fNIRS publications on PubMed: Nov 1, 2020 - Mar 31, 2021

Felipe Orihuela-Espina

Methodology. Searches were made in PubMed constraining the search period between Nov 1, 2020 and Mar 31, 2021. These were later processed for readability but no records were otherwise added or removed. In the preparation of this file, the following searches have been executed:

- fNIRS

Zheng J(1)(2), Shi P(1)(2)(3), Fan M(1)(2), Liang S(1)(2), Li S(1)(2), Yu H(1)(2)(3).
Author information: Institute of rehabilitation engineering and technology, University of Shanghai for Science and Technology. Shanghai Engineering Research Center of Assistive Devices. Key Laboratory of Neural-functional Information and Rehabilitation Engineering of the Ministry of Civil Affairs, Shanghai, People's Republic of China.
Effects of passive and active training modes of upper-limb rehabilitation robot on cortical activation: a functional near-infrared spectroscopy study.

Effect of force accuracy on hemodynamic response: an fNIRS study using fine visuomotor task.
Zheng Y, Tian B, Zhang Y, Wang D.
J Neural Eng. Mar
doi: 10.1088/1741-2552/abfOnline ahead of print.

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

insights obtained through this study also highlight the essential role of inter-region connectivity alterations for coping with task difficulty, enhance our understanding of the underlying motor neural processes, and provide the groundwork for developing adaptive neurorehabilitation strategies.

The impact of TMS-enhanced cognitive control on forgiveness processes.
Maier MJ, Rosenbaum D, Brne M, Fallgatter AJ, Ehlis AC.
Brain Behav. Mar 30:e
doi: 10.1002/brb3.Online ahead of print.

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

The acute effect of moderate-intensity exercise on inhibitory control and activation of prefrontal cortex in younger and older adults.
Fujihara H, Megumi A, Yasumura A.
Exp Brain Res. Mar
doi: 10.1007/s00221-021-06086-Online ahead of print.

Exercise has a significant effect on maintaining the health of inhibitory function, a fundamental cognitive ability that supports daily mental processes. While previous studies have shown that a single bout of exercise, called acute exercise, could improve inhibitory control by stimulating the prefrontal cortex (PFC) and the arousal state, few studies have focused on the differences in the effects of exercise by age. In this study, young and older adults (mean age, 22.7 1.4 and 68.7 5.3years, respectively) engaged in acute moderate-intensity exercise and inhibitory control. Before and at 5 and 30min after exercise, the participants were asked to complete the reverse Stroop task, and their arousal state and PFC activity were measured using functional near-infrared spectroscopy. The findings showed that the overall inhibitory control improved immediately after performing acute exercise and remained improved even after 30min. Particularly, there was a difference in the arousal state and middle PFC activity between the two age groups. Especially, the young adults showed an increase in the arousal state post-exercise, while the older adults tended to show an increase in the middle PFC activity. These results suggested that the acute exercise effects on the arousal state and PFC activity may vary depending on the developmental stage, but not for inhibitory control overtime. When these findings are considered, it is important to note that the exercise impact on cognitive control remained the same throughout the generations despite the observed changes in its impact on internal states.

Decoding of semantic categories of imagined concepts of animals and tools in fNIRS.
Ryb?M, Poli R, Daly I.
J Neural Eng. Mar

doi: 10.1088/1741-2552/abf2eOnline ahead of print.

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

Subject-Independent Functional Near-Infrared Spectroscopy-Based Brain-Computer Interfaces Based on Convolutional Neural Networks.

Kwon J, Im CH.

Front Hum Neurosci. Mar 12;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Functional near-infrared spectroscopy (fNIRS) has attracted increasing attention in the field of brain-computer interfaces (BCIs) owing to their advantages such as non-invasiveness, user safety, affordability, and portability. However, fNIRS signals are highly subject-specific and have low test-retest reliability. Therefore, individual calibration sessions need to be employed before each use of fNIRS-based BCI to achieve a sufficiently high performance for practical BCI applications. In this study, we propose a novel deep convolutional neural network (CNN)-based approach for implementing a subject-independent fNIRS-based BCI. A total of 18 participants performed the fNIRS-based BCI experiments, where the main goal of the experiments was to distinguish a mental arithmetic task from an idle state task. Leave-one-subject-out cross-validation was employed to evaluate the average classification accuracy of the proposed subject-independent fNIRS-based BCI. As a result, the average classification accuracy of the proposed method was reported to be 71.20 8.74%, which was higher than the threshold accuracy for effective BCI communication (70%) as well as that obtained using conventional shrinkage linear discriminant analysis (65.74 7.68%). To achieve a classification accuracy comparable to that of the proposed subject-independent fNIRS-based BCI, 24 training trials (of approximately 12 min) were necessary for the traditional subject-dependent fNIRS-based BCI. It is expected that our CNN-based approach would reduce the necessity of long-term individual calibration sessions, thereby enhancing the practicality of fNIRS-based BCIs significantly.

Influence of iTBS on the Acute Neuroplastic Change After BCI Training.

Ding Q, Lin T, Wu M, Yang W, Li W, Jing Y, Ren X, Gong Y, Xu G, Lan Y.

Front Cell Neurosci. Mar 12;15:
doi: 10.3389/fncel.2021. eCollection 2021.

Objective: Brain-computer interface (BCI) training is becoming increasingly popular in neurorehabilitation. However, around one third subjects have difficulties in controlling BCI devices effectively, which limits the application of BCI training. Furthermore, the effectiveness of BCI training is not satisfactory in stroke rehabilitation. Intermittent theta burst stimulation (iTBS) is a powerful neural modulatory

approach with strong facilitatory effects. Here, we investigated whether iTBS would improve BCI accuracy and boost the neuroplastic changes induced by BCI training. Methods: Eight right-handed healthy subjects (four males, age: 20-24) participated in this two-session study (BCI-only session and iTBS+BCI session in random order). Neuroplastic changes were measured by functional near-infrared spectroscopy (fNIRS) and single-pulse transcranial magnetic stimulation (TMS). In BCI-only session, fNIRS was measured at baseline and immediately after BCI training. In iTBS+BCI session, BCI training was followed by iTBS delivered on the right primary motor cortex (M1). Single-pulse TMS was measured at baseline and immediately after iTBS. fNIRS was measured at baseline, immediately after iTBS, and immediately after BCI training. Paired-sample t-tests were used to compare amplitudes of motor-evoked potentials, cortical silent period duration, oxygenated hemoglobin (HbO2) concentration and functional connectivity across time points, and BCI accuracy between sessions. Results: No significant difference in BCI accuracy was detected between sessions ($p > 0.05$). In BCI-only session, functional connectivity matrices between motor cortex and prefrontal cortex were significantly increased after BCI training (p's < 0.05). In iTBS+BCI session, amplitudes of motor-evoked potentials were significantly increased after iTBS (p's < 0.05), but no change in HbO2 concentration or functional connectivity was observed throughout the whole session (p's > 0.05). Conclusions: To our knowledge, this is the first study that investigated how iTBS targeted on M1 influences BCI accuracy and the acute neuroplastic changes after BCI training. Our results revealed that iTBS targeted on M1 did not influence BCI accuracy or facilitate the neuroplastic changes after BCI training. Therefore, M1 might not be an effective stimulation target of iTBS for the purpose of improving BCI accuracy or facilitate its effectiveness; other brain regions (i.e., prefrontal cortex) are needed to be further investigated as potentially effective stimulation targets.

Applications of brain imaging methods in driving behaviour research.

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

Accid Anal Prev. Mar 23;154:
doi: 10.1016/j.aap.2021.Online ahead of print.

Applications of neuroimaging methods have substantially contributed to the scientific understanding of human factors during driving by providing a deeper insight into the neuro-cognitive aspects of driver brain. This has been achieved by conducting simulated (and occasionally, field) driving experiments while collecting driver brain signals of various types. Here, this sector of studies is comprehensively reviewed at both macro and micro scales. At the macro scale, bibliometric aspects of these studies are analysed. At the micro scale, different themes of neuroimaging driving behaviour research are identified and the findings within each theme are synthesised. The surveyed literature has reported on applications of four major brain imaging methods. These include Functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), Functional Near-Infrared Spectroscopy (fNIRS) and Magnetoencephalography (MEG), with the first two being the most common methods in this domain. While collecting driver fMRI signal has been particularly instrumental in studying neural correlates of intoxicated driving (e.g. alcohol or cannabis) or distracted driving, the EEG method has been predominantly utilised in relation to the efforts aiming at development of automatic fatigue/drowsiness detection systems, a topic to which the literature on neuro-ergonomics of driving particularly has shown a spike of interest within the last few years. The survey also reveals that topics such as driver brain activity in semi-automated settings or neural activity of drivers with brain injuries or chronic neurological conditions have by contrast been investigated to a very limited extent. Potential topics in driving behaviour research are identified that could benefit from the adoption of neuroimaging methods in future studies. In terms of practicality, while fMRI and MEG experiments have proven rather invasive and technologically challenging for adoption in driving behaviour research, EEG and fNIRS applications have been more diverse. They have even been tested beyond simulated driving settings, in field driving experiments. Advantages and limitations of each of these four neuroimaging methods in the context of driving behaviour experiments are outlined in the paper.

Age-related deterioration of performance and increase of cortex activity comparing time- versus item-controlled fNIRS measurement.

Blum L, Rosenbaum D, Rben B, Dehnen K, Maetzler W, Suenkel U, Fallgatter AJ, Ehlis AC, Metzger FG.

Sci Rep. Mar 24;11(1):
doi: 10.1038/s41598-021-85762-w.

In our aging society, research into neurodegenerative processes is of great interest. Thereby, cortical activation under different neurocognitive conditions is considered to be a promising predictor. Against this background, the executive functions of a total of 250 healthy older adults (53-84years) have been investigated using the Trail Making Test (TMT) and functional near-infrared spectroscopy in a block design. We investigated effects of age on the performance and cortical blood oxygenation during the TMT. Since it is assumed that older people may compensate for cognitive deficits by slowing their processing speed, we additionally analyzed the cortical blood oxygenation per solved item. Our results showed a significant decrease in processing speed in older participants compared to middle-aged individuals, however, also lower error rates during TMTpart A. On a neurophysiological level, we observed increased cortical blood oxygenation in the older participants when completing the TMT. Finally, with respect to the combined measurement (O2Hb/item), no significantly higher hemodynamic cortical response per item was found within the older participants. The results confirm a deterioration of cognitive performance and an increase of cortical activity with increasing age. The findings are discussed in the light of current research.

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

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

J Neural Eng. Mar
doi: 10.1088/1741-2552/abfOnline ahead of print.

Development of a Brain-Computer Interface (BCI) requires classification of brain neural activities to different states. Functional Near-Infrared Spectroscopy (fNIRS) can measure the brain activities and has great potential for BCI. In recent years, a large number of classification algorithms have been proposed, in which deep learning methods, especially Convolutional Neural Network (CNN) methods are successful. fNIRS signal has typical time series properties, we combined fNIRS data and kinds of CNN-based Time Series Classification (TSC) methods to classify BCI task. In this study, participants were recruited for a Left and Right Hand Motor Imagery experiment and the cerebral neural activities were recorded by fNIRS equipment (FOIRE-3000). TSC methods are used to distinguish the brain activities when imagining the left or right hand. We have tested the overall person, single person and overall person with single-channel classification results, and these methods achieved excellent classification results. We also compared the CNN-based TSC methods with traditional classification methods such as SVM. Experiments showed that the CNN-based methods have significant advantages in classification accuracy: the CNN-based methods have achieved remarkable results in the classification of left-handed and right-handed imagination tasks, reaching 98.6% accuracy on overall person, 100% accuracy on single person, and in the single-channel classification an accuracy of 80.1% has been achieved with the best-performing channel. These results suggest that using the CNN-based TSC methods can significantly improve the BCI performance and also lay the foundation for the miniaturization and portability of training rehabilitation equipment.

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

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

Biol Psychol. Mar 20;161:
doi: 10.1016/j.biopsycho.2021. Online ahead of print.

Affective and anxiety disorders are the most prevalent and incident psychiatric disorders worldwide. Therapeutic approaches to these disorders using non-invasive brain stimulation (NIBS) and analogous techniques have been extensively investigated. In this paper, we discuss the combination of NIBS and neurofeedback in closed-loop setups and its application for affective symptoms and disorders. For this, we first provide a rationale for this combination by presenting some of the main original findings of NIBS, with a primary focus on transcranial magnetic stimulation (TMS), and neurofeedback, including protocols based on electroencephalography (EEG) and functional magnetic resonance imaging (fMRI). Then, we provide a scope review of studies combining real-time neurofeedback with NIBS protocols in the so-called closed-loop brain state-dependent neuromodulation (BSDS). Finally, we discuss the concomitant use of TMS and real-time functional near-infrared spectroscopy (fNIRS) as a possible solution to the current limitations of BSDS-based protocols for affective and anxiety disorders.

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

Orcioli-Silva D, Vit?? R, N??ga-Sousa P, Beretta VS, Concei? NRD, Oliveira AS, Pereira MP, Gobbi LTB.

Neurorehabil Neural Repair. Mar 23:

doi: 10.1177/Online ahead of print.

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

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

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

Exp Brain Res. Mar

doi: 10.1007/s00221-021-06073-Online ahead of print.

The Corsi Block-Tapping test (CBT) is a measure of spatial working memory (WM) in clinical practice, requiring an examinee to reproduce sequences of cubes tapped by an examiner. CBT implies complementary behaviors in the examiners and the examinees, as they have to attend a precise turn taking. Previous studies demonstrated that the Prefrontal Cortex (PFC) is activated during CBT, but scarce evidence is available on the neural correlates of CBT in the real setting. We assessed PFC activity in dyads of

examiner-examinee participants while completing the real version of CBT, during conditions of increasing and exceeding workload. This procedure allowed to investigate whether brain activity in the dyads is coordinated. Results in the examinees showed that PFC activity was higher when the workload approached or reached participants' spatial WM span, and lower during workload conditions that were largely below or above their span. Interestingly, findings in the examiners paralleled the ones in the examinees, as examiners' brain activity increased and decreased in a similar way as the examinees' one. In the examiners, higher left-hemisphere activity was observed suggesting the likely activation of non-spatial WM processes. Data support a bell-shaped relationship between cognitive load and brain activity, and provide original insights on the cognitive processes activated in the examiner during CBT.

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

Galati A, Schoppa R, Lu A.

IEEE Trans Vis Comput Graph. Mar 22;PP.

doi: 10.1109/TVCG.2021. Online ahead of print.

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

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

Behav Brain Res. Mar 15;406:

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

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

Comparing different pre-processing routines for infant fNIRS data.

Gemignani J, Gervain J.

Dev Cogn Neurosci. Mar 11;48:

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

Functional Near Infrared Spectroscopy (fNIRS) is an important neuroimaging technique in cognitive developmental neuroscience. Nevertheless, there is no general consensus yet about best pre-processing practices. This issue is highly relevant, especially since the development and variability of the infant hemodynamic response (HRF) is not fully known. Systematic comparisons between analysis methods are

thus necessary. We investigated the performance of five different pipelines, selected on the basis of a systematic search of the infant NIRS literature, in two experiments. In Experiment 1, we used synthetic data to compare the recovered HRFs with the true HRF and to assess the robustness of each method against increasing levels of noise. In Experiment 2, we analyzed experimental data from a published study, which assessed the neural correlates of artificial grammar processing in newborns. We found that with motion artifact correction (as opposed to rejection) a larger number of trials were retained, but HRF amplitude was often strongly reduced. By contrast, artifact rejection resulted in a high exclusion rate but preserved adequately the characteristics of the HRF. We also found that the performance of all pipelines declined as the noise increased, but significantly less so than if no pre-processing was applied. Finally, we found no difference between running the pre-processing on optical density or concentration change data. These results suggest that pre-processing should thus be optimized as a function of the specific quality issues a give dataset exhibits.

Deconvolution of hemodynamic responses along the cortical surface using personalized functional near infrared spectroscopy.

Machado A, Cai Z, Vincent T, Pellegrino G, Lina JM, Kobayashi E, Grova C.

Sci Rep. Mar 16;11(1):

doi: 10.1038/s41598-021-85386-0.

In functional near infrared spectroscopy (fNIRS), deconvolution analysis of oxy and deoxy-hemoglobin concentration changes allows estimating specific hemodynamic response functions (HRF) elicited by neuronal activity, taking advantage of the fNIRS excellent temporal resolution. Diffuse optical tomography (DOT) is also becoming the new standard reconstruction procedure as it is more accurate than the modified Beer Lambert law approach at the sensor level. The objective of this study was to assess the relevance of HRF deconvolution after DOT constrained along the cortical surface. We used local personalized fNIRS montages which consists in optimizing the position of fNIRS optodes to ensure maximal sensitivity to subject specific target brain regions. We carefully evaluated the accuracy of deconvolution when applied after DOT, using realistic simulations involving several HRF models at different signal to noise ratio (SNR) levels and on real data related to motor and visual tasks in healthy subjects and from spontaneous pathological activity in one patient with epilepsy. We demonstrated that DOT followed by deconvolution was able to accurately recover a large variability of HRFs over a large range of SNRs. We found good performances of deconvolution analysis for SNR levels usually encountered in our applications and we were able to reconstruct accurately the temporal dynamics of HRFs in real conditions.

Rehabilitation with accurate adaptability walking tasks or steady state walking: A randomized clinical trial in adults post-stroke.

Clark DJ, Rose DK, Butera KA, Hoisington B, DeMark L, Chatterjee SA, Hawkins KA, Otzel DM, Skinner JW, Christou EA, Wu SS, Fox EJ.

Clin Rehabil. Mar 16:

doi: 10.1177/ Online ahead of print.

OBJECTIVE: To assess changes in walking function and walking-related prefrontal cortical activity following two post-stroke rehabilitation interventions: an accurate adaptability (ACC) walking intervention and a steady state (SS) walking intervention. DESIGN: Randomized, single blind, parallel group clinical trial. SETTING: Hospital research setting. SUBJECTS: Adults with chronic post-stroke hemiparesis and walking deficits. INTERVENTIONS: ACC emphasized stepping accuracy and walking adaptability, while SS emphasized steady state, symmetrical stepping. Both included 36 sessions led by a licensed physical therapist. ACC walking tasks recruit cortical regions that increase corticospinal tract activation, while SS walking activates the corticospinal tract less intensely. MAIN MEASURES: The primary functional

outcome measure was preferred steady state walking speed. Prefrontal brain activity during walking was measured with functional near infrared spectroscopy to assess executive control demands. Assessments were conducted at baseline, post-intervention (three months), and follow-up (six months). RESULTS: Thirty-eight participants were randomized to the study interventions (mean age 59.6 9.1 years; mean months post-stroke 18.0 10.5). Preferred walking speed increased from baseline to post-intervention by 0.13 0.11 m/s in the ACC group and by 0.14 0.13 m/s in the SS group. The Time ?Group interaction was not statistically significant (P = 0.86). Prefrontal fNIRS during walking decreased from baseline to post-intervention, with a marginally larger effect in the ACC group (P = 0.05). CONCLUSIONS: The ACC and SS interventions produced similar changes in walking function. fNIRS suggested a potential benefit of ACC training for reducing demand on prefrontal (executive) resources during walking.

Language Familiarity and Proficiency Leads to Differential Cortical Processing During Translation Between Distantly Related Languages.

Shinozuka K, Niioka K, Tokuda T, Kyutoku Y, Okuno K, Takahashi T, Dan I.

Front Hum Neurosci. Feb 26;15:

doi: 10.3389/fnhum.2021. eCollection 2021.

In the midst of globalization, English is regarded as an international language, or Lingua Franca, but learning it as a second language (L2) remains still difficult to speakers of other languages. This is true especially for the speakers of languages distantly related to English such as Japanese. In this sense, exploring neural basis for translation between the first language (L1) and L2 is of great interest. There have been relatively many previous researches revealing brain activation patterns during translations between L1 and English as L2. These studies, which focused on language translation with close or moderate linguistic distance (LD), have suggested that the Broca area (BA 44/45) and the dorsolateral prefrontal cortex (DLPFC; BA 46) may play an important role on translation. However, the neural mechanism of language translation between Japanese and English, having large LD, has not been clarified. Thus, we used functional near infrared spectroscopy (fNIRS) to investigate the brain activation patterns during word translation between Japanese and English. We also assessed the effects of translation directions and word familiarity. All participants' first language was Japanese and they were learning English. Their English proficiency was advanced or elementary. We selected English and Japanese words as stimuli based on the familiarity for Japanese people. Our results showed that the brain activation patterns during word translation largely differed depending on their English proficiency. The advanced group elicited greater activation on the left prefrontal cortex around the Broca's area while translating words with low familiarity, but no activation was observed while translating words with high familiarity. On the other hand, the elementary group evoked greater activation on the left temporal area including the superior temporal gyrus (STG) irrespective of the word familiarity. These results suggested that different cognitive process could be involved in word translation corresponding to English proficiency in Japanese learners of English. These difference on the brain activation patterns between the advanced and elementary group may reflect the difference on the cognitive loads depending on the levels of automatization in one's language processing.

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

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

Curr Opin Biomed Eng. Jun;18:

doi: 10.1016/j.cobme.2021.Epub Feb 3.

Functional Near-Infrared Spectroscopy (fNIRS) assesses human brain activity by noninvasively mea-

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

Decoding of Walking Imagery and Idle State Using Sparse Representation Based on fNIRS.

Li H, Gong A, Zhao L, Zhang W, Wang F, Fu Y.

Comput Intell Neurosci. Feb 22;2021:
doi: 10.1155/2021/ eCollection 2021.

OBJECTIVES: Brain-computer interface (BCI) based on functional near-infrared spectroscopy (fNIRS) is expected to provide an optional active rehabilitation training method for patients with walking dysfunction, which will affect their quality of life seriously. Sparse representation classification (SRC) oxyhemoglobin (HbO) concentration was used to decode walking imagery and idle state to construct fNIRS-BCI based on walking imagery. METHODS: 15 subjects were recruited and fNIRS signals were collected during walking imagery and idle state. Firstly, band-pass filtering and baseline drift correction for HbO signal were carried out, and then the mean value, peak value, and root mean square (RMS) of HbO and their combinations were extracted as classification features; SRC was used to identify the extracted features and the result of SRC was compared with those of support vector machine (SVM), K-Nearest Neighbor (KNN), linear discriminant analysis (LDA), and logistic regression (LR). RESULTS: The experimental results showed that the average classification accuracy for walking imagery and idle state by SRC using three features combination was 91.553.30%, which was significantly higher than those of SVM, KNN, LDA, and LR (86.374.42%, 85.655.01%, 86.434.41%, and 76.145.32%, respectively), and the classification accuracy of other combined features was higher than that of single feature. CONCLUSIONS: The study showed that introducing SRC into fNIRS-BCI can effectively identify walking imagery and idle state. It also showed that different time windows for feature extraction have an impact on the classification results, and the time window of 2-8 s achieved a better classification accuracy (94.332.60%) than other time windows. Significance. The study was expected to provide a new and optional active rehabilitation training method for patients with walking dysfunction. In addition, the experiment was also a rare study based on fNIRS-BCI using SRC to decode walking imagery and idle state.

Characterizing the Action-Observation Network Through Functional Near-Infrared Spectroscopy: A Review.

Condy EE, Miguel HO, Millerhagen J, Harrison D, Khaksari K, Fox N, Gandjbakhche A.

Front Hum Neurosci. Feb 18;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Functional near-infrared spectroscopy (fNIRS) is a neuroimaging technique that has undergone tremendous growth over the last decade due to methodological advantages over other measures of brain activation. The action-observation network (AON), a system of brain structures proposed to have "mirroring" abilities (e.g., active when an individual completes an action or when they observe another complete that action), has been studied in humans through neural measures such as fMRI and electroencephalogram (EEG); however, limitations of these methods are problematic for AON paradigms. For this reason, fNIRS is proposed as a solution to investigating the AON in humans. The present review article briefly summarizes previous

neural findings in the AON and examines the state of AON research using fNIRS in adults. A total of 14 fNIRS articles are discussed, paying particular attention to methodological choices and considerations while summarizing the general findings to aid in developing better protocols to study the AON through fNIRS. Additionally, future directions of this work are discussed, specifically in relation to researching AON development and potential multimodal imaging applications.

Feasibility of combining functional near-infrared spectroscopy with electroencephalography to identify chronic stroke responders to cerebellar transcranial direct current stimulation-a computational modeling and portable neuroimaging methodological study.

Rezaee Z, Ranjan S, Solanki D, Bhattacharya M, Srivastava MVP, Lahiri U, Dutta A.

Cerebellum. Mar
doi: 10.1007/s12311-021-01249-Online ahead of print.

Feasibility of portable neuroimaging of cerebellar transcranial direct current stimulation (ctDCS) effects on the cerebral cortex has not been investigated vis-?is cerebellar lobular electric field strength. We studied functional near-infrared spectroscopy (fNIRS) in conjunction with electroencephalography (EEG) to measure changes in the brain activation at the prefrontal cortex (PFC) and the sensorimotor cortex (SMC) following ctDCS as well as virtual reality-based balance training (VBaT) before and after ctDCS treatment in 12 hemiparetic chronic stroke survivors. We performed general linear modeling (GLM) that putatively associated the lobular electric field strength with the changes in the fNIRS-EEG measures at the ipsilesional and contra-lesional PFC and SMC. Here, fNIRS-EEG measures were found in the latent space from canonical correlation analysis (CCA) between the changes in total hemoglobin (tHb) concentrations (0.01-0.07Hz and 0.07-0.13Hz bands) and log10-transformed EEG bandpower within 1-45 Hz where significant (Wilks' lambda>0.95) canonical correlations were found only for the 0.07-0.13-Hz band. Also, the first principal component (97.5% variance accounted for) of the mean lobular electric field strength was a good predictor of the latent variables of oxy-hemoglobin (O2Hb) concentrations and log10-transformed EEG bandpower. GLM also provided insights into non-responders to ctDCS who also performed poorly in the VBaT due to ideomotor apraxia. Future studies should investigate fNIRS-EEG joint-imaging in a larger cohort to identify non-responders based on GLM fitting to the fNIRS-EEG data.

Cortical Effects of Noisy Galvanic Vestibular Stimulation Using Functional Near-Infrared Spectroscopy.

Vald?BA, Lajoie K, Marigold DS, Menon C.

Sensors (Basel). Feb 20;21(4):
doi: 10.3390/s21041476.

Noisy galvanic vestibular stimulation (nGVS) can improve different motor, sensory, and cognitive behaviors. However, it is unclear how this stimulation affects brain activity to facilitate these improvements. Functional near-infrared spectroscopy (fNIRS) is inexpensive, portable, and less prone to motion artifacts than other neuroimaging technology. Thus, fNIRS has the potential to provide insight into how nGVS affects cortical activity during a variety of natural behaviors. Here we sought to: (1) determine if fNIRS can detect cortical changes in oxygenated (HbO) and deoxygenated (HbR) hemoglobin with application of subthreshold nGVS, and (2) determine how subthreshold nGVS affects this fNIRS-derived hemodynamic response. A total of twelve healthy participants received nGVS and sham stimulation during a seated, resting-state paradigm. To determine whether nGVS altered activity in select cortical regions of interest (BA40, BA39), we compared differences between nGVS and sham HbO and HbR concentrations. We found a greater HbR response during nGVS compared to sham stimulation in left BA40, a region previously associated with vestibular processing, and with all left hemisphere channels combined ($p < 0.05$). We did not detect differences in HbO responses for any region during nGVS ($p > 0.05$). Our results suggest that

fNIRS may be suitable for understanding the cortical effects of nGVS.

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

Yeung MK, Lee TL, Chan AS.

Psychophysiology. Mar 4:e
doi: 10.1111/psyp.Online ahead of print.

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

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

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

Pain Med. Feb 28:pnaa
doi: 10.1093/pm/pnaaOnline ahead of print.

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

study may lead to a simple and readily accessible objective measure of pain.

Brain Activation Changes While Walking in Adults with and without Neurological Disease: Systematic Review and Meta-Analysis of Functional Near-Infrared Spectroscopy Studies.

Bishnoi A, Holtzer R, Hernandez ME.

Brain Sci. Feb 26;11(3):

doi: 10.3390/brainsci11030291.

(1) Functional near-infrared spectroscopy (fNIRS) provides a useful tool for monitoring brain activation changes while walking in adults with neurological disorders. When combined with dual task walking paradigms, fNIRS allows for changes in brain activation to be monitored when individuals concurrently attend to multiple tasks. However, differences in dual task paradigms, baseline, and coverage of cortical areas, presents uncertainty in the interpretation of the overarching findings. (2) Methods: By conducting a systematic review of 35 studies and meta-analysis of 75 effect sizes from 17 studies on adults with or without neurological disorders, we show that the performance of obstacle walking, serial subtraction and letter generation tasks while walking result in significant increases in brain activation in the prefrontal cortex relative to standing or walking baselines. (3) Results: Overall, we find that letter generation tasks have the largest brain activation effect sizes relative to walking, and that significant differences between dual task and single task gait are seen in persons with multiple sclerosis and stroke. (4) Conclusions: Older adults with neurological disease generally showed increased brain activation suggesting use of more attentional resources during dual task walking, which could lead to increased fall risk and mobility impairments. PROSPERO ID: 235228.

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

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

Brain Cogn. Feb 25;150:

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

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

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

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

Dev Cogn Neurosci. Feb 19;48:

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

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

Activation of Prefrontal Cortex in Process of Oral and Finger Shape Discrimination: fNIRS Study.

Narita N, Kamiya K, Iwaki S, Ishii T, Endo H, Shimosaka M, Uchida T, Kantake I, Shibutani K.

Front Neurosci. Feb 5;15:
doi: 10.3389/fnins.2021. eCollection 2021.

BACKGROUND: The differences in the brain activities of the insular and the visual association cortices have been reported between oral and manual stereognosis. However, these results were not conclusive because of the inherent differences in the task performance-related motor sequence conditions. We hypothesized that the involvement of the prefrontal cortex may be different between finger and oral shape discrimination. This study was conducted to clarify temporal changes in prefrontal activities occurring in the processes of oral and finger tactual shape discrimination using prefrontal functional near-infrared spectroscopy (fNIRS). METHODS: Six healthy right-handed males [aged 30.8 8.2 years (mean SD)] were enrolled. Measurements of prefrontal activities were performed using a 22-channel fNIRS device (ETG-100, Hitachi Medical Co., Chiba, Japan) during experimental blocks that included resting state (REST), nonsense shape discrimination (SHAM), and shape discrimination (SHAPE). RESULTS: No significant difference was presented with regard to the number of correct answers during trials between oral and finger SHAPE discrimination. Additionally, a statistical difference for the prefrontal fNIRS activity between oral and finger shape discrimination was noted in CH 1. Finger SHAPE, as compared with SHAM, presented a temporally shifting onset and burst in the prefrontal activities from the frontopolar area (FPA) to the orbitofrontal cortex (OFC). In contrast, oral SHAPE as compared with SHAM was shown to be temporally overlapped in the onset and burst of the prefrontal activities in the dorsolateral prefrontal cortex (DLPFC)/FPA/OFC. CONCLUSION: The prefrontal activities temporally shifting from the FPA to the OFC during SHAPE as compared with SHAM may suggest the segregated serial prefrontal processing from the manipulation of a target image to the decision making during the process of finger shape discrimination. In contrast, the temporally overlapped prefrontal activities of the DLPFC/FPA/OFC in the oral SHAPE block may suggest the parallel procession of the repetitive involvement of generation, manipulation, and decision making in order to form a reliable representation of target objects.

Use of Functional Near Infrared Spectroscopy to Assess Syntactic Processing by Monolingual and Bilingual Adults and Children.

Ding G, Mohr KAJ, Orellana CI, Hancock AS, Juth S, Wada R, Gillam RB.
Front Hum Neurosci. Feb 3;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

This exploratory study assessed the use of functional Near Infrared Spectroscopy (fNIRS) to examine hemodynamic response patterns during sentence processing. Four groups of participants: monolingual English children, bilingual Chinese-English children, bilingual Chinese-English adults and monolingual English adults were given an agent selection syntactic processing task. Bilingual child participants were classified as simultaneous or sequential bilinguals to examine the impact of first language, age of second-language acquisition (AoL2A), and the length of second language experience on behavioral performance and cortical activation. Participants were asked to select the agent of four types of sentences: subject-verb-object (SVO), passive (PAS), subject-extracted relative clause (SR), and object-extracted relative clause (OR) adopted from the "Whatdunit" task by Montgomery et al. (2016). Semantic cues were removed by using inanimate nouns for agents and patients, which constrained participants to make decisions based on syntactic knowledge. Behavioral results showed greater accuracy for canonical SVO and SR sentence types than for noncanonical OR and PAS sentence types, which aligns with prior studies. Neuroimaging results revealed greater hemodynamic responses to relative clauses (i.e., SR and OR sentences) than to simple sentences (SVO and PAS), especially for Chinese-English bilinguals suggesting first-language transfer influencing sentence processing in English. The effects AoL2A and the length of second language experience showed no significant differences between simultaneous and sequential bilinguals or between bilingual adults and children for identifying the correct agent in each sentence. However, neuroimaging results demonstrated greater hemodynamic responses in right dorsolateral prefrontal cortex (DLPFC) and left inferior parietal lobule (IPL) in simultaneous bilinguals compared to sequential bilinguals and greater hemodynamic responses in left and right DLPFC and left IPL among bilingual adults. Different behavioral and neural hemodynamic response patterns afford new insights into the effects of syntactic knowledge on sentence processing.

Examination of the Prefrontal Cortex Hemodynamic Responses to the Fist-Edge-Palm Task in Na? Subjects Using Functional Near-Infrared Spectroscopy.

Kobayashi S, Iwama Y, Nishimaru H, Matsumoto J, Setogawa T, Ono T, Nishijo H.
Front Hum Neurosci. Feb 5;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

The Fist-Edge-Palm (FEP) task, a manual hand task, has been used to detect frontal dysfunctions in clinical situations: its performance failures are observed in various prefrontal cortex (PFC)-related disorders, including schizophrenia. However, previous imaging studies reported that the performance of the FEP task activated motor-related areas, but not the PFC. Here, we aimed to investigate the relationships between the performance of the FEP task and PFC functions. Hemodynamic activity in the PFC, including the dorsolateral PFC (area 46) and frontal pole (area 10), was recorded. Healthy young subjects performed the FEP task as well as a palm tapping (PT) task (control task) three times. The subjects also completed a Wisconsin Card Sorting Test (WCST) and Schizotypal Personality Scale (STA) questionnaire. We found that hemodynamic activity (Oxy-Hb) in the PFC increased in the first trial of the FEP task but decreased considerably in the second and third trials compared to the PT task. The number of performance errors in the FEP task also decreased in the second and third trials. Error reduction (i.e., learning) in the FEP task between the first and second trials was negatively correlated with schizotypal trait and the number of perseveration errors in the WCST. Furthermore, changes in the PFC hemodynamic activity between the first and second trials were positively correlated with error reduction in the FEP task between the first and second trials, and negatively correlated with the number of perseveration errors in the WCST. These results suggest that learning in the FEP task requires PFC activation, which is negatively associated with perseveration errors in the WCST. The results further suggest that the FEP task, in conjunction with near-infrared spectroscopy, may be useful as a diagnostic method for various disorders with PFC

dysfunction.

Monitoring the motor cortex hemodynamic response function in freely moving walking subjects: a time-domain fNIRS pilot study.

Lacerenza M, Spinelli L, Buttafava M, Dalla Mora A, Zappa F, Pifferi A, Tosi A, Cozzi B, Torricelli A, Contini D.

Neurophotonics. Jan;8(1):
doi: 10.1117/1.NPh.8.1.Epub Feb 22.

Significance: This study is a preliminary step toward the identification of a noninvasive and reliable tool for monitoring the presence and progress of gaiting dysfunctions. Aim: We present the results of a pilot study for monitoring the motor cortex hemodynamic response function (HRF) in freely walking subjects, with time-domain functional near-infrared spectroscopy (TD fNIRS). Approach: A compact and wearable single-channel TD fNIRS oximeter was employed. The lower limb motor cortex area of three healthy subjects was monitored while performing two different freely moving gaiting tasks: forward and backward walking. Results: The time course of oxygenated and deoxygenated hemoglobin was measured during the different walking tasks. Brain motor cortex hemodynamic activations have been analyzed throughout an adaptive HRF fitting procedure, showing a greater involvement of motor area in the backward walking task. By comparison with the HRF obtained in a finger-tapping task performed in a still condition, we excluded any effect of motion artifacts in the gaiting tasks. Conclusions: For the first time to our knowledge, the hemodynamic motor cortex response was measured by TD fNIRS during natural, freely walking exercises. The cortical response during forward and backward walking shows differences, possibly related to the diverse involvement of the motor cortex in the two types of gaiting.

Tinnitus and auditory cortex; Using adapted functional near-infrared-spectroscopy to expand brain imaging in humans.

Zhai T, Ash-Rafzadeh A, Hu X, Kim J, San Juan JD, Filipiak C, Guo K, Islam MN, Kovelman I, Basura GJ.

Laryngoscope Investig Otolaryngol. Dec 16;6(1):137-
doi: 10.1002/lio2.eCollection Feb.

OBJECTIVES: Phantom sound perception (tinnitus) may arise from altered brain activity within auditory cortex. Auditory cortex neurons in tinnitus animal models show increased spontaneous firing rates. This may be a core characteristic of tinnitus. Functional near-infrared spectroscopy (fNIRS) has shown similar findings in human auditory cortex. Current fNIRS approaches with cap recordings are limited to 3 cm depth of signal penetration due to the skull thickness. To address this limitation, we present an innovative fNIRS approach via probes adapted to the external auditory canal. The adapted probes were placed deeper and closer to temporal lobe of the brain to bypass confining skull bone and improve neural recordings. METHODS: Twenty adults with tinnitus and 20 nontinnitus controls listened to periods of silence and broadband noise (BBN) during standard cap and adapted ear canal fNIRS neuroimaging. The evaluators were not blinded, but the protocol and postprocessing for the two groups were identical. RESULTS: Standard fNIRS measurements in participants with tinnitus revealed increased auditory cortex activity during silence that was suppressed during auditory stimulation with BBN. Conversely, controls displayed increased activation with noise but not during silence. Importantly, adapted ear canal fNIRs probes showed similar hemodynamic responses seen with cap probes in both tinnitus and controls. CONCLUSIONS: In this proof of concept study, we have successfully fabricated, adapted, and utilized a novel fNIRS technology that replicates established findings from traditional cap fNIRS probes. This exciting new innovation, validated by replicating previous and current cap findings in auditory cortex, may have applications to future studies to investigate brain changes not only in tinnitus but in other pathologic

states that may involve the temporal lobe and surrounding brain regions. LEVEL OF EVIDENCE: NA.

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

Mu??Caracuel M, Mu??V, Ru?Mart?z FJ, Di Domenico D, Brigadoi S, G?? CM.

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

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

Targeting brain regions of interest in functional near-infrared spectroscopy-Scalp-cortex correlation using subject-specific light propagation models.

Cai L, Nitta T, Yokota S, Obata T, Okada E, Kawaguchi H.

Hum Brain Mapp. Feb
doi: 10.1002/hbm.Online ahead of print.

