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Auditory System

As fNIRS measurements are characterized by silent operations, innumerable possibilities of studies intended to explore cortical activation in the presence of controlled sounds can be achieved. Besides a better understanding of auditory processes in the brain, this may facilitate critical improvements on current solutions for cochlear implants.


For latest updates on health information pertaining to hearing, balance, taste, smell, and speech and language development, please visit:

http://www.nidcd.nih.gov/Pages/default.aspx

**Brain-Computer Interface (BCI)**

*Given its great performance in the presence of muscle movements and the possibility of setting up measurements in realistic environments, fNIRS presents itself as an ideal candidate for the acquisition of cortical signals as reliable and representative inputs for Brain-Computer Interface investigations.*


F. Dehais et al., “Monitoring pilot’s cognitive fatigue with engagement features in simulated and actual flight conditions using an hybrid fNIRS-EEG passive BCI,” in IEEE SMC, 2018, pp. 1–6


For latest updates on NIH and DARPA funded efforts for BCI funded research, please visit:

Brain Perfusion

Brain perfusion assessment in clinical environments has mostly been performed by techniques that cannot accomplish constant monitoring of the brain. Due to its intrinsic capability of constant monitoring as well as the unique portability, fNIRS has clear potential for intensive care unit applications.


For updates on the latest announcements on the NIH brain initiative: Brain Research through Advancing Innovative Neurotechnologies® (BRAIN), please visit:

http://braininitiative.nih.gov
**Clinical Neurology**

With the capabilities of constant monitoring of oxygenation, perfusion and autoregulation, fNIRS has a high potential for diagnoses of cerebrovascular disease and severe brain injury. Other clinical neurology methodologies, including epileptic disorders and central nervous system tumors, may benefit from the technique on the preoperative function localization.


Cognitive States

fNIRS adds another dimension to studies investigating cognitive functions and mental states, since it is a portable technique not too sensitive to motion artifacts. Attention processes, inhibition mechanisms, and working memory, as well as other cognitive states, may be studied in natural environments with a fast setup preparation.


S. Peci and F. Peci, “Hemoglobin (Hb) - Oxyhemoglobin (HbO) Variation in Rehabilitation Processes Involving Prefrontal Cortex,” Prefrontal Cortex, Nov. 2018.


For the latest description on NIH’s intramural efforts to explore cognition and its influences on mental health, please visit:

Complementary and Integrative Medicine

Acupuncture, interactions of herbal medicines with conventional drugs, pain management, meditation, Yoga, Tai Chi and Qi Gong are among other alternative therapies whose serious inquiry is well supported by fNIRS. NIRx experts can help you plan experimental strategies best suited to explore nontraditional yet promising methods.


For latest updates on complementary and integrative health strategies, please visit: [https://nccih.nih.gov](https://nccih.nih.gov)
Connectivity

fNIRS brings connectivity studies to a new level. The hyperscanning modality enables both online feedback as well as offline analysis regarding within- and between-subjects connectivity. In addition to that, fNIRS fast sampling rate for hemodynamic states allows for a quick update rate of connectivity feedback, resulting into enhanced subject engagement.


For a description of the Human Connectome Project, please visit:

http://www.neuroscienceblueprint.nih.gov/connectome/

**Developmental Changes**

*The portability of fNIRS, its performance in presence of general movements and the feasibility it offers in exploring cortical responses in social environments, represent the greatest advantages for studies on brain functional changes during development of infants and children.*


For updates from Dr. Catherine Spong, acting director of NICHD, on new program initiatives including Learning Disabilities Innovation Hubs, Precision Medicine Initiative, Intellectual and Developmental Disabilities Research Centers, please visit:

https://www.nichd.nih.gov/about/overview/directors_corner/Pages/default.aspx

**Emotions**

*Near-infrared spectroscopy is non-invasive and particularly well suited for evaluating activity in the prefrontal cortex, one of the regions involved in emotional processing. More specific areas related to emotional processing, such as the frontopolar cortex, are easily accessible for measurements by NIRS, making the technique particularly suited to explore the emotional domain.*


M. Balconi, M. E. Vanutelli, and E. Grippa, “Resting state and personality component (BIS/BAS) predict the brain activity (EEG and fNIRS measure) in response to emotional cues,” Brain Behav, p. n/a-n/a, Mar. 2017.


M. Balconi, E. Grippa, and M. E. Vanutelli, “What hemodynamic (fNIRS), electrophysiological (EEG) and autonomic integrated measures can tell us about emotional processing,” Brain Cogn, vol. 95, pp. 67–76, Apr. 2015.

**Event-Related Optical Signal**

*fNIRS is potentially the only imaging method that may be capable to measure both hemodynamics and neuronal activity. The Event-Related Optical Signal, caused by changes in light scattering from activated neurons, is observable when employing high frequency sampling with fNIRS.*


For an informative discussion on the various strategies of optical imaging techniques, please visit:


Infant Monitoring

Infant monitoring is based on continuous measurements of cortical activity within a population that may be characterized by its constant movement. The low sensitivity of fNIRS to motion artifacts make this technique an ideal choice for studies intended to explore the many unknown features of the infant brain.


For an informative summary of timelines for sensory, motor and psychosocial development in infants and young children, please visit:

Motor Execution

Motor execution and fine movements depend on coordinated action of brain function and peripheral muscles. Its portability, ease of use in natural environments, and compatibility with bioelectric measures make fNIRS an optimal choice for studies investigating motor execution.


