New papers about near-infrared spectroscopy (NIRS) and imaging (NIRI)

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Number of papers included: **117**

Note: The highlighted parts of the abstracts refer to the most important findings.

1. Brucker et al. (2015). **Watching corresponding gestures facilitates learning with animations by activating human mirror-neurons: An fNIRS study**

Abstract: This study investigates whether displaying gestures that correspond to the depicted movements enhances learning about non-human biological movements with dynamic visualizations compared to displaying non-corresponding gestures. Functional near-infrared spectroscopy (fNIRS) was used to assess whether both types of gestures activate the human mirror-neuron system (hMNS). Low-visuospatial-ability learners benefited from corresponding gestures only, whereas high-visuospatial-ability learners achieved good results with both types of gestures. Accordingly, only low-visuospatial-ability learners showed higher activation of the inferior-frontal cortex (part of the hMNS) for corresponding than for non-corresponding gestures. Furthermore, low-visuospatial-ability learners watching non-corresponding gestures yielded better results when their inferior-parietal cortex (another part of the hMNS) was activated. Thus, three factors predict positive learning outcomes: higher visuospatial abilities, inferior-frontal cortex activation, and inferior-parietal cortex activation. In sum, activating the hMNS seems to facilitate learning about biological movements, and stimulating the hMNS by means of corresponding gestures might be an adequate instructional strategy to support low-visuospatial-ability learners.

2. Cameron et al. (2015). **Near-infrared spectroscopy reveals link between chronic physical activity and anterior frontal oxygenated hemoglobin in healthy young women**

Abstract: Cerebrovascular and cognitive functioning peak developmentally in young adults, yet recent evidence indicates they may benefit on these fronts from regular engagement in physical activity. In light of epidemiological trends for increasingly sedentary lifestyles and the importance of optimal cerebrovascular and cognitive functioning, here we investigated relationships between physical activity levels, anterior frontal hemodynamics, and cognitive performance in 52 healthy young women. Analyses positively linked chronic physical activity level (CPAL) with anterior frontal oxygenated hemoglobin and cognitive inhibitory control, indicating regular physical activity may lead to hemodynamic and cognitive benefits, even in a cohort at developmental peak. In addition, higher anterior frontal oxygenated hemoglobin was linked to better performance for the most difficult cognitive task. Given the importance of oxygen availability for cognitive functioning, the current discovery of a relationship with CPAL may provide important insight toward understanding exercise-cognition links.

3. Dutta et al. (2015). **EEG-NIRS based assessment of neurovascular coupling during anodal transcranial direct current stimulation--a stroke case series**

Abstract: A method for electroencephalography (EEG) - near-infrared spectroscopy (NIRS) based assessment of neurovascular coupling (NVC) during anodal transcranial direct current stimulation (tDCS). Anodal tDCS modulates cortical neural activity leading to a hemodynamic response, which was used to identify impaired NVC functionality. In this study, the hemodynamic response was estimated with NIRS. NIRS recorded changes in

oxy-hemoglobin (HbO2) and deoxy-hemoglobin (Hb) concentrations during anodal tDCS-induced activation of the cortical region located under the electrode and in-between the light sources and detectors. Anodal tDCS-induced alterations in the underlying neuronal current generators were also captured with EEG. Then, a method for the assessment of NVC underlying the site of anodal tDCS was proposed that leverages the Hilbert-Huang Transform. The case series including four chronic (>6 months) ischemic stroke survivors (3 males, 1 female from age 31 to 76) showed non-stationary effects of anodal tDCS on EEG that correlated with the HbO2 response. Here, the initial dip in HbO2 at the beginning of anodal tDCS corresponded with an increase in the log-transformed mean-power of EEG within 0.5Hz-11.25Hz frequency band. The cross-correlation coefficient changed signs but was comparable across subjects during and after anodal tDCS. The log-transformed mean-power of EEG lagged HbO2 response during tDCS but then led post-tDCS. This case series demonstrated changes in the degree of neurovascular coupling to a 0.526 A/m(2) square-pulse (0-30 s) of anodal tDCS. The initial dip in HbO2 needs to be carefully investigated in a larger cohort, for example in patients with small vessel disease.

4. Quan (2015). **Reduced prefrontal activation during a verbal fluency task in Chinese-speaking patients with schizophrenia as measured by near-infrared spectroscopy**

Abstract: Near-infrared spectroscopy (NIRS) has been applied to examine the possible functional alternations during the performance of cognitive tasks in schizophrenia. With this technique, previous studies have observed that patients with schizophrenia are often associated with reduced brain activation in the prefrontal cortex during the verbal fluency task (VFT) of the English version or the Japanese version. However, it remains unclear whether there is a brain functional impairment in Chinese-speaking patients with schizophrenia. In this study, we designed a Chinese version of the VFT and performed a multichannel NIRS study in a large group of patients with schizophrenia and healthy controls. We investigated brain activation during the task period of the Chinese version of the VFT within a schizophrenia group and a healthy group, respectively, and compared the relative changes between the two groups. Our results confirmed that Chinese-speaking patients with schizophrenia had significantly lower brain activation in the prefrontal cortex and superior temporal cortex when compared with healthy controls. Such findings based on the NIRS data provided us reliable evidences about brain functional deficits in the Chinese-speaking patients with schizophrenia.

5. Jung (2015). **Activation patterns of different brain areas during incremental exercise measured by near-infrared spectroscopy**

Abstract: Recent studies postulated that increased oxygenation of the prefrontal cortex (PFC) during elevating exercise intensities reflects a specific activation of this region. Furthermore, the drop in PFC oxygenation often measured shortly before exhaustion is interpreted as a main factor limiting exercise. Nevertheless, a limitation of these studies is that they often measured NIRS only in the PFC. Within this study, we hypothesized that these findings are not region specific but rather result from systemic blood redistribution to the working skeletal muscle. NIRS was measured in three different brain regions and the working skeletal muscle during incremental cycling till exhaustion in nine healthy men. Oxygenated hemoglobin of the PFC increased from low to submaximal intensities and leveled off at maximal intensities. There was no drop in PFC oxygenation before exercise abortion. Interestingly, the occipital cortex was unaffected during exercise, while the motor cortex showed an increasing deoxygenation with elevating exercise intensities, just as observed in the skeletal muscle. In conclusion, this study does not support the notion that PFC deoxygenation is involved in the limitation of maximum exercise capacity. Against the hypothesis, the NIRS signals of the other cortices differed clearly, indicating that the previously reported findings indeed represent region-specific activations.

6. Boezeman (2015). **Spinal Near-Infrared Spectroscopy Measurements During and After Thoracoabdominal Aortic Aneurysm Repair: A Pilot Study**

Abstract: Background: Near-infrared spectroscopy (NIRS) is a noninvasive technique that allows continuous monitoring of regional hemoglobin oxygen saturation (rSo2). We evaluated its application to survey oxygenation of the spinal cord region during open thoracoabdominal aortic aneurysm (TAAA) repair and postoperatively in the intensive care unit (ICU). We also validated its association with motor-evoked potential (MEP) monitoring during the operation.
Methods: The rSo2 curves of 15 patients (8 men; mean age, 64.2 ± 7.7 years) were measured continuously with NIRS at spinal cord levels of the thoracic vertebrae T3 (optode 1, reference spot) and T12 (optode 2) during open TAAA repair. T12/T3 ratios were calculated. NIRS measurements were continued in the intensive care unit and stopped 24 hours after the operation. MEP monitoring was performed in all patients during the procedure.
Results: No clinical signs of spinal cord ischemia were documented in any of the patients. Continuous NIRS measurements were successfully performed in all patients during and after the operation. T12/T3 ratios were significantly lower in the MEP ratios that were less than 50% compared with the MEP ratios that were 50% or higher ($p = 0.037$).
Conclusions: NIRS is an easily applicable noninvasive tool for continuous surveillance of oxygenation of the spinal cord region during TAAA repair and postoperatively in the intensive care unit. The rSo2 curves provide useful information concerning hemodynamic changes in oxygenation of the spinal cord region and might contribute to early detection of spinal cord ischemia. Further investigation is needed before broad clinical implementation.

7. Di Domenico et al. (2015). **Decision-making conflict and the neural efficiency hypothesis of intelligence: A functional near-infrared spectroscopy investigation**

Abstract: Research on the neural efficiency hypothesis of intelligence (NEH) has revealed that the brains of more intelligent individuals consume less energy when performing easy cognitive tasks but more energy when engaged in difficult mental operations. However, previous studies testing the NEH have relied on cognitive tasks that closely resemble psychometric tests of intelligence, potentially confounding efficiency during intelligence-test performance with neural efficiency per se. The present study sought to provide a novel test of the NEH by examining patterns of prefrontal activity while participants completed an experimental paradigm that is qualitatively distinct from the contents of psychometric tests of intelligence. Specifically, participants completed a personal decision-making task (e.g., which occupation would you prefer, dancer or chemist?) in which they made a series of forced choices according to their subjective preferences. The degree of decisional conflict (i.e., choice difficulty) between the available response options was manipulated on the basis of participants' unique preference ratings for the target stimuli, which were obtained prior to scanning. Evoked oxygenation of the prefrontal cortex was measured using 16-channel continuous-wave functional near-infrared spectroscopy. Consistent with the NEH, intelligence predicted decreased activation of the right inferior frontal gyrus (IFG) during low-conflict situations and increased activation of the right-IFG during high-conflict situations. This pattern of right-IFG activity among more intelligent individuals was complemented by faster reaction times in high-conflict situations. These results provide new support for the NEH and suggest that the neural efficiency of more intelligent individuals generalizes to the performance of cognitive tasks that are distinct from intelligence tests.

8. Toricelli et al. (2015). **Neurophotonics: non-invasive optical techniques for monitoring brain functions**

Abstract: The aim of this review is to present the state of the art of neurophotonics, a recently founded discipline lying at the interface between optics and neuroscience. While neurophotonics also includes invasive techniques for animal studies, in this review we focus only on the non-invasive methods that use near infrared

light to probe functional activity in the brain, namely the fast optical signal, diffuse correlation spectroscopy, and functional near infrared spectroscopy methods. We also present an overview of the physical principles of light propagation in biological tissues, and of the main physiological sources of signal. Finally, we discuss the open issues in models, instrumentation, data analysis and clinical approaches.

9. Ohtani et al. (2015). **Association between longitudinal changes in prefrontal hemodynamic responses and social adaptation in patients with bipolar disorder and major depressive disorder**

Abstract: Background: Patients with affective disorders exhibit changes in regional brain function and show abnormal social adaptation. However, to our knowledge, no near-infrared spectroscopy (NIRS) study has examined the relationship between these two phenomena longitudinally. This study examined the region-specific functional abnormality associated with bipolar disorder (BD) and major depressive disorder (MDD), and the association between particular longitudinal changes in regional activation and social adaptation.
Methods: We evaluated frontotemporal functioning during a verbal fluency test (VFT) for patients with BD (N=18), those with MDD (N=10), and healthy controls (HCs; N=14) using NIRS. NIRS measurements and the Social Adaptation Self-evaluation Scale (SASS) were administered twice with an interval of approximately 6 months.
Results: The BD and MDD groups showed lesser activation than the HCs in the bilateral ventro-lateral prefrontal cortex and the anterior part of the temporal cortex (VLPFC/aTC). Longitudinal changes in SASS scores were positively associated with the extent of change in left VLPFC/aTC activation in the BD group and with right VLPFC/aTC activation in the MDD group.
Limitations: Our small sample size limited statistical power, and the effect of medication and multiple comparisons cannot be excluded, although these effects were considered in the interpretation of the present results.
Conclusion: Longitudinal increases of VLPFC/aTC activation were associated with improvement in social adaptation in patients with BD and those with MDD. NIRS measurement could be a useful tool for objective evaluation of changes in social adaptation in BD and MDD.

10. Maidan et al. (2015). **Changes in oxygenated hemoglobin link freezing of gait to frontal activation in patients with Parkinson disease: an fNIRS study of transient motor-cognitive failures**

Abstract: Recent studies have suggested that deficits in executive function contribute to freezing of gait (FOG), an episodic disturbance common among patients with Parkinson's disease (PD). To date, most findings provide only indirect evidence of this relationship. Here, we evaluated a more direct link between FOG and frontal lobe dysfunction. Functional, near infrared spectroscopy measured frontal activation, i.e., oxygenated hemoglobin (HbO2) levels in Brodmann area 10 before and during FOG. Eleven patients with PD and eleven healthy older adults were studied. Changes in frontal lobe activation before and during FOG that occurred during turns were determined. Altogether, 49 FOG episodes were observed—28 occurred during turns that were anticipated (i.e., the patient knew in advance that the turn was coming), 21 during unanticipated turns that were performed "abruptly", according to the examiner's request. During anticipated turns, HbO2 increased by 0.22 ± 0.08 μM ($p = 0.004$) before FOG and by an additional 0.19 ± 0.13 μM ($p = 0.072$) during FOG. In contrast, during unanticipated turns, HbO2 did not increase before or during FOG. HbO2 decreased by 0.32 ± 0.08 μM ($p = 0.004$) during turns without FOG; in healthy controls HbO2 did not change during turns. These findings support the existence of an association between FOG episodes and changes in frontal lobe HbO2. Increased activation in Brodmann area 10 before FOG, specifically during anticipated turns, highlights the connections between motor planning, information processing, and FOG. These results support the idea that alterations in executive control play a role in this debilitating motor disturbance.

11. Kamrani et al. (2015). **A Low-Power Photon-Counter Front-End Dedicated to NIRS Brain Imaging**

Abstract: This paper introduces a new miniaturized on-chip photodetector front-end targeted for portable near infrared spectroscopy as a noninvasive tool for real-time brain imaging. It includes silicon avalanche photodiodes (SiAPDs) with dual detection modes using a transimpedance amplifier (TIA) with on-chip gain/bias control, and a controllable mixed (active–passive) quench circuit, with tunable hold-off time, and a novel gated quench-reset technique. This integrated photoreceiver front-end has been fabricated using submicrometer standard CMOS technologies with a minimum fill-factor of 95%. Fabricated SiAPDs exhibit avalanche gains of 35 and 22 at 10 and 18 V bias voltages with red-shifted peak photon-detection efficiency and dark count-rates of 114 and 4 kHz (at 1 V excess bias voltage). The TIA consumes 1-mW power, and offers a transimpedance gain of 250 MV/A, a tunable bandwidth (1 kHz–1 GHz), and an input current referred noise <10 fA/ Hz at 1 kHz. The photon-counter exhibits a quench-time of 10 ns with a 0.4-mW power-consumption with an adaptive hold-off time control. The on-chip integration of SiAPDs and front-end circuit, reduced the power-consumption and after-pulsing, and increased the sensitivity.

12. Eggebrecht et al. (2015). **Mapping distributed brain function and networks with diffuse optical tomography**

Abstract: Mapping of human brain function has revolutionized systems neuroscience. However, traditional functional neuroimaging by positron emission tomography or functional magnetic resonance imaging cannot be used when applications require portability, or are contraindicated because of ionizing radiation (positron emission tomography) or implanted metal (functional magnetic resonance imaging). Optical neuroimaging offers a non-invasive alternative that is radiation free and compatible with implanted metal and electronic devices (for example, pacemakers). However, optical imaging technology has heretofore lacked the combination of spatial resolution and wide field of view sufficient to map distributed brain functions. Here, we present a high-density diffuse optical tomography imaging array that can map higher-order, distributed brain function. The system was tested by imaging four hierarchical language tasks and multiple resting-state networks including the dorsal attention and default mode networks. Finally, we imaged brain function in patients with Parkinson's disease and implanted deep brain stimulators that preclude functional magnetic resonance imaging.

13. Cui et al. (2015). **Sensitivity of fNIRS measurement to head motion: An applied use of smartphones in the lab**

Abstract: Background: Powerful computing capabilities in small, easy to use hand-held devices have made smart technologies such as smartphones and tablets ubiquitous in today's society. The capabilities of these devices provide scientists with many tools that can be used to improve the scientific method.
Method: Here, we demonstrate how smartphones may be used to quantify the sensitivity of functional near-infrared spectroscopy (fNIRS) signal to head motion. By attaching a smartphone to participants' heads during the fNIRS scan, we were able to capture data describing the degree of head motion.
Results: Our results demonstrate that data recorded from an off-the-shelf smartphone accelerometer may be used to identify correlations between head-movement and fNIRS signal change. Furthermore, our results identify correlations between the magnitudes of head-movement and signal artifact, as well as a relationship between the direction of head movement and the location of the resulting signal noise.
Conclusions: These data provide a valuable proof-of-concept for the use of off-the-shelf smart technologies in neuroimaging applications.

14. Cheng et al. (2015). **Synchronous brain activity during cooperative exchange depends on gender of partner: A fNIRS-based hyperscanning study**

Abstract: Previous studies have shown that brain activity between partners is synchronized during cooperative exchange. Whether this neural synchronization depends on the gender of partner (i.e., opposite or same to the participant) is open to be explored. In current study, we used functional near-infrared spectroscopy (fNIRS) based hyperscanning to study cooperation in a two-person game (female–female, female–male, and male–male) while assaying brain-to-brain interactions. Cooperation was greater in male–male pairs than in female–female pairs, with intermediate cooperation levels for female–male pairs. More importantly, in dyads with partners with opposite gender (female–male pairs), we found significant task-related cross-brain coherence in frontal regions (i.e., frontopolar cortex, orbitofrontal cortex, and left dorsolateral prefrontal cortex) whereas the cooperation in same gender dyads (female–female pairs and male–male pairs) was not associated with such synchronization. Moreover, the changes of such interbrain coherence across task blocks were significantly correlated with change in degree of cooperation only in mixed-sex dyads. These findings suggested that different neural processes underlie cooperation between mixed-sex and same-sex dyadic interactions.

15. Azuma et al. (2015). **Assessment of cerebral blood flow in patients with multiple chemical sensitivity using near-infrared spectroscopy—recovery after olfactory stimulation: a case–control study**

Abstract: Objectives: Multiple chemical sensitivity (MCS) is a chronic acquired disorder characterized by non-specific symptoms in multiple organ systems associated with exposure to odorous chemicals. We previously observed significant activations in the prefrontal cortex (PFC) during olfactory stimulation using several different odorants in patients with MCS by near-infrared spectroscopy (NIRS) imaging. We also observed that the patients with MCS did not adequately distinguish non-odorant in the late stage of the repeated olfactory stimulation test. The sensory recovery of the olfactory system in the patients with MCS may process odors differently from healthy subjects after olfactory stimulation.
Methods: We examined the recovery process of regional cerebral blood flow (rCBF) after olfactory stimulation in patients with MCS. NIRS imaging was performed in 6 patients with MCS and in 6 controls. The olfactory stimulation test was continuously repeated 10 times. The study also included a subjective assessment of the physical and psychological status and of the perception of irritating and hedonic odors.
Results: After olfactory stimulation, significant activations were observed in the PFC of patients with MCS on both the right and left sides compared with controls. The activations were specifically strong in the orbitofrontal cortex (OFC). Compared with controls, autonomic perception and feelings identification were poorer in patients with MCS. OFC is associated with stimuli response and the representation of preferences.
Conclusions: These results suggest that a past strong exposure to hazardous chemicals activates the PFC during olfactory stimuli in patients with MCS, and a strong activation in the OFC remains after the stimuli.

