$), which was the same as the FC between the ipsilateral M1 and the ipsilateral frontal lobe, and the FC between the contralateral M1 and the contralateral frontal lobe was also increased ($P < 0.05$). CONCLUSION: The findings demonstrate that BCI-based rehabilitation could be an effective intervention for the motor performance of patients after stroke with moderate or severe upper limb paresis and represents a potential strategy in stroke neurorehabilitation. Our results suggest that FC between ipsilesional M1 and frontal cortex might be enhanced after BCI training. CLINICAL TRIAL REGISTRATION: www.chictr.org.cn, identifier: ChiCTR2100046301.

Improving the diagnostic accuracy for major depressive disorder using machine learning algorithms integrating clinical and near-infrared spectroscopy data.

Ho CS, Chan YL, Tan TW, Tay GW, Tang TB.

J Psychiatr Res. 2022 Mar;147:194-202.
doi: 10.1016/j.jpsychires.2022.01.026. Epub 2022 Jan 12.

BACKGROUND: Given that major depressive disorder (MDD) is both biologically and clinically heterogeneous, a diagnostic system integrating neurobiological markers and clinical characteristics would allow for better diagnostic accuracy and, consequently, treatment efficacy. OBJECTIVE: Our study aimed to evaluate the discriminative and predictive ability of unimodal, bimodal, and multimodal approaches in a total of seven machine learning (ML) models-clinical, demographic, functional near-infrared spectroscopy (fNIRS), combinations of two unimodal models, as well as a combination of all three-for MDD. METHODS: We recruited 65 adults with MDD and 68 matched healthy controls, who provided both sociodemographic and clinical information, and completed the HAM-D questionnaire. They were also subject to fNIRS measurement when participating in the verbal fluency task. Using the nested cross validation procedure, the classification performance of each ML model was evaluated based on the area under the receiver operating characteristic curve (ROC), balanced accuracy, sensitivity, and specificity. RESULTS: The multimodal ML model was able to distinguish between depressed patients and healthy controls with the highest balanced accuracy of 87.988.84% (AUC=0.92; 95% CI (0.84-0.99) when compared with the uni- and bi-modal models. CONCLUSIONS: Our multimodal ML model demonstrated the highest diagnostic accuracy for MDD. This reinforces the biological and clinical heterogeneity of MDD and highlights the potential of this model to improve MDD diagnosis rates. Furthermore, this model is cost-effective and clinically applicable

enough to be established as a robust diagnostic system for MDD based on patients' biosignatures.

Functional Connectivity Analysis and Detection of Mental Fatigue Induced by Different Tasks Using Functional Near-Infrared Spectroscopy.

Peng Y, Li C, Chen Q, Zhu Y, Sun L.

Front Neurosci. 2022 Mar 15;15:771056.
doi: 10.3389/fnins.2021.771056. eCollection 2021.

OBJECTIVES: The objective of this study was to investigate common functional near-infrared spectroscopy (fNIRS) features of mental fatigue induced by different tasks. In addition to distinguishing fatigue from non-fatigue state, the early signs of fatigue were also studied so as to give an early warning of fatigue. METHODS: fNIRS data from 36 participants were used to investigate the common character of functional connectivity network corresponding to mental fatigue, which was induced by psychomotor vigilance test (PVT), cognitive work, or simulated driving. To analyze the network reorganizations quantitatively, clustering coefficient, characteristic path length, and small worldness were calculated in five sub-bands (0.6-2.0, 0.145-0.600, 0.052-0.145, 0.021-0.052, and 0.005-0.021 Hz). Moreover, we applied a random forest method to classify three fatigue states. RESULTS: In a moderate fatigue state: the functional connectivity strength between brain regions increased overall in 0.021-0.052 Hz, and an asymmetrical pattern of connectivity (right hemisphere > left hemisphere) was presented. In 0.052-0.145 Hz, the connectivity strength decreased overall, the clustering coefficient decreased, and the characteristic path length increased significantly. In severe fatigue state: in 0.021-0.052 Hz, the brain network began to deviate from a small-world pattern. The classification accuracy of fatigue and non-fatigue was 85.4%. The classification accuracy of moderate fatigue and severe fatigue was 82.8%. CONCLUSION: The preliminary research demonstrates the feasibility of detecting mental fatigue induced by different tasks, by applying the functional network features of cerebral hemoglobin signal. This universal and robust method has the potential to detect early signs of mental fatigue and prevent relative human error in various working environments.

Phonetic versus spatial processes during motor-oriented imitations of visuo-labial and visuo-lingual speech: A functional near-infrared spectroscopy study.

Zhao T, Hu A, Su R, Lyu C, Wang L, Yan N.

Eur J Neurosci. 2022 Jan;55(1):154-174.
doi: 10.1111/ejn.15550. Epub 2021 Dec 23.

While a large amount of research has studied the facilitation of visual speech on auditory speech recognition, few have investigated the processing of visual speech gestures in motor-oriented tasks that focus on the spatial and motor features of the articulator actions instead of the phonetic features of auditory and visual speech. The current study examined the engagement of spatial and phonetic processing of visual speech in a motor-oriented speech imitation task. Functional near-infrared spectroscopy (fNIRS) was used to measure the haemodynamic activities related to spatial processing and audiovisual integration in the superior parietal lobe (SPL) and the posterior superior/middle temporal gyrus (pSTG/pMTG) respectively. In addition, visuo-labial and visuo-lingual speech were compared with examine the influence of visual familiarity and audiovisual association on the processes in question. fNIRS revealed significant activations in the SPL but found no supra-additive audiovisual activations in the pSTG/pMTG, suggesting that the processing of audiovisual speech stimuli was primarily focused on spatial processes related to action comprehension and preparation, whereas phonetic processes related to audiovisual integration was minimal. Comparisons between visuo-labial and visuo-lingual speech imitations revealed no significant difference in the activation of the SPL or the pSTG/pMTG, suggesting that a higher degree of visual familiarity and audiovisual association did not significantly influence how visuo-labial speech was processed compared with visuo-lingual speech. The current study offered insights on the pattern of visual-speech processing under

a motor-oriented task objective and provided further evidence for the modulation of multimodal speech integration by voluntary selective attention and task objective.

Detecting concealed information using functional near-infrared spectroscopy (fNIRS) combined with skin conductance, heart rate, and behavioral measures.

Wang D, Wang C, Yi X, Sai L, Fu G, Lin XA.

Psychophysiology. 2022 Feb 22:e14029.
doi: 10.1111/psyp.14029. Online ahead of print.

In this study, brain imaging data from functional near-infrared spectroscopy (fNIRS) associated with skin conductance response (SCR), heart rate (HR), and reaction time (RT) were combined to determine if the combination of these indicators could improve the efficiency of deception detection in concealed information test (CIT). During the CIT, participants were presented with a series of names and cities that served as target, probe, or irrelevant stimuli. In the guilty group, the probe stimuli were the participants' own names and hometown cities, and they were asked to deny this information. Our results revealed that probe items were associated with longer RT, larger SCR, slower HR, and higher oxyhemoglobin (HbO) concentration changes in the inferior prefrontal gyrus (IFG), middle frontal gyrus (MFG), and the superior frontal gyrus (SFG) compared with irrelevant items for participants in the guilty group but not in the innocent group. Furthermore, our results suggested that the combination of RT, SCR, HR, and fNIRS indicators could improve the deception detection efficiency to a very high area under the ROC curve (0.94) compared with any of the single indicators (0.74-0.89). The improved deception detection efficiency might be attributed to the reduction of random error and the diversiform underlying the psychophysiological mechanisms reflected by each indicator. These findings demonstrate a feasible way to improve the deception detection efficiency by using combined multiple indicators.

The hyper-brain neural couplings distinguishing high-creative group dynamics: an fNIRS hyperscanning study.

Lu K, Gao Z, Wang X, Qiao X, He Y, Zhang Y, Hao N.

Cereb Cortex. 2022 Apr 19:bhac161.
doi: 10.1093/cercor/bhac161. Online ahead of print.

This hyperscanning study aimed to identify a neural coupling profile that distinguishes high-creative group dynamics through functional near infrared spectroscopy. A total of 123 dyads completed one creativity task (alternative uses task, AUT) and contrast task (objective characteristics task). A K-means clustering analysis on AUT performance grouped 31/29 dyads into high/low-creative group, respectively. In comparison with the low-creative group, the high-creative group showed: (i) higher collective flexibility and delayed perspective-taking behaviors, but lower immediate perspective-taking behaviors; (ii) enhanced interpersonal brain synchronization (IBS) between the left inferior frontal gyrus (lIFG) and right motor cortex, and nodal Eloc at the right superior temporal gyrus (rSTG); (iii) declined intrapersonal functional connectivity between the right angular gyrus (rAG) and rSTG, and IBS between the lIFG and rAG. The enhanced neural couplings positively correlated with group creative performance, whereas a reverse correlation pattern existed in the declined ones. A leave-one-out cross-validation analysis showed these neural couplings reliably predicted group creative performance within the sample. These indicate that high-creative group dynamics are characterized by utilizing partners' shared information when necessary (e.g. encountering idea exhaustion). A neural coupling profile consisting of sophisticated interplays between regions within frontal, temporal, and parietal lobes may underlie high-creative creative dynamics.

Distinct Contributions of Genes and Environment to Visual Size Illusion and the Underlying Neural Mechanism.

Chen L, Xu Q, Shen L, Yuan T, Wang Y, Zhou W, Jiang Y.

Cereb Cortex. 2022 Feb 19;32(5):1014-1023.
doi: 10.1093/cercor/bhab262.

As exemplified by the Ebbinghaus illusion, the perceived size of an object can be significantly biased by its surrounding context. The phenomenon is experienced by humans as well as other species, hence likely evolutionarily adaptive. Here, we examined the heritability of the Ebbinghaus illusion using a combination of the classic twin method and multichannel functional near-infrared spectroscopy. Results show that genes account for over 50% of the variance in the strength of the experienced illusion. Interestingly, activations evoked by the Ebbinghaus stimuli in the early visual cortex are explained by genetic factors whereas those in the posterior temporal cortex are explained by environmental factors. In parallel, the feedforward functional connectivity between the occipital cortex and the temporal cortex is modulated by genetic effects whereas the feedback functional connectivity is entirely shaped by environment, despite both being significantly correlated with the strength of the experienced illusion. These findings demonstrate that genetic and environmental factors work in tandem to shape the context-dependent visual size illusion, and shed new light on the links among genes, environment, brain, and subjective experience.

Characteristics of frontal activity relevant to cognitive function in bipolar depression: an fNIRS study.

Gao C, Zhou H, Liu J, Xiu J, Huang Q, Liang Y, Li T, Hu S.

Biomed Opt Express. 2022 Feb 16;13(3):1551-1563.
doi: 10.1364/BOE.448244. eCollection 2022 Mar 1.

Memory shortness, verbal influence, and disturbed attention are a few of the cognitive dysfunctions reported by individuals of bipolar disorder in depression phase (BD-D). As neuroimaging modalities can investigate such responses, therefore neuroimaging methods can be used to assist the diagnosis of bipolar disorder (BD). Functional near-infrared spectroscopy (fNIRS) is a neural imaging method that is proved to be prominent in the diagnosis of psychiatric disorders. It is the desired method because of its feasible setup, high resolution in time, and its partial resistance to head movements. This study aims to investigate the brain activity in subjects of BD-D during cognitive tasks compared to the healthy controls. A decreased activation level is expected in individuals of BD-D as compared to the healthy controls. This study aims to find new methods and experimental paradigms to assist in the diagnosis of bipolar depression. Participants of BD-D and healthy controls (HC) performed four cognitive tasks including verbal fluency task (VFT), symbol working memory task (symbol check), attention task (spotter) and multiple cognitive task (code break). fNIRS was used to measure levels of oxy-hemoglobin (HbO) representing the brain activity. The generalized linear model (GLM) method was used to estimate the hemodynamic response related to the task. The wavelet transform coherence (WTC) method was used to calculate the intra-hemispheric functional connectivity. We also analyzed the correlation between hemodynamic response and scores of psychiatric disorders. Results showed decreased levels of HbO in BD-D groups compared to the HC, indicating lower activity, during the tasks except for spotter. The difference between BD-D and HC was significant during VFT, symbol check and code break. Group difference during symbol working memory was significant both in brain activity and connectivity. Meanwhile, the individual brain activity during working memory is more related to the illness degree. Lower activity in BD-D reflects unspecific dysfunctions. Compared with other cognitive tasks, the single-trial symbol-check task may be more suitable to help the diagnosis of bipolar depression.

Protocol for a prospective open-label clinical trial to investigate the utility of concur-

rent TBS/fNIRS for antidepressant treatment optimisation.

Kan RLD, Mak ADP, Chan SKW, Zhang BBB, Fong KNK, Kranz GS.

BMJ Open. 2022 Feb 10;12(2):e053896.
doi: 10.1136/bmjopen-2021-053896.

INTRODUCTION: Repetitive transcranial magnetic stimulation (rTMS) with theta burst stimulation (i.e. TBS) of the dorsolateral prefrontal cortex (DLPFC) is an innovative treatment for major depressive disorder (MDD). However, fewer than 50% of patients show sufficient response to this treatment; markers for response prediction are urgently needed. Research shows considerable individual variability in the brain responses to rTMS. However, whether differences in individual DLPFC modulation by rTMS can be used as a predictive marker for treatment response remains to be investigated. Here, we present a research programme that will exploit the combination of functional near-infrared spectroscopy (fNIRS) with brain stimulation. Concurrent TBS/fNIRS will allow us to systematically investigate TBS-induced modulation of blood oxygenation as a proxy for induced brain activity changes. The findings from this study will (1) elucidate the immediate effects of excitatory and inhibitory TBS on prefrontal activity in TBS treatment-nave patients with MDD and (2) validate the potential utility of TBS-induced brain modulation at baseline for the prediction of antidepressant response to 4 weeks of daily TBS treatment. METHODS AND ANALYSIS: Open-label, parallel-group experiment consisting of two parts. In part 1, 70 patients and 37 healthy controls will be subjected to concurrent TBS/fNIRS. Intermittent TBS (iTBS) and continuous TBS (cTBS) will be applied on the left and right DLPFC, respectively. fNIRS data will be acquired before, during and several minutes after stimulation. In part 2, patients who participated in part 1 will receive a 4 week iTBS treatment of the left DLPFC, performed daily for 5 days per week. Psychometric evaluation will be performed periodically and at 1 month treatment follow-up. Statistical analysis will include a conventional, as well as a machine learning approach. ETHICS AND DISSEMINATION: Ethics approval was obtained from the Institutional Review Board. Findings will be disseminated through scientific journals, conferences and university courses. TRIAL REGISTRATION NUMBER: NCT04526002.