Targeting specific brain regions of interest by the accurate positioning of optodes (emission and detection probes) on the scalp remains a challenge for functional near-infrared spectroscopy (fNIRS). Since fNIRS data does not provide any anatomical information on the brain cortex, establishing the scalp-cortex correlation (SCC) between emission-detection probe pairs on the scalp and the underlying brain regions in fNIRS measurements is extremely important. A conventional SCC is obtained by a geometrical point-to-point manner and ignores the effect of light scattering in the head tissue that occurs in actual fNIRS measurements. Here, we developed a sensitivity-based matching (SBM) method that incorporated the broad spatial sensitivity of the probe pair due to light scattering into the SCC for fNIRS. The SCC was analyzed between head surface fiducial points determined by the international 10-10 system and automated anatomical labeling brain regions for 45 subject-specific head models. The performance of the SBM method was compared with that of three conventional geometrical matching (GM) methods. We reveal

that the light scattering and individual anatomical differences in the head affect the SCC, which indicates that the SBM method is compulsory to obtain the precise SCC. The SBM method enables us to evaluate the activity of cortical regions that are overlooked in the SCC obtained by conventional GM methods. Together, the SBM method could be a promising approach to guide fNIRS users in designing their probe arrangements and in explaining their measurement data.

The Effects of Perceived Pain in the Past Month on Prefrontal Cortex Activation Patterns Assessed During Cognitive and Motor Performances in Older Adults.

Pakray H, Seng E, Izzetoglu M, Holtzer R.

Pain Med. Feb 23;22(2):303-
doi: 10.1093/pm/pnaa404.

OBJECTIVE: Pain is prevalent and functionally impactful in older adults. The prefrontal cortex is involved in pain perception, attentional control, and cortical control of locomotion. Although pain is a known moderator of attentional capacity, its moderating effect on cortical control of locomotion has not been assessed. This study aimed to examine the effects of subjective pain on changes in functional near-infrared spectroscopy-derived measurements of oxygenated hemoglobin (HbO2), gait velocity, and cognitive accuracy from single- to dual-task walking conditions among older adults. SUBJECTS: The sample consisted of 383 healthy older adults (55% female). METHODS: Participants completed two single tasks (Single-Task-Walk [STW] and Cognitive Interference [Alpha]) and the Dual-Task-Walk (DTW), during which participants performed the two single tasks simultaneously. The Medical Outcomes Study Pain Severity Scale and Pain Effects Scale were used to assess pain severity and interference. ProtoKinetics Movement Analysis Software was used to assess gait velocity and rate of correct letter generation to assess cognitive accuracy. Functional Near-Infrared Spectroscopy (fNIRS) was used to assess HbO2 during active walking. RESULTS: Linear mixed-effects models revealed that HbO2 increased from single- to dual-task conditions. Perceived pain presence was associated with an attenuated increase in HbO2 from Alpha to DTW. Among those with pain, worse pain severity was associated with an attenuated increase in HbO2 from STW to DTW. Pain interference did not moderate the increase in HbO2 from single to dual tasks. Pain did not have a moderating effect on behavioral outcomes. CONCLUSIONS: Task-related changes in the hemodynamic response in the prefrontal cortex during walking may be a sensitive marker of the effects of subjective pain on brain function in healthy older adults.

Predicting Student Performance Using Machine Learning in fNIRS Data.

Oku AYA, Sato JR.

Front Hum Neurosci. Feb 5;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Increasing student involvement in classes has always been a challenge for teachers and school managers. In online learning, some interactivity mechanisms like quizzes are increasingly used to engage students during classes and tasks. However, there is a high demand for tools that evaluate the efficiency of these mechanisms. In order to distinguish between high and low levels of engagement in tasks, it is possible to monitor brain activity through functional near-infrared spectroscopy (fNIRS). The main advantages of this technique are portability, low cost, and a comfortable way for students to concentrate and perform their tasks. This setup provides more natural conditions for the experiments if compared to the other acquisition tools. In this study, we investigated levels of task involvement through the identification of correct and wrong answers of typical quizzes used in virtual environments. We collected data from the prefrontal cortex region (PFC) of 18 students while watching a video lecture. This data was modeled with supervised learning algorithms. We used random forests and penalized logistic regression to classify correct answers as a function of oxyhemoglobin and deoxyhemoglobin concentration. These models identify which regions

best predict student performance. The random forest and penalized logistic regression (GLMNET with LASSO) obtained, respectively, 0.67 and 0.65 area of the ROC curve. Both models indicate that channels F4-F6 and AF3-AFz are the most relevant for the prediction. The statistical significance of these models was confirmed through cross-validation (leave-one-subject-out) and a permutation test. This methodology can be useful to better understand the teaching and learning processes in a video lecture and also provide improvements in the methodologies used in order to better adapt the presentation content.

Functional Effects of Bilateral Dorsolateral Prefrontal Cortex Modulation During Sequential Decision-Making: A Functional Near-Infrared Spectroscopy Study With Offline Transcranial Direct Current Stimulation.

Schommartz I, Dix A, Passow S, Li SC.

Front Hum Neurosci. Feb 3;14:

doi: 10.3389/fnhum.2020. eCollection 2020.

The ability to learn sequential contingencies of actions for predicting future outcomes is indispensable for flexible behavior in many daily decision-making contexts. It remains open whether such ability may be enhanced by transcranial direct current stimulation (tDCS). The present study combined tDCS with functional near-infrared spectroscopy (fNIRS) to investigate potential tDCS-induced effects on sequential decision-making and the neural mechanisms underlying such modulations. Offline tDCS and sham stimulation were applied over the left and right dorsolateral prefrontal cortex (dlPFC) in young male adults (N = 29, mean age = 23.4 years, SD = 3.2) in a double-blind between-subject design using a three-state Markov decision task. The results showed (i) an enhanced dlPFC hemodynamic response during the acquisition of sequential state transitions that is consistent with the findings from a previous functional magnetic resonance imaging (fMRI) study; (ii) a tDCS-induced increase of the hemodynamic response in the dlPFC, but without accompanying performance-enhancing effects at the behavioral level; and (iii) a greater tDCS-induced upregulation of hemodynamic responses in the delayed reward condition that seems to be associated with faster decision speed. Taken together, these findings provide empirical evidence for fNIRS as a suitable method for investigating hemodynamic correlates of sequential decision-making as well as functional brain correlates underlying tDCS-induced modulation. Future research with larger sample sizes for carrying out subgroup analysis is necessary in order to decipher interindividual differences in tDCS-induced effects on sequential decision-making process at the behavioral and brain levels.

Effects of prefrontal theta burst stimulation on neuronal activity and subsequent eating behavior: an interleaved rTMS and fNIRS study.

Fatakdawala I, Ayaz H, Safati A, Sakib MN, Hall PA.

Soc Cogn Affect Neurosci. Feb 22:nsab

doi: 10.1093/scan/nsabOnline ahead of print.

The dorsolateral prefrontal cortex (dlPFC) and dorsomedial prefrontal cortex (dmPFC) are important nodes for self-control and decision-making, but through separable processes (cognitive control versus evaluative processing). This study aimed to examine the effects of excitatory brain stimulation (intermittent theta-burst stimulation; iTBS) targeting the dlPFC and dmPFC on food choice. iTBS was hypothesized to decrease consumption of appetitive snack foods, via enhanced interference control for dlPFC stimulation and reduced delay discounting for dmPFC stimulation. Using a single-blinded, between-subjects design, participants (N = 43) were randomly assigned to of the three conditions: 1) iTBS targeting the left dlPFC, 2) iTBS targeting bilateral dmPFC, or 3) sham. Participants then completed two cognitive tasks (delay discounting (DD) and Flanker), followed by a taste test. fNIRS imaging revealed increases in medial PFC activity were evident in the dmPFC stimulation group during the DD task; likewise, a neural efficiency effect was observed in the dlPFC stimulation group during the Flanker. Gender significantly moderated

consumption during the taste test, with females in the dmPFC showing paradoxical increases in food consumption compared to sham. Findings are consistent with possible amplification of positive evaluative processing in the presence of dietary restraint, vis-?is excitation of the mPFC.

The challenge of learning a new language in adulthood: Evidence from a multi-methodological neuroscientific approach.

Steber S, Rossi S.

PLoS One. Feb 19;16(2):e
doi: 10.1371/journal.pone. eCollection 2021.

Being proficient in several foreign languages is an essential part of every-day life. In contrast to childhood, learning a new language can be highly challenging for adults. The present study aims at investigating neural mechanisms supporting very initial foreign language learning in adulthood. For this reason, subjects underwent an implicit semantic associative training in which they had to learn new pseudoword-picture pairings. Learning success was measured via a recognition experiment presenting learned versus new pseudoword-picture pairings. Neural correlates were assessed by an innovative multi-methodological approach simultaneously applying electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS). Results indicate memory-related processes based on familiarity and mechanisms of cognitive control to be present during initial vocabulary learning. Findings underline the fascinating plasticity of the adult brain during foreign language learning, even after a short semantic training of only 18 minutes as well as the importance of comparing evidence from different neuroscientific methods and behavioral data.

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fNIRS study of prefrontal activation during emotion recognition-A Potential endophenotype for bipolar I disorder?

Segar R, Chhabra H, Sreeraj VS, Parlikar R, Kumar V, Ganesan V, Kesavan M.

J Affect Disord. Mar 1;282:869-
doi: 10.1016/j.jad.2020.12.Epub Dec 30.

BACKGROUND: Facial emotion recognition (FER) deficit is documented in many psychiatric disorders, including bipolar disorder (BD). However, its role as a risk-marker in BD is not well researched. In the present study, we investigated the role of FER and the corresponding prefrontal neurohemodynamic changes (PNHC) with functional near infra-red spectroscopy (fNIRS) in patients with BD and subjects at high risk for BD compared to healthy subject. METHODS: Using a cross-sectional case-control design we compared 14 patients with first episode mania (FEM) in remission (BD group), 14 healthy siblings of BD patients (HR group), and 13 matched healthy subjects (HC group). FER was assessed using a computer-based task called Tool for Recognition of Emotions in Neuropsychiatric Disorders (TRENDS). Simultaneously, the corresponding PNHC was recorded with fNIRS. Kruskal Wallis H test was used to analyze between-group differences and Spearman's rho for correlation analysis. RESULTS: The three groups were comparable on socio-demographics (all $p>0.09$) except education ($p=0.03$). HR group had the most hyper-activation in the bilateral DLPFC during the TRENDS task (all $p<0.05$). There was no significant between-group differences in the FER performance and no significant correlation between the FER performance and the PNHC in the HR and BD groups (all $p>0.35$). LIMITATIONS: The potential confounding effect of medications in the BD group. CONCLUSIONS: The hyper-activation of the DLPCF in HR group during FER could indicate an increased risk for BD. However, the lack of similar findings in the BD group might reflect a possible normalizing effect of medications. It is equally likely that differences in the PNHC are detectable earlier than the differences in FER task performance during the course of the illness. This requires further exploration.

Comparison of short-channel separation and spatial domain filtering for removal of non-neural components in functional near-infrared spectroscopy signals.

Noah JA, Zhang X, Dravida S, DiCocco C, Suzuki T, Aslin RN, Tachtsidis I, Hirsch J.

Neurophotonics. Jan;8(1):
doi: 10.1117/1.NPh.8.1.Epub Feb 13.

Significance: With the increasing popularity of functional near-infrared spectroscopy (fNIRS), the need to determine localization of the source and nature of the signals has grown. Aim: We compare strategies for removal of non-neural signals for a finger-thumb tapping task, which shows responses in contralateral motor cortex and a visual checkerboard viewing task that produces activity within the occipital lobe. Approach: We compare temporal regression strategies using short-channel separation to a spatial principal component (PC) filter that removes global signals present in all channels. For short-channel temporal regression, we compare non-neural signal removal using first and combined first and second PCs from a broad distribution of short channels to limited distribution on the forehead. Results: Temporal regression of non-neural information from broadly distributed short channels did not differ from forehead-only distribution. Spatial PC filtering provides results similar to short-channel separation using the temporal domain. Utilizing both first and second PCs from short channels removes additional non-neural information. Conclusions: We conclude that short-channel information in the temporal domain and spatial domain regression filtering methods remove similar non-neural components represented in scalp hemodynamics from fNIRS signals and that either technique is sufficient to remove non-neural components.

Corrigendum: Multi-Modal Integration of EEG-fNIRS for Brain-Computer Interfaces - Current Limitations and Future Directions.

Ahn S, Jun SC.

Front Hum Neurosci. Feb 1;15:
doi: 10.3389/fnhum.2021. eCollection 2021.

Erratum for Front Hum Neurosci. 2017 Oct 18;11:503.

An analysis framework for the integration of broadband NIRS and EEG to assess neurovascular and neurometabolic coupling.

Pinti P(#), Siddiqui MF(#), Levy AD, Jones EJH, Tachtsidis I.

Sci Rep. Feb 17;11(1):
doi: 10.1038/s41598-021-83420-9.

With the rapid growth of optical-based neuroimaging to explore human brain functioning, our research group has been developing broadband Near Infrared Spectroscopy (bNIRS) instruments, a technological extension to functional Near Infrared Spectroscopy (fNIRS). bNIRS has the unique capacity of monitoring brain haemodynamics/oxygenation (measuring oxygenated and deoxygenated haemoglobin), and metabolism (measuring the changes in the redox state of cytochrome-c-oxidase). When combined with electroencephalography (EEG), bNIRS provides a unique neuromonitoring platform to explore neurovascular coupling mechanisms. In this paper, we present a novel pipeline for the integrated analysis of bNIRS and EEG signals, and demonstrate its use on multi-channel bNIRS data recorded with concurrent EEG on healthy adults during a visual stimulation task. We introduce the use of the Finite Impulse Response functions within the General Linear Model for bNIRS and show its feasibility to statistically localize the haemodynamic and metabolic activity in the occipital cortex. Moreover, our results suggest that the fusion of haemodynamic and metabolic measures unveils additional information on brain functioning over haemodynamic imaging alone. The cross-correlation-based analysis of interrelationships between electrical (EEG) and haemodynamic/metabolic (bNIRS) activity revealed that the bNIRS metabolic signal offers a unique marker of brain activity, being more closely coupled to the neuronal EEG response.

Comparison of Human Social Brain Activity During Eye-Contact With Another Human and a Humanoid Robot.

Kelley MS, Noah JA, Zhang X, Scassellati B, Hirsch J.

Front Robot AI. Jan 29;7:
doi: 10.3389/frobt.2020. eCollection 2020.

Robot design to simulate interpersonal social interaction is an active area of research with applications in therapy and companionship. Neural responses to eye-to-eye contact in humans have recently been employed to determine the neural systems that are active during social interactions. Whether eye-contact with a social robot engages the same neural system remains to be seen. Here, we employ a similar approach to compare human-human and human-robot social interactions. We assume that if human-human and human-robot eye-contact elicit similar neural activity in the human, then the perceptual and cognitive processing is also the same for human and robot. That is, the robot is processed similar to the human. However, if neural effects are different, then perceptual and cognitive processing is assumed to be different. In this study neural activity was compared for human-to-human and human-to-robot conditions using near infrared spectroscopy for neural imaging, and a robot (Maki) with eyes that blink and move right and left. Eye-contact was confirmed by eye-tracking for both conditions. Increased neural activity was observed in human social systems including the right temporal parietal junction and the dorsolateral prefrontal cortex during human-human eye contact but not human-robot eye-contact. This suggests that the type of human-robot eye-contact used here is not sufficient to engage the right temporoparietal junction in the human. This study establishes a foundation for future research into human-robot eye-contact to determine how elements of robot design and behavior impact human social processing within this type of interaction and may offer a method for capturing difficult to quantify components of human-robot interaction, such as social engagement.

Interpersonal Agreement and Disagreement During Face-to-Face Dialogue: An fNIRS Investigation.

Hirsch J, Tiede M, Zhang X, Noah JA, Salama-Manteau A, Biriotti M.

Front Hum Neurosci. Jan 13;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Although the neural systems that underlie spoken language are well-known, how they adapt to evolving social cues during natural conversations remains an unanswered question. In this work we investigate the neural correlates of face-to-face conversations between two individuals using functional near infrared spectroscopy (fNIRS) and acoustical analyses of concurrent audio recordings. Nineteen pairs of healthy adults engaged in live discussions on two controversial topics where their opinions were either in agreement or disagreement. Participants were matched according to their a priori opinions on these topics as assessed by questionnaire. Acoustic measures of the recorded speech including the fundamental frequency range, median fundamental frequency, syllable rate, and acoustic energy were elevated during disagreement relative to agreement. Consistent with both the a priori opinion ratings and the acoustic findings, neural activity associated with long-range functional networks, rather than the canonical language areas, was also differentiated by the two conditions. Specifically, the frontoparietal system including bilateral dorsolateral prefrontal cortex, left supramarginal gyrus, angular gyrus, and superior temporal gyrus showed increased activity while talking during disagreement. In contrast, talking during agreement was characterized by increased activity in a social and attention network including right supramarginal gyrus, bilateral frontal eye-fields, and left frontopolar regions. Further, these social and visual attention networks were more synchronous across brains during agreement than disagreement. Rather than localized modulation of the canonical language system, these findings are most consistent with a model of distributed and adaptive language-related processes including cross-brain neural coupling that serves dynamic verbal exchanges.

Errata: Best practices for fNIRS publications.

Ycel MA, Lhmann AV, Scholkmann F, Gervain J, Dan I, Ayaz H, Boas D, Cooper RJ, Culver J, Elwell CE, Eggebrecht A, Franceschini MA, Grova C, Homae F, Lesage F, Obrig H, Tachtsidis I, Tak S, Tong Y, Torricelli A, Wabnitz H, Wolf M.

Neurophotonics. Jan;8(1):
doi: 10.1117/1.NPh.8.1.Epub Feb 8.

Erratum for Neurophotonics. 2021 Jan;8(1):012101.

Analysis of Human Gait Using Hybrid EEG-fNIRS-Based BCI System: A Review.

Khan H, Naseer N, Yazidi A, Eide PK, Hassan HW, Mirtaheri P.

Front Hum Neurosci. Jan 25;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Human gait is a complex activity that requires high coordination between the central nervous system, the limb, and the musculoskeletal system. More research is needed to understand the latter coordination's complexity in designing better and more effective rehabilitation strategies for gait disorders. Electroencephalogram (EEG) and functional near-infrared spectroscopy (fNIRS) are among the most used technologies for monitoring brain activities due to portability, non-invasiveness, and relatively low cost compared to others. Fusing EEG and fNIRS is a well-known and established methodology proven to enhance brain-computer interface (BCI) performance in terms of classification accuracy, number of control commands, and response time. Although there has been significant research exploring hybrid BCI (hBCI) involving both EEG and fNIRS for different types of tasks and human activities, human gait remains still underinvestigated. In this article, we aim to shed light on the recent development in the analysis of human gait using a hybrid EEG-fNIRS-based BCI system. The current review has followed guidelines of preferred reporting items for systematic reviews and meta-Analyses (PRISMA) during the data collection and selection phase. In this review, we put a particular focus on the commonly used signal processing and machine learning algorithms, as well as survey the potential applications of gait analysis. We distill some of the critical findings of this survey as follows. First, hardware specifications and experimental paradigms should be carefully considered because of their direct impact on the quality of gait assessment. Second, since both modalities, EEG and fNIRS, are sensitive to motion artifacts, instrumental, and physiological noises, there is a quest for more robust and sophisticated signal processing algorithms. Third, hybrid temporal and spatial features, obtained by virtue of fusing EEG and fNIRS and associated with cortical activation, can help better identify the correlation between brain activation and gait. In conclusion, hBCI (EEG + fNIRS) system is not yet much explored for the lower limb due to its complexity compared to the higher limb. Existing BCI systems for gait monitoring tend to only focus on one modality. We foresee a vast potential in adopting hBCI in gait analysis. Imminent technical breakthroughs are expected using hybrid EEG-fNIRS-based BCI for gait to control assistive devices and Monitor neuro-plasticity in neuro-rehabilitation. However, although those hybrid systems perform well in a controlled experimental environment when it comes to adopting them as a certified medical device in real-life clinical applications, there is still a long way to go.

Mind the food: behavioural characteristics and imaging signatures of the specific handling of food objects.

Max SM, Schroeder PA, Blechert J, Giel KE, Ehlis AC, Plewnia C.

Brain Struct Funct. Feb
doi: 10.1007/s00429-021-02232-Online ahead of print.

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

Cortical hemodynamics as a function of handgrip strength and cognitive performance: a cross-sectional fNIRS study in younger adults.

Herold F, Behrendt T, Trpel A, Hamacher D, Mller NG(#), Schega L(#).

BMC Neurosci. Feb 15;22(1):
doi: 10.1186/s12868-021-00615-6.

BACKGROUND: There is growing evidence for a positive correlation between measures of muscular strength and cognitive abilities. However, the neurophysiological correlates of this relationship are not well understood so far. The aim of this study was to investigate cortical hemodynamics [i.e., changes in concentrations of oxygenated (oxyHb) and deoxygenated hemoglobin (deoxyHb)] as a possible link between measures of muscular strength and cognitive performance. METHODS: In a cohort of younger adults (n = 39, 18-30years), we assessed (i) handgrip strength by a handhold dynamometer, (ii) short-term working memory performance by using error rates and reaction times in the Sternberg task, and (iii) cortical hemodynamics of the prefrontal cortex (PFC) via functional near-infrared spectroscopy (fNIRS). RESULTS: We observed low to moderate negative correlations (rp = - 0.38 to - 0.51; $p < 0.05$) between reaction time and levels of oxyHb in specific parts of the PFC. Furthermore, we noticed low to moderate positive correlations (rp = 0.34 to 0.45; $p < 0.05$) between reaction times and levels of deoxyHb in distinct parts of the PFC. Additionally, higher levels of oxyHb (rp (35) = 0.401; p = 0.014) and lower levels of deoxyHb (rp (34) = - 0.338; p = 0.043) in specific parts of the PFC were linked to higher percentage of correct answers. We also found low to moderate correlations ($p < 0.05$) between measures of handgrip strength and levels of oxyHb (rp = 0.35; $p < 0.05$) and levels of deoxyHb (rp = - 0.25 to - 0.49; $p < 0.05$) in specific parts of the PFC. However, there was neither a correlation between cognitive performance and handgrip strength nor did cortical hemodynamics in the PFC mediate the relationship between handgrip strength and cognitive performance ($p > 0.05$). CONCLUSION: The present study provides evidence for a positive neurobehavioral relationship between cortical hemodynamics and cognitive performance. Ourfindingsfurther imply that in younger adults higher levels of handgrip strength positivelyinfluence cortical hemodynamics although the latter did not necessarily culminate in better cognitive performance. Future research should examine whether the present findings can be generalized to other cohorts (e.g., older adults).

Quantitative Assessment of Resting-State for Mild Cognitive Impairment Detection:

A Functional Near-Infrared Spectroscopy and Deep Learning Approach.

Yang D, Hong KS.

J Alzheimers Dis. 2021;80(2):647-
doi: 10.3233/JAD-201163.

BACKGROUND: Mild cognitive impairment (MCI) is considered a prodromal stage of Alzheimer's disease. Early diagnosis of MCI can allow for treatment to improve cognitive function and reduce modifiable risk factors. OBJECTIVE: This study aims to investigate the feasibility of individual MCI detection from healthy control (HC) using a minimum duration of resting-state functional near-infrared spectroscopy (fNIRS) signals. METHODS: In this study, nine different measurement durations (i.e., 30, 60, 90, 120, 150, 180, 210, 240, and 270 s) were evaluated for MCI detection via the graph theory analysis and traditional machine learning approach, such as linear discriminant analysis, support vector machine, and K-nearest neighbor algorithms. Moreover, feature representation- and classification-based transfer learning (TL) methods were applied to identify MCI from HC through the input of connectivity maps with 30 and 90 s duration. RESULTS: There was no significant difference among the nine various time windows in the machine learning and graph theory analysis. The feature representation-based TL showed improved accuracy in both 30 and 90 s cases (i.e., 30 s: 81.27% and 90 s: 76.73%). Notably, the classification-based TL method achieved the highest accuracy of 95.81% using the pre-trained convolutional neural network (CNN) model with the 30 s interval functional connectivity map input. CONCLUSION: The results indicate that a 30 s measurement of the resting-state with fNIRS could be used to detect MCI. Moreover, the combination of neuroimaging (e.g., functional connectivity maps) and deep learning methods (e.g., CNN and TL) can be considered as novel biomarkers for clinical computer-assisted MCI diagnosis.

Neural basis for egalitarian sharing in five-to six-year-old children.

Meng X, Moriguchi Y.

Neuropsychologia. Apr 16;154:
doi: 10.1016/j.neuropsychologia.2021.Epub Feb 9.

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

Choosing an optimal wavelength to detect brain activity in functional near-infrared spectroscopy.

Cheng X, Sie EJ, Boas DA, Marsili F.

Opt Lett. Feb 15;46(4):924-
doi: 10.1364/OL.418284.
DOI: 10.1364/OL.418284 PMID: 33577549

Cortical Activity Linked to Clocking in Deaf Adults: fNIRS Insights with Static and Animated Stimuli Presentation.

Laurent S, Paire-Ficout L, Boucheix JM, Argon S, Hidalgo-Mu?? AR.

Brain Sci. Feb 5;11(2):
doi: 10.3390/brainsci11020196.

The question of the possible impact of deafness on temporal processing remains unanswered. Different findings, based on behavioral measures, show contradictory results. The goal of the present study is to analyze the brain activity underlying time estimation by using functional near infrared spectroscopy (fNIRS) techniques, which allow examination of the frontal, central and occipital cortical areas. A total of 37 participants (19 deaf) were recruited. The experimental task involved processing a road scene to determine whether the driver had time to safely execute a driving task, such as overtaking. The road scenes were presented in animated format, or in sequences of 3 static images showing the beginning, mid-point, and end of a situation. The latter presentation required a clocking mechanism to estimate the time between the samples to evaluate vehicle speed. The results show greater frontal region activity in deaf people, which suggests that more cognitive effort is needed to process these scenes. The central region, which is involved in clocking according to several studies, is particularly activated by the static presentation in deaf people during the estimation of time lapses. Exploration of the occipital region yielded no conclusive results. Our results on the frontal and central regions encourage further study of the neural basis of time processing and its links with auditory capacity.

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

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

Phys Ther. Feb 9:pzab
doi: 10.1093/ptj/pzabOnline ahead of print.
DOI: 10.1093/ptj/pzab058 PMID: 33561281

The Benefits of Physical Activity in Individuals with Cardiovascular Risk Factors: A Longitudinal Investigation Using fNIRS and Dual-Task Walking.

Talamonti D, Vincent T, Fraser S, Nigam A, Lesage F, Bherer L.

J Clin Med. Feb 4;10(4):
doi: 10.3390/jcm10040579.

Cardiovascular fitness is linked to better executive functions, preserved gait speed, and efficient cortical activity. Older adults with cardiovascular risk factors (CVRFs) typically show poor cognitive performance, low physical fitness, and altered brain functioning compared with healthy individuals. In the current study, the impact of regular physical activity on cognition, locomotion, and brain functions was explored in a cohort of older adults with low or high CVRFs. Cortical activation of the frontal areas was investigated using functional Near-Infrared Spectroscopy (fNIRS) at baseline, at 6 months and at 12 months. Evoked cortical response and behavioral performance were assessed using the dual-task walking paradigm, consisting of three conditions: single cognitive task (2-back task), single walking task (walking), and dual-task (2-back whilst walking). Results show greater task-related cortical response at baseline in individuals with

high CVRFs compared to those with low CVRFs. Moreover, participants with high CVRFs benefitted the most from participating in regular physical activity, as their cortical response decreased at the 12-month follow-up and became comparable to that of participants with low CVRFs. These changes were observed in conjunction with improved cognitive performance and stable gait speed throughout the 12-month period in both groups. Our findings provide evidence that participation in regular physical activity may be especially beneficial in individuals with CVRFs by promoting brain and cognitive health, thus potentially contributing to prevention of cognitive decline. Future research may explore whether such effects are maintained in the long-term in order to design ad-hoc interventions in this specific population.

Use of Virtual Reality Working Memory Task and Functional Near-Infrared Spectroscopy to Assess Brain Hemodynamic Responses to Methylphenidate in ADHD Children.

Jang S, Choi J, Oh J, Yeom J, Hong N, Lee N, Kwon JH, Hong J, Kim JJ, Kim E.

Front Psychiatry. Jan 21;11:
doi: 10.3389/fpsyt.2020. eCollection 2020.

Virtual reality (VR) neuropsychological tests have emerged as a method to explore drug effects in real-life contexts in attention deficit hyperactivity disorder (ADHD) children. Functional near-infrared spectroscopy (fNIRS) is a useful tool to measure brain activity during VR tasks in ADHD children with motor restlessness. The present study aimed to explore the acute effects of methylphenidate (MPH) on behavioral performance and brain activity during a VR-based working memory task simulating real-life classroom settings in ADHD children. In total, 23 children with ADHD performed a VR n-back task before and 2 h after MPH administration concurrent with measurements of oxygenated hemoglobin signal changes with fNIRS. Altogether, 12 healthy control (HC) subjects participated in the same task but did not receive MPH treatment. Reaction time (RT) was shortened after MPH treatment in the 1-back condition, but changes in brain activation were not observed. In the 2-back condition, activation of the left dorsolateral prefrontal cortex (DLPFC) and bilateral medial prefrontal cortex (mPFC) was decreased alongside behavioral changes such as shorter RT, lower RT variability, and higher accuracy after MPH administration. Bilateral mPFC activation in the 2-back condition inversely correlated with task accuracy in the pre-MPH condition; this inverse correlation was not observed after MPH administration. In ADHD children, deactivation of the default mode network mediated by mPFC reduced during high working memory load, which was restored through MPH treatment. Our results suggest that the combination of VR classroom tasks and fNIRS examination makes it easy to assess drug effects on brain activity in ADHD children in settings simulating real-life.

Neurodevelopmental effects of childhood malnutrition: A neuroimaging perspective.

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

Neuroimage. Feb 5;231:
doi: 10.1016/j.neuroimage.2021.Online ahead of print.

Approximately one in five children worldwide suffers from childhood malnutrition and its complications, including increased susceptibility to inflammation and infectious diseases. Due to improved early interventions, most of these children now survive early malnutrition, even in low-resource settings (LRS). However, many continue to exhibit neurodevelopmental deficits, including low IQ, poor school performance, and behavioral problems over their lifetimes. Most studies have relied on neuropsychological tests, school performance, and mental health and behavioral measures. Few studies, in contrast, have assessed brain structure and function, and to date, these have mainly relied on low-cost techniques, including electroencephalography (EEG) and evoked potentials (ERP). The use of more advanced methods of neuroimaging,

including magnetic resonance imaging (MRI) and functional near-infrared spectroscopy (fNIRS), has been limited by cost factors and lack of availability of these technologies in developing countries, where malnutrition is nearly ubiquitous. This report summarizes the current state of knowledge and evidence gaps regarding childhood malnutrition and the study of its impact on neurodevelopment. It may help to inform the development of new strategies to improve the identification, classification, and treatment of neurodevelopmental disabilities in underserved populations at the highest risk for childhood malnutrition.

Optical brain imaging and its application to neurofeedback.

Soekadar SR, Kohl SH, Mihara M, von Lhmann A.

Neuroimage Clin. Jan 26;30:

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

Besides passive recording of brain electric or magnetic activity, also non-ionizing electromagnetic or optical radiation can be used for real-time brain imaging. Here, changes in the radiation's absorption or scattering allow for continuous in vivo assessment of regional neurometabolic and neurovascular activity. Besides magnetic resonance imaging (MRI), over the last years, also functional near-infrared spectroscopy (fNIRS) was successfully established in real-time metabolic brain imaging. In contrast to MRI, fNIRS is portable and can be applied at bedside or in everyday life environments, e.g., to restore communication and movement. Here we provide a comprehensive overview of the history and state-of-the-art of real-time optical brain imaging with a special emphasis on its clinical use towards neurofeedback and brain-computer interface (BCI) applications. Besides pointing to the most critical challenges in clinical use, also novel approaches that combine real-time optical neuroimaging with other recording modalities (e.g. electro- or magnetoencephalography) are described, and their use in the context of neuroergonomics, neuroenhancement or neuroadaptive systems discussed.

Relationship Between Age and Cerebral Hemodynamic Response to Breath Holding: A Functional Near-Infrared Spectroscopy Study.

Karunakaran KD, Ji K, Chen DY, Chiaravalloti ND, Niu H, Alvarez TL, Biswal BB.

Brain Topogr. Mar;34(2):154-

doi: 10.1007/s10548-021-00818-Epub Feb 5.

Cerebrovascular reactivity (CVR) is routinely measured as a predictor of stroke in people with a high risk of ischemic attack. Neuroimaging techniques such as emission tomography, magnetic resonance imaging, and transcranial doppler are frequently used to measure CVR even though each technique has its limitations. Functional near-infrared spectroscopy (fNIRS), also based on the principle of neurovascular coupling, is relatively inexpensive, portable, and allows for the quantification of oxy- and deoxy-hemoglobin concentration changes at a high temporal resolution. This study examines the relationship between age and CVR using fNIRS in 45 young healthy adult participants aged 18-41years (6 females, 26.64 5.49years) performing a simple breath holding task. Eighteen of the 45 participants were scanned again after a week to evaluate the feasibility of fNIRS in reliably measuring CVR. Results indicate (a) a negative relationship between age and hemodynamic measures of breath holding task in the sensorimotor cortex of 45 individuals and (b) widespread positive coactivation within medial sensorimotor regions and between medial sensorimotor regions with supplementary motor area and prefrontal cortex during breath holding with increasing age. The intraclass correlation coefficient (ICC) indicated only a low to fair/good reliability of the breath hold hemodynamic measures from sensorimotor and prefrontal cortices. However, the average hemodynamic response to breath holding from the two sessions were found to be temporally and spatially in correspondence. Future improvements in the sensitivity and reliability of fNIRS metrics could facilitate fNIRS-based assessment of cerebrovascular function as a potential clinical tool.

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

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

Brain Cogn. Apr;149:

doi: 10.1016/j.bandc.2021.Epub Feb 1.

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

A Look Into the Power of fNIRS Signals by Using the Welch Power Spectral Estimate for Deception Detection.

Zhang J, Zhang J, Ren H, Liu Q, Du Z, Wu L, Sai L, Yuan Z, Mo S, Lin X.

Front Hum Neurosci. Jan 18;14:

doi: 10.3389/fnhum.2020. eCollection 2020.

Neuroimaging technologies have improved our understanding of deception and also exhibit their potential in revealing the origins of its neural mechanism. In this study, a quantitative power analysis method that uses the Welch power spectrum estimation of functional near-infrared spectroscopy (fNIRS) signals was proposed to examine the brain activation difference between the spontaneous deceptive behavior and controlled behavior. The power value produced by the model was applied to quantify the activity energy of brain regions, which can serve as a neuromarker for deception detection. Interestingly, the power analysis results generated from the Welch spectrum estimation method demonstrated that the spontaneous deceptive behavior elicited significantly higher power than that from the controlled behavior in the prefrontal cortex. Meanwhile, the power findings also showed significant difference between the spontaneous deceptive behavior and controlled behavior, indicating that the reward system was only involved in the deception. The proposed power analysis method for processing fNIRS data provides us an additional insight to understand the cognitive mechanism of deception.

Effect of Repeated Anodal HD-tDCS on Executive Functions: Evidence From a Pilot and Single-Blinded fNIRS Study.

Lu H, Gong Y, Huang P, Zhang Y, Guo Z, Zhu X, You X.

Front Hum Neurosci. Jan 18;14:

doi: 10.3389/fnhum.2020. eCollection 2020.

Executive functions are of vital importance in the process of active cognition, which is thought to be associated with the dorsolateral prefrontal cortex (DLPFC). As a valid brain stimulation technology, high-definition transcranial direct current stimulation (HD-tDCS) has been used to optimize cognitive function in healthy adults. Substantial evidence indicates that short-term or single anodal tDCS sessions over the left DLPFC will enhance the performance of executive functions. However, the changes in performance

and cortical activation of executive functions after modulation by repeated anodal HD-tDCS is as yet unexplored. This study aims to examine changes in three core components of executive functions (inhibitory control, working memory, and cognitive flexibility) produced by nine HD-tDCS sessions (1.5 mA, over left DLPFC, 20 min per session), and to use functional near-infrared spectroscopy (fNIRS) to bilaterally record DLPFC neural activity. A total of 43 participants were divided randomly into two study groups (anodal group vs. sham group) to complete nine interventions. Our results demonstrate that the enhancement of cognitive flexibility in the anodal group was significantly better than that in the sham group. Additionally, a Stroop effect-related decrease in oxygenated hemoglobin (HbO) concentration in the DLPFC was observed in the anodal group but not the sham group. In conclusion, our study found that repeated anodal HD-tDCS sessions can significantly promote cognitive flexibility, one of the core components of executive function, and that alterations in DLPFC activation can enhance our understanding of the neuroplastic modifications modulated by HD-tDCS.

Brain lateralization in children with upper-limb reduction deficiency.

Zuniga JM, Pierce JE, Copeland C, Cortes-Reyes C, Salazar D, Wang Y, Arun KM, Huppert T.

J Neuroeng Rehabil. Feb 3;18(1):
doi: 10.1186/s12984-020-00803-1.

BACKGROUND: The purpose of the current study was to determine the influence of upper-limb prostheses on brain activity and gross dexterity in children with congenital unilateral upper-limb reduction deficiencies (ULD) compared to typically developing children (TD). METHODS: Five children with ULD (3 boys, 2 girls, 8.76 3.37years of age) and five age- and sex-matched TD children (3 boys, 2 girls, 8.96 3.23years of age) performed a gross manual dexterity task (Box and Block Test) while measuring brain activity (functional near-infrared spectroscopy; fNIRS). RESULTS: There were no significant differences ($p = 0.948$) in gross dexterity performance between the ULD group with prosthesis (7.23 3.37 blocks per minute) and TD group with the prosthetic simulator (7.63 5.61 blocks per minute). However, there was a significant ($p = 0.001$) difference in Laterality Index (LI) between the ULD group with prosthesis (LI = -0.2888 0.0205) and TD group with simulator (LI = 0.0504 0.0296) showing in a significant ipsilateral control for the ULD group. Thus, the major finding of the present investigation was that children with ULD, unlike the control group, showed significant activation in the ipsilateral motor cortex on the non-preferred side using a prosthesis during a gross manual dexterity task. CONCLUSIONS: This ipsilateral response may be a compensation strategy in which the existing cortical representations of the non-affected (preferred) side are been used by the affected (non-preferred) side to operate the prosthesis. This study is the first to report altered lateralization in children with ULD while using a prosthesis. Trial registration The clinical trial (ClinicalTrial.gov ID: NCT04110730 and unique protocol ID: IRB # 614-16-FB) was registered on October 1, 2019 (https://clinicaltrials.gov/ct2/show/NCT04110730) and posted on October 1, 2019. The study start date was January 10, 2020. The first participant was enrolled on January 14, 2020, and the trial is scheduled to be completed by August 23, 2023. The trial was updated January 18, 2020 and is currently recruiting.

Novel Technique for Noninvasive Detection of Localized Dynamic Brain Signals by Using Transcranial Static Magnetic Fields.

Hiwaki O.

IEEE J Transl Eng Health Med. Nov 18;9:
doi: 10.1109/JTEHM.2020.eCollection 2021.

The techniques for noninvasive measurement of brain function such as electroencephalography (EEG), magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), and functional near-infrared spectroscopy (fNIRS) have been used in diagnosing brain conditions. However, the conventional

techniques have critical limitations of spatial or temporal resolution. Here, we developed a novel technique which enables the precise measurement of dynamic brain signals and localized identification of active brain regions. In this technique, termed as magnetically biased field (MBF), human brain signal is measured as the fluctuation of a transcranial static magnetic field emitted by a coil placed on the scalp. The validity of MBF was confirmed by the measurement of somatosensory evoked signals. Fast somatosensory evoked signals were successfully observed. Localized maximum positive and negative deflections appeared at the region which represents the right primary somatosensory area contralateral to the stimulated hand. The ability of MBF to detect dynamic brain activity precisely can have numerous applications such as diagnosing brain diseases and brain-machine interfaces.