16. Trafidlo et al. (2015). **Intraoperative monitoring of cerebral NIRS oximetry leads to better postoperative cognitive performance: A pilot study**

Abstract: Objectives: The aim of this study is the assessment of the regional cerebral oximetry – NIRS (near infrared spectroscopy) as an intraoperative monitoring system to protect the patient against the incidents of brain desaturations. We hypothesize that patients monitored with NIRS present a smaller range of postoperative cognitive dysfunctions (POCD) in comparison with those without NIRS monitoring during lumbar spine surgery in a prone position.
Settings: This study was performed at the Clinical Department of Neurosurgery and Oncology of the Central Nervous System, Medical University of Lodz, Poland.
Participants: The study completed 43 adult patients qualified for the surgical treatment of lumbar spondylosis. Before the procedures they were randomized into two subgroups: one monitored intraoperatively by means of

NIRS cerebral oximetry (INVOS 5100), which numbered 13 patients – 30.2% (13 NIRS devices were made available to the authors) and the other without NIRS intraoperative monitoring, totaling 30 people – 69.8%. The patients who presented a history of psychiatric, neurological and cardiovascular disorders which impair cognitive processes were disqualified from the study.
Primary and secondary outcome measures: A comprehensive battery of neuropsychological tests was preoperatively performed on all patients. The subjects were then divided into two groups: with and without NIRS monitoring. Both groups were statistically homogeneous. Computerized anesthesia records were used to obtain intraoperative data: mean arterial pressure, heart rate, pulsoximetry and cerebral regional oxygenation. The depth of anesthesia monitor was not used. Besides, all the patients passed the same battery of neurocognitive tests 7 days and 1 month postoperatively. The Mann–Whitney test was performed to compare POCD and therefore assess the usefulness of NIRS as a monitoring mechanism during anesthesia in the prone position.
Results: There was a significant ($p < 0.05$) difference in the presence of cognitive deficiencies between the subgroup monitored with NIRS and the subgroup without NIRS. It included: Digit Span Test overall score and forward repetition score 7 days after operation, N- back Test results after 30 days in version 0 "back" – time, N-back Test version 1 "back" results in the number of correct answers and the number of errors.
Conclusions: NIRS cerebral oximetry may be useful in reducing postoperative cognitive complications in patients operated on in the prone positioning.

17. Nakamura et al. (2015). **Cerebral blood volume measurement using near-infrared time-resolved spectroscopy and histopathological evaluation after hypoxic-ischemic insult in newborn piglets**

Abstract: The aim of this study was to assess the relationship between the cerebral blood volume (CBV) measured by near-infrared time-resolved spectroscopy (TRS) and pathological change of the brain in a hypoxic-ischemic (HI) piglet model.
Twenty-one anesthetized newborn piglets, including three sham controls, were studied. An HI event was induced by low inspired oxygen. CBV was measured using TRS (Hamamatsu TRS-10). Data were collected before, during, and 6 h after the insult. CBV was calculated as the change from the end of the insult. The piglets were allowed to recover from anesthesia for 6 h after the insult. At the age of 5 days, the brains of the piglets were perfusion-fixed, and histologic evaluations of brain tissue were performed. The extent of histopathological damage was graded in 0.5-unit intervals on a 9-step scale. CBV increments were well correlated with histopathological scores, especially at 1 and 3 h after resuscitation. Spearman's rank-correlation coefficients at 1, 3, and 6 h after resuscitation in the gray matter were 0.9016, 0.9127, and 0.6907, respectively.
We conclude that an increased CBV after HI insult indicates more marked histological brain damage. CBV measurement immediately after resuscitation provides a more precise prediction of the histological outcome.

18. Balconi et al. (2015). **What hemodynamic (fNIRS), electrophysiological (EEG) and autonomic integrated measures can tell us about emotional processing**

Abstract: Due to its fast temporal evolution and its representation and integration among complex and widespread neural networks, the emotion perception process should preferably be examined by means of multimethodological approach. Indeed the indubitable vantage of acquiring both the autonomic (arousal-related) and the central (cortical-related) activities stands in the possibility to better elucidate the reciprocal interplay of the two compartments. In the present study EEG (frequency band analysis), systemic SCR and heart rate (HR) were all recorded simultaneously with hemodynamic (NIRS, Near-Infrared Spectroscopy) measurements as potential biological markers of emotions, related to both central and peripheral systems. These multiple measures were then related to the self-report correlates, that is the subjective appraisal in term of valence (positive vs. negative) and arousal (high vs. low) by using SAM rating. Twenty subjects were submitted to emotional cues processing (IAPS) when fNIRS, frequency bands (alpha, beta, delta, theta), SCR and HR were

recorded. As shown by O2Hb increasing within the right hemisphere, the contribution of prefrontal cortex was elucidated, by pointing out a relevant lateralization effect (more right-PFC activity) induced by the specific valence (negative) of the emotional patterns. Secondly, EEG activity (mainly low-frequency theta and delta bands) was intrinsically associated with the cortical hemodynamic responsiveness to the negative emotional patterns, within the right side. Finally SCR increased mainly in response to negative patterns, and the autonomic behavior was related to explicit (SAM) and cortical (NIRS; EEG) activity. The intrinsic relationships between these three different levels are discussed.

19. Tak et al. (2015). **Dynamic causal modelling for functional near-infrared spectroscopy**

Abstract: Functional near-infrared spectroscopy (fNIRS) is an emerging technique for measuring changes in cerebral hemoglobin concentration via optical absorption changes. Although there is great interest in using fNIRS to study brain connectivity, current methods are unable to infer the directionality of neuronal connections. In this paper, we apply Dynamic Causal Modelling (DCM) to fNIRS data. Specifically, we present a generative model of how observed fNIRS data are caused by interactions among hidden neuronal states. Inversion of this generative model, using an established Bayesian framework (variational Laplace), then enables inference about changes in directed connectivity at the neuronal level. Using experimental data acquired during motor imagery and motor execution tasks, we show that directed (i.e., effective) connectivity from the supplementary motor area to the primary motor cortex is negatively modulated by motor imagery, and this suppressive influence causes reduced activity in the primary motor cortex during motor imagery. These results are consistent with findings of previous functional magnetic resonance imaging (fMRI) studies, suggesting that the proposed method enables one to infer directed interactions in the brain mediated by neuronal dynamics from measurements of optical density changes.

20. Haigh et al. (2015). **Cortical excitability and the shape of the haemodynamic response**

Abstract: Individual differences in the temporal dynamics of the haemodynamic response can reflect cortical excitation and can reveal underlying cortical physiology. Here, we show differences in the shape of the haemodynamic response that are dependent on stimulus parameters. Two sets of visual stimuli were used varying in parameters that are known to manipulate the haemodynamic response in the visual cortex. We measured the oxyhaemoglobin response using near infrared spectroscopy. The first set of stimuli comprised chromatic square-wave gratings that varied with respect to the separation in the CIE UCS chromaticities of the alternating bars. The gratings with large separations in chromaticity evoked an oxyhaemoglobin response with greater amplitude, consistent with greater activation of the visual cortex. The second set of stimuli comprised horizontal achromatic gratings that (1) were static, (2) drifted at a constant velocity towards fixation, or (3) reversed direction every half spatial cycle to create a vertical vibrating motion. Although the three types of grating had a similar effect on the amplitude of the oxyhaemoglobin response, the moving gratings (2 and 3) evoked a steeper decrease in oxyhaemoglobin concentration after stimulus-offset. The steeper slope appears to reflect the post-stimulus undershoot and the slope may provide a correlate of cortical excitability when the amplitude of the haemodynamic response has saturated.

21. Helmich et al. (2015). **Brain oxygenation patterns during the execution of tool use demonstration, tool use pantomime, and body-part-as-object tool use**

Abstract: Divergent findings exist whether left and right hemispheric pre- and postcentral cortices contribute to the production of tool use related hand movements. In order to clarify the neural substrates of tool use demonstrations with tool in hand, tool use pantomimes without tool in hand, and body-part-as-object presentations of tool use (BPO) in a naturalistic mode of execution, we applied functional Near InfraRed Spectroscopy (fNIRS) in twenty-three right-handed participants. Functional NIRS techniques allow for the

investigation of brain oxygenation during the execution of complex hand movements with an unlimited movement range. Brain oxygenation patterns were retrieved from 16 channels of measurement above pre- and postcentral cortices of each hemisphere. The results showed that tool use demonstration with tool in hand leads to increased oxygenation as compared to tool use pantomimes in the left hemispheric somatosensory gyrus. Left hand executions of the demonstration of tool use, pantomime of tool use, and BPO of tool use led to increased oxygenation in the premotor and somatosensory cortices of the left hemisphere as compared to right hand executions of either condition. The results indicate that the premotor and somatosensory cortices of the left hemisphere constitute relevant brain structures for tool related hand movement production when using the left hand, whereas the somatosensory cortex of the left hemisphere seems to provide specific mental representations when performing tool use demonstrations with the tool in hand.

22. Chiarelli et al. (2015). **A kurtosis-based wavelet algorithm for motion artifact correction of fNIRS data**

Abstract: Movements are a major source of artifacts in functional Near-Infrared Spectroscopy (fNIRS). Several algorithms have been developed for motion artifact correction of fNIRS data, including Principal Component Analysis (PCA), targeted Principal Component Analysis (tPCA), Spline Interpolation (SI), and Wavelet Filtering (WF). WF is based on removing wavelets with coefficients deemed to be outliers based on their standardized scores, and it has proven to be effective on both synthetized and real data. However, when the SNR is high, it can lead to a reduction of signal amplitude. This may occur because standardized scores inherently adapt to the noise level, independently of the shape of the distribution of the wavelet coefficients. Higher-order moments of the wavelet coefficient distribution may provide a more diagnostic index of wavelet distribution abnormality than its variance. Here we introduce a new procedure that relies on eliminating wavelets that contribute to generate a large fourth-moment (i.e., kurtosis) of the coefficient distribution to define "outliers" wavelets (kurtosis-based Wavelet Filtering, kbWF). We tested kbWF by comparing it with other existing procedures, using simulated functional hemodynamic responses added to real resting-state fNIRS recordings. These simulations show that kbWF is highly effective in eliminating transient noise, yielding results with higher SNR than other existing methods over a wide range of signal and noise amplitudes. This is because: (1) the procedure is iterative; and (2) kurtosis is more diagnostic than variance in identifying outliers. However, kbWF does not eliminate slow components of artifacts whose duration is comparable to the total recording time.

23. Alexandre et al. (2015). **Cortical motor output decreases after neuromuscular fatigue induced by electrical stimulation of the plantar flexor muscles**

Abstract: Aim: Neuromuscular electrical stimulation (NMES) causes early onset of neuromuscular fatigue. Peripheral electrophysiological explorations suggest that supra-spinal alterations are involved through sensitive afferent pathways. As sensory input is projected over the primary somatosensory cortex (S1), S1 area involvement in inhibiting the central motor drive can be hypothesized. This study assessed cortical activity under a fatiguing NMES protocol at low frequency.
Methods: Twenty healthy males performed five NMES sequences of 17 trains over the plantar flexors (30 Hz, 4 s on/6 s off). Before and after each sequence, neuromuscular tests composed of maximal voluntary contractions (MVCs) were carried out. Cortical activity was assessed during MVCs with functional near-infrared spectroscopy over S1 and primary motor (M1) areas, through oxy- [HbO] and deoxy-haemoglobin [HbR] variation. Electrophysiological data (H-reflex during MVC, EMG activity and level of voluntary activation) were also recorded.
Results: MVC torque significantly decreased after the first 17 NMES trains ($P < 0.001$). The electrophysiological data were consistent with supra-spinal alterations. In addition, [HbO] declined significantly during the protocol over the S1 and M1 areas from the first 17 NMES trains ($P < 0.01$ and $P < 0.001$ respectively), while [HbR] increased ($P < 0.05$ and $P < 0.01$ respectively), indicating early decline in cortical activity over both primary cortical areas.

Conclusions: The declining cortical activity over the M1 area is highly consistent with the electrophysiological findings and supports motor cortex involvement in the loss of force after a fatiguing NMES protocol. In addition, the declining cortical activity over the S1 area indicates that the decreased motor output from M1 is not due to increased S1 inhibitory activity.

24. Holtzer et al. (2015). **Online fronto-cortical control of simple and attention-demanding locomotion in humans**

Abstract: Knowledge of online functional brain mechanisms of locomotion is scarce due to technical limitations of traditional neuroimaging methods. Using functional Near Infrared Spectroscopy (fNIRS) we evaluated task-related changes in oxygenated hemoglobin levels (HbO2) in real-time over the pre-frontal-cortex (PFC) regions during simple (Normal Walk; NW) and attention-demanding (Walking While Talking; WWT) locomotion tasks in a large cohort of non-demented older adults. Results revealed that the assessment of task-related changes in HbO2 was internally consistent. Imposing greater demands on the attention system during locomotion resulted in robust bilateral PFC increases in HbO2 levels during WWT compared to NW and the cognitive interference tasks. Elevated PFC oxygenation levels were maintained throughout the course of WWT but not during the NW condition. Increased oxygenation levels in the PFC were related to greater stride length and better cognitive performance but not to faster gait velocity in WWT. These findings elucidate online brain mechanisms of locomotion, and confer significant implications for risk assessment and intervention for major mobility outcomes.

25. Tytgat et al. (2015). **Brain Oxygenation During Laparoscopic Correction of Hypertrophic Pyloric Stenosis**

Abstract: Background: Concern remains about the safety of carbon dioxide (CO2) pneumoperitoneum (PP) in young infants having surgery for pyloric stenosis via laparoscopy. Interests here mainly focus on possible jeopardized organ perfusion and in particular brain oxygenation with possible adverse neurodevelopmental outcomes. The aim of this study was to investigate the intraoperative effects of CO2 gas PP on cerebral oxygenation during laparoscopic surgery for hypertrophic pyloric stenosis in young infants.
Patients and Methods: In this single-center prospective observational study, we investigated brain oxygenation in 12 young infants receiving laparoscopic pyloromyotomy with CO2 PP, with a pressure of 8 mm Hg and a flow rate of 5 L/minute. Intraoperative hemodynamic parameters and transcranial near-infrared spectroscopy to assess regional cerebral oxygen saturation (rScO2) were monitored continuously during the whole procedure. Parameters were analyzed in four intervals: before insufflation (T0), during (start [T1] and end [T2]), and after cessation (T3) of the CO2 PP.
Results: Blood pressure and end-tidal CO2 (etCO2) increased during the procedure: mean arterial pressure, 35±5 mm Hg at T0 to 43±9 mm Hg at T2; etCO2, 35±4 mm Hg at T0 to 40±3 mm Hg at T3. The rScO2 remained stable throughout the whole anesthetic period. In none of the patients did the rScO2 drop below the safety threshold of 55% (rScO2, 68±14% at T0 to 71±9% at T3).
Conclusions: Our results indicate that a laparoscopic procedure with a CO2 PP of 8 mm Hg can be performed under safe anesthetic conditions in the presence of gradually increasing blood pressure and etCO2 without altering regional brain oxygenation levels.

26. Zhang et al. (2015). **A Biphasic Change of Regional Blood Volume in the Frontal Cortex During Non-rapid Eye Movement Sleep: A Near-Infrared Spectroscopy Study**

Abstract: Study Objectives: Current knowledge on hemodynamics in sleep is limited because available techniques do not allow continuous recordings and mainly focus on cerebral blood flow while neglecting other important parameters, such as blood volume (BV) and vasomotor activity.
Design: Observational study.

Participants and Settings: Continuous measures of hemodynamics over the left forehead and biceps were performed using near-infrared spectroscopy (NIRS) during nocturnal polysomnography in 16 healthy participants in sleep laboratory.
Measurements and Results: Temporal dynamics and mean values of cerebral and muscular HbO2, HHb, and BV during different sleep stages were compared. A biphasic change of cerebral BV was observed which contrasted a monotonic increase of muscular BV during non-rapid eye movement sleep. A significant decrement in cerebral oxygenated hemoglobin (HbO2) and BV accompanied by an increase of deoxygenated hemoglobin (HHb) was recorded at sleep onset (Phase I). Prior to slow wave sleep (SWS) HbO2 and BV turned to increase whereas HHb began to decrease in subsequent Phase II suggested increased brain perfusion during SWS. The cerebral HbO2 slope correlated to BV slope in Phase I and II, but it only correlated to HHb slope in Phase II. The occurrence time of infection points correlated to SWS latencies.
Conclusion: Initial decrease of brain perfusion with decreased BV and HbO2 together with increasing muscular BV fit thermoregulation process at sleep onset. The uncorrelated and correlated slopes of HbO2 and HHb indicate different mechanisms underlying the biphasic hemodynamic process in light sleep and SWS. In SWS, changes in vasomotor activity (i.e., increased vasodilatation) may mediate increasing cerebral and muscular BV.

27. Kreplin et al. (2015). **Effects of self-directed and other-directed introspection and emotional valence on activation of the rostral prefrontal cortex during aesthetic experience**

Abstract: The medial area of the rostral prefrontal cortex (rPFC) has been implicated in self-relevant processing, autobiographical memory and emotional processing, including the processing of pleasure during aesthetic experiences. The goal of this study was to investigate changes in rPFC activity using functional near-infrared spectroscopy (fNIRS) in response to affective stimuli viewed in a self-relevant or other-relevant context. Positive and negative images were displayed to 20 participants under two viewing conditions where participants were asked to think of their own emotions (self) or think about the emotions of the artist who created the work (other). The results revealed an increase of HbO when participants viewed images during the other-condition compared to the self-condition. It was concluded that viewing stimuli from the perspective of another was associated with an increase of cognitive demand. The analysis of deoxygenated haemoglobin (HHb) at right hemispheric areas revealed that activation of the rPFC during the other-condition was specific to the negative images. When images were viewed from the perspective of the self, activation of the rPFC significantly increased at the right-medial area of the rPFC for positive images. Our findings indicate that the influence of valence on rPFC activation during aesthetic experience is contingent on the context of the viewing experience and there is a bias towards positive emotion when images are viewed from the context of the self.

28. Piper et al. (2015). **Autonomic and prefrontal events during moral elevation**

Abstract: Moral elevation, or elevation, is a specific emotional state triggered by witnessing displays of profound virtue and moral beauty. This study set out to characterize the physiology underlying elevation with measurements of heart rate (HR), respiratory sinus arrhythmia (RSA), and medial prefrontal cortex (mPFC) activity. During elevation, HR and RSA increased. These findings illustrate that elevation involves an uncommon combination of both sympathetic and parasympathetic activation, which is present in circumstances where arousal and social engagement are both required. In addition, we show evidence of content-dependent alterations of mPFC activity during elevation peaks. Altogether, this study shows that the induction of moral elevation recruits an uncommon autonomic and neural pattern that is consistent with previous understanding of socioemotional-induced allostasis.