Distinct Neural Couplings to Shared Goal and Action Coordination in Joint Action: Evidence Based on fNIRS Hyperscanning.

Cheng X, Guo B, Hu Y.

Soc Cogn Affect Neurosci. 2022 Mar 24:nsac022.
doi: 10.1093/scan/nsac022. Online ahead of print.

Joint action is central to human nature, enabling individuals to coordinate in time and space to achieve a joint outcome. Such interaction typically involves two key elements: shared goal and action coordination. Yet the substrates entrained to these two components in joint action remained unclear. In the current study, dyads performed two tasks involving both sharing goal and action coordination, i.e., complementary joint action and imitative joint action, a task only involving shared goal, and a task only involving action coordination, while their brain activities recorded by the functional near-infrared spectroscopy (fNIRS) hyperscanning technique. The results showed that both complementary and imitative joint action (i.e., involving shared goal and action coordination) elicited better behavioral performance than the task only involving shared goal/action coordination. We observed that the inter-brain synchronization (IBS) at the right inferior frontal cortex (IFC) entrained more to shared goal, while left-IFC IBS entrained more to action coordination. We also observed that the right-IFC IBS was greater during completing a complementary action than an imitative action. Our results suggest that IFC plays an important role in joint action, with distinct lateralization for sub-components of joint action.

Systemic physiology augmented functional near-infrared spectroscopy hyperscanning: a first evaluation investigating entrainment of spontaneous activity of brain and body

physiology between subjects.

Guglielmini S, Bopp G, Marcar VL, Scholkmann F, Wolf M.

Neurophotonics. 2022 Apr;9(2):026601.
doi: 10.1117/1.NPh.9.2.026601. Epub 2022 Apr 18.

Significance: Functional near-infrared spectroscopy (fNIRS) enables measuring the brain activity of two subjects while they interact, i.e., the hyperscanning approach. Aim: In our exploratory study, we extended classical fNIRS hyperscanning by adding systemic physiological measures to obtain systemic physiology augmented fNIRS (SPA-fNIRS) hyperscanning while blocking and not blocking the visual communication between the subjects. This approach enables access brain-to-brain, brain-to-body, and body-to-body coupling between the subjects simultaneously. Approach: Twenty-four pairs of subjects participated in the experiment. The paradigm consisted of two subjects that sat in front of each other and had their eyes closed for 10min, followed by a phase of 10min where they made eye contact. Brain and body activity was measured continuously by SPA-fNIRS. Results: Our study shows that making eye contact for a prolonged time causes significant changes in brain-to-brain, brain-to-body, and body-to-body coupling, indicating that eye contact is followed by entrainment of the physiology between subjects. Subjects that knew each other generally showed a larger trend to change between the two conditions. Conclusions: The main point of this study is to introduce a new framework to investigate brain-to-brain, body-to-body, and brain-to-body coupling through a simple social experimental paradigm. The study revealed that eye contact leads to significant synchronization of spontaneous activity of the brain and body physiology. Our study is the first that employed the SPA-fNIRS approach and showed its usefulness to investigate complex interpersonal physiological changes.

Association of executive function capacity with gait motor imagery ability and PFC activity: An fNIRS study.

Kotegawa K, Teramoto W.

Neurosci Lett. 2022 Jan 1;766:136350.
doi: 10.1016/j.neulet.2021.136350. Epub 2021 Nov 13.

Individual differences exist in gait motor imagery ability. However, little is known about the underlying neural mechanisms. We previously conducted a study using functional near-infrared spectroscopy (fNIRS), which showed that participants who overestimated mental walking times to a greater degree exhibited greater activation in the right prefrontal cortex (PFC). The PFC is implicated in executive functions (EFs), including working memory (WM). Thus, this study investigated whether individual differences in EF capacity are associated with gait motor imagery ability and PFC activity. Thirty volunteers participated (mean age: 21.71.8years) in the study. Their EF capacity was assessed by the Trail Making Test - Part B (TMT-B). We measured the accuracy of gait motor imagery and PFC activity during mental walking using fNIRS, while changing task difficulty by varying the path width. The results showed that the overestimation of mental walking time over actual walking time and right PFC activity increased with an increase in the TMT-B times. These results suggest that the EF capacity, including WM, is strongly associated with gait motor imagery ability and right PFC activity. The brain network that includes the right PFC may play an important role in the maintenance and manipulation of gait motor imagery.

Cognitive inhibition tasks interfere with dual-task walking and increase prefrontal cortical activity more than working memory tasks in young and older adultsi.

St George RJ, Jayakody O, Healey R, Breslin M, Hinder MR, Callisaya ML.

Gait Posture. 2022 Apr 26;95:186-191.
doi: 10.1016/j.gaitpost.2022.04.021. Online ahead of print.

BACKGROUND: Prior work suggests there may be greater reliance on executive function for walking

in older people. The pre-frontal cortex (PFC), which controls aspects of executive function, is known to be active during dual-task walking (DTW). However, there is debate on how PFC activity during DTW is impacted by ageing and the requirements of the cognitive task. RESEARCH QUESTION: Functional near infrared spectroscopy, was used to investigate how PFC activity during walking was affected by (i) healthy ageing; and (ii) dual-tasks that utilise inhibition or working memory aspects of executive function. METHODS: Young (n=26, 16 females, mean 20.9 years) and older (n=26, 16 females, mean 70.3 years) adults performed five conditions: normal walking; Reciting Alternate Letters of the alphabet (RAL, requiring cognitive inhibition and working memory) during standing and walking; and serial subtraction by threes (SS3, requiring working memory alone) during standing and walking. Walking speed, cognitive performance, the PFC haemodynamic response, and fear of falling ratings were analysed using linear mixed-effects modelling. RESULTS: Compared to quiet standing, PFC activity increased during normal walking for older adults but decreased for young adults ($p<0.01$). Across both groups, fear of falling contributed to higher PFC activity levels when walking ($p<0.01$). PFC activity increased during DTW, and this increase was greater when performing RAL compared to the SS3 task ($p<0.01$). Although the rate of correct responses was higher for RAL, walking speed reduced more with RAL than SS3 in the young group ($p=0.01$), and the rate of correct responses reduced more when walking with RAL than SS3 in the older group ($p<0.01$). SIGNIFICANCE: Older adults have increased levels of PFC activation during walking compared to younger adults and fear of falling is a cofounding factor. The interference between gait and a concurrent cognitive task is higher when the cognitive task requires inhibition.

Acute effects of mindfulness-based intervention on athlete cognitive function: An fNIRS investigation.

Zhu Y, Sun F, Li C, Huang J, Hu M, Wang K, He S, Wu J.

J Exerc Sci Fit. 2022 Apr;20(2):90-99.
doi: 10.1016/j.jesf.2022.01.003. Epub 2022 Jan 22.

BACKGROUND: Mindfulness-based intervention (MBI) as a psychological treatment is adopted in the sports field, but its effect during competition has not been explored. This study investigated the acute effect of a brief MBI on athletes' cognitive function after a 45-min, lab-based soccer protocol. METHODS: In a single-blind randomized counter-balanced crossover design, 17 male soccer players completed two main trials-an MBI trial and a control trial. The MBI trial was provided with a brief MBI after 45-min exercise; the control trial was instead assigned a travel-related audio to listen to at that time. In each main trial, cognitive function (i.e., Stroop task for inhibition; Corsi-block tapping task for working memory), salivary cortisol, blood lactate and mental fatigue were measured at baseline (pretest) and after the intervention (posttest). The cerebral oxygenation status was recorded using functional near-infrared spectroscopy during the cognitive function test. RESULTS: The brief MBI improved working memory performance in terms of both reaction time (pre vs. post, $P=0.02$, $d=0.71$) and accuracy (pre vs. post, $P=0.009$, $d=0.58$), supported by eliciting increased oxyhemoglobin concentration in the prefrontal cortex of the brain. Whereas a slightly better cognitive performance for MBI trial than control trial at posttest ($P=0.37$, $d=0.32$) accompanied by a lower oxyhemoglobin concentration. A lower mental fatigue level ($P=0.05$, $d=0.6$) and lower cortisol concentration ($P=0.04$, $d=0.65$) were observed in the MBI trial than in the control trial after the intervention at posttest. The decreased cortisol concentration correlated with increased inhibition performance in the MBI trial. CONCLUSION: The acute effect of MBI on athletes' mental fatigue and cortisol concentration was detected, and the beneficial effect on working memory was preliminarily supported. In general, MBI is recommended to be adopted at half-time of a soccer game.

Subdividing Stress Groups into Eustress and Distress Groups Using Laterality Index Calculated from Brain Hemodynamic Response.

Bak S, Shin J, Jeong J.
Biosensors (Basel). 2022 Jan 9;12(1):33.
doi: 10.3390/bios12010033.

A stress group should be subdivided into eustress (low-stress) and distress (high-stress) groups to better evaluate personal cognitive abilities and mental/physical health. However, it is challenging because of the inconsistent pattern in brain activation. We aimed to ascertain the necessity of subdividing the stress groups. The stress group was screened by salivary alpha-amylase (sAA) and then, the brain's hemodynamic reactions were measured by functional near-infrared spectroscopy (fNIRS) based on the near-infrared biosensor. We compared the two stress subgroups categorized by sAA using a newly designed emotional stimulus-response paradigm with an international affective picture system (IAPS) to enhance hemodynamic signals induced by the target effect. We calculated the laterality index for stress (LIS) from the measured signals to identify the dominantly activated cortex in both the subgroups. Both the stress groups exhibited brain activity in the right frontal cortex. Specifically, the eustress group exhibited the largest brain activity, whereas the distress group exhibited recessive brain activity, regardless of positive or negative stimuli. LIS values were larger in the order of the eustress, control, and distress groups; this indicates that the stress group can be divided into eustress and distress groups. We built a foundation for subdividing stress groups into eustress and distress groups using fNIRS.

Offset analgesia is associated with opposing modulation of medial versus dorsolateral prefrontal cortex activations: A functional near-infrared spectroscopy study.

Alter BJ, Santosa H, Nguyen QH, Huppert TJ, Wasan AD.
Mol Pain. 2022 Jan-Dec;18:17448069221074991.
doi: 10.1177/17448069221074991.

Offset analgesia is defined by a dramatic drop in perceived pain intensity with a relatively small decrease in noxious input. Although functional magnetic resonance imaging studies implicate subcortical descending inhibitory circuits during offset analgesia, the role of cortical areas remains unclear. The current study identifies cortical correlates of offset analgesia using functional near infrared spectroscopy (fNIRS). Twenty-four healthy volunteers underwent fNIRS scanning during offset (OS) and control (Con) heat stimuli applied to the forearm. After controlling for non-neural hemodynamic responses in superficial tissues, widespread increases in cortical oxygenated hemoglobin concentration were observed, reflecting cortical activation during heat pain. OS-Con contrasts revealed deactivations in bilateral medial prefrontal cortex (mPFC) and bilateral somatosensory cortex (SSC) associated with offset analgesia. Right dorsolateral prefrontal cortex (dlPFC) showed activation only during OS. These data demonstrate opposing cortical activation patterns during offset analgesia and support a model in which right dlPFC underlies ongoing evaluation of pain intensity change. With predictions of decreasing pain intensity, right dlPFC activation likely inhibits ascending noxious input via subcortical pathways resulting in SSC and mPFC deactivation. This study identifies cortical circuitry underlying offset analgesia and introduces the use of fNIRS to study pain modulation in an outpatient clinical environment.

Cardiopulmonary Rehabilitation in Long-COVID-19 Patients with Persistent Breathlessness and Fatigue: The COVID-Rehab Study.

Besnier F, Brub B, Malo J, Gagnon C, Grgoire CA, Juneau M, Simard F, L'Allier P, Nigam A, Iglsies-Grau J, Vincent T, Talamonti D, Dupuy EG, Mohammadi H, Gayda M, Bherer L.
Int J Environ Res Public Health. 2022 Mar 31;19(7):4133.
doi: 10.3390/ijerph19074133.

(1) Background: Cardiopulmonary and brain functions are frequently impaired after COVID-19 infection. Exercise rehabilitation could have a major impact on the healing process of patients affected by

long COVID-19. (2) Methods: The COVID-Rehab study will investigate the effectiveness of an eight-week cardiopulmonary rehabilitation program on cardiorespiratory fitness (V?O2max) in long-COVID-19 individuals. Secondary objectives will include functional capacity, quality of life, perceived stress, sleep quality (questionnaires), respiratory capacity (spirometry test), coagulation, inflammatory and oxidative-stress profile (blood draw), cognition (neuropsychological tests), neurovascular coupling and pulsatility (fNIRS). The COVID-Rehab project was a randomised clinical trial with two intervention arms (1:1 ratio) that will be blindly evaluated. It will recruit a total of 40 individuals: (1) rehabilitation: centre-based exercise-training program (eight weeks, three times per week); (2) control: individuals will have to maintain their daily habits. (3) Conclusions: Currently, there are no specific rehabilitation guidelines for long-COVID-19 patients, but preliminary studies show encouraging results. Clinicaltrials.gov (NCT05035628).

Impairment of autonomic emotional response for executive function in children with ADHD: A multi-modal fNIRS and pupillometric study during the Wisconsin Card Sorting Test.

Kaga Y, Ohyama T, Goto Y, Aoyagi K, Ishii S, Inukai T, Aihara M.