Measures of prefrontal functional near-infrared spectroscopy in visuomotor learning.
Tinga AM, Clim MA, de Back TT, Louwerse MM.
Exp Brain Res. Feb
doi: 10.1007/s00221-021-06039-Online ahead of print.

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

Home assessment of visual working memory in pre-schoolers reveals associations between behaviour, brain activation and parent reports of life stress.
McKay CA, Shing YL, Rafetseder E, Wijeakumar S.
Dev Sci. Mar 9:e
doi: 10.1111/desc.Online ahead of print.

Visual working memory (VWM) is reliably predictive of fluid intelligence and academic achievements. The objective of the current study was to investigate individual differences in pre-schoolers' VWM processing by examining the association between behaviour, brain function and parent-reported measures related to the child's environment. We used a portable functional near-infrared spectroscopy system to record from the frontal and parietal cortices of 4.5-year-old children (N=74) as they completed a colour change-detection VWM task in their homes. Parents were asked to fill in questionnaires on temperament, academic aspirations, home environment and life stress. Children were median-split into a low-performing (LP) and a high-performing (HP) group based on the number of items they could successfully remember during the task. LPs increasingly activated channels in the left frontal and bilateral parietal cortices with increasing load, whereas HPs showed no difference in activation. Our findings suggest that LPs recruited more neural resources than HPs when their VWM capacity was challenged. We employed mediation analyses to examine the association between the difference in activation between the highest and lowest loads and variables from the questionnaires. The difference in activation between loads in the left parietal cortex partially

mediated the association between parent-reported stressful life events and VWM performance. Critically, our findings show that the association between VWM capacity, left parietal activation and indicators of life stress is important to understand the nature of individual differences in VWM in pre-school children.

Alterations of Cerebral Hemodynamics and Network Properties Induced by Newsvendor Problem in the Human Prefrontal Cortex.

Wanniarachchi H, Lang Y, Wang X, Pruitt T, Nerur S, Chen KY, Liu H.

Front Hum Neurosci. Jan 15;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

While many publications have reported brain hemodynamic responses to decision-making under various conditions of risk, no inventory management scenarios, such as the newsvendor problem (NP), have been investigated in conjunction with neuroimaging. In this study, we hypothesized (I) that NP stimulates the dorsolateral prefrontal cortex (DLPFC) and the orbitofrontal cortex (OFC) joined with frontal polar area (FPA) significantly in the human brain, and (II) that local brain network properties are increased when a person transits from rest to the NP decision-making phase. A 77-channel functional near infrared spectroscopy (fNIRS) system with wide field-of-view (FOV) was employed to measure frontal cerebral hemodynamics in response to NP in 27 healthy human subjects. NP-induced changes in oxy-hemoglobin concentration, ?[HbO], were investigated using a general linear model (GLM) and graph theory analysis (GTA). Significant activation induced by NP was shown in both DLPFC and OFC+FPA across all subjects. Specifically, higher risk NP with low-profit margins (LM) activated left-DLPFC but deactivated right-DLPFC in 14 subjects, while lower risk NP with high-profit margins (HM) stimulated both DLPFC and OFC+FPA in 13 subjects. The local efficiency, clustering coefficient, and path length of the network metrics were significantly enhanced under NP decision making. In summary, multi-channel fNIRS enabled us to identify DLPFC and OFC+FPA as key cortical regions of brain activations when subjects were making inventory-management risk decisions. We demonstrated that challenging NP resulted in the deactivation within right-DLPFC due to higher levels of stress. Also, local brain network properties were increased when a person transitioned from the rest phase to the NP decision-making phase.

Suppressed prefrontal cortex oscillations associate with clinical pain in fibrodysplasia ossificans progressiva.

Peng K(#), Karunakaran KD(#), Labadie R, Veliu M, Cheung C, Lee A, Yu PB, Upadhyay J.

Orphanet J Rare Dis. Jan 30;16(1):
doi: 10.1186/s13023-021-01709-4.

BACKGROUND: Pain is a highly prevalent symptom experienced by patients across numerous rare musculoskeletal conditions. Much remains unknown regarding the central, neurobiological processes associated with clinical pain in musculoskeletal disease states. Fibrodysplasia ossificans progressiva (FOP) is an inherited condition characterized by substantial physical disability and pain. FOP arises from mutations of the bone morphogenetic protein (BMP) receptor Activin A receptor type 1 (ACVR1) causing patients to undergo painful flare-ups as well as heterotopic ossification (HO) of skeletal muscles, tendons, ligaments, and fascia. To date, the neurobiological processes that underlie pain in FOP have rarely been investigated. We examined pain and central pain mechanism in FOP as a model primary musculoskeletal condition. Central nervous system (CNS) functional properties were investigated in FOP patients (N = 17) stratified into low (0-3; 0-10 Scale) and high (= 4) pain cohorts using functional near-infrared spectroscopy (fNIRS). Associations among clinical pain, mental health, and physical health were also quantified using responses derived from a battery of clinical questionnaires. RESULTS: Resting-state fNIRS revealed suppressed power of hemodynamic activity within the slow-5 frequency sub-band (0.01-0.027Hz) in the prefrontal cortex in high pain FOP patients, where reduced power of slow-5, prefrontal cortex oscillations

exhibited robust negative correlations with pain levels. Higher clinical pain intensities were also associated with higher magnitudes of depressive symptoms. CONCLUSIONS: Our findings not only demonstrate a robust coupling among prefrontal cortex functionality and clinical pain in FOP but lays the groundwork for utilizing fNIRS to objectively monitor and central pain mechanisms in FOP and other musculoskeletal disorders.

Perceived Mental Workload Classification Using Intermediate Fusion Multimodal Deep Learning.

Dolmans TC, Poel M, van 't Klooster JJR, Veldkamp BP.

Front Hum Neurosci. Jan 11;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

A lot of research has been done on the detection of mental workload (MWL) using various bio-signals. Recently, deep learning has allowed for novel methods and results. A plethora of measurement modalities have proven to be valuable in this task, yet studies currently often only use a single modality to classify MWL. The goal of this research was to classify perceived mental workload (PMWL) using a deep neural network (DNN) that flexibly makes use of multiple modalities, in order to allow for feature sharing between modalities. To achieve this goal, an experiment was conducted in which MWL was simulated with the help of verbal logic puzzles. The puzzles came in five levels of difficulty and were presented in a random order. Participants had 1 h to solve as many puzzles as they could. Between puzzles, they gave a difficulty rating between 1 and 7, seven being the highest difficulty. Galvanic skin response, photoplethysmograms, functional near-infrared spectrograms and eye movements were collected simultaneously using LabStreamingLayer (LSL). Marker information from the puzzles was also streamed on LSL. We designed and evaluated a novel intermediate fusion multimodal DNN for the classification of PMWL using the aforementioned four modalities. Two main criteria that guided the design and implementation of our DNN are modularity and generalisability. We were able to classify PMWL within-level accurate (0.985 levels) on a seven-level workload scale using the aforementioned modalities. The model architecture allows for easy addition and removal of modalities without major structural implications because of the modular nature of the design. Furthermore, we showed that our neural network performed better when using multiple modalities, as opposed to a single modality. The dataset and code used in this paper are openly available.

NIRS-KIT: a MATLAB toolbox for both resting-state and task fNIRS data analysis.

Hou X, Zhang Z, Zhao C, Duan L, Gong Y, Li Z, Zhu C.

Neurophotonics. Jan;8(1):
doi: 10.1117/1.NPh.8.1.Epub Jan 25.

Significance: Functional near-infrared spectroscopy (fNIRS) has been widely used to probe human brain function during task state and resting state. However, the existing analysis toolboxes mainly focus on task activation analysis, few software packages can assist resting-state fNIRS studies. Aim: We aimed to provide a versatile and easy-to-use toolbox to perform analysis for both resting state and task fNIRS. Approach: We developed a MATLAB toolbox called NIRS-KIT that works for both resting-state analysis and task activation detection. Results: NIRS-KIT implements common and necessary processing steps for performing fNIRS data analysis, including data preparation, quality control, preprocessing, individual-level analysis, group-level statistics with several popular statistical models, and multiple comparison correction methods, and finally results visualization. For resting-state fNIRS analysis, functional connectivity analysis, graph theory-based network analysis, and amplitude of low-frequency fluctuations analysis are provided. Additionally, NIRS-KIT also supports activation analysis for task fNIRS. Conclusions: NIRS-KIT offers an open source tool for researchers to analyze resting-state and/or task fNIRS data in one suite. It contains several key features: (1)good compatibility, supporting multiple fNIRS recording systems, data formats of

NIRS-SPM and Homer2, and the shared near-infrared spectroscopy format data format recommended by the fNIRS society; (2)flexibility, supporting customized preprocessing scripts; (3)ease-to-use, allowing processing fNIRS signals in batch manner with user-friendly graphical user interfaces; and (4)feature-packed data viewing and result visualization. We anticipate that this NIRS-KIT will facilitate the development of the fNIRS field.

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

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

Neuroimage. Jan 24;230:

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

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

The effects of age on brain cortical activation and functional connectivity during video game-based finger-to-thumb opposition movement: A functional near-infrared spectroscopy study.

Zhang N, Yuan X, Li Q, Wang Z, Gu X, Zang J, Ge R, Liu H, Fan Z, Bu L.

Neurosci Lett. Feb 16;746:

doi: 10.1016/j.neulet.2021.Epub Jan 23.

OBJECTIVES: This study aims to explore the age-related changes in cerebral cortex activation and functional connectivity (FC) during finger-to-thumb opposition movement based on video games (FTOMBVG). METHODS: A electronic fingercot was developed for FTOMBVG. The oxygenated hemoglobin concentration (Delta [HbO]) signals, measured by functional near-infrared spectroscopy (fNIRS), were recorded

from prefrontal cortex (PFC), motor cortex (MC) and occipital lobe (OL) of two groups of subjects (old and young). RESULTS: The cognitive region of the old group showed bilateral activation, while the young group only showed unilateral activation. Both groups showed a wide range of bilateral activation in the motor region. The FC between cognitive region and motor region of the old group was enhanced considerably. CONCLUSION: Changes in cerebral cortex activation and the FC of different brain regions in the old group help explain the decline in cognitive executive and motor control function in the old from the perspective of brain functional structure, and provide a theoretical reference for the prevention of neural diseases caused by aging.

Tracking Brain Development from Neonates to the Elderly by Hemoglobin Phase Measurement using Functional Near-infrared Spectroscopy.

Liang Z, Tian H, Yang HC, Arimitsu T, Takahashi T, Sassaroli A, Fantini S, Niu H, Minagawa Y, Tong Y.

IEEE J Biomed Health Inform. Jan 25;PP.

doi: 10.1109/JBHI.2021. Online ahead of print.

DOI: 10.1109/JBHI.2021.3053900 PMID: 33493123

Recent findings on neurofeedback training for auditory hallucinations in schizophrenia.

Hirano Y, Tamura S.

Curr Opin Psychiatry. May 1;34(3):245-

doi: 10.1097/YCO.0000000000000693.

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

Decoding Three Different Preference Levels of Consumers Using Convolutional Neural Network: A Functional Near-Infrared Spectroscopy Study.

Qing K, Huang R, Hong KS.

Front Hum Neurosci. Jan 6;14:

doi: 10.3389/fnhum.2020. eCollection 2020.

This study decodes consumers' preference levels using a convolutional neural network (CNN) in neuromarketing. The classification accuracy in neuromarketing is a critical factor in evaluating the intentions of the consumers. Functional near-infrared spectroscopy (fNIRS) is utilized as a neuroimaging modal-

ity to measure the cerebral hemodynamic responses. In this study, a specific decoding structure, called CNN-based fNIRS-data analysis, was designed to achieve a high classification accuracy. Compared to other methods, the automated characteristics, constant training of the dataset, and learning efficiency of the proposed method are the main advantages. The experimental procedure required eight healthy participants (four female and four male) to view commercial advertisement videos of different durations (15, 30, and 60 s). The cerebral hemodynamic responses of the participants were measured. To compare the preference classification performances, CNN was utilized to extract the most common features, including the mean, peak, variance, kurtosis, and skewness. Considering three video durations, the average classification accuracies of 15, 30, and 60 s videos were 84.3, 87.9, and 86.4%, respectively. Among them, the classification accuracy of 87.9% for 30 s videos was the highest. The average classification accuracies of three preferences in females and males were 86.2 and 86.3%, respectively, showing no difference in each group. By comparing the classification performances in three different combinations (like vs. so-so, like vs. dislike, and so-so vs. dislike) between two groups, male participants were observed to have targeted preferences for commercial advertising, and the classification performance 88.4% between "like" vs. "dislike" out of three categories was the highest. Finally, pairwise classification performance are shown as follows: For female, 86.1% (like vs. so-so), 87.4% (like vs. dislike), 85.2% (so-so vs. dislike), and for male 85.7, 88.4, 85.1%, respectively.

Cortical Hemodynamic Response Associated with Spatial Coding: A Near-Infrared Spectroscopy Study.

Derbie AY, Chau B, Lam B, Fang YH, Ting KH, Wong CYH, Tao J, Chen LD, Chan CCH.

Brain Topogr. Mar;34(2):207-
doi: 10.1007/s10548-021-00821-Epub Jan 23.

Allocentric and egocentric are two types of spatial coding. Previous studies reported the dorsal attention network's involvement in both types. To eliminate possible paradigm-specific confounds in the results, this study employed fine-grained cue-to-target paradigm to dissociate allocentric (aSC) and egocentric (eSC) spatial coding. Twenty-two participants completed a custom visuospatial task, and changes in the concentration of oxygenated hemoglobin (O2-Hb) were recorded using functional near-infrared spectroscopy (fNIRS). The least absolute shrinkage and selection operator-regularized principal component (LASSO-RPC) algorithm was used to identify cortical sites that predicted the aSC and eSC conditions' reaction times. Significant changes in O2-Hb concentration in the right inferior parietal lobule (IPL) and post-central gyrus regions were common in both aSC and eSC. Results of inter-channel correlations further substantiate cortical activities in both conditions were predominantly over the right parieto-frontal areas. Together with right superior frontal gyrus areas be the reaction time neural correlates, the results suggest top-down attention and response-mapping processes are common to both spatial coding types. Changes unique to aSC were in clusters over the right intraparietal sulcus, right temporo-parietal junction, and left IPL. With the left pre-central gyrus region, be the reaction time neural correlate, aSC is likely to involve more orienting attention, updating of spatial information, and object-based response selection and inhibition than eSC. Future studies will use other visuospatial task designs for testing the robustness of the findings on spatial coding processes.

The rostro-caudal gradient in the prefrontal cortex and its modulation by subthalamic deep brain stimulation in Parkinson's disease.

Schumacher FK, Schumacher LV, Amtage F, Horn A, Egger K, Piroth T, Weiller C, Schelter BO, Coenen VA, Kaller CP.

Sci Rep. Jan 22;11(1):
doi: 10.1038/s41598-021-81535-7.

Deep brain stimulation of the subthalamic nucleus (STN-DBS) alleviates motor symptoms in Parkin-

son's disease (PD) but also affects the prefrontal cortex (PFC), potentially leading to cognitive side effects. The present study tested alterations within the rostro-caudal hierarchy of neural processing in the PFC induced by STN-DBS in PD. Granger-causality analyses of fast functional near-infrared spectroscopy (fNIRS) measurements were used to infer directed functional connectivity from intrinsic PFC activity in 24 PD patients treated with STN-DBS. Functional connectivity was assessed ON stimulation, in steady-state OFF stimulation and immediately after the stimulator was switched ON again. Results revealed that STN-DBS significantly enhanced the rostro-caudal hierarchical organization of the PFC in patients who had undergone implantation early in the course of the disease, whereas it attenuated the rostro-caudal hierarchy in late-implanted patients. Most crucially, this systematic network effect of STN-DBS was reproducible in the second ON stimulation measurement. Supplemental analyses demonstrated the significance of prefrontal networks for cognitive functions in patients and matched healthy controls. These findings show that the modulation of prefrontal functional networks by STN-DBS is dependent on the disease duration before DBS implantation and suggest a neurophysiological mechanism underlying the side effects on prefrontally-guided cognitive functions observed under STN-DBS.

Validating the use of functional Near-Infrared Spectroscopy in monkeys: The case of brain activation lateralization in Papio anubis.

Debracque C, Gruber T, Lacoste R, Grandjean D, Meguerditchian A.

Behav Brain Res. Apr 9;403:

doi: 10.1016/j.bbr.2021.Epub Jan 19.

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

The Development of Brain Network in Males with Autism Spectrum Disorders from Childhood to Adolescence: Evidence from fNIRS Study.

Cao W, Zhu H, Li Y, Wang Y, Bai W, Lao U, Zhang Y, Ji Y, He S, Zou X.

Brain Sci. Jan 18;11(1):

doi: 10.3390/brainsci11010120.

In the current study, functional near-infrared spectroscopy (fNIRS) was used to collect resting-state signals from 77 males with autism spectrum disorders (ASD, age: 6 16.25) and 40 typically developing (TD) males (age: 6 16.58) in the theory-of-mind (ToM) network. The graph theory analysis was used to obtain the brain network properties in ToM network, and the multiple regression analysis demonstrated that males with ASD showed a comparable global network topology, and a similar age-related decrease

in the medial prefrontal cortex area (mPFC) compared to TD individuals. Nevertheless, participants with ASD showed U-shaped trajectories of nodal metrics of right temporo-parietal junction (TPJ), and an age-related decrease in the left middle frontal gyrus (MFG), while trajectories of TD participants were opposite. The nodal metrics of the right TPJ was negatively associated with the social deficits of ASD, while the nodal metrics of the left MFG was negatively associated with the communication deficits of ASD. Current findings suggested a distinct developmental trajectory of the ToM network in males with ASD from childhood to adolescence.

Single-Trial Recognition of Video Gamer's Expertise from Brain Haemodynamic and Facial Emotion Responses.

Andreu-Perez AR, Kiani M, Andreu-Perez J, Reddy P, Andreu-Abela J, Pinto M, Izzetoglu K.

Brain Sci. Jan 14;11(1):
doi: 10.3390/brainsci11010106.

With an increase in consumer demand of video gaming entertainment, the game industry is exploring novel ways of game interaction such as providing direct interfaces between the game and the gamers' cognitive or affective responses. In this work, gamer's brain activity has been imaged using functional near infrared spectroscopy (fNIRS) whilst they watch video of a video game (League of Legends) they play. A video of the face of the participants is also recorded for each of a total of 15 trials where a trial is defined as watching a gameplay video. From the data collected, i.e., gamer's fNIRS data in combination with emotional state estimation from gamer's facial expressions, the expertise level of the gamers has been decoded per trial in a multi-modal framework comprising of unsupervised deep feature learning and classification by state-of-the-art models. The best tri-class classification accuracy is obtained using a cascade of random convolutional kernel transform (ROCKET) feature extraction method and deep classifier at 91.44%. This is the first work that aims at decoding expertise level of gamers using non-restrictive and portable technologies for brain imaging, and emotional state recognition derived from gamers' facial expressions. This work has profound implications for novel designs of future human interactions with video games and brain-controlled games.

Individual Differences in Hemodynamic Responses Measured on the Head Due to a Long-Term Stimulation Involving Colored Light Exposure and a Cognitive Task: A SPA-fNIRS Study.

Zohdi H, Scholkmann F, Wolf U.

Brain Sci. Jan 5;11(1):
doi: 10.3390/brainsci11010054.

When brain activity is measured by neuroimaging, the canonical hemodynamic response (increase in oxygenated hemoglobin ([O2Hb]) and decrease in deoxygenated hemoglobin ([HHb]) is not always seen in every subject. The reason for this intersubject-variability of the responses is still not completely understood. This study is performed with 32 healthy subjects, using the systemic physiology augmented functional near-infrared spectroscopy (SPA-fNIRS) approach. We investigate the intersubject variability of hemodynamic and systemic physiological responses, due to a verbal fluency task (VFT) under colored light exposure (CLE; blue and red). Five and seven different hemodynamic response patterns were detected in the subgroup analysis of the blue and red light exposure, respectively. We also found that arterial oxygen saturation and mean arterial pressure were positively correlated with [O2Hb] at the prefrontal cortex during the CLE-VFT independent of the color of light and classification of the subjects. Our study finds that there is substantial intersubject-variability of cerebral hemodynamic responses, which is partially explained by subject-specific systemic physiological changes induced by the CLE-VFT. This means that both subgroup analyses and the additional assessment of systemic physiology are of crucial importance to achieve a comprehensive

understanding of the effects of a CLE-VFT on human subjects.

Neural correlates of distraction and reappraisal in the family context: Associations with symptoms of anxiety and depression in youth.

Bettis AH, Siciliano RE, Rogers BP, Ichinose M, Compas BE.

Child Neuropsychol. Jan 18:1-
doi: 10.1080/09297049.2020.Online ahead of print.

Objective: Youth coping is consistently associated with risk and resilience for youth internalizing psychopathology. Integrating questionnaire and experimental methods is an important next step in understanding how youth develop, learn, and implement these skills and to identify possible neurobiological mechanisms that underlie these processes. The current study aims to explore associations among youth self-reported and laboratory-based measures of two methods of coping (distraction and reappraisal). Further, the current study aims to examine associations among neural correlates of distraction and reappraisal with symptoms of anxiety and depression in youth. Methods: Youth (N =69; M =12.24, SD=1.83; 52.9% female) completed self-report measures of secondary control coping (RSQ) and symptoms of anxiety (SCARED) and depression (CES-D) and a laboratory coping task. While completing the task, prefrontal hemodynamic changes were measured using functional near-infrared spectroscopy (fNIRS). Results: Neural activation during reappraisal was significantly negatively correlated with youth anxiety symptoms, and both neural activation and self-reported coping were significant independent predictors of anxiety. Youth self-reported coping was not associated with neural activation during reappraisal or distraction. Conclusions: The measurement of possible neural markers of risk and resilience in youth is an important area of continued research. Identification of possible mechanisms of change related to anxiety and depression in youth may inform targets of intervention.

Effect of exergaming versus combined exercise on cognitive function and brain activation in frail older adults: A randomized controlled trial.

Liao YY, Chen IH, Hsu WC, Tseng HY, Wang RY.

Ann Phys Rehabil Med. Jan 14:
doi: 10.1016/j.rehab.2021. Online ahead of print.

BACKGROUND: Cognitive impairment is prevalent among frail older adults. Traditional exercise and exergaming positively affect cognition in healthy older people. However, few studies have investigated the effects of exergaming on cognition and brain activation in frail older adults. OBJECTIVE: This study compared the effect of Kinect based exergaming (EXER) and combined physical exercise (CPE) training on cognitive function and brain activation in frail older adults in Taiwan. We hypothesized that EXER would be superior to CPE in this population. METHODS: We randomized 46 community-dwelling frail older adults to the EXER or CPE group for 36 sessions (three 60-min training sessions per week) over 12 weeks. Outcome measures for cognitive function included global cognition measured by the Montreal Cognitive Assessment, executive function measured by the Executive Interview 25, verbal memory measured by the Chinese version of the California Verbal Learning Test, attention measured by the Stroop Color and Word Test and Trail Making Test (part B), and working memory measured by spatial n-back tests. Prefrontal cortex activation during the global cognition test was documented with functional near-infrared spectroscopy (fNIRS). RESULTS: Both groups improved significantly in global cognition ($p<0.05$), executive function ($p<0.05$), and attention ($p<0.05$) after the 12-week intervention. The group?ime interaction indicated that EXER training significantly enhanced global cognition more than CPE training ($F(1,44)=5.277$, $p=0.026$). Moreover, only the EXER group showed significant improvements in verbal ($p<0.05$) and working ($p<0.05$) memory after the intervention. The fNIRS hemodynamics data revealed decreased activation in prefrontal cortices of both groups ($p<0.05$) during the post-training cognitive as-

sessment, thereby suggesting greater neural efficiency; however, we found no significant group difference. CONCLUSION: In frail older adults, exergaming and CPE could improve cognitive function, most likely by increasing neural efficiency. Moreover, exergaming may be superior to CPE, particularly in improving global cognition.

Brain activity during real-time walking and with walking interventions after stroke: a systematic review.

Lim SB, Louie DR, Peters S, Liu-Ambrose T, Boyd LA, Eng JJ.

J Neuroeng Rehabil. Jan 15;18(1):
doi: 10.1186/s12984-020-00797-w.

Investigations of real-time brain activations during walking have become increasingly important to aid in recovery of walking after a stroke. Individual brain activation patterns can be a valuable biomarker of neuroplasticity during the rehabilitation process and can result in improved personalized medicine for rehabilitation. The purpose of this systematic review is to explore the brain activation characteristics during walking post-stroke by determining: (1) if different components of gait (i.e., initiation/acceleration, steady-state, complex) result in different brain activations, (2) whether brain activations differ from healthy individuals. Six databases were searched resulting in 22 studies. Initiation/acceleration showed bilateral activation in frontal areas; steady-state and complex walking showed broad activations with the majority exploring and finding increases in frontal regions and some studies also showing increases in parietal activation. Asymmetrical activations were often related to performance asymmetry and were more common in studies with slower gait speed. Hyperactivations and asymmetrical activations commonly decreased with walking interventions and as walking performance improved. Hyperactivations often persisted in individuals who had experienced severe strokes. Only a third of the studies included comparisons to a healthy group: individuals post-stroke employed greater brain activation compared to young adults, while comparisons to older adults were less clear and limited. Current literature suggests some indicators of walking recovery however future studies investigating more brain regions and comparisons with healthy age-matched adults are needed to further understand the effect of stroke on walking-related brain activation.

Identification of autism spectrum disorder based on short-term spontaneous hemodynamic fluctuations using deep learning in a multi-layer neural network.

Xu L, Sun Z, Xie J, Yu J, Li J, Wang J.

Clin Neurophysiol. Feb;132(2):457-
doi: 10.1016/j.clinph.2020.11. Epub Dec 30.

OBJECTIVE: To classify children with autism spectrum disorder (ASD) and typical development (TD) using short-term spontaneous hemodynamic fluctuations and to explore the abnormality of inferior frontal gyrus and temporal lobe in ASD. METHODS: 25 ASD children and 22 TD children were measured with functional near-infrared spectroscopy located on the inferior frontal gyrus and temporal lobe. To extract features used to classify ASD and TD, a multi-layer neural network was applied, combining with a three-layer convolutional neural network, a layer of long and short-term memory network (LSTM) and a layer of LSTM with Attention mechanism. In order to shorten the time of data collection and get more information from limited samples, a sliding window with 3.5s width was utilized after comparisons, and numerous short (3.5s) fNIRS time series were then obtained and used as the input of the multi-layer neural network. RESULTS: A good classification between ASD and TD was obtained with considerably high accuracy by using a multi-layer neural network in different brain regions, especially in the left temporal lobe, where sensitivity of 90.6% and specificity of 97.5% achieved. CONCLUSIONS: The "CLAttention" multi-layer neural network has the potential to excavate more meaningful features to distinguish between ASD and TD. Moreover, the temporal lobe may be worth further study. SIGNIFICANCE: The findings in

this study may have implications for rapid diagnosis of children with ASD and provide a new perspective for future medical diagnosis.

Best practices for fNIRS publications.

Ycel MA, Lhmann AV, Scholkmann F, Gervain J, Dan I, Ayaz H, Boas D, Cooper RJ, Culver J, Elwell CE, Eggebrecht A, Franceschini MA, Grova C, Homae F, Lesage F, Obrig H, Tachtsidis I, Tak S, Tong Y, Torricelli A, Wabnitz H, Wolf M.

Neurophotonics. Jan;8(1):
doi: 10.1117/1.NPh.8.1.Epub Jan 7.

Erratum in Neurophotonics. 2021 Jan;8(1):019802.

Trends and Challenges of Wearable Multimodal Technologies for Stroke Risk Prediction.

Chen YH, Sawan M.

Sensors (Basel). Jan 11;21(2):
doi: 10.3390/s21020460.

We review in this paper the wearable-based technologies intended for real-time monitoring of stroke-related physiological parameters. These measurements are undertaken to prevent death and disability due to stroke. We compare the various characteristics, such as weight, accessibility, frequency of use, data continuity, and response time of these wearables. It was found that the most user-friendly wearables can have limitations in reporting high-precision prediction outcomes. Therefore, we report also the trend of integrating these wearables into the internet of things (IoT) and combining electronic health records (EHRs) and machine learning (ML) algorithms to establish a stroke risk prediction system. Due to different characteristics, such as accessibility, time, and spatial resolution of various wearable-based technologies, strategies of applying different types of wearables to maximize the efficacy of stroke risk prediction are also reported. In addition, based on the various applications of multimodal electroencephalography-functional near-infrared spectroscopy (EEG-fNIRS) on stroke patients, the perspective of using this technique to improve the prediction performance is elaborated. Expected prediction has to be dynamically delivered with high-precision outcomes. There is a need for stroke risk stratification and management to reduce the resulting social and economic burden.

Accurate hemodynamic response estimation by removal of stimulus-evoked superficial response in fNIRS signals.

Galli A, Brigadoi S, Giorgi G, Sparacino G, Narduzzi C.

J Neural Eng. Jan
doi: 10.1088/1741-2552/abdb3a. Online ahead of print.

ObjectiveWe address the problem of hemodynamic response estimation when task-evoked extra-cerebral components are present in functional near-infrared spectroscopy (fNIRS) signals. These components might bias the hemodynamic response estimation, therefore careful and accurate denoising of data is needed.ApproachWe propose a dictionary-based algorithm to process every single event-related segment of the acquired signal for both long separation and short separation channels. Stimulus-evoked components and physiological noise are modeled by means of two distinct waveform dictionaries. For each segment, after removal of the physiological noise component in each channel, a template is employed to estimate stimulus-evoked responses in both channels. Then, the estimate from the short-separation channel is employed to correct for the evoked superficial response and refine the hemodynamic response estimate from

the long-separation channel.Main resultsAnalysis of simulated, semi-simulated and real data shows that, by averaging single-segment estimates over multiple trials in an experiment, reliable results and improved accuracy compared to other methods can be obtained. The average estimation error of the proposed method for the semi-simulated data set is 34% for HbO and 78% for HbR, considering 40 trials. The proposed method outperforms the results of the methods proposed in the literature. While still far from the possibility of single-trial hemodynamic response estimation, a significant reduction in the number of averaged trials can also be obtained.SignificanceThis work proves that dedicated dictionaries can be successfully employed to model all different components of fNIRS signals. It demonstrates the effectiveness of a specifically designed algorithm structure in dealing with a complex denoising problem, enhancing the possibilities of fNIRS-based hemodynamic response analysis.

Enhanced spatiotemporal resolution imaging of neuronal activity using joint electroencephalography and diffuse optical tomography.

Cao J, Huppert TJ, Grover P, Kainerstorfer JM.

Neurophotonics. Jan;8(1):

doi: 10.1117/1.NPh.8.1.Epub Jan 1.

Significance: Electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) are both commonly used methodologies for neuronal source reconstruction. While EEG has high temporal resolution (millisecond-scale), its spatial resolution is on the order of centimeters. On the other hand, in comparison to EEG, fNIRS, or diffuse optical tomography (DOT), when used for source reconstruction, can achieve relatively high spatial resolution (millimeter-scale), but its temporal resolution is poor because the hemodynamics that it measures evolve on the order of several seconds. This has important neuroscientific implications: e.g., if two spatially close neuronal sources are activated sequentially with only a small temporal separation, single-modal measurements using either EEG or DOT alone would fail to resolve them correctly. Aim: We attempt to address this issue by performing joint EEG and DOT neuronal source reconstruction. Approach: We propose an algorithm that utilizes DOT reconstruction as the spatial prior of EEG reconstruction, and demonstrate the improvements using simulations based on the ICBM152 brain atlas. Results: We show that neuronal sources can be reconstructed with higher spatiotemporal resolution using our algorithm than using either modality individually. Further, we study how the performance of the proposed algorithm can be affected by the locations of the neuronal sources, and how the performance can be enhanced by improving the placement of EEG electrodes and DOT optodes. Conclusions: We demonstrate using simulations that two sources separated by 2.3-3.3cm and 50ms can be recovered accurately using the proposed algorithm by suitably combining EEG and DOT, but not by either in isolation. We also show that the performance can be enhanced by optimizing the electrode and optode placement according to the locations of the neuronal sources.

Dynamic Functional Connectivity as a complex random walk: Definitions and the dFCwalk toolbox.

Arbabyazd LM, Lombardo D, Blin O, Didic M, Battaglia D, Jirsa V.

MethodsX. Dec 1;7:

doi: 10.1016/j.mex.2020.eCollection 2020.

?We have developed a framework to describe the dynamics of Functional Connectivity (dFC) estimated from brain activity time-series as a complex random walk in the space of possible functional networks. This conceptual and methodological framework considers dFC as a smooth reconfiguration process, combining "liquid" and "coordinated" aspects. Unlike other previous approaches, our method does not require the explicit extraction of discrete connectivity states.?In our previous work, we introduced several metrics for the quantitative characterization of the dFC random walk. First, dFC speed analyses extract the

distribution of the time-resolved rate of reconfiguration of FC along time. These distributions have a clear peak (typical dFC speed, that can already serve as a biomarker) and fat tails (denoting deviations from Gaussianity that can be detected by suitable scaling analyses of FC network streams). Second, meta-connectivity (MC) analyses identify groups of functional links whose fluctuations co-vary in time and that define veritable dFC modules organized along specific dFC meta-hub controllers (differing from conventional FC modules and hubs). The decomposition of whole-brain dFC by MC allows performing dFC speed analyses separately for each of the detected dFC modules.?We present here blocks and pipelines for dFC random walk analyses that are made easily available through a dedicated MATLAB? toolbox (dFCwalk), openly downloadable. Although we applied such analyses mostly to fMRI resting state data, in principle our methods can be extended to any type of neural activity (from Local Field Potentials to EEG, MEG, fNIRS, etc.) or even non-neural time-series.

Role of prefrontal cortex during Sudoku task: fNIRS study.

Ashlesh P, Deepak KK, Preet KK.

Transl Neurosci. Nov 3;11(1):419-

doi: 10.1515/tnsci-2020- eCollection 2020.

BACKGROUND: Sudoku is a popular cognitively stimulating leisure-time activity. Many studies have been directed toward finding an algorithm to solve Sudoku, but the investigation of the neural substrates involved in Sudoku has been challenging. METHODS: Sudoku task was divided into two steps to understand the differential function of the prefrontal cortex (PFC) while applying heuristic rules. PFC activity was recorded at 16 optode locations using functional near infrared spectroscopy. Classical two-way analysis of variance as well as general linear model-based approach was used to analyze the data from 28 noise-free recordings obtained from right-handed participants. RESULTS: Post hoc analysis showed a significant increase in oxyhemoglobin concentrations and decrease in deoxyhemoglobin concentrations at all 16 optode locations during step 1 (3 ?3 subgrids) and step 2 (easy level 9 ?9 Sudoku) when compared with the rest ($p < 0.0001$). Contrasting the step 2 - step 1 revealed that medial regions of PFC were preferentially activated. CONCLUSION: Both the medial and lateral regions of PFC are activated during Sudoku task. However, the medial regions of PFC play a differential role, especially when we consider searching and selecting the heuristic rules. Thus, Sudoku may be used for cognitive remediation training in neuropsychiatric disorders involving PFC.

Spontaneous Eye Blink Rate Connects Missing Link between Aerobic Fitness and Cognition.

Kuwamizu R, Suwabe K, Damrongthai C, Fukuie T, Ochi G, Hyodo K, Hiraga T, Nagano-Saito A, Soya H.

Med Sci Sports Exerc. Dec 29;Publish Ahead of Print.

doi: 10.1249/MSS.Online ahead of print.

PURPOSE: Higher aerobic fitness, a physiological marker of habitual physical activity, is likely to predict higher executive function based on the prefrontal cortex (PFC), according to current cross-sectional studies. The exact biological link between the brain and brawn remains unclear, but the brain dopaminergic system, which acts as a driving force for physical activity and exercise, can be hypothesized to connect the missing link above. Recently, spontaneous eye blink rate (sEBR) was proposed and has been used as a potential, non-invasive marker of brain dopaminergic activity in the neuroscience field. To address the hypothesis above, we sought to determine whether sEBR is a mediator of the association between executive function and aerobic fitness. METHODS: Thirty-five healthy young males (18-24 years old) had their sEBR measured while staring at a fixation cross while at rest. They underwent an aerobic fitness assessment using a graded exercise test to exhaustion and performed a color-word Stroop task as an index

of executive function. Stroop-task-related cortical activation in the left dorsolateral PFC (l-DLPFC) was monitored using functional near-infrared spectroscopy (fNIRS). RESULTS: Correlation analyses revealed significant correlations among higher aerobic fitness, less Stroop interference, and higher sEBR. Moreover, mediation analyses showed that sEBR significantly mediated the association between aerobic fitness and Stroop interference. In addition, higher sEBR was correlated with higher neural efficiency of the l-DLPFC (i.e., executive function was high, and the corresponding l-DLPFC activation was relatively low). CONCLUSION: These results indicate that the sEBR mediates the association between aerobic fitness and executive function through prefrontal neural efficiency, which clearly supports the hypothesis that brain dopaminergic function works to connect, at least in part, the missing link between aerobic fitness and executive function.

Prefrontal Cortex Involvement during Dual-Task Stair Climbing in Healthy Older Adults: An fNIRS Study.

Salzman T, Aboualmagd A, Badawi H, Tob??allejo D, Kim H, Dahroug L, Laamarti F, El Saddik A, Fraser S.

Brain Sci. Jan 7;11(1):
doi: 10.3390/brainsci11010071.

Executive function and motor control deficits adversely affect gait performance with age, but the neural correlates underlying this interaction during stair climbing remains unclear. Twenty older adults (72.7 6.9 years) completed single tasks: standing and responding to a response time task (SC), ascending or descending stairs (SMup, SMdown); and a dual-task: responding while ascending or descending stairs (DTup, DTdown). Prefrontal hemodynamic response changes (?HbO2, ?HbR) were examined using functional near-infrared spectroscopy (fNIRS), gait speed was measured using in-shoe smart insoles, and vocal response time and accuracy were recorded. Findings revealed increased ?HbO2 ($p = 0.020$) and slower response times ($p < 0.001$) during dual- versus single tasks. ?HbR ($p = 0.549$), accuracy ($p = 0.135$) and gait speed ($p = 0.475$) were not significantly different between tasks or stair climbing conditions. ?HbO2 and response time findings suggest that executive processes are less efficient during dual-tasks. These findings, in addition to gait speed and accuracy maintenance, may provide insights into the neural changes that precede performance declines. To capture the subtle differences between stair ascent and descent and extend our understanding of the neural correlates of stair climbing in older adults, future studies should examine more difficult cognitive tasks.

Hybrid Deep Learning (hDL)-Based Brain-Computer Interface (BCI) Systems: A Systematic Review.

Alzahab NA, Apollonio L, Di Iorio A, Alshalak M, Iarlori S, Ferracuti F, Monteri A, Porcaro C.

Brain Sci. Jan 8;11(1):
doi: 10.3390/brainsci11010075.