29. Rickards et al. (2015). **Coupling between arterial pressure, cerebral blood velocity, and cerebral tissue oxygenation with spontaneous and forced oscillations**

Abstract: We tested the hypothesis that transmission of arterial pressure to brain tissue oxygenation is low under conditions of arterial pressure instability. Two experimental models of hemodynamic instability were used in healthy human volunteers; (1) oscillatory lower body negative pressure (OLBNP) (N = 8; 5 male, 3 female), and; (2) maximal LBNP to presyncope (N = 21; 13 male, 8 female). Mean arterial pressure (MAP), middle cerebral artery velocity (MCAv), and cerebral tissue oxygen saturation (ScO2) were measured non-invasively. For the OLBNP protocol, between 0 and −60 mmHg negative pressure was applied for 20 cycles at 0.05 Hz, then 20 cycles at 0.1 Hz. For the maximal LBNP protocol, progressive 5 min stages of chamber decompression were applied until the onset of presyncope. Spectral power of MAP, mean MCAv, and ScO2 were calculated within the VLF (0.04–0.07 Hz), and LF (0.07–0.2 Hz) ranges, and cross-spectral coherence was calculated for MAP-mean MCAv, MAP-ScO2, and mean MCAv-ScO2 at baseline, during each OLBNP protocol, and at the level prior to pre-syncope during maximal LBNP (sub-max). The key findings are (1) both 0.1 Hz OLBNP and sub-max LBNP elicited increases in LF power for MAP, mean MCAv, and ScO2 ($p \leq 0.08$); (2) 0.05 Hz OLBNP increased VLF power in MAP and ScO2 only ($p \leq 0.06$); (3) coherence between MAP-mean MCAv was consistently higher (≥0.71) compared with MAP-ScO2, and mean MCAv-ScO2 (≤0.43) during both OLBNP protocols, and sub-max LBNP ($p \leq 0.04$). These data indicate high linearity between pressure and cerebral blood flow variations, but reduced linearity between cerebral tissue oxygenation and both arterial pressure and cerebral blood flow. Measuring arterial pressure variability may not always provide adequate information about the downstream effects on cerebral tissue oxygenation, the key end-point of interest for neuronal viability.

30. Winklewski et al. (2015). **Wavelet transform analysis to assess oscillations in pial artery pulsation at the human cardiac frequency**

Abstract: Pial artery adjustments to changes in blood pressure (BP) may last only seconds in humans. Using a novel method called near-infrared transillumination backscattering sounding (NIR-T/BSS) that allows for the non-invasive measurement of pial artery pulsation (cc-TQ) in humans, we aimed to assess the relationship between spontaneous oscillations in BP and cc-TQ at frequencies between 0.5 Hz and 5 Hz. We hypothesized that analysis of very short data segments would enable the estimation of changes in the cardiac contribution to the BP vs. cc-TQ relationship during very rapid pial artery adjustments to external stimuli.

BP and pial artery oscillations during baseline (70 s and 10 s signals) and the response to maximal breath-hold apnea were studied in eighteen healthy subjects. The cc-TQ was measured using NIR-T/BSS; cerebral blood flow velocity, the pulsatility index and the resistive index were measured using Doppler ultrasound of the left internal carotid artery; heart rate and beat-to-beat systolic and diastolic blood pressure were recorded using a Finometer; end-tidal CO2 was measured using a medical gas analyzer. Wavelet transform analysis was used to assess the relationship between BP and cc-TQ oscillations.

The recordings lasting 10 s and representing 10 cycles with a frequency of ~ 1 Hz provided sufficient accuracy with respect to wavelet coherence and wavelet phase coherence values and yielded similar results to those obtained from approximately 70 cycles (70 s). A slight but significant decrease in wavelet coherence between augmented BP and cc-TQ oscillations was observed by the end of apnea.

Wavelet transform analysis can be used to assess the relationship between BP and cc-TQ oscillations at cardiac frequency using signals intervals as short as 10 s. Apnea slightly decreases the contribution of cardiac activity to BP and cc-TQ oscillations.

31. Fanti et al. (2015). **Unemotional on all counts: Evidence of reduced affective responses in individuals with high callous-unemotional traits across emotion systems and valences**

Abstract: The current study aimed to identify atypical neurophysiological activity associated with deficient affective processing in individuals with high callous-unemotional traits (CU). Fifty-six participants (M age =

20.52; 46% male) divided in two groups, differentiated on levels of CU traits, were invited to participate in the experimental phase of the study. Medial prefrontal cortex activity, measured with functional Near-Infrared Spectroscopy, and facial electro-myography activity were recorded during videos depicting violent, comedy and neutral scenes. Individuals high on CU traits showed similar medial prefrontal cortex oxygenated hemoglobin (HbO2) activity to positive and negative films, while the pre-frontal cortical responses of low CU individuals were more pronounced to positive than negative materials. High CU participants also showed reduced facial electromyography at the corrugator muscle in response to violent films, which was not differentiated from their responses to comedy films. These findings suggest that individuals high on CU traits show reduced but not absent (i.e., flat) affect to emotional material. Deficits in processing positive and negative valent material, measured with different neuro-physiological modalities, might be essential to understand CU traits.

32. Moghimi et al. (2015). **Variability in Prefrontal Hemodynamic Response during Exposure to Repeated Self-Selected Music Excerpts, a Near-Infrared Spectroscopy Study**

Abstract: Music-induced brain activity modulations in areas involved in emotion regulation may be useful in achieving therapeutic outcomes. Clinical applications of music may involve prolonged or repeated exposures to music. However, the variability of the observed brain activity patterns in repeated exposures to music is not well understood. We hypothesized that multiple exposures to the same music would elicit more consistent activity patterns than exposure to different music. In this study, the temporal and spatial variability of cerebral prefrontal hemodynamic response was investigated across multiple exposures to self-selected musical excerpts in 10 healthy adults. The hemodynamic changes were measured using prefrontal cortex near infrared spectroscopy and represented by instantaneous phase values. Based on spatial and temporal characteristics of these observed hemodynamic changes, we defined a consistency index to represent variability across these domains. The consistency index across repeated exposures to the same piece of music was compared to the consistency index corresponding to prefrontal activity from randomly matched non-identical musical excerpts. Consistency indexes were significantly different for identical versus non-identical musical excerpts when comparing a subset of repetitions. When all four exposures were compared, no significant difference was observed between the consistency indexes of randomly matched non-identical musical excerpts and the consistency index corresponding to repetitions of the same musical excerpts. This observation suggests the existence of only partial consistency between repeated exposures to the same musical excerpt, which may stem from the role of the prefrontal cortex in regulating other cognitive and emotional processes.

33. Wakata et al. (2015). **Brain activity and the perception of self-agency while viewing a video of hand grasping: a functional near-infrared spectroscopy study**

Abstract: Self-agency is the recognition of one's own movement and plays a vital role in purposeful, voluntary movement. A sense of self-agency can be elicited in individuals who view their own simple finger movements as they are projected onto a screen and aligned with their actual hand position. Here, we examined whether individuals perceived self-agency when they viewed a video of a hand grasping a wooden cylinder and whether the perception of self-agency correlated with simultaneous changes in oxy-hemoglobin in the parietal or the prefrontal cortical areas. All participants reported the perception of self-agency, which was correlated with oxy-hemoglobin increases in the right prefrontal area. We conclude that self-agency also relates to hand-held objects displayed on video.

34. Pian et al. (2015). **Hyperspectral Single-Pixel Wide-Field Time Domain Diffuse Optical Tomography**

Abstract: We report on the instrumentation design and experimental validation of a hyperspectral single-pixel wide-field time-resolved diffuse optical tomography (DOT) system. Reconstruction results show quantification and cross-talk improvements in fluorophore concentration mapping in turbid media.

35. Drenckhahn et al. (2014). **A validation study of the use of near-infrared spectroscopy imaging in primary and secondary motor areas of the human brain**

Abstract: The electroencephalographically measured Bereitschafts (readiness)-potential in the supplementary motor area (SMA) serves as a signature of the preparation of motor activity. Using a multichannel, noninvasive near-infrared spectroscopy (NIRS) imager, we studied the vascular correlate of the readiness potential.
Sixteen healthy subjects performed a self-paced or externally triggered motor task in a single or repetitive pattern, while NIRS simultaneously recorded the task-related responses of deoxygenated hemoglobin (HbR) in the primary motor area (M1) and the SMA.
Right-hand movements in the repetitive sequence trial elicited a significantly greater HbR response in both the SMA and the left M1 compared to left-hand movements. During the single sequence condition, the HbR response in the SMA, but not in the M1, was significantly greater for self-paced than for externally cued movements. Nonetheless, an unequivocal temporal delay was not found between the SMA and M1.
Near-infrared spectroscopy is a promising, noninvasive bedside tool for the neuromonitoring of epileptic seizures or cortical spreading depolarizations (CSDs) in patients with epilepsy, stroke, or brain trauma because these pathological events are associated with typical spatial and temporal changes in HbR. Propagation is a characteristic feature of these events which importantly supports their identification and characterization in invasive recordings. Unfortunately, the present noninvasive study failed to show a temporal delay during self-paced movements between the SMA and M1 as a vascular correlate of the readiness potential. Although this result does not exclude, in principle, the possibility that scalp-NIRS can detect a temporal delay between different regions during epileptic seizures or CSDs, it strongly suggests that further technological development of NIRS should focus on both improved spatial and temporal resolution.

36. Racek et al. (2014). **Different Brain Responses to Pain and Its Expectation in the Dental Chair**

Abstract: A dental appointment commonly prompts fear of a painful experience, yet we have never fully understood how our brains react to the expectation of imminent tooth pain once in a dental chair. In our study, 21 patients with hypersensitive teeth were tested using nonpainful and painful stimuli in a clinical setting. Subjects were tested in a dental chair using functional near-infrared spectroscopy to measure cortical activity during a stepwise cold stimulation of a hypersensitive tooth, as well as nonpainful control stimulation on the same tooth. Patients' sensory-discriminative and emotional-cognitive cortical regions were studied through the transition of a neutral to a painful stimulation. In the putative somatosensory cortex contralateral to the stimulus, 2 well-defined hemodynamic peaks were detected in the homuncular orofacial region: the first peak during the nonpainful phase and a second peak after the pain threshold was reached. Moreover, in the upper-left and lower-right prefrontal cortices, there was a significant active hemodynamic response in only the first phase, before the pain. Subsequently, the same prefrontal cortical areas deactivated after a painful experience had been reached. Our study indicates for the first time that pain perception and expectation elicit different hemodynamic cortical responses in a dental clinical setting.

37. Mori et al. (2015). **Neuroimaging in autism spectrum disorders: ^{1}H-MRS and NIRS study**

Abstract: Using proton magnetic resonance spectroscopy (1H-MRS), we measured chemical metabolites in the left amygdala and the bilateral orbito-frontal cortex (OFC) in children with autism spectrum disorders (ASD). The concentrations of N-acetylaspartate (NAA) in these regions of ASD were significantly decreased compared to those in the control group. In the autistic patients, the NAA concentrations in these regions correlated with their social quotient. These findings suggest the presence of neuronal dysfunction in the amygdala and OFC in ASD. Dysfunction in the amygdala and OFC may contribute to the pathogenesis of ASD. We performed a near-infrared spectroscopy (NIRS) study to evaluate the mirror neuron system in children with ASD. The concentrations of oxygenated hemoglobin (oxy-Hb) were measured with frontal probes using a 34-channel NIRS machine while the subjects imitated emotional facial expressions. The increments in the concentration of oxy-Hb in the pars opercularis of the inferior frontal gyrus in autistic subjects were significantly lower than those in the controls. However, the concentrations of oxy-Hb in this area were significantly elevated in autistic subjects after they were trained to imitate emotional facial expressions. The results suggest that mirror neurons could be activated by repeated imitation in children with ASD.

38. Watanabe et al. (2015). **Prefrontal activation during two Japanese Stroop tasks revealed with multi-channel near-infrared spectroscopy**

Abstract: The Stroop task is sometimes used in psychiatric research to elicit prefrontal activity, which presumably reflects cognitive functioning. Although there are two Stroop tasks (Kana script and Kanji script) in Japan, it is unclear whether these tasks elicit the same hemoglobin changes. Moreover, it is unclear whether psychological conditions or characteristics influence hemoglobin changes in the Japanese Stroop task. The aim of this study was to clarify whether hemoglobin changes elicited by the two Japanese Stroop tasks accurately reflected cognitive functioning. Hemoglobin changes were measured with multi-channel near-infrared spectroscopy (NIRS) in 100 healthy Japanese participants performing two Japanese Stroop tasks. The Beck-Depression Inventory (BDI), State-Trait-Anxiety Inventory (STAI), and Maudsley Obsessive Compulsive Inventory (MOCI) were administered to participants to identify psychological conditions or personality characteristics. Compared with the Kanji task, the Kana task produced a greater Stroop effect and a larger increase in oxyhemoglobin (oxy-Hb) concentration. Moreover there were no significant correlations between oxy-Hb concentration and BDI, STAI-trait, STAI-state, or MOCI scores. Therefore we found that a participant's psychological conditions or characteristics did not influence the hemodynamic changes during either task. These data suggest the Kana Stroop task is more useful than the Kanji Stroop task for NIRS studies in psychiatric research.

39. Huang et al. (2015). **Predicting N2pc from anticipatory HbO activity during sustained visuospatial attention: A concurrent fNIRS–ERP study**

Abstract: Understanding the properties of attentional control, along with the neural mechanisms subserving them, has long invited intense scrutiny in research groups. However, it has not been demonstrated how the top-down anticipatory hemodynamic activation influences the subsequent attentional processing of targets and distractors. Here, with concurrent fNIRS–ERP recording, we explored the potential contribution of anticipatory oxygenated hemoglobin (HbO) based brain activity to attentional control by examining how HbO influences the subsequent ERP N2pc components assumed to reflect attentional selection. We found that expecting a target led to a larger increase of preparatory HbO response over the visual cortex contralateral to the upcoming target, which was positively correlated with the subsequent target-evoked N2pc amplitude. Further, anticipation concerning the presence of a competing distractor resulted in large and prolonged preparatory HbO signals in the visual cortex contralateral to the distractor, indicating that the salient distractor might be actively suppressed by preparatory top-down attentional control. However, the pre-suppressed distractor still captured part of the attention in the subsequent visual search as revealed by a decrease in the N2pc amplitude, and such

a distraction effect on N2pc was negatively correlated with preparatory HbO enhancement contralateral to the anticipated distractor. Overall, each individuals attentional shift to the target and resistance to the distractor measured by ERP is predictable in advance via anticipatory hemodynamic activity in the visual cortex measured by fNIRS.

40. Jiang et al. (2015). **Leader emergence through interpersonal neural synchronization**

Abstract: Great leaders are often great communicators. However, little is known about the neural basis of leader–follower communication. Only recently have neuroscientists been able to examine interpersonal neural synchronization (INS) between leaders and followers during social interactions. Here, we show that INS is significantly higher between leaders and followers than between followers and followers, suggesting that leaders emerge by synchronizing their brain activity with that of the followers. Moreover, the quality rather than frequency of the leaders' communications makes a significant contribution to the increase of INS. This result supports the "quality of communication" hypothesis in leader emergence. Finally, our results show that leadership can be predicted shortly after the onset of a task based on INS as well as communication behaviors.

41. Gateau et al. (2015). **Real-Time State Estimation in a Flight Simulator Using fNIRS**

Abstract: Working memory is a key executive function for flying an aircraft. This function is particularly critical when pilots have to recall series of air traffic control instructions. However, working memory limitations may jeopardize flight safety. Since the functional near-infrared spectroscopy (fNIRS) method seems promising for assessing working memory load, our objective is to implement an on-line fNIRS-based inference system that integrates two complementary estimators. The first estimator is a real-time state estimation MACD-based algorithm dedicated to identifying the pilot's instantaneous mental state (not-on-task vs. on-task). It does not require a calibration process to perform its estimation. The second estimator is an on-line SVM-based classifier that is able to discriminate task difficulty (low working memory load vs. high working memory load). These two estimators were tested with 19 pilots who were placed in a realistic flight simulator and were asked to recall air traffic control instructions. We found that the estimated pilot's mental state matched significantly better than chance with the pilot's real state (62% global accuracy, 58% specificity, and 72% sensitivity). The second estimator, dedicated to assessing single trial working memory loads, led to 80% classification accuracy, 72% specificity, and 89% sensitivity. These two estimators establish reusable blocks for further fNIRS-based passive brain computer interface development.

42. Yin et al. (2015). **A hybrid BCI based on EEG and fNIRS signals improves the performance of decoding motor imagery of both force and speed of hand clenching**

Abstract: Objective. In order to increase the number of states classified by a brain–computer interface (BCI), we utilized a motor imagery task where subjects imagined both force and speed of hand clenching. Approach. The BCI utilized simultaneously recorded electroencephalographic (EEG) and functional near-infrared spectroscopy (fNIRS) signals. The time-phase-frequency feature was extracted from EEG, whereas the HbD [the difference of oxy-hemoglobin (HbO) and deoxy-hemoglobin (Hb)] feature was used to improve the classification accuracy of fNIRS. The EEG and fNIRS features were combined and optimized using the joint mutual information (JMI) feature selection criterion; then the extracted features were classified with the extreme learning machines (ELMs). Main results. In this study, the averaged classification accuracy of EEG signals achieved by the time-phase-frequency feature improved by 7%, to 18%, more than the single-type feature, and improved by 15% more than common spatial pattern (CSP) feature. The HbD feature of fNIRS signals improved the accuracy by 1%, to 4%, more than Hb, HbO, or HbT (total hemoglobin). The EEG–fNIRS feature for decoding motor imagery of both force and speed of hand clenching achieved an accuracy of 89% ± 2%, and improved the accuracy by 1% to 5% more than the sole EEG or fNIRS feature. Significance. Our novel motor imagery paradigm improves BCI

performance by increasing the number of extracted commands. Both the time-phase-frequency and the HbD feature improve the classification accuracy of EEG and fNIRS signals, respectively, and the hybrid EEG–fNIRS technique achieves a higher decoding accuracy for two-class motor imagery, which may provide the framework for future multi-modal online BCI systems.

43. Miura et al. (2015). **Brain activation in parietal area during manipulation with a surgical robot simulator**

Abstract: Purpose: we present an evaluation method to qualify the embodiment caused by the physical difference between master–slave surgical robots by measuring the activation of the intraparietal sulcus in the user's brain activity during surgical robot manipulation. We show the change of embodiment based on the change of the optical axis-to-target view angle in the surgical simulator to change the manipulator's appearance in the monitor in terms of hand–eye coordination. The objective is to explore the change of brain activation according to the change of the optical axis-to-target view angle.
Methods: In the experiments, we used a functional near-infrared spectroscopic topography (f-NIRS) brain imaging device to measure the brain activity of the seven subjects while they moved the hand controller to insert a curved needle into a target using the manipulator in a surgical simulator. The experiment was carried out several times with a variety of optical axis-to-target view angles.
Results: Some participants showed a significant peak (P value = 0.037, F-number = 2.841) when the optical axis-to-target view angle was 75∘.
Conclusions: The positional relationship between the manipulators and endoscope at 75∘ would be the closest to the human physical relationship between the hands and eyes.

