fNIRS publications on PubMed: Jun 15 - Sep 30, 2019

Felipe Orihuela-Espina

Methodology. Searches were made in PubMed constraining the search period between June 15, 2019 and September, 30, 2019. 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

Assessing the brain 'on the line': An ecologically-valid assessment of the impact of repetitive assembly line work on hemodynamic response and fine motor control using fNIRS.
Han W(1), Gao L(1), Wu J(1), Pelowski M(2), Liu T(3).
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Brain Cogn. Sep 24;136:
doi: 10.1016/j.bandc.2019.[Epub ahead of print]

Autism Symptoms Modulate Interpersonal Neural Synchronization in Children with Autism Spectrum Disorder in Cooperative Interactions.
Wang Q, Han Z, Hu X, Feng S, Wang H, Liu T, Yi L.
Brain Topogr. Sep
doi: 10.1007/s10548-019-00731-x. [Epub ahead of print]

Previous neuroscience studies exploring the neural mechanisms of social deficits of individuals with autism spectrum disorder (ASD) have mainly examined single participants' brain responses to pictures or video-clips displayed on a monitor from the perspective of a passive observer. The present study examined inter-brain communication between children with ASD and their parents in a socio-interactive context. We used a functional near-infrared spectroscopy (fNIRS)-based hyperscanning technique to simultaneously measure the prefrontal activations in 16 pairs of children with ASD and their parents in a two-person key-press task. The children's task was to press a key together with their parents in a cooperation condition when a "go" signal was present or to press a key as fast as possible under the observation by their parents in a single-person condition. We also measured children's severity of autism symptoms.We found that children with ASD showed increased interpersonal neural synchronization in the frontal cortex when engaging in cooperative interactions with their parents than when performing solo and non-interactive behaviors. Furthermore, this neural synchronization was modulated by the children's autism symptoms, which also covaried with their cooperation task performance. That is, children with severer autism symptoms showed lower level of action and neural synchronization with their parents during cooperation. Our study moved a major step forward in understanding the neural correlates underlying social deficits in ASD and provided important implications for the treatment and behavioral training of ASD.

Evaluation of Neural Degeneration Biomarkers in the Prefrontal Cortex for Early Identification of Patients With Mild Cognitive Impairment: An fNIRS Study.

Yang D, Hong KS, Yoo SH, Kim CS.

Front Hum Neurosci. Sep 6;13:
doi: 10.3389/fnhum.2019.eCollection 2019.

Mild cognitive impairment (MCI), a condition characterizing poor cognition, is associated with aging and depicts early symptoms of severe cognitive impairment, known as Alzheimer's disease (AD). Meanwhile, early detection of MCI can prevent progression to AD. A great deal of research has been performed in the past decade on MCI detection. However, availability of biomarkers for MCI detection requires greater attention. In our study, we evaluated putative and reliable biomarkers for diagnosing MCI by performing different mental tasks (i.e., N-back task, Stroop task, and verbal fluency

task) using functional near-infrared spectroscopy (fNIRS) signals on a group of 15 MCI patients and 9 healthy control (HC). The 15 digital biomarkers (i.e., five means, seven slopes, peak, skewness, and kurtosis) and two image biomarkers (t-map, correlation map) in the prefrontal cortex (PFC) (i.e., left PFC, middle PFC, and right PFC) between the MCI and HC groups were investigated by the statistical analysis, linear discriminant analysis (LDA), and convolutional neural network (CNN) individually. The results reveal that the statistical analysis using digital biomarkers (with a p-value < 0.05) could not distinguish the MCI patients from the HC over 60% accuracy. Therefore, the current statistical analysis needs to be improved to be used for diagnosing the MCI patients. The best accuracy with LDA was 76.67% with the N-back and Stroop tasks. However, the CNN classification results trained by image biomarkers showed a high accuracy. In particular, the CNN results trained via t-maps revealed the best accuracy (90.62%) with the N-back task, whereas the CNN result trained by the correlation maps was 85.58% with the N-back task. Also, the results illustrated that investigating the sub-regions (i.e., right, middle, left) of the PFC for detecting MCI would be better than examining the whole PFC. The t-map (or/and the correlation map) is conclusively recommended as an image biomarker for early detection of AD. The combination of CNN and image biomarkers can provide a reliable clinical tool for diagnosing MCI patients.

Median Nerve Electrical Stimulation-Induced Changes in Effective Connectivity in Patients With Stroke as Assessed With Functional Near-Infrared Spectroscopy.

Huo C, Li X, Jing J, Ma Y, Li W, Wang Y, Liu W, Fan Y, Yue S, Wang Y, Li Z.

Neurorehabil Neural Repair. Sep 24:
doi: 10.1177/[Epub ahead of print]

Background. The cortical plastic changes in response to median nerve electrical stimulation (MNES) in stroke patients have not been entirely illustrated. Objective. This study aimed to investigate MNES-related changes in effective connectivity (EC) within a cortical network after stroke by using functional near-infrared spectroscopy (fNIRS). Methods. The cerebral oxygenation signals in the bilateral prefrontal cortex (LPFC/RPFC), motor cortex (LMC/RMC), and occipital lobe (LOL/ROL) of 20 stroke patients with right hemiplegia were measured by fNIRS in 2 conditions: (1) resting state and (2) MNES applied to the right wrist. Coupling function together with

dynamical Bayesian inference was used to assess MNES-related changes in EC among the cerebral low-frequency fluctuations. Results. Compared with the resting state, EC from LPFC and RPFC to LOL was significantly increased during the MNES state in stroke patients. Additionally, MNES triggered significantly higher coupling strengths from LMC and LOL to RPFC. The interregional main coupling direction was observed from LPFC to bilateral motor and occipital areas in responding to MNES, suggesting that MNES could promote the regulation function of ipsilesional prefrontal areas in the functional network. MNES can induce muscle twitch of the stroke-affected hand involving a decreased neural coupling of the contralesional motor area on the ipsilesional MC. Conclusions. MNES can trigger sensorimotor stimulations of the affected hand that sequentially involved functional reorganization of distant cortical areas after stroke. Investigating MNES-related changes in EC after stroke may help further our understanding of the neural mechanisms underlying MNES.

Effects of Acupuncture Therapy on MCI Patients Using Functional Near-Infrared Spectroscopy.

Ghafoor U, Lee JH, Hong KS, Park SS, Kim J, Yoo HR.

Front Aging Neurosci. Aug 30;11:
doi: 10.3389/fnagi.2019.00237. eCollection 2019.

Acupuncture therapy (AT) is a non-pharmacological method of treatment that has been applied to various neurological diseases. However, studies on its longitudinal effect on the neural mechanisms of patients with mild cognitive impairment (MCI) for treatment purposes are still lacking in the literature. In this clinical study, we assess the longitudinal effects of ATs on MCI patients using two methods: (i) Montreal Cognitive Assessment test (MoCA-K, Korean version), and (ii) the hemodynamic response (HR) analyses using functional near-infrared spectroscopy (fNIRS). fNIRS signals of a working memory (WM) task were acquired from the prefrontal cortex. Twelve elderly MCI patients and 12 healthy people were recruited as target and healthy control (HC) groups, respectively. Each group went through an fNIRS scanning procedure three times: The initial data were obtained without any ATs, and subsequently a total of 24 AT sessions were conducted for MCI patients (i.e., MCI-0: the data prior to ATs, MCI-1: after 12 sessions of ATs for 6 weeks, MCI-2: another 12 sessions of ATs for 6 weeks). The mean HR responses of all MCI-0-2 cases were lower than those of HCs. To compare the effects of AT on MCI patients, MoCA-K results, temporal HR

data, and spatial activation patterns (i.e., t-maps) were examined. In addition, analyses of functional connectivity (FC) and graph theory upon WM tasks were conducted. With ATs, (i) the averaged MoCA-K test scores were improved (MCI-1, $p = 0.002$; MCI-2, $p = 2.9e\text{-}4$); (ii) the mean HR response of WM tasks was increased ($p < 0.001$); and (iii) the t-maps of MCI-1 and MCI-2 were enhanced. Furthermore, an increased FC in the prefrontal cortex in both MCI-1/MCI-2 cases in comparison to MCI-0 was obtained ($p < 0.01$), and an increasing trend in the graph theory parameters was observed. All these findings reveal that ATs have a positive impact on improving the cognitive function of MCI patients. In conclusion, ATs can be used as a therapeutic tool for MCI patients as a non-pharmacological method (Clinical trial registration number: KCT 0002451 https://cris.nih.go.kr/cris/en/).

Neural Efficiency of Human-Robotic Feedback Modalities Under Stress Differs With Gender.

Nuamah JK, Mantooth W, Karthikeyan R, Mehta RK, Ryu SC.

Front Hum Neurosci. Aug 30;13:
doi: 10.3389/fnhum.2019.00287. eCollection 2019.

Sensory feedback, which can be presented in different modalities - single and combined, aids task performance in human-robotic interaction (HRI). However, combining feedback modalities does not always lead to optimal performance. Indeed, it is not known how feedback modalities affect operator performance under stress. Furthermore, there is limited information on how feedback affects neural processes differently for males and females and under stress. This is a critical gap in the literature, particularly in the domain of surgical robotics, where surgeons are under challenging sociotechnical environments that burden them physiologically. In the present study, we posited operator performance as the summation of task performance and neurophysiological cost of maintaining that performance. In a within-subject design, we used functional near-infrared spectroscopy to assess cerebral activations of 12 participants who underwent a 3D manipulation task within a virtual environment with concurrent feedback (visual and visual + haptic) in the presence and absence of a cognitive stressor. Cognitive stress was induced with the serial-7 subtraction test. We found that while task performance was higher with visual than visual + haptic feedback, it degraded under stress. The two feedback modalities were found to be associated with varying neural activities and neural efficiencies, and these were stress- and gender-dependent. Our findings engender further in-

vestigation into effectiveness of feedback modalities on males and females under stressful conditions in HRI.

A Functional Near-Infrared Spectroscopy Study on the Cortical Haemodynamic Responses During the Maastricht Acute Stress Test.

Schaal NK, Hepp P, Schweda A, Wolf OT, Krampe C.

Sci Rep. Sep 17;9(1):
doi: 10.1038/s41598-019-49826-2.

In order to better understand stress responses, neuroimaging studies have investigated the underlying neural correlates of stress. Amongst other brain regions, they highlight the involvement of the prefrontal cortex. The aim of the present study was to explore haemodynamic changes in the prefrontal cortex during the Maastricht Acute Stress Test (MAST) using mobile functional Near-Infrared Spectroscopy (fNIRS), examining the stress response in an ecological environment. The MAST includes a challenging mental arithmic task and a physically stressful ice-water task. In a between-subject design, participants either performed the MAST or a non-stress control condition. FNIRS data were recorded throughout the test. Additionally, subjective stress ratings, heart rate and salivary cortisol were evaluated, confirming a successful stress induction. The fNIRS data indicated significantly increased neural activity of brain regions of the dorsolateral prefrontal cortex (dlPFC) and the orbitofrontal cortex (OFC) in response to the MAST, compared to the control condition. Furthermore, the mental arithmetic task indicated an increase in neural activity in brain regions of the dlPFC and OFC; whereas the physically stressful hand immersion task indicated a lateral decrease of neural activity in the left dlPFC. The study highlights the potential use of mobile fNIRS in clinical and applied (stress) research.

Multimodal exploration of non-motor neural functions in ALS patients using simultaneous EEG-fNIRS recording.

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

J Neural Eng. Sep
doi: 10.1088/1741-2552/ab456c. [Epub ahead of print]

OBJECTIVE: Despite the high prevalence of non-motor impairments re-

ported in patients with amyotrophic lateral sclerosis (ALS), little is known about the functional neural markers underlying such dysfunctions. In this study, a new dual-task multimodal framework relying on simultaneous electroencephalogram (EEG) and functional near-infrared spectroscopy (fNIRS) recordings was developed to characterize integrative non-motor neural functions in people with ALS. METHODS: Simultaneous EEG-fNIRS data were recorded from six subjects with ALS and twelve healthy controls. Through a proposed visuo-mental paradigm, subjects performed a set of visuo-mental arithmetic operations. The data recorded were analyzed with respect to event-related changes both in the time and frequency domains for EEG and de/oxygen-hemoglobin level (HbR/HbO) changes for fNIRS. The correlation of EEG spectral features with fNIRS HbO/HbR features were then evaluated to assess the mechanisms of ALS on the electrical (EEG)-vascular (fNIRS) interrelationships. RESULTS: We observed overall smaller increases in EEG delta and theta power, decreases in beta power, reductions in HbO responses, and distortions both in early and later EEG event-related potentials (ERPs) in ALS subjects compared to healthy controls. While significant correlations between EEG features and HbO responses were observed in healthy controls, these patterns were absent in ALS patients. Distortions in both electrical and hemodynamic responses are speculated to be associated with cognitive deficits in ALS that center primarily on attentional and working memory processing. SIGNIFICANCE: Our results highlight the important role of ALS non-motor dysfunctions in electrical and hemodynamic neural dynamics as well as their interrelationships. The insights obtained through this study can enhance our understanding of the underlying non-motor neural processes in ALS and enrich future diagnostic and prognostic techniques.

The impact of physiological noise on hemodynamic-derived estimates of directed functional connectivity.

Schumacher FK, Steinborn C, Weiller C, Schelter BO, Reinhard M, Kaller CP.

Brain Struct Funct. Sep
doi: 10.1007/s00429-019-01954-[Epub ahead of print]

Measuring the strength of directed functional interactions between brain regions is fundamental to understand neural networks. Functional near-infrared spectroscopy (fNIRS) is a suitable method to map directed interactions between brain regions but is based on the neurovascular coupling. It, thus, relies on vasomotor reactivity and is potentially biased by

non-neural physiological noise. To investigate the impact of physiological noise on fNIRS-based estimates of directed functional connectivity within the rostro-caudal hierarchical organization of the prefrontal cortex (PFC), we systematically assessed the effects of pathological perturbations of vasomotor reactivity and of externally triggered arterial blood pressure (aBP) fluctuations. Fifteen patients with unilateral stenosis of the internal carotid artery (ICA) underwent multi-channel fNIRS during rest and during metronomic breathing, inducing aBP oscillations at 0.1Hz. Comparisons between the healthy and pathological hemispheres served as quasi-experimental manipulation of the neurovascular system's capability for vasomotor reactivity. Comparisons between rest and breathing served as experimental manipulation of two different levels of physiological noise that were expected to differ between healthy and pathological hemispheres. In the hemisphere affected by ICA stenosis, the rostro-caudal hierarchical organization of the PFC was compromised reflecting the pathological effect on the vascular and neural level. Breathing-induced aBP oscillations biased the magnitude of directed interactions in the PFC, but could be adjusted using either the aBP time series (intra-individual approach) or the aBP-induced fNIRS signal variance (inter-individual approach). Multi-channel fNIRS, hence, provides a sound basis for analyses of directed functional connectivity as potential bias due to physiological noise can be effectively controlled for.