BACKGROUND: Brain-Computer Interface (BCI) is becoming more reliable, thanks to the advantages of Artificial Intelligence (AI). Recently, hybrid Deep Learning (hDL), which combines different DL algorithms, has gained momentum over the past five years. In this work, we proposed a review on hDL-based BCI starting from the seminal studies in 2015. OBJECTIVES: We have reviewed 47 papers that apply hDL to the BCI system published between 2015 and 2020 extracting trends and highlighting relevant aspects to the topic. METHODS: We have queried four scientific search engines (Google Scholar, PubMed, IEEE Xplore and Elsevier Science Direct) and different data items were extracted from each paper such as the database used, kind of application, online/offline training, tasks used for the BCI, pre-processing methodology adopted, type of normalization used, which kind of features were extracted, type of DL architecture used, number of layers implemented and which optimization approach were used as well. All these items

were then investigated one by one to uncover trends. RESULTS: Our investigation reveals that Electroencephalography (EEG) has been the most used technique. Interestingly, despite the lower Signal-to-Noise Ratio (SNR) of the EEG data that makes pre-processing of that data mandatory, we have found that the pre-processing has only been used in 21.28% of the cases by showing that hDL seems to be able to overcome this intrinsic drawback of the EEG data. Temporal-features seem to be the most effective with 93.94% accuracy, while spatial-temporal features are the most used with 33.33% of the cases investigated. The most used architecture has been Convolutional Neural Network-Recurrent Neural Network CNN-RNN with 47% of the cases. Moreover, half of the studies have used a low number of layers to achieve a good compromise between the complexity of the network and computational efficiency. SIGNIFICANCE: To give useful information to the scientific community, we make our summary table of hDL-based BCI papers available and invite the community to published work to contribute to it directly. We have indicated a list of open challenges, emphasizing the need to use neuroimaging techniques other than EEG, such as functional Near-Infrared Spectroscopy (fNIRS), deeper investigate the advantages and disadvantages of using pre-processing and the relationship with the accuracy obtained. To implement new combinations of architectures, such as RNN-based and Deep Belief Network DBN-based, it is necessary to better explore the frequency and temporal-frequency features of the data at hand.

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

Gu?n SMR, Vincent MA, Karageorghis CI, Delevoye-Turrell YN.

Neuroimage. Jan 6;230:

doi: 10.1016/j.neuroimage.2020.Online ahead of print.

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Interpersonal Neural Synchrony During Father-Child Problem Solving: An fNIRS Hyperscanning Study.

Nguyen T, Schleihauf H, Kungl M, Kayhan E, Hoehl S, Vrticka P.

Child Dev. Jan

doi: 10.1111/cdev.Online ahead of print.

Interpersonal neural synchrony (INS) has been previously evidenced in mother-child interactions, yet findings concerning father-child interaction are wanting. The current experiment examined whether fathers and their 5- to 6-year-old children (N=66) synchronize their brain activity during a naturalistic interaction, and addressed paternal and child factors related to INS. Compared to individual problem solving and rest, father-child dyads showed increased INS in bilateral dorsolateral prefrontal cortex and left temporo-parietal junction during cooperative problem solving. Furthermore, the father's attitude toward his role as a parent was positively related to INS during the cooperation condition. These results highlight the implication of the father's attitude to parenting in INS processes for the first time.

NeuroRA: A Python Toolbox of Representational Analysis From Multi-Modal Neural Data.

Lu Z, Ku Y.

Front Neuroinform. Dec 23;14:

doi: 10.3389/fninf.2020. eCollection 2020.

In studies of cognitive neuroscience, multivariate pattern analysis (MVPA) is widely used as it offers richer information than traditional univariate analysis. Representational similarity analysis (RSA), as one method of MVPA, has become an effective decoding method based on neural data by calculating

the similarity between different representations in the brain under different conditions. Moreover, RSA is suitable for researchers to compare data from different modalities and even bridge data from different species. However, previous toolboxes have been made to fit specific datasets. Here, we develop NeuroRA, a novel and easy-to-use toolbox for representational analysis. Our toolbox aims at conducting cross-modal data analysis from multi-modal neural data (e.g., EEG, MEG, fNIRS, fMRI, and other sources of neruroelectrophysiological data), behavioral data, and computer-simulated data. Compared with previous software packages, our toolbox is more comprehensive and powerful. Using NeuroRA, users can not only calculate the representational dissimilarity matrix (RDM), which reflects the representational similarity among different task conditions and conduct a representational analysis among different RDMs to achieve a cross-modal comparison. Besides, users can calculate neural pattern similarity (NPS), spatiotemporal pattern similarity (STPS), and inter-subject correlation (ISC) with this toolbox. NeuroRA also provides users with functions performing statistical analysis, storage, and visualization of results. We introduce the structure, modules, features, and algorithms of NeuroRA in this paper, as well as examples applying the toolbox in published datasets.

Frontal Functional Network Disruption Associated with Amyotrophic Lateral Sclerosis: An fNIRS-Based Minimum Spanning Tree Analysis.

Borgheai SB, McLinden J, Mankodiya K, Shahriari Y.

Front Neurosci. Dec 23;14:
doi: 10.3389/fnins.2020. eCollection 2020.

Recent evidence increasingly associates network disruption in brain organization with multiple neurodegenerative diseases, including amyotrophic lateral sclerosis (ALS), a rare terminal disease. However, the comparability of brain network characteristics across different studies remains a challenge for conventional graph theoretical methods. One suggested method to address this issue is minimum spanning tree (MST) analysis, which provides a less biased comparison. Here, we assessed the novel application of MST network analysis to hemodynamic responses recorded by functional near-infrared spectroscopy (fNIRS) neuroimaging modality, during an activity-based paradigm to investigate hypothetical disruptions in frontal functional brain network topology as a marker of the executive dysfunction, one of the most prevalent cognitive deficit reported across ALS studies. We analyzed data recorded from nine participants with ALS and ten age-matched healthy controls by first estimating functional connectivity, using phase-locking value (PLV) analysis, and then constructing the corresponding individual and group MSTs. Our results showed significant between-group differences in several MST topological properties, including leaf fraction, maximum degree, diameter, eccentricity, and degree divergence. We further observed a global shift toward more centralized frontal network organizations in the ALS group, interpreted as a more random or dysregulated network in this cohort. Moreover, the similarity analysis demonstrated marginally significantly increased overlap in the individual MSTs from the control group, implying a reference network with lower topological variation in the healthy cohort. Our nodal analysis characterized the main local hubs in healthy controls as distributed more evenly over the frontal cortex, with slightly higher occurrence in the left prefrontal cortex (PFC), while in the ALS group, the most frequent hubs were asymmetrical, observed primarily in the right prefrontal cortex. Furthermore, it was demonstrated that the global PLV (gPLV) synchronization metric is associated with disease progression, and a few topological properties, including leaf fraction and tree hierarchy, are linked to disease duration. These results suggest that dysregulation, centralization, and asymmetry of the hemodynamic-based frontal functional network during activity are potential neuro-topological markers of ALS pathogenesis. Our findings can possibly support new bedside assessments of the functional status of ALS' brain network and could hypothetically extend to applications in other neurodegenerative diseases.

Comparing verbal working memory load in auditory and visual modalities using functional near-infrared spectroscopy.

Rovetti J, Goy H, Nurgitz R, Russo FA.

Behav Brain Res. Mar 26;402:
doi: 10.1016/j.bbr.2020.Epub Jan 7.

The verbal identity n-back task is commonly used to assess verbal working memory (VWM) capacity. Only three studies have compared brain activation during the n-back when using auditory and visual stimuli. The earliest study, a positron emission tomography study of the 3-back, found no differences in VWM-related brain activation between n-back modalities. In contrast, two subsequent functional magnetic resonance imaging (fMRI) studies of the 2-back found that auditory VWM was associated with greater left dorsolateral prefrontal cortex (DL-PFC) activation than visual VWM, perhaps suggesting that auditory VWM requires more cognitive effort than its visual counterpart. The current study aimed to assess whether DL-PFC activation (i.e., cognitive effort) differs by VWM modality. To do this, 16 younger adults completed an auditory and visual n-back, both at four levels of VWM load. Concurrently, activation of the PFC was measured using functional near-infrared spectroscopy (fNIRS), a silent neuroimaging method. We found that DL-PFC activation increased with VWM load, but it was not affected by VWM modality or the interaction between load and modality. This supports the view that both VWM modalities require similar cognitive effort, and perhaps that previous fMRI results were an artefact of scanner noise. We also found that, across conditions, DL-PFC activation was positively correlated with reaction time. This may further support DL-PFC activation as an index of cognitive effort, and fNIRS as a method to measure it.

Cortical activity measured by functional near infrared spectroscopy during a theory of mind task in subjects with schizophrenia, bipolar disorder and healthy controls.

Sayar-Akaslan D, Baskak B, Kir Y, Kusman A, Yalcinkaya B, ?kmak IB, Munir K.

J Affect Disord. Mar 1;282:329-
doi: 10.1016/j.jad.2020.12.Epub Dec 29.

Theory of Mind (ToM) deficits interfere in social cognitive functioning in schizophrenia (SCZ) and are increasingly recognized to do so in bipolar disorder (BD), however their clinical and neurobiological correlates remain unclear. This study represents the first direct comparison of subjects with SCZ (N=26), BD (N=26) and healthy controls (N=33) in cortical activity during the Reading the Mind in the Eyes Task (RMET) using functional Near Infrared Spectroscopy (fNIRS) with the control condition (CC) involving gender identification via the same stimuli. The three groups were compared with a comprehensive ToM battery and assessed in terms of the relationship of ToM performance with clinical symptoms, insight and functioning. The controls scored higher than the SCZ and BD groups in ToM assessments, with SCZ group showing the worse performance in terms of meta-representation and empathy. The SCZ group ToM scores inversely correlated with negative symptom severity and positively correlated with insight; BD group ToM scores negatively correlated with subclinical mania symptoms and projected functioning. Cortical activity was higher during the ToM condition compared to the CC in the pre-motor and supplementary-motor cortices, middle and superior temporal gyri, and the primary somatosensory cortex. Group x Condition interaction was detected whereby activity was higher during the ToM condition among controls with no detected difference between SCZ and BD groups. The results suggest that ToM is represented similarly in cortical activity in SCZ and BD compared to healthy controls pointing to possible neurobiological convergence of SCZ and BD in underlying impairments of social cognition.

Hemodynamic and behavioral changes in older adults during cognitively demanding dual tasks.

Salzman T, Tob??allejo D, Polskaia N, Michaud L, St-Amant G, Lajoie Y, Fraser S.

Brain Behav. Mar;11(3):e
doi: 10.1002/brb3.Epub Jan 8.

INTRODUCTION: Executive functions play a fundamental role in walking by integrating information from cognitive-motor pathways. Subtle changes in brain and behavior may help identify older adults who are more susceptible to executive function deficits with advancing age due to prefrontal cortex deterioration. This study aims to examine how older adults mitigate executive demands while walking during cognitively demanding tasks. METHODS: Twenty healthy older adults (M=71.8years, SD=6.4) performed simple reaction time (SRT), go/no-go (GNG), n-back (NBK), and double number sequence (DNS) cognitive tasks of increasing difficulty while walking (i.e., dual task). Functional near infra-red spectroscopy (fNIRS) was used to measure the hemodynamic response (i.e., oxy- [HbO2] and deoxyhemoglobin [HbR]) changes in the prefrontal cortex (PFC) during dual and single tasks (i.e., walking alone). In addition, performance was measured using gait speed (m/s), response time (s), and accuracy (% correct). RESULTS: Using repeated measures ANOVAs, neural findings demonstrated a main effect of task such that ?HbO2 (p=.047) and ?HbR (p=.040) decreased between single and dual tasks. An interaction between task and cognitive difficulty (p=.014) revealed that gait speed decreased in the DNS between single and dual tasks. A main effect of task in response time indicated that the SRT response time was faster than all other difficulty levels (p<.001). Accuracy performance declined between single and dual tasks (p=.028) and across difficulty levels (p<.001) but was not significantly different between the NBK and DNS. CONCLUSION: Findings suggest that a healthy older adult sample might mitigate executive demands using an automatic locomotor control strategy such that shifting conscious attention away from walking during the dual tasks resulted in decreased ?HbO2 and ?HbR. However, decreased prefrontal activation was inefficient at maintaining response time and accuracy performance and may be differently affected by increasing cognitive demands.

Domain adaptation for robust workload level alignment between sessions and subjects using fNIRS.

Lyu B, Pham T, Blaney G, Haga Z, Sassaroli A, Fantini S, Aeron S.

J Biomed Opt. Jan;26(2):
doi: 10.1117/1.JBO.26.2.022908.

SIGNIFICANCE: We demonstrated the potential of using domain adaptation on functional near-infrared spectroscopy (fNIRS) data to classify different levels of n-back tasks that involve working memory. AIM: Domain shift in fNIRS data is a challenge in the workload level alignment across different experiment sessions and subjects. To address this problem, two domain adaptation approaches-Gromov-Wasserstein (G-W) and fused Gromov-Wasserstein (FG-W) were used. APPROACH: Specifically, we used labeled data from one session or one subject to classify trials in another session (within the same subject) or another subject. We applied G-W for session-by-session alignment and FG-W for subject-by-subject alignment to fNIRS data acquired during different n-back task levels. We compared these approaches with three supervised methods: multiclass support vector machine (SVM), convolutional neural network (CNN), and recurrent neural network (RNN). RESULTS: In a sample of six subjects, G-W resulted in an alignment accuracy of 68 % 4 % (weighted mean standard error) for session-by-session alignment, FG-W resulted in an alignment accuracy of 55 % 2 % for subject-by-subject alignment. In each of these cases, 25% accuracy represents chance. Alignment accuracy results from both G-W and FG-W are significantly greater than those from SVM, CNN, and RNN. We also showed that removal of motion artifacts from the fNIRS data plays an important role in improving alignment performance. CONCLUSIONS: Domain adaptation has potential for session-by-session and subject-by-subject alignment of mental workload by using fNIRS data.

Subject-independent decoding of affective states using functional near-infrared spectroscopy.

Trambaiolli LR, Tossato J, Cravo AM, Biazoli CE Jr, Sato JR.
PLoS One. Jan 7;16(1):e
doi: 10.1371/journal.pone. eCollection 2021.

Affective decoding is the inference of human emotional states using brain signal measurements. This approach is crucial to develop new therapeutic approaches for psychiatric rehabilitation, such as affective neurofeedback protocols. To reduce the training duration and optimize the clinical outputs, an ideal clinical neurofeedback could be trained using data from an independent group of volunteers before being used by new patients. Here, we investigated if this subject-independent design of affective decoding can be achieved using functional near-infrared spectroscopy (fNIRS) signals from frontal and occipital areas. For this purpose, a linear discriminant analysis classifier was first trained in a dataset (49 participants, 24.653.23 years) and then tested in a completely independent one (20 participants, 24.003.92 years). Significant balanced accuracies between classes were found for positive vs. negative (64.50 12.03%, $p<0.01$) and negative vs. neutral (68.25 12.97%, $p<0.01$) affective states discrimination during a reactive block consisting in viewing affective-loaded images. For an active block, in which volunteers were instructed to recollect personal affective experiences, significant accuracy was found for positive vs. neutral affect classification (71.25 18.02%, $p<0.01$). In this last case, only three fNIRS channels were enough to discriminate between neutral and positive affective states. Although more research is needed, for example focusing on better combinations of features and classifiers, our results highlight fNIRS as a possible technique for subject-independent affective decoding, reaching significant classification accuracies of emotional states using only a few but biologically relevant features.

Examining Mental Workload in a Spatial Navigation Transfer Game via Functional near Infrared Spectroscopy.
Galoyan T, Betts K, Abramian H, Reddy P, Izzetoglu K, Shewokis PA.
Brain Sci. Jan 4;11(1):
doi: 10.3390/brainsci11010045.

The goal of this study was to examine the effects of task-related variables, such as the difficulty level, problem scenario, and experiment week, on performance and mental workload of 27 healthy adult subjects during problem solving within the spatial navigation transfer (SNT) game. The study reports task performance measures such as total time spent on a task (TT) and reaction time (RT); neurophysiological measures involving the use of functional near-infrared spectroscopy (fNIRS); and a subjective rating scale for self-assessment of mental workload (NASA TLX) to test the related hypotheses. Several within-subject repeated-measures factorial ANOVA models were developed to test the main hypothesis. The results revealed a number of interaction effects for the dependent measures of TT, RT, fNIRS, and NASA TLX. The results showed (1) a decrease in TT and RT across the three levels of difficulty from Week 1 to Week 2; (2) an increase in TT and RT for high and medium cognitive load tasks as compared to low cognitive load tasks in both Week 1 and Week 2; (3) an overall increase in oxygenation from Week 1 to Week 2. These findings confirmed that both the behavioral performance and mental workload were sensitive to task manipulations.

Prefrontal Asymmetry BCI Neurofeedback Datasets.
Charles F, De Castro Martins C, Cavazza M.
Front Neurosci. Dec 18;14:
doi: 10.3389/fnins.2020. eCollection 2020.

Prefrontal cortex (PFC) asymmetry is an important marker in affective neuroscience and has attracted significant interest, having been associated with studies of motivation, eating behavior, empathy, risk propensity, and clinical depression. The data presented in this paper are the result of three different exper-

iments using PFC asymmetry neurofeedback (NF) as a Brain-Computer Interface (BCI) paradigm, rather than a therapeutic mechanism aiming at long-term effects, using functional near-infrared spectroscopy (fNIRS) which is known to be particularly well-suited to the study of PFC asymmetry and is less sensitive to artifacts. From an experimental perspective the BCI context brings more emphasis on individual subjects' baselines, successful and sustained activation during epochs, and minimal training. The subject pool is also drawn from the general population, with less bias toward specific behavioral patterns, and no inclusion of any patient data. We accompany our datasets with a detailed description of data formats, experiment and protocol designs, as well as analysis of the individualized metrics for definitions of success scores based on baseline thresholds as well as reference tasks. The work presented in this paper is the result of several experiments in the domain of BCI where participants are interacting with continuous visual feedback following a real-time NF paradigm, arising from our long-standing research in the field of affective computing. We offer the community access to our fNIRS datasets from these experiments. We specifically provide data drawn from our empirical studies in the field of affective interactions with computer-generated narratives as well as interfacing with algorithms, such as heuristic search, which all provide a mechanism to improve the ability of the participants to engage in active BCI due to their realistic visual feedback. Beyond providing details of the methodologies used where participants received real-time NF of left-asymmetric increase in activation in their dorsolateral prefrontal cortex (DLPFC), we re-establish the need for carefully designing protocols to ensure the benefits of NF paradigm in BCI are enhanced by the ability of the real-time visual feedback to adapt to the individual responses of the participants. Individualized feedback is paramount to the success of NF in BCIs.

Prefrontal cortex activation during working memory task in schizophrenia: A fNIRS study.

Kumar V, Nichenmetla S, Chhabra H, Sreeraj VS, Rao NP, Kesavan M, Varambally S, Venkatasubramanian G, Gangadhar BN.

Asian J Psychiatr. Feb;56:
doi: 10.1016/j.ajp.2020.Epub Dec 20.

Neurocognitive cognitive deficits including working memory (WM) impairment is a key component of schizophrenia (SCZ). Though a prefrontal cortex (PFC) abnormality is recognised to contribute to WM impairment, the exact nature of its neurobiological basis in SCZ is not well established. Functional near infra-red spectroscopy (fNIRS) is an emerging low-cost neuroimaging tool to study neuro-hemodynamics. In this background, we examined the hemodynamic activity during a WM task in schizophrenia using fNIRS. fNIRS was acquired during computerised N-back (zero-, one- & two-back) task in 15 SCZ patients and compared with 22 healthy controls. Performance in N-back test were calculated using signal detection theory alongside the mean reaction times. Concentration and latencies of oxy-, deoxy-, and totalhaemoglobin, and oxygen saturation were computed from 8*8 optodes positioned over bilateral PFC. SCZ performed poorly as measured by most of the WM parameters ($p<0.05$). Lesser deoxyhemoglobin concentration (two>zero, at right BA10, $p=0.006$) was noted in the right frontopolar cortex in SCZ surviving multiple-comparison correction. In addition, olanzapine equivalent doses correlated negatively with right frontopolar cortex activation (two>zero back, BA10, ?=0.70, $p=0.004$) and better performance in two back (false alarm rate, ?=0.61, $p=0.015$). A delayed but compensatory hyperactivation of right frontopolar cortex noted in SCZ may underlie the WM deficit in SCZ. Future studies are recommended to replicate the role of right frontopolar cortex in WM using larger samples and systematically explore the effect of antipsychotics on them.

Research on blood oxygen activity in cerebral cortical motor function areas with adjustment intention during gait.

Li C, Zhu Y, Qu W, Sun L.
Technol Health Care. Dec
doi: 10.3233/THC-Online ahead of print.
DOI: 10.3233/THC-202580 PMID: 33386834

The feasibility of fNIRS as a diagnostic tool for pediatric TBI: A pilot study.

DA C, Jj L, Metting Z, Se R, Jm S, Jwj E, van der Naalt J.
Eur J Paediatr Neurol. Jan;30:22-
doi: 10.1016/j.ejpn.2020.12.Epub Dec 27.

BACKGROUND: Functional near-infrared spectroscopy (fNIRS) enables assessment of prefrontal hemodynamic response. This study explored the feasibility of fNIRS in determining hemodynamic changes related to cognitive task performance in pediatric traumatic brain injury (TBI) in order to assess its potential as a diagnostic tool. METHODS: We measured changes in oxygenated hemoglobin [O2Hb] during a verbal fluency task (VFT), which activates frontal brain regions involved in working memory, in 15 TBI patients and 21 healthy controls using a 3-channel fNIRS system. Baseline and absolute changes in [O2Hb] during the VFT were compared to the rest condition to obtain effect-scores. Patients were tested in the acute phase and six weeks after injury. Task-related fNIRS responses were categorized into positive, negative, and no response. RESULTS: For patients and controls, a positive response was observed in 61% (n=22), a negative response in 19% (n=7), and no response in 19% (n=7). Patients showed a mean [O2Hb] effect-score of 2.18 compared to 2.52 in the control group (p=0.743) in the acute phase after injury. Follow-up effect-scores did not differ significantly (p=0.721). Decreased task performance was associated with a higher effect-score in controls compared to decreased task performance with lower effect-score in the patient group. DISCUSSION: Our study shows that it is feasible to assess hemodynamic response with fNIRS in pediatric TBI patients. A trend of reduced prefrontal hemodynamic response in patients in the acute phase after injury was found suggesting impairment in cognitive performance that warrants further study.

Evidence of fNIRS-Based Prefrontal Cortex Hypoactivity in Obesity and Binge-Eating Disorder.

Rsch SA, Schmidt R, Lhrs M, Ehlis AC, Hesse S, Hilbert A.
Brain Sci. Dec 26;11(1):
doi: 10.3390/brainsci11010019.

Obesity (OB) and associated binge-eating disorder (BED) show increased impulsivity and emotional dysregulation. Albeit well-established in neuropsychiatric research, functional near-infrared spectroscopy (fNIRS) has rarely been used to study OB and BED. Here, we investigated fNIRS-based food-specific brain signalling, its association with impulsivity and emotional dysregulation, and the temporal variability in individuals with OB with and without BED compared to an age- and sex-stratified normal weight (NW) group. Prefrontal cortex (PFC) responses were recorded in individuals with OB (n = 15), OB + BED (n = 13), and NW (n = 12) in a passive viewing and a response inhibition task. Impulsivity and emotional dysregulation were self-reported; anthropometrics were objectively measured. The OB and NW groups were measured twice 7 days apart. Relative to the NW group, the OB and OB + BED groups showed PFC hyporesponsivity across tasks, whereas there were few significant differences between the OB and OB + BED groups. Greater levels of impulsivity were significantly associated with stronger PFC responses, while more emotional dysregulation was significantly associated with lower PFC responses. Temporal differences were found in the left orbitofrontal cortex responses, yet in opposite directions in the OB and NW groups. This study demonstrated diminished fNIRS-based PFC responses across OB phenotypes relative to a NW group. The association between impulsivity, emotional dysregulation, and PFC hypoactivity supports the

assumption that BED constitutes a specific OB phenotype.

Differentiating between bipolar and unipolar depression using prefrontal activation patterns: Promising results from functional near infrared spectroscopy (fNIRS) findings.

Feng K, Law S, Ravindran N, Chen GF, Ma XY, Bo X, Zhang XQ, Shen CY, Li J, Wang Y, Liu XM, Sun JJ, Hu S, Liu PZ.

J Affect Disord. Feb 15;281:476-
doi: 10.1016/j.jad.2020.12.Epub Dec 16.

BACKGROUND: Bipolar depression (BD) is a unique, severe and prevalent mental illness that shares many similarities in symptoms with unipolar depression (UD). Improving precision of their diagnoses would enhance treatment outcome and prognosis for both conditions. This study aims to provide evidence from functional Near-Infrared Spectroscopy (fNIRS) as a potential tool to differentiate UD and BD based on their differences in hemodynamic change in the prefrontal cortex during verbal fluency tasks (VFT). METHODS: We enrolled 179 participants with clinically confirmed diagnoses, including 69 UD patients, 68 BD patients and 42 healthy controls(HC). Every participant was assessed using a 45-channel fNIRS and various clinical scales. FINDINGS: Compared with HC, region-specific fNIR leads show UD patients had significant lower hemodynamic activation in 4 particular pre-frontal regions: 1) the left dorsolateral prefrontal cortex (DLPFC), 2) orbitofrontal cortex (OFC), 3) bilateral ventrolateral prefrontal cortex (VLPFC) and 4) left inferior frontal gyrus (IFG). In contrast, BD vs. HC comparisons showed only significant lower hemodynamic activation in the LIFG area. Furthermore, compared to BD patients, UD patients showed decreased hemodynamic activation changes in the VLPFC region. CONCLUSION: Our results show significant frontal lobe activation pattern differences between UD and BD groups. fNIRS can be a potential tool to increase diagnostic precision for these conditions. In particular, the VLPFC area holds promise to be a useful site for such differentiation for further investigations.

Signs of Warning: Do Health Warning Messages on Sweets Affect the Neural Prefrontal Cortex Activity?

Mehlhose C, Risius A.

Nutrients. Dec 21;12(12):
doi: 10.3390/nu12123903.

In the global attempt to combat rising obesity rates, the introduction of health warning messages on food products is discussed as one possible approach. However, the perception of graphical health warning messages in the food context and the possible impact that they may have, in particular at the neuronal level, have hardly been studied. Therefore, the aim of this explorative study was to examine consumers' reactions (measured as neuronal activity and subjective reporting) of two different types of graphical health warning messages on sweets compared to sweets without warning messages. One type used the red road traffic stop sign as graphical information ("Stop"), while the other one used shocking pictures ("Shock"), an approach similar to the images on cigarette packages. The neural response of 78 participants was examined with the neuroimaging technique functional near-infrared spectroscopy (fNIRS). Different hemodynamic responses in the orbitofrontal cortex (OFC), the frontopolar cortex (FOC), and the dorsolateral prefrontal cortex (dlPFC) were observed, regions which are associated with reward evaluation, social behavior consequences, and self-control. Further, the health warning messages were actively and emotionally remembered by the participants. These findings point to an interesting health information strategy, which should be explored and discussed further.

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

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

J Neurosci Res. Apr;99(4):1108-
doi: 10.1002/jnr.Epub Dec 23.

The functional connectivity (FC) between multiple brain regions during tasks is currently gradually being explored with functional near-infrared spectroscopy (fNIRS). However, the FC present during grip force tracking tasks performed under visual feedback remains unclear. In the present study, we used fNIRS to measure brain activity during resting states and grip force tracking tasks at 25%, 50%, and 75% of maximum voluntary contraction (MVC) in 11 healthy subjects, and the activity was measured from four target brain regions: the left prefrontal cortex (lPFC), right prefrontal cortex (rPFC), left sensorimotor cortex (lSMC), and right sensorimotor cortex (rSMC). We determined the FC between these regions utilizing three different methods: Pearson's correlation method, partial correlation method, and a pairwise maximum entropy model (MEM). The results showed that the FC of lSMC-rSMC and lPFC-rPFC (interhemispheric homologous pairs) were significantly stronger than those of other brain region pairs. Moreover, FC of lPFC-rPFC was strengthened during the 75% MVC task compared to the other task states and the resting states. The FC of lSMC-lPFC and rSMC-rPFC (intrahemispheric region pairs) strengthened with a higher task load. The results provided new insights into the FC between brain regions during visuo-guided grip force tracking tasks.

Hybrid EEG-fNIRS BCI Fusion Using Multi-Resolution Singular Value Decomposition (MSVD).

Khan MU, Hasan MAH.

Front Hum Neurosci. Dec 8;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Brain-computer interface (BCI) multi-modal fusion has the potential to generate multiple commands in a highly reliable manner by alleviating the drawbacks associated with single modality. In the present work, a hybrid EEG-fNIRS BCI system-achieved through a fusion of concurrently recorded electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) signals-is used to overcome the limitations of uni-modality and to achieve higher tasks classification. Although the hybrid approach enhances the performance of the system, the improvements are still modest due to the lack of availability of computational approaches to fuse the two modalities. To overcome this, a novel approach is proposed using Multi-resolution singular value decomposition (MSVD) to achieve system- and feature-based fusion. The two approaches based up different features set are compared using the KNN and Tree classifiers. The results obtained through multiple datasets show that the proposed approach can effectively fuse both modalities with improvement in the classification accuracy.

Changes in Prefrontal Cortical Activity During Walking and Cognitive Functions Among Patients With Parkinson's Disease.

Ranchet M, Hoang I, Cheminon M, Derollepot R, Devos H, Perrey S, Luaut?, Danaila T, Paire-Ficout L.

Front Neurol. Dec 10;11:
doi: 10.3389/fneur.2020.eCollection 2020.

Background: Walking becomes more and more degraded as Parkinson's Disease (PD) progresses. Previous research examined factors contributing to this deterioration. Among them, changes in brain cortical activity during walking have been less studied in this clinical population. Objectives: This study aimed to: (1) investigate changes in dorsolateral prefrontal cortex (DLPFC) activation during usual walking and dual-task walking conditions in patients with PD; (2) examine the association between cortical activity

and behavioral/cognitive outcomes; and (3) explore which factors best predict increased activation of the DLPFC during usual walking. Methods: Eighteen patients with early stage PD and 18 controls performed 4 conditions: (1) standing while subtracting, (2) usual walking, (3) walking while counting forward, and (4) walking while subtracting. Cortical activity in DLPFC, assessed by changes in oxy-hemoglobin (?HbO2) and deoxy-hemoglobin (?HbR), was measured using functional near infrared spectroscopy (fNIRS). Gait performance was recorded using wearables sensors. Cognition was also assessed using neuropsychological tests, including the Trail Making Test (TMT). Results: DLPFC activity was higher in patients compared to controls during both usual walking and walking while subtracting conditions. Patients had impaired walking performance compared to controls only during walking while subtracting task. Moderate-to-strong correlations between ?HbO2 and coefficients of variation of all gait parameters were found for usual walking and during walking while counting forward conditions. Part-B of TMT predicted 21% of the variance of ?HbO2 during usual walking after adjustment for group status. Conclusions: The increased DLPFC activity in patients during usual walking suggests a potential compensation for executive deficits. Understanding changes in DLPFC activity during walking may have implications for rehabilitation of gait in patients with PD.

Viewing Fantastical Events in Animated Television Shows: Immediate Effects on Chinese Preschoolers' Executive Function.

Li H, Hsueh Y, Yu H, Kitzmann KM.

Front Psychol. Dec 11;11:
doi: 10.3389/fpsyg.2020. eCollection 2020.

Three experiments were conducted to test whether watching an animated show with frequent fantastical events decreased Chinese preschoolers' post-viewing executive function (EF), and to test possible mechanisms of this effect. In all three experiments, children were randomly assigned to watch a video with either frequent or infrequent fantastical events; their EF was immediately assessed after viewing, using behavioral measures of working memory, sustained attention, and cognitive flexibility. Parents completed a questionnaire to assess preschoolers' hyperactivity level as a potential confounding variable. In Experiment 1 (N = 90), which also included a control group, there was an immediate negative effect of watching frequent fantastical events, as seen in lower scores on the behavioral EF tasks. In Experiment 2 (N = 20), eye tracking data showed more but shorter eye fixations in the high frequency group, suggesting a higher demand on cognitive resources; this group also did more poorly on behavioral measures of EF. In Experiment 3 (N = 20), functional near-infrared spectroscopy (fNIRS) data showed that the high frequency group had a higher concentration of oxygenated hemoglobin (Coxy-Hb), an indicator of higher brain activation consistent with a greater use of cognitive resources; this group also had lower scores on the behavioral EF tasks. The findings are discussed in reference to models of limited cognitive resources.

Neural Correlates of Mental Rotation in Preschoolers With High or Low Working Memory Capacity: An fNIRS Study.

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

Front Psychol. Dec 10;11:
doi: 10.3389/fpsyg.2020. eCollection 2020.

This study explored the differentiated neural correlates of mental rotation (MR) in preschoolers with high and low working memory capacity using functional near-infrared spectroscopy (fNIRS). Altogether 38 Chinese preschoolers (M = 5.0 years, SD = 0.69 years) completed the Working Memory Capacity (WMC) test, the Mental Rotation (MR), and its Control tasks (without MR). They were divided into High-WMC (N1 = 9) and Low-WMC (N 2 = 18) groups based on the WMC scores. The behavioral and fNIRS results indicated that: (1) there were no significant differences in MR task performance between the High-WMC

(M mr = 23.44, SD = 0.88) and Low-WMC group (M mr = 23.67, SD = 0.59); (2) the Low-WMC group activated BA6, BA8, BA 9, and BA 44, whereas the High-WMC group activated BA8, BA10 and BA 44 during mental rotation; (3) significant differences were found in the activation of BA44 and BA9 between the High-WMC and Low-WMC groups during mental rotation; and (4) the High-WMC and Low-WMC groups differed significantly in the activation of BA 9 and BA10 during the control tasks, indicating that both areas might be responsible for the group differences in working memory.

Neural Correlates of Age-Related Changes in Precise Grip Force Regulation: A Combined EEG-fNIRS Study.

Berger A, Steinberg F, Thomas F, Doppelmayr M.

Front Aging Neurosci. Dec 10;12:

doi: 10.3389/fnagi.2020. eCollection 2020.

Motor control is associated with suppression of oscillatory activity in alpha (8-12 Hz) and beta (12-30 Hz) ranges and elevation of oxygenated hemoglobin levels in motor-cortical areas. Aging leads to changes in oscillatory and hemodynamic brain activity and impairments in motor control. However, the relationship between age-related changes in motor control and brain activity is not yet fully understood. Therefore, this study aimed to investigate age-related and task-complexity-related changes in grip force control and the underlying oscillatory and hemodynamic activity. Sixteen younger [age (mean SD) = 25.4 1.9, 20-30 years] and 16 older (age = 56.7 4.7, 50-70 years) healthy men were asked to use a power grip to perform six trials each of easy and complex force tracking tasks (FTTs) with their right dominant hand in a randomized within-subject design. Grip force control was assessed using a sensor-based device. Brain activity in premotor and primary motor areas of both hemispheres was assessed by electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS). Older adults showed significantly higher inaccuracies and higher hemodynamic activity in both FTTs than did young adults. Correlations between grip force control owing to task complexity and beta activity were different in the contralateral premotor cortex (PMC) between younger and older adults. Collectively, these findings suggest that aging leads to impairment of grip force control and an increase in hemodynamic activity independent of task complexity. EEG beta oscillations may represent a task-specific neurophysiological marker for age-related decline in complex grip force control and its underlying compensation strategies. Further EEG-fNIRS studies are necessary to determine neurophysiological markers of dysfunctions underlying age-related motor disabilities for the improvement of individual diagnosis and therapeutic approaches.

Comparing fNIRS signal qualities between approaches with and without short channels.

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

PLoS One. Dec 23;15(12):e

doi: 10.1371/journal.pone. eCollection 2020.

Functional near-infrared spectroscopy (fNIRS) is a non-invasive technique used to measure changes in oxygenated (HbO) and deoxygenated (HbR) hemoglobin, related to neuronal activity. fNIRS signals are contaminated by the systemic responses in the extracerebral tissue (superficial layer) of the head, as fNIRS uses a back-reflection measurement. Using shorter channels that are only sensitive to responses in the extracerebral tissue but not in the deeper layers where target neuronal activity occurs has been a 'gold standard' to reduce the systemic responses in the fNIRS data from adults. When shorter channels are not available or feasible for implementation, an alternative, i.e., anti-correlation (Anti-Corr) method has been adopted. To date, there has not been a study that directly assesses the outcomes from the two approaches. In this study, we compared the Anti-Corr method with the 'gold standard' in reducing systemic responses to improve fNIRS neural signal qualities. We used eight short channels (8-mm) in a group of adults,

and conducted a principal component analysis (PCA) to extract two components that contributed the most to responses in the 8 short channels, which were assumed to contain the global components in the extracerebral tissue. We then used a general linear model (GLM), with and without including event-related regressors, to regress out the 2 principal components from regular fNIRS channels (30 mm), i.e., two GLM-PCA methods. Our results found that, the two GLM-PCA methods showed similar performance, both GLM-PCA methods and the Anti-Corr method improved fNIRS signal qualities, and the two GLM-PCA methods had better performance than the Anti-Corr method.

Evaluating cortical responses to speech in children: A functional near-infrared spectroscopy (fNIRS) study.

Lawrence RJ, Wiggins IM, Hodgson JC, Hartley DEH.

Hear Res. Mar 1;401:

doi: 10.1016/j.heares.2020.Epub Dec 15.

Functional neuroimaging of speech processing has both research and clinical potential. This work is facilitating an ever-increasing understanding of the complex neural mechanisms involved in the processing of speech. Neural correlates of speech understanding also have potential clinical value, especially for infants and children, in whom behavioural assessments can be unreliable. Such measures would not only benefit normally hearing children experiencing speech and language delay, but also hearing impaired children with and without hearing devices. In the current study, we examined cortical correlates of speech intelligibility in normally hearing paediatric listeners. Cortical responses were measured using functional near-infrared spectroscopy (fNIRS), a non-invasive neuroimaging technique that is fully compatible with hearing devices, including cochlear implants. In nineteen normally hearing children (aged 6 - 13 years) we measured activity in temporal and frontal cortex bilaterally whilst participants listened to both clear- and noise-vocoded sentences targeting four levels of speech intelligibility. Cortical activation in superior temporal and inferior frontal cortex was generally stronger in the left hemisphere than in the right. Activation in left superior temporal cortex grew monotonically with increasing speech intelligibility. In the same region, we identified a trend towards greater activation on correctly vs. incorrectly perceived trials, suggesting a possible sensitivity to speech intelligibility per se, beyond sensitivity to changing acoustic properties across stimulation conditions. Outside superior temporal cortex, we identified other regions in which fNIRS responses varied with speech intelligibility. For example, channels overlying posterior middle temporal regions in the right hemisphere exhibited relative deactivation during sentence processing (compared to a silent baseline condition), with the amplitude of that deactivation being greater in more difficult listening conditions. This finding may represent sensitivity to components of the default mode network in lateral temporal regions, and hence effortful listening in normally hearing paediatric listeners. Our results indicate that fNIRS has the potential to provide an objective marker of speech intelligibility in normally hearing children. Should these results be found to apply to individuals experiencing language delay or to those listening through a hearing device, such as a cochlear implant, fNIRS may form the basis of a clinically useful measure of speech understanding.

An optical window into brain function in children and adolescents: A systematic review of functional near-infrared spectroscopy studies.

Yeung MK.

Neuroimage. Feb 15;227:

doi: 10.1016/j.neuroimage.2020.Epub Dec 24.