K. N. de Winkel, A. Nesti, H. Ayaz, and H. H. Bülthoff, “Neural correlates of
decision making on whole body yaw rotation: An fNIRS study," 


Multi-modal

In order to render measurements more robust, information may be provided by different modalities. Many groups appreciate multi-modal applications with fNIRS. Typical combinations are fNIRS and EEG, Eye-Tracking or fMRI, but tDCS and TMS have also been applied to concurrently modulate brain activity.


A. Berger, N. H. Pixa, F. Steinberg, and M. Doppelmayr, “Brain Oscillatory and Hemodynamic Activity in a Bimanual Coordination Task Following


M. Balconi, E. Grippa, and M. E. Vanutelli, “What hemodynamic (fNIRS), electrophysiological (EEG) and autonomic integrated measures can tell us about emotional processing,” Brain Cogn, vol. 95, pp. 67–76, Apr. 2015.


W. Guo, P. Yao, X. Sheng, H. Liu, and X. Zhu, “A wireless wearable sEMG and NIRS acquisition system for an enhanced human-computer interface,”

V. V. Nikulin et al., “Monochromatic ultra-slow (~0.1 Hz) oscillations in the human electroencephalogram and their relation to hemodynamics,” *Neuroimage*, vol. 97, pp. 71–80, Aug. 2014.


Naturalistic Environment

With the advent of portable and wearable solutions, in addition to its intrinsic performance in the presence of movements, fNIRS is currently the ideal solution for studies that intend to evaluate cortical activity within naturalistic environments.


**Neuroeconomics**

A key interest of neuroeconomics research is value-based decision making, in which the prefrontal lobe is an important player. Although prefrontal activity has been explored with fMRI, the restricted environment does impose a limit to the number of applications that can be explored. fNIRS may represent a conspicuous improvement to the field, as it enables outdoor measurements that can be combined with simultaneous Eye-Tracking.


Pain Research

Obtaining pain indicators from brain activity can be particularly interesting when the efficiency of pain treatments is to be evaluated, or when determining pain levels from people that may not be able to verbally communicate. fNIRS in particular, is a promising tool for this area giving its portability and noninvasiveness.


Social Interaction

The ability of fNIRS to measure two or more subjects simultaneously, enables researchers to study cortical activity in response to social interaction. This way, a new dimension is added to studies investigating topics such as empathy, competitive and cooperative tasks, mother-child interactions and truth telling.


Somatosensory

fNIRS determines changes in hemoglobin oxygenation in the human head non-invasively, and has the advantage of being more robust to motion artifacts than fMRI. In addition, the application of fNIRS is more convenient for somatosensory research, especially when measuring patients with chronic pain, as measurements can take place on a more comfortable bench compared to the MR scanner bench.


A. Vrana, M. L. Meier, S. Hotz-Boendermaker, B. K. Humphreys, and F. Scholkmann, “Different mechanosensory stimulations of the lower back elicit specific changes in hemodynamics and oxygenation in cortical sensorimotor areas—A fNIRS study,” Brain Behav, p. n/a-n/a, Sep. 2016.


Speech and Language

Realistic experiments involve verbalized speech. As such, they should account for the muscle movements that are required for this process, and the eventual artifacts that these may cause. The robustness of fNIRS in the presence of muscle movements as well as its portability in comparison to other imaging techniques, render this technology a very promising tool for studying speech and language under a great variety of conditions.


N. Altvater-Mackensen and T. Grossmann, “Modality-independent recruitment of inferior frontal cortex during speech processing in human


**Stroke Rehabilitation**

_In addition to advantages towards brain perfusion monitoring, stroke rehabilitation studies may benefit from fNIRS because of its portability and ease of application. These features allow for assessment during whole-body movements as well as neurofeedback methods that are indicative of brain function, which may be of particular interest for rehabilitation strategies that take place at home._

S. Peci and F. Peci, “Hemoglobin (Hb) - Oxyhemoglobin (HbO) Variation in Rehabilitation Processes Involving Prefrontal Cortex,” *Prefrontal Cortex*, Nov. 2018.


Technological Advances

Frequently, research is limited by the technologies available. Efforts towards overcoming current limits, by design of new hardware and software solutions, is therefore much appreciated. Research aiming for technological advance constantly pushes forward and creates a wide range of new possibilities to be explored by the whole scientific community.


Traumatic Brain Injury (TBI)

fNIRS offers a practical, portable, and relatively inexpensive alternative to assess correlates of brain oxygenation. Moreover, it allows to coregister other neurophysiological and behavioral data in a “near natural” environment. Because of this, the technique is promising for the field of clinical neurology, and indeed fNIRS has been used to detect changes in cerebral hemodynamics after severe Traumatic Brain Injury.

Visual Stimulation

FNIRS techniques have become increasingly popular because of their easy and safe operation, cost-efficiency, good temporal resolution, and the clear and robust results they deliver in real time. As such, FNIRS is ideal to explore visual stimulation, and indeed vision-related FNIRS research is very active.


NIRX is a world-leader in providing integrated solutions for fNIRS neuro-imaging. In 1988 we introduced the concept of tomographic imaging (i.e., multi-distance measurements) in dense scattered media based on diffusely scattered light. This approach has since been widely adapted and has served to launch the modern day field of fNIRS tomography.

Through our offices in Berlin, Minneapolis, Los Angeles and New York, our engineers and grant-funded investigators are providing a growing number of research teams worldwide with comprehensive technology solutions for the most demanding investigative applications.

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