Virtual training leads to real acute physical, cognitive, and neural benefits on healthy adults: study protocol for a randomized controlled trial.

Burin D, Yamaya N, Ogitsu R, Kawashima R.

Trials. Sep 11;20(1):
doi: 10.1186/s13063-019-3591-1.

BACKGROUND: Keeping a certain level of physical activity has beneficial effects on the body itself but also, surprisingly, on cognition: specifically, physical high-intensity intermittent aerobic exercise (HIE) can show improvement on cognitive executive functions. Although, in some cases performing strength or aerobic training is problematic or not feasible. Immersive virtual reality (IVR) can induce the illusory feeling of ownership and agency over a moving virtual body, therefore showing comparable physiological reactions: for example, if an individual is sitting on a chair but his virtual body climbs a hill, the individual's heart rate increases coherently, as if he is actually walking. In this study, we investigate whether

this same illusion can show beneficial consequences on the body as well as on executive functions (using the color-word matching Stroop task) and on its neural substrates (using functional near-infrared spectroscopy [fNIRS]). METHODS: In a cross-over randomized controlled trial, 30 healthy young adults will experience HIE training in IVR (i.e. the virtual body will perform eight sets of 30 s of running followed by 30 s of slow walking, while the participant is completely still) according to two random-ordered conditions: during the experimental condition, the virtual body is displayed in first-person perspective (1PP), while in the control condition, the virtual body is displayed in third-person perspective (3PP). To confirm that individuals have the illusion of ownership and agency over the virtual body in 1PP (and not in 3PP), we will record the heart rate, in addition to subjective questionnaires. Before and after every IVR sessions (one week apart), we will measure cortical hemodynamic changes in the participants' prefrontal cortex using the fNIRS device during the Stroop task's execution. DISCUSSION: From a theoretical perspective, we could prove that the sense of body ownership and agency can modulate physical and cognitive parameters, even in the absence of actual movements; from a clinical perspective, these results could be useful to train cognition and body simultaneously, in a completely safe environment. TRIAL REGISTRATION: University Hospital Medical Information Network Clinical Trial Registry, UMIN000034255 . Registered on 1 October2018.

Implementing neuroimaging and eye tracking methods to assess neurocognitive development of young infants in low- and middle-income countries.

Katus L, Hayes NJ, Mason L, Blasi A, McCann S, Darboe MK, de Haan M, Moore SE, Lloyd-Fox S, Elwell CE.

Gates Open Res. Aug 27;3:

doi: 10.12688/gatesopenres.12951.2. eCollection 2019.

Infants and children in low- and middle-income countries (LMICs) are frequently exposed to a range of environmental risk factors which may negatively affect their neurocognitive development. The mechanisms by which factors such as undernutrition and poverty impact development and cognitive outcomes in early childhood are poorly understood. This lack of knowledge is due in part to a paucity of objective assessment tools which can be implemented across different cultural settings and in very young infants. Over the last decade, technological advances, particularly in neu-

roimaging, have opened new avenues for research into the developing human brain, allowing us to investigate novel biological associations. This paper presents functional near-infrared spectroscopy (fNIRS), electroencephalography (EEG) and eye tracking (ET) as objective, cross-cultural methods for studying infant neurocognitive development in LMICs, and specifically their implementation in rural Gambia, West Africa. These measures are currently included, as part of a broader battery of assessments, in the Brain Imaging for Global Health (BRIGHT) project, which is developing brain function for age curves in Gambian and UK infants from birth to 24 months of age. The BRIGHT project combines fNIRS, EEG and ET with behavioural, growth, health and sociodemographic measures. The implementation of these measures in rural Gambia are discussed, including methodological and technical challenges that needed to be addressed to ensure successful data acquisition. The aim is to provide guidance to other groups seeking to implement similar methods in their research in other LMICs to better understand associations between environmental risk and early neurocognitive development.

Changes in neurovascular coupling during cycling exercise measured by multi-distance fNIRS: a comparison between endurance athletes and physically active controls.

Seidel O, Carius D, Roediger J, Rumpf S, Ragert P.

Exp Brain Res. Sep

doi: 10.1007/s00221-019-05646-[Epub ahead of print]

It is well known that endurance exercise modulates the cardiovascular, pulmonary, and musculoskeletal system. However, knowledge about its effects on brain function and structure is rather sparse. Hence, the present study aimed to investigate exercise-dependent adaptations in neurovascular coupling to different intensity levels in motor-related brain regions. Moreover, expertise effects between trained endurance athletes (EA) and active control participants (ACP) during a cycling test were investigated using multi-distance functional near-infrared spectroscopy (fNIRS). Initially, participants performed an incremental cycling test (ICT) to assess peak values of power output (PPO) and cardiorespiratory parameters such as oxygen consumption volume (VO2max) and heart rate (HRmax). In a second session, participants cycled individual intensity levels of 20, 40, and 60% of PPO while measuring cardiorespiratory responses and neurovascular coupling. Our results revealed exercise-induced decreases of deoxygenated hemoglobin (HHb), indicating an increased activation in motor-related brain areas such

as primary motor cortex (M1) and premotor cortex (PMC). However, we could not find any differential effects in brain activation between EA and ACP. Future studies should extend this approach using whole-brain configurations and systemic physiological augmented fNIRS measurements, which seems to be of pivotal interest in studies aiming to assess neural activation in a sports-related context.

Real-life creative problem solving in teams: fNIRS based hyperscanning study.

Mayseless N, Hawthorne G, Reiss AL.

Neuroimage. Sep 4;203:

doi: 10.1016/j.neuroimage.2019.[Epub ahead of print]

It is often assumed that groups of individuals can work together to achieve innovation and solve complex problems they are unable to solve on their own. One of the underlying assumptions is that a group can be more creative and innovative than single individuals. Previous research has begun to examine the process by which problem solving occurs in teams looking to achieve innovation. Despite this progress, a clear, brain-based model that informs how team interactivity contributes and impacts the outcome of an innovation event is lacking. Here we present a naturalistic study designed to examine creative problem solving involving team cooperation. We used functional near infrared spectroscopy (fNIRS) to measure interbrain synchrony (IBS) between interacting partners engaged in a creative design task. Results implicate the involvement of cognitive control coupled with the mentalizing and mirror neuron networks in IBS. Post hoc behavioral and temporal analyses revealed an increase in cooperation over time in association with reduction in IBS. Our results demonstrate the importance of a naturalistic design for investigating the neural underpinnings of team interactions as well as suggest a possible mechanism for team creativity.

A Combined EEG-fNIRS Study Investigating Mechanisms Underlying the Association between Aerobic Fitness and Inhibitory Control in Young Adults.

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

Neuroscience. Sep pii: S0306-4522(19)30627-X.

doi: 10.1016/j.neuroscience.2019.08.[Epub ahead of print]

The current evidence suggests that aerobic fitness is associated with inhibitory control of executive functioning in children and older adults. However, the relative contributions of different neurophysiological mechanisms to this relation remain unclear and have not yet been examined in young adults. The present study aimed to compare inhibitory control between high and low-fit young adult men, and to investigate a possible mediation of fitness effects by conflict monitoring (N450 component of event-related potentials) and lateralized oxygenation difference (LOD) in the DLPFC. For the present cross-sectional study, participants with different physical activity levels were recruited and divided into low-fit and high-fit participants based on relative power on the PWC170. A Stroop Color-Word task was administered and combined EEG-fNIRS was simultaneously utilized to assess the N450 and LOD, because these parameters are linked with behavioral performance. The results of the statistical analysis showed that high-fit compared to low-fit participants showed less Stroop interference and lower negativity of the N450, whereas no difference was found for LOD. Path-analyses further revealed that the relation between aerobic fitness levels and Stroop interference was indirect and mediated by N450. In contrast, LOD was inversely correlated with Stroop interference, but did not explain the relation of aerobic fitness with behavioral performance. The present findings indicate that greater inhibitory control in high- compared to low-fit young men can be explained by more effective conflict monitoring. Moreover, young adults with left-lateralized DLPFC oxygenation also show higher inhibitory control, but this oxygenation pattern is not influenced by aerobic fitness.

Prior physical synchrony enhances rapport and inter-brain synchronization during subsequent educational communication.

Nozawa T, Sakaki K, Ikeda S, Jeong H, Yamazaki S, Kawata KHDS, Kawata NYDS, Sasaki Y, Kulason K, Hirano K, Miyake Y, Kawashima R.

Sci Rep. Sep 4;9(1):
doi: 10.1038/s41598-019-49257-z.

Physical synchrony has been suggested to have positive effects on not only concurrent but also subsequent communication, but the underlying neural processes are unclear. Using functional near-infrared spectroscopy (fNIRS) hyperscanning, we tested the effects of preceding physical synchrony on subsequent dyadic teaching-learning communication. Thirty-two pairs of participants performed two experimental sessions. In each session,

they underwent a rhythmic arm movement block with synchronous or asynchronous conditions, and then taught/learned unknown words to/from each other according to a given scenario. Neural activities in their medial and left lateral prefrontal cortex (PFC) were measured and inter-brain synchronization (IBS) during the teaching-learning blocks was evaluated. Participants rated their subjective rapport during the teaching-learning blocks, and took a word memory test. The analyses revealed that (1) prior physical synchrony enhanced teacher-learner rapport; (2) prior physical synchrony also enhanced IBS in the lateral PFC; and (3) IBS changes correlated positively with rapport changes. Physical synchrony did however not affect word memory performance. These results suggest that IBS can be useful to measure the effects of social-bonding facilitation activities for educational communication.

Acute changes in cortical activation during active ankle movement after whole-body vibration for spasticity in hemiplegic legs of stroke patients: a functional near-infrared spectroscopy study.

Miyara K, Kawamura K, Matsumoto S, Ohwatashi A, Itashiki Y, Uema T, Noma T, Ikeda K, Shimodozono M.

Top Stroke Rehabil. Sep 4:1-
doi: 10.1080/10749357.2019.[Epub ahead of print]

Background: A recent study revealed that whole-body vibration (WBV) tends to decrease spasticity in stroke-related hemiplegic legs. However, acute changes in cortical activation after WBV are unclear. Objective: To examine whether WBV induces acute changes in sensorimotor cortical activation in patients with stroke-related hemiplegic legs. Methods: Eleven stroke patients (mean age 52.6 [SD 15.4] years; median time after stroke 3 [25th and 75th percentiles; 3 and 10.5, respectively] months) participated in a comparative before-and-after intervention trial. Six healthy adults were also studied. WBV at 30Hz was applied for 5min to the hamstrings, gastrocnemius, and soleus muscles. Spasticity was assessed according to the modified Ashworth scale (MAS). Active and passive range of motion (A-ROM and P-ROM, respectively) were also measured. Change in Oxy-Hb concentration in bilateral sensorimotor cortex associated with voluntary ankle dorsiflexion of the affected limb was assessed via functional near-infrared spectroscopy (fNIRS) before and immediately after WBV. Results: MAS score, A-ROM, and P-ROM improved immediately after WBV. In the patients, while there

was no significant interaction between effects of region (ipsilesional and contralesional sensorimotor cortex) and the WBV intervention (before and immediately after WBV) (F1,10=0.702, p =.422), there was a significant main effect of the WBV intervention (F1,10=6.971, p =.025). In the healthy participants, there was no association with the WBV intervention or region. Conclusions: In patients with stroke-related spastic-hemiplegic legs, WBV might result not only in clinical improvement but also in acute increase in sensorimotor cortical activation.

A Brief Review of the Application of Neuroergonomics in Skilled Cognition During Expert Sports Performance.

Tan SJ, Kerr G, Sullivan JP, Peake JM.

Front Hum Neurosci. Aug 16;13:
doi: 10.3389/fnhum.2019.00278. eCollection 2019.

The elite sports environment provides a unique setting for studying human performance, where both cognitive and physical demands are high. Successful performance in sport is contingent upon key cognitive skills such as attention, perception, working memory and decision-making. The demands of competitive sport also increase loading on the central nervous system (CNS). Neuroimaging methods such as functional magnetic resonance imaging (fMRI), functional near infrared spectroscopy (fNIRS) and electroencephalography (EEG) offer the potential to investigate the cognitive demands of sport, neuroplasticity of athletes, and biofeedback training. However, practical and technical limitations of these methods have generally limited their use to laboratory-based studies of athletes during simulated sporting tasks. This review article, provides a brief overview of research that has applied neuroimaging technology to study various aspects of cognitive function during sports performance in athletes, alternative methods for measuring CNS loading [e.g., direct current (DC) potential], possible solutions and avenues of focus for future neuroergonomics research in sport.

Prenatal exposure to organophosphate pesticides and functional neuroimaging in adolescents living in proximity to pesticide application.

Sagiv SK, Bruno JL, Baker JM, Palzes V, Kogut K, Rauch S, Gunier R, Mora AM, Reiss AL, Eskenazi B.

Proc Natl Acad Sci U S A. Sep 10;116(37):18347-
doi: 10.1073/pnas.Epub Aug 26.

We have reported consistent associations of prenatal organophosphate pesticide (OP) exposure with poorer cognitive function and behavior problems in our Center for the Health Assessment of Mothers and Children of Salinas (CHAMACOS), a birth cohort of Mexican American youth in California's agricultural Salinas Valley. However, there is little evidence on how OPs affect neural dynamics underlying associations. We used functional near-infrared spectroscopy (fNIRS) to measure cortical activation during tasks of executive function, attention, social cognition, and language comprehension in 95 adolescent CHAMACOS participants. We estimated associations of residential proximity to OP use during pregnancy with cortical activation in frontal, temporal, and parietal regions using multiple regression models, adjusting for sociodemographic characteristics. OP exposure was associated with altered brain activation during tasks of executive function. For example, with a 10-fold increase in total OP pesticide use within 1 km of maternal residence during pregnancy, there was a bilateral decrease in brain activation in the prefrontal cortex during a cognitive flexibility task (beta = -4.74; 95% CI: -8.18, -1.31 and beta = -4.40; 95% CI: -7.96, -0.84 for the left and right hemispheres, respectively). We also found that prenatal OP exposure was associated with sex differences in brain activation during a language comprehension task. This first functional neuroimaging study of prenatal OP exposure suggests that pesticides may impact cortical brain activation, which could underlie previously reported OP-related associations with cognitive and behavioral function. Use of fNIRS in environmental epidemiology offers a practical alternative to neuroimaging technologies and enhances our efforts to assess the impact of chemical exposures on neurodevelopment.

Exploring cortical activation and connectivity in infants with and without familial risk for autism during naturalistic social interactions: A preliminary study.

Bhat AN, McDonald NM, Eilbott JE, Pelphrey KA.