Brain Dev. 2022 Apr 4:S0387-7604(22)00054-7.
doi: 10.1016/j.braindev.2022.03.007. Online ahead of print.

OBJECTIVE: Children with attention deficit hyperactivity disorder (ADHD) often experience difficulties with emotional control and a consequent inability to perform tasks. To clarify the effects of emotional behavior on cognitive functions, we aimed to determine the association between emotional changes and executive functions in children with ADHD by measuring the pupil diameter changes associated with emotional changes. PARTICIPANTS AND METHODS: This study included 14 children with ADHD and 10 typically developing children (TDC) aged between 10 and 16years. During the Wisconsin Card Sorting Test (WCST), which is related to context formation and task switching among executive functions, changes in pupil diameter and frontal oxygenated hemoglobin (oxy-Hb) using functional near-infrared spectroscopy (fNIRS) were recorded simultaneously. Pupil diameter changes during "cognitive shift" and "consecutive correction" were compared between both groups. RESULTS: During cognitive shift, the pupils of children with ADHD contracted, whereas those of the TDC were mydriatic. During consecutive correction, the pupils of children with ADHD were mydriatic, whereas those of the TDC tended to contract. These results correlated with WCST performance. Moreover, during cognitive shifts, changes in bilateral frontal blood flow were increased in TDC, but not in children with ADHD. CONCLUSION: The locus coeruleus-norepinephrine (LC-NE) system plays an important role in pupillary diameter response. These results suggest that the LC-NE system may be dysfunctional in children with ADHD, and the system's abnormality may lead to affective abnormalities in such patients, which results in poor performance on WCST (i.e., impaired executive functions).

Neural Variability in the Prefrontal Cortex as a Reflection of Neural Flexibility and Stability in Patients With Parkinson Disease.

Maidan I, Hacham R, Galperin I, Giladi N, Holtzer R, Hausdorff JM, Mirelman A.

Neurology. 2022 Feb 22;98(8):e839-e847.
doi: 10.1212/WNL.0000000000013217. Epub 2021 Dec 14.

BACKGROUND AND OBJECTIVES: Functional near-infrared spectroscopy (fNIRS) studies provide direct evidence of the important role of the prefrontal cortex (PFC) during walking in aging and Parkinson disease (PD). Most studies explored mean hemoglobin (HbO2) levels, while moment-to-moment variability measures have rarely been investigated. Variability measures can inform on flexibility, which is imperative for adaptive function. We hypothesized that patients with PD will show less variability in HbO2 signals during walking compared to healthy controls. METHODS: Two hundred six participants, 57 healthy

controls (age 68.9 1.0 years, 27 women) and 149 patients with idiopathic PD (age 69.8 0.6 years, 50 women, disease duration 8.27 5.51 years), performed usual walking and dual-task walking (serial 3 subtractions) with an fNIRS sensor placed on the forehead. HbO2 variability was calculated from the SD, range, and mean detrended time series of fNIRS-derived HbO2 signal evaluated during each walking task. HbO2 variability was compared between groups and between walking tasks with mixed model analyses. RESULTS: Higher variability (SD, range, mean detrended time series) was observed during dual-task walking compared to usual walking ($p < 0.025$), but this was derived from the differences within the healthy control group (group task interaction $p < 0.007$). On the other hand, task repetition demonstrated reduced variability in healthy controls but increased variability in patients with PD (interaction group walk repetition $p < 0.048$). The Movement Disorder Society Unified Parkinson's Disease Rating Scale motor score correlated with HbO2 range ($r = 0.142$, $p = 0.050$) and HbO2 SD ($r = 0.173$, $p = 0.018$) during usual walking among all participants. DISCUSSION: In this study, we suggest a new way to interpret changes in HbO2 variability. We relate increased HbO2 variability to flexible adaptation to environmental challenges and decreased HbO2 variability to the stability of performance. Our results show that both are limited in PD; however, further investigation of these concepts is required. Moreover, HbO2 variability measures are an important aspect of brain function that add new insights into the role of PFC during walking with aging and PD. TRIAL REGISTRATION INFORMATION: ClinicalTrials.gov Identifier: NCT01732653. CLASSIFICATION OF EVIDENCE: This study provides Class III evidence that patients with PD have more variability within HbO2 signals during usual walking compared to healthy controls but not during dual-task walking.

Movement observation activates motor cortex in fibromyalgia patients: a fNIRS study.

Gentile E, Brunetti A, Ricci K, Bevilacqua V, Craighero L, de Tommaso M.

Sci Rep. 2022 Mar 18;12(1):4707.

doi: 10.1038/s41598-022-08578-2.

Scientific evidence points to a shared neural representation between performing and observing an action. The action observation notoriously determines a modulation of the observer's sensorimotor system, a phenomenon called Motor Resonance (MR). Fibromyalgia (FM) patients suffer from a condition characterized by generalized musculoskeletal pain in which even simple movement can exacerbate their symptoms. Maladaptive functioning of the primary motor cortex is a common finding in patients with chronic pain. Activation of the motor cortex is known to induce an analgesic effect in patients with chronic pain. In this exploratory study, we intend to verify if the mere observation of a movement couldelicit activation of themotor cortical areas in patients with FM. Therefore, the purpose of this study was to examine the presence of MR in patients affected by fibromyalgia. We adopted a behavioral paradigm known for detecting the presence of MR and a neurophysiological experiment. Participants watched videos showing gripping movements towards a graspable or an ungraspable object, respectively, and were asked to press a button the instant the agent touched the object (Time-to-contact detection session). In a different experimental session, participants were only requested to observe and pay attention to the videos (Observation-only session). During each experimental session, the participants' cerebral hemodynamic activity was recorded using the functional Near-Infrared Spectroscopy method. The behavioral task analysis revealed the presence of MR in both FM patients and healthy controls. Moreover, neurophysiological findings suggested that the observation of movement during the Observation-only session provoked activation and modulation of the cortical motor networks of FM patients. These results could represent evidence of the possible beneficial effects of movement observation in restarting motor activation, notoriously reduced, in FM patients.

Hemispheric Lateralization of Visuospatial Attention Is Independent of Language Production on Right-Handers: Evidence From Functional Near-Infrared Spectroscopy.

Jia G, Liu G, Niu H.
Front Neurol. 2022 Jan 14;12:784821.
doi: 10.3389/fneur.2021.784821. eCollection 2021.

It is well-established that visuospatial attention is mainly lateralized to the right hemisphere, whereas language production is mainly left-lateralized. However, there is a significant controversy regarding how these two kinds of lateralization interact with each other. The present research used functional near-infrared spectroscopy (fNIRS) to examine whether visuospatial attention is indeed right-lateralized, whereas language production is left-lateralized, and more importantly, whether the extent of lateralization in the visuospatial task is correlated with that in the task involving language. Specifically, fifty-two healthy right-handed participants participated in this study. Multiple-channel fNIRS technique was utilized to record the cerebral hemodynamic changes when participants were engaged in naming objects depicted in pictures (the picture naming task) or judging whether a presented line was bisected correctly (the landmark task). The degree of hemispheric lateralization was quantified according to the activation difference between the left and right hemispheres. We found that the picture-naming task predominantly activated the inferior frontal gyrus (IFG) of the left hemisphere. In contrast, the landmark task predominantly activated the inferior parietal sulcus (IPS) and superior parietal lobule (SPL) of the right hemisphere. The quantitative calculation of the laterality index also showed a left-lateralized distribution for the picture-naming task and a right-lateralized distribution for the landmark task. Intriguingly, the correlation analysis revealed no significant correlation between the laterality indices of these two tasks. Our findings support the independent hypothesis, suggesting that different cognitive tasks may engender lateralized processing in the brain, but these lateralized activities may be independent of each other. Meanwhile, we stress the importance of handedness in understanding the relationship between functional asymmetries. Methodologically, we demonstrated the effectiveness of using the multichannel fNIRS technique to investigate the hemispheric specialization of different cognitive tasks and their lateralization relations between different tasks. Our findings and methods may have important implications for future research to explore lateralization-related issues in individuals with neural pathologies.

Effect of Shift Work on Cognitive Function in Chinese Coal Mine Workers: A Resting-State fNIRS Study.

Tian F, Li H, Tian S, Shao J, Tian C.
Int J Environ Res Public Health. 2022 Apr 1;19(7):4217.
doi: 10.3390/ijerph19074217.

AIM: Pilot study to examine the impact of shift work on cognitive function in Chinese coal mine workers. BACKGROUND: Shift work is commonly used in modern industries such as the coal industry, and there is growing concern over the impact that shift work has on miners' work performance and personal well-being. METHOD: A total of 54 miners working three shifts (17 in morning shift, 18 in afternoon, and 19 in night shift) participated in this exploratory study. A resting-state fNIRS functional connectivity method was conducted to assess the cognitive ability before and after the work shift. RESULTS: Results showed significant differences in cognitive ability between before and after the work shifts among the three-shift workers. The brain functional connectivity was reduced ranking as the night, afternoon, and morning shifts. Decreased brain functional connectivity at the end of the working shift was found compared with before in the morning and afternoon shifts. Opposite results were obtained during the night shift. The resting-state functional brain networks in the prefrontal cortex of all groups exhibited small-world properties. Significant differences in betweenness centrality and nodal local efficiency were found in the prefrontal cortex in the morning and night shifts. CONCLUSIONS: The current findings provide new insights regarding the effect of shift work on the cognitive ability of Chinese coal mine workers from the view of brain science.

Identifying neuroimaging biomarkers of major depressive disorder from cortical hemodynamic responses using machine learning approaches.

Li Z, McIntyre RS, Husain SF, Ho R, Tran BX, Nguyen HT, Soo SC, Ho CS, Chen N.

EBioMedicine. 2022 May;79:104027.
doi: 10.1016/j.ebiom.2022.104027. Epub 2022 Apr 28.

BACKGROUND: Early diagnosis of major depressive disorder (MDD) could enable timely interventions and effective management which subsequently improve clinical outcomes. However, quantitative and objective assessment tools for the suspected cases who present with depressive symptoms have not been fully established. METHODS: Based on a large-scale dataset (n=363 subjects) collected with functional near-infrared spectroscopy (fNIRS) measurements during the verbal fluency task (VFT), this study proposed a data representation method for extracting spatiotemporal characteristics of NIRS signals, which emerged as candidate predictors in a two-phase machine learning framework to detect distinctive biomarkers for MDD. Supervised classifiers (e.g., support vector machine (SVM), k-nearest neighbors (KNN)) cooperated with cross-validation were implemented to evaluate the predictive capability of selected features in a training set. Another test set that was not involved in developing the algorithms enabled the independent assessment of the model's generalization. FINDINGS: For the classification with the optimal fusion features, the SVM classifier achieved the highest accuracy of 75.6%4.7% in the nested cross-validation, and the correct prediction rate of 78.0% with a sensitivity of 75.0% and a specificity of 81.4% in the test set. Moreover, the multiway ANOVA test on clinical and demographic factors confirmed that twenty out of 39 optimal features were significantly correlated with the MDD-distinctive consequence. INTERPRETATION: The abnormal prefrontal activity of MDD may be quantified as diminished relative intensity and inappropriate activation timing of hemodynamic response, resulting in an objectively measurable biomarker for assessing cognitive deficits and screening MDD at the early stage. FUNDING: This study was funded by NUS iHeathtech Other Operating Expenses (R-722-000-004-731).

A neural signature for combined action observation and motor imagery? An fNIRS study into prefrontal activation, automatic imitation, and self-other perceptions.

Emerson JR, Scott MW, van Schaik P, Butcher N, Kenny RPW, Eaves DL.

Brain Behav. 2022 Feb;12(2):e2407.
doi: 10.1002/brb3.2407. Epub 2022 Jan 7.

INTRODUCTION: Research indicates that both observed and imagined actions can be represented in the brain as two parallel sensorimotor representations. One proposal is that higher order cognitive processes would align these two hypothetical action simulations. METHODS: We investigated this hypothesis using an automatic imitation paradigm, with functional near-infrared spectroscopy recordings over the prefrontal cortex during different motor simulation states. On each trial, participants (n = 14) observed a picture of a rhythmical action (instructed action) followed by a distractor movie showing the same or different action. Participants then executed the instructed action. Distractor actions were manipulated to be fast or slow, and instructions were manipulated during distractor presentation: action observation (AO), combined action observation and motor imagery (AO+MI) and observe to imitate (intentional imitation). A pure motor imagery (MI) condition was also included. RESULTS: Kinematic analyses showed that although distractor speed effects were significant under all instructions (shorter mean cycle times in execution for fast compared to slow trials), this imitation bias was significantly stronger for combined AO+MI than both AO and MI, and stronger for intentional imitation than the other three automatic imitation conditions. In the left prefrontal cortex, cerebral oxygenation was significantly greater for combined AO+MI than all other instructions. Participants reported that their representation of the self overlapped with the observed model significantly more during AO+MI than AO. CONCLUSION: Left prefrontal activation may therefore be a neural signature of AO+MI, supporting attentional switching between concurrent representations of self (MI, top-down) and other (AO, bottom-up) to increase imitation and perceived closeness.

Feasibility study of immersive virtual prism adaptation therapy with depth-sensing camera using functional near-infrared spectroscopy in healthy adults.

Cho S(#), Chang WK(#), Park J, Lee SH, Lee J, Han CE, Paik NJ, Kim WS.
Sci Rep. 2022 Jan 14;12(1):767.
doi: 10.1038/s41598-022-04771-5.