44. Duret et al. (2015). **Skeletal muscle oxygenation in severe trauma patients during haemorrhagic shock resuscitation**

Abstract: Introduction: Early alterations in tissue oxygenation may worsen patient outcome following traumatic haemorrhagic shock. We hypothesized that muscle oxygenation measured using near-infrared spectroscopy (NIRS) on admission could be associated with subsequent change in the SOFA score after resuscitation.
Methods: The study was conducted in two Level I trauma centres and included 54 consecutive trauma patients with haemorrhagic shock, presenting within 6 hours of injury. Baseline tissue haemoglobin oxygen saturation (StO2) in the thenar eminence muscle and StO2 changes during a vascular occlusion test (VOT) were determined at 6 hours (H6) and 72 hours (H72) after the admission to the emergency room. Patients showing an improved SOFA score at H72 (SOFA improvers) were compared to those for whom it was unchanged or worse (SOFA non-improvers).
Results: Of the 54 patients, 34 patients were SOFA improvers and 20 SOFA non-improvers. They had comparable injury severity scores on admission. SOFA improvers had higher baseline StO2 values and a steeper StO2 desaturation slope at H6 compared to the SOFA non-improvers. These StO2 variables similarly correlated with the intra-hospital mortality. The StO2 reperfusion slope at H6 was similar between the two groups of patients.
Conclusions: Differences in StO2 parameters on admission of traumatic haemorrhagic shock were found between patients who had an improvement in organ failure in the first 72 hours and those who had unchanged or worse conditions. The use of NIRS to guide the initial management of trauma patients with haemorrhagic shock warrants further investigations.

45. Closhen et al. (2015). **Changes in cerebral oxygen saturation following prone positioning for orthopaedic surgery under general anaesthesia: a prospective observational study**

Abstract: BACKGROUND: Prone positioning is often necessary in orthopaedic surgery. The prone position, however, may result in impaired cerebral venous drainage with a subsequent reduction in cerebral perfusion. As a consequence, cerebral hypoxia may occur with the potential for neurological impairment.
OBJECTIVE: We assessed the changes in cerebral oxygen saturation with near-infrared spectroscopy using two different monitors after positioning the patient from supine to prone.
DESIGN: Prospective observational study.
SETTING: Primary Care University Hospital, from May 2010 to February 2011.
PARTICIPANTS: Forty patients undergoing general anaesthetic procedures, of which 35 completed the investigation. Similar measurements were done in 35 volunteers, who were studied while awake.
INTERVENTIONS: Near-infrared spectroscopy was measured throughout anaesthesia using INVOS (a trend monitor using two infrared wavelengths) for one hemisphere and FORE-SIGHT (a monitor using four wavelengths of laser light to calculate absolute oxygen saturation) for the other hemisphere in an alternate randomisation pattern.
OUTCOME MEASUREMENTS: The primary outcome was a change in cerebral oxygen saturation of more than 5% during prone positioning. A comparison with the changes obtained in awake volunteers following similar positioning was also made.
RESULTS: Cerebral oxygen saturation increased during prone positioning with INVOS 0.032% per minute ($P < 0.01$) and with FORE-SIGHT 0.032% per minute ($P < 0.01$) in anaesthetised patients. Awake volunteers showed an increase of 0.171% per minute (INVOS) and 0.082% per minute (FORE-SIGHT) during prone positioning. Comparison of INVOS with FORE-SIGHT showed a good association, with a gradient of 0.80% per 1% change ($P < 0.01$).
CONCLUSION: Both monitors detected a small increase in cerebral oxygen saturation of less than 5% in patients undergoing orthopaedic surgery in the prone position and in awake volunteers. This small increase is of limited clinical relevance and prone positioning may be regarded as safe in terms of the maintenance of cerebral oxygen saturation.

46. Baek et al. (2015). **Effects of intravenously administered indocyanine green on near-infrared cerebral oximetry and pulse oximetry readings**

Abstract: Background: Intravenously administered indocyanine green (ICG) may cause misreadings of cerebral oximetry and pulse oximetry in patients undergoing carotid endarterectomy under general anesthesia. The present study determined the effects of two different doses (12.5 mg vs. 25 mg) of ICG on regional cerebral tissue oxygen saturation (SctO2) and percutaneous peripheral oxygen saturation (SpO2).
Methods: Twenty-six patients receiving ICG for videoangiography were divided into two groups according to the dosage (12.5 mg and 25 mg, n = 13 in each group). Heart rate, arterial blood pressure, SctO2, and SpO2 were measured before and after an intravenous bolus administration of ICG.
Results: Following the dye administration, no changes in heart rate or arterial blood pressure were noted in either group. SctO2 was increased in both groups; however, the magnitude of the increase was greater (21.6 ± 5.8% vs. 12.6 ± 4.1%, $P < 0.0001$) and more prolonged (28.4 ± 9.6 min vs. 13.8 ± 5.2 min, $P < 0.0001$) in the 25 mg group than in the 12.5 mg group. In contrast, SpO2 was decreased in both groups; the magnitude of the decrease was greater in the 25 mg group than in the 12.5 mg group (4.0 ± 0.8% vs. 1.6 ± 1.0%, $P < 0.0001$). There were no differences in the time to reach the peak SctO2 or to reach the nadir SpO2 between the two groups.
Conclusions: In patients given ICG for videoangiography, a 25 mg bolus results in a greater and more prolonged increase in SctO2 and a greater reduction in SpO2 than a 12.5 mg bolus, with no differences in the time to reach the peak SctO2 or to reach the nadir SpO2.

47. Balconi et al. (2015). **Resting lateralized activity predicts the cortical response and appraisal of emotions: an fNIRS study**

Abstract: This study explored the effect of lateralized left–right resting brain activity on prefrontal cortical responsiveness to emotional cues and on the explicit appraisal (stimulus evaluation) of emotions based on their valence. Indeed subjective responses to different emotional stimuli should be predicted by brain resting activity and should be lateralized and valence-related (positive vs negative valence). A hemodynamic measure was considered (functional near-infrared spectroscopy). Indeed hemodynamic resting activity and brain response to emotional cues were registered when subjects (N = 19) viewed emotional positive vs negative stimuli (IAPS). Lateralized index response during resting state, LI (lateralized index) during emotional processing and self-assessment manikin rating were considered. Regression analysis showed the significant predictive effect of resting activity (more left or right lateralized) on both brain response and appraisal of emotional cues based on stimuli valence. Moreover, significant effects were found as a function of valence (more right response to negative stimuli; more left response to positive stimuli) during emotion processing. Therefore, resting state may be considered a predictive marker of the successive cortical responsiveness to emotions. The significance of resting condition for emotional behavior was discussed.

48. Nakagawa et al. (2015). **Functional brain measurements within the prefrontal area on pseudo-"blindsight" induced by extremely low frequency electromagnetic stimulations**

Abstract: For evaluating the effects of phosphene as pseudo-blindsight closely, we used functional near-infrared spectroscopy to investigate whether or not the phosphene appearance itself substantially affects the hemodynamic responses of the prefrontal area. Seven healthy volunteers ranging in age from 22 to 72 participated in the visual stimulation experiments. First, we examined the influences of electromagnetic stimulations at around the threshold (10 mT) for a blindsight-like phosphene on the responses. According to the results of the aged volunteers, we found the possibility that the delay in the phosphene perception might be caused by aging beyond a certain age. In the results of our measurements using the stimulation of 50 mT, no significant difference in the perception delay for all the volunteers could be detected. When the field strength was decreased from 50 mT to the threshold in steps of 10 mT, the results obtained at the threshold are equivalent to that obtained at 50 mT. Our data strongly support the hypothesis that pseudo-blindsight induced by electromagnetic stimulation of above 50 mT is able to excite all the volunteers' retinal photoreceptor cells provisionally. Hence the continuous stimulations for a long period of time might gradually activate synaptic plasticity on the neural network of the retina.

49. Pu et al. (2015). **Suicidal ideation is associated with reduced prefrontal activation during a verbal fluency task in patients with major depressive disorder**

Abstract: Background: Despite the known relationship between prefrontal function and increased suicidality during major depressive episodes, the links between prefrontal function and suicidality remain unclear in major depressive disorder (MDD). Suicidal ideation usually precedes a suicide attempt. If prefrontal cortex (PFC) activity is a biomarker for suicidal ideation in depression, monitoring it could be useful for suicide prevention. Therefore, in this study, we assessed the association between prefrontal function and suicidal ideation in MDD.
Methods: Prefrontal function in 67 patients with MDD (31 with suicidal ideation and 36 without) and 67 age-, gender-, and intelligence quotient-matched healthy controls (HCs) was evaluated using near-infrared spectroscopy (NIRS) during a verbal fluency task (VFT). Suicidal ideation was assessed using item 3 of the Hamilton Depression Rating Scale (HAMD).
Results: Regional hemodynamic changes were significantly smaller in patients with MDD than in HCs in prefrontal and temporal regions. Hemodynamic changes in the right dorsolateral PFC (DLPFC), orbitofrontal cortex (OFC), and right frontopolar cortex (FPC) regions in patients with MDD with suicidal ideation were

significantly smaller than in those without suicidal ideation. In addition, hemodynamic changes correlated negatively with the severity of suicidal ideation in the DLPFC, OFC, and FPC in patients with MDD.
Limitations: Further studies with a larger sample size are required to verify our findings.
Conclusions: These results suggest that the DLPFC, OFC, and FPC are brain substrates of suicidal ideation in depressive states in patients with MDD, and that NIRS data can be employed as a clinically useful biomarker for the assessment of suicide risk.

50. Southern et al. (2015). **Reduced skeletal muscle oxidative capacity and impaired training adaptations in heart failure**

Abstract: Systolic heart failure (HF) is associated with exercise intolerance that has been attributed, in part, to skeletal muscle dysfunction. The purpose of this study was to compare skeletal muscle oxidative capacity and training-induced changes in oxidative capacity in participants with and without HF. Participants with HF (n = 16, 65 ± 6.6 years) were compared with control participants without HF (n = 23, 61 ± 5.0 years). A subset of participants (HF: n = 7, controls: n = 5) performed 4 weeks of wrist-flexor exercise training. Skeletal muscle oxidative capacity was determined from the recovery kinetics of muscle oxygen consumption measured by near-infrared spectroscopy (NIRS) following a brief bout of wrist-flexor exercise. Oxidative capacity, prior to exercise training, was significantly lower in the HF participants in both the dominant (1.31 ± 0.30 min−1 vs. 1.59 ± 0.25 min−1, P = 0.002; HF and control groups, respectively) and nondominant arms (1.29 ± 0.24 min−1 vs. 1.46 ± 0.23 min−1, P = 0.04; HF and control groups, respectively). Following 4 weeks of endurance training, there was a significant difference in the training response between HF and controls, as the difference in oxidative training adaptations was 0.69 ± 0.12 min−1 (P < 0.001, 95% CI 0.43, 0.96). The wrist-flexor training induced a ~50% improvement in oxidative capacity in participants without HF (mean difference from baseline = 0.66 ± 0.09 min−1, P < 0.001, 95% CI 0.33, 0.98), whereas participants with HF showed no improvement in oxidative capacity (mean difference from baseline = −0.04 ± 0.08 min−1, P = 0.66, 95% CI −0.24, 0.31), suggesting impairments in mitochondrial biogenesis. In conclusion, participants with HF had reduced oxidative capacity and impaired oxidative adaptations to endurance exercise compared to controls.

51. Liebert et al. (2015). **Dynamic Mapping of the Human Brain by Time-Resolved NIRS Techniques**

Abstract: Dynamic mapping of the human brain by time-resolved near-infrared-spectroscopy (trNIRS), or functional NIRS (fNIRS), is based on the injection of picosecond or sub-nanosecond laser pulses into the head and the measurement of the pulse shape and the intensity after diffusion through the tissue. By analysing the pulse shape and the intensity of the signals at different detector and source positions and different wavelengths, changes in the oxy- and deoxy-haemoglobin concentration are obtained for extracerebral and intracerebral tissue layers and for different depth in the brain. The technique can by combined with the injection of a bolus of an exogenous absorber. By recording either absorption or fluorescence, the in- and outflow of the absorber in different brain compartments can be monitored. The in- and outflow dynamics reveal differences in the blood flow caused by impaired perfusion or stroke. In this chapter, we describe the technical principle of TCSPC-based fNIRS and the associated data processing techniques. Typical results are shown for the haemodynamic response of the brain on visual-cortex stimulation, and for brain perfusion measurement by ICG bolus injection.

52. Wabnitz et al. (2015). **Time-Domain Diffuse Optical Imaging of Tissue by Non-contact Scanning**

Abstract: We present the concept, design and first in vivo tests of a novel non-contact scanning imaging system for time-domain near-infrared spectroscopy of tissues. Employing a supercontinuum laser in combination with an acousto-optic tunable filter as light source, the tissue was scanned by a galvanometer scanner from a distance of more than 10 cm. The distance between the illumination spot (source) and the detection spot from which the diffusely remitted photons were collected was small (few mm) and kept fixed during the scan. A fast-gated

single-photon avalanche diode was employed to eliminate the intense early part of the diffusely remitted signal and to detect late photons only. Polarization-selective detection was additionally applied to suppress specular reflections from the object. An array of gated time-of-flight distributions of photons was recorded by imaging TCSPC synchronized with the movement of the galvanometer scanner. A tissue area of several cm2 was scanned with 32 × 32 pixels within a frame rate of 1 s−1. The wavelength was switched line by line between two bands centred at 760 and 860 nm. Concentration changes of oxy- and deoxy-haemoglobin were derived from changes in photon counts in a selected time window of the gated distributions at the two wavelengths. First in vivo tests included the recording of haemodynamics during arm occlusion as well as brain activation tasks. These tests demonstrated the successful non-contact imaging of haemoglobin concentration changes in deeper tissues. Additional applications seem feasible by increasing the spectral information content of the non-contact scanning approach. To this end we implemented and tested the non-contact scanning in combination with eight-wavelength multiplexing.

53. Becker et al. (2015). **Introduction to Multi-dimensional TCSPC**

Abstract: Classic time-correlated single photon counting (TCSPC) detects single photons of a periodic optical signal, determines the times of the photons relative to a reference pulse, and builds up the waveform of the signal from the detection times. The technique achieves extremely high time resolution and near-ideal detection efficiency. The modern implementation of TCSPC is multi-dimensional. For each photon not only the time in the signal period is determined but also other parameters, such as the wavelength of the photons, the time from the start of the experiment, the time after a stimulation of the sample, the time within the period of an additional modulation of the excitation light source, spatial coordinates within an image area, or other parameters which can either vary randomly or are actively be modulated in the external experiment setup. The recording process builds up a photon distribution over these parameters. The result can be interpreted as a (usually large) number of optical waveforms for different combination of the parameters. The advantage of multi-dimensional TCSPC is that the recording process does not suppress any photons, and that it works even when the parameters vary faster than the photon detection rate. Typical multi-dimensional TCSPC implementations are multi-wavelength recording, recording at different excitation wavelengths, time-series recording, combined fluorescence and phosphorescence decay recording, fluorescence lifetime imaging, and combinations of these techniques. Modern TCSPC also delivers parameter-tagged data of the individual photons. These data can be used to build up fluorescence correlation and cross-correlation spectra (FCS and FCCS), to record fluorescence data from single molecules, or to record time-traces of photon bursts originating from single molecules diffusing through a small detection volume. These data are used to derive multi-dimensional histograms of the changes in the fluorescence signature of a single molecules over time or over a large number of different molecules passing the detection volume. The chapter describes the technical principles of the various multi-dimensional TCSPC configurations and gives examples of typical applications.

54. Becker et al. (2015). **Healthy term and moderately preterm infants have similar cerebral oxygen saturation and cerebral blood flow volumes during early post-natal transition**

Abstract: Aim: This pilot study evaluated changes in regional cerebral oxygen saturation and cerebral blood flow volume during the transitional period in healthy term and moderately preterm infants.
Methods: The cohort comprised 16 preterm infants and seven full-term infants with mean gestational ages of 34 and 39 weeks, respectively. Longitudinal measurements were conducted during the first three days after birth. Regional cerebral oxygen saturation was determined bilaterally by frequency domain near-infrared spectroscopy. Flow volumes were determined in internal carotid and vertebral arteries by multiplying the time-averaged velocity by the cross-sectional area: cerebral blood flow volume was calculated as the sum of flow volumes and adjusted for brain weight.
Results: Brain weight-adjusted cerebral blood flow volumes and regional cerebral oxygen saturation were similar in preterm and term infants. Regional cerebral oxygen saturation did not correlate with brain weight-adjusted

cerebral blood flow volume. Right and left brain weight-adjusted internal carotid flow volumes did not correlate with right and left regional cerebral oxygen saturation.
Conclusion: Our findings suggest that during the first three days after birth there was adequate cardiorespiratory adaptation, cerebral perfusion and adequate compensation through the arterial circle of Willis in both healthy term and moderately preterm infants.

55. Demel et al. (2015). **Cerebral, renal and mesenteric regional oxygen saturation of term infants during transition**

Abstract: Objective: To measure cerebral regional oxygen saturation (CrSO2), renal regional oxygenation saturation (RrSO2) and mesenteric tissue regional oxygen saturation (MrSO2) during immediate transition and continuously for the first 9 hours of age. Fractional tissue oxygen extraction of the brain (CtFOE), kidneys (RtFOE), splanchnic tissue (MtFOE) were also assessed.
Study design: Prospective, observational study of 61 term infants, delivered by elective caesarean section. Using near-infrared spectroscopy, changes in CrSO2, RrSO2, MrSO2 and changes in CtFOE, RtFOE and MtFOE were measured all through the first 9 hours of life. All the episodes of feeding during this period were recorded.
Results: Mean CrSO2 increased quickly to 7 minutes, with no further changes. On the other hand, mean RrSO2 and mean MrSO2 increased for 10 minutes and thereafter they remained on their newly reached level. RrSO2 and MrSO2 were significantly lower at 3-4-5-6-7 minutes of life compared to the CrSO2 ($p < 0.05$). RtFOE and MtFOE were significantly higher at 3-4-5-6-7 minutes of life compared to the CtFOE ($p < 0.05$). During feeding, CrSO2, RrSO2 and MrSO2 did not significantly change.
Conclusions: During early adaptive period, oxygen delivery is preserved to 'vital' organs, like brain, at the expense of kidneys and splanchnic tissue. Term infants can provide for the increasing metabolic activity of the intestinal tract during feeding periods without compromising oxygenation.

56. Taskin et al. (2015). **Comparison of pulse oxymeter and cerebral oxymeter values in healthy newborns in the first five minutes of life**

Abstract: Objective: Practical approaches in delivery rooms have been discussed about oxygen usage in recent years. In this study, it was aimed to correlate preductal arterial oxygen saturation (SpO2), heart rate per minute and serebral oxygen saturation (SbO2) values of first five minutes of life and to try the pulse oxymeter (PO) and cerebral oxymeter (SO) usage practice in delivery room. Material and Method: A hundred healthy term uncomplicated newborn babies, who were born via normally spontan vaginal route, were included in the study. SpO2, SbO2, heart rate measurements and blood gase analysis of first five minutes of postnatal life were completed. Babies, who needed oxygen during measurements, were not taken in to the study. Results: While postnatal 1st minute SpO2 value was 83.0±4.4 (74-94)%; at 5th minute these measurements reached to 92.9±3.5 (85-98)% with gradually increment. Except values of 4th and 5th minutes; SpO2 values were found statistically significant high with each other ($p<0.05$). At SbO2 measurements, suitable data was taken from 100% of the babies in first minute of life. While postnatal mean SbO2 value of the first minute was 48.9±9.9 (32-74)%; these measurements were reached to 69.9±9.5 (46-89)% at 5^{th} minute gradually increment as like as SpO2 values.
Conclusion: SO is complementary to PO in delivery room and can be used routinely. It was seen also in our study; oxygen need of newborns can be determined faster and more accurately with SO use in delivery room so unnecessary oxygen usage and its potential risks can be avoided.