Infant Behav Dev. Aug 23;57:
doi: 10.1016/j.infbeh.2019.[Epub ahead of print]

Behavioral signs of Autism Spectrum Disorder (ASD) are typically observable by the second year of life and a reliable diagnosis of ASD is possible by 2 to 3 years of age. Studying infants with familial risk for ASD allows for

the investigation of early signs of ASD risk within the first year. Brain abnormalities such as hyper-connectivity within the first year may precede the overt signs of ASD that emerge later in life. In this preliminary study, we use functional near-infrared spectroscopy (fNIRS), an infant-friendly neuroimaging tool that is relatively robust against motion artifacts, to examine functional activation and connectivity during naturalistic social interactions in 9 high-risk (HR; older sibling with ASD) and 6 low-risk (LR; no family history of ASD) infants from 6 to 9 months of age. We obtained two 30-second baseline periods and a 5-minute social interaction period. HR infants showed reduced right and left-hemispheric activation compared to LR infants based on oxy (HbO2) and deoxy (HHb) signal trends. HR infants also had greater functional connectivity than LR infants during the pre- and post-social periods and showed a drop in connectivity during the social period. Our findings are consistent with previous work suggesting early differences in cortical activation associated with familial risk for ASD, and highlight the promise of fNIRS in evaluating potential markers of ASD risk during naturalistic social contexts.

How does the embodied metaphor affect creative thinking?

Wang X, He Y, Lu K, Deng C, Qiao X, Hao N.

Neuroimage. Aug 20;202:
doi: 10.1016/j.neuroimage.2019.[Epub ahead of print]

This study aimed to explore the neural correlates of the embodied metaphor "breaking the rules" and how it affects creativity by using functional near-infrared spectroscopy (fNIRS). To embody the metaphor "breaking the rules," we created a circumstance in which participants can experience "breaking the walls" through virtual reality (VR) technology. Participants were randomly assigned to three conditions: the "break-wall" condition, where they broke the walls to move forward; the "auto-wall" condition, where the barrier wall opened automatically; and the "no-wall" condition, where no barrier walls appeared. While walking in the virtual scenes, participants were asked to solve a creativity-demanding problem and to wear the fNIRS device to record their neural activities. It was found that participants showed better creative performance in the "break-wall" condition than in the other conditions. Weaker activations were found in the frontopolar cortex, the dorsolateral prefrontal cortex, and the somatosensory association cortex under the "break-wall" condition, which may be associated with rule-breaking behaviors, creative performance, and sense of embodiment. These findings

may indicate that physical actions of "breaking the wall" activate the conceptual metaphor of "breaking the rules," which triggers brain activities related to rule-breaking, thus affecting creative performance.

Differential pathlength factor in continuous wave functional near-infrared spectroscopy: reducing hemoglobin's cross talk in high-density recordings.

Chiarelli AM, Perpetuini D, Filippini C, Cardone D, Merla A.

Neurophotonics. Jul;6(3):
doi: 10.1117/1.NPh.6.3.Epub 2019 Aug 10.

Functional near-infrared spectroscopy (fNIRS) estimates the functional oscillations of oxyhemoglobin and deoxyhemoglobin in the cortex through scalp-located multiwavelength recordings. Hemoglobin oscillations are inferred through temporal changes in continuous-wave (CW) light attenuation. However, because of the diffusive multilayered head tissue structures, the photon path is longer than the source-detector separation, complicating hemoglobin evaluation. This aspect is incorporated in the modified Beer-Lambert law where the source-detector distance is multiplied by the differential pathlength factor (DPF). Since DPF estimation requires photons' time-of-flight information, DPF is assumed a priori in CW-fNIRS. Importantly, errors in the DPF spectrum induce hemoglobin cross talk, which is detrimental for fNIRS. We propose to estimate subject-specific DPF spectral dependence relying on multidistance high-density measurements. The procedure estimates the effective attenuation coefficient (EAC), which is proportional to the geometric mean of absorption and reduced scattering. Since DPF depends on the scattering-to-absorption ratio, EAC limits the spectral dependence assumption to scattering. This approach was compared to a standard frequency-domain multidistance procedure. A good association between the two methods (r 2 = 0.69) was obtained. This approach could estimate low-resolution maps of the DPF spectral dependence through large field of view, high-density systems, reducing hemoglobin cross talk, and increasing fNIRS sensitivity and specificity to brain activity without instrumentation modification.

Observing brain function via functional near-infrared spectroscopy during cognitive program training (dual task) in

young people.

Techayusukcharoen R, Iida S, Aoki C.

J Phys Ther Sci. Jul;31(7):550-
doi: 10.1589/jpts.31.Epub Jul 9.

[Purpose] To study the brain function during a dual task (cycling exercise and cognitive training) via functional near-infrared spectroscopy in young males. [Participants and Methods] Twenty Japanese young male participants were divided into intervention and control groups by simple randomization (n=10 per group). In the intervention group, participants were given a cognitive program training and cycling exercise (dual task). The control group was given the cognitive program training (single task) only. The cognitive program training consisted of a warm up, followed by 2 minutes of rock-paper-scissors, 2 minutes of numeric memory, 2 minutes of color matching, 2 minutes of calculations, and a cool down. Brain function tests were performed individually throughout the programs by functional near-infrared spectroscopy. [Results] The oxyhemoglobin levels significantly increased in the frontal lobe of the intervention and control groups after program completion compared to before. And the oxyhemoglobin levels of the intervention group also significantly increased more than control group in the prefrontal cortex and motor area. [Conclusion] This program used by Cognibike was also effective for improving hemoglobin oxygen levels at the frontal lobe in young males.

The role of the right prefrontal cortex in recognition of facial emotional expressions in depressed individuals: fNIRS study.

Manelis A, Huppert TJ, Rodgers E, Swartz HA, Phillips ML.

J Affect Disord. Nov 1;258:151-
doi: 10.1016/j.jad.2019.08.Epub Aug 5.

BACKGROUND: Depressed individuals often perceive neutral facial expressions as emotional. Neurobiological underpinnings of this effect remain unclear. We investigated the differences in prefrontal cortical (PFC) activation in depressed individuals vs. healthy controls (HC) during recognition of emotional and neutral facial expressions using functional near infrared spectroscopy (fNIRS). METHOD: In Experiment 1, 33 depressed individuals and 20 HC performed the Emotion Intensity Rating task in which they rated intensity of facial emotional expressions. In Experiment 2, a different set of participants (18 depressed individuals and 16 HC) performed the same task while their PFC activation was measured using fNIRS. RESULTS:

Both experiments showed that depressed individuals were slower and less accurate in recognizing neutral, but not happy or fearful, facial emotional expressions. Experiment 2 revealed that lower accuracy for neutral facial emotional expressions was associated with lower right PFC activation in depressed individuals, but not HC. In addition, depressed individuals, compared to HC, had lower right PFC activation during recognition of happy facial expressions. LIMITATIONS: Relatively small sample size CONCLUSIONS: Recognition of neutral facial expressions is impaired in depressed individuals. Greater impairment corresponds to lower right PFC activation during neutral face processing. Recognition of happy facial expressions is comparable for depressed individuals and HC, but the former have significantly lower right PFC activation. Taken together, these findings suggest that the ability of depressed individuals to discriminate neutral and emotional signals in the environment may be affected by aberrant functioning of right PFC.

Brain activation and adaptation of deception processing during dyadic face-to-face interaction.

Tang H, Zhang S, Jin T, Wu H, Su S, Liu C.

Cortex. Jul 13;120:326-
doi: 10.1016/j.cortex.2019.07.[Epub ahead of print]

Though deception is consistently characterized by the slippery-slope effect, i.e., the escalation of small lies over time, differing interactive situations and interacting processes may influence the trajectories of deception. To explore this influence, we investigated naturalistic face-to-face (FF) and computer-mediated face-blocked (FB) interactions using functional near-infrared spectroscopy (fNIRS). Pairs of participants acted as deceivers and receivers in an adapted ultimatum game while brain activity in the right dorsolateral prefrontal cortex (rDLPFC) and temporoparietal junction (rTPJ) was recorded. Comparison of deception in the two types of interactions showed that the FF interactions resulted in more successful deception, as well as acceptance of deception, and prompted more neural activation in the rDLPFC than the FB interactions. We found that the deception magnitude escalated in both FF and FB interactions, but rDLPFC activity during deception diminished over time only in the FF interactions but not in FB interactions, suggesting that the deceivers behaviourally adapted to deception over time in both types of interactions, but the neural adaptation occurred only in the FF interactions. Furthermore, neural adaptation in FF interac-

tions was associated with behavioural switching after deception, indicating that the rDLPFC contributes to deception adaptation and the control of switching between deception and honesty. The FF interactions were also characterized by activity in the rTPJ, which showed an adaptation to deception. These findings highlight the importance of interactive situations in dyadic naturalistic settings for deception and the role of the rDLPFC and rTPJ in the slippery-slope effect in deception.

Influence of acute combined physical and cognitive exercise on cognitive function: an NIRS study.

Ji Z, Feng T, Mei L, Li A, Zhang C.

PeerJ. Aug 2;7:e

doi: 10.7717/peerj.eCollection 2019.

The purpose of this study is to investigate the effects of different types of acute exercise on cognitive function and cerebral oxygenation. A within-subject design was adopted. In total, 20 healthy older adults were enrolled in the study. They came to the laboratory individually on four separate days and completed four conditions of activity. Four conditions were sedentary reading control (RC), cognitive exercise (CE), physical exercise (PE) and cognitive + physical exercise (CE + PE). During these visits, participants completed the Stroop task before and immediately after the experimental condition, which consisted of 15 min of aerobic exercise, verbal fluency task (VFT), and dual task. The Stroop task included the following two conditions: a naming condition and an executive condition. The fNIRS is an optical method using near-infrared light to measure relative changes of oxygenated (O2Hb) and deoxygenated (HHb) hemoglobin in the cortex. The results indicate that acute exercise facilitates performance for executive tasks, not only combined cognition, but also the different results between combined exercise and single exercise. The fNIRS findings showed that acute single exercise influences oxygenation for executive tasks but not for naming tasks. Greater improvement was observed in the post-exercise session of combined exercise during the modified Stroop. These findings demonstrate that acute single exercise, single cognition exercise, and combined exercise enhanced the performance of the inhibition control task. Only acute combined exercise has a general facilitative effect on inhibition control. Combined exercise was shown to be superior to single exercise for task-efficient cerebral oxygenation and improved oxygen utilization during cortical activation in older individuals. Also, to maximize the performance of cognition it may be im-

portant for older adults to take part in more cognitive demand exercise or take more kinds of exercise.

Hand motor learning in a musical context and prefrontal cortex hemodynamic response: a functional near-infrared spectroscopy (fNIRS) study.

Alves Heinze R, Vanzella P, Zimeo Morais GA, Sato JR.

Cogn Process. Aug

doi: 10.1007/s10339-019-00925-y. [Epub ahead of print]

Due to movement automatization, the engagement of high-order cognitive processing during the motor execution of a task is expected to decrease over repetitions and practice. In this study, we assessed single session changes in the prefrontal hemodynamic signals in response to training a piano chord progression in an ecological experimental setting. We acquired functional near-infrared spectroscopy signals from 15 subjects without any previous experience on playing keyboard instruments. Our findings were that oxygenated hemoglobin changes at orbitofrontal cortex followed an inverted U-shaped curve over task execution, while the subjects' performance presented a steady slope. These results suggest an initial executive function engagement followed by facilitation of motor execution over time.

Analgesia-enhancing effects of repetitive transcranial magnetic stimulation on neuropathic pain after spinal cord injury:An fNIRS study.

Sun X, Long H, Zhao C, Duan Q, Zhu H, Chen C, Sun W, Ju F, Sun X, Zhao Y, Xue B, Tian F, Mou X, Yuan H.

Restor Neurol Neurosci. Jul

doi: 10.3233/RNN-[Epub ahead of print]

BACKGROUND: Repetitive transcranial magnetic stimulation (rTMS) is a promising treatment for chronic intractable neuropathic pain in patients with spinal cord injury (SCI). However, the analgesia-enhancing effects of rTMS on conventional interventions (e.g., medications), and the underlying mechanisms remain poorly understood. OBJECTIVE: To investigate the enhancement of analgesia and change of cortex activation by rTMS treatment on neuropathic pain following SCI. METHODS: A double-blind, sham-controlled, clinical trial was performed. Twenty-one patients with neu-

ropathic pain after SCI were randomized (2:1) to receive a session of rTMS (10 Hz, a total of 1200 pulses at an intensity of 80% resting motor threshold) or sham treatment over the left primary motor cortex (M1) corresponding to the hand area daily for six weeks with a one-day interval per week. At T0 (before rTMS treatment), T1 (after the first session rTMS), T2 (after one week), T3 (after two weeks), T4 (after four weeks) and T5 (after six weeks), activations in the bilateral M1, primary somatosensory cortex (S1), premotor cortex (PMC) and prefrontal cortex (PFC) during the handgrip task were measured using functional near-infrared spectroscopy (fNIRS). In addition, the numerical rating scale (NRS) was used to assess pain. RESULTS: The pain intensity or activation in PFC, PMC, M1 or S1 was not remarkably changed at T1. Along with the time, the pain intensity gradually decreased in both the rTMS and sham groups. The real rTMS, compared with the sham, showed more pain relief from two weeks (T3) to six weeks (T5), and the activations of the motor-related areas M1 and PMC were remarkably suppressed. CONCLUSIONS: The findings of this preliminary study with a small patient sample suggest that the analgesia-enhancing effects of high-frequency rTMS might be related with the amelioration of M1 and PMC hypersensitivity, shedding light upon the clinical treatment of SCI-related neuropathic pain.

Bilingual exposure enhances left IFG specialization for language in children.

Arredondo MM, Hu XS, Seifert E, Satterfield T, Kovelman I.

Biling (Camb Engl). Aug;22(4):783-
doi: 10.1017/SEpub Jun 18.

Language acquisition is characterized by progressive use of inflectional morphology marking verb tense and agreement. Linguistic milestones are also linked to left-brain lateralization for language specialization. We used neuroimaging (fNIRS) to investigate how bilingual exposure influences children's cortical organization for processing morpho-syntax. In Study 1, monolinguals and bilinguals (n=39) completed a grammaticality judgment task that included English sentences with violations in earlier- (verb agreement) and later-acquired (verb tense/agreement) structures. Groups showed similar performance and greater activation in left inferior frontal region (IFG) for later- than earlier-acquired conditions. Bilinguals showed stronger and more restricted left IFG activation. In Study 2, bilinguals completed a comparable Spanish task revealing patterns of left IFG activation similar to

English. Taken together, the findings suggest that bilinguals with linguistic competence at parity with monolingual counterparts have a higher degree of cortical specialization for language, likely a result of enriched linguistic experiences.