Prism Adaptation (PA) is used to alleviate spatial neglect. We combined immersive virtual reality with a depth-sensing camera to develop virtual prism adaptation therapy (VPAT), which block external visual cues and easily quantify and monitor errors than conventional PA. We conducted a feasibility study to investigate whether VPAT can induce behavioral adaptations by measuring after-effect and identifying which cortical areas were most significantly activated during VPAT using functional near-infrared spectroscopy (fNIRS). Fourteen healthy subjects participated in this study. The experiment consisted of four sequential phases (pre-VPAT, VPAT-10, VPAT-20, and post-VPAT). To compare the most significantly activated cortical areas during pointing in different phases against pointing during the pre-VPAT phase, we analyzed changes in oxyhemoglobin concentration using fNIRS during pointing. The pointing errors of the virtual hand deviated to the right-side during early pointing blocks in the VPAT-10 and VPAT-20 phases. There was a left-side deviation of the real hand to the target in the post-VPAT phase, demonstrating after-effect. The most significantly activated channels during pointing tasks were located in the right hemisphere, and possible corresponding cortical areas included the dorsolateral prefrontal cortex and frontal eye field. In conclusion, VPAT may induce behavioral adaptation with modulation of the dorsal attentional network.

Searching for the Mechanism of Action of Extremely Low Frequency Electromagnetic Field-The Pilot fNIRS Research.

Jezierska K, Sekowska-Namiotko A, Pala B, Lietz-Kijak D, Gronwald H, Podraza W.
Int J Environ Res Public Health. 2022 Mar 28;19(7):4012.
doi: 10.3390/ijerph19074012.

There is an ongoing debate on the benefits of magnetic stimulation in neurological disorders. OBJECTIVES: We aimed to evaluate the influence of magnetic stimulation on blood oxygenation of the motor cortex using functional near-infrared spectroscopy (fNIRS). METHODS: A total of 16 healthy volunteer participants were subjected to four protocols. In the first two protocols, the participants remained at rest without (and then with) magnetic stimulation. In the next two protocols, motor cortex stimulation was achieved using a finger-tapping task, with and without magnetic stimulation. Changes in blood oxygenation levels within the motor cortex were recorded and analysed. RESULTS: No characteristic changes in the blood oxygenation level-dependent responses were observed in resting participants after magnetic stimulation. No statistically significant difference was observed in the amplitude of the fNIRS signal before and after magnetic stimulation. We observed characteristic blood oxygenation level-dependent responses after the finger-tapping task in the second protocol, but not after magnetic stimulation. CONCLUSIONS: Although we did not observe any measurable effect of the magnetic field on the haemodynamic response of the motor cortex, understanding the mechanism(s) of magnetic stimulation may be important. Additional, detailed studies are needed to prove or negate the potential of this medical procedure.

Inter-Brain Neural Mechanism Underlying Turn-Based Interaction Under Acute Stress in Women: A Hyperscanning Study Using Functional Near-Infrared Spectroscopy.

Zhao H, Li Y, Wang X, Kan Y, Xu S, Duan H.
Soc Cogn Affect Neurosci. 2022 Jan 26:nsac005.
doi: 10.1093/scan/nsac005. Online ahead of print.

With the ever-changing social environment, stress has exerted the substantial influence on the social interaction. The present study examined the underlying cognitive and neural mechanism on how acute stress affected the real-time cooperative and competitive interaction with four hypothesized path models. We used the hyperscanning technique based on a functional near-infrared spectroscopy (fNIRS) device to examine brain-to-brain coherence within the dyads engaging Pattern Game (PG) under acute stress manipulated through Trier Social Stress Test for Groups (TSST-G). Behavioral results showed stressed dyads exhibited better cooperative performance and higher self-other overlap level during the cooperative session than dyads in control group. The fNIRS results identified higher interpersonal brain synchronization (IBS) in right temporal-parietal junction (r-TPJ) stronger Granger causality from partner to builder during the cooperative session in stress group when comparing with control group. Our results corroborated better performance in the cooperative context and further identified that brain-to-brain coherence in r-TPJ and self-other overlap serially mediated the effect of acute stress on cooperative performance.

Increasing motor cortex activation during grasping via novel robotic mirror hand therapy: a pilot fNIRS study.

Kim DH(#), Lee KD(#), Bulea TC, Park HS.

J Neuroeng Rehabil. 2022 Jan 24;19(1):8.
doi: 10.1186/s12984-022-00988-7.

BACKGROUND: Mirror therapy (MT) has been used for functional recovery of the affected hand by providing the mirrored image of the unaffected hand movement, which induces neural activation of the cortical hemisphere contralateral to the affected hand. Recently, many wearable robots assisting the movement of the hand have been developed, and several studies have proposed robotic mirror therapy (RMT) that uses a robot to provide mirrored movements of the unaffected hand to the affected hand with the robot controlled by measuring electromyography or posture of the unaffected hand. In some cases of RMT a mirror is placed to allow the person to observe only the unaffected hand but in others users simply observe the robotically assisted hand performing the mirrored movements, as was the case in this study. There have been limited evaluations of the cortical activity during RMT compared to MT and robotic therapy (RT) providing passive movements despite the difference in the modality of sensory feedback and the involvement of motor intention, respectively. METHODS: This paper analyzes bilateral motor cortex activation in nine healthy subjects and five chronic stroke survivors during a pinching task performed in MT, RT, and RMT conditions using functional near infrared spectroscopy (fNIRS). In the MT condition, the person moved the unaffected hand and observed it in a mirror while the affected hand remained still. In RT condition passive movements were provided to the affected hand with a cable-driven soft robotic glove, while, in RMT condition, the posture of the unaffected hand was measured by a sensing glove and the soft robotic glove mirrored its movement on the affected hand. RESULTS: For both groups, the RMT condition showed the greatest mean cortical activation on the motor cortex contralateral to the affected (non-dominant for the healthy group) hand compared to other conditions. Individual results indicate that RMT induces similar or greater neural activation on the motor cortex compared to MT and RT conditions. The interhemispheric activations of both groups were balanced in RMT condition. In MT condition, significantly greater activation was shown on the hemisphere ipsilateral to the affected (dominant for the healthy group) hand for both subject groups, while the contralateral side showed significantly greater activation for the healthy group in RT condition. CONCLUSION: The experimental results indicate that combining visual feedback, somatosensory feedback, and motor intention are important for greater stimulation on the contralateral motor cortex of the affected hand. RMT that includes these factors is hypothesized to achieve a more effective functional rehabilitation due to greater and more balanced cortical activation.

Transcranial Direct Current Stimulation May Reduce Prefrontal Recruitment During Dual Task Walking in Functionally Limited Older Adults - A Pilot Study.

Jor'dan AJ, Bernad-Elazari H, Mirelman A, Gouskova NA, Lo OY, Hausdorff JM, Manor B.

Front Aging Neurosci. 2022 Mar 11;14:843122.
doi: 10.3389/fnagi.2022.843122. eCollection 2022.

INTRODUCTION: Transcranial direct current stimulation (tDCS) targeting the left dorsolateral prefrontal cortex (dlPFC) improves dual task walking in older adults, when tested just after stimulation. The acute effects of tDCS on the cortical physiology of walking, however, remains unknown. METHODS: In a previous study, older adults with slow gait and executive dysfunction completed a dual task walking assessment before and after 20 min of tDCS targeting the left dlPFC or sham stimulation. In a subset of seven participants per group, functional near-infrared spectroscopy (fNIRS) was used to quantify left and right prefrontal recruitment defined as the oxygenated hemoglobin response to usual and dual task walking (?HbO2), as well as the absolute change in this metric from usual to dual task conditions (i.e., ?HbO2 cost). Paired t-tests examined pre- to post-stimulation differences in each fNIRS metric within each group. RESULTS: The tDCS group exhibited pre- to post-stimulation reduction in left prefrontal ?HbO2 cost ($p = 0.03$). This mitigation of dual task "cost" to prefrontal recruitment was induced primarily by a reduction in left prefrontal ?HbO2 specifically within the dual task condition ($p = 0.001$), an effect that was observed in all seven participants within this group. Sham stimulation did not influence ?HbO2 cost or ?HbO2 in either walking condition ($p > 0.35$), and neither tDCS nor sham substantially influenced right prefrontal recruitment ($p > 0.16$). DISCUSSION: This preliminary fNIRS data suggests that tDCS over the left dlPFC may modulate prefrontal recruitment, as reflected by a relative reduction in the oxygen consumption of this brain region in response to dual task walking.

The Frequency Effect of the Motor Imagery Brain Computer Interface Training on Cortical Response in Healthy Subjects: A Randomized Clinical Trial of Functional Near-Infrared Spectroscopy Study.

Lin Q, Zhang Y, Zhang Y, Zhuang W, Zhao B, Ke X, Peng T, You T, Jiang Y, Yilifate A, Huang W, Hou L, You Y, Huai Y, Qiu Y, Zheng Y, Ou H.

Front Neurosci. 2022 Mar 31;16:810553.
doi: 10.3389/fnins.2022.810553. eCollection 2022.

BACKGROUND: The motor imagery brain computer interface (MI-BCI) is now available in a commercial product for clinical rehabilitation. However, MI-BCI is still a relatively new technology for commercial rehabilitation application and there is limited prior work on the frequency effect. The MI-BCI has become a commercial product for clinical neurological rehabilitation, such as rehabilitation for upper limb motor dysfunction after stroke. However, the formulation of clinical rehabilitation programs for MI-BCI is lack of scientific and standardized guidance, especially limited prior work on the frequency effect. Therefore, this study aims at clarifying how frequency effects on MI-BCI training for the plasticity of the central nervous system. METHODS: Sixteen young healthy subjects (aged 22.94 3.86 years) were enrolled in this randomized clinical trial study. Subjects were randomly assigned to a high frequency group (HF group) and low frequency group (LF group). The HF group performed MI-BCI training once per day while the LF group performed once every other day. All subjects performed 10 sessions of MI-BCI training. functional near-infrared spectroscopy (fNIRS) measurement, Wolf Motor Function Test (WMFT) and brain computer interface (BCI) performance were assessed at baseline, mid-assessment (after completion of five BCI training sessions), and post-assessment (after completion of 10 BCI training sessions). RESULTS: The results from the two-way ANOVA of beta values indicated that GROUP, TIME, and GROUP TIME interaction of the right primary sensorimotor cortex had significant main effects [GROUP: $F(1,14) = 7.251$, $P = 0.010$; TIME: $F(2,13) = 3.317$, $P = 0.046$; GROUP TIME: $F(2,13) = 5.676$, $P = 0.007$]. The degree of activation was affected by training frequency, evaluation time point and interaction. The activation of left primary sensory motor cortex was also affected by group (frequency) ($P = 0.003$). Moreover, the TIME

variable was only significantly different in the HF group, in which the beta value of the mid-assessment was higher than that of both the baseline assessment (P = 0.027) and post-assessment (P = 0.001), respectively. Nevertheless, there was no significant difference in the results of WMFT between HF group and LF group. CONCLUSION: The major results showed that more cortical activation and better BCI performance were found in the HF group relative to the LF group. Moreover, the within-group results also showed more cortical activation after five sessions of BCI training and better BCI performance after 10 sessions in the HF group, but no similar effects were found in the LF group. This pilot study provided an essential reference for the formulation of clinical programs for MI-BCI training in improvement for upper limb dysfunction.

Increased prefrontal cortical activation during challenging walking conditions in persons with lower limb amputation - an fNIRS observational study.

Schack J, Pripp AH, Mirtaheri P, Steen H, Gler E, Gjvaag T.

Physiother Theory Pract. 2022 Feb;38(2):255-265.
doi: 10.1080/09593985.2020.1758979. Epub 2020 May 5.

Background: Lower limb amputation (LLA) alters the sensorimotor control systems. Despite the self-reports of increased attention during mobility, the interaction between mobility and cognitive control mechanisms is not fully understood.Objective: Concurrently evaluate walking performance and prefrontal cortical (PFC) activity in persons with and without LLA during different walking conditions.Methods: Thirty-nine persons with LLA and thirty-three able-bodied controls participated. Walking performance was evaluated using the Figure-of 8-walk-test during three conditions: 1) UW (Usual walking with self-selected walking speed); 2) WCT (walking and carrying a tray with two cups filled with water); and 3) WUT (walking on uneven terrain). PFC activity was assessed using functional near-infrared spectroscopy (fNIRS). Linear mixed models were used to detect changes between groups and between walking conditions within each group.Results: Between-group comparisons showed increased PFC activity in persons with LLA during UW and WUT, and a significant decrease in walking performance during WCT and WUT compared to controls. Within-group comparisons showed increased PFC activity during WUT compared with UW and WCT and an overall difference in walking performance between the conditions (WU > WUT > WCT) in both groups. However, the effect of walking condition on PFC activity and walking performance was not modified by group (P >.1).Conclusion: The results suggest that persons with LLA have increased attentional demands during walking but choose the same cognitive-mobility strategy during challenging walking conditions as able-bodied persons. However, the attentional demands seem to depend on the complexity of the task.

Is There a Difference in Brain Functional Connectivity between Chinese Coal Mine Workers Who Have Engaged in Unsafe Behavior and Those Who Have Not?

Tian F, Li H, Tian S, Tian C, Shao J.

Int J Environ Res Public Health. 2022 Jan 3;19(1):509.
doi: 10.3390/ijerph19010509.

(1) Background: As a world-recognized high-risk occupation, coal mine workers need various cognitive functions to process the surrounding information to cope with a large number of perceived hazards or risks. Therefore, it is necessary to explore the connection between coal mine workers' neural activity and unsafe behavior from the perspective of cognitive neuroscience. This study explored the functional brain connectivity of coal mine workers who have engaged in unsafe behaviors (EUB) and those who have not (NUB). (2) Methods: Based on functional near-infrared spectroscopy (fNIRS), a total of 106 workers from the Hongliulin coal mine of Shaanxi North Mining Group, one of the largest modern coal mines in China, completed the test. Pearson's Correlation Coefficient (COR) analysis, brain network analysis, and two-

sample t-test were used to investigate the difference in brain functional connectivity between the two groups. (3) Results: The results showed that there were significant differences in functional brain connectivity between EUB and NUB among the frontopolar area ($p = 0.002325$), orbitofrontal area ($p = 0.02102$), and pars triangularis Broca's area ($p = 0.02888$). Small-world properties existed in the brain networks of both groups, and the dorsolateral prefrontal cortex had significant differences in clustering coefficient ($p = 0.0004$), nodal efficiency ($p = 0.0384$), and nodal local efficiency ($p = 0.0004$). (4) Conclusions: This study is the first application of fNIRS to the field of coal mine safety. The fNIRS brain functional connectivity analysis is a feasible method to investigate the neuropsychological mechanism of unsafe behavior in coal mine workers in the view of brain science.