57. Chen et al. (2015). **Wavelength and model selection for hyperspectral imaging of tissue oxygen saturation**

Abstract: Hyperspectral imaging (HSI) is an emerging technique that is suitable for tissue oxygen saturation (StO2) assessment. In the past, different ranges of wavelengths and different Beer Lambert law models were

employed for the assessment. However, the reasons why these spectral ranges and models were chosen remain unknown. The aim of the present paper is to elucidate why subsets of spectral data and modified Beer Lambert models are more suitable than others. We used four different Beer Lambert models under various subset spectral regions within 450–850 nm to deduce StO2 of a human palm under two illumination conditions. Experimental results show that the subset spectral region between 516 and 580 nm is more suitable than other subset regions to assess StO2 and that the modified Beer Lambert model using three chromophores can give the smallest fitting error. This work suggests that this subset of spectra and the modified Beer Lambert model are more appropriate for StO2 assessment using HSI.

58. Anderson et al. (2015). **Early red cell transfusion favourably alters cerebral oxygen extraction in very preterm newborns**

Abstract: Background Elevated cerebral fractional tissue oxygen extraction (cFTOE; ≥0.4) predicts early brain injury in very preterm infants. While blood transfusion increases oxygen-carrying capacity, its ability to improve cerebral oxygen kinetics in the immediate newborn period remains unknown.
Objective To investigate the effect of red blood cell (RBC) transfusion in the first 24 h of life on cFTOE in infants ≤29 weeks gestation.
Methods cFTOE was calculated from cerebral tissue oxygenation index (TOI) and cutaneous oximetry measured over a 30 min epoch before and after transfusion. Infants were dichotomised according to pre-transfusion cFTOE (low <0.4 vs high ≥0.4).
Results 24 babies were included, 12 in each group. Pre- and post-transfusion Hb were similar between the groups. cFTOE significantly reduced after transfusion in the high but not low-extraction group ($p<0.01$).
Conclusions Early RBC transfusion favourably alters cerebral oxygen kinetics in infants with elevated cFTOE, showing potential for modification of the risk of hypoxic (brain) injury.

59. Nakai et al. (2015). **Effect of anticipation triggered by a prior dyspnea experience on brain activity**

Abstract: Oxygenated hemoglobin (oxy-Hb) concentrations in the prefrontal cortex are closely associated with dyspnea. Dyspnea is influenced not only by physical activity, but also by visual stimuli, and several studies suggest that oxy-Hb concentrations change in response to certain external stimuli. However, the effects of internal psychological states on dyspnea have not been reported. This study explored the influence of anticipation triggered by previous episodes of dyspnea on brain activity. [Subjects] The subjects were 15 healthy volunteers with a mean age of 25.0 ± 3.0 years. [Methods] The subjects were shown a variety of photographs and instructed to expect breathing resistance matched to the affective nature of the particular photograph. After viewing the images, varying intensities of breathing resistance that were identical to, easier than, or harder than those shown in the images were randomly administered to the subjects; in fact, the image and resistance were identical 33% of the time and discordant 66% of the time. [Results] The concentrations of oxy-Hb in the right medial prefrontal cortex (rMPFC) increased significantly with an inspiratory pressure that was 30% of the maximum intensity in the subjects shown a pleasant image compared to the concentrations in subjects shown an unpleasant image. Moreover, rMPFC activity was significantly correlated with the magnitude of the dyspnea experienced. [Conclusion] These results suggest that a correlation exists between increased oxy-Hb in the rMPFC and the effects of expectations on dyspnea.

60. Yan et al. (2015). **Use of functional near-infrared spectroscopy to evaluate the effects of anodal transcranial direct current stimulation on brain connectivity in motor-related cortex**

Abstract: Transcranial direct current stimulation (tDCS) is a noninvasive, safe and convenient neuro-modulatory technique in neurological rehabilitation, treatment, and other aspects of brain disorders. However,

evaluating the effects of tDCS is still difficult. We aimed to evaluate the effects of tDCS using hemodynamic changes using functional near-infrared spectroscopy (fNIRS). Five healthy participants were employed and anodal tDCS was applied to the left motor-related cortex, with cathodes positioned on the right dorsolateral supraorbital area. fNIRS data were collected from the right motor-related area at the same time. Functional connectivity (FC) between intracortical regions was calculated between fNIRS channels using a minimum variance distortion-less response magnitude squared coherence (MVDR-MSC) method. The levels of Oxy-HbO change and the FC between channels during the prestimulation, stimulation, and poststimulation stages were compared. Results showed no significant level difference, but the FC measured by MVDR-MSC significantly decreased during tDCS compared with pre-tDCS and post-tDCS, although the FC difference between pre-tDCS and post-tDCS was not significant. We conclude that coherence calculated from resting state fNIRS may be a useful tool for evaluating the effects of anodal tDCS and optimizing parameters for tDCS application.

61. Mora et al. (2015). **Towards next-generation time-domaindiffuse optics for extreme depth penetration and sensitivity**

Abstract: Light is a powerful tool to non-invasively probe highly scattering media for clinical applications ranging from oncology to neurology, but also for molecular imaging, and quality assessment of food, wood and pharmaceuticals. Here we show that, for a paradigmatic case of diffuse optical imaging, ideal yet realistic time-domain systems yield more than 2-fold higher depth penetration and many decades higher contrast as compared to ideal continuous-wave systems, by adopting a dense source-detector distribution with picosecond time-gating. Towards this aim, we demonstrate the first building block made of a source-detector pair directly embedded into the probe based on a pulsed Vertical-Cavity Surface-Emitting Laser (VCSEL) to allow parallelization for dense coverage, a Silicon Photomultiplier (SiPM) to maximize light harvesting, and a Single-Photon Avalanche Diode (SPAD) to demonstrate the time-gating capability on the basic SiPM element. This paves the way to a dramatic advancement in terms of increased performances, new high impact applications, and availability of devices with orders of magnitude reduction in size and cost for widespread use, including quantitative wearable imaging.

62. Mundiyanapurath et al. (2015). **Circulatory and Respiratory Parameters during Acute Endovascular Stroke Therapy in Conscious Sedation or General Anesthesia**

Abstract: Background: Whether patients suffering from acute ischemic stroke and undergoing endovascular recanalization should be treated under general anesthesia (GA) or conscious sedation (CS) is a matter of debate. According to retrospective studies, GA appears to be associated with a worse outcome than CS. The underlying mechanisms are unknown, but hypotension and hypocapnia during GA have been suggested. There are no prospective data on this question.
Methods: We prospectively analyzed consecutive patients who were treated with endovascular recanalization from 11, 2013 to 03, 2014 regarding blood pressure, end-tidal carbon dioxide (etCO2), cerebral oximetry (by near-infrared spectroscopy), ventilation parameters, response to commands, basic parameters (age, gender, percentage of posterior circulation stroke, National Institutes of Health Stroke Scale score [NIHSSS] on admission, NIHSSS at discharge, rate of successful recanalization [thrombolysis in cerebral infarction scale >2a], duration of intervention, symptom-to-recanalization time, and door-to-needle time), and medication used.
Results: Forty-four patients (29 under GA and 15 in CS) were included. Significant differences between the groups (GA versus CS) were found in the median dose of norepinephrine (.4 mg/hour versus .1 mg/hour, P = .003), mean systolic blood pressure (139.67 mm Hg versus 155.00 mm Hg, P = .003), mean duration of relative hypotension (systolic blood pressure <140 mm Hg; 42.75 versus 15 minutes, P = .004), and mean etCO2 values (37.29 mm Hg versus 27.33 mm Hg, P = .004).
Conclusions: In this small prospective study, patients under CS required less vasopressor medication and had a higher mean blood pressure than those under GA, but they also showed signs of hyperventilation. The impact of these physiological differences on outcome needs to be studied in randomized trials.

63. Cavuoto et al. (2015). **Role of obesity on cerebral hemodynamics and cardiorespiratory responses in healthy men during repetitive incremental lifting**

Abstract: Purpose: The goal of this study was to quantify obesity-related differences in systemic physiologic responses and cerebral hemodynamics during physical work to exhaustion.
Methods: Twenty men, ten who are obese and ten of healthy weight, completed an incremental exercise lifting a box from 25 cm below to 25 cm above knuckle height at 10 lifts/min. The lifting started with a load of 5 kg and was increased by 2 kg every 2 min until participants reached either voluntary fatigue or two of the American College of Sports Medicine endpoints for maximum aerobic capacity. Cardiorespiratory and prefrontal hemodynamic responses were measured simultaneously during rest, incremental lifting, and recovery.
Results: The non-obese group lifted for ~64 % longer than the obese group. Both groups reached similar peak pulmonary oxygen uptake at the termination of exercise; however, when these responses were expressed relative to their body mass, the obese group had ~60 % reduced oxygen uptake. As the load increased, steady increases in cerebral oxygenation and blood volume responses were observed in both groups up to ~90 % of the lifting trial. In contrast, at higher intensities (near 100 % of the lifting trial), cerebral oxygenation and blood volume decreased in the obese group, whereas it plateaued or slightly increased in the non-obese group, with greatest cerebral oxygen extraction occurring at the cessation of lifting trial.
Conclusion: These findings suggest that acute exposure to repetitive lifting exercise decreases cardiorespiratory responses and cerebral hemodynamics in the group who are obese, which may contribute to their reduced lifting capacity.

64. Ward et al. (2015). **Reduced Haemodynamic Response in the Ageing Visual Cortex Measured by Absolute fNIRS**

Abstract: The effect of healthy ageing on visual cortical activation is still to be fully explored. This study aimed to elucidate whether the haemodynamic response (HDR) of the visual cortex altered as a result of ageing. Visually normal (healthy) participants were presented with a simple visual stimulus (reversing checkerboard). Full optometric screening was implemented to identify two age groups: younger adults (n = 12, mean age 21) and older adults (n = 13, mean age 71). Frequency-domain Multi-distance (FD-MD) functional Near-Infrared Spectroscopy (fNIRS) was used to measure absolute changes in oxygenated [HbO] and deoxygenated [HbR] haemoglobin concentrations in the occipital cortices. Utilising a slow event-related design, subjects viewed a full field reversing checkerboard with contrast and check size manipulations (15 and 30 minutes of arc, 50% and 100% contrast). Both groups showed the characteristic response of increased [HbO] and decreased [HbR] during stimulus presentation. However, older adults produced a more varied HDR and often had comparable levels of [HbO] and [HbR] during both stimulus presentation and baseline resting state. Younger adults had significantly greater concentrations of both [HbO] and [HbR] in every investigation regardless of the type of stimulus displayed ($p<0.05$). The average variance associated with this age-related effect for [HbO] was 88% and [HbR] 91%. Passive viewing of a visual stimulus, without any cognitive input, showed a marked age-related decline in the cortical HDR. Moreover, regardless of stimulus parameters such as check size, the HDR was characterised by age. In concurrence with present neuroimaging literature, we conclude that the visual HDR decreases as healthy ageing proceeds.

65. Yang et al. (2015). **Studying cerebral hemodynamics and metabolism using simultaneous near-infrared spectroscopy and transcranial Doppler ultrasound: a hyperventilation and caffeine study**

Abstract: Caffeine is one of the most widely consumed psycho-stimulants in the world, yet little is known about its effects on brain oxygenation and metabolism. Using a double-blind, placebo-controlled, randomized cross-over study design, we combined transcranial Doppler ultrasound (TCD) and near-infrared spectroscopy (NIRS) to study caffeine's effect on middle cerebral artery peak blood flow velocity (Vp), brain tissue oxygenation (StO2),

total hemoglobin (tHb), and cerebral oxygen metabolism (CMRO2) in five subjects. Hyperventilation-induced hypocapnia served as a control to verify the sensitivity of our measurements. During hypocapnia (~16 mmHg below resting values), Vp decreased by 40.0 ± 2.4% (95% CI, P < 0.001), while StO2 and tHb decreased by 2.9 ± 0.3% and 2.6 ± 0.4%, respectively (P = 0.003 and P = 0.002, respectively). CMRO2, calculated using the Fick equation, was reduced by 29.3 ± 9% compared to the isocapnic-euoxia baseline (P < 0.001). In the pharmacological experiments, there was a significant decrease in Vp, StO2, and tHb after ingestion of 200 mg of caffeine compared with placebo. There was no significant difference in CMRO2 between caffeine and placebo. Both showed a CMRO2 decline compared to baseline showing the importance of a placebo control. In conclusion, this study showed that profound hypocapnia impairs cerebral oxidative metabolism. We provide new insight into the effects of caffeine on cerebral hemodynamics. Moreover, this study showed that multimodal NIRS/TCD is an excellent tool for studying brain hemodynamic responses to pharmacological interventions and physiological challenges.

66. Doshi et al. (2015). **Hyperostosis frontalis interna as a potential source of cerebral oximetry signal interference: A case report**

Abstract: – not available –

67. Lesage & Orbig (2015). **Montreal SfNIRS conference shines light on the brain**

Abstract: – not available –

68. Matsumoto et al. (2015). **Measurement of oxyhemoglobin concentration changes in interstitial cystitis female patients: A near-infrared spectroscopy study**

Abstract: Objectives: To investigate brain activity related to bladder sensation in interstitial cystitis patients.
Methods: A total of 10 interstitial cystitis patients (all women; mean age 68 years) and 10 healthy controls (all women; mean age 64 years) participated in the present study. Frontal lobe blood flow was measured non-invasively by using multichannel near-infrared spectroscopy with large and small bladder volumes (created by infusing water) up to the first desire to void.
Results: The frontal cortex of the right and left hemisphere was activated, and the activation was detected as an increase in oxyhemoglobin concentration. The increase during the first desire to void in the interstitial cystitis group was greater than that in the control group. In addition, this difference was particularly observed in Brodmann's areas 9, 44, 45 and 46, reportedly associated with micturition and sensory modulation.
Conclusions: The present study shows that the frontal area is largely activated during bladder filling in interstitial cystitis patients. Our findings suggest that the major change in cerebral blood flow is related to the characteristic urinary symptoms of interstitial cystitis patients.

69. Tong et al. (2015). **Can apparent resting state connectivity arise from systemic fluctuations?**

Abstract: It is widely accepted that the fluctuations in resting state blood oxygenation level dependent (BOLD) functional MRI (fMRI) reflect baseline neuronal activation through neurovascular coupling; this data is used to infer functional connectivity in the human brain during rest. Consistent activation patterns, i.e., resting state networks (RSN) are seen across groups, conditions, and even species. In this study, we show that some of these patterns can also be generated from the dynamic, systemic, non-neuronal physiological low frequency oscillations (sLFOs) in the BOLD signal alone. We have previously used multimodal imaging to demonstrate the wide presence of the same sLFOs in the brain (BOLD) and periphery with different time delays. This study shows that these sLFOs from BOLD signals alone can give rise to stable spatial patterns, which can be detected during

resting state analyses. We generated synthetic resting state data for 11 subjects based only on subject-specific, dynamic sLFO information obtained from resting state data using concurrent peripheral optical imaging or a novel recursive procedure. We compared the results obtained by performing a group independent component analysis (ICA) on this synthetic data (i.e., the result from simulation) to the results obtained from analysis of the real data. ICA detected most of the eight well-known RSNs, including visual, motor, and default mode networks (DMNs), in both the real and the synthetic data sets. These findings suggest that RSNs may reflect, to some extent, vascular anatomy associated with systemic fluctuations, rather than neuronal connectivity.

70. Fujimori et al. (2015). **Comparison of Cortical Activation during Mahjong Game Play in a Video Game Setting and a Real-life Setting**

Abstract: The purpose of this study was to compare the hemodynamic changes that occur during Mahjong game play in virtual and real-life settings. Fourteen healthy right-handed men (average age ± standard deviation; 36.7 ± 14.9 years) played: 1) a Mahjong solitaire game on a video console against virtual rivals; 2) a Mahjong game against human opponents without conversation; and 3) a Mahjong game against human opponents with conversation. We measured oxygenated hemoglobin concentration at 44 locations over both hemispheres during Mahjong game play in each setting using near-infrared spectroscopy. The increase in oxygenated hemoglobin concentration at several locations, including Broca's area, the somatosensory cortex, the somatosensory association cortex, the supramarginal gyrus part of Wernicke's area, the primary and auditory association cortex, the angular gyrus part of Wernicke's area, and the associative visual cortex was greater during game play in the real-life settings than during game play in the video game setting. There were no significant differences during game play in real-life settings without and with conversation. Each cortical area correlated with broad or specific areas. The common correlation areas were found at Angular gyrus part of Wernicke's area of left hemisphere during real-life settings without and with conversation, but not during game play in a video game setting. These results suggest that the brain responds differently to game play in real world and virtual world settings, and indicate that comparison of games played in the virtual world and the real world may be an effective model to enhance understanding of the effects of video game on the brain.

71. Yamamuro et al. (2015). **Prefrontal dysfunction in pediatric Tourette's disorder as measured by near-infrared spectroscopy**

Abstract: Background: Tourette's disorder (TD) is a chronic childhood-onset disorder characterized by the presence of multiple motor and vocal tics. Despite strong evidence that the pathophysiology of TD involves structural and functional disturbances of the basal ganglia and cortical frontal areas, in vivo imaging studies have produced conflicting results. Recent developments in near-infrared spectroscopy (NIRS) technology have enabled noninvasive assessment of brain function in people with psychiatric disorders.
Methods: We asked 10 individuals with pediatric TD and 10 healthy controls who were age- and sex- matched to perform the Stroop color-word task during NIRS. We used prefrontal probes and a 24-channel NIRS machine to measure the relative concentrations of oxyhemoglobin (oxy-Hb) every 0.1 s during the task.
Results: We found that oxy-Hb changes in the prefrontal cortex were significantly smaller in the TD group compared with the control group, especially in the left dorsolateral prefrontal cortex.
Conclusions: Our data suggest that individuals with pediatric TD have a reduced prefrontal hemodynamic response as measured by NIRS.