Despite decades of research, our understanding of functional brain development throughout childhood and adolescence remains limited due to the challenges posed by certain neuroimaging modalities. Recently, there has been a growing interest in using functional near-infrared spectroscopy (fNIRS) to elucidate the

neural basis of cognitive and socioemotional development and identify the factors shaping these types of development. This article, focusing on the fNIRS methods, presents an up-to-date systematic review of fNIRS studies addressing the effects of age and other factors on brain functions in children and adolescents. Literature searches were conducted using PubMed and PsycINFO. A total of 79 fNIRS studies involving healthy individuals aged 3-17 years that were published in peer-reviewed journals in English before July 2020 were included. Six methodological aspects of these studies were evaluated, including the research design, experimental paradigm, fNIRS measurement, data preprocessing, statistical analysis, and result presentation. The risk of bias, such as selective outcome reporting, was assessed throughout the review. A qualitative synthesis of study findings in terms of the factor effects on changes in oxyhemoglobin concentration was also performed. This unregistered review highlights the strengths and limitations of the existing literature and suggests directions for future research to facilitate the improved use of fNIRS in developmental cognitive neuroscience research.

Probing the association between maternal anxious attachment style and mother-child brain-to-brain coupling during passive co-viewing of visual stimuli.

Azhari A, Gabrieli G, Bizzego A, Bornstein MH, Esposito G.

Attach Hum Dev. Dec 28:1-

doi: 10.1080/14616734.2020.Online ahead of print.

Brain-to-braincoupling during co-viewing of video stimuli reflects similar intersubjective mentalisation processes. During an everyday joint activity of watching video stimuli (television shows) with her child, an anxiously attached mother's preoccupation with her child is likely to distract her from understanding the mental state of characters in the show. To test the hypothesis that reduced coupling in the medial prefrontal cortex (PFC) would be observed with increasing maternal attachment anxiety (MAA), we profiled mothers' MAA using the Attachment Style Questionnaire and used functional Near-infraredSpectroscopy (fNIRS) to assess PFC coupling in 31 mother-child dyads while they watched three 1-min animation videos together. Reducedcoupling was observed with increasing MAA in the medial right PFC cluster which is implicated in mentalisation processes. This result did not survive control analyses and should be taken as preliminary. Reduced coupling between anxiously-attachedmothers and their children during co-viewing could undermine quality of shared experiences.

One-dimensional statistical parametric mapping identifies impaired orthostatic cerebrovascular and cardiovascular response in frailty index.

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

J Gerontol A Biol Sci Med Sci. Dec 23:glaa

doi: 10.1093/gerona/glaa Online ahead of print.

BACKGROUND: Orthostasis is a potent physiological stressor which adapts with age. The age-related accumulation of health deficits in multiple physiological systems may impair the physiological response to orthostasis and lead to negative health outcomes such as falls, depression and cognitive decline. Research to date has focused on changes with orthostasis at prespecified intervals of time, without consideration for whole signal approaches. METHODS: One-dimensional statistical parametric mapping (SPM 1d) identified regions in time of significant association between variables of interest using a general linear model. Frailty index operationalized accumulated health and social deficits using 32-items from an computer-assisted interview. This study examined the association of frailty index on blood pressure, heart rate and cerebral oxygenation during an orthostatic test in a sample of 2,742 adults aged 50 or older from The Irish Longitudinal Study on Ageing. RESULTS: Frailty index was seen to be negatively associated with cerebral oxygenation changes from baseline over a period of 7 seconds ($p = 0.036$). Heart rate and systolic blood pressure were positively and negatively associated with frailty index over periods of 17 seconds ($p = 0.001$)

and 10 seconds (p = 0.015) respectively. CONCLUSIONS: SPM demonstrated these significant regions of cerebral oxygenation during orthostasis provide indirect evidence of impaired autoregulation associated with frailty. SPM also replicated prior relationships in heart rate and systolic blood pressure associated with a higher frailty index. These findings highlight the utility of one dimensional statistical parametric modelling in identifying significant regions of interest in physiological recordings.

Applications of functional near-infrared spectroscopy (fNIRS) in neonates.

Peng C, Hou X.

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Functional near-infrared spectroscopy (fNIRS) is a method of monitoring brain oxygenation. This technique investigates hemodynamic changes in the cerebral cortex. fNIRS is widely used in clinical and scientific research. In this review, we focus on the applications of fNIRS on neonates. Here, applications form two distinct categories: task associated studies, and hemoglobin phase change studies. fNIRS is non-invasive, easily performed, and repeatable. However, it has limited monitoring depth and spatial resolution when used in newborns. Moreover, with recent technological advances, it is now possible to explore neuronal activity patterns using fNIRS in both healthy and pathological conditions. For more than 20 years, fNIRS has enabled clinicians to gain insight into cerebral development and mechanisms of injury in neonates. fNIRS is a useful supplement to existing technologies due to its ability to interrogate the neonatal brain function.

Qualitative and Comparative Cortical Activity Data Analyses from a Functional Near-Infrared Spectroscopy Experiment Applying Block Design.

Saita K, Morishita T, Arima H, Ogata T, Inoue T.

J Vis Exp. Dec 3;(166).
doi: 10.3791/61836.

Neuroimaging studies play a pivotal role in the evaluation of pre- vs. post-interventional neurological conditions such as in rehabilitation and surgical treatment. Among the many neuroimaging technologies used to measure brain activity, functional near-infrared spectroscopy (fNIRS) enables the evaluation of dynamic cortical activities by measuring the local hemoglobin levels similar to functional magnetic resonance imaging (fMRI). Also, due to lesser physical restriction in fNIRS, multiple variants of sensorimotor tasks can be evaluated. Many laboratories have developed several methods for fNIRS data analysis; however, despite the fact that the general principles are the same, there is no universally standardized method. Here, we present the qualitative and comparative analytic methods of data obtained from a multi-channel fNIRS experiment using a block design. For qualitative analysis, we used a software for NIRS as a mass-univariate approach based on the generalized linear model. The NIRS-SPM analysis shows qualitative results for each session by visualizing the activated area during the task. In addition, the non-invasive three-dimensional digitizer can be used to estimate the fNIRS channel locations relative to the brain. To corroborate the NIRS-SPM findings, the amplitude of the changes in hemoglobin levels induced by the sensorimotor task can be statistically analyzed by comparing the data obtained from two different sessions (before and after intervention) of the same study subject using a multi-channel hierarchical mixed model. Our methods can be used to measure the pre- vs. post-intervention analysis in a variety of neurological disorders such as movement disorders, cerebrovascular diseases, and neuropsychiatric disorders.

Amplitude of fNIRS Resting-State Global Signal Is Related to EEG Vigilance Mea-

sures: A Simultaneous fNIRS and EEG Study.

Chen Y, Tang J, Chen Y, Farrand J, Craft MA, Carlson BW, Yuan H.

Front Neurosci. Dec 3;14:
doi: 10.3389/fnins.2020. eCollection 2020.

Recently, functional near-infrared spectroscopy (fNIRS) has been utilized to image the hemodynamic activities and connectivity in the human brain. With the advantage of economic efficiency, portability, and fewer physical constraints, fNIRS enables studying of the human brain at versatile environment and various body positions, including at bed side and during exercise, which complements the use of functional magnetic resonance imaging (fMRI). However, like fMRI, fNIRS imaging can be influenced by the presence of a strong global component. Yet, the nature of the global signal in fNIRS has not been established. In this study, we investigated the relationship between fNIRS global signal and electroencephalogram (EEG) vigilance using simultaneous recordings in resting healthy subjects in high-density and whole-head montage. In Experiment 1, data were acquired at supine, sitting, and standing positions. Results found that the factor of body positions significantly affected the amplitude of the resting-state fNIRS global signal, prominently in the frequency range of 0.05-0.1 Hz but not in the very low frequency range of less than 0.05 Hz. As a control, the task-induced fNIRS or EEG responses to auditory stimuli did not differ across body positions. However, EEG vigilance plays a modulatory role in the fNIRS signals in the frequency range of less than 0.05 Hz: resting-state sessions of low EEG vigilance measures are associated with high amplitudes of fNIRS global signals. Moreover, in Experiment 2, we further examined the epoch-to-epoch fluctuations in concurrent fNIRS and EEG data acquired from a separate group of subjects and found a negative temporal correlation between EEG vigilance measures and fNIRS global signal amplitudes. Our study for the first time revealed that vigilance as a neurophysiological factor modulates the resting-state dynamics of fNIRS, which have important implications for understanding and processing the noises in fNIRS signals.

Inferior parietal lobule is sensitive to different semantic similarity relations for concrete and abstract words.

Montefinese M, Pinti P, Ambrosini E, Tachtsidis I, Vinson D.

Psychophysiology. Mar;58(3):e
doi: 10.1111/psyp.Epub Dec 19.

Similarity measures, the extent to which two concepts have similar meanings, are the key to understand how concepts are represented, with different theoretical perspectives relying on very different sources of data from which similarity can be calculated. While there is some commonality in similarity measures, the extent of their correlation is limited. Previous studies also suggested that the relative performance of different similarity measures may also vary depending on concept concreteness and that the inferior parietal lobule (IPL) may be involved in the integration of conceptual features in a multimodal system for the semantic categorization. Here, we tested for the first time whether theory-based similarity measures predict the pattern of brain activity in the IPL differently for abstract and concrete concepts. English speakers performed a semantic decision task, while we recorded their brain activity in IPL through fNIRS. Using representational similarity analysis, results indicated that the neural representational similarity in IPL conformed to the lexical co-occurrence among concrete concepts (regardless of the hemisphere) and to the affective similarity among abstract concepts in the left hemisphere only, implying that semantic representations of abstract and concrete concepts are characterized along different organizational principles in the IPL. We observed null results for the decoding accuracy. Our study suggests that the use of the representational similarity analysis as a complementary analysis to the decoding accuracy is a promising tool to reveal similarity patterns between theoretical models and brain activity recorded through fNIRS.

Exploring the relation between brain response to speech at 6-months and language outcomes at 24-months in infants at high and low risk for autism spectrum disorder: A preliminary functional near-infrared spectroscopy study.

Pecukonis M, Perdue KL, Wong J, Tager-Flusberg H, Nelson CA.

Dev Cogn Neurosci. Feb;47:
doi: 10.1016/j.dcn.2020.Epub Dec 8.

Infants at high familial risk for autism spectrum disorder (ASD) are at increased risk for language impairments. Studies have demonstrated that atypical brain response to speech is related to language impairments in this population, but few have examined this relation longitudinally. We used functional near-infrared spectroscopy (fNIRS) to investigate the neural correlates of speech processing in 6-month-old infants at high (HRA) and low risk (LRA) for autism. We also assessed the relation between brain response to speech at 6-months and verbal developmental quotient (VDQ) scores at 24-months. LRA infants exhibited greater brain response to speech in bilateral anterior regions of interest (ROIs) compared to posterior ROIs, while HRA infants exhibited similar brain response across all ROIs. Compared to LRA infants, HRA+ infants who were later diagnosed with ASD had reduced brain response in bilateral anterior ROIs, while HRA- infants who were not later diagnosed with ASD had increased brain response in right posterior ROI. Greater brain response in left anterior ROI predicted VDQ scores for LRA infants only. Findings highlight the importance of studying HRA+ and HRA- infants separately, and implicate a different, more distributed neural system for speech processing in HRA infants that is not related to language functioning.

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

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

Hum Brain Mapp. Apr 15;42(6):1657-
doi: 10.1002/hbm.Epub Dec 17.

The quality of optode arrangement is crucial for group imaging studies when using functional near-infrared spectroscopy (fNIRS). Previous studies have demonstrated the promising effectiveness of using transcranial brain atlases (TBAs), in a manual and intuition-based way, to guide optode arrangement when individual structural MRI data are unavailable. However, the theoretical basis of using TBA to optimize optode arrangement remains unclear, which leads to manual and subjective application. In this study, we first describe the theoretical basis of TBA-based optimization of optode arrangement using a mathematical framework. Second, based on the theoretical basis, an algorithm is proposed for automatically arranging optodes on a virtual scalp. The resultant montage is placed onto the head of each participant guided by a low-cost and portable navigation system. We compared our method with the widely used 10/20-system-assisted optode arrangement procedure, using finger-tapping and working memory tasks as examples of both low- and high-level cognitive systems. Performance, including optode montage designs, locations on each participant's scalp, brain activation, as well as ground truth indices derived from individual MRI data were evaluated. The results give convergent support for our method's ability to provide more accurate, consistent and efficient optode arrangements for fNIRS group imaging than the 10/20 method.

Interbrain Synchrony in the Expectation of Cooperation Behavior: A Hyperscanning Study Using Functional Near-Infrared Spectroscopy.

Zhang M, Jia H, Zheng M.

Front Psychol. Nov 10;11:
doi: 10.3389/fpsyg.2020. eCollection 2020.

Expectation of others' cooperative behavior plays a core role in economic cooperation. However, the

dynamic neural substrates of expectation of cooperation (hereafter EOC) are little understood. To fully understand EOC behavior in more natural social interactions, the present study employed functional near-infrared spectroscopy (fNIRS) hyperscanning to simultaneously measure pairs of participants' brain activations in a modified prisoner's dilemma game (PDG). The data analysis revealed the following results. Firstly, under the high incentive condition, team EOC behavior elicited higher interbrain synchrony (IBS) in the right inferior frontal gyrus (rIFG) than individual EOC behavior. Meanwhile, the IBS in the IFG could predict the relationship between empathy/agreeableness and EOC behavior, and this prediction role was modulated by social environmental cues. These results indicate the involvement of the human mirror neuron system (MNS) in the EOC behavior and the different neural substrates between team EOC and individual EOC, which also conform with theory that social behavior was affected by internal (i.e., empathy/agreeableness) and external factors (i.e., incentive). Secondly, female dyads exhibited a higher IBS value of cooperative expectation than male dyads in the team EOC than the individual EOC in the dorsal medial prefrontal cortex (DMPFC), while in the individual EOC stage, the coherence value of female dyads was significantly higher than that of male dyads under the low incentive reward condition in the rIFG. These sex effects thus provide presumptive evidence that females are more sensitive to environmental cues and also suggest that during economic social interaction, females' EOC behavior depends on more social cognitive abilities. Overall, these results raise intriguing questions for future research on human cooperative behaviors.

Measuring the Cognitive Workload During Dual-Task Walking in Young Adults: A Combination of Neurophysiological and Subjective Measures.

Hoang I, Ranchet M, Derollepot R, Moreau F, Paire-Ficout L.

Front Hum Neurosci. Nov 20;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Background: Walking while performing a secondary task (dual-task (DT) walking) increases cognitive workload in young adults. To date, few studies have used neurophysiological measures in combination to subjective measures to assess cognitive workload during a walking task. This combined approach can provide more insights into the amount of cognitive resources in relation with the perceived mental effort involving in a walking task. Research Question: The objective was to examine cognitive workload in young adults during walking conditions varying in complexity. Methods: Twenty-five young adults (mean = 24.4 5.4) performed four conditions: (1) usual walking, (2) simple DT walking, (3) complex DT walking and (4) standing while subtracting. During the walking task, mean speed, cadence, stride time, stride length, and their respective coefficient of variation (CV) were recorded. Cognitive workload will be measured through changes in oxy- and deoxy-hemoglobin (?HbO2 and ?HbR) during walking in the dorsolateral prefrontal cortex (DLPFC) and perceived mental demand score from NASA-TLX questionnaire. Results: In young adults, ?HbO2 in the DLPFC increased from usual walking to both DT walking conditions and standing while subtracting condition. ?HbO2 did not differ between the simple and complex DT and between the complex DT and standing while subtracting condition. Perceived mental demand gradually increased with walking task complexity. As expected, all mean values of gait parameters were altered according to task complexity. CV of speed, cadence and stride time were significantly higher during DT walking conditions than during usual walking whereas CV of stride length was only higher during complex DT walking than during usual walking. Significance: Young adults had greater cognitive workload in the two DT walking conditions compared to usual walking. However, only the mental demand score from NASA-TLX questionnaire discriminated simple from complex DT walking. Subjective measure provides complementary information to objective one on changes in cognitive workload during challenging walking tasks in young adults. These results may be useful to improve our understanding of cognitive workload during walking.

Measuring dlPFC Signals to Predict the Success of Merchandising Elements at the Point-of-Sale - A fNIRS Approach.

Gier NR, Strelow E, Krampe C.

Front Neurosci. Nov 20;14:
doi: 10.3389/fnins.2020. eCollection 2020.

The (re-)launch of products is frequently accompanied by point-of-sale (PoS) marketing campaigns in order to foster sales. Predicting the success of these merchandising elements at the PoS on sales is of interest to research and practice, as the misinvestments that are based on the fragmented PoS literature are tremendous. Likewise, the predictive power of neuropsychological methods has been demonstrated in various research work. Nevertheless, the practical application of these neuropsychological methods is still limited. In order to foster the application of neuropsychological methods in research and practice, the current research work aims to explore, whether mobile functional near-infrared spectroscopy (fNIRS) - as a portable neuroimaging method - has the potential to predict the success of PoS merchandising elements by rendering significant neural signatures of brain regions of the dorsolateral prefrontal cortex (dlPFC), highlighting its potential to forecast shoppers' behaviour aka sales at the PoS. Building on previous research findings, the results of the given research work indicate that the neural signal of brain regions of the dlPFC, measured with mobile fNIRS, is able to predict actual sales associated with PoS merchandising elements, relying on the cortical relief effect. More precisely, the research findings support the hypothesis that the reduced neural activity of brain regions associated with the dlPFC can predict sales at the PoS, emphasising another crucial neural signature to predict shoppers' purchase behaviour, next to the frequently cited reward association system. The research findings offer an innovative perspective on how to design and evaluate PoS merchandising elements, indicating fruitful theoretical and practical implications.

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fNIRS-based functional connectivity estimation using semi-metric analysis to study decision making by nursing students and registered nurses.

Chong JS, Chan YL, Ebenezer EGM, Chen HY, Kiguchi M, Lu CK, Tang TB.

Sci Rep. Dec 16;10(1):
doi: 10.1038/s41598-020-79053-z.

This study aims to investigate the generalizability of the semi-metric analysis of the functional connectivity (FC) for functional near-infrared spectroscopy (fNIRS) by applying it to detect the dichotomy in differential FC under affective and neutral emotional states in nursing students and registered nurses during decision making. The proposed method employs wavelet transform coherence to construct FC networks and explores semi-metric analysis to extract network redundancy features, which has not been considered in conventional fNIRS-based FC analyses. The trials of the proposed method were performed on 19 nursing students and 19 registered nurses via a decision-making task under different emotional states induced by affective and neutral emotional stimuli. The cognitive activities were recorded using fNIRS, and the emotional stimuli were adopted from the International Affective Digitized Sound System (IADS). The induction of emotional effects was validated by heart rate variability (HRV) analysis. The experimental results by the proposed method showed significant difference (FDR-adjusted $p = 0.004$) in the nursing students' cognitive FC network under the two different emotional conditions, and the semi-metric percentage (SMP) of the right prefrontal cortex (PFC) was found to be significantly higher than the left PFC (FDR-adjusted $p = 0.036$). The benchmark method (a typical weighted graph theory analysis) gave no significant results. In essence, the results support that the semi-metric analysis can be generalized and extended to fNIRS-based functional connectivity estimation.

Coupling neuroscience and driving simulation: A systematic review of studies on crash-

risk behaviors in young drivers.

Banz BC, Hersey D, Vaca FE.

Traffic Inj Prev. 2021;22(1):90-
doi: 10.1080/15389588.2020.Epub Dec 15.

OBJECTIVE: Motor vehicle crashes are a leading cause of death for adolescents and young adults. The aim of this study is to examine and discuss the state-of-the-art literature which uses neuroscience methods in the context of driving simulation to study adolescent and young adult drivers. METHODS: We conducted a systematic English-language literature search of Ovid MEDLINE (1946-2020), PsycINFO (1967-2020), PubMed, Web of Science, SCOPUS, and CINAHL using keywords and MeSH terms. Studies were excluded if participants were not within the ages of 15-25, if the driving simulator did not include a visual monitor/computer monitor/projection screen and steering wheel and foot pedals, or brain data (specifically EEG [electroencephalogram], fNIRS [functional near-infrared spectroscopy], or fMRI [functional magnetic resonance imaging]) was not collected at the same time as driving simulation data. RESULTS: Seventy-six full text articles of the 736 studies that met inclusion criteria were included in the final review. The 76 articles used one of the following neuroscience methods: electrophysiology, functional near-infrared spectroscopy, or functional magnetic resonance imaging. In the identified studies, there were primarily two areas of investigation pursued; driving impairment and distraction in driving. Impairment studies primarily explored the areas of drowsy/fatigued driving or alcohol-impaired driving. Studies of distracted driving primarily focused on cognitive load and auditory and visual distractors. CONCLUSIONS: Our state of the science systematic review highlights the feasibility for coupling neuroscience with driving simulation to study the neurocorrelates of driving behaviors in the context of young drivers and neuromaturation. Findings show that, to date, most research has focused on examining brain correlates and driving behaviors related to contributing factors for fatal motor vehicle crashes. However, there remains a considerable paucity of research designed to understand underlying brain mechanisms that might otherwise facilitate greater understanding of individual variability of normative and risky driving behavior within the young driving population.

Reduced functional connectivity in the prefrontal cortex of elderly catatonia patients: A longitudinal study using functional near-infrared spectroscopy.

Nakamura T, Sasayama D, Hagiwara T, Kito H, Washizuka S.

Neurosci Res. Dec 11:S0168-0102(20)30485-
doi: 10.1016/j.neures.2020.10.Online ahead of print.

Catatonia is a syndrome that manifests in patients with mental disorders and general medical conditions. However, functional changes to the brain that cause catatonia remain unknown. In the present study, we used functional near-infrared spectroscopy (fNIRS) to assess spontaneous hemodynamic activities in the brain at the times of onset and resolution of catatonic symptoms in patients with catatonia. We used 22-channel and 49-channel fNIRS to examine hemodynamic activities in the prefrontal cortex (PFC), and both frontal and parietal cortices, respectively. A total of ten patients who were diagnosed with catatonia were included in the study. Resting state measurements were taken for five minutes at the time of the onset and resolution of catatonic symptoms. Analyses were performed for the prefrontal region and the motor cortex within the parietal-frontal region of the brain. Functional connectivity between the cerebral hemispheres was evaluated systematically based on spontaneous oscillation of ?[HbO2]. In the PFC, the resting state functional connectivity (RSFC) was significantly lower in the catatonic state than in the eyes-closed non-catatonic state ($p = 0.047$). The study demonstrated that the RSFC in the PFC, measured using fNIRS, may be an objective indicator of the change in catatonic symptoms.

Unsupervised fNIRS feature extraction with CAE and ESN autoencoder for driver

cognitive load classification.

Liu R, Reimer B, Song S, Mehler B, Solovey E.

J Neural Eng. Dec
doi: 10.1088/1741-2552/abd2ca. Online ahead of print.

OBJECTIVE: Understanding the cognitive load of drivers is crucial for road safety. Brain sensing has the potential to provide an objective measure of driver cognitive load. We aim to develop an advanced machine learning framework for classifying driver cognitive load using functional near-infrared spectroscopy (fNIRS). APPROACH: We conducted a study using fNIRS in a driving simulator with the n-back task used as a secondary task to impart structured cognitive load on drivers. To classify different driver cognitive load levels, we examined the application of convolutional autoencoder (CAE) and Echo State Network (ESN) autoencoder for extracting features from fNIRS. MAIN RESULTS: By using CAE, the accuracies for classifying two and four levels of driver cognitive load with the 30s window were 73.25% and 47.21, respectively. The proposed ESN autoencoder achieved state-of-art classification results for group-level models without window selection, with accuracies of 80.61% and 52.45 for classifying two and four levels of driver cognitive load. SIGNIFICANCE: This work builds a foundation for using fNIRS to measure driver cognitive load in real-world applications. Also, the results suggest that the proposed ESN autoencoder can effectively extract temporal information from fNIRS data and can be useful for other fNIRS data classification tasks.

The motor-related brain activity that supports joint action: A review.

Bolt NK, Loehr JD.

Acta Psychol (Amst). Jan;212:
doi: 10.1016/j.actpsy.2020. Epub Dec 8.

Recent years have seen a rapid increase in research investigating the motor-related brain activity that supports joint action. This research has employed a variety of joint action tasks and an array of neuroimaging techniques, including fMRI, fNIRS, EEG, and TMS. In this review, we provide an overview of this research to delineate what is known about the motor-related brain activity that contributes to joint action and to highlight key questions for future research. Taken together, the surveyed research supports three major conclusions. First, the mere presence of a joint action context is sufficient to modulate motor activity elicited by observing others' actions. Second, joint action is supported by dissociable motor activity associated with a person's own actions, their partner's actions, and the joint action, and by between-brain coupling of motor-related oscillatory activity. Third, the structure of a joint action modulates the motor activity involved: Unique motor activity is associated with performing joint actions comprised of complementary actions and with holding the roles of leader and follower within a joint action. We conclude the review by highlighting overarching themes and key questions for future research.

Amplitude of low frequency fluctuations (ALFF) of spontaneous and induced rumination in major depression: An fNIRS study.

Rosenbaum D, Int-Veen I, Kroczek A, Hilsendegen P, Velten-Schurian K, Bihlmaier I, Fallgatter AJ, Ehlis AC.

Sci Rep. Dec 9;10(1):
doi: 10.1038/s41598-020-78317-y.

In the current study, we investigated the amplitude of low frequency fluctuations (ALFF) at rest and during a rumination induction. Specifically, we explored the differences of cortical blood oxygenation using fNIRS in subjects with Major Depressive Disorder (MDD) and healthy controls (HC). Rumination was assessed as state and trait measure, as well as with a qualitative semi-structured interview. Qualitative and quantitative measures of rumination indicated that the MDD group showed elevated rumination re-

garding state and trait measures. Furthermore, rumination differed qualitatively between the groups. The MDD group showed higher levels of general rumination and increased rumination during the rumination induction. However, the MDD group did not show a carry-overeffect of elevated rumination after the induction paradigm to the following resting-state measurement. On a neuronal level, we observed a general hypoactivity in the MDD group compared to the HC group. Moreover, both groups showed increased ALFF during the rumination induction compared to the rest phase, especially in temporo-parietal areas. However, no interaction effect of MDD status and rumination induction was found. The current findings are discussed with respect to the literature of paradigms used in the investigation of rumination and suggestions on general improvements in rumination research are given.

Enhancing Classification Performance of fNIRS-BCI by Identifying Cortically Active Channels Using the z-Score Method.

Nazeer H, Naseer N, Mehboob A, Khan MJ, Khan RA, Khan US, Ayaz Y.

Sensors (Basel). Dec 7;20(23):
doi: 10.3390/s20236995.

A state-of-the-art brain-computer interface (BCI) system includes brain signal acquisition, noise removal, channel selection, feature extraction, classification, and an application interface. In functional near-infrared spectroscopy-based BCI (fNIRS-BCI) channel selection may enhance classification performance by identifying suitable brain regions that contain brain activity. In this study, the z-score method for channel selection is proposed to improve fNIRS-BCI performance. The proposed method uses cross-correlation to match the similarity between desired and recorded brain activity signals, followed by forming a vector of each channel's correlation coefficients' maximum values. After that, the z-score is calculated for each value of that vector. A channel is selected based on a positive z-score value. The proposed method is applied to an open-access dataset containing mental arithmetic (MA) and motor imagery (MI) tasks for twenty-nine subjects. The proposed method is compared with the conventional t-value method and with no channel selected, i.e., using all channels. The z-score method yielded significantly improved ($p < 0.0167$) classification accuracies of 87.2 7.0%, 88.4 6.2%, and 88.1 6.9% for left motor imagery (LMI) vs. rest, right motor imagery (RMI) vs. rest, and mental arithmetic (MA) vs. rest, respectively. The proposed method is also validated on an open-access database of 17 subjects, containing right-hand finger tapping (RFT), left-hand finger tapping (LFT), and dominant side foot tapping (FT) tasks.The study shows an enhanced performance of the z-score method over the t-value method as an advancement in efforts to improve state-of-the-art fNIRS-BCI systems' performance.

Inner versus Overt Speech Production: Does This Make a Difference in the Developing Brain?

Stephan F, Saalbach H, Rossi S.

Brain Sci. Dec 5;10(12):
doi: 10.3390/brainsci10120939.

Studies in adults showed differential neural processing between overt and inner speech. So far, it is unclear whether inner and overt speech are processed differentially in children. The present study examines the pre-activation of the speech network in order to disentangle domain-general executive control from linguistic control of inner and overt speech production in 6- to 7-year-olds by simultaneously applying electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS). Children underwent a picture-naming task in which the pure preparation of a subsequent speech production and the actual execution of speech can be differentiated. The preparation phase does not represent speech per se but it resembles the setting up of the language production network. Only the fNIRS revealed a larger activation for overt, compared to inner, speech over bilateral prefrontal to parietal regions during the preparation

phase. Findings suggest that the children's brain can prepare the subsequent speech production. The preparation for overt and inner speech requires different domain-general executive control. In contrast to adults, the childrens brain did not show differences between inner and overt speech when a concrete linguistic content occurs and a concrete execution is required. This might indicate that domain-specific executive control processes are still under development.

Development of the neural processing of vocal emotion during the first year of life.

Zhao C, Schiessl I, Wan MW, Chronaki G, Abel KM.

Child Neuropsychol. Apr;27(3):333-
doi: 10.1080/09297049.2020. Epub Dec 8.

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

Working Memory Decline in Alzheimer's Disease Is Detected by Complexity Analysis of Multimodal EEG-fNIRS.

Perpetuini D, Chiarelli AM, Filippini C, Cardone D, Croce P, Rotunno L, Anzoletti N, Zito M, Zappasodi F, Merla A.

Entropy (Basel). Dec 6;22(12):
doi: 10.3390/e22121380.

Alzheimer's disease (AD) is characterized by working memory (WM) failures that can be assessed at early stages through administering clinical tests. Ecological neuroimaging, such as Electroencephalography (EEG) and functional Near Infrared Spectroscopy (fNIRS), may be employed during these tests to support AD early diagnosis within clinical settings. Multimodal EEG-fNIRS could measure brain activity along with neurovascular coupling (NC) and detect their modifications associated with AD. Data analysis procedures based on signal complexity are suitable to estimate electrical and hemodynamic brain activity or their mutual information (NC) during non-structured experimental paradigms. In this study, sample entropy of whole-head EEG and frontal/prefrontal cortex fNIRS was evaluated to assess brain activity in early AD and healthy controls (HC) during WM tasks (i.e., Rey-Osterrieth complex figure and Raven's progressive matrices). Moreover, conditional entropy between EEG and fNIRS was evaluated as indicative of NC. The findings demonstrated the capability of complexity analysis of multimodal EEG-fNIRS to detect WM decline in AD. Furthermore, a multivariate data-driven analysis, performed on these entropy metrics and based on the General Linear Model, allowed classifying AD and HC with an AUC up to 0.88. EEG-fNIRS may represent a powerful tool for the clinical evaluation of WM decline in early AD.

Applications of EEG indices for the quantification of human cognitive performance: A systematic review and bibliometric analysis.

Ismail LE, Karwowski W.

PLoS One. Dec 4;15(12):e
doi: 10.1371/journal.pone. eCollection 2020.

BACKGROUND: Neuroergonomics combines neuroscience with ergonomics to study human performance using recorded brain signals. Such neural signatures of performance can be measured using a variety of neuroimaging techniques, including functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (fNIRS), and electroencephalography (EEG). EEG has an excellent temporal resolution, and EEG indices are highly sensitive to human brain activity fluctuations. OBJECTIVE: The focus of this systematic review was to explore the applications of EEG indices for quantifying human performance in a variety of cognitive tasks at the macro and micro scales. To identify trends and the state of the field, we examined global patterns among selected articles, such as journal contributions, highly cited papers, affiliations, and high-frequency keywords. Moreover, we discussed the most frequently used EEG indices and synthesized current knowledge regarding the EEG signatures of associated human performance measurements. METHODS: In this systematic review, we analyzed articles published in English (from peer-reviewed journals, proceedings, and conference papers), Ph.D. dissertations, textbooks, and reference books. All articles reviewed herein included exclusively EEG-based experimental studies in healthy participants. We searched Web-of-Science and Scopus databases using specific sets of keywords. RESULTS: Out of 143 papers, a considerable number of cognitive studies focused on quantifying human performance with respect to mental fatigue, mental workload, mental effort, visual fatigue, emotion, and stress. An increasing trend for publication in this area was observed, with the highest number of publications in 2017. Most studies applied linear methods (e.g., EEG power spectral density and the amplitude of event-related potentials) to evaluate human cognitive performance. A few papers utilized nonlinear methods, such as fractal dimension, largest Lyapunov exponent, and signal entropy. More than 50% of the studies focused on evaluating an individual's mental states while operating a vehicle. Several different methods of artifact removal have also been noted. Based on the reviewed articles, research gaps, trends, and potential directions for future research were explored. CONCLUSION: This systematic review synthesized current knowledge regarding the application of EEG indices for quantifying human performance in a wide variety of cognitive tasks. This knowledge is useful for understanding the global patterns of applications of EEG indices for the analysis and design of cognitive tasks.

Caffeine Effect on Cognitive Function during a Stroop Task: fNIRS Study.

Yuan Y, Li G, Ren H, Chen W.

Neural Plast. Nov 21;2020:
doi: 10.1155/2020/eCollection 2020.

Acting as a brain stimulant, coffee resulted in heightening alertness, keeping arousal, improving executive speed, maintaining vigilance, and promoting memory, which are associated with attention, mood, and cognitive function. Functional near-infrared spectroscopy (fNIRS) is a noninvasive optical method to monitor brain activity by measuring the absorption of the near-infrared light through the intact skull. This study is aimed at acquiring brain activation during executing task performance. The aim is to explore the effect of coffee on cognitive function by the fNIRS neuroimaging method, particularly on the prefrontal cortex regions. The behavioral experimental results on 31 healthy subjects with a Stroop task indicate that coffee can easily and effectively modulate the execute task performance by feedback information of the response time and accuracy rate. The findings of fNIRS showed that apparent hemodynamic changes were detected in the bilateral VLPFC regions and the brain activation regions varied with different coffee conditions.

Accurate Image-guided (Re)Placement of NIRS Probes.

Wu ST, Rubianes Silva JAI, Novi SL, de Souza NGSR, Forero EJ, Mesquita RC.

Comput Methods Programs Biomed. Mar;200:
doi: 10.1016/j.cmpb.2020.Epub Nov 21.

BACKGROUND AND OBJECTIVE: Functional near-infrared spectroscopy (fNIRS) has become an attractive choice to neuroscience because of its high temporal resolution, ease of use, non-invasiveness, and affordability. With the advent of wearable fNIRS technology, on-the-spot studies of brain function have become viable. However, the lack of within-subject reproducibility is one of the barriers to the full acceptability of fNIRS. To support the validation of the claim that within-subject reproducibility of fNIRS could benefit from accurate anatomical information, we present in this paper a method to develop an image-based system that improves the placement of the sensors on the scalp at interactive rates. METHODS: The proposed solution consists of an electromagnetic digitizer and an interactive visualization system that allows monitoring the movements of the digitizer on a real head with respect to the underlying cerebral cortical structures. GPU-based volume raycasting rendering is applied to unveil these structures from the corresponding magnetic resonance imaging volume. Scalp and cortical surface are estimated from the scanned volume to improve depth perception. An alignment algorithm between the real and scanned heads is devised to visually feedback the position of the stylus of the digitizer. Off-screen rendering of the depthmaps of the visible surfaces makes spatial positioning of a 2D interaction pointer possible. RESULTS: We evaluated the alignment accuracy using four to eight anatomical landmarks and found seven to be a good compromise between precision and efficiency. Next, we evaluated reproducibility in positioning five arbitrarily chosen points on three volunteers by four operators over five sessions. In every session, seven anatomical landmarks were applied in the alignment of the real and the scanned head. For the same volunteer, one-way analysis of variance (ANOVA) revealed no significant differences within the five points digitized by the same operator over five sessions ($a = 0.05$). In addition, preliminary study of motor cortex activation by right-hand finger tapping showed the potential of our approach to increase functional fNIRS reproducibility. CONCLUSIONS: Results of experiments suggest that the enhancement of the visualization of the location of the probes on the scalp, relative to the underlying cortical structures, improves reproducibility of fNIRS measurements. As further work, we plan to study the fNIRS reproducibility in other cortical regions and in clinical settings using the proposed system.

Comparison of cerebral cortex activation induced by tactile stimulation between natural teeth and implants.

Sekido D, Otsuka T, Shimazaki T, Ohno A, Fuchigami K, Nagata K, Yamaguchi T, Kimoto K.

J Clin Exp Dent. Nov 1;12(11):e1021-e
doi: 10.4317/jced. eCollection Nov.

BACKGROUND: The purpose of this study was to assess the cortical-level sensory differences between natural teeth with a periodontal membrane and dental implants. MATERIAL AND METHODS: We used functional near-infrared spectroscopy (fNIRS) to measure brain activity in the cerebral cortex of 12 patients who had both natural teeth and dental implants in the lower molar region. Painless vibratory tactile stimulation was performed on both the natural teeth and the dental implants. RESULTS: Activation was seen in the somatosensory cortex during stimulation of both natural teeth and dental implants. A comparison of cortical activation showed no significant differences between natural teeth and dental implants. CONCLUSIONS: These results indicate the possible existence of sensory input to the cerebral cortex via dental implants as well as natural teeth, and thus suggest that may not only the periodontal membrane be involved in the signaling pathway. The data from this experiment may help us for understanding the neural mechanisms underlying natural teeth and dental implants. Key words:fNIRS, natural teeth, implants, brain activity, somatosensory cortex.

Functional near-infrared spectroscopy can detect low-frequency hemodynamic oscillations in the prefrontal cortex during steady-state visual evoked potential-inducing periodic facial expression stimuli presentation.

Wang MY, Yuan A, Zhang J, Xiang Y, Yuan Z.

Vis Comput Ind Biomed Art. Dec 1;3(1):
doi: 10.1186/s42492-020-00065-7.

Brain oscillations are vital to cognitive functions, while disrupted oscillatory activity is linked to various brain disorders. Although high-frequency neural oscillations (> 1 Hz) have been extensively studied in cognition, the neural mechanisms underlying low-frequency hemodynamic oscillations (LFHO) < 1 Hz have not yet been fully explored. One way to examine oscillatory neural dynamics is to use a facial expression (FE) paradigm to induce steady-state visual evoked potentials (SSVEPs), which has been used in electroencephalography studies of high-frequency brain oscillation activity. In this study, LFHO during SSVEP-inducing periodic flickering stimuli presentation were inspected using functional near-infrared spectroscopy (fNIRS), in which hemodynamic responses in the prefrontal cortex were recorded while participants were passively viewing dynamic FEs flickering at 0.2 Hz. The fast Fourier analysis results demonstrated that the power exhibited monochronic peaks at 0.2 Hz across all channels, indicating that the periodic events successfully elicited LFHO in the prefrontal cortex. More importantly, measurement of LFHO can effectively distinguish the brain activation difference between different cognitive conditions, with happy FE presentation showing greater LFHO power than neutral FE presentation. These results demonstrate that stimuli flashing at a given frequency can induce LFHO in the prefrontal cortex, which provides new insights into the cognitive mechanisms involved in slow oscillation.

Tinnitus and auditory cortex: using adapted functional near-infrared spectroscopy to measure resting-state functional connectivity.

San Juan JD, Zhai T, Ash-Rafzadeh A, Hu XS, Kim J, Filipak C, Guo K, Islam MN, Kovelman I, Basura GJ.

Neuroreport. Jan 6;32(1):66-
doi: 10.1097/WNR.0000000000001561.