A Functional Near-Infrared Spectroscopy Examination of the Neural Correlates of Mental Rotation for Individuals With Different Depressive Tendencies.

Wang L, Ke J, Zhang H.

Front Hum Neurosci. 2022 Feb 7;16:760738.
doi: 10.3389/fnhum.2022.760738. eCollection 2022.

The present study aimed to examine the neural mechanisms underlying the ability to process the mental rotation with mirrored stimuli for different depressive tendencies with psychomotor retardation. Using functional near-infrared spectroscopy (fNIRS), we measured brain cortex activation of participants with higher and lower depressive tendencies while performing a left-right paradigm of object mental rotation or a same-different paradigm of subject mental rotation. Behavioral data revealed no differences in reaction time and rotation speed. The fNIRS data revealed a higher deactivation of oxyhemoglobin (HbO) change for the higher depression group in the perceptual stage of object mental rotation with mirrored stimuli in the superior external frontal cortex (BA46), inferior frontal gyrus (BA45), premotor cortex (BA6), and primary motor cortex (BA4) (study 1). In addition, there existed a significant difference between the two groups in premotor cortex (BA6) in subject mental rotation with mirrored stimuli (study 2). These results suggest that the neural mechanism of higher depression individuals connected with psychomotor retardation exists in the frontal and motor areas when processing object mental rotation with mirrored stimuli, and the motor cortex when processing subject mental rotation.

Biasing the neurocognitive processing of videos with the presence of a real cultural other.

Zhou S, Xu X, He X, Zhou F, Zhai Y, Chen J, Long Y, Zheng L, Lu C.

Cereb Cortex. 2022 Mar 26:bhac122.
doi: 10.1093/cercor/bhac122. Online ahead of print.

In the digital age, while short videos present vital events with powerful information, the presence of cultural cues may bias our processing of videos of foreign cultures. However, the underlying neurocognitive processes remain unclear. In this study, we hypothesized that cultural cues might bias video processing by either enhancing cultural perspective-taking or shifting cultural self-schema. To test these hypotheses, we used a novel paradigm in which the cultural cue was a real cultural other (the priming participants) who watched American/Chinese videos together with the primed participants. The results showed that when the cue was present, the right temporoparietal junction (rTPJ) response to videos with other cultural content was shifted, showing a priming effect. Moreover, the activity pattern in the rTPJ was more congruent with the primed culture than with the original culture, reflecting a neural biasing effect. Finally, intersubject representational similarity analysis indicated that the neural biasing effect in the rTPJ was more closely associated with cultural perspective-taking than with cultural self-schema. In summary, these findings support the perspective-taking hypothesis, suggesting that cultural cues can significantly bias our cultural mindset by altering cultural perspective-taking when we are exposed to culture-relevant naturalistic stimuli.

Differences in brain activity between fast and slow responses on psychomotor vigilance task: an fNIRS study.

Nogueira MG, Silvestrin M, Barreto CSF, Sato JR, Mesquita RC, Biazoli C, Baptista AF.
Brain Imaging Behav. 2022 Jan 29.
doi: 10.1007/s11682-021-00611-8. Online ahead of print.

Attention is a basic human function underlying every other cognitive process. It is demonstrated in the functional Magnetic Resonance Imaging literature that frontoparietal networks are involved with attentive performance while default mode networks are involved with inattentive performance. Yet, it is still not clear whether similar results would be found with functional Near-Infrared Spectroscopy. The goal of our study was to investigate differences in hemodynamic activity measured by functional Near-Infrared Spectroscopy between fast and slow responses on a simple sustained attention task both before and after stimulus onset. Thirty healthy adults took part in the study. Our results have shown differences between fast and slow responses only on channels over medial frontal cortex and inferior parietal cortex ($p < 0,05$). These differences were observed both before and after stimulus presentation. It is discussed that functional Near-Infrared Spectroscopy is a good tool to investigate the frontoparietal network and its relationship with performance in attention tasks; it could be used to further investigate other approaches on attention, such as the dual network model of cognitive control and brain states views based on complex systems analysis; and finally, it could be used to investigate attention in naturalistic settings.

Using Hebbian-Type Stimulation to Rescue Arm Function After Stroke: Study Protocol for a Randomized Clinical Trial.

Xu R, Zhu GY, Zhu J, Wang Y, Xing XX, Chen LY, Li J, Shen FQ, Chen JB, Hua XY, Xu DS.
Front Neural Circuits. 2022 Feb 10;15:789095.
doi: 10.3389/fncir.2021.789095. eCollection 2021.

BACKGROUND: Upper-extremity hemiplegia after stroke remains a significant clinical problem. The supplementary motor area (SMA) is vital to the motor recovery outcomes of chronic stroke patients. Therefore, rebuilding the descending motor tract from the SMA to the paralyzed limb is a potential approach to restoring arm motor function after stroke. Paired associative stimulation (PAS), which is based on Hebbian theory, is a potential method for reconstructing the connections in the impaired motor neural circuits. The study described in this protocol aims to assess the effects of cortico-peripheral Hebbian-type stimulation (HTS), involving PAS, for neural circuit reconstruction to rescue the paralyzed arm after stroke. METHODS: The study is a 4-month double-blind randomized sham-controlled clinical trial. We will recruit 90 post-stroke individuals with mild to moderate upper limb paralysis. Based on a 1:1 ratio, the participants will be randomly assigned to the HTS and sham groups. Each participant will undergo 5-week HTS or sham stimulation. Assessments will be conducted at baseline, immediately after the 5-week treatment, and at a 3-month follow-up. The primary outcome will be the Wolf Motor Function Test (WMFT). The secondary outcomes will be Fugl-Meyer Assessment for Upper Extremity (FMA-UE), Functional Independence Measure (FIM), and functional near-infrared spectroscopy (fNIRS) parameters. The adverse events will be recorded throughout the study. DISCUSSION: Upper-limb paralysis in stroke patients is due to neural circuit disruption, so the reconstruction of effective motor circuits is a promising treatment approach. Based on its anatomical structure and function, the SMA is thought to compensate for motor dysfunction after focal brain injury at the cortical level. Our well-designed randomized controlled trial will allow us to analyze the clinical efficacy of this novel Hebbian theory-based neuromodulation strategy regarding promoting the connection between the cortex and peripheral limb. The results may have significance for the development and implementation of effective neurorehabilitation treatments. CLINICAL TRIAL REGISTRATION: [www.ClinicalTrials.gov], identifier [ChiCTR2000039949].

Reducing false discoveries in resting-state functional connectivity using short channel correction: an fNIRS study.

Paranawithana I, Mao D, Wong YT, McKay CM.

Neurophotonics. 2022 Jan;9(1):015001.
doi: 10.1117/1.NPh.9.1.015001. Epub 2022 Jan 18.

Significance: Functional near-infrared spectroscopy (fNIRS) is a neuroimaging tool that can measure resting-state functional connectivity; however, non-neuronal components present in fNIRS signals introduce false discoveries in connectivity, which can impact interpretation of functional networks. Aim: We investigated the effect of short channel correction on resting-state connectivity by removing non-neuronal signals from fNIRS long channel data. We hypothesized that false discoveries in connectivity can be reduced, hence improving the discriminability of functional networks of known, different connectivity strengths. Approach: A principal component analysis-based short channel correction technique was applied to resting-state data of 10 healthy adult subjects. Connectivity was analyzed using magnitude-squared coherence of channel pairs in connectivity groups of homologous and control brain regions, which are known to differ in connectivity. Results: By removing non-neuronal components using short channel correction, significant reduction of coherence was observed for oxy-hemoglobin concentration changes in frequency bands associated with resting-state connectivity that overlap with the Mayer wave frequencies. The results showed that short channel correction reduced spurious correlations in connectivity measures and improved the discriminability between homologous and control groups. Conclusions: Resting-state functional connectivity analysis with short channel correction performs better than without correction in its ability to distinguish functional networks with distinct connectivity characteristics.

Consumers in the Face of COVID-19-Related Advertising: Threat or Boost Effect?

Balconi M, Sansone M, Angioletti L.

Front Psychol. 2022 Mar 7;13:834426.
doi: 10.3389/fpsyg.2022.834426. eCollection 2022.

The COVID-19 pandemic has prompted the production of a vast amount of COVID-19-themed brand commercials, in an attempt to exploit the salience of the topic to reach more effectively the consumers. However, the literature has produced conflicting findings of the effectiveness of negative emotional contents in advertisings. The present study aims at exploring the effect of COVID-19-related contents on the hemodynamic brain correlates of the consumer approach or avoidance motivation. Twenty Italian participants were randomly assigned to two different groups that watched COVID-19-related or non-COVID-19-related commercials. The hemodynamic response [oxygenated (O2Hb) and deoxygenated hemoglobin modulations] within the left and right prefrontal cortices (PFC) was monitored with Functional Near-Infrared Spectroscopy (fNIRS) while brand commercials were presented, as the prefrontal lateralization was shown to be indicative of the attitude toward the brand and of the approach-avoidance motivation. First, the findings showed that the COVID-19-related contents were able to prompt emotional processing within the PFC to a higher extent compared to contents non-related to COVID-19. Moreover, the single-channel analysis revealed increased O2Hb activity of the left dorsolateral PFC compared to the left pars triangularis Broca's area in the group of participants that watched the COVID-19-related commercials, suggesting that the commercials may have driven participants to dedicate more attention toward the processing of the emotional components compared to the semantic meaning conveyed by the ad. To conclude, despite expressing unpleasant emotions, commercials referring to the highly emotional pandemic experience may benefit the advertising efficacy, increasing the capability to reach customers.

Diffuse optical reconstructions of functional near infrared spectroscopy data using max-

imum entropy on the mean.

Cai Z, Machado A, Chowdhury RA, Spilkin A, Vincent T, Aydin , Pellegrino G, Lina JM, Grova C.
Sci Rep. 2022 Feb 10;12(1):2316.
doi: 10.1038/s41598-022-06082-1.

Functional near-infrared spectroscopy (fNIRS) measures the hemoglobin concentration changes associated with neuronal activity. Diffuse optical tomography (DOT) consists of reconstructing the optical density changes measured from scalp channels to the oxy-/deoxy-hemoglobin concentration changes within the cortical regions. In the present study, we adapted a nonlinear source localization method developed and validated in the context of Electro- and Magneto-Encephalography (EEG/MEG): the Maximum Entropy on the Mean (MEM), to solve the inverse problem of DOT reconstruction. We first introduced depth weighting strategy within the MEM framework for DOT reconstruction to avoid biasing the reconstruction results of DOT towards superficial regions. We also proposed a new initialization of the MEM model improving the temporal accuracy of the original MEM framework. To evaluate MEM performance and compare with widely used depth weighted Minimum Norm Estimate (MNE) inverse solution, we applied a realistic simulation scheme which contained 4000 simulations generated by 250 different seeds at different locations and 4 spatial extents ranging from 3 to 40[Formula: see text] along the cortical surface. Our results showed that overall MEM provided more accurate DOT reconstructions than MNE. Moreover, we found that MEM was remained particularly robust in low signal-to-noise ratio (SNR) conditions. The proposed method was further illustrated by comparing to functional Magnetic Resonance Imaging (fMRI) activation maps, on real data involving finger tapping tasks with two different montages. The results showed that MEM provided more accurate HbO and HbR reconstructions in spatial agreement with the main fMRI cluster, when compared to MNE.

Effects of working memory load on frontal connectivity in children with autism spectrum disorder: a fNIRS study.

Han YMY, Chan MC, Chan MMY, Yeung MK, Chan AS.
Sci Rep. 2022 Jan 27;12(1):1522.
doi: 10.1038/s41598-022-05432-3.

Individuals with autism spectrum disorder (ASD) perform poorly in working memory (WM) tasks, with some literature suggesting that their impaired performance is modulated by WM load. While some neuroimaging and neurophysiological studies have reported altered functional connectivity during WM processing in individuals with autism, it remains largely unclear whether such alterations are moderated by WM load. The present study aimed to examine the effect of WM load on functional connectivity within the prefrontal cortex (PFC) in ASD using functional near-infrared spectroscopy (fNIRS). Twenty-two children with high-functioning ASD aged 8-12years and 24 age-, intelligent quotient (IQ)-, sex- and handedness-matched typically developing (TD) children performed a number n-back task with three WM loads (0-back, 1-back, and 2-back). Hemodynamic changes in the bilateral lateral and medial PFC during task performance were monitored using a multichannel NIRS device. Children with ASD demonstrated slower reaction times, specifically during the "low load" condition, than TD children. In addition, the ASD and TD groups exhibited differential load-dependent functional connectivity changes in the lateral and medial PFC of the right but not the left hemisphere. These findings indicate that WM impairment in high-functioning ASD is paralleled by load-dependent alterations in right, but not left, intrahemispheric connectivity during WM processing in children with ASD. A disruption of functional neural connections that support different cognitive processes may underlie poor performance in WM tasks in ASD.

Effects of a 6-Min Treadmill Walking Test on Dual-Task Gait Performance and Prefrontal Hemodynamics in People With Multiple Sclerosis.

Broscheid KC, Behrens M, Dettmers C, Jbges M, Schega L.
Front Neurol. 2022 Apr 7;13:822952.
doi: 10.3389/fneur.2022.822952. eCollection 2022.