72. Michelet et al. (2015). **Intraoperative changes in blood pressure associated with cerebral desaturation in infants**

Abstract: Background: Intraoperative hypotension has been linked to poor postoperative neurological outcomes. However, the definition of hypotension remains controversial in children. We sought to determine arterial blood pressure threshold values associated with cerebral desaturation in infants.
Methods: After ethics committee approval, infants younger than 3 months were included in this prospective observational study. Cerebral saturation was assessed using near-infrared spectroscopy. The primary goal of the study was to determine percentage reductions in intraoperative systolic blood pressure (SBP) and mean blood pressure (MBP) associated with decreases in cerebral blood oxygen saturation of >20%, when compared to baseline. Analyses were performed using a bootstrap receiving operator characteristic (ROC) curves with determination of the gray zone.
Results: Sixty patients were recruited and 960 measurement points were recorded. Fifty-nine data points (6.1%) recorded cerebral desaturation of >20% when compared to baseline. The areas under the ROC curves were 0.79 (0.74–0.84) and 0.67 (0.6–0.75) for percentage decreases in SBP and MBP, respectively. Gray zone values with false-positive and negative rates <10% were SBP decreases of 20.5% and 37.5%, respectively, and MBP decreases of 15.5% and 44.5%, respectively.
Conclusion: Our results indicate that falls in noninvasive systolic blood pressure of <20% from baseline are associated with a <10% chance of cerebral desaturation in neonates and infants <3 months of age undergoing noncardiac surgery. As such, maintaining systolic blood pressure above this threshold value appears a valid clinical target.

73. Mintzer et al. (2015). **Effects of sodium bicarbonate correction of metabolic acidosis on regional tissue oxygenation in very low birth weight neonates**

Abstract: Objective: To determine the effects of sodium bicarbonate (NaHCO3) correction of metabolic acidosis on cardiopulmonary, laboratory, and cerebral, renal and splanchnic regional oxygen saturation (rSO2) and fractional tissue oxygen extraction (FTOE) in extremely premature neonates during the first postnatal week.
Study Design: Observational cohort data were collected from 500 to 1250 g neonates who received NaHCO3 'half' corrections (0.3 * Weight (kg) * Base Deficit (mmol l−1)) for presumed renal losses.
Result: Twelve subjects with normal blood pressure and heart rate received 17 NaHCO3 corrections. Mean (±s.d.) gestational age was 27±2 week and birth weight was 912±157 g. NaHCO3 corrections provided a mean (±s.d.) 4.5±1.0 ml kg−1 fluid bolus, shifted mean (±s.d.) base deficit from 7.6±1.8 to 3.4±2.1 mmol l−1 (P<0.05), and increased median (±s.d.) pH from 7.23±0.06 to 7.31±0.05 (P<0.05). No significant changes in blood pressure, pulse oximetry, PCO2, lactate, sodium, blood urea nitrogen, creatinine or hematocrit were observed. Cerebral, renal and splanchnic rSO2 (74%, 66% and 44%, respectively, at baseline) and FTOE (0.21, 0.29 and 0.52, respectively, at baseline) were unchanged following NaHCO3 correction.
Conclusion: NaHCO3 infusions decreased base deficits and increased pH though produced no discernible effects or benefits on cardiopulmonary parameters including rSO2 and FTOE. These findings warrant further prospective evaluation in larger populations with more significant metabolic acidosis to determine the utility of tissue oxygenation monitoring in differentiating metabolic acidosis due to oxygen delivery/consumption imbalance versus renal bicarbonate losses.

74. Rojas et al. (2015). **Analysis of Pain Hemodynamic Response Using Near-Infrared Spectroscopy (NIRS)**

Abstract: Despite recent advances in brain research, understanding the various signals for pain and pain intensities in the brain cortex is still a complex task due to temporal and spatial variations of brain hemodynamics. In this paper we have investigated pain based on cerebral hemodynamics via near-infrared spectroscopy (NIRS). This study presents a pain stimulation experiment that uses three acupuncture

manipulation techniques to safely induce pain in healthy subjects. Acupuncture pain response was presented and hemodynamic pain signal analysis showed the presence of dominant channels and their relationship among surrounding channels, which contribute the further pain research area.

75. Aasted et al. (2015). **Anatomical guidance for functional near-infrared spectroscopy: AtlasViewer tutorial**

Abstract: Functional near-infrared spectroscopy (fNIRS) is an optical imaging method that is used to noninvasively measure cerebral hemoglobin concentration changes induced by brain activation. Using structural guidance in fNIRS research enhances interpretation of results and facilitates making comparisons between studies. AtlasViewer is an open-source software package we have developed that incorporates multiple spatial registration tools to enable structural guidance in the interpretation of fNIRS studies. We introduce the reader to the layout of the AtlasViewer graphical user interface, the folder structure, and user files required in the creation of fNIRS probes containing sources and detectors registered to desired locations on the head, evaluating probe fabrication error and intersubject probe placement variability, and different procedures for estimating measurement sensitivity to different brain regions as well as image reconstruction performance. Further, we detail how AtlasViewer provides a generic head atlas for guiding interpretation of fNIRS results, but also permits users to provide subject-specific head anatomies to interpret their results. We anticipate that AtlasViewer will be a valuable tool in improving the anatomical interpretation of fNIRS studies.

76. Boyer et al. (2015). **Investigating Mental Workload Changes in a Long Duration Supervisory Control Task**

Abstract: With improving automation in many critical domains, operators will be expected to handle long periods of low task load while monitoring a system, and possibly responding to emergent situations. Monitoring the psychophysiological state of the operator during low task load may detect maladapted attention states in order to predict performance and facilitate a more effective workload transition during critical periods. This research explored the question of detecting anomalous attention states during transitions to high workload following extended periods of boredom using a non-invasive neuroimaging technique called functional near-infrared spectroscopy (fNIRS). Subjects at the point of lowest engagement and priming had a diminished hemodynamic response and performed worse on missile defense task, showing fNIRS may be useful for concurrent monitoring of the operator in such settings.

77. Weyand et al. (2015). **Usability and performance-informed selection of personalized mental tasks for an online near-infrared spectroscopy brain-computer interface**

Abstract: Brain–computer interfaces (BCIs) allow individuals to use only cognitive activities to interact with their environment. The widespread use of BCIs is limited, due in part to their lack of user-friendliness. The main goal of this work was to develop a more user-centered BCI and determine if: (1) individuals can acquire control of an online near-infrared spectroscopy BCI via usability and performance-informed selection of mental tasks without compromising classification accuracy and (2) the combination of usability and performance-informed selection of mental tasks yields subjective ease-of-use ratings that exceed those attainable with prescribed mental tasks. Twenty able-bodied participants were recruited. Half of the participants served as a control group, using the state-of-the-art prescribed mental strategies. The other half of the participants comprised the study group, choosing their own personalized mental strategies out of eleven possible tasks. It was concluded that users were, in fact, able to acquire control of the more user-centered BCI without a significant change in accuracy compared to the prescribed task BCI. Furthermore, the personalized BCI yielded higher subjective ease-of-use ratings than the prescribed BCI. Average online accuracies of 77±12.9% and 73±12.9% were achieved by the personalized and prescribed mental task groups, respectively.

78. Nakamura et al. (2015). **Simultaneous measurement of cerebral hemoglobin oxygen saturation and blood volume in asphyxiated neonates by near-infrared time-resolved spectroscopy**

Abstract: Background: Hypoxic-ischemic encephalopathy (HIE) usually results in a poor clinical outcome even when treated with hypothermic therapy (HT). Early postnatal changes in cerebral blood oxygenation and hemodynamics may be critical determinants of brain injury and the efficacy of HT.
Objectives: We measured cerebral hemoglobin oxygen saturation (ScO2) and cerebral blood volume (CBV) by near-infrared time-resolved spectroscopy (TRS) in HT-treated and non-HT-treated neonatal HIE patients to assess the influence of these parameters on clinical outcome.
Methods: We retrospectively compared ScO2, CBV, and clinical outcomes of 11 neonates with HIE: 5 were treated by HT (HT-treated; 33.5 °C ± 0.5 °C for 72 h starting approximately 6 h after delivery) and 6 were not (non-HT-treated). Both CBV and ScO2 were measured by TRS at 6, 24, 48, and 72 h after birth. Magnetic resonance imaging (MRI) was performed 1–2 weeks after birth to assess brain injury.
Results: Five neonates had adverse outcomes (3 HT-treated, 2 non-HT-treated). Of these, 1 died within 3 days of birth and 4 had abnormal MRI findings, including basal ganglia, white matter, and/or thalamic lesions. The other 6 neonates had normal MRI findings (favorable outcome). At 6 h after birth, CBV was significantly higher in neonates with adverse outcomes compared with those with a favorable outcome. At 24 h after birth, ScO2 was significantly higher in neonates with adverse outcomes. Furthermore, we found that combined CBV at 24 h after birth plus ScO2 had the best predictive ability for neurological outcome: sensitivity, specificity, positive predictive value, and negative predictive value were all 100%.
Conclusion: Early postnatal CBV and ScO2 elevations were predictive of a poor outcome in HIE. Therefore, measuring combined CBV plus ScO2 at 24 h after birth can allow more precise prediction of neurological outcome. Control of postnatal CBV and ScO2 is critical for effective HIE treatment.

79. Tuna et al. (2015). **Effects of carbon dioxide insufflation on regional cerebral oxygenation during laparoscopic surgery in children: a prospective study**

Abstract: Background and objectives: Laparoscopic surgery has become a popular surgical tool when compared to traditional open surgery. There are limited data on pediatric patients regarding whether pneumoperitoneum affects cerebral oxygenation although end-tidal CO2 concentration remains normal. Therefore, this study was designed to evaluate the changes of cerebral oxygen saturation using near-infrared spectroscope during laparoscopic surgery in children.
Methods: The study comprised forty children who were scheduled for laparoscopic (Group L, n = 20) or open (Group O, n = 20) appendectomy. Hemodynamic variables, right and left regional cerebral oxygen saturation (RrSO2 and LrSO2), fraction of inspired oxygen, end-tidal carbon dioxide pressure (PETCO2), peak inspiratory pressure (Ppeak), respiratory minute volume, inspiratory and end-tidal concentrations of sevoflurane and body temperature were recorded. All parameters were recorded after anesthesia induction and before start of surgery (T0, baseline), 15 min after start of surgery (T1), 30 min after start of surgery (T2), 45 min after start of surgery (T3), 60 min after start of surgery (T4) and end of the surgery (T5).
Results: There were progressive decreases in both RrSO2 and LrSO2 levels in both groups, which were not statistically significant at T1, T2, T3, T4. The RrSO2 levels of Group L at T5 were significantly lower than that of Group O. One patient in Group L had an rSO2 value <80% of the baseline value.
Conclusions: Carbon dioxide insufflation during pneumoperitoneum in pediatric patients may not affect cerebral oxygenation under laparoscopic surgery.

80. Bhutta et al. (2015). **Single-trial lie detection using a combined fNIRS-polygraph system**

Abstract: Deception is a human behavior that many people experience in daily life. It involves complex neuronal activities in addition to several physiological changes in the body. A polygraph, which can measure some of the physiological responses from the body, has been widely employed in lie-detection. Many researchers, however,

believe that lie detection can become more precise if the neuronal changes that occur in the process of deception can be isolated and measured. In this study, we combine both measures (i.e., physiological and neuronal changes) for enhanced lie-detection. Specifically, to investigate the deception-related hemodynamic response, functional near-infrared spectroscopy (fNIRS) is applied at the prefrontal cortex besides a commercially available polygraph system. A mock crime scenario with a single-trial stimulus is set up as a deception protocol. The acquired data are classified into "true" and "lie" classes based on the fNIRS-based hemoglobin-concentration changes and polygraph-based physiological signal changes. Linear discriminant analysis is utilized as a classifier. The results indicate that the combined fNIRS-polygraph system delivers much higher classification accuracy than that of a singular system. This study demonstrates a plausible solution toward single-trial lie-detection by combining fNIRS and the polygraph.

81. Tataranno et al. (2015). **Early oxygen-utilization and brain activity in preterm infants**

Abstract: The combined monitoring of oxygen supply and delivery using Near-InfraRed spectroscopy (NIRS) and cerebral activity using amplitude-integrated EEG (aEEG) could yield new insights into brain metabolism and detect potentially vulnerable conditions soon after birth. The relationship between NIRS and quantitative aEEG/EEG parameters has not yet been investigated. Our aim was to study the association between oxygen utilization during the first 6 h after birth and simultaneously continuously monitored brain activity measured by aEEG/EEG. Forty-four hemodynamically stable babies with a GA < 28 weeks, with good quality NIRS and aEEG/EEG data available and who did not receive morphine were included in the study. aEEG and NIRS monitoring started at NICU admission. The relation between regional cerebral oxygen saturation (rScO2) and cerebral fractional tissue oxygen extraction (cFTOE), and quantitative measurements of brain activity such as number of spontaneous activity transients (SAT) per minute (SAT rate), the interval in seconds (i.e. time) between SATs (ISI) and the minimum amplitude of the EEG in μV (min aEEG) were evaluated. rScO2 was negatively associated with SAT rate (β=-3.45 [CI=-5.76- -1.15], p=0.004) and positively associated with ISI (β=1.45 [CI=0.44-2.45], p=0.006). cFTOE was positively associated with SAT rate (β=0.034 [CI=0.009-0.059], p=0.008) and negatively associated with ISI (β=-0.015 [CI=-0.026- -0.004], p=0.007). Oxygen delivery and utilization, as indicated by rScO2 and cFTOE, are directly related to functional brain activity, expressed by SAT rate and ISI during the first hours after birth, showing an increase in oxygen extraction in preterm infants with increased early electro-cerebral activity. NIRS monitored oxygenation may be a useful biomarker of brain vulnerability in high-risk infants.

82. Sorensen et al. (2015). **Near infrared spectroscopy for frontal lobe oxygenation during non-vascular abdominal surgery**

Abstract: Purpose: Cerebral deoxygenation, as determined by near infrared spectroscopy (NIRS), seems to predict postoperative complications following cardiac surgery. We identify the type of non-vascular abdominal surgery associated with cerebral deoxygenation and/or hyperoxygenation, how such deviations affect patient outcome, and whether maintained cerebral oxygenation improves outcome.
Methods: A systematic literature search was performed on PubMed, EMBASE, Web of Science and Clinicaltrials.gov.
Results: A total of 901 patients from 24 publications are described. A decrease in NIRS (>15% relative to baseline) manifested with reverse Trendelenburg's positioning and in 24% (median) of especially elderly patients undergoing open surgery and demonstrated a correlation to hospital stay (LOS). However, if cerebral deoxygenation was reversed promptly, improved postoperative cognitive function (28 versus 26; mini-mental state examination) and reduced LOS (14 versus 23 days) were seen. Also, during liver transplantation (LTx), impaired cerebral autoregulation (25%), cerebral deoxygenation in the anhepatic phase (36%) and cerebral hyperoxygenation with reperfusion of the grafted liver (14%) were identified by NIRS and could lead to adverse neurological outcome, that is seizures, transient hemiparesis and stroke.

Conclusion: NIRS seems important for predicting neurological complications associated with LTx. Also, surgery in reverse Trendelenburg's position and in other types of abdominal surgery about one-fourth of the patients are subjected to episodes of cerebral deoxygenation that seems to predict a poor outcome. Although there are currently only few studies available for patients going through abdominal surgery, the available evidence points to that it is an advantage to maintain the NIRS-determined cerebral oxygenation.

83. Tai-You et al. (2015). **Assessments of Muscle Oxygenation and Cortical Activity Using Functional Near-infrared Spectroscopy in Healthy Adults During Hybrid Activation**

Abstract: Hybrid activation (HA), patterned electrical stimulation (ES) superimposed on attempted voluntary movement in close synchrony, can augment muscle force output. It has been proposed for limb function restoration and neuromodulation. Limited studies have been performed to investigate the influences of HA on muscle oxygenation and brain cortical activity. The present study investigates muscle oxygenation and cortical activity during isometric knee extension tasks with voluntary contraction (VOL) only, ES only, and with HA at three stimulation intensities, namely 10 mA (HA-I), 30 mA (HA-II), and 50 mA (HA-III). A frequency-domain near-infrared spectroscopy system was employed to assess the muscle oxygenation in the vastus lateralis as well as the cortical activity from the bilateral sensorimotor cortices (SMCs), premotor cortices (PMCs), and supplementary motor areas (SMAs). Our results show that the increased ES contribution during HA significantly increased O2 demand in working muscle, implying that the intervention of ES accelerates the muscle metabolism during muscle contraction. For cortical activation, ES only had a similar cortical activation pattern to that during VOL but with lower activation in SMCs, PMCs, and SMAs. Augmented sensorimotor activation was observed during the HA-II condition. The enhanced level of cortical activation during HA was not only affected by the ES contribution within HA but also related to the functional specificity of cortical areas. Our results suggest that HA can effectively enhance the muscle oxygen demand as well as the activation of cortical regions, and that the ES contribution within HA is a key factor.

84. Drenckhahn et al. (2015). **A validation study of the use of near-infrared spectroscopy imaging in primary and secondary motor areas of the human brain**

Abstract: The electroencephalographically measured Bereitschafts (readiness)-potential in the supplementary motor area (SMA) serves as a signature of the preparation of motor activity. Using a multichannel, noninvasive near-infrared spectroscopy (NIRS) imager, we studied the vascular correlate of the readiness potential. Sixteen healthy subjects performed a self-paced or externally triggered motor task in a single or repetitive pattern, while NIRS simultaneously recorded the task-related responses of deoxygenated hemoglobin (HbR) in the primary motor area (M1) and the SMA. Right-hand movements in the repetitive sequence trial elicited a significantly greater HbR response in both the SMA and the left M1 compared to left-hand movements. During the single sequence condition, the HbR response in the SMA, but not in the M1, was significantly greater for self-paced than for externally cued movements. Nonetheless, an unequivocal temporal delay was not found between the SMA and M1. Near-infrared spectroscopy is a promising, noninvasive bedside tool for the neuromonitoring of epileptic seizures or cortical spreading depolarizations (CSDs) in patients with epilepsy, stroke, or brain trauma because these pathological events are associated with typical spatial and temporal changes in HbR. Propagation is a characteristic feature of these events which importantly supports their identification and characterization in invasive recordings. Unfortunately, the present noninvasive study failed to show a temporal delay during self-paced movements between the SMA and M1 as a vascular correlate of the readiness potential. Although this result does not exclude, in principle, the possibility that scalp-NIRS can detect a temporal delay between different regions during epileptic seizures or CSDs, it strongly suggests that further technological development of NIRS should focus on both improved spatial and temporal resolution. This article is part of a Special Issue entitled Status Epilepticus.

85. Uysal et al. (2015). **Evaluation of learning environments for object-oriented programming: measuring cognitive load with a novel measurement technique**

Abstract: Various methods and tools have been proposed to overcome the learning obstacles for Object-Oriented Programming (OOP). However, it remains difficult especially for novice learners. The problem may be not only adopting an instructional method, but also an Integrated Development Environment (IDE). Learners employ IDEs as a means to solve programming problems and an inappropriate IDE may impose additional cognitive load. Therefore, this quasi-experimental study tried to identify the cognitive effects of a more visually supportive and functional IDE. It was explored by the functional near-infrared spectroscopy method, which is a relatively new physiological tool for measuring cognitive load. Novice students participated in the study in two experimental groups and they were required to write a Java application using two different IDEs. The results indicated a significant difference between the experimental groups and the findings are discussed in view of the principles of Cognitive Load Theory and Multimedia Learning.