Mindfulness and hemodynamics in asians: a literature review.
Choo CC, Lee JJW, Kuek JHL, Ang KK, Yu JH, Ho CS, Ho RC.
Asian J Psychiatr. Jul 24;44:112-
doi: 10.1016/j.ajp.2019.07.[Epub ahead of print]

INTRODUCTION: Mindfulness interventions have been increasingly incorporated into clinical settings. Evidence supporting mindfulness practices are predominantly established in Western populations. Neurophysiological evidence has not been established to support the effectiveness of mindfulness practice in Asian populations. Greater understanding of the neurophysiological mechanisms underlying mindfulness would enable hemodynamics as measured by fNIRS to be used to monitor mindfulness practice as an adjunct to psychotherapy with Asian clients. METHOD: Research relating to fNIRS and hemodynamics for mindfulness in Asians was reviewed. The inclusion criteria for this review were recent publications in peer-reviewed journals from 2008 to 2018, with the search terms 'fNIRS', 'hemodynamics' and 'mindfulness', for studies in Asia. FINDINGS: Databases included Medline, PubMed, PSYCINFO, Google Scholar and SCOPUS. Initial searches yielded 86 results. Five duplicated articles were removed, and remaining abstracts were screened; and assessed for eligibility against the structured performa. Three full text papers which fit the inclusion criteria were included in the current review. CONCLUSION: This review highlighted the paucity of rigorous empirically validated research for hemodynamics as measured with fNIRS for mindfulness practice in Asia.

Reward motivation and neurostimulation interact to improve working memory performance in healthy older adults: A simultaneous tDCS-fNIRS study.
Di Rosa E, Brigadoi S, Cutini S, Tarantino V, Dell'Acqua R, Mapelli D, Braver TS, Vallesi A.
Neuroimage. Jul 29;202:
doi: 10.1016/j.neuroimage.2019.[Epub ahead of print]

Several studies have evaluated the effect of anodal transcranial direct current stimulation (tDCS) over the prefrontal cortex (PFC) for the enhancement of working memory (WM) performance in healthy older adults. However, the mixed results obtained so far suggest the need for concurrent brain imaging, in order to more directly examine tDCS effects. The present study adopted a continuous multimodal approach utilizing functional near-infrared spectroscopy (fNIRS) to examine the interactive effects of tDCS combined with manipulations of reward motivation. Twenty-one older adults (mean age = 69.7 years; SD = 5.05) performed an experimental visuo-spatial WM task before, during and after the delivery of 1.5 mA anodal tDCS/sham over the left prefrontal cortex (PFC). During stimulation, participants received performance-contingent reward for every fast and correct response during the WM task. In both sessions, hemodynamic activity of the bilateral frontal, motor and parietal areas was recorded across the entire duration of the WM task. Cognitive functions and reward sensitivity were also assessed with standard measures. Results demonstrated a significant impact of tDCS on both WM performance and hemodynamic activity. Specifically, faster responses in the WM task were observed both during and after anodal tDCS, while no differences were found under sham control conditions. However, these effects emerged only when taking into account individual visuo-spatial WM capacity. Additionally, during and after the anodal tDCS, increased hemodynamic activity relative to sham was observed in the bilateral PFC, while no effects of tDCS were detected in the motor and parietal areas. These results provide the first evidence of tDCS-dependent functional changes in PFC activity in healthy older adults during the execution of a WM task. Moreover, they highlight the utility of combining reward motivation with prefrontal anodal tDCS, as a potential strategy to improve WM efficiency in low performing healthy older adults.

Aging Affects the Ability to Process the Optic Flow Stimulations: A Functional Near-Infrared Spectrometry Study.

Hinderaker M, Sylcott B, Williams K, Lin CC.

J Mot Behav. Jul 30:1-
doi: 10.1080/00222895.2019.[Epub ahead of print]

Optic flow (OF) has been utilized to investigate the sensory integration of visual stimuli during postural control. It is little known how the OF speed affects the aging brain during the sensory integration process of postural control. This study was to examine the effect of OF speeds on the brain

activation using functional near-infrared spectroscopy (fNIRS) and postural sway between younger and older adults. Eleven healthy younger adults (5M/6F, age 22 1-year-old) and ten healthy older adults (4M/6F, age 71 5-year-old) participated in this study. A virtual reality headset was used to provide the OF stimulus at different speeds. A forceplate was used to record the center-of-pressure to compute the amplitude of postural sway (peak-to-peak). Compared with younger adults, older adults showed significantly increased activation in the OF speed of 10 m/s and decreased activation in the OF speed of 20 m/s in the left dorsolateral prefrontal cortex. Older adults also showed decreased activation in the left temporoparietal region (VEST) in the OF speed of 20 m/s. A significant difference in peak-to-peak was found between groups. Our results indicated that age might be associated with the ability to process fast OF stimulation.

Magnetic Source Imaging and Infant MEG: Current Trends and Technical Advances.

Kao C, Zhang Y.

Brain Sci. Jul 27;9(8). pii: E
doi: 10.3390/brainsci9080181.

Magnetoencephalography (MEG) is known for its temporal precision and good spatial resolution in cognitive brain research. Nonetheless, it is still rarely used in developmental research, and its role in developmental cognitive neuroscience is not adequately addressed. The current review focuses on the source analysis of MEG measurement and its potential to answer critical questions on neural activation origins and patterns underlying infants' early cognitive experience. The advantages of MEG source localization are discussed in comparison with functional magnetic resonance imaging (fMRI) and functional near-infrared spectroscopy (fNIRS), two leading imaging tools for studying cognition across age. Challenges of the current MEG experimental protocols are highlighted, including measurement and data processing, which could potentially be resolved by developing and improving both software and hardware. A selection of infant MEG research in auditory, speech, vision, motor, sleep, cross-modality, and clinical application is then summarized and discussed with a focus on the source localization analyses. Based on the literature review and the advancements of the infant MEG systems and source analysis software, typical practices of infant MEG data collection and analysis are summarized as the basis for future developmental cognitive research.

Exercise Intensity Influences Prefrontal Cortex Oxygenation during Cognitive Testing.

Moriarty T, Bourbeau K, Bellovary B, Zuhl MN.

Behav Sci (Basel). Jul 26;9(8). pii: E
doi: 10.3390/bs9080083.

Activation changes in the prefrontal cortex (PFC) regions have been linked to acute exercise-induced improvements in cognitive performance. The type of exercise performed may influence PFC activation, and further impact cognitive function. The present study aimed to compare PFC activation during cognitive testing after moderate-intensity, high intensity, and yoga exercises, and to determine if PFC activation is linked to cognitive performance. Eight subjects (four male and four female), aged 35 5 completed a control, high intensity, moderate intensity, and yoga exercises followed by administration of a cognitive task (NIH Toolbox Fluid Cognition). Left and right PFC activation (LPFC and RPFC, respectively) were evaluated by measuring hemoglobin difference (Hbdiff) changes during post-exercise cognitive assessment using functional near infrared spectroscopy (fNIRS). Activation during the cognitive test was higher in the LPFC after moderate intensity exercise compared to control, high intensity, and yoga (5.30 6.65 vs. 2.26 2.40, 2.50 1.48, 2.41 2.36 μ M, $p < 0.05$, respectively). A negative relationship was detected between LPFC and processing speed after exercise. PFC activation did not align with cognitive performance. However, acute exercise, regardless of type, appeared to alter neural processing. Specifically, less PFC activation was required for a given neural output after exercise.

Investigating the vestibular system using modern imaging techniques-A review on the available stimulation and imaging methods.

Ertl M, Boegle R.

J Neurosci Methods. Oct 1;326:
doi: 10.1016/j.jneumeth.2019.108363. Epub Jul 25.

The vestibular organs, located in the inner ear, sense linear and rotational acceleration of the head and its position relative to the gravitational field of the earth. These signals are essential for many fundamental skills such as the coordination of eye and head movements in the three-dimensional space or the bipedal locomotion of humans. Furthermore, the vestibular

signals have been shown to contribute to higher cognitive functions such as navigation. As the main aim of the vestibular system is the sensation of motion it is a challenging system to be studied in combination with modern imaging methods. Over the last years various different methods were used for stimulating the vestibular system. These methods range from artificial approaches like galvanic or caloric vestibular stimulation to passive full body accelerations using hexapod motion platforms, or rotatory chairs. In the first section of this review we provide an overview over all methods used in vestibular stimulation in combination with imaging methods (fMRI, PET, E/MEG, fNIRS). The advantages and disadvantages of every method are discussed, and we summarize typical settings and parameters used in previous studies. In the second section the role of the four imaging techniques are discussed in the context of vestibular research and their potential strengths and interactions with the presented stimulation methods are outlined.

Similarities and Differences Between Native and Non-native Speakers' Processing of Formulaic Sequences: A Functional Near-Infrared Spectroscopy (fNIRS) Study.

Zhao L, Yasunaga D, Kojima H.

J Psycholinguist Res. Jul
doi: 10.1007/s10936-019-09655-w. [Epub ahead of print]

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

Functional Near-Infrared Spectroscopy to Probe tDCS-Induced Cortical Functioning Changes in Tinnitus.

Verma R, Jha A, Singh S.

J Int Adv Otol. Aug;15(2):321-
doi: 10.5152/iao.2019.6022.

There are limited treatment options for successful management of tinnitus, which is highly prevalent worldwide. The pathogenetic role of auditory cortex activation changes in tinnitus has been reported by various functional studies that suggest that the emerging neuromodulation techniques may pave way toward better treatment response. The current case report depicts the use of functional near-infrared spectroscopy (fNIRS) based on the assessment of improvement in auditory cortex functioning in chronic tinnitus by transcranial direct current stimulation (tDCS).

Infant brain activity in response to yawning using functional near-infrared spectroscopy.

Tsurumi S, Kanazawa S, Yamaguchi MK.

Sci Rep. Jul 23;9(1):
doi: 10.1038/s41598-019-47129-0.

Yawning is contagious in human adults. While infants do not show contagious yawning, it remains unclear whether infants perceive yawning in the same manner as other facial expressions of emotion. We addressed this problem using functional near-infrared spectroscopy (fNIRS) and behavioural experiments. We confirmed behaviourally that infants could discriminate between yawning and unfamiliar mouth movements. Furthermore, we found that the hemodynamic response of infants to a yawning movement was greater than that to mouth movement, similarly to the observations in adult fMRI study. These results suggest that the neural mechanisms underlying yawning movement perception have developed in advance of the development of contagious yawning.

Use of fNIRS to Characterize the Neural Mechanism of Inter-Individual Rhythmic Movement Coordination.

Niu R, Yu Y, Li Y, Liu Y.

Front Physiol. Jul 4;10:
doi: 10.3389/fphys.2019.eCollection 2019.

Background: Inter-individual rhythmic movement coordination plays an important role in daily life, particularly in competitive sports. Behaviorally, it is more challenging to coordinate alternating movements than symmetrical movements. The neural activity underlying these different movement coordination modes remains to be clarified, particularly considering complex inter-individual coordination differences. Methods: To further test the neural basis of inter-individual rhythmic movement coordination, a revised experimental paradigm of inter-individual coordination was adopted. Participants were asked to perform symmetric, alternate, or single movements (swinging the lower part of the leg) in the same rhythm. A multi-channel, continuous wave, functional near-infrared spectral (fNIRS) imaging instrument was used to monitor hemodynamic activity while 40 volunteers (9 male pairs and 11 female pairs) performed the task. Multivariate analyses of variance were conducted to compare mean oxy-hemoglobin concentration ([HbO]) across experimental conditions. Results: A significant three-way interaction (leg-swing condition ROI laterality) on mean [HbO] was observed. Post hoc analysis revealed a significant main effect of leg-swing condition only in brain regions of interest [right inferior parietal lobule (IPL)] contralateral to movement execution. Activation in brain regions of interest [right inferior parietal lobule (IPL)] was much stronger in alternate mode compared with symmetric or single modes, and the differences between symmetric and single mode were not statistically significant. This result suggests that the alternate mode of movement coordination was more likely to be supported by the IPL region than the other modes. Conclusion: The present findings provide neural evidence relevant to the theory of self-organization of movement coordination, in which an alternating movement mode appeared to be a more demanding condition than symmetrical movement.

Individual Differences in Math Ability Determine Neurocognitive Processing of Arithmetic Complexity: A Combined fNIRS-EEG Study.

Artemenko C, Soltanlou M, Bieck SM, Ehlis AC, Dresler T, Nuerk HC.
Front Hum Neurosci. Jul 3;13:
doi: 10.3389/fnhum.2019.eCollection 2019.

Some individuals experience more difficulties with math than others, in particular when arithmetic problems get more complex. Math ability, on one hand, and arithmetic complexity, on the other hand, seem to partly share neural underpinnings. This study addresses the question of whether this

leads to an interaction of math ability and arithmetic complexity for multiplication and division on behavioral and neural levels. Previously screened individuals with high and low math ability solved multiplication and division problems in a written production paradigm while brain activation was assessed by combined functional near-infrared spectroscopy (fNIRS) and electroencephalography (EEG). Arithmetic complexity was manipulated by using single-digit operands for simple multiplication problems and operands between 2 and 19 for complex multiplication problems and the corresponding division problems. On the behavioral level, individuals with low math ability needed more time for calculation, especially for complex arithmetic. On the neural level, fNIRS results revealed that these individuals showed less activation in the left supramarginal gyrus (SMG), superior temporal gyrus (STG) and inferior frontal gyrus (IFG) than individuals with high math ability when solving complex compared to simple arithmetic. This reflects the greater use of arithmetic fact retrieval and also the more efficient processing of arithmetic complexity by individuals with high math ability. Oscillatory EEG analysis generally revealed theta and alpha desynchronization with increasing arithmetic complexity but showed no interaction with math ability. Because of the discovered interaction for behavior and brain activation, we conclude that the consideration of individual differences is essential when investigating the neurocognitive processing of arithmetic.

The Association between Prefrontal Cortex Activity and Turning Behavior in People with and without Freezing of Gait.

Belluscio V, Stuart S, Bergamini E, Vannozzi G, Mancini M.

Neuroscience. Jul 19;416:168-
doi: 10.1016/j.neuroscience.2019.07.024. [Epub ahead of print]

Turning elicits Freezing of Gait (FoG) episodes in people with Parkinson's disease (PD) and is thought to require higher cortical control compared to straight ahead gait. Functional near infrared spectroscopy (fNIRS) has been used to examine prefrontal cortex (PFC) activity while walking, but the relationship between PFC activity and turn performance remains unclear. The aim of this pilot study was to examine PFC activity during turning in PD and healthy controls, and to investigate the association between PFC activity and turning. Thirty-two subjects, 15 freezers (PD + FoG) and 17 non-freezers (PD - FoG), and 8 controls were asked to perform a 2-min turning-in-place test under single-task (ST) and dual-task (DT) conditions. Each participant wore an fNIRS system to measure changes in

oxyhemoglobin, as measure of PFC activity, and inertial sensors to quantify turning. Our results show a significant group (p = .050), task (p = .039), and interaction (p = .047) for the PFC activity during turning. Specifically, PD + FoG show higher PFC during turning compared to the other groups; PFC activity during DT is overall different compared to ST with an opposite trend in PD + FoG compared to controls and PD - FoG. In addition, higher PFC is associated with worse FoG in PD + FoG (r = 0.57, p = .048) and with lower number of turns in PD - FoG (r = -0.70, p = .002). The increased PFC activity in PD and the association between higher PFC activity and poorer turning performance may be a sign of poor movement automaticity in PD. Although further investigations are required, these pilot findings may guide development of personalized treatments to improve motor automaticity in PD.