Fatigue is one of the most limiting symptoms in people with multiple sclerosis (pwMS) and can be subdivided into trait and state fatigue. Activity-induced state fatigue describes the temporary decline in motor and/or cognitive performance (motor and cognitive performance fatigability, respectively) and/or the increase in the perception of fatigue (perceived fatigability) in response to motor or cognitive tasks. To the best of our knowledge, the effects of a 6-min walk test (6MWT), which was often used to assess motor performance fatigability in pwMS, on motor-cognitive dual-task performance (i.e., walking + arithmetic task) and prefrontal cortex (PFC) hemodynamics are not well-known. This is of importance, since daily activities are often performed as multitasks and a worse dual-task walking performance is associated with an increased risk of falling. Consequently, we investigated the effect of a fast 6MWT (comfort velocity + 15%) performed on a treadmill on motor-cognitive performance fatigability (spatio-temporal gait parameters/accuracy during the arithmetic task) and perceived fatigability measures (rating of perceived exhaustion; RPE) as well as PFC hemodynamics recorded during dual-task walking in pwMS and healthy controls (HCs). Twenty pwMS (48.3 9.0 years; 13 females/7 males; expanded disability status scale 2.7 1.0, first diagnosis 13.8 8.8 years) and 24 HC with similar age and sex (48.6 7.9 years; 17 females/7 males) were included. Only cognitive performance fatigability (increased error rate) during dual-task walking was found after the fast 6MWT on the treadmill in pwMS. However, the changes in gait parameters did not indicate motor performance fatigability, although both the groups reported perceived fatigability (increased RPE) after the fast 6MWT. Moreover, no change in the PFC activation was detected in both groups. Our results suggest that the intensity and/or duration of the fast 6MWT was not sufficient to induce motor performance fatigability in pwMS. These factors should be addressed by future studies on this topic, which should also consider further parameters, e.g., muscular oxygenation and/or myoelectrical activity, to verify that exercise intensity and/or duration was appropriate to induce motor performance fatigability in pwMS. CLINICAL TRIAL REGISTER: DRKS00021057.

Synaptosomal-Associated Protein 25 Gene Polymorphisms Affect Treatment Efficiency of Methylphenidate in Children With Attention-Deficit Hyperactivity Disorder: An fNIRS Study.

Li J, Yan WJ, Wu Y, Tian XX, Zhang YW.
Front Behav Neurosci. 2022 Jan 5;15:793643.
doi: 10.3389/fnbeh.2021.793643. eCollection 2021.

Methylphenidate (MPH) is the first-line drug for the treatment of children with attention-deficit hyperactivity disorder (ADHD); however, individual curative effects of MPH vary. Many studies have demonstrated that synaptosomal-associated protein 25 (SNAP-25) gene MnlI polymorphisms may be related to the efficacy of MPH. However, the association between SNAP-25MnlI polymorphisms and changes in brain hemodynamic responses after MPH treatment is still unclear. This study used functional near-infrared spectroscopy (fNIRS) to preliminarily investigate the interaction of MPH treatment-related prefrontal inhibitory functional changes with the genotype status of the SNAP-25 gene in children with ADHD. In total, 38 children with ADHD aged 6.76-12.08 years were enrolled in this study and divided into the following two groups based on SNAP-25 gene MnlI polymorphisms: T/T genotype group (wild-type group, 27 children) and G allele carrier group (mutation group, 11 children). The averaged oxygenated hemoglobin concentration changes [?avg oxy-Hb] and deoxyhemoglobin concentration changes [?avg deoxy-Hb] in the frontal cortex before MPH treatment and after 1.5 h (post-MPH1.5h) and 4 weeks (post-MPH4w) of MPH treatments were monitored using fNIRS during the go/no-go task. SNAP-IV scores were evaluated both pre-MPH and post-MPH4w treatments. In the T/T genotype group, [?avg oxy-Hb] in the dorsolateral prefrontal cortex was significantly higher after 4 weeks of MPH (post-MPH4W) treatment than pre-treatment; however, in the G allele group, no significant differences in [?avg oxy-Hb] were observed between pre- and

post-treatments. In the go/no-go task, the accuracy was significantly increased post-MPH4w treatment in the T/T genotype group, while no significant differences were observed in response time and accuracy of the "go" sand no-go task in the G allele group for pre-MPH, post-MPH1.5h, and post-MPH4w treatments. The T/T genotype group exhibited a significant decrease in SNAP-IV scores after MPH treatment, while the G allele group showed no significant difference. In conclusion, fNIRS data combined with SNAP-25 MnlI polymorphism analysis may be a useful biomarker for evaluating the effects of MPH in children with ADHD.

Greater prefrontal activation during sitting toe tapping predicts severer freezing of gait in Parkinson's disease: an fNIRS study.

Pu L, Liu T, Tang WC, Song C, Jin M, Ren L, Li T, Liang Z.

Cereb Cortex. 2022 Mar 26:bhac114.
doi: 10.1093/cercor/bhac114. Online ahead of print.

OBJECTIVE: Previous studies have revealed that, compared with Parkinson's disease (PD) patients without freezing of gait (FoG), the ones with FoG showed greater prefrontal activation while doing lower-limb movements involving standing, walking and turning, which require both locomotor and balance control. However, the relation between FoG and pure locomotor control as well as its underlying mechanism remain unclear. METHODS: A total of 56 PD subjects were recruited and allocated to PD-FoG and PD-noFoG subgroups, and 34 age-matched heathy adults were included as heathy control (HC). Functional near-infrared spectroscopy was used to measure their prefrontal activation in a sitting lower-limb movement task, wherein subjects were asked to sit and tap their right toes as big and as fast as possible. RESULTS: Result of one-way ANOVA (Group: PD-FoG vs. PD-noFoG vs. HC) revealed greater activation in the right prefrontal cortex in the PD-FoG group than in the other 2 groups. Linear mixed-effects model showed consistent result. Furthermore, the right prefrontal activation positively correlated with the severity of FoG symptoms in PD-FoG patients. CONCLUSION: These findings suggested that PD patients with FoG require additional cognitive resources to compensate their damaged automaticity in locomotor control, which is more pronounced in severe FoG patients than milder ones.

Different brain activation patterns in the prefrontal area between self-paced and high-speed driving tasks.

Hirano D, Kimura N, Yano H, Enoki M, Aikawa M, Goto Y, Taniguchi T.

J Biophotonics. 2022 Feb 1:e202100295.
doi: 10.1002/jbio.202100295. Online ahead of print.

The purpose of this study was to investigate the effects on prefrontal cortex brain activity when participants attempted to stop a car accurately at a stop line when driving at different speeds using functional near-infrared spectroscopy (fNIRS). Twenty healthy subjects with driving experience drove their own cars for a distance of 60 m five times each at their own pace or as fast as possible. The variation in the distance between the stop line and the car was not significantly different between the self-paced and high-speed tasks. However, oxygenated hemoglobin concentration in the prefrontal cortex was significantly higher in the high-speed task than in the self-paced task. These findings suggest that driving at high speed requires more divided attention than driving at self-paced speed, even though the participants were able to stop the car at the same distance from the target. This study shows the advantages and usefulness of fNIRS .

Interoceptive Attentiveness Induces Significantly More PFC Activation during a Synchronized Linguistic Task Compared to a Motor Task as Revealed by Functional Near-

Infrared Spectroscopy.

Balconi M, Angioletti L.

Brain Sci. 2022 Feb 23;12(3):301.
doi: 10.3390/brainsci12030301.

Currently, there is little understanding of how interoceptive attentiveness (IA) affects brain responses during synchronized cognitive or motor tasks. This pilot study explored the effect of explicit IA manipulation on hemodynamic correlates of simple cognitive tasks implying linguistic or motor synchronization. Eighteen healthy participants completed two linguistic and motor synchronization tasks during explicit IA and control conditions while oxygenated (O2Hb) and deoxygenated (HHb) hemoglobin variations were recorded by functional Near-Infrared Spectroscopy (fNIRS). The findings suggested that the brain regions associated with sustained attention, such as the right prefrontal cortex (PFC), were more involved when an explicit focus on the breath was induced during the cognitive linguistic task requiring synchronization with a partner, as indicated by increased O2Hb. Interestingly, this effect was not significant for the motor task. In conclusion, for the first time, this pilot research found increased activity in neuroanatomical regions that promote sustained attention, attention reorientation, and synchronization when a joint task is carried out and the person is focusing on their physiological body reactions. Moreover, the results suggested that the benefits of conscious concentration on physiological interoceptive correlates while executing a task demanding synchronization, particularly verbal alignment, may be related to the right PFC.

Transcutaneous electrical acupoint stimulation for children with attention-deficit/hyperactivity disorder: a randomized clinical trial.

Zhuo L(#), Zhao X(#), Zhai Y(#), Zhao B, Tian L, Zhang Y, Wang X, Zhang T, Gan X, Yang C, Wang W, Gao W, Wang Q, Rohde LA, Zhang J, Li Y.

Transl Psychiatry. 2022 Apr 21;12(1):165.
doi: 10.1038/s41398-022-01914-0.

Little is known about the effects of transcutaneous electrical acupoint stimulation (TEAS) for children with attention-deficit/hyperactivity disorder (ADHD). Here, we carried out a 4 week randomized clinical trial in which patients aged 6-12 years old with an ADHD diagnosis received TEAS or sham TEAS. The primary outcome measure was the investigator-rated Clinical Global Impression-Improvement (CGI-I) score at week 4. Secondary outcomes included changes from baseline to week 4 in the investigator-rated Clinical Global Impression-Severity of Illness (CGI-S) score, the Conners' Parent/Teacher Rating Scales-Revised: Short Form (CPRS-R: S/CTRS-R: S) score, go/no-go task performance, and functional near-infrared spectroscopy (fNIRS)-based oxygenated hemoglobin level within the prefrontal cortex. At week 4, the CGI-I score indicated improvement in 33.3% of the TEAS group compared with 7.7% of the sham group ($P = 0.005$). The TEAS group had a greater decrease in the mean CGI-S score (-0.87) than the sham TEAS group (-0.28) ($P = 0.003$). A greater enhancement in the mean cerebral oxygenated hemoglobin within the prefrontal cortex was found in the TEAS group (0.099 mM mm) compared with the sham TEAS group (0.005 mM mm) ($P < 0.001$). CPRS-R: S score, CTRS-R: S score, and go/no-go performance exhibited no significant improvement after TEAS treatment. The manipulation-associated adverse events were uncommon in both groups, and events were very mild. Our results show that noninvasive TEAS significantly improved general symptoms and increased prefrontal cortex blood flow within 4 weeks for children with ADHD. Further clinical trials are required to understand the long-term efficacy in a larger clinical sample. This trial was registered on ClinicalTrials.gov (NCT03917953).

Case Report: A Case Study on the Neurodevelopmental Profile of a Child With Pallister-Killian Syndrome and His Unaffected Twin.

Samango-Sprouse CA, Hamzik MP, Rosenbaum K, Khaksari K, Mitchell F, Kommareddi R, Brooks MR,

Tipton E, Sadeghin T, Gropman AL.
Front Pediatr. 2022 Mar 15;10:817133.
doi: 10.3389/fped.2022.817133. eCollection 2022.

Pallister-Killian syndrome is an uncommon genetic disorder that has broad developmental and multisystemic effects. While medical complications are widely reported throughout the literature, research on the neurodevelopmental profile has been limited. Case reports make up the majority of the few existing studies regarding the neurodevelopmental phenotype associated with this disorder. The current case report describes a 3-year-old male with Pallister-Killian syndrome (AF), reports the neurodevelopmental evaluation of his unaffected twin brother (MF), and outlines the results of an optical imaging study on both boys. AF presents with severe developmental delays, however, he ambulates with support and engages in conversation using his communication device. Most severely impaired was AF's speech and expressive language, with childhood apraxia of speech (CAS) as a possible explanation for these severe deficits. MF, the sibling, demonstrated neurotypical abilities and often advanced scores for his age. Both subjects completed a functional near-infrared spectroscopy (fNIRS) study, revealing decreased temporal and frontal lobe function in AF and typical functioning in MF. This case report expands on the existing literature on PKS by describing variances in fraternal twin presentation and novel reporting on fNIRS findings in both boys.

A deep convolutional neural network for estimating hemodynamic response function with reduction of motion artifacts in fNIRS.

Kim M, Lee S, Dan I, Tak S.
J Neural Eng. 2022 Feb 3;19(1).
doi: 10.1088/1741-2552/ac4bfc.

Objective. Functional near-infrared spectroscopy (fNIRS) is a neuroimaging technique for monitoring hemoglobin concentration changes in a non-invasive manner. However, subject movements are often significant sources of artifacts. While several methods have been developed for suppressing this confounding noise, the conventional techniques have limitations on optimal selections of model parameters across participants or brain regions. To address this shortcoming, we aim to propose a method based on a deep convolutional neural network (CNN).Approach. The U-net is employed as a CNN architecture. Specifically, large-scale training and testing data are generated by combining variants of hemodynamic response function (HRF) with experimental measurements of motion noises. The neural network is then trained to reconstruct hemodynamic response coupled to neuronal activity with a reduction of motion artifacts.Main results. Using extensive analysis, we show that the proposed method estimates the task-related HRF more accurately than the existing methods of wavelet decomposition and autoregressive models. Specifically, the mean squared error and variance of HRF estimates, based on the CNN, are the smallest among all methods considered in this study. These results are more prominent when the semi-simulated data contain variants of shapes and amplitudes of HRF.Significance. The proposed CNN method allows for accurately estimating amplitude and shape of HRF with significant reduction of motion artifacts. This method may have a great potential for monitoring HRF changes in real-life settings that involve excessive motion artifacts.

Effects of Acute Moderate- and High-Intensity Aerobic Exercise on Oxygenation in Prefrontal Cortex of Male Methamphetamine-Dependent Patients.

Gao S, Zhou C, Chen Y.
Front Psychol. 2022 Jan 26;13:801531.
doi: 10.3389/fpsyg.2022.801531. eCollection 2022.

The aim of this study was to explore the influence of different intensities of acute aerobic exercise on brain activation in male methamphetamine (MA)-dependent patients during exercise. Twenty MA-

dependent patients were divided randomly into two groups participating in 35 min of either moderate- or high-intensity aerobic exercise. Functional near-infrared spectral imaging (fNIRS) was used to detect hemodynamic changes in prefrontal cortex during the main 25-min exercise stage. The results revealed that high-intensity acute aerobic exercise aroused more cerebral oxygenation changes in the prefrontal cortex and left dorsolateral prefrontal cortex during exercise as compared with moderate-intensity exercise. Furthermore, there was a stronger positive connection observed between orbital frontal cortex and left dorsolateral prefrontal cortex in the high-intensity group than in the moderate-intensity group. Together these results suggest that for submaximal exercise intensities, high-intensity exercise may bring more benefits to male MA-dependent patients than moderate-intensity.