86. Li et al. (2015). **Tutorial on use of intraclass correlation coefficients for assessing intertest reliability and its application in functional near-infrared spectroscopy–based brain imaging**

Abstract: Test-retest reliability of neuroimaging measurements is an important concern in the investigation of cognitive functions in the human brain. To date, intraclass correlation coefficients (ICCs), originally used in inter-rater reliability studies in behavioral sciences, have become commonly used metrics in reliability studies on neuroimaging and functional near-infrared spectroscopy (fNIRS). However, as there are six popular forms of ICC, the adequateness of the comprehensive understanding of ICCs will affect how one may appropriately select, use, and interpret ICCs toward a reliability study. We first offer a brief review and tutorial on the statistical rationale of ICCs, including their underlying analysis of variance models and technical definitions, in the context of assessment on intertest reliability. Second, we provide general guidelines on the selection and interpretation of ICCs. Third, we illustrate the proposed approach by using an actual research study to assess intertest reliability of fNIRS-based, volumetric diffuse optical tomography of brain activities stimulated by a risk decision-making protocol. Last, special issues that may arise in reliability assessment using ICCs are discussed and solutions are suggested.

87. Rizki et al. (2015). **Determination of epileptic focus side in mesial temporal lobe epilepsy using long-term noninvasive fNIRS/EEG monitoring for presurgical evaluation**

Abstract: Noninvasive localization of an epileptogenic zone is a fundamental step for presurgical evaluation of epileptic patients. Here, we applied long-term simultaneous functional near-infrared spectroscopy (fNIRS)/electroencephalogram (EEG) monitoring for focus diagnosis in patients with mesial temporal lobe epilepsy (MTLE). Six MTLE patients underwent long-term (8–16 h per day for 4 days) fNIRS/EEG monitoring for the occurrence of spontaneous seizures. Four spontaneous seizures were successfully recorded out of the six patients. To determine oxy-Hb amplitude, the period-average values of oxy-Hb across 20 s from the EEG- or clinically defined epileptic onset were calculated for both hemispheres from the simultaneously recorded fNIRS data. The average oxy-Hb values for the temporal lobe at the earlier EEG- or clinically defined epileptic onsets were greater for the epileptic side than for the contralateral side after EEG activity suppression, spike train, and clinical seizure in all four cases. The true laterality was determined based on the relief of seizures by selective amygdalo-hippocampectomy. Thus, oxy-Hb amplitude could be a reliable measure for determining the epileptic focus side. Long-term simultaneous fNIRS/EEG measurement serves as an effective tool for recording spontaneous seizures. Cerebral hemodynamic measurement by fNIRS would serve as a valuable supplementary noninvasive measurement method for presurgical evaluation of MTLE.

88. Morita et al. (2015). **Right Dorsolateral Prefrontal Cortex Activation during a Time Production Task: A Functional Near-Infrared Spectroscopy**

Abstract: Accurate time estimation is crucial for many human activities and necessitates the use of working memory, in which the dorsolateral prefrontal cortex (DLPFC) plays a critical role. We tested the hypothesis that the DLPFC is activated in participants attempting time estimations that require working memory. Specifically, we used functional near-infrared spectroscopy (fNIRS) to investigate prefrontal cortical activity in the brains of individuals performing a prospective time production task. We measured cerebral hemodynamic responses in 26 healthy right-handed university students while they marked the passage of specified time intervals (3, 6, 9, 12, or 15 s) or performed a button-pressing (control) task. The behavioral results indicated that participants' time estimations were accurate with minimal variability. The fNIRS data showed that activity was significantly higher in the right DLPFC during the time estimation task compared to the control task. Theoretical considerations and the results of this study suggest that DLPFC activation resulting from time estimation indicates that the working memory system is in use.

89. Agostini et al. (2015). **NIRS assessment of brain hemodynamics**

Abstract: Near Infrared Spectroscopy (NIRS) allows for assessing brain hemodynamics non-invasively. In NIRS studies, the maneuver of breath holding is frequently used as an activation of the brain autoregulation response. However, breath holding is not always feasible or effective in the clinical practice. We explored the possibility of using kapalabathi, an ancient yoga respiration technique, as an alternate activation maneuver. We studied the brain oxygenation response to kapalabathi, in yoga practitioners, in three different postures. In all the three postures considered Kapalabathi produces a measurable effect on the oxygen availability at the brain cortex level. Remarkable differences were observed in the brain autoregulatory response of smoker and non-smoker practitioners.

90. Highton et al. (2015). **Monitoring Cerebral Autoregulation After Brain Injury: Multimodal Assessment of Cerebral Slow-Wave Oscillations Using Near-Infrared Spectroscopy**

Abstract: BACKGROUND: Continuous monitoring of cerebral autoregulation might provide novel treatment targets and identify therapeutic windows after acute brain injury. Slow oscillations of cerebral hemodynamics (0.05-0.003 Hz) are visible in multimodal neuromonitoring and may be analyzed to provide novel, surrogate measures of autoregulation. Near-infrared spectroscopy (NIRS) is an optical neuromonitoring technique, which shows promise for widespread clinical applicability because it is noninvasive and easily delivered across a wide range of clinical scenarios. The aim of this study is to identify the relationship between NIRS signal oscillations and multimodal neuromonitoring, examining the utility of near infrared derived indices of cerebrovascular reactivity.
METHODS: Twenty-seven sedated, ventilated, brain-injured patients were included in this observational study. Intracranial pressure, transcranial Doppler-derived flow velocity in the middle cerebral artery, and ipsilateral cerebral NIRS variables were continuously monitored. Signals were compared using wavelet measures of phase and coherence to examine the spectral features involved in reactivity index calculations. Established indices of autoregulatory reserve such as the pressure reactivity index (PRx) and mean velocity index (Mx) and the NIRS indices such as total hemoglobin reactivity index (THx) and tissue oxygen reactivity index (TOx) were compared using correlation and Bland-Altman analysis.
RESULTS: NIRS indices correlated significantly between PRx and THx ($r_s = 0.63$, $P < 0.001$), PRx and TOx ($r = 0.40$, $P = 0.04$), and Mx and TOx ($r = 0.61$, $P = 0.004$) but not between Mx and THx ($r_s = 0.26$, $P = 0.28$) and demonstrated wide limits between these variables: PRx and THx (bias, -0.06; 95% limits, -0.44 to 0.32) and Mx and TOx (bias, +0.15; 95% limits, -0.34 to 0.64). Analysis of slow-wave activity throughout the intracranial pressure, transcranial Doppler, and NIRS recordings revealed statistically significant interrelationships, which varied dynamically and were nonsignificant at frequencies <0.008 Hz.

CONCLUSIONS: Although slow-wave activity in intracranial pressure, transcranial Doppler, and NIRS is significantly similar, it varies dynamically in both time and frequency, and this manifests as incomplete agreement between reactivity indices. Analysis informed by a priori knowledge of physiology underpinning NIRS variables combined with sophisticated analysis techniques has the potential to deliver noninvasive surrogate measures of autoregulation, guiding therapy.

91. Kamran et al. (2015). **Optimal hemodynamic response model for functional near-infrared spectroscopy**

Abstract: Functional near-infrared spectroscopy (fNIRS) is an emerging non-invasive brain imaging technique and measures brain activities by means of near-infrared light of 650–950 nm wavelengths. The cortical hemodynamic response (HR) differs in attributes at different brain regions and on repetition of trials, even if the experimental paradigm is kept exactly the same. Therefore, an HR model that can estimate such variations in the response is the objective of this research. The canonical hemodynamic response function (cHRF) is modeled by two Gamma functions with six unknown parameters (four of them to model the shape and other two to scale and baseline respectively). The HRF model is supposed to be a linear combination of HRF, baseline, and physiological noises (amplitudes and frequencies of physiological noises are supposed to be unknown). An objective function is developed as a square of the residuals with constraints on 12 free parameters. The formulated problem is solved by using an iterative optimization algorithm to estimate the unknown parameters in the model. Inter-subject variations in HRF and physiological noises have been estimated for better cortical functional maps. The accuracy of the algorithm has been verified using 10 real and 15 simulated data sets. Ten healthy subjects participated in the experiment and their HRF for finger-tapping tasks have been estimated and analyzed. The statistical significance of the estimated activity strength parameters has been verified by employing statistical analysis (i.e., t-value > tcritical and p-value < 0.05).

92. Brigadoi & Cooper (2015). **How short is short? Optimum source–detector distance for short-separation channels in functional near-infrared spectroscopy**

Abstract: In recent years, it has been demonstrated that using functional near-infrared spectroscopy (fNIRS) channels with short separations to explicitly sample extra-cerebral tissues can provide a significant improvement in the accuracy and reliability of fNIRS measurements. The aim of these short-separation channels is to measure the same superficial hemodynamics observed by standard fNIRS channels while also being insensitive to the brain. We use Monte Carlo simulations of photon transport in anatomically informed multilayer models to determine the optimum source–detector distance for short-separation channels in adult and newborn populations. We present a look-up plot that provides (for an acceptable value of short-separation channel brain sensitivity relative to standard channel brain sensitivity) the optimum short-separation distance. Though values vary across the scalp, when the acceptable ratio of the short-separation channel brain sensitivity to standard channel brain sensitivity is set at 5%, the optimum short-separation distance is 8.4 mm in the typical adult and 2.15 mm in the term-age infant.

93. Mora et al. (2015). **Fast silicon photomultiplier improves signal harvesting and reduces complexity in time-domain diffuse optics**

Abstract: We present a proof of concept prototype of a time-domain diffuse optics probe exploiting a fast Silicon PhotoMultiplier (SiPM), featuring a timing resolution better than 80 ps, a fast tail with just 90 ps decay time-constant and a wide active area of 1 mm2. The detector is hosted into the probe and used in direct contact with the sample under investigation, thus providing high harvesting efficiency by exploiting the whole SiPM numerical aperture and also reducing complexity by avoiding the use of cumbersome fiber bundles. Our tests also demonstrate high accuracy and linearity in retrieving the optical properties and suitable contrast and depth

sensitivity for detecting localized inhomogeneities. In addition to a strong improvement in both instrumentation cost and size with respect to legacy solutions, the setup performances are comparable to those of state-of-the-art time-domain instrumentation, thus opening a new way to compact, low-cost and high-performance time-resolved devices for diffuse optical imaging and spectroscopy.

94. Vinetta et al. (2015). **Artifact reduction in long-term monitoring of cerebral hemodynamics using near-infrared spectroscopy**

Abstract: Near-infrared spectroscopy (NIRS) is a noninvasive neuroimaging technique used to assess cerebral hemodynamics. Its portability, ease of use, and relatively low operational cost lend itself well to the long-term monitoring of hemodynamic changes, such as those in epilepsy, where events are unpredictable. Long-term monitoring is associated with challenges including alterations in behaviors and motion that can result in artifacts. Five patients with epilepsy were assessed for interictal hemodynamic changes and alterations in behavior or motion. Based on this work, visual inspection was used to identify NIRS artifacts during a period of interest, specifically prior to seizures, in four patients. A motion artifact reduction algorithm (MARA, also known as the spline interpolation method) was tested on these data. Alterations in the NIRS measurements often occurred simultaneously with changes in motion and behavior. Occasionally, sharp shift artifacts were observed in the data. When artifacts appeared as sustained baseline shifts in the data, MARA reduced the standard deviation of the data and the appearance improved. We discussed motion and artifacts as challenges associated with long-term monitoring of cerebral hemodynamics in patients with epilepsy and our group's approach to circumvent these challenges and improve the quality of the data collected.

95. Hirasawa et al. (2015). **Near-infrared spectroscopy determined cerebral oxygenation with eliminated skin blood flow in young males**

Abstract: We estimated cerebral oxygenation during handgrip exercise and a cognitive task using an algorithm that eliminates the influence of skin blood flow (SkBF) on the near-infrared spectroscopy (NIRS) signal. The algorithm involves a subtraction method to develop a correction factor for each subject. For twelve male volunteers (age 21 ± 1 yrs) +80 mmHg pressure was applied over the left temporal artery for 30 s by a custom-made headband cuff to calculate an individual correction factor. From the NIRS-determined ipsilateral cerebral oxyhemoglobin concentration (O2Hb) at two source-detector distances (15 and 30 mm) with the algorithm using the individual correction factor, we expressed cerebral oxygenation without influence from scalp and scull blood flow. Validity of the estimated cerebral oxygenation was verified during cerebral neural activation (handgrip exercise and cognitive task). With the use of both source-detector distances, handgrip exercise and a cognitive task increased O2Hb ($P < 0.01$) but O2Hb was reduced when SkBF became eliminated by pressure on the temporal artery for 5 s. However, when the estimation of cerebral oxygenation was based on the algorithm developed when pressure was applied to the temporal artery, estimated O2Hb was not affected by elimination of SkBF during handgrip exercise ($P = 0.666$) or the cognitive task ($P = 0.105$). These findings suggest that the algorithm with the individual correction factor allows for evaluation of changes in an accurate cerebral oxygenation without influence of extracranial blood flow by NIRS applied to the forehead.

96. Selb et al. (2015). **Effect of motion artifacts and their correction on near-infrared spectroscopy oscillation data: a study in healthy subjects and stroke patients**

Abstract: Functional near-infrared spectroscopy is prone to contamination by motion artifacts (MAs). Motion correction algorithms have previously been proposed and their respective performance compared for evoked brain activation studies. We study instead the effect of MAs on "oscillation" data which is at the basis of functional connectivity and autoregulation studies. We use as our metric of interest the interhemispheric correlation (IHC), the correlation coefficient between symmetrical time series of oxyhemoglobin oscillations. We

show that increased motion content results in a decreased IHC. Using a set of motion-free data on which we add real MAs, we find that the best motion correction approach consists of discarding the segments of MAs following a careful approach to minimize the contamination due to band-pass filtering of data from "bad" segments spreading into adjacent "good" segments. Finally, we compare the IHC in a stroke group and in a healthy group that we artificially contaminated with the MA content of the stroke group, in order to avoid the confounding effect of increased motion incidence in the stroke patients. After motion correction, the IHC remains lower in the stroke group in the frequency band around 0.1 and 0.04 Hz, suggesting a physiological origin for the difference. We emphasize the importance of considering MAs as a confounding factor in oscillation-based functional near-infrared spectroscopy studies.

97. Ferreri et al. (2015). **The Influence of Music on Prefrontal Cortex during Episodic Encoding and Retrieval of Verbal Information: A Multichannel fNIRS Study**

Abstract: Music can be thought of as a complex stimulus able to enrich the encoding of an event thus boosting its subsequent retrieval. However, several findings suggest that music can also interfere with memory performance. A better understanding of the behavioral and neural processes involved can substantially improve knowledge and shed new light on the most efficient music-based interventions. Based on fNIRS studies on music, episodic encoding, and the dorsolateral prefrontal cortex (PFC), this work aims to extend previous findings by monitoring the entire lateral PFC during both encoding and retrieval of verbal material. Nineteen participants were asked to encode lists of words presented with either background music or silence and subsequently tested during a free recall task. Meanwhile, their PFC was monitored using a 48-channel fNIRS system. Behavioral results showed greater chunking of words under the music condition, suggesting the employment of associative strategies for items encoded with music. fNIRS results showed that music provided a less demanding way of modulating both episodic encoding and retrieval, with a general prefrontal decreased activity under the music versus silence condition. This suggests that music-related memory processes rely on specific neural mechanisms and that music can positively influence both episodic encoding and retrieval of verbal information.

98. Yokoyama et al. (2015). **Dysfunction of ventrolateral prefrontal cortex underlying social anxiety disorder: A multi-channel NIRS study**

Abstract: Social anxiety disorder (SAD) is characterized by strong fear and anxiety during social interactions. Although ventrolateral prefrontal cortex (VLPFC) activity in response to emotional stimuli is related to pathological anxiety, little is known about the relationship between VLPFC activity and social anxiety. This study aimed to investigate whether VLPFC activity was involved in SAD and whether VLPFC activity was related to the level of social anxiety. Twenty-four drug-naïve patients with SAD and 35 healthy controls underwent near-infrared spectroscopy (NIRS) scanning while performing a verbal fluency task (VFT). Results indicated that, compared to the healthy controls, the SAD patients exhibited smaller changes of oxygenated hemoglobin (oxy-Hb) concentrations in the VLPFC during the VFT. Furthermore, the right VLPFC activation was negatively correlated with social avoidance. In contrast to the latter, the healthy controls exhibited a positive correlation between changes of oxy-Hb concentrations in the bilateral VLPFC and social fear. Our findings provide evidence for VLPFC dysfunction in SAD, and indicate that the VLPFC dysfunction may contribute to the difference between normal and abnormal social anxiety.

99. Idelson et al. (2015). **Effect of mechanical optical clearing on near-infrared spectroscopy**

Abstract: Near-infrared Spectroscopy (NIRS) is a broadly utilized technology with many emerging applications including clinical diagnostics, sports medicine, and functional neuroimaging, to name a few. For functional brain imaging NIR light is delivered at multiple wavelengths through the scalp and skull to the brain to enable spatial oximetry measurements. Dynamic changes in brain oxygenation are highly correlated with neural stimulation,

activation, and function. Unfortunately, NIRS is currently limited by its low spatial resolution, shallow penetration depth, and, perhaps most importantly, signal corruption due to light interactions with superficial non-target tissues such as scalp and skull. In response to these issues, we have combined the non-invasive and rapidly reversible method of mechanical tissue optical clearing (MOC) with a commercially available NIRS system. MOC utilizes a compressive loading force on tissue, causing the lateral displacement of blood and water, while simultaneously thinning the tissue. A MOC-NIRS Breath Hold Test displayed a ~3.5-fold decrease in the time-averaged standard deviation between channels, consequentially promoting greater channel agreement. A Skin Pinch Test was implemented to negate brain and muscle activity from affecting the recorded signal. These results displayed a 2.5–3.0 fold increase in raw signal amplitude. Existing NIRS instrumentation has been further integrated within a custom helmet device to provide a uniform force distribution across the NIRS sensor array. These results showed a gradual decrease in time-averaged standard deviation among channels with an increase in applied pressure. Through these experiments, and the development of the MOC-NIRS helmet device, MOC appears to provide enhancement of NIRS technology beyond its current limitations.

100. Milej et al. (2015). **Estimation of light detection efficiency for different light guides used in time-resolved near-infrared spectroscopy**

Abstract: Time-resolved near-infrared spectroscopy is a technique enabling the assessment of changes in oxygenation and perfusion of tissue with depth discrimination. A challenge in time-resolved measurements remains to provide sufficiently high efficiency of photons detection together with high temporal resolution of the setup. The aim of this study was to compare the performance of different fiber bundles and liquid light guides which can be used in time-resolved near-infrared spectroscopy measurements. The comparison was carried out by measurements of the instrument response function and of the responsivity of the optical detection system equipped with different types of light guides. The responsivity was estimated employing a test phantom with known diffuse transmittance factor. The results suggest that application of liquid light guides provides higher efficiency of photon collection in comparison to fiber bundles which are typically used in tissue optics instrumentation.

101. Nemani et al. (2015). **Surgical motor skill differentiation via functional near infrared spectroscopy**

Abstract: This study proposes a method to objectively differentiate surgical motor skill by analyzing brain activation in the prefrontal cortex, supplementary motor area (SMA), and primary motor cortex (M1) using functional near infrared spectroscopy (fNIRS) while performing a bimanual surgical task. Results show that experts have a significant decrease (p<;0.05) in functional activation in the prefrontal cortex, SMA, and M1 compared to surgical novices for the physical trainer bimanual task. However, experts show a significant increase in functional activation in the prefrontal cortex and SMA compared to novices for the virtual trainer bimanual surgical task.