Prediction of epileptic seizures with convolutional neural networks and functional near-infrared spectroscopy signals.

Rosas-Romero R, Guevara E, Peng K, Nguyen DK, Lesage F, Pouliot P, Lima-Saad WE.

Comput Biol Med. Aug;111:
doi: 10.1016/j.compbiomed.2019.Epub Jul 10.

There have been different efforts to predict epileptic seizures and most of them are based on the analysis of electroencephalography (EEG) signals; however, recent publications have suggested that functional Near-Infrared Spectroscopy (fNIRS), a relatively new technique, could be used to predict seizures. The objectives of this research are to show that the application of fNIRS to epileptic seizure detection yields results that are superior to those based on EEG and to demonstrate that the application of deep learning to this problem is suitable given the nature of fNIRS recordings. A Convolutional Neural Network (CNN) is applied to the prediction of epileptic seizures from fNIRS signals, an optical modality for recording brain waves. The implementation of the proposed method is presented in this work. Application of CNN to fNIRS recordings showed an accuracy ranging between 96.9% and 100%, sensitivity between 95.24% and 100%, specificity between 98.57% and 100%, a positive predictive value between 98.52% and 100%, and a negative predictive value between 95.39% and 100%. The most important aspect of this research is the combination of fNIRS signals with the particular CNN algorithm. The fNIRS modality has not been used in epileptic seizure prediction. A CNN is suitable for this application because

fNIRS recordings are high dimensional data and they can be modeled as three-dimensional tensors for classification.

The difference in hemodynamic responses between dominant and non-dominant hands during muscle contraction and relaxation: An fNIRS study.

Yokoyama N, Ohtaka C, Kato K, Kubo H, Nakata H.

PLoS One. Jul 19;14(7):e

doi: 10.1371/journal.pone.0220100. eCollection 2019.

The present study used functional near-infrared spectroscopy (fNIRS), and investigated the differences in neural activation of ipsi- or contralateral hemispheres between right dominant and left non-dominant hands among right-handed subjects using consecutive motor tasks with muscle contraction and relaxation. The subjects performed tasks under four conditions: (1) right hand up (R-Up), (2) left hand up (L-Up), (3) right hand down (R-Down), and (4) left hand down (L-Down). The peak amplitude of oxy-Hb was significantly larger at the contralateral than ipsilateral hemisphere in the premotor area (PM) under the R-Up condition, and no significant differences were observed between contra- and ipsilateral hemispheres under the L-Up condition. In addition, the peak amplitude was more negative at the contra- than ipsilateral hemisphere in the PM under the R-Down condition, while the peak amplitude was significantly more negative at the ipsi- than contralateral hemisphere in the PM under the L-Down condition. These results suggest that the PM of the left hemisphere among right-handed subjects plays an important role in muscle contraction and relaxation with force control.

Neural Compensatory Response During Complex Cognitive Function Tasks in Mild Cognitive Impairment: A Near-Infrared Spectroscopy Study.

Yoon JA, Kong IJ, Choi J, Baek JY, Kim EJ, Shin YI, Ko MH, Shin YB, Shin MJ.

Neural Plast. Jun 19;2019:

doi: 10.1155/2019/eCollection 2019.

The present pilot study was aimed at conducting a comparative analysis of the level of activation in the prefrontal cortex among a normal el-

derly group and amnestic and nonamnestic mild cognitive impairment (MCI) groups and investigating the presence of neural compensatory mechanisms according to types of MCI and different cognitive tasks. We performed functional near-infrared spectroscopy (fNIRS) along with cognitive tasks, including two-back test, Korean color word Stroop test, and semantic verbal fluency task (SVFT), to investigate hemodynamic response and the presence of neural compensation and neuroplasticity in the prefrontal cortex of patients with amnestic and nonamnestic MCI compared with a healthy elderly group. During the two-back test, there was no significant difference in the bilateral region-of-interest (ROI) analysis in the three groups. During the Stroop test, right-sided hyperactivation compared to the left side during the task was shown in the nonamnestic MCI and normal groups with statistical significance. Mean acc ΔHbO2 on the right side was highest in the nonamnestic MCI group (0.30 μM) followed by the normal group (0.07 μM) and the amnestic MCI group (-0.10 μM). Otherwise, intergroup ROI analysis of acc ΔHbO2 in these activated right sides showed no significant difference. During the VFT test, there was no significant difference in the bilateral region-of-interest analysis in the three groups. The highest mean acc ΔHbO2 was shown in the normal group (0.79 μM) followed by the nonamnestic MCI group (0.52 μM) and the amnestic MCI group (0.21 μM). Otherwise, there was no significant difference between groups. The hemodynamic response during fNIRS showed different findings according to MCI types and cognitive tasks. Among the three tasks, the Stroop test showed results that were suggestive of neural compensatory mechanisms in the prefrontal cortex in nonamnestic MCI.

Interpreting Prefrontal Recruitment During Walking After Stroke: Influence of Individual Differences in Mobility and Cognitive Function.

Chatterjee SA, Fox EJ, Daly JJ, Rose DK, Wu SS, Christou EA, Hawkins KA, Otzel DM, Butera KA, Skinner JW, Clark DJ.

Front Hum Neurosci. Jun 18;13:
doi: 10.3389/fnhum.2019.00194. eCollection 2019.

Background: Functional near-infrared spectroscopy (fNIRS) is a valuable neuroimaging approach for studying cortical contributions to walking function. Recruitment of prefrontal cortex during walking has been a particular area of focus in the literature. The present study investigated whether task-related change in prefrontal recruitment measured by fNIRS is affected by

individual differences in people post-stroke. The primary hypotheses were that poor mobility function would contribute to prefrontal over-recruitment during typical walking, and that poor cognitive function would contribute to a ceiling in prefrontal recruitment during dual-task walking (i.e., walking with a cognitive task). Methods: Thirty-three adults with chronic post-stroke hemiparesis performed three tasks: typical walking at preferred speed (Walk), serial-7 subtraction (Serial7), and walking combined with serial-7 subtraction (Dual-Task). Prefrontal recruitment was measured with fNIRS and quantified as the change in oxygenated hemoglobin concentration (ΔO2Hb) between resting and active periods for each task. Spatiotemporal gait parameters were measured on an electronic walkway. Stepwise regression was used to assess how prefrontal recruitment was affected by individual differences including age, sex, stroke region, injured hemisphere, stroke chronicity, 10-meter walking speed, balance confidence measured by Activities-specific Balance Confidence (ABC) Scale, sensorimotor impairment measured by Fugl-Meyer Assessment, and cognitive function measured by Mini-Mental State Examination (MMSE). Results: For Walk, poor balance confidence (ABC Scale score) significantly predicted greater prefrontal recruitment (ΔO2Hb; R 2 = 0.25, p = 0.003). For Dual-Task, poor cognitive function (MMSE score) significantly predicted lower prefrontal recruitment (ΔO2Hb; R 2 = 0.25, p = 0.002). Conclusions: Poor mobility function predicted higher prefrontal recruitment during typical walking, consistent with compensatory over-recruitment. Poor cognitive function predicted lower prefrontal recruitment during dual-task walking, consistent with a recruitment ceiling effect. These findings indicate that interpretation of prefrontal recruitment should carefully consider the characteristics of the person and demands of the task.

Evaluating time-reversed speech and signal-correlated noise as auditory baselines for isolating speech-specific processing using fNIRS.

Mushtaq F, Wiggins IM, Kitterick PT, Anderson CA, Hartley DEH.
PLoS One. Jul 17;14(7):e
doi: 10.1371/journal.pone.0219927. eCollection 2019.

Evidence using well-established imaging techniques, such as functional magnetic resonance imaging and electrocorticography, suggest that speech-specific cortical responses can be functionally localised by contrasting speech responses with an auditory baseline stimulus, such as time-reversed (TR)

speech or signal-correlated noise (SCN). Furthermore, these studies suggest that SCN is a more effective baseline than TR speech. Functional near-infrared spectroscopy (fNIRS) is a relatively novel, optically-based imaging technique with features that make it ideal for investigating speech and language function in paediatric populations. However, it is not known which baseline is best at isolating speech activation when imaging using fNIRS. We presented normal speech, TR speech and SCN in an event-related format to 25 normally-hearing children aged 6-12 years. Brain activity was measured across frontal and temporal brain areas in both cerebral hemispheres whilst children passively listened to the auditory stimuli. In all three conditions, significant activation was observed bilaterally in channels targeting superior temporal regions when stimuli were contrasted against silence. Unlike previous findings in infants, we found no significant activation in the region of interest over superior temporal cortex in school-age children when normal speech was contrasted against either TR speech or SCN. Although no statistically significant lateralisation effects were observed in the region of interest, a left-sided channel targeting posterior temporal regions showed significant activity in response to normal speech only, and was investigated further. Significantly greater activation was observed in this left posterior channel compared to the corresponding channel on the right side under the normal speech vs SCN contrast only. Our findings suggest that neither TR speech nor SCN are suitable auditory baselines for functionally isolating speech-specific processing in an experimental set up involving fNIRS with 6-12 year old children.

Prefrontal Cortex Activation During Dual Task With Increasing Cognitive Load in Subacute Stroke Patients: A Pilot Study.

Hermand E, Tapie B, Dupuy O, Fraser S, Compagnat M, Salle JY, Daviet JC, Perrochon A.

Front Aging Neurosci. Jul 2;11:
doi: 10.3389/fnagi.2019.00160. eCollection 2019.

Stroke patients often exhibit difficulties performing a cognitive task while walking, defined as a dual task (DT). Their prefrontal cortex (PFC) activity is higher in DT than in single task (ST). The effects of an increasing load on PFC activity during DT in subacute stroke patients remains unexplored. Our objective was to assess the effects of N-back tasks (low/high load) on cerebral activity, gait parameters, and cognitive performances. Eleven sub-

acute stroke patients (days post-stroke 45.8 31.6) participated in this pilot study (71.4 10 years, BMI 26.7 4.8 kg.m-2, Barthel index 81.8 11.0). Patients completed a STwalk, and 4 conditions with 1-back (low load) and 2-back (high load): STlow, SThigh, DTlow, and DThigh. Overground walking was performed at a comfortable pace and -N-back conditions were carried out verbally. Both gait (speed, stride variability) and cognitive (rate of correct answers) performances were recorded. Changes in PFC oxyhemoglobin (ΔO2Hb) and deoxyhemoglobin (ΔHHb) were measured by functional near infrared spectroscopy (fNIRS). Results showed an increase of ΔO2Hb while walking, which was not augmented by cognitive loads in DT. Walking speed was reduced by low and high cognitive loads in DT compared to STwalk ($P < 0.05$), but was not different between DTlow and DThigh. Cognitive performances were negatively impacted by both walking ($P < 0.05$) and cognitive load (between "low" and "high," $P < 0.001$). These data highlight a "ceiling" effect in ΔO2Hb levels while walking, leaving no available resources for simultaneous cognitive tasks, during the early recovery period following stroke. In these patients, cognitive, but not motor, performances declined with a higher cognitive load.

Put on your (fNIRS) thinking cap: Frontopolar activation during augmented state creativity.

Tempest GD, Radel R.

Behav Brain Res. Nov 5;373:
doi: 10.1016/j.bbr.2019.Epub 2019 Jul 10.

Thinking creatively requires the ability to consciously augment creative insight through processes such as analogical reasoning and relational cognition. Prior work has examined augmented states of creativity using a modified verb generation task which requires brief engagement in attempts to think creatively during MRI. In this study, we employed the verb generation task to examine augmented creative states and frontopolar cortex activation in a less-constrained setting using functional near infrared spectroscopy (fNIRS). Participants ($n = 29$) were presented with a noun and were required to think of an associated verb. In 50% of the trials, participants were instructed to 'think creatively' (cued condition) as opposed to stating the first or most prominent verb that came to mind (uncued condition). The task was administered in French to native speakers. Hemodynamic responses were recorded over the frontopolar cortex using fNIRS. The relatedness of the noun-verb pairs was calculated and other measures of creativity (the Al-

ternate Uses Test, Compound Remote Associate Test and the Biographical Inventory of Creative Behaviors) were recorded. We showed that in the cued condition, semantic scores were higher (indicating more creative responses), positively associated with other measures of creativity, and changes in oxygenated hemoglobin were larger and more extensive in the left frontopolar cortex, than in the uncued condition. Our findings support the use of the verb generation task (administered in French) to augment creative states and provides further validation of the use of the task to capture creativity (i.e., processes involved in generating creative responses through distant associations). We highlight the use of fNIRS to measure associated regional changes in frontopolar cortex activity during augmented states of creativity.

Fronto-temporoparietal connectivity and self-awareness in 18-month-olds: A resting state fNIRS study.

Bulgarelli C, Blasi A, de Klerk CCJM, Richards JE, Hamilton A, Southgate V.

Dev Cogn Neurosci. Aug;38:
doi: 10.1016/j.dcn.2019.Epub Jun 22.

How and when a concept of the 'self' emerges has been the topic of much interest in developmental psychology. Self-awareness has been proposed to emerge at around 18 months, when toddlers start to show evidence of physical self-recognition. However, to what extent physical self-recognition is a valid indicator of being able to think about oneself, is debated. Research in adult cognitive neuroscience has suggested that a common network of brain regions called Default Mode Network (DMN), including the temporoparietal junction (TPJ) and the medial prefrontal cortex (mPFC), is recruited when we are reflecting on the self. We hypothesized that if mirror self-recognition involves self-awareness, toddlers who exhibit mirror self-recognition might show increased functional connectivity between frontal and temporoparietal regions of the brain, relative to those toddlers who do not yet show mirror self-recognition. Using fNIRS, we collected resting-state data from 18 Recognizers and 22 Non-Recognizers at 18 months of age. We found significantly stronger fronto-temporoparietal connectivity in Recognizers compared to Non-Recognizers, a finding which might support the hypothesized relationship between mirror-self recognition and self-awareness in infancy.

Behavioral response to tactile stimuli relates to brain response to affective touch in 12-month-old infants.

Miguel HO, Gonalves F, Sampaio A.

Dev Psychobiol. Jul
doi: 10.1002/dev.[Epub ahead of print]

Affective touch activates a brain network responsible for processing social-emotional stimuli in infants, children, and adults, with a core node in the superior temporal sulcus (STS). STS is known to be a region highly susceptible to individual variability, including for tactile stimuli processing. However, little is known about how this region is recruited to process affective touch in infancy. The aim of this study was to examine brain activity to affective touch in the temporal region (STS) and understand if it relates to behavioral patterns of sensory-over responsivity (SOR) to touch. Twelve-month-old infants (n=24) were given affective and discriminative stimuli to the forearm while they were watching a silent movie. Brain activation was recorded in the STS for measures of oxy-hemoglobin (HbO2) and deoxy-hemoglobin (Hbb) using functional near infra-red spectroscopy (fNIRS). Aversive responses to tactile stimuli were measured using the Infant-Toddler Sensory Profile. A significant hemodynamic response increase in HbO2 to affective touch was observed in the STS for infants with less aversive behavioral responses to tactile stimuli. The findings suggest that brain activity in the STS for affective touch might be related to individual differences in the affective reaction toward touch.