OBJECTIVE: Tinnitus, phantom sound perception, arises from aberrant brain activity within auditory cortex. In tinnitus animal models, auditory cortex neurons show increased spontaneous firing and neural synchrony. In humans, similar hyperactivation in auditory cortex has been displayed with functional near-infrared spectroscopy (fNIRS). Resting-state functional connectivity (RSFC) or increased connectivity between brain regions has also been shown in tinnitus using fNIRS. However, current fNIRS technology utilizes infrared (IR)-sources and IR-detectors placed on the scalp that restricts (3 cm depth IR penetration) signal capture to outer cerebral cortex due to skin and skull bone. To overcome this limitation, in this proof of concept study, we adapted fNIRS probes to fit in the external auditory canal (EAC) to physically place IR-probes deeper within the skull thereby extracting neural signals from deeper auditory cortex. METHODS: Twenty adults with tinnitus and 20 nontinnitus controls listened to periods of silence and broadband noise before and after 5 min of silence to calculate RSFC. Concurrent scalp probes over auditory cortex and an adapted probe placed in the right EAC were utilized. RESULTS: For standard probes, left and right auditory cortex in tinnitus showed increased RSFC to each other and to other nonauditory cortices. Interestingly, adapted fNIRS probes showed trends toward increased RSFC. CONCLUSION: While many areas for the adapted probes did not reach significance, these data using a highly innovative and newly created probe adapting fNIRS technology to the EAC substantiates our previously published data in human tinnitus and concurrently validates this technology as a useful and expanded brain imaging modality.

Acute Effects of Two Types of Dumbbell Exercise on Oxygenated Hemodynamic Concentration of Cerebral Activation in Healthy Young Male Adults: A Functional Near-Infrared Spectroscopy Study.

Wang Y, L J, Rong J, Song L, Wang W, Jiang Y, Liu Y, Huang L.

Front Hum Neurosci. Nov 5;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Purpose: To examine cerebral cortical activation differences in the frontal cortex and parietal lobe during the performance of two types of dumbbell exercise. Methods: A total of 22 young healthy male adults (mean age, 23.8 2.05 years; height, 1.75 0.06 m; weight, 71.4 8.80 kg) participated in a crossover design study that involved two experimental exercise conditions: momentum dumbbell and conventional dumbbell. Performance tasks included 10, 10-s sets of single-arm dumbbell exercise, with a rest interval of 60 s between sets and a 5-min washout period between conditions. The primary outcome was the cerebral concentrations of oxygenated hemoglobin (HbO2) in the frontal cortex and parietal lobe assessed during performance of both exercises using functional near-infrared spectroscopy (fNIRS). The secondary outcome was upper-limb muscle activation measured using surface electromyography (sEMG). Outcome data were ascertained during exercise. Results: A significant between-condition difference in HbO2 was observed in the frontal and parietal regions with an increase in HbO2 during momentum, relative to conventional, dumbbell exercise ($p < 0.05$). Compared to conventional dumbbell exercise, performing a momentum dumbbell exercise led to a higher level of muscle activation in the anterior and posterior deltoids of the upper arm and in the flexor carpi radialis and extensor carpi radialis longus of the forearm ($p < 0.05$). However, no between-condition differences were found in the biceps and triceps brachii ($p > 0.05$). Conclusion: Dynamic, compared with conventional, dumbbell exercise resulted in higher hemodynamic responses and greater upper-limb muscle activation in young healthy adults. The findings of this study showed differential cortical hemodynamic responses during performance of the two types of dumbbell exercise with a higher activation level produced during momentum-based dumbbell exercise.

Neural responses to happy, fearful and angry faces of varying identities in 5- and 7-month-old infants.

Bayet L, Perdue KL, Behrendt HF, Richards JE, Westerlund A, Cataldo JK, Nelson CA 3rd.

Dev Cogn Neurosci. Feb;47:
doi: 10.1016/j.dcn.2020.Epub Nov 10.

The processing of facial emotion is an important social skill that develops throughout infancy and early childhood. Here we investigate the neural underpinnings of the ability to process facial emotion across changes in facial identity in cross-sectional groups of 5- and 7-month-old infants. We simultaneously measured neural metabolic, behavioral, and autonomic responses to happy, fearful, and angry faces of different female models using functional near-infrared spectroscopy (fNIRS), eye-tracking, and heart rate measures. We observed significant neural activation to these facial emotions in a distributed set of frontal and temporal brain regions, and longer looking to the mouth region of angry faces compared to happy and fearful faces. No differences in looking behavior or neural activations were observed between 5- and 7-month-olds, although several exploratory, age-independent associations between neural activations and looking behavior were noted. Overall, these findings suggest more developmental stability than previously thought in responses to emotional facial expressions of varying identities between 5- and 7-months of age.

The Influence of an Acute Exercise Bout on Adolescents' Stress Reactivity, Interference Control, and Brain Oxygenation Under Stress.

Mcke M, Ludyga S, Colledge F, Phse U, Gerber M.

Front Psychol. Nov 10;11:
doi: 10.3389/fpsyg.2020. eCollection 2020.

BACKGROUND: High psychosocial stress can impair executive function in adolescents, whereas acute exercise has been reported to benefit this cognitive domain. The aim of this study was to investigate whether an acute bout of aerobic exercise improves the inhibitory aspect of executive function and the associated dorsolateral prefrontal cortex (DLPFC) oxygenation when under stress. METHODS: Sixty male high school students aged 16-20 years performed a Stroop task (baseline condition) and were randomly assigned to an exercise group (30 min on ergometer at 70% of maximum heart rate) and a control group (30 min of reading). Subsequently, all participants underwent a modified Trier Social Stress Test, which included a Stroop task under enhanced stress. The Stroop tasks in both conditions were combined with functional near-infrared spectroscopy to record changes in DLPFC oxygenation in response to the tasks. Stress reactivity was measured with saliva samples (cortisol, alpha-amylase), heart rate monitoring, and anxiety scores. RESULTS: All stress parameters indicated increases in response to the stressor ($p < 0.001$), with higher alpha-amylase [$t(58) = -3.45$, $p = 0.001$, $d = 1.93$] and anxiety [$t(58) = -2.04$, $p = 0.046$, $d = 0.53$] reactions in the control compared to the exercise group. Controlling for these two parameters, repeated measures analyses of covariance targeting changes in Stroop interference scores showed no main effect of stress [$F(1,58) = 3.80$, $p = 0.056$, ?p2 = 0.063] and no stress ? group interaction [$F(1,58) = 0.43$, $p = 0.517$, ?p2 = 0.008]. Similarly, there was no main effect of stress [$F(1,58) = 2.38$, $p = 0.128$, ?p2 = 0.040] and no stress ?group interaction [$F(1,58) = 2.80$, $p = 0.100$, ?p2 = 0.047] for DLPFC oxygenation. CONCLUSION: Our study confirms potentially health-enhancing effects of acute exercise on some of the physiological and psychological stress reactivity indicators. However, our data do not support the notion of an effect on interference control and DLPFC activation under stress.

Capturing Human Interaction in the Virtual Age: A Perspective on the Future of fNIRS Hyperscanning.

Balters S, Baker JM, Hawthorne G, Reiss AL.

Front Hum Neurosci. Nov 3;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Advances in video conferencing capabilities combined with dramatic socio-dynamic shifts brought about by COVID-19, have redefined the ways in which humans interact in modern society. From business meetings to medical exams, or from classroom instruction to yoga class, virtual interfacing has permeated nearly every aspect of our daily lives. A seemingly endless stream of technological advances combined with our newfound reliance on virtual interfacing makes it likely that humans will continue to use this modern form of social interaction into the future. However, emergent evidence suggests that virtual interfacing may not be equivalent to face-to-face interactions. Ultimately, too little is currently understood about the mechanisms that underlie human interactions over the virtual divide, including how these mechanisms differ from traditional face-to-face interaction. Here, we propose functional near-infrared spectroscopy (fNIRS) hyperscanning-simultaneous measurement of two or more brains-as an optimal approach to quantify potential neurocognitive differences between virtual and in-person interactions. We argue that increased focus on this understudied domain will help elucidate the reasons why virtual conferencing doesn't always stack up to in-person meetings and will also serve to spur new technologies designed to improve the virtual interaction experience. On the basis of existing fNIRS hyperscanning literature, we highlight the current gaps in research regarding virtual interactions. Furthermore, we provide insight into current hurdles regarding fNIRS hyperscanning hardware and methodology that should be addressed in order to shed light on this newly critical element of everyday life.

Performance Improvement for Detecting Brain Function Using fNIRS: A Multi-Distance

Probe Configuration With PPL Method.

Song X, Chen X, Chen L, An X, Ming D.

Front Hum Neurosci. Nov 6;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

To improve the spatial resolution of imaging and get more effective brain function information, a multi-distance probe configuration with three distances (28.2, 40, and 44.7 mm) and 52 channels is designed. At the same time, a data conversion method of modified Beer-Lambert law (MBLL) with partial pathlength (PPL) is proposed. In the experiment, three kinds of tasks, grip of left hand, grip of right hand, and rest, are performed with eight healthy subjects. First, with a typical single-distance probe configuration (30 mm, 24 channels), the feasibility of the proposed MBLL with PPL is preliminarily validated. Further, the characteristic of the proposed method is evaluated with the multi-distance probe configuration. Compared with MBLL with differential pathlength factor (DPF), the proposed MBLL with PPL is able to acquire more obvious concentration change and can achieve higher classification accuracy of the three tasks. Then, with the proposed method, the performance of the multi-distance probe configuration is discussed. Results show that, compared with a single distance, the combination of the three distances has better spatial resolution and could explore more accurate brain activation information. Besides, the classification accuracy of the three tasks obtained with the combination of three distances is higher than that of any combination of two distances. Also, with the combination of the three distances, the two-class classification between different tasks is carried out. Both theory and experimental results demonstrate that, using multi-distance probe configuration and the MBLL with PPL method, the performance of brain function detected by NIRS can be improved.

Neural Signatures of Handgrip Fatigue in Type 1 Diabetic Men and Women.

Tyagi O, Zhu Y, Johnson C, Mehta RK, Sasangohar F, Erraguntla M, Qaraqe K.

Front Hum Neurosci. Nov 9;14:
doi: 10.3389/fnhum.2020. eCollection 2020.

Type 1 diabetes (T1D) is associated with reduced muscular strength and greater muscle fatigability. Along with changes in muscular mechanisms, T1D is also linked to structural changes in the brain. How the neurophysiological mechanisms underlying muscle fatigue is altered with T1D and sex related differences of these mechanisms are still not well investigated. The aim of this study was to determine the impact of T1D on the neural correlates of handgrip fatigue and examine sex and T1D related differences in neuromuscular performance parameters, neural activation and functional connectivity patterns between the motor regions of the brain. Forty-two adults, balanced by condition (healthy vs T1D) and sex (male vs female), and performed submaximal isometric handgrip contractions until voluntary exhaustion. Initial strength, endurance time, strength loss, force variability, and complexity measures were collected. Additionally, hemodynamic responses from motor-function related cortical regions, using functional near-infrared spectroscopy (fNIRS), were obtained. Overall, females exhibited lower initial strength ($p < 0.0001$), and greater strength loss ($p = 0.023$) than males. While initial strength was significantly lower in the T1D group ($p = 0.012$) compared to the healthy group, endurance times and strength loss were comparable between the two groups. Force complexity, measured as approximate entropy, was found to be lower throughout the experiment for the T1D group ($p = 0.0378$), indicating lower online motor adaptability. Although, T1D and healthy groups fatigued similarly, only the T1D group exhibited increased neural activation in the left ($p = 0.095$) and right ($p = 0.072$) supplementary motor areas (SMA) over time. A sex ?condition ?fatigue interaction effect ($p = 0.044$) showed that while increased activation was observed in both T1D females and healthy males from the Early to Middle phase, this was not observed in healthy females or T1D males. These findings demonstrate that T1D adults had lower adaptability to fatigue which they compensated for by increasing neural effort. This study highlights the importance of examining both neural and motor performance signatures when investigating the impact of chronic conditions on neuromuscular fatigue. Additionally, the findings have implications for developing intervention strategies for training, rehabilitation,

and ergonomics considerations for individuals with chronic conditions.

Effortful Control and Prefrontal Cortex Functioning in Children with Autism Spectrum Disorder: An fNIRS Study.

Krishnamurthy K, Yeung MK, Chan AS, Han YMY.

Brain Sci. Nov 20;10(11):
doi: 10.3390/brainsci10110880.

Effortful control (EC) is an important dimension of temperament, but is impaired in autism spectrum disorder (ASD). While EC is associated with the prefrontal cortex (PFC) functioning in typically developing (TD) children, it is unclear whether EC deficits are associated with PFC dysfunction in ASD. This study examines the relationship between EC and PFC activation and connectivity in children with high-functioning ASD. Thirty-nine right-handed children (ASD: n = 20; TD: n = 19) aged 8-12 years were recruited. The EC level was assessed with the Early Adolescent Temperament Questionnaire-Revised (EATQ-R), and PFC functioning, in terms of activation and connectivity during a frontal-sensitive (n-back) task, was assessed using functional near-infrared spectroscopy (fNIRS). Children with ASD showed a significant deficit in EC and its related constructs (i.e., executive, and socioemotional functions) compared to TD controls. They also showed significantly increased overall PFC activation and reduced right frontal connectivity during the n-back task. Among children with ASD, the EC level correlated significantly with neither PFC activation nor connectivity; it significantly correlated with social functioning only. This study demonstrated EC deficits and altered PFC functioning in children with ASD, but the exact neural basis of EC deficits remains to be determined.

Facial and neural mechanisms during interactive disclosure of biographical information.

Ca??eral R, Zhang X, Noah JA, Tachtsidis I, Hamilton AFC, Hirsch J.

Neuroimage. Feb 1;226:
doi: 10.1016/j.neuroimage.2020.Epub Nov 19.

Pairs of participants mutually communicated (or not) biographical information to each other. By combining simultaneous eye-tracking, face-tracking and functional near-infrared spectroscopy, we examined how this mutual sharing of information modulates social signalling and brain activity. When biographical information was disclosed, participants directed more eye gaze to the face of the partner and presented more facial displays. We also found that spontaneous production and observation of facial displays was associated with activity in the left SMG and right dlPFC/IFG, respectively. Moreover, mutual information-sharing increased activity in bilateral TPJ and left dlPFC, as well as cross-brain synchrony between right TPJ and left dlPFC. This suggests that a complex long-range mechanism is recruited during information-sharing. These multimodal findings support the second-person neuroscience hypothesis, which postulates that communicative interactions activate additional neurocognitive mechanisms to those engaged in non-interactive situations. They further advance our understanding of which neurocognitive mechanisms underlie communicative interactions.

Intrinsic organization of cortical networks predicts state anxiety: an functional near-infrared spectroscopy (fNIRS) study.

Duan L, Van Dam NT, Ai H, Xu P.

Transl Psychiatry. Nov 20;10(1):
doi: 10.1038/s41398-020-01088-7.

Although state anxiety has been characterized by hyper-responsive subcortical activity and its bottom-

up connectivity with cortical regions, the role of cortical networks in state anxiety is not yet well understood. To this end, we decoded individual state anxiety by using a machine-learning approach based on resting-state functional connectivity (RSFC) with functional near-infrared spectroscopy (fNIRS). Our results showed that the RSFC among a set of cortical networks were highly predictive of state anxiety, rather than trait anxiety. Specifically, these networks included connectivity between cortical areas in the default mode network (DMN) and dorsal attention network (DAN), and connectivity within the DMN, which were negatively correlated with state anxiety; connectivity between cortical areas in the DMN and frontoparietal network (FPN), FPN and salience network (SN), FPN and DAN, DMN and SN, which were positively correlated with state anxiety. These findings suggest a predictive role of intrinsic cortical organization in the assessment of state anxiety. The work provides new insights into potential neural mechanisms of emotion states and implications for prognosis, diagnosis, and treatment of affective disorders.

The influence of prior intention on joint action: an fNIRS-based hyperscanning study.
Chen Y, Zhang Q, Yuan S, Zhao B, Zhang P, Bai X.
Soc Cogn Affect Neurosci. Dec 24;15(12):1351-
doi: 10.1093/scan/nsaa152.

Motor performances of the same action are affected by prior intentions to move unintentionally, cooperatively or competitively. Here, a back-and-forth movement task combined with a motion capture system and functional near-infrared spectroscopy (fNIRS)-based hyperscanning technology was utilized to record both the behavioral and neural data of 18 dyads of participants acting in pairs [joint conditions: no-intention, cooperative (Coop) and competitive (Comp)] or alone (single conditions: self-paced and fast-speed). The results revealed that Coop or Comp intentions in the joint conditions significantly sped up motor performance compared with similar single conditions, e.g. shorter movement times (MTs) in the Coop/Comp condition than the self-paced/fast-speed condition. Hemodynamic response analysis demonstrated that stronger activities for all joint conditions than the single conditions in the premotor and the supplementary motor cortex (Brodmann area 6) were independent of variations of MTs, indicating that they might reflect more complex aspects of action planning rather than simple execution-based processes. The comparisons of joint conditions across distinct prior intentions before acting yielded significant results for both behavioral and neural measures, with the highest activation of the temporo-parietal junction (TPJ) and the shortest MTs in the Comp condition considered to be implications for the top-down influence of prior intentions on joint performance.

Thirst perception exacerbates objective mental fatigue.
Goodman SPJ, Marino FE.
Neuropsychologia. Jan 8;150:
doi: 10.1016/j.neuropsychologia.2020.Epub Nov 16.

Thirst is represented within the anterior cingulate and insular cortices, and may share some common neuroanatomical structures that are implicated with the regulation of mental fatigue. This novel study investigated whether thirst might modulate the subjective, behavioural, or neurophysiological representations of mental fatigue. In a crossover design, thirst was monitored in 15 males during 60min of cycling in normothermic conditions. Participants either consumed water to the dictates of their thirst (sated), or fluid was withheld and replaced with periodic salt water mouth rinses (thirst). Following either satiety or thirst, a 60min modified Stroop task was completed to evoke mental fatigue. Prefrontal cortex (PFC) haemodynamics were monitored throughout the prolonged task, and subjective perceptions of fatigue were reported through a visual analogue scale. Behavioural performance was quantified as the total number of Stroop task iterations completed in the mentally fatiguing task, and by collating response time and accuracy into the inverse efficiency score (IES) for each 5min interval throughout the task. During thirst,

fewer iterations were completed and poorer IES performance was evident toward the latter portion of the mentally fatiguing task. Compensatory elevations in PFC oxyhaemoglobin were produced in each condition, however, differed temporally, and were premature during thirst. A diminished capacity to sustain cognitive performance is likely the product of an inability to preserve the distribution of resources within the prefrontal cortex, due to heightened activation about thirst regulatory centres. These data provide novel insight into the relationship between thirst and mental fatigue, and suggest that drinking to the dictates of thirst may be a pertinent strategy to sustain prolonged cognitive performance.

Infants understand collaboration: Neural evidence for 9-month-olds' attribution of shared goals to coordinated joint actions.

Begus K, Curioni A, Knoblich G, Gergely G.

Soc Neurosci. Dec;15(6):655-
doi: 10.1080/17470919.2020.Epub Dec 22.

Interpreting others' actions as goal-directed, even when the actions are unfamiliar, is indispensable for social learning, and can be particularly important for infants, whose own action repertoire is limited. Indeed, young infants have been shown to attribute goals to unfamiliar actions as early as 3months of age, but this ability appears restricted to actions performed by individuals. In contrast, attributing shared goals to actions performed by multiple individuals seems to emerge only in the second year of life. Considering the restrictions that this would impose on infants' understanding and learning from interactions in their environment, we reexamine this ability by introducing 9-month-old infants to simple joint actions, in which two agents coordinate their actions toward the same goal. To establish whether infants formed an expectation about future actions of these agents, infants' cortical activity was measured using functional near-infrared spectroscopy (fNIRS). The hemodynamic response, recorded in (p)STS, indicated that infants attributed goals to simultaneous and coordinated joint actions of two individuals. Thus, even prior to actively engaging in collaborative activities themselves, infants can attribute shared goals to observed joint actions, enabling infants to learn from, and about, the complementary roles of social interactions, a central characteristic of human culture.

Athlete-Specific Neural Strategies under Pressure: A fNIRS Pilot Study.

Park I, Kim Y, Kim SK.

Int J Environ Res Public Health. Nov 16;17(22):
doi: 10.3390/ijerph17228464.

(1) Background: Stress and pressure during competition and training impair athletes' performance in sports. However, the influence of mental stress on the prefrontal cortex (PFC) functioning in an athlete during the visual simulation task is unknown. The purpose of this pilot study was to investigate hemodynamic responses during the visual-simulation task that induces pressure and stress using functional near-infrared spectroscopy. (2) Methods: Ten archers and ten non-athlete collegiate students performed a visual-simulation task. Participants' current stress levels were collected using a visual analog scale before and after the task. Average oxygenated hemoglobin (HbO), deoxygenated hemoglobin (HbR), and total hemoglobin (HbT) levels and their variability (standard deviation (SD) HbO, SD HbR, and SD HbT) were computed to compare the neural efficiency between athlete and non-athlete. (3) Results: In general, both groups exhibited increased stress levels after the simulation task, and there was no group difference in overall average hemodynamic response from PFC and dorsolateral prefrontal cortex (DLPFC). While the average hemodynamic response level did not differ between groups, variability in hemodynamic responses from the archer group showed a more stable pattern than the non-athlete group. (4) Conclusion: Under this experimental setting, decreasing the variability in hemodynamic responses during the visual simulation, potentially via stabilizing the fluctuation of PFC, was characterized by the stress-related compensatory

neural strategy of elite archers.

Objective measurement of tinnitus using functional near-infrared spectroscopy and machine learning.

Shoushtarian M, Alizadehsani R, Khosravi A, Acevedo N, McKay CM, Nahavandi S, Fallon JB.

PLoS One. Nov 18;15(11):e

doi: 10.1371/journal.pone. eCollection 2020.

Chronic tinnitus is a debilitating condition which affects 10-20% of adults and can severely impact their quality of life. Currently there is no objective measure of tinnitus that can be used clinically. Clinical assessment of the condition uses subjective feedback from individuals which is not always reliable. We investigated the sensitivity of functional near-infrared spectroscopy (fNIRS) to differentiate individuals with and without tinnitus and to identify fNIRS features associated with subjective ratings of tinnitus severity. We recorded fNIRS signals in the resting state and in response to auditory or visual stimuli from 25 individuals with chronic tinnitus and 21 controls matched for age and hearing loss. Severity of tinnitus was rated using the Tinnitus Handicap Inventory and subjective ratings of tinnitus loudness and annoyance were measured on a visual analogue scale. Following statistical group comparisons, machine learning methods including feature extraction and classification were applied to the fNIRS features to classify patients with tinnitus and controls and differentiate tinnitus at different severity levels. Resting state measures of connectivity between temporal regions and frontal and occipital regions were significantly higher in patients with tinnitus compared to controls. In the tinnitus group, temporal-occipital connectivity showed a significant increase with subject ratings of loudness. Also in this group, both visual and auditory evoked responses were significantly reduced in the visual and auditory regions of interest respectively. Na? Bayes classifiers were able to classify patients with tinnitus from controls with an accuracy of 78.3%. An accuracy of 87.32% was achieved using Neural Networks to differentiate patients with slight/ mild versus moderate/ severe tinnitus. Our findings show the feasibility of using fNIRS and machine learning to develop an objective measure of tinnitus. Such a measure would greatly benefit clinicians and patients by providing a tool to objectively assess new treatments and patients' treatment progress.

An fNIRS-Based Motor Imagery BCI for ALS: A Subject-Specific Data-Driven Approach.

Hosni SM, Borgheai SB, McLinden J, Shahriari Y.

IEEE Trans Neural Syst Rehabil Eng. Dec;28(12):3063-

doi: 10.1109/TNSRE.2020.Epub Jan 28.

DOI: 10.1109/TNSRE.2020.3038717 PMID: 33206606

Brief Report: Classification of Autistic Traits According to Brain Activity Recoded by fNIRS Using e-Complexity Coefficients.

Dahan A, Dubnov YA, Popkov AY, Gutman I, Probolovski HG.

J Autism Dev Disord. Nov

doi: 10.1007/s10803-020-04793-w. Online ahead of print.

Individuals with ASD have been shown to have different pattern of functional connectivity. In this study, brain activity of participants with many and few autistic traits, was recorded using an fNIRS device, as participants preformed an interpersonal synchronization task. This type of task involves synchronization and functional connectivity of different brain regions. A novel method for assessing signal complexity, using e-complexity coefficients, applied for the first i.e. on fNIRS recording, was used to classify brain recording

of participants with many/few autistic traits. Successful classification was achieved implying that this method may be useful for classification of fNIRS recordings and that there is a difference in brain activity between participants with low and high autistic traits as they perform an interpersonal synchronization task.

Brief Relaxation Practice Induces Significantly More Prefrontal Cortex Activation during Arithmetic Tasks Comparing to Viewing Greenery Images as Revealed by Functional Near-Infrared Spectroscopy (fNIRS).

Zhang Z, Olszewska-Guizzo A, Husain SF, Bose J, Choi J, Tan W, Wang J, Xuan Tran B, Wang B, Jin Y, Xuan W, Yan P, Li M, Ho CSH, Ho R.

Int J Environ Res Public Health. Nov 12;17(22):
doi: 10.3390/ijerph17228366.

BACKGROUND: There is little understanding on how brief relaxation practice and viewing greenery images would affect brain responses during cognitive tasks. In the present study, we examined the variation in brain activation of the prefrontal cortex during arithmetic tasks before and after viewing greenery images, brief relaxation practice, and control task using functional near-infrared spectroscopy (fNIRS). METHOD: This randomized controlled study examined the activation patterns of the prefrontal cortex (PFC) in three groups of research participants who were exposed to viewing greenery images (n = 10), brief relaxation practice (n = 10), and control task (n = 11). The activation pattern of the PFC was measured pre- and post-intervention using a portable fNIRS device and reported as mean total oxygenated hemoglobin (HbO m). Primary outcome of the study is the difference in HbO m between post- and pre-intervention readings during a cognitive task that required the research participants to perform arithmetic calculation. RESULTS: In terms of intervention-related differences, there was significant difference in average HbO m when performing arithmetic tasks before and after brief relaxation practice ($p < 0.05$). There were significant increases in average HbO m in the right frontopolar cortex ($p = 0.029$), the left frontopolar cortex ($p = 0.01$), and the left orbitofrontal cortex ($p = 0.033$) during arithmetic tasks after brief relaxation practice. In contrast, there were no significant differences in average HbO m when performing arithmetic tasks before and after viewing greenery images ($p > 0.05$) and the control task ($p > 0.05$). CONCLUSION: Our preliminary findings show that brief relaxation practice but not viewing greenery images led to significant frontal lobe activation during arithmetic tasks. The present study demonstrated, for the first time, that there was an increase in activation in neuroanatomical areas including the combined effort of allocation of attentional resources, exploration, and memory performance after the brief relaxation practice. Our findings suggest the possibility that the right frontopolar cortex, the left frontopolar cortex, and the left orbitofrontal cortex may be specifically associated with the benefits of brief relaxation on the brain.

Functional Near-infrared Spectroscopy Reveals the Compensatory Potential of Prefrontal Cortical Activity for Standing Balance in Young and Older Adults.

St George RJ, Hinder MR, Puri R, Walker E, Callisaya ML.

Neuroscience. Jan 1;452:208-
doi: 10.1016/j.neuroscience.2020.10. Epub Nov 14.

Recent evidence suggests increased activity of the pre-frontal cortex (PFC) is associated with sensorimotor disturbances of standing balance. Here we manipulate sensorimotor inputs and concurrently load cognitive resources in order to investigate the functional role of PFC activity during standing balance, and how this changes with healthy ageing. Healthy younger (n=24; mean age=20.8years) and older (n=25; mean age=70.6years) adults maintained balance while sensorimotor inputs were manipulated by removing vision, reducing the base of support, and reducing proprioceptive feedback. To load cognitive resources, each balance condition was undertaken alone or simultaneously with a cognitive task (dual-task). Func-

tional near infrared spectroscopy (fNIRS) measured PFC activity and a force-plate measured postural sway. When comparing dual-tasks relative to single balance tasks (dual-task effect), at lower levels of balance task demand, the older adults exhibited increased PFC activity and similar levels of postural sway. However, at higher levels of balance task demand, a limit to PFC activity was observed and postural sway became more unstable in older adults. In contrast, for younger adults at higher levels of balance task demand, the dual-task effect resulted in an increase in PFC activity and postural sway was not unduly affected. These results suggest that PFC activity is compensating for sensorimotor deficits to maintain stability, and that a cognitive resource limit is reached for easier balance tasks in older people compared to younger people. These results suggest that increasing cortical capacity in older people may improve their balance.

Multimodal Neuroimaging Using Concurrent EEG/fNIRS for Poststroke Recovery Assessment: An Exploratory Study.

Li R, Li S, Roh J, Wang C, Zhang Y.

Neurorehabil Neural Repair. Dec;34(12):1099-
doi: 10.1177/Epub Nov 16.

BACKGROUND: Persistent motor deficits are very common in poststroke survivors and often lead to disability. Current clinical measures for profiling motor impairment and assessing poststroke recovery are largely subjective and lack precision. OBJECTIVE: A multimodal neuroimaging approach was developed based on concurrent functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG) to identify biomarkers associated with motor function recovery and document the poststroke cortical reorganization. METHODS: EEG and fNIRS data were simultaneously recorded from 9 healthy controls and 18 stroke patients during a hand-clenching task. A novel fNIRS-informed EEG source imaging approach was developed to estimate cortical activity and functional connectivity. Subsequently, graph theory analysis was performed to identify network features for monitoring and predicting motor function recovery during a 4-week intervention. RESULTS: The task-evoked strength at ipsilesional primary somatosensory cortex was significantly lower in stroke patients compared with healthy controls ($P < .001$). In addition, across the 4-week rehabilitation intervention, the strength at ipsilesional premotor cortex (PMC) ($R = 0.895$, $P = .006$) and the connectivity between bilateral primary motor cortices (M1) ($R = 0.9$, $P = .007$) increased in parallel with the improvement of motor function. Furthermore, a higher baseline strength at ipsilesional PMC was associated with a better motor function recovery ($R = 0.768$, $P = .007$), while a higher baseline connectivity between ipsilesional supplementary motor cortex (SMA)-M1 implied a worse motor function recovery ($R = -0.745$, $P = .009$). CONCLUSION: The proposed multimodal EEG/fNIRS technique demonstrates a preliminary potential for monitoring and predicting poststroke motor recovery. We expect such findings can be further validated in future study.

Interpersonal brain synchronization under bluffing in strategic games.

Wang Z, Wang Y, Zhou X, Yu R.

Soc Cogn Affect Neurosci. Dec 24;15(12):1326-
doi: 10.1093/scan/nsaa154.

People commonly use bluffing as a strategy to manipulate other people's beliefs about them for gain. Although bluffing is an important part of successful strategic thinking, the inter-brain mechanisms underlying bluffing remain unclear. Here, we employed a functional near-infrared spectroscopy hyperscanning technique to simultaneously record the brain activity in the right temporal-parietal junction in 32 pairs of participants when they played a bluffing game against each other or with computer opponents separately. We also manipulated the penalty for bluffing (high vs low). Under the condition of high relative to low penalty, results showed a higher bluffing rate and a higher calling rate in human-to-human as compared to human-to-computer pairing. At the neural level, high relative to low penalty condition increased the

interpersonal brain synchronization (IBS) in the right angular gyrus (rAG) during human-to-human as compared to human-to-computer interaction. Importantly, bluffing relative to non-bluffing, under the high penalty and human-to-human condition, resulted in an increase in response time and enhanced IBS in the rAG. Participants who bluffed more frequently also elicited stronger IBS. Our findings support the view that regions associated with mentalizing become synchronized during bluffing games, especially under the high penalty and human-to-human condition.

Intraindividual variability in neural activity in the prefrontal cortex during active walking in older adults.

Holtzer R, Ross D, Izzetoglu M.

Psychol Aging. Dec;35(8):1201-
doi: 10.1037/pagEpub Nov 12.

Intraindividual variability in gait and cognitive performance is distinct from central-tendency measures and associated with clinical outcomes in aging. Knowledge concerning intraindividual variability in neural activity, however, has been relatively scarce, and no research to date has reported on such variability during active walking. The current study addressed this major gap in knowledge. Participants were community-residing older adults (n = 394; mean age = 76.29 6.65 years; %female = 55). Functional near-infrared spectroscopy (fNIRS) was used to measure oxygenated hemoglobin (HbO2) in the prefrontal cortex under three experimental conditions: single-task-walk, single-task-alpha (cognitive task), and dual-task-walk, which required the participants to perform the two single tasks simultaneously. Intraindividual variability in neural activity was operationalized using the standard deviation of fNIRS-derived HbO2 observations assessed during a 30-s interval in each experimental condition. The increase in intraindividual variability in neural activity in the dual-task-walk condition compared to both single-task conditions was associated with the presence of cognitive impairments and being a male. Furthermore, measures of intraindividual variability in neural activity and gait performance were positively correlated only under the dual-task-walk condition. Intraindividual variability in the neural activity of gait may be a novel marker for age-related impairments in mobility and cognitive function. (PsycInfo Database Record (c) 2020 APA, all rights reserved).

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fNIRS Assessment of Speech Comprehension in Children with Normal Hearing and Children with Hearing Aids in Virtual Acoustic Environments: Pilot Data and Practical Recommendations.

Bell L, Peng ZE, Pausch F, Reindl V, Neuschaefer-Rube C, Fels J, Konrad K.

Children (Basel). Nov 7;7(11):
doi: 10.3390/children7110219.

The integration of virtual acoustic environments (VAEs) with functional near-infrared spectroscopy (fNIRS) offers novel avenues to investigate behavioral and neural processes of speech-in-noise (SIN) comprehension in complex auditory scenes. Particularly in children with hearing aids (HAs), the combined application might offer new insights into the neural mechanism of SIN perception in simulated real-life acoustic scenarios. Here, we present first pilot data from six children with normal hearing (NH) and three children with bilateral HAs to explore the potential applicability of this novel approach. Children with NH received a speech recognition benefit from low room reverberation and target-distractors' spatial separation, particularly when the pitch of the target and the distractors was similar. On the neural level, the left inferior frontal gyrus appeared to support SIN comprehension during effortful listening. Children with HAs showed decreased SIN perception across conditions. The VAE-fNIRS approach is critically compared to traditional SIN assessments. Although the current study shows that feasibility still needs to be improved, the combined application potentially offers a promising tool to investigate novel research questions

in simulated real-life listening. Future modified VAE-fNIRS applications are warranted to replicate the current findings and to validate its application in research and clinical settings.

Neurophysiological correlates of age differences in driving behavior during concurrent subtask performance.

Stojan R, Voelcker-Rehage C.

Neuroimage. Jan 15;225:
doi: 10.1016/j.neuroimage.2020.Epub Oct 24.

Driving is a complex cognitive-motor task that requires the continuous integration of multisensory information, cognitive processes, and motor actions. With higher age, driving becomes increasingly challenging as a result of naturally declining neurophysiological resources. Performing additional subtasks, such as conversations with passengers or interactions with in-vehicle devices (e.g., adjusting the radio), may further challenge neurocognitive resources that are required to maintain driving performance. Based on declining brain physiological resources and inferior neurocognitive functioning, older adults (OA) may show higher brain activation and larger performance decrements than younger adults (YA) when engaging in additional subtasks during driving. Age differences, however, may further vary for different neurocognitive task demands, such that driving performance of OA might be particularly affected by certain subtasks. In this study, we hence investigated the brain functional correlates of age differences in driving behavior during concurrent subtask performance in YA and OA. Our final sample consisted of thirty younger (21.801.73y, 15 female) and thirty older (69.433.30y, 12 female) regular drivers that drove along a typical rural road (25 - 30min) in a driving simulator and performed three different concurrent subtasks that were presented auditorily or visually: typing a 3-digit number (TYPE), comparing traffic news and gas station prices (working memory, WM), and stating arguments (ARG). We measured variability in lateral car position, velocity, and following distance to a frontal lead car as the standard deviation from 0 to 15s after subtask onset. Brain activity was continuously recorded using functional near-infrared spectroscopy over the dorsolateral prefrontal cortex. Both YA and OA particularly varied in their lateral position during TYPE with a more pronounced effect in OA. For YA, in contrast, ARG led to higher variability in velocity compared to TYPE and WM, whereas OA showed no task-specific differences. Substantiating our behavioral findings, OA revealed the largest brain functional response to TYPE, while YA demonstrated a very distinct activation during ARG and smaller hemodynamic responses to TYPE and WM. Brain activity in the DLPFC was, overall, not significantly, but small to moderately related to certain behavioral performance parameters (mainly lateral position). We conclude that both OA and YA are vulnerable to distractive subtasks while driving. Age differences, however, seem to largely depend on neurocognitive task demands. OA may be at higher risk for accidents when performing visuo-motor subtasks (e.g., interacting with navigational systems) during driving while YA may be more (cognitively) distracted when talking to passengers.

Roles of the prefrontal cortex in learning to time the onset of pre-existing motor programs.

Lee BC, Choi J, Martin BJ.

PLoS One. Nov 9;15(11):e
doi: 10.1371/journal.pone. eCollection 2020.

The prefrontal cortex (PFC) is involved in cognitive control of motor activities and timing of future intensions. This study investigated the cognitive control of balance recovery in response to unpredictable gait perturbations and the role of PFC subregions in learning by repetition. Bilateral dorsolateral (DLPFC), ventrolateral (VLPFC), frontopolar (FPFC) and orbitofrontal (OFC) cortex hemodynamic changes induced by unpredictable slips were analyzed as a function of successive trials in ten healthy young adults. Slips were induced by the acceleration of one belt as the participant walked on a split-belt treadmill. A portable

functional near-infrared spectroscope monitored PFC activities quantified by oxyhemoglobin (?O2Hb) and deoxyhemoglobin (?HbR) during the consecutive trial phases: standing, walking, slip-recovery. During the first 3 trials, the average oxyhemoglobin (?O2Hbavg) in the DLPFC, VLPFC, FPFC, and OFC cortex was significantly higher during slip-recovery than unperturbed walking or the standing baseline. Then, ?O2Hbavg decreased progressively from trial-to-trial in the DLPFC, VLPFC, and FPFC, but increased and then remained constant in the OFC. The average deoxyhemoglobin (?HbRavg) presented mirror patterns. These changes after the third trial were paralleled by the progressive improvement of recovery revealed by kinematic variables. The results corroborate our previous hypothesis that only timing of the onset of a "good enough recovery motor program" is learned with practice. They also strongly support the assumption that the PFC contributes to the recall of pre-existing motor programs whose onset timing is adjusted by the OFC. Hence, learning is clearly divided into two steps delineated by the switch in activity of the OFC. Additionally, motor processes appear to share the working memory as well as decisional and predictive resources of the cognitive system.

NIRS measures in pain and analgesia: Fundamentals, features, and function.

Karunakaran KD, Peng K, Berry D, Green S, Labadie R, Kussman B, Borsook D.

Neurosci Biobehav Rev. Jan;120:335-

doi: 10.1016/j.neubiorev.2020.10.Epub Nov 4.

Current pain assessment techniques based only on clinical evaluation and self-reports are not objective and may lead to inadequate treatment. Having a functional biomarker will add to the clinical fidelity, diagnosis, and perhaps improve treatment efficacy in patients. While many approaches have been deployed in pain biomarker discovery, functional near-infrared spectroscopy (fNIRS) is a technology that allows for non-invasive measurement of cortical hemodynamics. The utility of fNIRS is especially attractive given its ability to detect specific changes in the somatosensory and high-order cortices as well as its ability to measure (1) brain function similar to functional magnetic resonance imaging, (2) graded responses to noxious and innocuous stimuli, (3) analgesia, and (4) nociception under anesthesia. In this review, we evaluate the utility of fNIRS in nociception/pain with particular focus on its sensitivity and specificity, methodological advantages and limitations, and the current and potential applications in various pain conditions. Everything considered, fNIRS technology could enhance our ability to evaluate evoked and persistent pain across different age groups and clinical populations.