102. Li et al. (2015). **Dynamic functional connectivity revealed by resting-state functional near-infrared spectroscopy**

Abstract: The brain is a complex network with time-varying functional connectivity (FC) and network organization. However, it remains largely unknown whether resting-state fNIRS measurements can be used to characterize dynamic characteristics of intrinsic brain organization. In this study, for the first time, we used the whole-cortical fNIRS time series and a sliding-window correlation approach to demonstrate that fNIRS measurement can be ultimately used to quantify the dynamic characteristics of resting-state brain connectivity. Our results reveal that the fNIRS-derived FC is time-varying, and the variability strength (Q) is correlated negatively with the time-averaged, static FC. Furthermore, the Q values also show significant differences in

connectivity between different spatial locations (e.g., intrahemispheric and homotopic connections). The findings are reproducible across both sliding-window lengths and different brain scanning sessions, suggesting that the dynamic characteristics in fNIRS-derived cerebral functional correlation results from true cerebral fluctuation.

103. Plenger et al. (2015). **fNIRS-based investigation of the Stroop task after TBI**

Abstract: To evaluate neural changes during a Stroop task among individuals with TBI using functional near-infrared spectroscopy (fNIRS). Thirteen healthy controls and 14 patients with moderate to severe TBI were included in this study. Oxygenated hemoglobin (HbO) was recorded every tenth of a second using a 52-channel fNIRS unit. Data were acquired using a block design during a Stroop task (i.e., Condition A = Dot Color Naming, Condition B = Incongruent Condition). Visual stimuli were presented on a computer monitor. Behaviorally, response accuracy was similar between groups for condition A, but the TBI group made more errors than the control group during condition B. During condition A, the patient group demonstrated significant increases in HbO within bilateral frontal regions compared to controls ($p < 0.01$). When examining the Stroop interference effect (B-A), controls showed increased HbO in bilateral frontal lobes and left inferior parietal region suggesting increased neural response to increased cognitive demand, whereas no differences were detected among the TBI group ($p < 0.05$). No between group differences in latency of HbO response was observed during either condition. While the TBI group performed as accurately as controls on the simpler dot color naming condition of the Stroop task, neural activity was greater within the frontal lobes during this relatively simple task among the TBI group suggesting neural inefficiency. Furthermore, the spatial distribution of neural activity related to the interference effect was not different among patients, suggesting the neural demand for the simpler task was comparable to that of the more cognitive demanding task among the TBI sample. The results suggest that fNIRS can identify frontal lobe inefficiency in TBI commonly observed with fMRI.

104. Mekari et al. (2015). **The relationship between exercise intensity, cerebral oxygenation and cognitive performance in young adults**

Abstract: Purpose: To assess the relationship between exercise intensity, cerebral HbO2 and cognitive performance (Executive and non-Executive) in young adults.
Methods: We measured reaction time (RT) and accuracy, during a computerized Stroop task, in 19 young adults (7 males and 12 females). Their mean ± SD age, height, body mass and body mass index (BMI) were 24 ± 4 years, 1.67 ± 0.07 m, 72 ± 14 kg and 25 ± 3 kg m−2, respectively. Each subject performed the Stroop task at rest and during cycling at exercise of low intensity [40 % of peak power output (PPO)], moderate intensity (60 % of PPO) and high intensity (85 % of PPO). Cerebral oxygenation was monitored during the resting and exercise conditions over the prefrontal cortex (PFC) using near-infrared spectroscopy (NIRS).
Results: High-intensity exercise slowed RT in both the Naming ($p = 0.04$) and the Executive condition ($p = 0.04$). The analysis also revealed that high-intensity exercise was associated with a decreased accuracy when compared to low-intensity exercise ($p = 0.021$). Neuroimaging results confirm a decrease of cerebral oxygenation during high-intensity exercise in comparison to low- ($p = 0.004$) and moderate-intensity exercise ($p = 0.003$). Correlations revealed that a lower cerebral HbO2 in the prefrontal cortex was associated with slower RT in the Executive condition only ($p = 0.04$, $g = -0.72$).
Conclusion: Results of the present study suggest that low to moderate exercise intensity does not alter Executive functioning, but that exercise impairs cognitive functions (Executive and non-Executive) when the physical workload becomes heavy. The cerebral HbO2 correlation suggests that a lower availability of HbO2 was associated with slower RT in the Executive condition only.

105. Baik et al. (2015). **Cerebral haemorrhage in preterm neonates: does cerebral regional oxygen saturation during the immediate transition matter?**

Abstract: Objectives To investigate the occurrence of peri/intraventricular haemorrhage (P/IVH) in preterm infants and its potential association with cerebral regional oxygen saturation (crSO2) during the immediate transition.
Methods In this two-centre prospective observational cohort study, crSO2 was measured with near-infrared spectroscopy in preterm infants (<32 weeks of gestational age) during the immediate neonatal transition (15 min). In addition, arterial oxygen saturation (SpO2) and heart rate (HR) were monitored with pulse oximetry. Cranial ultrasound scans were performed on day 4, day 7 and day 14 after birth and before discharge. Neonates with IVH of any grade (IVH group) were matched to the neonates without IVH (Non-IVH group) on gestational age (±1 week) and birth weight (±100 g). The duration and magnitude of deviation from the 10th centile in crSO2 during immediate transition was analysed and expressed in %minutes.
Results IVH was found in 12 of the included neonates, who were matched to 12 neonates without IVH. There was no difference in SpO2 and HR between these two groups. The duration and magnitude of centiles-deviation of crSO2 was significantly pronounced in the IVH group compared with the Non-IVH group (1870%min vs 456%min).
Conclusions The neonates of the IVH group showed significantly lower crSO2 values during the immediate transition, although there was no difference concerning SpO2 and HR. The additional monitoring of crSO2 during the immediate transition could reveal neonates with higher risk of developing an IVH later in the course.

106. Durand et al. (2015). **Intraoperative monitoring by imaging and electrophysiological techniques during giant intracranial aneurysm surgery**

Abstract: Difficulties in giant intracranial aneurysm surgery are the consequence of aneurysmal wall histology and the complex angioarchitecture of the vascular tree. In order to reduce complications and risks of those procedures, various imaging and electrophysiological techniques can be implemented perioperatively. The authors review the principles, goals and main results in this context of micro-Doppler and flowmeter techniques, near-infrared spectroscopy, operative microscope-integrated indocyanine green video-angiography, neuro-endoscopy, selective intraoperative angiography and electrophysiological monitoring.

107. Tamura et al. (2015). **Effectiveness of the Use of Near-Infrared Spectroscopy to Treat Acute Type A Aortic Dissection Complicated with Limb Ischemia: Report of a Case**

Abstract: We report an effectiveness of the use of near-infrared spectroscopy to evaluate the limb perfusion, which helps to continuously measure the tissue oxygen index of bilateral legs in treating acute type A aortic dissection complicated with limb ischemia. A 62-year-old man underwent total arch replacement for acute type A aortic dissection with limb ischemia. Intraoperative retrograde true lumen perfusion via bilateral femoral arteries during cardiopulmonary bypass improved ischemic condition of bilateral legs before the resection of primary intimal tear, and the use of near-infrared spectroscopy made it possible to assess additional revascularizations to the lower limbs were required or not.

108. Watanabe et al. (2015). **Temporal changes in NIRS outputs in prefrontal regions when listening to languages**

Abstract: As a non-invasive brain activity measurement method, near-infrared spectroscopy (NIRS) technology has been used widely, but it has the problem of noise corruption by baseline drifting. In this paper, we employ a time derivative of NIRS output which is the blood flow with high-pass filtering characteristics. We investigate whether blood flow can reasonably localize and represent brain activity or not when listening to languages. The

blood flow distribution pattern by advanced second language (L2) listeners when listening to L2 was determined to be the most similar to that when listening to their first language (L1). This study shows this form of analysis has proved to be more accurate than conventional parameters. In experiments with 40 healthy subjects, the blood flow was localized to the left BA46 of advanced L2 listeners and to the right BA46 of intermediate L2 listeners. Hence, the blood flow is insensitive to the baseline drift noise and stably localizes brain activity areas.

109. Lu et al. (2015). **Maintaining Gait Performance by Cortical Activation during Dual-Task Interference: A Functional Near-Infrared Spectroscopy Study**

Abstract: In daily life, mobility requires walking while performing a cognitive or upper-extremity motor task. Although previous studies have evaluated the effects of dual tasks on gait performance, few studies have evaluated cortical activation and its association with gait disturbance during dual tasks. In this study, we simultaneously assessed gait performance and cerebral oxygenation in the bilateral prefrontal cortices (PFC), premotor cortices (PMC), and supplemental motor areas (SMA), using functional near-infrared spectroscopy, in 17 young adults performing dual tasks. Each participant was evaluated while performing normal-pace walking (NW), walking while performing a cognitive task (WCT), and walking while performing a motor task (WMT). Our results indicated that the left PFC exhibited the strongest and most sustained activation during WCT, and that NW and WMT were associated with minor increases in oxygenation levels during their initial phases. We observed increased activation in channels in the SMA and PMC during WCT and WMT. Gait data indicated that WCT and WMT both caused reductions in walking speed, but these reductions resulted from differing alterations in gait properties. WCT was associated with significant changes in cadence, stride time, and stride length, whereas WMT was associated with reductions in stride length only. During dual-task activities, increased activation of the PMC and SMA correlated with declines in gait performance, indicating a control mechanism for maintaining gait performance during dual tasks. Thus, the regulatory effects of cortical activation on gait behavior enable a second task to be performed while walking.

110. Farina et al. (2015). **In-vivo multilaboratory investigation of the optical properties of the human head**

Abstract: The in-vivo optical properties of the human head are investigated in the 600–1100 nm range on different subjects using continuous wave and time domain diffuse optical spectroscopy. The work was performed in collaboration with different research groups and the different techniques were applied to the same subject. Data analysis was carried out using homogeneous and layered models and final results were also confirmed by Monte Carlo simulations. The depth sensitivity of each technique was investigated and related to the probed region of the cerebral tissue. This work, based on different validated instruments, is a contribution to fill the existing gap between the present knowledge and the actual in-vivo values of the head optical properties.

111. Feddersen et al. (2015). **Regional differences in the cerebral blood flow velocity response to hypobaric hypoxia at high altitudes**

Abstract: Symptoms of acute mountain sickness (AMS) may appear above 2,500 m altitude, if the time allowed for acclimatization is insufficient. As the mechanisms underlying brain adaptation to the hypobaric hypoxic environment are not fully understood, a prospective study was performed investigating neurophysiological changes by means of near infrared spectroscopy, electroencephalograpy (EEG), and transcranial doppler sonography at 100, 3,440 and 5,050 m above sea level in the Khumbu Himal, Nepal. Fourteen of the 26 mountaineers reaching 5,050 m altitude developed symptoms of AMS between 3,440 and 5,050 m altitude (Lake-Louise Score greater than or equal to3). Their EEG frontal beta activity and occipital alpha activity increased between 100 and 3,440 m altitude, i.e., before symptoms appeared. Cerebral blood flow velocity (CBFV) in the anterior and middle cerebral arteries (MCAs) increased in all mountaineers between 100 and 3,440 m altitude.

During further ascent to 5,050 m altitude, mountaineers with AMS developed a further increase in CBFV in the MCA, whereas in all mountaineers CBFV decreased continuously with increasing altitude in the posterior cerebral arteries. These results indicate that hypobaric hypoxia causes different regional changes in CBFV despite similar electrophysiological changes.

112. Noah et al. (2015). **fMRI Validation of fNIRS Measurements During a Naturalistic Task**

Abstract: We present a method to compare brain activity recorded with near-infrared spectroscopy (fNIRS) in a dance video game task to that recorded in a reduced version of the task using fMRI (functional magnetic resonance imaging). Recently, it has been shown that fNIRS can accurately record functional brain activities equivalent to those concurrently recorded with functional magnetic resonance imaging for classic psychophysical tasks and simple finger tapping paradigms. However, an often quoted benefit of fNIRS is that the technique allows for studying neural mechanisms of complex, naturalistic behaviors that are not possible using the constrained environment of fMRI. Our goal was to extend the findings of previous studies that have shown high correlation between concurrently recorded fNIRS and fMRI signals to compare neural recordings obtained in fMRI procedures to those separately obtained in naturalistic fNIRS experiments. Specifically, we developed a modified version of the dance video game Dance Dance Revolution (DDR) to be compatible with both fMRI and fNIRS imaging procedures. In this methodology we explain the modifications to the software and hardware for compatibility with each technique as well as the scanning and calibration procedures used to obtain representative results. The results of the study show a task-related increase in oxyhemoglobin in both modalities and demonstrate that it is possible to replicate the findings of fMRI using fNIRS in a naturalistic task. This technique represents a methodology to compare fMRI imaging paradigms which utilize a reduced-world environment to fNIRS in closer approximation to naturalistic, full-body activities and behaviors. Further development of this technique may apply to neurodegenerative diseases, such as Parkinson's disease, late states of dementia, or those with magnetic susceptibility which are contraindicated for fMRI scanning.

113. Bigliassi et al. (2015). **How does the prefrontal cortex "listen" to classical and techno music? A functional near-infrared spectroscopy (fNIRS) study**

Abstract: The aim of the present study was to investigate the effects of 2 extremely different music genres (techno and classical) on emotional responses and brain activity. Functional near-infrared spectroscopy was used to measure the activity of the prefrontal cortex (PFC) area (medial, left dorsolateral, and right dorsolateral). Emotional responses were assessed through physiological and psychological measures by using heart rate variability and the Self-Assessment Manikin, respectively. Both pieces of music increased the PFC activity, but classical music caused greater activity in the dorsolateral areas. Classical music was capable of increasing parasympathetic activity; conversely, techno music reduced parasympathetic activation after 10 min of music exposure. Multiple physiological systems interact as a means to process sensory stimuli. The general message carried by the auditory stimuli is capable of accelerating or decelerating the activity of the autonomic system. Psychological assessments were not sufficiently sensitive to capture those modifications.

114. Hasseinzadeh et al. (2015). **Ipsilateral resistance exercise prevents exercise-induced central sensitization in the contralateral limb: a randomized controlled trial**

Abstract: Purpose: This study aimed to investigate the hypothesis that a repeated bout of eccentric exercise (ECC2) would result in smaller increase in the sensitivity of spinal nociceptive system, and smaller decrease in the local muscle blood oxygenation response in both the ipsilateral and the contralateral tibialis anterior muscle (TA) when compared with the initial bout (ECC1). It was hypothesized that the magnitude of the repeated bout effect (RBE) would be greater for the ipsilateral side than the contralateral side.

Methods: Twenty-six healthy young men performed two bouts of high-intensity eccentric exercise of TA separated by 2 weeks. Half of the participants used the same leg for both bouts (IPSI) and the other half used the contralateral leg for ECC2 (CONTRA). Nociceptive withdrawal reflex threshold (NWRT) and local muscle blood oxygenation were assessed for the exercised TA muscle before, immediately after, and one day after exercise.
Results: Significant decreases in NWRT and muscle oxygenation were observed after ECC1 ($p < 0.05$), but NWRT did not change after ECC2 in both groups. Smaller decreases in muscle oxygenation were observed after ECC2 than ECC1 in both groups with a similar magnitude of the difference between bouts, but an increase in muscle oxygen re-perfusion before ECC2 was only observed in the IPSI group.
Conclusion: These results suggest that contralateral RBE was associated with spinal facilitation of the neuronal pathways situated at a homologous innervation level, and it is unlikely that oxygen re-perfusion improvement plays a major role in the contralateral RBE.

115. Yano et al. (2015). **Coherence between tissue oxygen indexes in vastus lateralis and gastrocnemius in repetition of impulse exercise with high intensity**

Abstract: The purpose of this study was to determine whether tissue oxygen indices (TOIs) in two muscle groups oscillated and were synchronized in repetition of impulse exercise with high intensity. Five impulse exercises of 400 watts for 10 s were repeated with intervals of 6 min. During this period, TOI was determined by near-infrared spectroscopy in the vastus lateralis and gastrocnemius muscles. TOIs in the two muscles oscillated at rest. The TOIs rapidly decreased during each impulse exercise and then recovered and overshot after each impulse. The TOIs oscillated during each interval period. During this test period, coherent and phase differences were determined. There was high coherence between TOIs in the two muscles with a peak value at 0.019 Hz. There was a phase difference of −45 ± 32.4 degrees between TOIs in the two muscles. This phase difference corresponded to about 6 s in time scale. It seemed from this time delay that impulse exercise was not a trigger factor for the starting point of TOIs in the two muscles. It has been concluded that TOIs oscillate and are synchronized between two muscles in repetition of impulse exercise with high intensity.

116. Perlman et al. (2015). **Functional Near-Infrared Spectroscopy Evidence for Development of Prefrontal Engagement in Working Memory in Early Through Middle Childhood**

Abstract: The neural underpinnings of working memory are hypothesized to develop incrementally across preschool and early school age, coinciding with the rapid maturation of executive function occurring during this period. This study investigates the development of prefrontal cortex function between the ages of 3 and 7. Children (n = 68) participated in a novel spatial working memory task while their middle and lateral prefrontal cortex (LPFC) was monitored using functional near infrared spectroscopy (fNIRS). We found increased activation of the LPFC when comparing working memory to rest. Greater LPFC increase was noted for longer compared with shorter delay periods. Increase in LPFC activation, accuracy, and response speed were positively correlated with child age, suggesting that developmental changes in prefrontal function might underlie effective development of executive function in this age range.

Publications from the BORL, Zurich

117. Vögeli et al. (2015). **Housing conditions influence cortical and behavioural reactions of sheep in response to videos showing social interactions of different valence**

Abstract: Mood, as a long-term affective state, is thought to modulate short-term emotional reactions in animals, but the details of this interplay have hardly been investigated experimentally. Apart from a basic

interest in this affective system, mood is likely to have an important impact on animal welfare, as bad mood may taint all emotional experience. In the present study about mood – emotion interaction, 29 sheep were kept under predictable, stimulus-rich or unpredictable, stimulus-poor housing conditions, to induce different mood states. In an experiment, the animals were confronted with video sequences of social interactions of conspecifics showing agonistic interactions, ruminating or tolerantly co-feeding as stimuli of different valences. Emotional reactions were assessed by measuring frontal brain activity using functional near-infrared spectroscopy and by recording behavioral reactions. Attentiveness of the sheep decreased from videos showing agonistic interactions to ruminating sheep to those displaying co-feeding sheep. Seeing agonistic interactions was also associated with a deactivation of the frontal cortex, specifically in animals living under predictable, stimulus-rich housing conditions. These sheep generally showed less attentiveness and locomotor activity and they had their ears in a forward position less often and in a backward position more often than the sheep from the unpredictable, stimulus-poor conditions. Housing conditions influenced how the sheep behaved, which can either be thought to be mediated by mood or by the animals' previous experience with stimulus-richness in their housing conditions. Frontal cortical activity may not depend on valence only, but also on the perceptual channel through which the stimuli were perceived.