Activity of the inferior parietal cortex is modulated by visual feedback delay in the robot hand illusion.

Ismail MAFB, Shimada S.

Sci Rep. Jul 11;9(1):
doi: 10.1038/s41598-019-46527-8.

The robot hand illusion (RoHI) is the perception of self-ownership and self-agency of a virtual (robot) hand that moves consistently with one's own. The phenomenon shows that self-attribution can be established via temporal integration of visual and movement information. Our previous study showed that participants felt significantly greater RoHI (sense of self-ownership and sense of self-agency) when visuomotor temporal discrepancies were less than 200 ms. A weaker RoHI effect (sense of self-agency only) was observed when temporal discrepancies were between 300 and 500 ms. Here, we used functional near-infrared spectroscopy (fNIRS) to investigate brain activity asso-

ciated with the RoHI under different visual feedback delays (100 ms, 400 ms, 700 ms). We found that the angular and supramarginal gyri exhibited significant activation in the 100-ms feedback condition. ANOVA indicated a significant difference between the 100-ms condition and the other conditions ($p < 0.01$). These results demonstrate that activity in the posterior parietal cortex was modulated by the delay between the motor command and the visual feedback of the virtual hand movements. Thus, we propose that the inferior parietal cortex is essential for integrating motor and visual information to distinguish one's own body from others.

What Guides Us to Neurally and Behaviorally Align With Anyone Specific? A Neurobiological Model Based on fNIRS Hyperscanning Studies.

Gvirts HZ, Perlmutter R.

Neuroscientist. Jul 11:
doi: 10.1177/1073858419861912. [Epub ahead of print]

An emerging body of hyperscanning functional near-infrared spectroscopy (fNIRS) research shows interbrain neural synchrony (IBS) during different forms of social interaction. Here we review the recent literature and propose several factors that facilitate IBS, leading us to ask the following question: In a world full of people and opportunities to synchronize with them, what directs our neural and behavioral alignment with anyone specific? We suggest that IBS between what we deem the "mutual social attention systems" of interacting partners-that is, the coupling between participants' temporoparietal junctions and/or prefrontal cortices-facilitates and enhances the ability to tune in to the specific interaction, its participants and its goals. We propose that this process is linked to social alignment, reinforcing one another to facilitate successful and lucrative social interactions. We further suggest that neurochemical mechanisms of dopamine and oxytocin underlie the activation of this suggested loop. Finally, we suggest possible directions for future studies, emphasizing the need to develop a brain-to-brain neurofeedback system with IBS between the mutual social attention systems of the participants as the direct regulating target.

Pre-operative Brain Imaging Using Functional Near-Infrared Spectroscopy Helps Predict Cochlear Implant Outcome in

Deaf Adults.

Anderson CA, Wiggins IM, Kitterick PT, Hartley DEH.

J Assoc Res Otolaryngol. Jul
doi: 10.1007/s10162-019-00729-z. [Epub ahead of print]

Currently, it is not possible to accurately predict how well a deaf individual will be able to understand speech when hearing is (re)introduced via a cochlear implant. Differences in brain organisation following deafness are thought to contribute to variability in speech understanding with a cochlear implant and may offer unique insights that could help to more reliably predict outcomes. An emerging optical neuroimaging technique, functional near-infrared spectroscopy (fNIRS), was used to determine whether a pre-operative measure of brain activation could explain variability in cochlear implant (CI) outcomes and offer additional prognostic value above that provided by known clinical characteristics. Cross-modal activation to visual speech was measured in bilateral superior temporal cortex of pre- and post-lingually deaf adults before cochlear implantation. Behavioural measures of auditory speech understanding were obtained in the same individuals following 6months of cochlear implant use. The results showed that stronger pre-operative cross-modal activation of auditory brain regions by visual speech was predictive of poorer auditory speech understanding after implantation. Further investigation suggested that this relationship may have been driven primarily by the inclusion of, andgroup differences between, pre- and post-lingually deaf individuals. Nonetheless, pre-operative cortical imaging provided additional prognostic value above that of influential clinical characteristics, including the age-at-onset and duration of auditory deprivation, suggesting that objectively assessing the physiological status of the brain using fNIRS imaging pre-operatively may support more accurate prediction of individual CI outcomes. Whilst activation of auditory brain regions by visual speech prior to implantation was related to the CI user's clinical history of deafness, activation to visual speech did not relate to the future ability of these brain regions to respond to auditory speech stimulation with a CI. Greater pre-operative activation of left superior temporal cortex by visual speech was associated with enhanced speechreading abilities, suggesting that visual speech processing may help to maintain left temporal lobe specialisation for language processing during periods of profound deafness.

Visuospatial task-related prefrontal activity is correlated with negative symptoms in schizophrenia.

Curtin A, Sun J, Zhao Q, Onaral B, Wang J, Tong S, Ayaz H.
Sci Rep. Jul 3;9(1):
doi: 10.1038/s41598-019-45893-7.

Control of attention is thought to be specifically impaired in schizophrenia due to abnormal function in the prefrontal cortex (PFC). The PFC plays a critical role in the identification of relevant stimuli and the development of appropriate biases for the identified signals, including selection of an appropriate attentional 'zoom'. We examined how demands associated with changes in attentional requirements in a Sustained Attention Task (SAT) may contribute to differences in functional involvement of the PFC and relation to clinical status. A group of 24 individuals with schizophrenia and 16 healthy controls (N = 40) performed the SAT and a visuospatial condition (vSAT) while activity in the bilateral anterior PFC was monitored using functional Near Infrared Spectroscopy (fNIRS). The results confirm that the right frontopolar region plays a role in control of attention for both patients and healthy controls. However, patients with schizophrenia exhibited a general attentional deficit and inefficient right-medial PFC activation. Additionally, we observed a strong regional association between left Middle Frontal Gyrus (MFG) activity during the vSAT task and the PANSS score driven by the negative symptom subscale. The presence of aberrant activation differences within the left-MFG region may describe a dysregulation of attentional networks linked to the clinical expression of negative and general symptoms.

Hemodynamic responses to visual cues during attentive listening in autonomous versus manual simulated driving: A pilot study.

Hidalgo-Muoz AR, Jallais C, Evennou M, Ndiaye D, Moreau F, Ranchet M, Derollepot R, Fort A.
Brain Cogn. Oct;135:
doi: 10.1016/j.bandc.2019.Epub Jun 27.

Emerging automation technologies could have a strong impact on the allocation of drivers' attentional resources. The first objective of this pilot study is to investigate the hemodynamic responses evoked to relevant visual stimuli in manual and autonomous driving. The second aim is to examine how the inclusion of a secondary task (attentive listening to a broadcast) modulates these hemodynamic responses in both driving situations. Frontal, temporo-parietal and occipital activations were recorded using a functional

Near-InfraRed Spectroscopy (fNIRS) system. Event-related analysis was used to determine whether visual cue processing (specifically, the lighting of a lead vehicle's brake-lights) could induce different brain responses depending on the driving mode and on the presence or absence of a competing task. Mind-wandering as reported by the participants was more pronounced during autonomous compared to manual driving. Our results showed an increase in the OxyHb concentration in the right temporo-parietal and occipital areas during manual compared to autonomous driving, suggesting greater allocation of attentional resources for processing visual cues in the first condition. Finally, an event-related decrease in right frontal activity during autonomous driving when listening was observed, suggesting that attentional resources were more focused on the secondary task than on monitoring the driving scene.

Bilingual effects on lexical selection: A neurodevelopmental perspective.

Arredondo MM, Hu XS, Satterfield T, Tsutsumi Riobo A, Gelman SA, Kovelman I.

Brain Lang. Aug;195:
doi: 10.1016/j.bandl.2019.Epub Jun 26.

When a listener hears a word, multiple lexical items may come to mind; for instance, /kn/ may activate concepts with similar phonological onsets such as candy and candle. Acquisition of two lexicons may increase such linguistic competition. Using functional Near-Infrared Spectroscopy neuroimaging, we investigate whether bilingualism impacts word processing in the child's brain. Bilingual and monolingual children (N = 52; ages 7-10) completed a lexical selection task in English, where participants adjudicated phonological competitors (e.g., car/cat vs. car/pen). Children were less accurate and responded more slowly during competing than non-competing items. In doing so, children engaged top-down fronto-parietal regions associated with cognitive control. In comparison to bilinguals, monolinguals showed greater activity in left frontal regions, a difference possibly due to bilinguals' adaptation for dual-lexicons. These differences provide insight to theories aiming to explain the role of experience on children's emerging neural networks for lexical selection and language processing.

Recommendations for motion correction of infant fNIRS data applicable to multiple data sets and acquisition systems.

Di Lorenzo R, Pirazzoli L, Blasi A, Bulgarelli C, Hakuno Y, Minagawa Y, Brigadoi S.

Neuroimage. Oct 15;200:511-
doi: 10.1016/j.neuroimage.2019.06.Epub Jun 25.

Despite motion artifacts are a major source of noise in fNIRS infant data, how to approach motion correction in this population has only recently started to be investigated. Homer2 offers a wide range of motion correction methods and previous work on simulated and adult data suggested the use of Spline interpolation and Wavelet filtering as optimal methods for the recovery of trials affected by motion. However, motion artifacts in infant data differ from those in adults' both in amplitude and frequency of occurrence. Therefore, artifact correction recommendations derived from adult data might not be optimal for infant data. We hypothesized that the combined use of Spline and Wavelet would outperform their individual use on data with complex profiles of motion artifacts. To demonstrate this, we first compared, on infant semi-simulated data, the performance of several motion correction techniques on their own and of the novel combined approach; then, we investigated the performance of Spline and Wavelet alone and in combination on real cognitive data from three datasets collected with infants of different ages (5, 7 and 10 months), with different tasks (auditory, visual and tactile) and with different NIRS systems. To quantitatively estimate and compare the efficacy of these techniques, we adopted four metrics: hemodynamic response recovery error, within-subject standard deviation, between-subjects standard deviation and number of trials that survived each correction method. Our results demonstrated that (i) it is always better correcting for motion artifacts than rejecting the corrupted trials; (ii) Wavelet filtering on its own and in combination with Spline interpolation seems to be the most effective approach in reducing the between- and the within-subject standard deviations. Importantly, the combination of Spline and Wavelet was the approach providing the best performance in semi-simulation both at low and high levels of noise, also recovering most of the trials affected by motion artifacts across all datasets, a crucial result when working with infant data.

Frontal haemodynamic responses in depression and the effect of electroconvulsive therapy.

Downey D, Brigadoi S, Trevithick L, Elliott R, Elwell C, McAllister-Williams RH, Anderson IM.
J Psychopharmacol. Aug;33(8):1003-
doi: 10.1177/Epub Jun 25.

BACKGROUND: Reduced frontal cortex metabolism and blood flow in depression may be associated with low mood and cognitive impairment. Further reduction has been reported during a course of electroconvulsive therapy but it is not known if this relates to mood and cognitive changes caused by electroconvulsive therapy. AIMS: The purpose of this study was to investigate frontal function while undertaking cognitive tasks in depressed patients compared with healthy controls, and following electroconvulsive therapy in patients. METHODS: We measured frontal haemodynamic responses to a category verbal fluency task and a working memory N-back task using portable functional near infra-red spectroscopy (fNIRS) in 51 healthy controls and 18 severely depressed patients, 12 of whom were retested after the fourth treatment of a course of electroconvulsive therapy. Mood was assessed using the Montgomery sberg Depression Rating Scale and cognitive function using category Verbal Fluency from the Controlled Oral Word Association Test and Digit Span backwards. RESULTS: Compared to healthy controls, depressed patients had bilaterally lower frontal oxyhaemoglobin responses to the cognitive tasks, although this was only significant for the N-Back task where performance correlated inversely with depression severity in patients. After four electroconvulsive therapy treatments oxyhaemoglobin responses were further reduced during the Verbal Fluency task but the changes did not correlate with mood or cognitive changes. DISCUSSION: Our results confirmed a now extensive literature showing impaired frontal fNIRS oxyhaemoglobin responses to cognitive tasks in depression, and showed for the first time that these are further reduced during a course of electroconvulsive therapy. Further research is needed to investigate the biology and clinical utility of frontal fNIRS in psychiatric patients.

IQ estimation by means of EEG-fNIRS recordings during a logical-mathematical intelligence test.

Firooz S, Setarehdan SK.
Comput Biol Med. Jul;110:218-
doi: 10.1016/j.compbiomed.2019.05.017. Epub May 24.

Intelligence differences of individuals are attributed to the structural and functional differences of the brain. Neural processing operations of the

human brain vary according to the difficulty level of the problem and the intelligence level of individuals. In this study, we used a bimodal system consisting of functional Near-Infrared Spectroscopy (fNIRS) and Electroencephalogram (EEG) to investigate these inter-individual differences. A continuous wave 32-channel fNIRS from OxyMonfNIRS device (Artinis) and 19-channel EEG from (g.tec's company) were utilized to study the oxygenation procedure as well as the electrical activity of the brain when doing the problems of Raven's Progressive Matrix (RPM) intelligence test. We used this information to estimate the Intelligence Quotient (IQ) of the individual without performing a complete logical-mathematical intelligence test in a long-time period and examining the answers of people to the questions. After EEG preprocessing, different features including Higuchi's fractal dimension, Shannon entropy values from wavelet transform coefficients, and average power of frequency sub-bands were extracted. Clean fNIRS signals were also used to compute features such as slope, mean, variance, kurtosis, skewness, and peak. Then dimension reduction algorithms such as Linear Discriminant Analysis (LDA) and Principal Component Analysis (PCA) were applied to select an effective feature set from fNIRS and EEG in order to improve the IQ estimation process. We utilized two regression methods, i.e., Linear Regression (LR) and Support Vector Regression (SVR), to extract optimum models for the IQ determination. The best regression models based on fNIRS-EEG and fNIRS presented 3.093% and 3.690% relative error for 11 subjects, respectively.

Cognitive flexibility-related prefrontal activation in preschoolers: A biological approach to temperamental effortful control.
Quiones-Camacho LE, Fishburn FA, Camacho MC, Wakschlag LS, Perlman SB.
Dev Cogn Neurosci. Aug;38:
doi: 10.1016/j.dcn.2019.Epub May 24.

Individual differences in temperament have been theorized to be supported by differential recruitment of key neural regions, resulting in the distinct patterns of behavior observed throughout life. Although a compelling model, its rigorous and systematic testing is lacking, particularly within the heightened neuroplasticity of early childhood. The current study tested a model of the link between temperament, the brain, and behavior for cognitive flexibility in a sample of 4-5-year-old children (N = 123) using functional near-infrared spectroscopy (fNIRS) to assess prefrontal cortex

(PFC) activation. Structural Equation Modeling (SEM) was used to explore the link between survey reports of temperamental effortful control, and both performance-based and neuroimaging measures of cognitive flexibility. Results indicated that greater parent-reported temperamental effortful control was associated with better performance on a cognitive flexibility task, and less activation of the DLPFC in preschoolers. These findings support the theorized model of the interrelatedness between temperamental tendencies, behavior, and brain activation and suggest that better temperamentally regulated children use the DLPFC more efficiently for cognitive flexibility.