Functional imaging of the developing brain with wearable high-density diffuse optical tomography: A new benchmark for infant neuroimaging outside the scanner environment.

Frijia EM, Billing A, Lloyd-Fox S, Vidal Rosas E, Collins-Jones L, Crespo-Llado MM, Amad??, Austin T, Edwards A, Dunne L, Smith G, Nixon-Hill R, Powell S, Everdell NL, Cooper RJ.

Neuroimage. Jan 15;225:

doi: 10.1016/j.neuroimage.2020.Epub Oct 24.

Studies of cortical function in the awake infant are extremely challenging to undertake with traditional neuroimaging approaches. Partly in response to this challenge, functional near-infrared spectroscopy (fNIRS) has become increasingly common in developmental neuroscience, but has significant limitations including resolution, spatial specificity and ergonomics. In adults, high-density arrays of near-infrared sources and detectors have recently been shown to yield dramatic improvements in spatial resolution and specificity when compared to typical fNIRS approaches. However, most existing fNIRS devices only permit the acquisition of 20-100 sparsely distributed fNIRS channels, and increasing the number of optodes presents significant mechanical challenges, particularly for infant applications. A new generation of wearable, modular, high-density diffuse optical tomography (HD-DOT) technologies has recently emerged that

overcomes many of the limitations of traditional, fibre-based and low-density fNIRS measurements. Driven by the development of this new technology, we have undertaken the first study of the infant brain using wearable HD-DOT. Using a well-established social stimulus paradigm, and combining this new imaging technology with advances in cap design and spatial registration, we show that it is now possible to obtain high-quality, functional images of the infant brain with minimal constraints on either the environment or on the infant participants. Our results are consistent with prior low-density fNIRS measures based on similar paradigms, but demonstrate superior spatial localization, improved depth specificity, higher SNR and a dramatic improvement in the consistency of the responses across participants. Our data retention rates also demonstrate that this new generation of wearable technology is well tolerated by the infant population.

Gut microbiota composition is associated with newborn functional brain connectivity and behavioral temperament.

Kelsey CM, Prescott S, McCulloch JA, Trinchieri G, Valladares TL, Dreisbach C, Alhusen J, Grossmann T.

Brain Behav Immun. Jan;91:472-
doi: 10.1016/j.bbi.2020.11.Epub Nov 4.

The gut microbiome appears to play an important role in human health and disease. However, only little is known about how variability in the gut microbiome contributes to individual differences during early and sensitive stages of brain and behavioral development. The current study examined the link between gut microbiome, brain, and behavior in newborn infants (N=63; M [age]=25days). Infant gut microbiome diversity was measured from stool samples using metagenomic sequencing, infant functional brain network connectivity was assessed using a resting state functional near infrared spectroscopy (rs-fNIRS) procedure, and infant behavioral temperament was assessed using parental report. Our results show that gut microbiota composition is linked to individual variability in brain network connectivity, which in turn mediated individual differences in behavioral temperament, specifically negative emotionality, among infants. Furthermore, virulence factors, possibly indexing pathogenic activity, were associated with differences in brain network connectivity linked to negative emotionality. These findings provide novel insights into the early developmental origins of the gut microbiome-brain axis and its association with variability in important behavioral traits. This suggests that the gut microbiome is an important biological factor to consider when studying human development and health.

People With Parkinson's Disease Exhibit Reduced Cognitive and Motor Cortical Activity When Undertaking Complex Stepping Tasks Requiring Inhibitory Control.

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

Neurorehabil Neural Repair. Dec;34(12):1088-
doi: 10.1177/Epub Nov 6.

BACKGROUND: People with Parkinson's disease (PD) have difficulties generating quick and accurate steps in anticipation of and/or in response to environmental hazards. However, neural mechanisms underlying performance in cognitively demanding stepping tasks are unclear. OBJECTIVE: This study compared activation patterns in cognitive and motor cortical regions using functional near-infrared spectroscopy (fNIRS) between people with PD and age-matched healthy older adults (HOA) during stepping tasks. METHODS: Fifty-two people with PD and 95 HOA performed a simple choice stepping reaction time test (CSRT) and 2 cognitively demanding stepping tests (inhibitory CSRT [iCSRT] and Stroop stepping test [SST]) on a computerized step mat. Cortical activation in the dorsolateral prefrontal cortex (DLPFC), Broca's area, supplementary motor area (SMA), and premotor cortex (PMC) were recorded using fNIRS. Stepping performance and cortical activity were contrasted between groups and between

the CSRT and the iCSRT and SST. RESULTS: The PD group performed worse than the HOA in all 3 stepping tests. A consistent pattern of interactions indicated differential hemodynamic responses between the groups. Compared with the CSRT, the PD group exhibited reduced DLPFC activity in the iCSRT and reduced SMA and PMC activity in the SST. The HOA exhibited increased DLPFC, SMA, and PMC activity when performing the SST in comparison with the CSRT task. CONCLUSIONS: In contrast to the HOA, the PD group demonstrated reduced cortical activity in the DLPFC, SMA, and PMC during the more complex stepping tasks requiring inhibitory control. This may reflect subcortical and/or multiple pathway damage with subsequent deficient use of cognitive and motor resources.

Executive Control of Walking in People With Parkinson's Disease With Freezing of Gait.

Vitorio R, Stuart S, Mancini M.

Neurorehabil Neural Repair. Dec;34(12):1138-
doi: 10.1177/Epub Nov 6.

BACKGROUND: Walking abnormalities in people with Parkinson's disease (PD) are characterized by a shift in locomotor control from healthy automaticity to compensatory prefrontal executive control. Indirect measures of automaticity of walking (eg, step-to-step variability and dual-task cost) suggest that freezing of gait (FoG) may be associated with reduced automaticity of walking. However, the influence of FoG status on actual prefrontal cortex (PFC) activity during walking remains unclear. OBJECTIVE: To investigate the influence of FoG status on automaticity of walking in people with PD. METHODS: Forty-seven people with PD were distributed into 2 groups based on FoG status, which was assessed by the New Freezing of Gait Questionnaire: PD-FoG (n = 23; UPDRS-III = 35) and PD+FoG (n = 24; UPDRS-III = 43.1). Participants walked over a 9-m straight path (with a 180 turn at each end) for 80 seconds. Two conditions were tested off medication: single- and dual-task walking (ie, with a concomitant cognitive task). A portable functional near-infrared spectroscopy system recorded PFC activity while walking (including turns). Wearable inertial sensors were used to calculate spatiotemporal gait parameters. RESULTS: PD+FoG had greater PFC activation during both single and dual-task walking than PD-FoG (P = .031). There were no differences in gait between PD-FoG and PD+FoG. Both groups decreased gait speed (P = .029) and stride length (P < .001) during dual-task walking compared with single-task walking. CONCLUSIONS: These findings suggest that PD+FoG have reduced automaticity of walking, even in absence of FoG episodes. PFC activity while walking seems to be more sensitive than gait measures in identifying reduction in automaticity of walking in PD+FoG.

Shedding Light on the Effects of Moderate Acute Exercise on Working Memory Performance in Healthy Older Adults: An fNIRS Study.

Stute K, Hudl N, Stojan R, Voelcker-Rehage C.

Brain Sci. Nov 3;10(11):
doi: 10.3390/brainsci10110813.

Numerous studies have reported the beneficial effects of acute exercise on executive functions. Less is known, however, about the effects of exercise on working memory as one subcomponent of executive functions and about its effects on older adults. We investigated the effects of acute moderate-intensity exercise on working memory performance, the respective cortical hemodynamic activation patterns, and the development and persistence of such effects in healthy older adults. Forty-four participants (M: 69.18 years 3.92; 21 females) performed a letter 2-back task before and at three time points after (post 15 min, post 30 min, and post 45 min) either listening to an audiobook or exercising (15 min; 50% VO2-peak). Functional near-infrared spectroscopy (fNIRS) was used to assess cortical hemodynamic activation and brain-behavior correlations in the fronto-parietal working memory network. Overall, we found no

group differences for working memory performance. However, only within the experimental group, 2-back performance was enhanced 15 min and 45 min post-exercise. Furthermore, 15 min post-exercise frontal activation predicted working memory performance, regardless of group. In sum, our results indicate slight beneficial effects of acute moderate-intensity exercise on working memory performance in healthy older adults. Findings are discussed in light of the cognitive aging process and moderators affecting the exercise-cognition relationship.

The Role of the Prefrontal Cortex and Functional Connectivity during Maritime Operations: An fNIRS study.

Fan S, Blanco-Davis E, Zhang J, Bury A, Warren J, Yang Z, Yan X, Wang J, Fairclough S.

Brain Behav. Jan;11(1):e
doi: 10.1002/brb3.Epub Nov 4.

INTRODUCTION: Watchkeeping is a significant activity during maritime operations, and failures of sustained attention and decision-making can increase the likelihood of a collision. METHODS: A study was conducted in a ship bridge simulator where 40 participants (20 experienced/20 inexperienced) performed: (1) a 20-min period of sustained attention to locate a target vessel and (2) a 10-min period of decision-making/action selection to perform an evasive maneuver. Half of the participants also performed an additional task of verbally reporting the position of their vessel. Activation of the prefrontal cortex (PFC) was captured via a 15-channel functional near-infrared spectroscopy (fNIRS) montage, and measures of functional connectivity were calculated frontal using graph-theoretic measures. RESULTS: Neurovascular activation of right lateral area of the PFC decreased during sustained attention and increased during decision-making. The graph-theoretic analysis revealed that density declined during decision-making in comparison with the previous period of sustained attention, while local clustering declined during sustained attention and increased when participants prepared their evasive maneuver. A regression analysis revealed an association between network measures and behavioral outcomes, with respect to spotting the target vessel and making an evasive maneuver. CONCLUSIONS: The right lateral area of the PFC is sensitive to watchkeeping and decision-making during operational performance. Graph-theoretic measures allow us to quantify patterns of functional connectivity and were predictive of safety-critical performance.

Interpersonal Neural Synchronization during Interpersonal Touch Underlies Affiliative Pair Bonding between Romantic Couples.

Long Y, Zheng L, Zhao H, Zhou S, Zhai Y, Lu C.

Cereb Cortex. Feb 5;31(3):1647-
doi: 10.1093/cercor/bhaa316.

Interpersonal touch plays a key role in creating and maintaining affiliative pair bonds in romantic love. However, the neurocognitive mechanism of interpersonal touch in affiliative pair bonding remains unclear. Here, we hypothesized that interpersonal neural synchronization (INS) during interpersonal touch underlies affiliative pair bonding between romantic couples. To test this hypothesis, INS between heterosexual romantic couples and between opposite-sex friends was measured using functional near-infrared spectroscopy-based hyperscanning, while the pairs of participants touched or vocally communicated with each other. The results showed significantly greater INS between the mentalizing and sensorimotor neural systems of two members of a pair during interpersonal touch than during vocal communication between romantic couples but not between friends. Moreover, touch-induced INS was significantly correlated with the self-reported strength of romantic love. Finally, the results also showed that men's empathy positively modulated the association between touch-induced INS increase and the strength of romantic love. These findings support the idea that INS during interpersonal touch underlies affiliative pair bonding between romantic couples and suggest that empathy plays a modulatory role in the neurocognitive mechanism of

interpersonal touch in affiliative pair bonding.

Age-related decline in visuo-spatial working memory is reflected by dorsolateral prefrontal activation and cognitive capabilities.

Kronovsek T, Hermand E, Berthoz A, Castilla A, Gallou-Guyot M, Daviet JC, Perrochon A.

Behav Brain Res. Feb 1;398:
doi: 10.1016/j.bbr.2020.Epub Nov 2.

INTRODUCTION: Visuo-spatial working memory (VSWM) performances undergo a decline throughout aging and are affected by the space in which the task is performed (reaching or navigational). Cerebral oxygenation and cognitive capabilities could explain this decline. We assessed the effects of age on cerebral oxygenation of the dorsolateral prefrontal cortex (dlPFC) in VSWM tasks in reaching and navigational space. We also assessed cognitive correlates of VSWM performance in each space. METHOD: Thirty-one (31) young adults (YA) and 24 healthy older adults (OA) performed a battery of neuropsychological tests and the electronic Corsi Block-tapping Test in reaching space (e-CBT) and in navigational space on the "Virtual Carpet" (VWCT). Participants were asked to memorize and recall a sequential pathway, progressively increasing from 2 to 9 blocks. Their span score reflected VSWM performance. The dlPFC oxygenation (oxyhaemoglobin: ?O2Hb and deoxyhaemoglobin: ?HHb) was measured by using functional Near-Infrared Spectroscopy (fNIRS) during the encoding of the sequential pathway in both tasks. RESULTS: YA had higher span scores than OA in both spaces. We identified a significantly stronger decrease of ?HHb in YA compared to OA during encoding in VWCT. OA also exhibited significantly lower cerebral oxygenation in VWCT compared to e-CBT. A decrease of ?HHb was also associated with a better performance in VWCT. Finally, we identified the association of mental rotation and executive functions with VSWM performance in both tasks. CONCLUSION: VSWM performance and cerebral oxygenation during encoding are impacted by aging. Space in which the task was performed was found to be associated with different cognitive functions and revealed differences in cerebral oxygenation.

Differences in perceived durations between plausible biological and non-biological stimuli.

Giorjiani GM, Biazoli CE Jr, Caetano MS.

Exp Brain Res. Jan;239(1):161-
doi: 10.1007/s00221-020-05904-w. Epub Nov 2.

Visual motion stimuli can sometimes distort our perception of time. This effect is dependent on the apparent speed of the moving stimulus, where faster stimuli are usually perceived lasting longer than slower stimuli. Although it has been shown that neural and cognitive processing of biological motion stimuli differ from non-biological motion stimuli, no study has yet investigated whether perceived durations of biological stimuli differ from non-biological stimuli across different speeds. Here, a prospective temporal reproduction task was used to assess that question. Biological motion stimuli consisted of a human silhouette running in place. Non-biological motion stimuli consisted of a rectangle moving in a pendular way. Amount and plausibility of movement for each stimulus and frame-rate (speed) were evaluated by an independent group of participants. Although the amount of movement perceived was positively correlated to frame rate both for biological and non-biological stimuli, movie clips involving biological motion stimuli were judged to last longer than non-biological motion stimuli only at frame rates for which movement was rated as plausible. These results suggest that plausible representations of biomechanical movement induce additional temporal distortions to those modulated by increases in stimulus speed. Moreover, most studies reporting neural and cognitive differences in the processing of biological and non-biological motion stimuli acquired neurophysiological data using fMRI. Here, we report differences in the processing of biological and non-biological motion stimuli across different speeds using functional near-infrared spectroscopy (fNIRS),

a less costly and portable form of neurophysiological data acquisition.

Decoding visual information from high-density diffuse optical tomography neuroimaging data.

Tripathy K, Markow ZE, Fishell AK, Sherafati A, Burns-Yocum TM, Schroeder ML, Svoboda AM, Eggebrecht AT, Anastasio MA, Schlaggar BL, Culver JP.

Neuroimage. Feb 1;226:
doi: 10.1016/j.neuroimage.2020.Epub Oct 31.

BACKGROUND: Neural decoding could be useful in many ways, from serving as a neuroscience research tool to providing a means of augmented communication for patients with neurological conditions. However, applications of decoding are currently constrained by the limitations of traditional neuroimaging modalities. Electrocorticography requires invasive neurosurgery, magnetic resonance imaging (MRI) is too cumbersome for uses like daily communication, and alternatives like functional near-infrared spectroscopy (fNIRS) offer poor image quality. High-density diffuse optical tomography (HD-DOT) is an emerging modality that uses denser optode arrays than fNIRS to combine logistical advantages of optical neuroimaging with enhanced image quality. Despite the resulting promise of HD-DOT for facilitating field applications of neuroimaging, decoding of brain activity as measured by HD-DOT has yet to be evaluated. OBJECTIVE: To assess the feasibility and performance of decoding with HD-DOT in visual cortex. METHODS AND RESULTS: To establish the feasibility of decoding at the single-trial level with HD-DOT, a template matching strategy was used to decode visual stimulus position. A receiver operating characteristic (ROC) analysis was used to quantify the sensitivity, specificity, and reproducibility of binary visual decoding. Mean areas under the curve (AUCs) greater than 0.97 across 10 imaging sessions in a highly sampled participant were observed. ROC analyses of decoding across 5 participants established both reproducibility in multiple individuals and the feasibility of inter-individual decoding (mean AUCs > 0.7), although decoding performance varied between individuals. Phase-encoded checkerboard stimuli were used to assess more complex, non-binary decoding with HD-DOT. Across 3 highly sampled participants, the phase of a 60 wide checkerboard wedge rotating 10 per second through 360 was decoded with a within-participant error of 25.824.7. Decoding between participants was also feasible based on permutation-based significance testing. CONCLUSIONS: Visual stimulus information can be decoded accurately, reproducibly, and across a range of detail (for both binary and non-binary outcomes) at the single-trial level (without needing to block-average test data) using HD-DOT data. These results lay the foundation for future studies of more complex decoding with HD-DOT and applications in clinical populations.

Right STS responses to biological motion in infancy - An fNIRS study using point-light walkers.

Lisboa IC, Miguel H, Sampaio A, Mouta S, Santos JA, Pereira AF.

Neuropsychologia. Dec;149:
doi: 10.1016/j.neuropsychologia.2020.Epub Nov 1.

Biological motion perception-our capacity to perceive the intrinsic motion of humans and animals-has been implicated as a precursor of social development in infancy. In the adult brain, several biological motion neural correlates have been identified; of particular importance, the right posterior superior temporal sulcus (rpSTS). We present a study, conducted with fNIRS, which measured brain activations in infants' right posterior temporal region to point-light walkers, a standard stimulus category of biological motion perception studies. Seven-month-old infants (n=23) participated in a within-subject blocked design with three experimental conditions and one baseline. Infants viewed: an intact upright point-light walker of a person approaching the observer; the same point-light walker stimulus but inverted; and a selected frame from the point-light walker stimulus, approaching the viewer at constant velocity with no articulated

motion, close to object motion. We found activations for both the upright and the inverted point-light walkers. The rigid moving point-light walker frame did not elicit any response consistent with a functional activation in this region. Our results suggest that biological motion is processed differently in the right middle posterior temporal cortex in infancy, and that articulated motion is a critical feature in biological motion processing at this early age.

The Role of Reward System in Dishonest Behavior: A Functional Near-Infrared Spectroscopy Study.

Liang Y, Fu G, Yu R, Bi Y, Ding XP.

Brain Topogr. Jan;34(1):64-
doi: 10.1007/s10548-020-00804-Epub Nov 1.

Previous studies showed that the cortical reward system plays animportant role in deceptive behavior. However, how the reward system activates during the whole course of dishonest behavior and how it affects dishonest decisions remain unclear. The current study investigated these questions. One hundred and two participants were included in the final analysis. They completed two tasks: monetary incentive delay (MID) task and an honesty task. The MID task served as the localizer task and the honesty task was used to measure participants' deceptive behaviors. Participants' spontaneous responses in the honesty task were categorized into three conditions: Correct-Truth condition (tell the truth after guessing correctly), Incorrect-Truth condition (tell the truth after guessing incorrectly), and Incorrect-Lie condition (tell lies after guessing incorrectly). To reduce contamination from neighboring functional regions as well as to increase sensitivity to small effects (Powell et al., Devel Sci 21:e12595, 2018), we adopted the individual functional channel of interest (fCOI) approach to analyze the data. Specially, we identified the channels of interest in the MID task in individual participants and then applied them to the honesty task. The result suggested that the reward system showed different activation patterns during different phases: In the pre-decision phase, the reward system was activated with the winning of the reward. During the decision and feedback phase, the reward system was activated when people made the decisions to be dishonest and when they evaluated the outcome of their decisions. Furthermore, the result showed that neural activity of the reward system toward the outcome of their decision was related to subsequent dishonest behaviors. Thus, the present study confirmed the important role of the reward system in deception. These results can also shed light on how one could use neuroimaging techniques to perform lie-detection.

Immediate effects of visual-motor illusion on resting-state functional connectivity.

Sakai K, Goto K, Watanabe R, Tanabe J, Amimoto K, Kumai K, Shibata K, Morikawa K, Ikeda Y.

Brain Cogn. Dec;146:
doi: 10.1016/j.bandc.2020.Epub Oct 28.

Visual-motor illusion (VMI) is to evoke a kinesthetic sensation by viewing images of oneself performing physical exercise while the body is at rest. Previous studies demonstrated that VMI activates the motor association brain areas; however, it is unclear whether VMI immediately alters the resting-state functional connectivity (RSFC). This study is aimed to verify whether the VMI induction changed the RSFC using functional near-infrared spectroscopy (fNIRS). The right hands of 13 healthy adults underwent illusion and observation conditions for 20min each. Before and after each condition, RSFC was measured using fNIRS. After each condition, degree of kinesthetic illusion and a sense of body ownership measured using the Likert scale. Our results indicated that, compared with the observation condition, the degree of kinesthetic illusion and the sense of body ownership were significantly higher after the illusion condition. Compared with the observation condition, RSFC after the illusion condition significantly increased brain areas associated with kinesthetic illusion, a sense of body ownership, and motor execution. In conclusion, RSFC has become a biomarker that shows changes in brain function occurring due to VMI. VMI may be

applied to the treatment of patients with stroke or orthopedic diseases.

Morality and management: an oxymoron? fNIRS and neuromanagement perspective explain us why things are not like this.

Balconi M, Fronda G.

Cogn Affect Behav Neurosci. Dec;20(6):1336-
doi: 10.3758/s13415-020-00841-Epub Oct 29.

The neuroscience interest for moral decision-making has recently increased. To investigate the processes underlying moral behavior, this research aimed to investigate neurophysiological and behavioral correlates of decision-making in moral contexts. Specifically, functional Near-infrared spectroscopy (fNIRS) allowed to record oxygenated (O2Hb) and deoxygenated (HHb) cerebral hemoglobin concentrations during different moral conditions (professional fit, company fit, social fit) and offers types (fair, unfair, neutral). Moreover, individuals' responses to offers types and reaction time (RTs) were considered. Specifically, from hemodynamic results emerged a difference in O2Hb and HHb activity according to moral conditions and offers types in different brain regions. In particular, O2Hb increase and a HHb decrease were observed in ventromedial and dorsolateral prefrontal cortex (VMPFC, DLPFC) for fair offers in professional fit condition and in superior temporal sulcus (STS) for unfair offers in social fit condition. Moreover, an increase of left O2Hb activity in professional fit condition and in right VMPFC for unfair offers in company fit condition was observed. In addition, from behavioral results, an RTs increase in company and social fit condition for fair and unfair offers emerged. This study, therefore, shows the behavioral and neurophysiological correlates of moral decision-making that guide moral behavior in different context, such as company one.

Significance of the ability to differentiate emotional prosodies for the early diagnosis and prognostic prediction of mild hypoxic-ischemic encephalopathy in neonates.

Liu L, Geng Y, Cui Y, Zhou Y, Sun G, Peng C, Zhang R, Ma Y, Liu Y, Sun C, Hou X, Chen J.

Int J Dev Neurosci. Feb;81(1):51-
doi: 10.1002/jdn.Epub Nov 17.

BACKGROUND: Perinatal brain injury affects around 300,000 neonates in China each year, early diagnosis and active intervention are also crucial for timely treatment and better prognoses. As hearing is the earliest as well as the most sensitive sense to develop in neonates, we propose that the ability to differentiate among different emotional prosodies may differ between neonates with and without brain injuries. METHODS: We enrolled full-term neonates admitted to the neonatology department of Peking University First Hospital from January 2016 to December 2016, conducted functional near-infrared spectroscopy (fNIRS) monitoring within 24hr of admission, and analyzed changes in oxyhemoglobin (?HbO2) and deoxyhemoglobin (?Hb) to study the ability of neonates to differentiate among emotional prosodies. The neonates were followed up to 36months for neurological outcome evaluation. RESULTS AND CONCLUSIONS: We found that neonates showed the early ability to differentiate among emotional prosodies, responding most sensitively to positive emotions, and this ability may have been impaired following brain injury.

Classification of schizophrenia using general linear model and support vector machine via fNIRS.

Chen L, Li Q, Song H, Gao R, Yang J, Dong W, Dang W.

Phys Eng Sci Med. Dec;43(4):1151-
doi: 10.1007/s13246-020-00920- Epub Oct 28.

Schizophrenia is a type of serious mental illness. In clinical practice, it is still a challenging problem to identify schizophrenia-related brain patterns due to the lack of objective physiological data support and a unified data analysis method, physicians can only use the subjective experience to distinguish schizophrenia patients and healthy people, which may easily lead to misdiagnosis. In this study, we designed an optimized data-preprocessing method accompanied with techniques of general linear model feature extraction, independent sample t-test feature selection and support vector machine to identify a set of robust fNIRS pattern features as a biomarker to discriminate schizophrenia patients and healthy people. Experimental results demonstrated that the proposed combination way of data preprocessing, feature extraction, feature selection and support vector machine classification can effectively identify schizophrenia patients and the healthy people with a leave-one-out-cross-validation classification accuracy of 89.5%.

Electrical and Hemodynamic Neural Functions in People With ALS: An EEG-fNIRS Resting-State Study.

Deligani RJ, Hosni SI, Borgheai SB, McLinden J, Zisk AH, Mankodiya K, Shahriari Y.

IEEE Trans Neural Syst Rehabil Eng. Dec;28(12):3129-

doi: 10.1109/TNSRE.2020.Epub Jan 28.

DOI: 10.1109/TNSRE.2020.3031495 PMCID: PMC7952040 PMID: 33055020

Neuronal correlates of the visual-spatial processing measured with functional near-infrared spectroscopy in healthy elderly individuals.

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

Neuropsychologia. Nov;148:

doi: 10.1016/j.neuropsychologia.2020.Epub Oct 9.

Alzheimer's disease (AD) and Mild Cognitive Impairment (MCI) are a globally rising issue. It is necessary to detect such diseases early to find strategies for prevention. Typically, patients with MCI or AD show deviant neuronal patterns, which could be detected early through brain imaging techniques enabling assumptions about pre-existing diseases. Functional Near-Infrared Spectroscopy (fNIRS) is an appropriate imaging method because of its easy and economical nature with hardly any drawbacks. An early measurable risk factor indicating neurodegenerative processes could be a deficit in visual-spatial processing, which is localized in the parietal cortex. In this study, we aimed to measure the hemodynamic response of the visual-spatial processing in the healthy elderly participants of our long-term Vogel Study with fNIRS during the clock-hand-angle-discrimination task (ADT) to deepen our understanding of healthy brain mechanisms. Our results revealed for our healthy sample a significantly increased neuronal brain activity with increasing task difficulties, namely from the long to the middle to the short clock hand during ADT and significantly higher activation in the right hemisphere compared to the left hemisphere as well as in the superior parietal cortex compared to the inferior parietal cortex. Additionally, our behavioral data demonstrated longer reaction times and more errors with an increasing task requirement. We, therefore, assume that visual-spatial processing can successfully be operationalized with fNIRS for healthy elderly people based on ADT. Further fNIRS analyses are planned to investigate pathological neuronal correlates of visual-spatial function in MCI or AD study participants.

Functional connectivity in the developing language network in 4-year-old children predicts future reading ability.

Jasinska KK, Shuai L, Lau ANL, Frost S, Landi N, Pugh KR.

Dev Sci. Mar;24(2):e

doi: 10.1111/desc.Epub Oct 28.

Understanding how pre-literate children's language abilities and neural function relate to future reading ability is important for identifying children who may be at-risk for reading problems. Pre-literate children are already proficient users of spoken language and their developing brain networks for language become highly overlapping with brain networks that emerge during literacy acquisition. In the present longitudinal study, we examined language abilities, and neural activation and connectivity within the language network in pre-literate children (mean age=4.2years). We tested how language abilities, brain activation, and connectivity predict children's reading abilities 1year later (mean age=5.2years). At Time 1, children (n=37) participated in a functional near infrared spectroscopy (fNIRS) experiment of speech processing (listening to words and pseudowords) and completed a standardized battery of language and cognitive assessments. At Time 2, children (n=28) completed standardized reading assessments. Using psychophysiological interaction (PPI) analyses, we observed significant connectivity between the left IFG and right STG in pre-literate children, which was modulated by task (i.e., listening to words). Neural activation in left IFG and STG and increased task-modulated connectivity between the left IFG and right STG was predictive of multiple reading outcomes. Increased connectivity was associated later with increased reading ability.

Neural reference groups: a synchrony-based classification approach for predicting attitudes using fNIRS.

Dieffenbach MC, Gillespie GSR, Burns SM, McCulloh IA, Ames DL, Dagher MM, Falk EB, Lieberman MD.

Soc Cogn Affect Neurosci. Jan 18;16(1-2):117-
doi: 10.1093/scan/nsaa115.

Social neuroscience research has demonstrated that those who are like-minded are also 'like-brained.' Studies have shown that people who share similar viewpoints have greater neural synchrony with one another, and less synchrony with people who 'see things differently.' Although these effects have been demonstrated at the 'group level,' little work has been done to predict the viewpoints of specific 'individuals' using neural synchrony measures. Furthermore, the studies that have made predictions using synchrony-based classification at the individual level used expensive and immobile neuroimaging equipment (e.g. functional magnetic resonance imaging) in highly controlled laboratory settings, which may not generalize to real-world contexts. Thus, this study uses a simple synchrony-based classification method, which we refer to as the 'neural reference groups' approach, to predict individuals' dispositional attitudes from data collected in a mobile 'pop-up neuroscience' lab. Using functional near-infrared spectroscopy data, we predicted individuals' partisan stances on a sociopolitical issue by comparing their neural timecourses to data from two partisan neural reference groups. We found that partisan stance could be identified at above-chance levels using data from dorsomedial prefrontal cortex. These results indicate that the neural reference groups approach can be used to investigate naturally occurring, dispositional differences anywhere in the world.

The association of prefrontal cortex response during a natural reward cue-reactivity paradigm, anhedonia, and demoralization in persons maintained on methadone.

Huhn AS, Brooner RK, Sweeney MM, Antoine D, Hammond AS, Ayaz H, Dunn KE.

Addict Behav. Feb;113:
doi: 10.1016/j.addbeh.2020.Epub Sep 28.

Persons with opioid use disorder (OUD) often experience anhedonia and demoralization, yet there is relatively little research on the pathophysiology of anhedonia and demoralization in OUD treatment and recovery. In the current study, persons maintained on methadone (N=29) underwent a natural reward-cue

paradigm during functional near-infrared spectroscopy (fNIRS) imaging. Natural reward cues included highly palatable food, positive social interactions (e.g., a happy family at the dinner table), and emotional intimacy (e.g. couples embracing or kissing, but no erotic images). Participants also self-reported symptoms of anhedonia on the Snaith-Hamilton Pleasure Scale (SHPS) and demoralization on the Demoralization Scale II (DS-II). Participants who reported clinically-significant anhedonia on the SHPS displayed decreased neural activity in the right prefrontal cortex (PFC) in response to natural reward cues (F(1,25)=3.612, p=0.027, ?p2=0.302). In linear regression models of positive social cues, decreased neural activity in the right VMPFC was associated with increased SHPS total score (F(1,27)=7.131, R2=0.209, p=.013), and decreased neural activity in an area encompassing the right lateral VMPFC and DLPFC was associated with increased DS-II total score (F(1,27)=10.641, R2=0.283, p=0.003). This study provides initial evidence that the prefrontal cortex is involved in the pathophysiology of anhedonia and demoralization in persons in recovery from OUD. Anhedonia and demoralization are important treatment outcomes that should be queried along with a constellation of physical and mental health outcomes, to assess areas of needed improvement in methadone maintenance and other OUD treatment modalities.

Altered Brain Activation in Youth following Concussion: Using a Dual-task Paradigm.

Urban K, Schudlo L, Keightley M, Alain S, Reed N, Chau T.

Dev Neurorehabil. Apr;24(3):187-
doi: 10.1080/17518423.2020. Epub Oct 4.

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

Effect of Different Intensities of Transcranial Direct Current Stimulation on Postural Response to External Perturbation in Patients With Parkinson's Disease.

Beretta VS, Vit?? R, N??ga-Sousa P, Concei? NR, Orcioli-Silva D, Pereira MP, Gobbi LTB.

Neurorehabil Neural Repair. Nov;34(11):1009-
doi: 10.1177/Epub Oct 1.

BACKGROUND: Habituation of postural response to perturbations is impaired in people with Parkinson's disease (PD) due to deficits in cortico-basal pathways. Although transcranial direct current stimulation (tDCS) modulate cortico-basal networks, it remains unclear if it can benefit postural control in PD. OBJECTIVE: To analyze the effect of different intensities of anodal tDCS on postural responses and prefrontal cortex (PFC) activity during the habituation to the external perturbation in patients with PD (n = 24). METHODS: Anodal tDCS was applied over the primary motor cortex (M1) with 1 mA, 2 mA, and sham stimulation in 3 different sessions (2 weeks apart) during 20 minutes immediately before the postural assessment. External perturbation (7 trials) was applied by a support base posterior translation (20 cm/s and 5 cm). Primary outcome measures included lower limb electromyography and center of pressure parameters. Measures of PFC activity are reported as exploratory outcomes. Analyses of variance

(Stimulation Condition ?Trial) were performed. RESULTS: Habituation of perturbation was evidenced independent of the stimulation conditions. Both active stimulation intensities had shorter recovery time and a trend for lower cortical activity in the stimulated hemisphere when compared to sham condition. Shorter onset latency of the medial gastrocnemius as well as lower cortical activity in the nonstimulated hemisphere were only observed after 2 mA concerning the sham condition. CONCLUSIONS: tDCS over M1 improved the postural response to external perturbation in PD, with better response observed for 2 mA compared with 1 mA. However, tDCS seems to be inefficient in modifying the habituation of perturbation.

Watching video of discrete maneuvers yields better action memory and greater activation in the middle temporal gyrus in half-pipe snowboarding athletes.

Chen Y, Wang Y, Zhao Q, Wang Y, Lu Y, Zhou C.

Neurosci Lett. Nov 20;739:
doi: 10.1016/j.neulet.2020.Epub Sep 28.

Although motor performance training often involves action observation, it has been controversial whether individual aesthetic sport athletes benefit more from watching videos of discrete maneuvers (DMs) or continuous runs (CRs). In the present study, half-pipe snowboarding athletes completed a visual 2-back task with DM and CR conditions. To explore the neural mechanisms of action memory processing, brain hemodynamic activity during the task was monitored with functional near-infrared spectroscopy (fNIRS). Compared to watching CR videos, watching DM videos tended to yield better action memory performance and greater activation in the middle temporal gyrus to these athletes, suggesting that watching DM videos may have a tendency to improve action memory more effectively. Evidence of two pathways underlying half-pipe snowboarding action processing was obtained. Watching of CR videos and watching of DM videos might be associated with activation of more sensorimotor regions and more semantic regions, respectively, during memory consolidation.

A Unified Analytical Framework With Multiple fNIRS Features for Mental Workload Assessment in the Prefrontal Cortex.

Lim LG, Ung WC, Chan YL, Lu CK, Sutoko S, Funane T, Kiguchi M, Tang TB.

IEEE Trans Neural Syst Rehabil Eng. Nov;28(11):2367-
doi: 10.1109/TNSRE.2020.Epub Nov 6.

DOI: 10.1109/TNSRE.2020.3026991 PMID: 32986555

Altered prefrontal cortex responses in older adults with subjective memory complaints and dementia during dual-task gait: An fNIRS study.

Teo WP, Rantalainen T, Nuzum N, Valente L, Macpherson H.

Eur J Neurosci. Feb;53(4):1324-
doi: 10.1111/ejn.Epub Oct 12.

People with cognitive impairments show deficits during physical performances such as gait, in particular during cognitively challenging conditions (i.e. dual-task gait [DTG]). However, it is unclear if people at risk of dementia, such as those with subjective memory complaints (SMC), also display gait and central deficits associated with DTG. In this study, we investigated the effects of single- and dual-task gait (STG and DTG), on left prefrontal cortex (PFC) activation in elderly people with subjective memory complaints (SMC) and Dementia. A total of 58 older adults (aged 65-94years; 26 Healthy; 23 SMC; 9 Dementia) were recruited. Gait spatiotemporal characteristics (i.e. stride velocity and length) were assessed using an instrumented walkway during STG and DTG. Single-channel functional near-infrared spectroscopy over

the left PFC was used to measure changes in oxyhaemoglobin (O2 Hb) during gait. Stride velocity and length during STG (all p<.05) and DTG (all p<.000) were significantly impaired in people with Dementia compared to Healthy and SMC individuals. No differences were observed between Healthy and SMC. For STG, a greater increase in O2 Hb (p<.05) was observed in those with Dementia compared to the Healthy and SMC, while no differences were observed between Healthy and SMC. A significant increase and decline in O2 Hb was observed during DTG in the SMC and Dementia groups, respectively, compared to Healthy. Our findings indicate an altered pattern of cerebral haemodynamic response of the left PFC in DTG in people with SMC and Dementia, which may suggest that central changes precede functional impairments in people with SMC.

Interictal hemodynamic abnormality during motor activation in sporadic hemiplegic migraine: An explorative study.

Lo YL, Wee SL, Zhao YJ, Narasimhalu K.

J Neurol Sci. Nov 15;418:
doi: 10.1016/j.jns.2020.Epub Sep 21.

INTRODUCTION: The motor weakness in sporadic hemiplegic migraine (SHM) is a poorly understood aura manifestation. Cortical spreading depression affecting motor excitability and alterations of neurovascular coupling may be integral to the development of migraine aura. METHODS: We studied 10 right-handed SHM patients and 17 healthy controls with functional near-infrared spectroscopy (fNIRS) in the interictal period. Subjects performed a finger opposition task and had real time determination of oxyhemoglobin (OxyHb) and deoxyhemoglobin (deOxyHb) changes. Recordings were completed with 10 left and 10 right sided cortical channels. RESULTS: Mean baseline to peak changes were significantly reduced in SHM patients as compared to controls bilaterally only for OxyHb measurements in the anteromedial channels. Mean time to peak changes were significant delayed in SHM patients compared to controls bilaterally largely for OxyHb measurements in the posterolateral channels, with the exception of 2 recording channels. CONCLUSIONS: Our findings suggest presence of abnormal interictal hemodynamic responses to increased metabolic demands during motor activation in SHM. These bilateral cerebrovascular changes involve OxyHb to a much larger degree than deOxyHb. Baseline to peak changes were evident more in the anteromedial channels, whereas time to peak changes were more evident in the posterolateral channels. These findings suggest that oxygen inflow into specific brain regions may be defective in SHM as opposed to oxygen utilization. Our findings suggest that in SHM, enduring hemodynamic deficits in response to an impending motor task are evident, which can be further explored in future studies, and possibly therapeutic trials.

A Systematic Review of the Application of Functional Near-Infrared Spectroscopy to the Study of Cerebral Hemodynamics in Healthy Aging.

Yeung MK, Chan AS.

Neuropsychol Rev. Mar;31(1):139-
doi: 10.1007/s11065-020-09455-Epub Sep 22.

Positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) studies have shown that healthy aging is associated with functional brain deterioration that preferentially affects the prefrontal cortex. This article reviews the application of an alternative method, functional near-infrared spectroscopy (fNIRS), to the study of age-related changes in cerebral hemodynamics and factors that influence cerebral hemodynamics in the elderly population. We conducted literature searches in PudMed and PsycINFO, and selected only English original research articles that used fNIRS to study healthy individuals with a mean age of = 55 years. All articles were published in peer-reviewed journals between 1977 and May 2019. We synthesized 114 fNIRS studies examining hemodynamic changes that occurred in

the resting state and during the tasks of sensation and perception, motor control, semantic processing, word retrieval, attentional shifting, inhibitory control, memory, and emotion and motivation in healthy older adults. This review, which was not registered in a registry, reveals an age-related reduction in resting-state cerebral oxygenation and connectivity in the prefrontal cortex. It also shows that aging is associated with a reduction in functional hemispheric asymmetry and increased compensatory activity in the frontal lobe across multiple task domains. In addition, this article describes the beneficial effects of healthy lifestyles and the detrimental effects of cardiovascular disease risk factors on brain functioning among nondemented older adults. Limitations of this review include exclusion of gray and non-English literature and lack of meta-analysis. Altogether, the fNIRS literature provides some support for various neurocognitive aging theories derived from task-based PET and fMRI studies. Because fNIRS is relatively motion-tolerant and environmentally unconstrained, it is a promising tool for fostering the development of aging biomarkers and antiaging interventions.

Exercise-Based Cardiac Rehabilitation Improves Cognitive Function Among Patients With Cardiovascular Disease.

Moriarty TA, Bourbeau K, Mermier C, Kravitz L, Gibson A, Beltz N, Negrete O, Zuhl M.

J Cardiopulm Rehabil Prev. Nov;40(6):407-
doi: 10.1097/HCR.0000000000000545.

PURPOSE: To investigate the effects of cardiac rehabilitation (CR) exercise training on cognitive performance and whether the changes are associated with alterations in prefrontal cortex (PFC) oxygenation among patients with cardiovascular disease. METHODS: Twenty (men: n = 15; women: n = 5) participants from an outpatient CR program were enrolled in the study. Each participant completed a cognitive performance test battery and a submaximal graded treadmill evaluation on separate occasions prior to and again upon completion of 18 individualized CR sessions. A functional near-infrared spectroscopy (fNIRS) device was used to measure left and right prefrontal cortex (LPFC and RPFC) oxygenation parameters (oxyhemoglobin [O2Hb], deoxyhemoglobin [HHb], total hemoglobin [tHb], and oxyhemoglobin difference [Hbdiff]) during the cognitive test battery. RESULTS: Patients showed improvements in cardiorespiratory fitness (+1.4 metabolic equivalents [METs]) and various cognitive constructs. A significant increase in PFC oxygenation, primarily in the LPFC region, occurred at post-CR testing. Negative associations between changes in cognition (executive function [LPFC O2Hb: r = -0.45, P = .049; LPFC tHb: r = -0.49, P = .030] and fluid composite score [RPFC Hbdiff: r = -0.47, P = .038; LPFC Hbdiff: r = -0.45, P = .048]) and PFC changes were detected. The change in cardiorespiratory fitness was positively associated with the change in working memory score (r = 0.55, P = .016). CONCLUSION: Cardiovascular disease patients enrolled in CR showed significant improvements in multiple cognitive domains along with increased cortical activation. The negative associations between cognitive functioning and PFC oxygenation suggest an improved neural efficiency.

Hemodynamic and behavioral peculiarities in response to emotional stimuli in children with attention deficit hyperactivity disorder: An fNIRS study.

Mauri M, Grazioli S, Crippa A, Bacchetta A, Pozzoli U, Bertella S, Gatti E, Maggioni E, Rosi E, Diwadkar V, Brambilla P, Molteni M, Nobile M.

J Affect Disord. Dec 1;277:671-
doi: 10.1016/j.jad.2020.08.Epub Sep 1.

BACKGROUND: Children with attention deficit hyperactivity disorder (ADHD) exhibit behavioral inhibition deficits, which often lead to emotional dysregulation (ED) affecting individual ability to control emotions and behavioral responses. In ADHD, ED is associated with poor outcomes and comorbidities, with both externalizing and internalizing disorders. This work aims to evaluate sensitivity to emotional

stimuli in children with ADHD using functional Near Infrared Spectroscopy (fNIRS). METHODS: During frontal fNIRS recording, 20 children with ADHD and 25 typically developing (TD) peers performed a visual continuous performance task with stimuli of different emotional content (i.e., positive, negative, neutral, and control stimuli without emotional content). This is a cognitive task designed to evaluate the ability to recognize emotional stimuli and to deal with emotional interference. RESULTS: The ADHD sample showed more variability in response time to stimuli and more false alarms compared to TD group. fNIRS data showed between-group differences in right prefrontal and frontal cortices, with wider hemoglobin concentration changes in the TD group, during positive, negative, and neutral conditions. LIMITATIONS: Owing to the limited possibility of near infrared light to penetrate tissue, fNIRS can only measure cortical activations, while it would be of interest to identify the subcortical areas linked to emotional processing, too. CONCLUSIONS: Findings suggest the presence of emotional processing deficits in children with ADHD, as suggested by poor performances on the e-CPT task, and of peculiar sensitivity to emotional stimuli, linked to atypical hemodynamics of right prefrontal and frontal areas.

Dopaminergic therapy and prefrontal activation during walking in individuals with Parkinson's disease: does the levodopa overdose hypothesis extend to gait?

Dagan M, Herman T, Bernad-Elazari H, Gazit E, Maidan I, Giladi N, Mirelman A, Manor B, Hausdorff JM.

J Neurol. Feb;268(2):658-

doi: 10.1007/s00415-020-10089-x. Epub Sep 9.

The "levodopa-overdose hypothesis" posits that dopaminergic replacement therapy (1) increases performance on tasks that depend on the nigrostriatal-pathway (e.g., motor-control circuits), yet (2) decreases performance on tasks that depend upon the mesocorticolimbic-pathway (e.g., prefrontal cortex, PFC). Previous work in Parkinson's disease (PD) investigated this model while focusing on cognitive function. Here, we evaluated whether this model applies to gait in patients with PD and freezing of gait (FOG). Forty participants were examined in both the OFF anti-Parkinsonian medication state (hypo-dopaminergic) and ON state (hyper-dopaminergic) while walking with and without the concurrent performance of a serial subtraction task. Wireless functional near-infrared spectroscopy measured PFC activation during walking. Consistent with the "overdose-hypothesis", performance on the subtraction task decreased ($p = 0.027$) after dopamine intake. Moreover, the effect of walking condition on PFC activation depended on the dopaminergic state (i.e., interaction effect $p = 0.001$). Gait significantly improved after levodopa administration ($p < 0.001$). Nonetheless, PFC activation was higher ($p = 0.013$) in this state than in the OFF state during usual-walking. This increase in PFC activation in the ON state suggests that dopamine treatment interfered with PFC functioning. Otherwise, PFC activation, putatively a reflection of cognitive compensation, should have decreased. Moreover, in contrast to the OFF state, in the ON state, PFC activation failed to increase ($p = 0.313$) during dual-tasking, perhaps due to a "ceiling effect". These findings extend the "levodopa-overdose hypothesis" and suggest that it also applies to gait in PD patients. While dopaminergic therapy improves certain aspects of motor performance, optimal treatment should consider the "double-edged sword" of levodopa.

Functional Near-Infrared Spectroscopy to Assess Central Pain Responses in a Non-pharmacologic Treatment Trial of Osteoarthritis.

Pollonini L, Montero-Hernandez S, Park L, Miao H, Mathis K, Ahn H.

J Neuroimaging. Nov;30(6):808-

doi: 10.1111/jon.Epub Sep 8.

BACKGROUND AND PURPOSE: Knee osteoarthritis (OA) is a common source of pain in older adults. Although OA-induced pain can be relieved with analgesics and anti-inflammatory drugs, the current opioid

epidemic is fostering the exploration of nonpharmacologic strategies for pain mitigation. Amongs these, transcranial direct current stimulation (tDCS) and mindfulness-based meditation (MBM) hold potential for pain-relief efficacy due to their neuromodulatory effects of the central nervous system, which is known to play a fundamental role in pain perception and processing. METHODS: In this double-blind study, we used functional near-infrared spectroscopy (fNIRS) to investigate the effects of tDCS combined with MBM on underlying pain processing mechanisms at the central nervous level in older adults with knee OA. Nineteen subjects were randomly assigned to two groups undergoing a 10-day active tDCS and MBM regimen and a sham tDCS and MBM regimen, respectively. RESULTS: Our results showed that the neuromodulatory intervention significantly relieved pain only in the group receiving active treatment. We also found that only the active treatment group showed a significant increase in oxyhemoglobin activation of the superior motor and somatosensory cortices colocated to the placement of the tDCS anodal electrode. To our knowledge, this is the first study in which the combined effect of tDCS and MBM is investigated using fNIRS. CONCLUSION: In conclusion, fNIRS can be effectively used to investigate neural mechanisms of pain at the cortical level in association with nonpharmacological, self-administered treatments.

Virtual training leads to physical, cognitive and neural benefits in healthy adults.

Burin D, Liu Y, Yamaya N, Kawashima R.

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Physical activity, such as high-intensity intermittent aerobic exercise (HIE), can improve executive functions. Although performing strength or aerobic training might be problematic or not feasible for someone. An experimental situation where there is no actual movement, but the body shows physiological reactions, is during the illusion through immersive virtual reality (IVR). We aimed to demonstrate whether a virtual HIE-based intervention (vHIE) performed exclusively by the own virtual body has physical, cognitive, and neural benefits on the real body. 45 healthy young adults (cross-over design) experienced HIE training in IVR (i.e., the virtual body performed eight sets of 30s of running followed by 30s of slow walking, while the subject is completely still) in two random-ordered conditions (administered in two sessions one week apart): the virtual body is displayed in first-person perspective (1PP) or third-person perspective (3PP). During the vHIE, we recorded the heart rate and subjective questionnaires to confirm the effectiveness of the illusion; before and after vHIE, we measured cortical hemodynamic changes in the participants' left dorsolateral prefrontal cortex (lDLPFC) using the fNIRS device during the Stroop task to test our main hypothesis. Preliminary, we confirmed that the illusion was effective: during the vHIE in 1PP, subjects' heart rate increased coherently with the virtual movements, and they reported subjective feelings of ownership and agency. Primarily, subjects were faster in executing the Stroop task after the vHIE in 1PP; also, the lDLPFC activity increased coherently. Clinically, these results might be exploited to train cognition and body simultaneously. Theoretically, we proved that the sense of body ownership and agency can affect other parameters, even in the absence of actual movements.

Cerebral hemodynamics predicts the cortical area and coding scheme in the human brain for force generation by wrist muscles.

Kim H.

Behav Brain Res. Jan 1;396:
doi: 10.1016/j.bbr.2020.Epub Aug 20.

Erratum in Behav Brain Res. 2021 Feb 26;400:113054.

The role of COMT polymorphism in modulation of prefrontal activity during verbal fluency in bipolar disorder.

Devrimci-Ozguven H, Hosgoren Alici Y, Demirbugen Oz M, Suzen HS, Kale HE, Baskak B.

Neurosci Lett. Nov 1;738:
doi: 10.1016/j.neulet.2020.Epub Aug 18.

OBJECTIVE: Verbal fluency (VF) impairment is a strong predictor of social functioning in bipolar disorder (BPD). The enzyme catechol-O- methyltransferase (COMT) has a critical role in cognitive responses by modulating dopaminergic activity in the prefrontal cortex (PFC). Here, we investigated the role of COMT polymorphism (i) in VF performance as well as (ii) in modulation of PFC activity during a VF-task in euthymic BPD patients. METHODS: 30 subjects with remitted BPD-I and 23 healthy controls (HCs) were genotyped for COMT Val158Met (rs4680) polymorphism and were compared in a VF-task. PFC activity was measured by 24-Channel Functional Near Infrared Spectroscopy. RESULTS: Bipolar subjects displayed lower VF performance than HCs. During the VF-task, BPD-group displayed higher activity than HCs in the Brocca's area, Premotor-cortex and supplementary motor area (SMA). In the index group, Val/Met polymorphism was associated with higher activity in the left- frontopolar and dorsolateral PFC (DLPFC) during the VF-task. LIMITATIONS: Antipsychotic use may have interfered with the results. CONCLUSIONS: Increased activity in the Brocca's area may represent compensation of low VF performance, whereas hyperactivity in premotor-cortex and SMA may be associated with increased behavioral intention and/or restlessness in BPD. Higher activity in left-frontopolar and DLPC among Val/Met individuals compared to Met-homozygotes may represent less effective prefrontal dopaminergic signaling in Val/Met individuals with BPD.

Development and validation of a behavioural video coding scheme for detecting mental workload in manual assembly.

Van Acker BB, Parmentier DD, Conradie PD, Van Hove S, Biondi A, Bombeke K, Vlerick P, Saldien J.

Ergonomics. Jan;64(1):78-
doi: 10.1080/00140139.2020.Epub Aug 31.

Manual assembly in the future Industry 4.0 workplace will put high demands on operators' cognitive processing. The development of mental workload (MWL) measures therefore looms large. Physiological gauges such as electroencephalography (EEG) show promising possibilities, but still lack sufficient reliability when applied in the field. This study presents an alternative measure with a substantial ecological validity. First, we developed a behavioural video coding scheme identifying 11 assembly behaviours potentially revealing MWL being too high. Subsequently, we explored its validity by analysing videos of 24 participants performing a high and a low complexity assembly. Results showed that five of the behaviours identified, such as freezing and the amount of part rotations, significantly differed in occurrence and/or duration between the two conditions. The study hereby proposes a novel and naturalistic method that could help practitioners to map and redesign critical assembly phases, and researchers to enrich validation of MWL-measures through measurement triangulation. Practitioner summary: Current physiological mental workload (MWL) measures still lack sufficient reliability when applied in the field. Therefore, we identified several observable assembly behaviours that could reveal MWL being too high. The results propose a method to map MWL by observing specific assembly behaviours such as freezing and rotating parts. Abbreviations: MWL: mental workload; EEG: electroencephalography; fNIRS: functional near infrared spectroscopy; AOI: area of interest; SMI: SensoMotoric Instruments, ETG: Eye-Tracking Glasses; FPS: frames per second; BORIS: Behavioral Observation Research Interactive Software; IRR: inter-rater reliability; SWAT: Subjective Workload Assessment Technique; NASA-TLX: National Aeronautics and Space Administration Task Load Index; EL: emotional load; DSSQ: Dundee Stress State Questionnaire; PHL: physical load; SBO: Strategisch Basis Onderzoek.

Neural alignment during face-to-face spontaneous deception: Does gender make a difference?

Chen M, Zhang T, Zhang R, Wang N, Yin Q, Li Y, Liu J, Liu T, Li X.

Hum Brain Mapp. Dec;41(17):4964-
doi: 10.1002/hbm.Epub Aug 18.

This study investigated the gender differences in deception and their neural basis in the perspective of two-person neuroscience. Both male and female dyads were asked to perform a face-to-face spontaneous sender-receiver deception task, while their neural activities in the prefrontal cortex (PFC) and right temporal parietal junction (rTPJ) were recorded simultaneously using functional near-infrared spectroscopy (fNIRS)-based hyperscanning. Male and female dyads displayed similar deception rate, successful deception rate, and eye contact in deception trials. Moreover, eye contact in deception trials was positively correlated with the success rate of deception in both genders. The fNIRS data showed that the interpersonal neural synchronization (INS) in PFC was significantly enhanced only in female dyads when performed the deception task, while INS in rTPJ was increased only in male dyads. Such INS was correlated with the success rate of deception in both dyads. Granger causality analysis showed that no significant directionality between time series of PFC (or rTPJ) in each dyad, which could indicate that sender and receiver played equally important role during deception task. Finally, enhanced INS in PFC in female dyads mediated the contribution of eye contact to the success rate of deception. All findings in this study suggest that differential patterns of INS are recruited when male and female dyads perform the face-to-face deception task. To our knowledge, this is the first interbrain evidence for gender difference of successful deception, which could make us a deeper understanding of spontaneous face-to-face deception.

Age-related prefrontal cortex activation in associative memory: An fNIRS pilot study.

Talamonti D, Montgomery CA, Clark DPA, Bruno D.

Neuroimage. Nov 15;222:
doi: 10.1016/j.neuroimage.2020.Epub Aug 5.

Older adults typically perform more poorly than younger adults in free recall memory tests. This age-related deficit has been linked to decline of brain activation and brain prefrontal lateralization, which may be the result of compensatory mechanisms. In the present pilot study, we investigated the effect of age on prefrontal cortex (PFC) activation during performance of a task that requires memory associations (temporal vs. spatial clustering), using functional Near-Infrared Spectroscopy (fNIRS). Ten younger adults, ten cognitively high-performing older individuals, and ten low-performing older individuals completed a free recall task, where either a temporal or spatial strategy (but not both simultaneously) could be employed to retrieve groups of same-category stimuli, whilst changes in PFC hemodynamics were recorded by means of a 12-channel fNIRS system. The results suggest PFC activation, and right lateralization specific to younger adults. Moreover, age did not affect use of memory organization, given that temporal clustering was preferred over spatial clustering in all groups. These findings are in line with previous literature on the aging brain and on temporal organization of memory. Our results also suggest that the PFC may be specifically involved in memory for temporal associations. Future research may consider whether age-related deficits in temporal organization may be an early sign of PFC pathology and possible neurodegeneration.

Identifying Resting-State Functional Connectivity Changes in the Motor Cortex Using fNIRS During Recovery from Stroke.

Arun KM, Smitha KA, Sylaja PN, Kesavadas C.

Brain Topogr. Nov;33(6):710-
doi: 10.1007/s10548-020-00785-Epub Jul 19.

Resting-state functional imaging has been used to study the functional reorganization of the brain. The application of functional near-infrared spectroscopy (fNIRS) to assess resting-state functional connectivity (rsFC) has already been demonstrated in recent years. The present study aimed to identify the difference in rsFC patterns during the recovery from the upper-limb deficit due to stroke. Twenty patients with mild stroke having an onset of four to eight weeks were recruited from the stroke clinic of our institute and an equal number of healthy volunteers were included in the study after ethical committee approval. The fNIRS signals were recorded bilaterally over the premotor area and supplementary motor area and over the primary motor cortex. Pearson Correlation is the method used to compute rsFC for the healthy group and patient group. For the healthy group, both intra-hemispheric and inter-hemispheric connections were stronger. RSFC analysis demonstrated changes from the healthy pattern for the patient group with an upper-limb deficit. The left hemisphere affected group showed disrupted ipsilesional and an increased contra-lesionalconnectivity. The longitudinal data analysis of rsFC showed improvement in the connections in the ipsilesional hemisphere between the primary motor area, somatosensory area, and premotor areas. In the future, the rsFC changes during the recovery could be used to predict the extent of recovery from stroke motor deficits.

Brain and motor synchrony in children and adolescents with ASD-a fNIRS hyperscanning study.

Kruppa JA, Reindl V, Gerloff C, Oberwelland Weiss E, Prinz J, Herpertz-Dahlmann B, Konrad K, Schulte-Rther M.

Soc Cogn Affect Neurosci. Jan 18;16(1-2):103-
doi: 10.1093/scan/nsaa092.

Brain-to-brain synchrony has been proposed as an important mechanism underlying social interaction. While first findings indicate that it may be modulated in children with autism spectrum disorder (ASD), no study to date has investigated the influence of different interaction partners and task characteristics. Using functional near-infrared spectroscopy hyperscanning, we assessed brain-to-brain synchrony in 41 male typically developing (TD) children (8-18years; control sample), as well as 18 children with ASD and age-matched TD children (matched sample), while performing cooperative and competitive tasks with their parents and an adult stranger. Dyads were instructed either to respond jointly in response to a target (cooperation) or to respond faster than the other player (competition). Wavelet coherence was calculated for oxy- and deoxyhemoglobin brain signals. In the control sample, a widespread enhanced coherence was observed for parent-child competition, and a more localized coherence for parent-child cooperation in the frontopolar cortex. While behaviorally, children with ASD showed a lower motor synchrony than children in the TD group, no significant group differences were observed on the neural level. In order to identify biomarkers for typical and atypical social interactions in the long run, more research is needed to investigate the neurobiological underpinnings of reduced synchrony in ASD.

Is Cortical Activation During Walking Different Between Parkinson's Disease Motor Subtypes?

Orcioli-Silva D, Vit?? R, Beretta VS, da Concei? NR, N??ga-Sousa P, Oliveira AS, Gobbi LTB.

J Gerontol A Biol Sci Med Sci. Mar 31;76(4):561-
doi: 10.1093/gerona/glaa174.

Parkinson's disease (PD) is often classified into tremor dominant (TD) and postural instability gait disorder (PIGD) subtypes. Degeneration of subcortical/cortical pathways is different between PD subtypes, which leads to differences in motor behavior. However, the influence of PD subtype on cortical activity during walking remains poorly understood. Therefore, we aimed to investigate the influence of PD motor subtypes on cortical activity during unobstructed walking and obstacle avoidance. Seventeen PIGD and

19 TD patients performed unobstructed walking and obstacle avoidance conditions. Brain activity was measured using a mobile functional near-infrared spectroscopy-electroencephalography (EEG) systems, and gait parameters were analyzed using an electronic carpet. Concentrations of oxygenated hemoglobin (HbO2) of the prefrontal cortex (PFC) and EEG absolute power from alpha, beta, and gamma bands in FCz, Cz, CPz, and Oz channels were calculated. These EEG channels correspond to supplementary motor area, primary motor cortex, posterior parietal cortex, and visual cortex, respectively. Postural instability gait disorder patients presented higher PFC activity than TD patients, regardless of the walking condition. Tremor dominant patients presented reduced beta power in the Cz channel during obstacle avoidance compared to unobstructed walking. Both TD and PIGD patients decreased alpha and beta power in the FCz and CPz channels. In conclusion, PIGD patients need to recruit additional cognitive resources from the PFC for walking. Both TD and PIGD patients presented changes in the activation of brain areas related to motor/sensorimotor areas in order to maintain balance control during obstacle avoidance, being that TD patients presented further changes in the motor area (Cz channel) to avoid obstacles.

Neural synchrony in mother-child conversation: Exploring the role of conversation patterns.

Nguyen T, Schleihauf H, Kayhan E, Matthes D, Vrticka P, Hoehl S.

Soc Cogn Affect Neurosci. Jan 18;16(1-2):93-
doi: 10.1093/scan/nsaa079.

Conversations are an essential form of communication in daily family life. Specific patterns of caregiver-child conversations have been linked to children's socio-cognitive development and child-relationship quality beyond the immediate family environment. Recently, interpersonal neural synchronization has been proposed as a neural mechanism supporting conversation. Here, we present a functional near-infrared spectroscopy (fNIRS) hyperscanning study looking at the temporal dynamics of neural synchrony during mother-child conversation. Preschoolers (20 boys and 20 girls, M age 5;07years) and their mothers (M age 36.37years) were tested simultaneously with fNIRS hyperscanning while engaging in a free verbal conversation lasting for 4 min. Neural synchrony (using wavelet transform coherence analysis) was assessed over time. Furthermore, each conversational turn was coded for conversation patterns comprising turn-taking, relevance, contingency and intrusiveness. Results from linear mixed-effects modeling revealed that turn-taking, but not relevance, contingency or intrusiveness predicted neural synchronization during the conversation over time. Results are discussed to point out possible variables affecting parent-child conversation quality and the potential functional role of interpersonal neural synchronization for parent-child conversation.

The role of anterior prefrontal cortex (area 10) in face-to-face deception measured with fNIRS.

Pinti P, Devoto A, Greenhalgh I, Tachtsidis I, Burgess PW, de C Hamilton AF.

Soc Cogn Affect Neurosci. Jan 18;16(1-2):129-
doi: 10.1093/scan/nsaa086.

Anterior prefrontal cortex (PFC, Brodmann area 10) activations are often, but not always, found in neuroimaging studies investigating deception, and the precise role of this area remains unclear. To explore the role of the PFC in face-to-face deception, we invited pairs of participants to play a card game involving lying and lie detection while we used functional near infrared spectroscopy (fNIRS) to record brain activity in the PFC. Participants could win points for successfully lying about the value of their cards or for detecting lies. We contrasted patterns of brain activation when the participants either told the truth or lied, when they were either forced into this or did so voluntarily and when they either succeeded or failed to detect a lie. Activation in the anterior PFC was found in both lie production and detection, unrelated to

reward. Analysis of cross-brain activation patterns between participants identified areas of the PFC where the lead player's brain activity synchronized their partner's later brain activity. These results suggest that during situations that involve close interpersonal interaction, the anterior PFC supports processing widely involved in deception, possibly relating to the demands of monitoring one's own and other people's behaviour.

Cortical activity during social acceptance and rejection task in social anxiety disorder: A controlled functional near infrared spectroscopy study.

Kir Y, Sayar-Akaslan D, Agtas-Ertan E, Kusman A, Baskak N, Baran Z, Munir K, Baskak B.

Prog Neuropsychopharmacol Biol Psychiatry. Jan 10;104:
doi: 10.1016/j.pnpbp.2020.Epub Jun 14.

BACKGROUND: The cognitive and emotional vulnerability of individuals with social anxiety disorder (SAD) and their response to repeated experiences of social rejection and social acceptance are important factors for the emergence and maintenance of symptoms of the disorder. Functional neuroimaging studies of SAD reveal hyperactivity in regions involved in the fear circuit such as amygdala, insula, anterior cingulate, and prefrontal cortices (PFC) in response to human faces with negative emotions. Observation of brain activity, however, involving studies of responses to standardized human interaction of social acceptance and social rejection have been lacking. METHODS: We compared a group of index subjects with SAD (N=22, mean age:26.35.4, female/male: 7/15) (SADG) with a group of healthy controls (CG) (N=21, mean age:28.74.5, female/male: 14/7) in measures of cortical activity during standardized experiences of human interaction involving social acceptance (SA) and social rejection (SR) video-simulated handshaking tasks performed by real actors. In a third, control condition (CC), the subjects were expected to press a switch button in an equivalent space. Subjects with a concurrent mood episode were excluded and the severity of subclinical depressive symptoms was controlled. 52-channel functional near-infrared spectroscopy (fNIRS) was used to measure cortical activity. RESULTS: Activity was higher in the SAD subjects compared to healthy controls, in particular in channels that project to middle and superior temporal gyri (STG), frontal eye fields (FEF) and dorsolateral prefrontal cortex (DLPFC) in terms of both SA and SR conditions. Cortical activity during the CC was not different between the groups. Only in the SAD-group, activity in the pre-motor and supplementary motor cortices, inferior and middle temporal gyri and fronto-polar area was higher during the rejection condition than the other two conditions. Anxiety scores were correlated with activity in STG, DLPFC, FEF and premotor cortex, while avoidance scores were correlated with activity in STG and FEF. CONCLUSIONS: SA and SR are represented differently in terms of cortical activity in SAD subjects compared to healthy controls. Higher activity in both social conditions in SAD subjects compared to controls may imply biological sensitivity to these experiences and may underscore the importance of increased cortical activity during social interaction experiences as a putative mediator of vulnerability to SAD. Higher cortical activity in the SADG may possibly indicate stronger need for inhibitory control mechanisms and higher recruitment of theory of mind functions during social stress. Higher activity during the SR compared to the SA condition in the SAD subjects may also suggest distinct processing of social cues, whether they involve acceptance or rejection.

How brain imaging provides predictive biomarkers for therapeutic success in the context of virtual reality cognitive training.

Ansado J, Chasen C, Bouchard S, Northoff G.

Neurosci Biobehav Rev. Jan;120:583-
doi: 10.1016/j.neubiorev.2020.05.Epub Jun 10.

As Virtual reality (VR) is increasingly used in neurological disorders such as stroke, traumatic brain injury, or attention deficit disorder, the question of how it impacts the brain's neuronal activity and function

becomes essential. VR can be combined with neuroimaging to offer invaluable insight into how the targeted brain areas respond to stimulation during neurorehabilitation training. That, in turn, could eventually serve as a predictive marker for therapeutic success. Functional magnetic resonance imaging (fMRI) identified neuronal activity related to blood flow to reveal with a high spatial resolution how activation patterns change, and restructuring occurs after VR training. Portable and quiet, electroencephalography (EEG) conveniently allows the clinician to track spontaneous electrical brain activity in high temporal resolution. Then, functional near-infrared spectroscopy (fNIRS) combines the spatial precision level of fMRIs with the portability and high temporal resolution of EEG to constitute an ideal measuring tool in virtual environments (VEs). This narrative review explores the role of VR and concurrent neuroimaging in cognitive rehabilitation.

Affective, Social, and Informative Gestures Reproduction in Human Interaction: Hyperscanning and Brain Connectivity.

Balconi M, Fronda G, Bartolo A.

J Mot Behav. 2021;53(3):296-
doi: 10.1080/00222895.2020.Epub Jun 11.

Gestural communication characterizes daily individuals' interactions in order to share information and to modify others' behavior. Social neuroscience has investigated the neural bases which support recognizing of different gestures. The present research, through the use of the hyperscanning approach, that allows the simultaneously recording of the activity of two or more individuals involved in a joint action, aims to investigate the neural bases of gestural communication. Moreover, by using hyperscanning paradigm we explore the inter-brain connectivity between two inter-agents, the one who performed the gesture (encoder) and the one who received it (decoder), with functional Near-infrared Spectroscopy (fNIRS) during the reproduction of affective, social and informative gestures with positive and negative valence. Result showed an increase in oxygenated hemoglobin concentration (O2Hb) and inter-brain connectivity in the dorsolateral prefrontal cortex (DLPFC) for affective gestures, in the superior frontal gyrus (SFG) for social gestures and the frontal eye fields (FEF) for informative gestures, for both encoder and decoder. Furthermore, it emerged that positive gestures activate more the left DLPFC, with an increase in inter-brain connectivity in DLPFC and SFG. The present study revealed the relevant function of the type and valence of gestures in affecting intra- and inter-brain connectivity.

Exhaustion disorder and altered brain activity in frontal cortex detected with fNIRS.

Skau S, Jonsdottir IH, Sjrs Dahlman A, Johansson B, Kuhn HG.

Stress. Jan;24(1):64-
doi: 10.1080/10253890.2020.Epub Jun 26.

Patients with stress-related Exhaustion Disorder (ED) have problems with memory and executive function. These problems have been associated with deviant activity in prefrontal cortex (PFC). We investigated cognitive performance and functional activity in the PFC during prolonged mental activity in patients with ED (n = 20, 16 women) with a mean duration since diagnosis of 46 23 months in comparison to healthy individuals (n = 20, 12 women). A block of six neuropsychological tests was performed in a sequence that was repeated once. The brain imaging technique, functional near infrared spectroscopy (fNIRS) was used for all tests. There were no differences between the groups in terms of changes over time, i.e. difference between first and second test block. In the Stroop-Simon test, the controls showedhigher functional activity in the frontal cortex. In the left ventrolateral PFC, we observed an increased activity in controls in the incongruent compared to the congruent trials, whereas no changes were detected in the ED patient group. During processing speed tasks, only ED patients showed higher functional activity in right dorsolateral PFC. The ED patients reported lower subjective energy level and they also performed less

well on a mental control task compared to healthy individuals. In conclusion, ED patients showed altered functional activity compared to controls, indicating that ED patients process information differently in the prefrontal cortex, but the functional activity did not change during the 2hr procedure, as revealed by the test-retest design. Lay summary In this paper we show that patient with exhaustion disorder have a reduced functional activity in the prefrontal cortex. This functional activity was not affected by 2.5 hours mental activity.

Frontal Hemodynamic Response During Step Initiation Under Cognitive Conflict in Older and Young Healthy People.

Coelho DB, Baz?PR, Zimeo Morais GA, Balardin JB, Batista AX, de Oliveira CEN, Los Angeles E, Bernardo C, Sato JR, de Lima-Pardini AC.

J Gerontol A Biol Sci Med Sci. Jan 18;76(2):216-

doi: 10.1093/gerona/glaa125.

Gait initiation is a daily challenge even for healthy individuals as it requires the timely coupling between the automatic anticipatory postural adjustment (APA) and the voluntary step according to the context. Modulation of this motor event has been thought to involve higher level brain control, including cognitive inhibitory circuitries. Despite the known participation of the supplementary motor area (SMA) in the modulation of some parameters of APA, the participation of areas controlling inhibition during gait initiation still needs to be investigated. In this study, the hemodynamic responses of the SMA and dorsolateral prefrontal cortex (DLPFC) were assessed using functional near-infrared spectroscopy (fNIRS) during a gait initiation task under cognitive conflict to select the foot to step (congruent [CON] and incongruent [INC] conditions). The older group (OG) showed worse inhibitory control than the young group (YG) along with more impairments in APA parameters. OG also had a lower amplitude of hemodynamic responses in both areas than YG in the INC. The INC increased the correlation between SMA and DLPFC only in the YG. Aging seems to impair the interaction between the hemodynamic responses of SMA and DLPFC, which influences APA performance in gait initiation under cognitive conflict.

Cap-Based Transcranial Optical Tomography in an Awake Infant.

Zhu B, Sevick-Muraca EM, Nguyen RD, Shah MN.

IEEE Trans Med Imaging. Nov;39(11):3300-

doi: 10.1109/TMI.2020.Epub Oct 28.

DOI: 10.1109/TMI.2020.2990823 PMID: 32356740

Functional near-infrared spectroscopy in toddlers: Neural differentiation of communicative cues and relation to future language abilities.

Smith EG, Condy E, Anderson A, Thurm A, Manwaring SS, Swineford L, Gandjbakhche A, Redcay E.

Dev Sci. Nov;23(6):e

doi: 10.1111/desc.Epub Mar 20.

The toddler and preschool years are a time of significant development in both expressive and receptive communication abilities. However, little is known about the neurobiological underpinnings of language development during this period, likely due to difficulties acquiring functional neuroimaging data. Functional near-infrared spectroscopy (fNIRS) is a motion-tolerant neuroimaging technique that assesses cortical brain activity and can be used in very young children. Here, we use fNIRS during perception of communicative and noncommunicative speech and gestures in typically developing 2- and 3-year-olds (Study 1, n=15, n=12 respectively) and in a sample of 2-year-olds with both fNIRS data collected at age 2 and language outcome

data at age 3 (Study 2, n=18). In Study 1, 2- and 3-year-olds differentiated between communicative and noncommunicative stimuli as well as between speech and gestures in the left lateral frontal region. However, 2-year-olds showed different patterns of activation from 3-year-olds in right medial frontal regions. In Study 2, which included two toddlers identified with early language delays along with 16 typically developing toddlers, neural differentiation of communicative stimuli in the right medial frontal region at age 2 predicted receptive language at age 3. Specifically, after accounting for variance related to verbal ability at age 2, increased neural activation for communicative gestures (vs. both communicative speech and noncommunicative gestures) at age 2 predicted higher receptive language scores at age 3. These results are discussed in the context of the underlying mechanisms of toddler language development and use of fNIRS in prediction of language outcomes.

Use of prefrontal cortex activity as a measure of learning curve in surgical novices: results of a single blind randomised controlled trial.

Khoe HCH, Low JW, Wijerathne S, Ann LS, Salgaonkar H, Lomanto D, Choi J, Baek J, Tam WW, Pei H, Ho RCM.

Surg Endosc. Dec;34(12):5604-
doi: 10.1007/s00464-019-07331-Epub Jan 17.

BACKGROUND: Neurobiological feedback in surgical training could translate to better educational outcomes such as measures of learning curve. This work examined the variation in brain activation of medical students when performing laparoscopic tasks before and after a training workshop, using functional near-infrared spectroscopy (fNIRS). METHODS AND PROCEDURES: This single blind randomised controlled trial examined the prefrontal cortex activity (PFCA) differences in two groups of novice medical students during the acquisition of four laparoscopic tasks. Both groups were shown a basic tutorial video, with the "Trained-group" receiving an additional standardised one-to-one training on the tasks. The PFCA was measured pre- and post-intervention using a portable fNIRS device and reported as mean total oxygenated hemoglobin (HbOm). Primary outcome of the study is the difference in HbOm between post- and pre-intervention readings for each of the four laparoscopic tasks. The pre- and post-intervention laparoscopic tasks were recorded and assessed by two blinded individual assessors for objective scores of the performance. RESULTS: 16 Trained and 16 Untrained, right-handed medical students with an equal sex distribution and comparable age distribution were recruited. Trained group had an attenuated left PFCA in the "Precision cutting" ($p = 0.007$) task compared to the Untrained group. Subgroup analysis by sex revealed attenuation in left PFCA in Trained females compared to Untrained females across two laparoscopic tasks: "Peg transfer" ($p = 0.005$) and "Precisioncutting" ($p = 0.003$). No significant PFCA attenuation was found in male students who underwent training compared to Untrained males. CONCLUSION: A standardised laparoscopic training workshop promoted greater PFCA attenuation in female medical students compared to males. This suggests that female and male students respond differently to the same instructional approach. Implications include a greater focus on one-to-one surgical training for female students and use of PFCA attenuation as a form of neurobiological feedback in surgical training.

Hemodynamic responses related to intrinsically photosensitive retinal ganglion cells in migraine.

Yamakawa M, Tachibana A, Tatsumoto M, Okajima K, Ueda S, Hirata K.

Neurosci Res. Nov;160:57-
doi: 10.1016/j.neures.2019.11.Epub Nov 29.

To clarify whether photoreception of intrinsically photosensitive retinal ganglion cells (ipRGCs) is related to migraine, we investigated the relationship between hemodynamic responses related to neural activity and visual stimulation of ipRGCs. It has been established that photoreception in ipRGCs is asso-

ciated with photophobia in migraine. However, the relationship between visual stimulation of ipRGCs and hemodynamic responses in the visual cortex has not been clarified. Hemodynamic responses in the visual cortex were measured using functional near-infrared spectroscopy (fNIRS) as signals reflecting changes in oxygenated and deoxygenated hemoglobin concentrations. Different types of visual stimulation generated by a metamerism method were applied to the peripheral field of the eye of patients with migraine (N = 20) and healthy participants (N = 21). The stimulation intensity on the retina was controlled using an artificial pupil. In the primary visual cortex of patients with migraine, statistically significant changes in fNIRS signals dependent on visual stimulation intensity applied to ipRGCs were observed ($p < 0.01$), while no such changes were observed in healthy participants. These results reveal that visual stimulation of ipRGCs projecting to the primary visual cortex is involved in hemodynamic responses in patients with migraine, suggesting that ipRGCs, in addition to photometric values related to cones, are associated with migraine.

Parent-child neural synchrony: a novel approach to elucidating dyadic correlates of preschool irritability.

Qui??s-Camacho LE, Fishburn FA, Camacho MC, Hlutkowsky CO, Huppert TJ, Wakschlag LS, Perlman SB.

J Child Psychol Psychiatry. Nov;61(11):1213-
doi: 10.1111/jcpp. Epub Nov 26.

BACKGROUND: Research to date has largely conceptualized irritability in terms of intraindividual differences. However, the role of interpersonal dyadic processes has received little consideration. Nevertheless, difficulties in how parent-child dyads synchronize during interactions may be an important correlate of irritably in early childhood. Innovations in developmentally sensitive neuroimaging methods now enable the use of measures of neural synchrony to quantify synchronous responses in parent-child dyads and can help clarify the neural underpinnings of these difficulties. We introduce the Disruptive Behavior Diagnostic Observation Schedule: Biological Synchrony (DB-DOS:BioSync) as a paradigm for exploring parent-child neural synchrony as a potential biological mechanism for interpersonal difficulties in preschool psychopathology. METHODS: Using functional near-infrared spectroscopy (fNIRS) 4- to 5-year-olds (N=116) and their mothers completed the DB-DOS:BioSync while assessing neural synchrony during mild frustration and recovery. Child irritability was measured using a latent irritability factor that was calculated from four developmentally sensitive indicators. RESULTS: Both the mild frustration and the recovery contexts resulted in neural synchrony. However, less neural synchrony during the recovery context only was associated with more child irritability. CONCLUSIONS: Our results suggest that recovering after a frustrating period might be particularly challenging for children high in irritability and offer support for the use of the DB-DOS:BioSync task to elucidate interpersonal neural mechanisms of developmental psychopathology.