Brain bases of English morphological processing: A comparison between Chinese-English, Spanish-English bilingual, and English monolingual children.

Sun X, Marks RA, Zhang K, Yu CL, Eggleston RL, Nickerson N, Chou TL, Hu XS, Tardif T, Satterfield T, Kovelman I.

Dev Sci. 2022 Feb 21:e13251.
doi: 10.1111/desc.13251. Online ahead of print.

How do early bilingual experiences influence children's neural architecture for word processing? Dual language acquisition can yield common influences that may be shared across different bilingual groups, as well as language-specific influences stemming from a given language pairing. To investigate these effects, we examined bilingual English speakers of Chinese or Spanish, and English monolinguals, all raised in the US (N=152, ages 5-10). Children completed an English morphological word processing task during fNIRS neuroimaging. The findings revealed both language-specific and shared bilingual effects. The language-specific effects were that Chinese and Spanish bilinguals showed principled differences in their neural organization for English lexical morphology. The common bilingual effects shared by the two groups were that in both bilingual groups, increased home language proficiency was associated with stronger left superior temporal gyrus (STG) activation when processing the English word structures that are most dissimilar from the home language. The findings inform theories of language and brain development during the key periods of neural reorganization for learning to read by illuminating experience-based plasticity in linguistically diverse learners.

Whole Brain Hemodynamic Response Based on Synchrony Analysis of Brain Signals for Effective Application of HD-tDCS in Stroke Patients: An fNIRS Study.

Lee G, Lee J, Kim J, Kim H, Chang WH, Kim YH.

J Pers Med. 2022 Mar 10;12(3):432.
doi: 10.3390/jpm12030432.

In this study, the effective application of high-definition transcranial direct current stimulation (HD-tDCS) based on the whole brain hemodynamic response in stroke patients was investigated using functional near-infrared spectroscopy (fNIRS). The intrahemispheric and interhemispheric synchronization and cortical activity based on the time during 1 mA HD-tDCS were examined in 26 chronic cerebrovascular disease patients. At the beginning of HD-tDCS, the synchronization and brain activity in the whole brain increased rapidly and decreased after 5 min. In the middle of tDCS, the synchronization began to increase again, and strong synchronic connections were formed around the desired stimulation area. After tDCS, strong cortical activation was observed in the stimulation area, indicating that the baseline of the oxyhemoglobin (HbO) signal increased in the desired stimulation area. Therefore, the results of this study indicate that HD-tDCS can be applied efficiently to enhance the effect of tDCS. This stimulation method with tDCS can be explored clinically for more neurorehabilitation of patients with degenerative brain diseases.

Entropy Could Quantify Brain Activation Induced by Mechanical Impedance-Restrained Active Arm Motion: A Functional NIRS Study.

Yu B, Jang SH, Chang PH.

Entropy (Basel). 2022 Apr 15;24(4):556.
doi: 10.3390/e24040556.

Brain activation has been used to understand brain-level events associated with cognitive tasks or physical tasks. As a quantitative measure for brain activation, we propose entropy in place of signal amplitude and beta value, which are widely used, but sometimes criticized for their limitations and shortcomings as such measures. To investigate the relevance of our proposition, we provided 22 subjects with physical stimuli through elbow extension-flexion motions by using our exoskeleton robot, measured brain activation in terms of entropy, signal amplitude, and beta value; and compared entropy with the other two. The results show that entropy is superior, in that its change appeared in limited, well established, motor areas, while signal amplitude and beta value changes appeared in a widespread fashion, contradicting the modularity theory. Entropy can predict increase in brain activation with task duration, while the other two cannot. When stimuli shifted from the rest state to the task state, entropy exhibited a similar increase as the other two did. Although entropy showed only a part of the phenomenon induced by task strength, it showed superiority by showing a decrease in brain activation that the other two did not show. Moreover, entropy was capable of identifying the physiologically important location.

Prefrontal cortical activation in Internet Gaming Disorder Scale high scorers during actual real-time internet gaming: A preliminary study using fNIRS.

Cho TH, Nah Y, Park SH, Han S.

J Behav Addict. 2022 Apr 7.
doi: 10.1556/2006.2022.00017. Online ahead of print.

BACKGROUND: Observation of real-time neural characteristics during gameplay would provide distinct evidence for discriminating the currently controversial diagnosis of internet gaming disorder (IGD), and elucidate neural mechanisms that may be involved in addiction. We aimed to provide preliminary findings on possible neural features of IGD during real-time internet gaming using functional near-infrared spectroscopy (fNIRS). METHODS: Prefrontal cortical activations accompanying positive and negative in-game events were investigated. Positive events: (1) participant's champion slays or assists in slaying an opponent without being slain. (2) the opposing team's nexus is destroyed. Negative events: (1) participant's champion is slain without slaying or assisting in slaying any opponent. (2) the team's nexus is destroyed. Collected data were compared between the IGD group and control group, each with 15 participants. RESULTS: The IGD group scored significantly higher than the CTRL group on the craving scale. Following positive events, the IGD group displayed significantly stronger activation in the DLPFC. Following negative events, the IGD group displayed significantly weaker activation in the lateral OFC. DISCUSSION AND CONCLUSIONS: Individuals scoring high on the IGD scale may crave for more internet gaming after encountering desired events during the game. Such observations are supported by the correlation between the craving scale and DLPFC activation. The IGD group may also show diminished punishment sensitivity to negative in-game experiences rendering them to continue playing the game. The present study provides preliminary evidence that IGD may demonstrate neural characteristics observed in other addictive disorders and suggests the use of fNIRS in behavioral addiction studies.

Control of Transcranial Direct Current Stimulation Duration by Assessing Functional Connectivity of Near-Infrared Spectroscopy Signals.

Yaqub MA, Hong KS, Zafar A, Kim CS.

Int J Neural Syst. 2022 Jan;32(1):2150050.
doi: 10.1142/S0129065721500507. Epub 2021 Oct 5.

Transcranial direct current stimulation (tDCS) has been shown to create neuroplasticity in healthy and diseased populations. The control of stimulation duration by providing real-time brain state feedback using neuroimaging is a topic of great interest. This study presents the feasibility of a closed-loop modulation for the targeted functional network in the prefrontal cortex. We hypothesize that we cannot improve the brain state further after reaching a specific state during a stimulation therapy session. A high-definition tDCS of 1[Formula: see text]mA arranged in a ring configuration was applied at the targeted right prefrontal cortex of 15 healthy male subjects for 10[Formula: see text]min. Functional near-infrared spectroscopy was used to monitor hemoglobin chromophores during the stimulation period continuously. The correlation matrices obtained from filtered oxyhemoglobin were binarized to form subnetworks of short- and long-range connections. The connectivity in all subnetworks was analyzed individually using a new quantification measure of connectivity percentage based on the correlation matrix. The short-range network in the stimulated hemisphere showed increased connectivity in the initial stimulation phase. However, the increase in connection density reduced significantly after 6[Formula: see text]min of stimulation. The short-range network of the left hemisphere and the long-range network gradually increased throughout the stimulation period. The connectivity percentage measure showed a similar response with network theory parameters. The connectivity percentage and network theory metrics represent the brain state during the stimulation therapy. The results from the network theory metrics, including degree centrality, efficiency, and connection density, support our hypothesis and provide a guideline for feedback on the brain state. The proposed neuro-feedback scheme is feasible to control the stimulation duration to avoid overdosage.

Increased Prefrontal Activation During Verbal Fluency Task After Repetitive Transcranial Magnetic Stimulation Treatment in Depression: A Functional Near-Infrared Spectroscopy Study.

Huang J, Zhang J, Zhang T, Wang P, Zheng Z.

Front Psychiatry. 2022 Apr 4;13:876136.
doi: 10.3389/fpsyt.2022.876136. eCollection 2022.

BACKGROUND: Previous studies have shown the clinical effect of 2 Hz repetitive transcranial magnetic stimulation (rTMS) for depression; however, its underlying neural mechanisms are poorly understood. The aim of this study was to examine the effects of rTMS on the activity of the prefrontal cortex in patients with depression, using functional near-infrared spectroscopy (fNIRS). METHODS: Forty patients with major depressive disorder (MDD) and 40 healthy controls were enrolled in this study. Patients underwent 4 weeks of 2 Hz TMS delivered to the right dorsolateral prefrontal cortex (DLPFC). fNIRS was used to measure the changes in the concentration of oxygenated hemoglobin ([oxy-Hb]) in the prefrontal cortex during a verbal fluency task (VFT) in depressed patients before and after rTMS treatment. The severity of depression was assessed using the Hamilton Rating Scale for Depression-24 item (HAMD-24). RESULTS: Prior to rTMS, depressed patients exhibited significantly smaller [oxy-Hb] values in the bilateral prefrontal cortex during the VFT compared with the healthy controls. After 4 weeks of 2 Hz right DLPFC rTMS treatment, increased [oxy-Hb] values in the bilateral frontopolar prefrontal cortex (FPPFC), ventrolateral prefrontal cortex (VLPFC) and left DLPFC during the VFT were observed in depressed patients. The increased [oxy-Hb] values from baseline to post-treatment in the right VLPFC in depressed patients were positively related to the reduction of HAMD score following rTMS. CONCLUSION: These findings suggest that the function of the prefrontal cortex in depressed patients was impaired and could be recovered by 2 Hz rTMS. The fNIRS-measured prefrontal activation during a cognitive task is a potential biomarker for monitoring depressed patients' treatment response to rTMS.

Open access dataset of task-free hemodynamic activity in 4-month-old infants during sleep using fNIRS.

Blanco B, Molnar M, Carreiras M, Caballero-Gaudes C.

Sci Data. 2022 Mar 25;9(1):102.
doi: 10.1038/s41597-022-01210-y.

Spontaneous, task-free, hemodynamic activity of the brain provides useful information about its functional organization, as it can describe how different brain regions communicate to each other. Neuroimaging studies measuring the spontaneous activity of the brain are conducted while the participants are not engaged in a particular task or receiving any external stimulation. This approach is particularly useful in developmental populations as brain activity can be measured without the need for infant compliance and the risks of data contamination due to motion artifacts. In this project we sought to i) characterize the intrinsic functional organization of the brain in 4-month-old infants and ii) investigate whether bilingualism, as a specific environmental factor, could lead to adaptations on functional brain network development at this early age. Measures of spontaneous hemodynamic activity were acquired in 4-month-old infants (n = 104) during natural sleep using functional near-infrared spectroscopy (fNIRS). Emphasis was placed on acquiring high-quality data that could lead to reproducible results and serve as a valuable resource for researchers investigating the developing functional connectome.

Central effects of galcanezumab in migraine: a pilot study on Steady State Visual Evoked Potentials and occipital hemodynamic response in migraine patients.

de Tommaso M, La Rocca M, Quitadamo SG, Ricci K, Tancredi G, Clemente L, Gentile E, Ammendola E, Delussi M.

J Headache Pain. 2022 Apr 29;23(1):52.
doi: 10.1186/s10194-022-01421-z.

BACKGROUND: The discovery of the prominent action of Calcitonin Gene Related Peptide -CGRP- on trigeminal afferents and meningeal vessels, opened a new era in migraine treatment. However, how the block of nociceptive afferents could act on central mechanisms of migraine is still not clear. In this pilot study we aimed to test the effect of 3 months Galcanezumab (CGA) therapy on occipital visual reactivity in migraine patients, using the Steady State Visual Evoked Potentials-SSVEPs and Functional Near Infrared Spectroscopy -fNIRS. METHOD: Thirteen migraine patients underwent clinical and neurophysiological examination in basal condition (T0), 1 h after GCA injection (T1) and after 3 months of GCA treatment (T2). Ten healthy volunteers were also evaluated. RESULTS: At T2, there was a reduction of headache frequency and disability. At T2, the EEG power significantly diminished as compared to T0 and T1 at occipital sites, and the topographical analysis confirmed a restoration of SSVEPs within normal values. The Oxyhemoglobin levels in occipital cortex, which were basically increased during visual stimulation in migraine patients, reverted to normal values at T2. CONCLUSIONS: The present pilot study indicates that Galcanezumab could act on cortical targets located beyond the pain network, restoring the abnormal occipital reactivity. This effect could indicate the possible disease modifying properties of CGRP related monoclonal antibodies.

Task-Related Hemodynamic Changes Induced by High-Definition Transcranial Direct Current Stimulation in Chronic Stroke Patients: An Uncontrolled Pilot fNIRS Study.

Kim H, Kim J, Lee G, Lee J, Kim YH.

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doi: 10.3390/brainsci12040453.

High-definition transcranial direct current stimulation (HD-tDCS) has recently been proposed as a tDCS approach that can be used on a specific cortical region without causing undesirable stimulation

effects. In this uncontrolled pilot study, the cortical hemodynamic changes caused by HD-tDCS applied over the ipsilesional motor cortical area were investigated in 26 stroke patients. HD-tDCS using one anodal and four cathodal electrodes at 1 mA was administered for 20 min to C3 or C4 in four daily sessions. Cortical activation was measured as changes in oxyhemoglobin (oxyHb) concentration, as found using a functional near-infrared spectroscopy (fNIRS) system during the finger tapping task (FTT) with the affected hand before and after HD-tDCS. Motor-evoked potential and upper extremity functions were also measured before (T0) and after the intervention (T1). A group statistical parametric mapping analysis showed that the oxyHb concentration increased during the FTT in both the affected and unaffected hemispheres before HD-tDCS. After HD-tDCS, the oxyHb concentration increased only in the affected hemisphere. In a time series analysis, the mean and integral oxyHb concentration during the FTT showed a noticeable decrease in the channel closest to the hand motor hotspot (hMHS) in the affected hemisphere after HD-tDCS compared with before HD-tDCS, in accordance with an improvement in the function of the affected upper extremity. These results suggest that HD-tDCS might be helpful to rebalance interhemispheric cortical activity and to reduce the hemodynamic burden on the affected hemisphere during hand motor tasks. Noticeable changes in the area adjacent to the affected hMHS may imply that personalized HD-tDCS electrode placement is needed to match each patient's individual hMHS location.