Semantic and BCI-performance in completely paralyzed patients: Possibility of language attrition in completely locked in syndrome.

Khalili Ardali M, Rana A, Purmohammad M, Birbaumer N, Chaudhary U.
Brain Lang. Jul;194:93-
doi: 10.1016/j.bandl.2019.05.Epub May 28.

Patients with completely locked-in syndrome (CLIS) are incapable of any voluntary muscle movement and do not have any means of communication. Recently functional near infrared spectroscopy (fNIRS) based brain computer interface (BCI) has been successfully used to enable communication with these patients. The developed fNIRS-BCI system relies on the intactness of language comprehension in these patients in all dimensions of language. Interwoven language and motor cortex in brain, and lack of muscular activity in long run, can cause language attrition due to complete immobility in CLIS patients. In this study we have investigated effects of semantic content of sentences presented to a CLIS patient on the performance of the BCI system during a YES/NO paradigm. Comparison of communication success rate in BCI classification between different semantic categories indicate that semantic content of sentences presented to a CLIS patient can affect the BCI performance. Affected concepts are mostly associated with executive words. These findings can be beneficial towards development of more reliable communication device for patients in CLIS. In addition, these results may assist in elucidating the cognitive changes in completely paralyzed patients with the passage of time since the onset of total immovability.

Increased Sensorimotor Cortex Activation With Decreased

Motor Performance During Functional Upper Extremity Tasks Poststroke.

Lim SB, Eng JJ.

J Neurol Phys Ther. Jul;43(3):141-
doi: 10.1097/NPT.0000000000000277.

BACKGROUND AND PURPOSE: Current literature has focused on identifying neuroplastic changes associated with stroke through tasks and in positions that are not representative of functional rehabilitation. Emerging technologies such as functional near-infrared spectroscopy (fNIRS) provide new methods of expanding the area of neuroplasticity within rehabilitation. This study determined the differences in sensorimotor cortex activation during unrestrained reaching and gripping after stroke. METHODS: Eleven individuals with chronic stroke and 11 neurologically healthy individuals completed reaching and gripping tasks under 3 conditions using their (1) stronger, (2) weaker, and (3) both arms together. Performance and sensorimotor cortex activation using fNIRS were collected. Group and arm differences were calculated using mixed analysis of covariance (covariate: age). Pairwise comparisons were used for post hoc analyses. Partial Pearson correlations between performance and activation were assessed for each task, group, and hemisphere. RESULTS: Larger sensorimotor activations in the ipsilesional hemisphere were found for the stroke compared with healthy group for reaching and gripping conditions despite poorer performance. Significant correlations were observed between gripping performance (with the weaker arm and both arms simultaneously) and sensorimotor activation for the stroke group only. DISCUSSION AND CONCLUSIONS: Stroke leads to significantly larger sensorimotor activation during functional reaching and gripping despite poorer performance. This may indicate an increased sense of effort, decreased efficiency, or increased difficulty after stroke. fNIRS can be used for assessing differences in brain activation during movements in functional positions after stroke. This can be a promising tool for investigating possible neuroplastic changes associated with functional rehabilitation interventions in the stroke population.Video Abstract available for more insights from the authors (see Video Abstract, Supplemental Digital Content 1, available at: http://links.lww.com/JNPT/A269).

Shared neural representations of syntax during online dyadic communication.

Liu W, Branigan HP, Zheng L, Long Y, Bai X, Li K, Zhao H, Zhou S,

Pickering MJ, Lu C.
Neuroimage. Sep;198:63-
doi: 10.1016/j.neuroimage.2019.05.Epub May 16.

When people communicate, they come to see the world in a similar way to each other by aligning their mental representations at such levels as syntax. Syntax is an essential feature of human language that distinguishes humans from other non-human animals. However, whether and how communicators share neural representations of syntax is not well understood. Here we addressed this issue by measuring the brain activity of both communicators in a series of dyadic communication contexts, by using functional near-infrared spectroscopy (fNIRS)-based hyperscanning. Two communicators alternatively spoke sentences either with the same or with different syntactic structures. Results showed a significantly higher-level increase of interpersonal neural synchronization (INS) at right posterior superior temporal cortex when communicators produced the same syntactic structures as each other compared to when they produced different syntactic structures. These increases of INS correlated significantly with communication quality. Our findings provide initial evidence for shared neural representations of syntax between communicators.

Application of functional near-infrared spectroscopy to explore the neural mechanism of transcranial direct current stimulation for post-stroke depression.

Li H, Zhu N, Klomparens EA, Xu S, Wang M, Wang Q, Wang J, Song L.
Neurol Res. Aug;41(8):714-
doi: 10.1080/01616412.2019.Epub 2019 May 16.

Objectives: We investigated the neural mechanism of transcranial direct current stimulation (tDCS) in the treatment of post-stroke depression (PSD) using functional near-infrared spectroscopy (fNIRS). Methods: Twenty-six patients with PSD were randomly divided into an experimental group receiving tDCS and a control group receiving sham stimulation. The anode and cathode were placed on the left and right dorsolateral prefrontal cortex (PFC). Patients underwent fNIRS before and after treatment, combined with an emotional face sex judgment task and a '1-back' working memory task to assess reaction times and relative concentration changes of oxyhemoglobin (Oxy-Hb) in the PFC. Results: Reaction times for faces showing positive emotions decreased after treatment in the experimental group ($P<0.05$). For faces showing negative emotions, relative Oxy-Hb concentra-

tion changes in the PFC were higher after treatment (P<0.05), but there was no significant difference between the experimental and the control group. Reaction times during the working memory task in the experimental group were shorter after treatment (P<0.05), and there was a significant difference between the groups (P<0.05). Relative Oxy-Hb concentration changes in the left PFC were significantly higher after treatment in the experimental group (P<0.05), and concentration changes in the right PFC after treatment were significantly higher in the experimental than in the control group (P<0.05). Discussion: tDCS may improve the processing of negative emotions and working memory in patients with PSD by enhancing aerobic metabolism in the PFC, thereby improving depressive symptoms.

Enhancing neural efficiency of cognitive processing speed via training and neurostimulation: An fNIRS and TMS study.

Curtin A, Ayaz H, Tang Y, Sun J, Wang J, Tong S.

Neuroimage. Sep;198:73-
doi: 10.1016/j.neuroimage.2019.05.Epub May 9.

Speed of Processing (SoP) represents a fundamental limiting step in cognitive performance which may underlie General Intelligence. The measure of SoP is particularly sensitive to aging, neurological or cognitive diseases, and has become a benchmark for diagnosis, cognitive remediation, and enhancement. Neural efficiency of the Dorsolateral Prefrontal Cortex (DLPFC) is proposed to account for individual differences in SoP. However, the mechanisms by which DLPFC efficiency is shaped by training and whether it can be enhanced remain elusive. To address this, we monitored the brain activity of sixteen healthy participants using functional Near Infrared Spectroscopy (fNIRS) while practicing a common SoP task (Symbol Digit Substitution Task) across 4 sessions. Furthermore, in each session, participants received counterbalanced excitatory repetitive transcranial magnetic stimulation (rTMS) during mid-session breaks. Results indicate a significant involvement of the left-DLPFC in SoP, whose neural efficiency is consistently increased through task practice. Active neurostimulation, but not Sham, significantly enhanced the neural efficiency. These findings suggest a common mechanism by which neurostimulation may aid to accelerate learning.

Delta-9-tetrahydrocannabinol intoxication is associated with increased prefrontal activation as assessed with functional near-infrared spectroscopy: A report of a potential biomarker of intoxication.

Gilman JM, Ycel MA, Pachas GN, Potter K, Levar N, Broos H, Manghis EM, Schuster RM, Evins AE.

Neuroimage. Aug 15;197:575-
doi: 10.1016/j.neuroimage.2019.05.Epub May 7.

The primary psychoactive compound in cannabis, Δ9-tetrahydrocannabinol (THC), binds to cannabinoid receptors (CB1) present in high concentrations in the prefrontal cortex (PFC). It is unknown whether the PFC hemodynamic response changes with THC intoxication. We conducted the first double-blind, placebo-controlled, cross-over study of the effect of THC intoxication on functional near infrared spectroscopy (fNIRS) measures of PFC activation. Fifty-four adult, regular (at least weekly) cannabis users received a single oral dose of synthetic THC (dronabinol; 5-50 mg, dose individually tailored to produce intoxication) and identical placebo on two visits at least one week apart. fNIRS recordings were obtained during a working memory task (N-Back) at three timepoints: before THC/placebo, at 100 min (when peak effects were expected), and at 200 min after THC/placebo administration. Functional data were collected using a continuous-wave NIRS device, with 8 sources and 7 detectors arrayed over the forehead, resulting in 20 channels covering PFC regions. Participants also completed frequent heart rate measures and subjective ratings of intoxication. Approximately half of participants reported significant intoxication. Intoxication ratings were not correlated with dose of THC. Increases in heart rate significantly correlated with intoxication ratings after THC dosing. Results indicated that 100 min after THC administration, oxygenated hemoglobin (HbO) response significantly increased from pre-dose HbO levels throughout the PFC in participants who reported significant intoxication. Changes in HbO response significantly correlated with self-reported intoxication at 100 min after THC administration. Among those who reported intoxication, HbO response decreased at 200 min after THC, when intoxication had largely resolved, compared to the peak THC time point. This study demonstrates that THC intoxication causes increased PFC activity, and fNIRS of the PFC can measure this effect. Increased neural activation in PFC represents a potential biomarker for cannabis intoxication.

Anticipatory alpha oscillation predicts attentional selection and hemodynamic response.

Zhao C, Guo J, Li D, Tao Y, Ding Y, Liu H, Song Y.

Hum Brain Mapp. Aug 15;40(12):3606-
doi: 10.1002/hbm.Epub 2019 May 7.

In covert visual attention, one fundamental question is how advance knowledge facilitates subsequent neural processing and behavioral performance. In this study, with a rapid event-related simultaneous electroencephalography (EEG) and functional near infrared spectroscopy recording in humans, we explored the potential contribution of anticipatory electrophysiological activation and hemodynamic activation by examining how anticipatory low-frequency oscillations and changes in oxygenated hemoglobin (HbO) concentration influence the subsequent event-related potential (ERP) marker of attentional selection. We found that expecting a target led to both a posterior lateralization of alpha-band (8-12 Hz) oscillation power and a lateralization of HbO response over the visual cortex. Importantly, the magnitude of cue-induced alpha lateralization was positively correlated with the nearby HbO lateralization in the visual cortex, and such a cue-induced alpha lateralization predicted the subsequent target-evoked N2pc amplitudes assumed to reflect attentional selection. Our results suggest that each individual's attentional selection biomarker as reflected by N2pc is predictable in advance via the anticipation-induced alpha lateralization, and such cue-induced alpha lateralization seems to play an important role in the functional coupling effects between the low-frequency EEG and the nearby hemodynamic activation.

Using functional near-infrared spectroscopy to assess social information processing in poor urban Bangladeshi infants and toddlers.

Perdue KL, Jensen SKG, Kumar S, Richards JE, Kakon SH, Haque R, Petri WA Jr, Lloyd-Fox S, Elwell C, Nelson CA.

Dev Sci. Sep;22(5):e
doi: 10.1111/desc.Epub May 17.

Children living in low-resource settings are at risk for failing to reach their developmental potential. While the behavioral outcomes of growing up in such settings are well-known, the neural mechanisms underpinning poor outcomes have not been well elucidated, particularly in the context of low- and middle-income countries. In this study, we measure brain metabolic

responses to social and nonsocial stimuli in a cohort of 6- and 36-month-old Bangladeshi children. Study participants in both cohorts lived in an urban slum and were exposed to a broad range of adversity early in life including extreme poverty, malnutrition, recurrent infections, and low maternal education. We observed brain regions that responded selectively to social stimuli in both ages indicating that these specialized brain responses are online from an early age. We additionally show that the magnitude of the socially selective response is related to maternal education, maternal stress, and the caregiving environment. Ultimately our results suggest that a variety of psychosocial hazards have a measurable relationship with the developing social brain.

Investigation of brain functional connectivity in patients with mild cognitive impairment: A functional near-infrared spectroscopy (fNIRS) study.

Nguyen T, Kim M, Gwak J, Lee JJ, Choi KY, Lee KH, Kim JG.

J Biophotonics. Sep;12(9):e

doi: 10.1002/jbio.Epub 2019 May 17.

This study examines brain functional connectivity in both cognitively normal seniors and patients with mild cognitive impairment (MCI) to elucidate prospective markers of MCI. A homemade four-channel functional near-infrared spectroscopy (fNIRS) system was employed to measure hemodynamic responses in the subjects' prefrontal cortex during a resting state, an oddball task, a 1-back task, and a verbal fluency task. Brain functional connectivity was calculated as the Pearson correlation coefficients between fNIRS channels. The results show that during the verbal fluency task, while the healthy control (HC) group presents a significantly stronger inter-hemispheric connectivity compared to intra-hemispheric connectivity, there is no difference between the inter- and intra-hemispheric connectivity in the MCI group. In addition, a comparison between the MCI and HC connectivity reveals that the MCI group has a statistically higher right and inter-hemispheric connectivity during the resting state, but a significantly lower left and inter-hemispheric connectivity during the verbal fluency test. These findings demonstrate the potential of fNIRS to study brain functional connectivity in neurodegenerative diseases.

Creativity slumps and bumps: Examining the neurobehavioral basis of creativity development during middle childhood.
Saggar M, Xie H, Beaty RE, Stankov AD, Schreier M, Reiss AL.
Neuroimage. Aug 1;196:94-
doi: 10.1016/j.neuroimage.2019.03.Epub Apr 6.

Developmental research has found that children's creative thinking ability tends to decline during middle childhood. However, this decline has not been consistently demonstrated, and the underlying neural and behavioral factors that affect fluctuations in children's creative thinking ability remain uncharacterized. Using a longitudinal cohort-sequential experimental design, we investigated the neurobehavioral basis of creative thinking ability during middle childhood in a sample of 48 children (n = 21 starting 3rd grade, n = 27 starting 4th grade) assessed longitudinally at three time-points across one year. For the first time, we used data-driven methods to reveal distinct trajectories in creative thinking ability during middle childhood. We found that although some children show a classic decline in creative ability, others exhibit a significant increase in creativity over time. These trajectories were not associated with differences in intelligence, age, or sex, but rather other developmentally-relevant constructs, including heightened externalizing behavior (i.e., rule-breaking and aggression). Using functional near-infrared spectroscopy (fNIRS) in a smaller cohort (n = 26), we examined longitudinal changes in bilateral frontal neural connectivity and found that increased right lateral frontal segregation or functional specialization tracked developmental improvements in creative thinking ability. Taken together, the findings reveal distinct profiles of change in creative thinking ability during middle childhood and identify behavioral and neural mechanisms potentially underlying changes in children's ability to think creatively.