Broadband-NIRS System Identifies Epileptic Focus in a Child with Focal Cortical Dysplasia-A Case Study.

Vezyroglou A, Hebden P, De Roever I, Thornton R, Mitra S, Worley A, Alves M, Dean E, Cross JH, Tachtsidis I.

Metabolites. 2022 Mar 17;12(3):260.
doi: 10.3390/metabo12030260.

Epileptic seizures are transiently occurring symptoms due to abnormal excessive or synchronous neuronal activity in the brain. Previous functional near-infrared spectroscopy (fNIRS) studies during seizures have focused in only monitoring the brain oxygenation and haemodynamic changes. However, few tools are available to measure actual cellular metabolism during seizures, especially at the bedside. Here we use an in-house developed multichannel broadband NIRS (or bNIRS) system, that, alongside the changes in oxy-, deoxy- haemoglobin concentration (HbO2, HHb), also quantifies the changes in oxidised cytochrome-c-oxidase ?(oxCCO), a marker of cellular oxygen metabolism, simultaneously over 16 different brain locations. We used bNIRS to measure metabolic activity alongside brain tissue haemodynamics/oxygenation during 17 epileptic seizures at the bedside of a 3-year-old girl with seizures due to an extensive malformation of cortical development in the left posterior quadrant. Simultaneously Video-EEG data was recorded from 12 channels. Whilst we did observe the expected increase in brain tissue oxygenation (HbD) during seizures, it was almost diminished in the area of the focal cortical dysplasia. Furthermore, in the area of seizure origination (epileptic focus) ?oxCCO decreased significantly at the time of seizure generalization when compared to the mean change in all other channels. We hypothesize that this indicates an incapacity to sustain and increase brain tissue metabolism during seizures in the region of the epileptic focus.

Three heads are better than one: cooperative learning brains wire together when a consensus is reached.

Pan Y, Cheng X, Hu Y.

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doi: 10.1093/cercor/bhac127. Online ahead of print.

Theories of human learning converge on the view that individuals working together learn better than do those working independently. Little is known, however, about the neural mechanisms of learning through cooperation. We addressed this research gap by leveraging functional near-infrared spectroscopy to record

the brain activity of triad members in a group simultaneously. Triads were instructed to analyze an ancient Chinese poem either cooperatively or independently. Four main findings emerged. First, we observed significant within-group neural synchronization (GNS) in the left superior temporal cortex, supramarginal gyrus, and postcentral gyrus during cooperative learning compared with independent learning. Second, the enhancement of GNS in triads was amplified when a consensus was reached (vs. elaboration or argument) during cooperative learning. Third, GNS was predictive of learning outcome at an early stage (156-170s after learning was initiated). Fourth, social factors such as social closeness (e.g. how much learners liked one other) were reflected in GNS and co-varied with learning engagement. These results provide neuroscientific support for Piaget's theory of cognitive development and favor the notion that successful learning through cooperation involves dynamic consensus-building, which is captured in neural patterns shared across learners in a group.

Theoretical investigation of photon partial pathlengths in multilayered turbid media.

Garca HA, Vera DA, Waks Serra MV, Baez GR, Iriarte DI, Pomarico JA.

Biomed Opt Express. 2022 Mar 28;13(4):2516-2529.
doi: 10.1364/BOE.449514. eCollection 2022 Apr 1.

Functional near infrared spectroscopy (fNIRS) is a valuable tool for assessing oxy- and deoxyhemoglobin concentration changes (?[HbO] and ?[HbR], respectively) in the human brain. To this end, photon pathlengths in tissue are needed to convert from light attenuation to ?[HbO] and ?[HbR]. Current techniques describe the human head as a homogeneous medium, in which case these pathlengths are easily computed. However, the head is more appropriately described as a layered medium; hence, the partial pathlengths in each layer are required. The current way to do this is by means of Monte Carlo (MC) simulations, which are time-consuming and computationally expensive. In this work, we introduce an approach to theoretically calculate these partial pathlengths, which are computed several times faster than MC simulations. Comparison of our approach with MC simulations show very good agreement. Results also suggest that these analytical expressions give much more specific information about light absorption in each layer than in the homogeneous case.

Reduced temporal activation during a verbal fluency test in clinical high risk of psychosis: a functional near-infrared spectroscopy-based study.

Wei Y(#), Tang X(#), Zhang T, Su W, Xu L, Cui H, Qian Z, Zhang T, Wang J.

Gen Psychiatr. 2022 Apr 28;35(2):e100702.
doi: 10.1136/gpsych-2021-100702. eCollection 2022.

BACKGROUND: Clinical high risk (CHR) of psychosis is a state in which positive symptoms cause the subjects distress but do not approach a severity level that fulfils the criteria for a psychotic episode. CHR exhibits cognitive deficits; however, the underlying neurobiological mechanisms remain unclear. This study aimed to investigate whether brain activation measured by the levels of oxygenated hemoglobin (oxy-Hb) in CHR subjects could be correlated with cognitive deficits. METHODS: Fifty-eight CHR individuals who fulfilled the criteria for attenuated positive syndrome as specified in the Structured Interview for Prodromal Syndrome (SIPS) and the Scale of Prodromal Syndrome (SOPS) and 58 age- and sex-matched healthy participants were included in the study. All subjects completed the Measurement and Treatment Research to Improve Cognition in Schizophrenia (MATRICS) Consensus Cognitive Battery (MCCB) that includes tests measuring attention, verbal memory, verbal fluency, executive function, and general intelligence. Functional near-infrared spectroscopy (fNIRS) was used to measure the level of oxy-Hb in the dorsolateral prefrontal and frontotemporal cortices. RESULTS: We observed significantly decreased oxy-Hb levels in channel 32 (located in the right superior temporal gyrus, rSTG)) within the CHR individuals compared with that in the healthy controls (HCs) (t=-3.44, Bonferroni-corrected p=0.002), indicating lower brain

activity. A significant positive correlation was observed between task-related values and working memory in the CHR group (r=0.35, p=0.008). CONCLUSIONS: The brain activation of rSTG is abnormal among subjects at clinicial high risk for psychosis. This abnormality is probably associated with the neural mechanisms of deficits in the working memory during the early stage of psychosis.

Involvement of the Rostromedial Prefrontal Cortex in Human-Robot Interaction: fNIRS Evidence From a Robot-Assisted Motor Task.

Le DT, Watanabe K, Ogawa H, Matsushita K, Imada N, Taki S, Iwamoto Y, Imura T, Araki H, Araki O, Ono T, Nishijo H, Fujita N, Urakawa S.

Front Neurorobot. 2022 Mar 17;16:795079.
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Assistive exoskeleton robots are being widely applied in neurorehabilitation to improve upper-limb motor and somatosensory functions. During robot-assisted exercises, the central nervous system appears to highly attend to external information-processing (IP) to efficiently interact with robotic assistance. However, the neural mechanisms underlying this process remain unclear. The rostromedial prefrontal cortex (rmPFC) may be the core of the executive resource allocation that generates biases in the allocation of processing resources toward an external IP according to current behavioral demands. Here, we used functional near-infrared spectroscopy to investigate the cortical activation associated with executive resource allocation during a robot-assisted motor task. During data acquisition, participants performed a right-arm motor task using elbow flexion-extension movements in three different loading conditions: robotic assistive loading (ROB), resistive loading (RES), and non-loading (NON). Participants were asked to strive for kinematic consistency in their movements. A one-way repeated measures analysis of variance and general linear model-based methods were employed to examine task-related activity. We demonstrated that hemodynamic responses in the ventral and dorsal rmPFC were higher during ROB than during NON. Moreover, greater hemodynamic responses in the ventral rmPFC were observed during ROB than during RES. Increased activation in ventral and dorsal rmPFC subregions may be involved in the executive resource allocation that prioritizes external IP during human-robot interactions. In conclusion, these findings provide novel insights regarding the involvement of executive control during a robot-assisted motor task.

How Does the Implicit Awareness of Consumers Influence the Effectiveness of Public Service Announcements? A Functional Near-Infrared Spectroscopy Study.

Fu J, Li X, Zhao X, Zhang K, Cui N.

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A large number of scholars have conducted detailed studies on the effectiveness of commercial advertising by using neuroimaging methods, but only a few scholars have used this method to study the effectiveness of public service announcements (PSAs). To research the relationship between the effectiveness of PSAs and the audience's implicit awareness, functional near-infrared spectroscopy (fNIRS) was employed to record the neural activity data of participants in this study. The results showed that there was a correlation between activation of dorsolateral prefrontal cortex (dlPFC) and the effectiveness of PSAs; The activation of the dlPFC could also be used as an indicator to represent the appeal of advertising content. The results means that neuroimaging tool can also be used to investigate the effectiveness of PSAs, not just commercial advertisements and a few PSAs study, and that neural activity can predict and improve the effectiveness of PSAs before they are released.

Synergistic Immediate Cortical Activation on Mirror Visual Feedback Combined With a Soft Robotic Bilateral Hand Rehabilitation System: A Functional Near Infrared Spectroscopy Study.

Qiu Y, Zheng Y, Liu Y, Luo W, Du R, Liang J, Yilifate A, You Y, Jiang Y, Zhang J, Chen A, Zhang Y, Huang S, Wang B, Ou H, Lin Q.

Front Neurosci. 2022 Feb 4;16:807045.
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BACKGROUND: Mirror visual feedback (MVF) has been widely used in neurological rehabilitation. Due to the potential gain effect of the MVF combination therapy, the related mechanisms still need be further analyzed. METHODS: Our self-controlled study recruited 20 healthy subjects (age 22.150 2.661 years) were asked to perform four different visual feedback tasks with simultaneous functional near infrared spectroscopy (fNIRS) monitoring. The right hand of the subjects was set as the active hand (performing active movement), and the left hand was set as the observation hand (static or performing passive movement under soft robotic bilateral hand rehabilitation system). The four VF tasks were designed as RVF Task (real visual feedback task), MVF task (mirror visual feedback task), BRM task (bilateral robotic movement task), and MVF + BRM task (Mirror visual feedback combined with bilateral robotic movement task). RESULTS: The beta value of the right pre-motor cortex (PMC) of MVF task was significantly higher than the RVF task (RVF task: -0.015 0.029, MVF task: 0.011 0.033, P = 0.033). The beta value right primary sensorimotor cortex (SM1) in MVF + BRM task was significantly higher than MVF task (MVF task: 0.006 0.040, MVF + BRM task: 0.037 0.036, P = 0.016). CONCLUSION: Our study used the synchronous fNIRS to compare the immediate hemodynamics cortical activation of four visual feedback tasks in healthy subjects. The results showed the synergistic gain effect on cortical activation from MVF combined with a soft robotic bilateral hand rehabilitation system for the first time, which could be used to guide the clinical application and the future studies.

Laterality of prefrontal hemodynamic response measured by functional near-infrared spectroscopy before and after repetitive transcranial magnetic stimulation: A potential biomarker of clinical outcome.

Yamazaki R, Inoue Y, Matsuda Y, Kodaka F, Kitamura Y, Kita Y, Shigeta M, Kito S.

Psychiatry Res. 2022 Apr;310:114444.
doi: 10.1016/j.psychres.2022.114444. Epub 2022 Feb 13.

The factors associated with the clinical outcomes of repetitive transcranial magnetic stimulation (rTMS) in patients with major depressive disorder (MDD) remain largely unexplored. Therefore, this study aimed to examine whether rTMS can change the functional laterality of the prefrontal hemodynamic response and whether baseline functional laterality can predict the clinical outcomes of rTMS using functional near-infrared spectroscopy (fNIRS). We included 19 patients with MDD who were treated with high-frequency rTMS. The verbal fluency task was used as the activation task. We calculated the laterality index (LI) based on the task-related oxygenation response in the frontal region. First, the LI was compared before and after rTMS treatment. Second, the reduction in the Montgomery-sberg Depression Rating Scale (MADRS) score was compared between the rightward dominance group (pre-LI < 0) and the leftward dominance group (pre-LI $= 0$). The findings showed a significant change in the LI after rTMS treatment. The rightward dominance group had a significantly greater reduction in MADRS score than the leftward dominance group. Subsequently, the laterality of the task-related hemodynamic response of the prefrontal region shifted leftward following left high-frequency rTMS treatment. Thus, the pre-LI calculated using fNIRS data is a possible predictor of rTMS outcomes in patients with MDD.

Differentiation of task complexity in long-term memory retrieval using multifractal

detrended fluctuation analysis of fNIRS recordings.

Kubota M, Zouridakis G.

Exp Brain Res. 2022 Apr 24.
doi: 10.1007/s00221-022-06365-z. Online ahead of print.

The retrieval of phonological, lexical, semantic, or syntactic language information from long-term memory plays an important role in language processing. However, it remains unclear whether variability analysis of brain signals obtained using functional near-infrared spectroscopy (fNIRS) is able to separate language-related task conditions. This study employed multifractal detrended fluctuation (MFDF) analysis focusing on the width of the multifractal spectrum to elucidate whether high complexity tasks increase the fractal dynamics of brain activation signals compared to low complexity tasks. Nine Japanese college students participated in a long-term memory retrieval experiment using low (n 1) and high (n 2) complexity tasks. Our results showed that high complexity tasks induced a significantly larger multifractal spectral width in the posterior medial temporal gyri bilaterally, due to higher cognitive demands. These findings suggest that in addition to conventional techniques based on mean amplitude analysis and general linear modelling of fNIRS data, the use of MFDF analysis offers a powerful alternative methodology to gain a deeper understanding of long-term memory retrieval in language memory processing.