Dynamic interpersonal neural synchronization underlying pain-induced cooperation in females.
Wang C, Zhang T, Shan Z, Liu J, Yuan D, Li X.
Hum Brain Mapp. Aug 1;40(11):3222-
doi: 10.1002/hbm.Epub 2019 Apr 4.

Individuals in pain are motivated to be cooperative in social interaction. Yet, there has been little research on how pain dynamically affects cooperation at a neural level. The present study investigated the cooperative behavior under acute physical pain by asking dyads to complete three

blocks of button-press cooperative task, while neural activities were recorded simultaneously on each subject by the fNIRS-based hyperscanning. Results showed that individuals in pain improved their cooperation rate across task blocks. Accordingly, increased interpersonal neural synchronization (INS) was found at the left prefrontal cortex in second block, whereas increased INS was found at the right prefrontal cortex and the right parietal cortex in third block compared to the first block. Moreover, the change of INS in right parietal cortex was positively correlated with subjective pain rating in the pain treatment group. In addition, dynamic interpersonal neural networks were identified in painful condition with increasing frontoparietal networks across time. By uncovering dissociative neural processes involved in how pain affects cooperation in social interaction, the present work provides the first interbrain evidence to highlight the sociality of pain on social interaction in perspective of motivational aspect of pain.

Selective facial mimicry of native over foreign speakers in preverbal infants.

de Klerk CCJM, Bulgarelli C, Hamilton A, Southgate V.

J Exp Child Psychol. Jul;183:33-
doi: 10.1016/j.jecp.2019.01.Epub Mar 8.

Mimicry, the spontaneous copying of others' behaviors, plays an important role in social affiliation, with adults selectively mimicking in-group members over out-group members. Despite infants' early documented sensitivity to cues to group membership, previous work suggests that it is not until 4 years of age that spontaneous mimicry is modulated by group status. Here we demonstrate that mimicry is sensitive to cues to group membership at a much earlier age if the cues presented are more relevant to infants. 11-month-old infants observed videos of facial actions (e.g., mouth opening, eyebrow raising) performed by models who either spoke the infants' native language or an unfamiliar foreign language while we measured activation of the infants' mouth and eyebrow muscle regions using electromyography to obtain an index of mimicry. We simultaneously used functional near-infrared spectroscopy to investigate the neural mechanisms underlying differential mimicry responses. We found that infants showed greater facial mimicry of the native speaker compared to the foreign speaker and that the left temporal parietal cortex was activated more strongly during the observation of facial actions performed by the native speaker compared to the foreign speaker. Although the exact mechanisms underlying this selective

mimicry response will need to be investigated in future research, these findings provide the first demonstration of the modulation of facial mimicry by cues to group status in preverbal infants and suggest that the foundations for the role that mimicry plays in facilitating social bonds seem to be present during the first year of life.

Early adversity in rural India impacts the brain networks underlying visual working memory.

Wijeakumar S, Kumar A, Delgado Reyes LM, Tiwari M, Spencer JP.

Dev Sci. Sep;22(5):e
doi: 10.1111/desc.Epub Mar 21.

There is a growing need to understand the global impact of poverty on early brain and behavioural development, particularly with regard to key cognitive processes that emerge in early development. Although the impact of adversity on brain development can trap children in an intergenerational cycle of poverty, the massive potential for brain plasticity is also a source of hope: reliable, accessible, culturally agnostic methods to assess early brain development in low resource settings might be used to measure the impact of early adversity, identify infants for timely intervention and guide the development and monitor the effectiveness of early interventions. Visual working memory (VWM) is an early marker of cognitive capacity that has been assessed reliably in early infancy and is predictive of later academic achievement in Western countries. Here, we localized the functional brain networks that underlie VWM in early development in rural India using a portable neuroimaging system, and we assessed the impact of adversity on these brain networks. We recorded functional brain activity as young children aged 4-48months performed a VWM task. Brain imaging results revealed localized activation in the frontal cortex, replicating findings from a Midwestern US sample. Critically, children from families with low maternal education and income showed weaker brain activity and poorer distractor suppression in canonical working memory areas in the left frontal cortex. Implications of this work are far-reaching: it is now cost-effective to localize functional brain networks in early development in low-resource settings, paving the way for novel intervention and assessment methods.

Habituation and novelty detection fNIRS brain responses in

5- and 8-month-old infants: The Gambia and UK.

Lloyd-Fox S, Blasi A, McCann S, Rozhko M, Katus L, Mason L, Austin T, Moore SE, Elwell CE; BRIGHT project team.

Dev Sci. Sep;22(5):e
doi: 10.1111/desc.Epub Mar 13.

The first 1,000days of life are a critical window of vulnerability to exposure to socioeconomic and health challenges (i.e. poverty/undernutrition). The Brain Imaging for Global Health (BRIGHT) project has been established to deliver longitudinal measures of brain development from 0 to 24months in UK and Gambian infants and to assess the impact of early adversity. Here results from the Habituation-Novelty Detection (HaND) functional near-infrared spectroscopy (fNIRS) task at 5 and 8months are presented (N=62 UK; N=115 Gambia). In the UK cohort distinct patterns of habituation and recovery of response to novelty are seen, becoming more robust from 5 to 8months of age. In The Gambia, an attenuated habituation response is evident: a larger number of trials are required before the response sufficiently suppresses relative to the response during the first presented trials. Furthermore, recovery of response to novelty is not evident at 5 or 8months of age. As this longitudinal study continues in The Gambia, the parallel collection of socioeconomic, caregiving, health and nutrition data will allow us to stratify how individual trajectories of habituation and recovery of response to novelty associate with different risk factors and adaptive mechanisms in greater depth. Given the increasing interest in the use of neuroimaging methods within global neurocognitive developmental studies, this study provides a novel cross-culturally appropriate paradigm for the study of brain responses associated with attention and learning mechanisms across early development.

Newborns are sensitive to multiple cues for word segmentation in continuous speech.

Fl A, Brusini P, Macagno F, Nespor M, Mehler J, Ferry AL.

Dev Sci. Jul;22(4):e
doi: 10.1111/desc.Epub Feb 20.

Before infants can learn words, they must identify those words in continuous speech. Yet, the speech signal lacks obvious boundary markers, which poses a potential problem for language acquisition (Swingley, Philos Trans R Soc Lond. Series B, Biol Sci 364(1536), 3617-3632, 2009). By the middle of the first year, infants seem to have solved this problem (Bergelson

& Swingley, Proc Natl Acad Sci 109(9), 3253-3258, 2012; Jusczyk & Aslin, Cogn Psychol 29, 1-23, 1995), but it is unknown if segmentation abilities are present from birth, or if they only emerge after sufficient language exposure and/or brain maturation. Here, in two independent experiments, we looked at two cues known to be crucial for the segmentation of human speech: the computation of statistical co-occurrences between syllables and the use of the language's prosody. After a brief familiarization of about 3min with continuous speech, using functional near-infrared spectroscopy, neonates showed differential brain responses on a recognition test to words that violated either the statistical (Experiment 1) or prosodic (Experiment 2) boundaries of the familiarization, compared to words that conformed to those boundaries. Importantly, word recognition in Experiment 2 occurred even in the absence of prosodic information at test, meaning that newborns encoded the phonological content independently of its prosody. These data indicate that humans are born with operational language processing and memory capacities and can use at least two types of cues to segment otherwise continuous speech, a key first step in language acquisition.

Improvement in Recovery of Hemodynamic Responses by Extended Kalman Filter With Non-Linear State-Space Model and Short Separation Measurement.

Dong S, Jeong J.

IEEE Trans Biomed Eng. Aug;66(8):2152-

doi: 10.1109/TBME.2018. Epub Nov 30.

DOI: 10.1109/TBME.2018.2884169 PMID: 30507523

Objective assessment of surgical skill transfer using non-invasive brain imaging.

Nemani A, Kruger U, Cooper CA, Schwaitzberg SD, Intes X, De S.

Surg Endosc. Aug;33(8):2485-

doi: 10.1007/s00464-018-6535-z. Epub Oct 17.

BACKGROUND: Physical and virtual surgical simulators are increasingly being used in training technical surgical skills. However, metrics such as completion time or subjective performance checklists often show poor correlation to transfer of skills into clinical settings. We hypothesize that non-invasive brain imaging can objectively differentiate and classify surgi-

cal skill transfer, with higher accuracy than established metrics, for subjects based on motor skill levels. STUDY DESIGN: 18 medical students at University at Buffalo were randomly assigned into control, physical surgical trainer, or virtual trainer groups. Training groups practiced a surgical technical task on respective simulators for 12 consecutive days. To measure skill transfer post-training, all subjects performed the technical task in an ex-vivo environment. Cortical activation was measured using functional near-infrared spectroscopy (fNIRS) in the prefrontal cortex, primary motor cortex, and supplementary motor area, due to their direct impact on motor skill learning. RESULTS: Classification between simulator trained and untrained subjects based on traditional metrics is poor, where misclassification errors range from 20 to 41%. Conversely, fNIRS metrics can successfully classify physical or virtual trained subjects from untrained subjects with misclassification errors of 2.2% and 8.9%, respectively. More importantly, untrained subjects are successfully classified from physical or virtual simulator trained subjects with misclassification errors of 2.7% and 9.1%, respectively. CONCLUSION: fNIRS metrics are significantly more accurate than current established metrics in classifying different levels of surgical motor skill transfer. Our approach brings robustness, objectivity, and accuracy in validating the effectiveness of future surgical trainers in translating surgical skills to clinically relevant environments.

Brain asymmetry in directing attention during dichotic listening test: An fNIRS study.

Eskicioglu E, Taslica S, Narin B, Guducu C, Oniz A, Ozgoren M.

Laterality. Jul;24(4):377-
doi: 10.1080/1357650X.2018.Epub 2018 Sep 27.

In a classical dichotic listening paradigm, besides auditory brain asymmetry, cognitive functions such as attention and conflict resolution play a major role. The aim of this study is to reveal the possible haemodynamic mechanisms of higher attentional performance in prefrontal cortex during dichotic listening test. Twenty-six healthy participants underwent a dichotic listening task in three sessions; non-forced attention, attention focused to right ear, and attention focused to left ear. In each session, haemodynamic activity of prefrontal brain area was recorded using functional near-infrared spectroscopy (fNIRS). Effects of focused attention and performance level of the task on oxy-, deoxy-, and total haemoglobin levels were investigated. Oxy- and total haemoglobin levels in right prefrontal regions during forced-

right and forced-left sessions were significantly higher than levels of the non-forced session. This might be an indicator of inhibition and orienting attentional functions of right inferior frontal gyrus. High performers had significantly higher deoxyhaemoglobin levels in the forced-left session compared to the non-forced session, while low performers' deoxyhaemoglobin levels did not differ among these sessions. Observing this difference only in the forced-left session but not in the forced-right session might suggest conflict resolution in top-down and bottom-up processes during the forced-left session for right-handed participants.

Modulation of Cortical Activity by High-Frequency Whole-Body Vibration Exercise: An fNIRS Study.

Choi DS, Lee HJ, Shin YI, Lee A, Kim HG, Kim YH.

J Sport Rehabil. Sep 1;28(7):665-
doi: 10.1123/jsr.2017-0012.
DOI: 10.1123/jsr.2017-0012 PMID: 30222484

Distinct fNIRS-Derived HbO2 Trajectories During the Course and Over Repeated Walking Trials Under Single- and Dual-Task Conditions: Implications for Within Session Learning and Prefrontal Cortex Efficiency in Older Adults.

Holtzer R, Izzetoglu M, Chen M, Wang C.

J Gerontol A Biol Sci Med Sci. Jun 18;74(7):1076-
doi: 10.1093/gerona/gly181.

BACKGROUND: Neural trajectories of gait are not well established. We determined two distinct, clinically relevant neural trajectories, operationalized via functional near-infrared spectroscopy (fNIRS) HbO2 measures in the prefrontal cortex (PFC), under Single-Task-Walk (STW), and Dual-Task-Walk (DTW) conditions. Course trajectory assessed neural activity associated with attention during the course of a walking task; the second trajectory assessed neural activity associated with learning over repeated walking trials. Improved neural efficiency was defined as reduced PFC HbO2 after practice. METHODS: Walking was assessed under STW and DTW conditions. fNIRS was utilized to quantify HbO2 in the PFC while walking. Burst measurement included three repeated trials for each experimental condition. The course of each walking task consisted of six

consecutive segments. RESULTS: Eighty-three nondemented participants (mean age = 78.05 6.37 years; %female = 49.5) were included. Stride velocity (estimate = -0.5259 cm/s, p = <.0001) and the rate of correct letter generation (log estimate of rate ratio = -0.0377, p < .0001) declined during the course of DTW. In contrast, stride velocity (estimate = 1.4577 cm/s, p < .0001) and the rate of correct letter generation (log estimate of rate ratio = 0.0578, p < .0001) improved over repeated DTW trials. Course and trial effects were not significant in STW. HbO2 increased during the course of DTW (estimate = 0.0454 μM, p < .0001) but declined over repeated trials (estimate = -0.1786 μM, p < .0001). HbO2 declined during the course of STW (estimate = -.0542 μM, p < .0001) but did not change significantly over repeated trials. CONCLUSION: We provided evidence for distinct attention (course) and learning (repeated trials) trajectories and their corresponding PFC activity. Findings suggest that learning and improved PFC efficiency were demonstrated in one experimental session involving repeated DTW trials.

Binary Classification Using Neural and Clinical Features: An Application in Fibromyalgia With Likelihood-Based Decision Level Fusion.

Gokcay D, Eken A, Baltaci S.

IEEE J Biomed Health Inform. Jul;23(4):1490-
doi: 10.1109/JBHI.2018.Epub Jun 5.

DOI: 10.1109/JBHI.2018.2844300 PMID: 29994341

Assess BA10 activity in slide-based and immersive virtual reality prospective memory task using functional near-infrared spectroscopy (fNIRS).

Dong D, Wong LKF, Luo Z.

Appl Neuropsychol Adult. Sep-Oct;26(5):465-
doi: 10.1080/23279095.2018.Epub Mar 16.

By using slide-based task in a laboratory setting, previous studies have found that activation of the rostral prefrontal cortex (BA10) is related to prospective memory performance. In this present study, we used immersive virtual reality (VR) technology to measure PM performance in a real-life task in a simulated virtual environment. Functional near-infrared spec-

troscopy was used simultaneously to record the rostral prefrontal cortex activities of the subjects. By comparing the data against the ones from the slide-based task, the result suggested that the activation of BA10 in the VR tasks were greater than the one in the slide-based tasks, and the VR tasks have the potential to identify the particular location of BA10 that is connected to the PM performance in our daily lives.