fNIRS literature 2023 overview

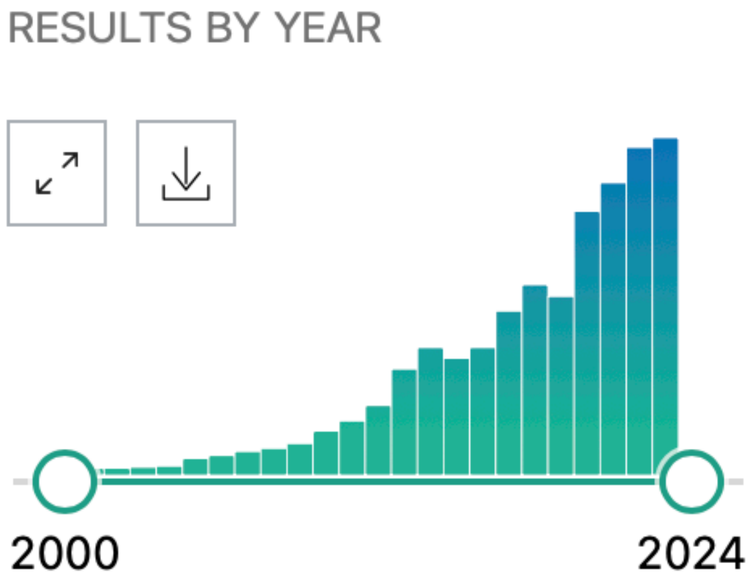
fNIRS journal club

Danielle Evenblij Tuesday 12-12-23

Numbers

- **Search term**: fnirs OR "functional near-infrared spectroscopy”
- Total fNIRS results: 337
  - 18 neurofeedback studies
  - 8 BCI studies
  - 18 hyperscanning studies
  - 44 resting-state/connectivity studies
  - 6 high-density or DOT studies
  - 3 meditation/mindfulness studies

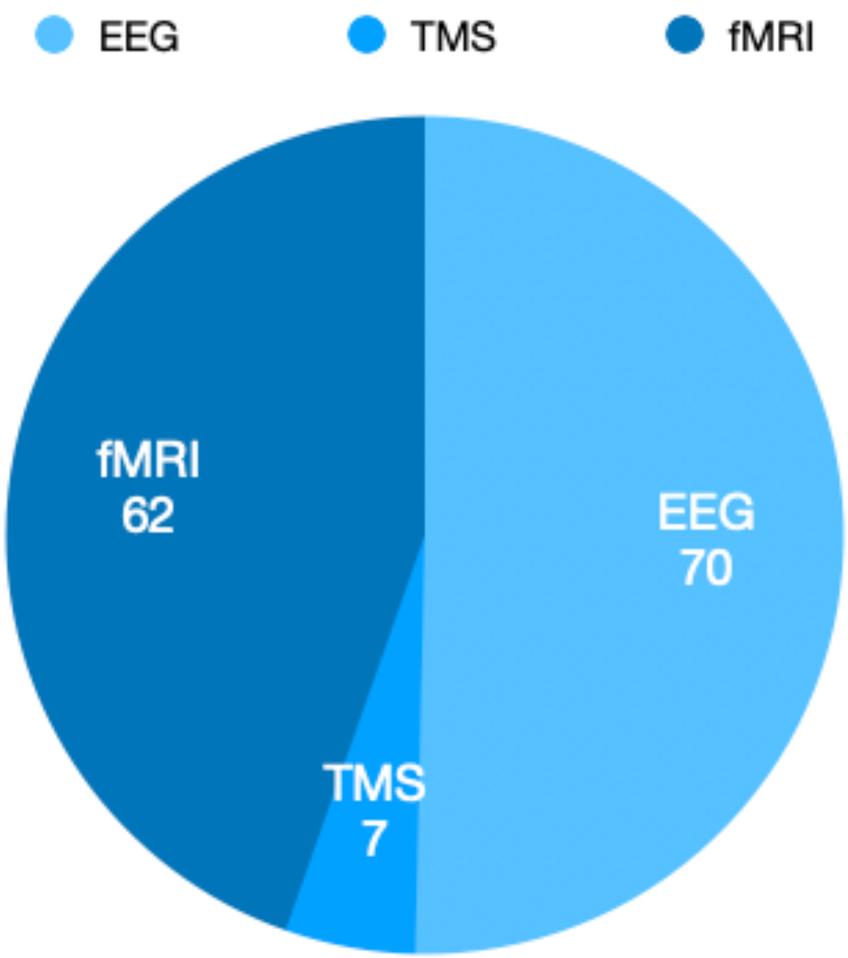
Total fNIRS: 646 results for year 2023



Pubmed

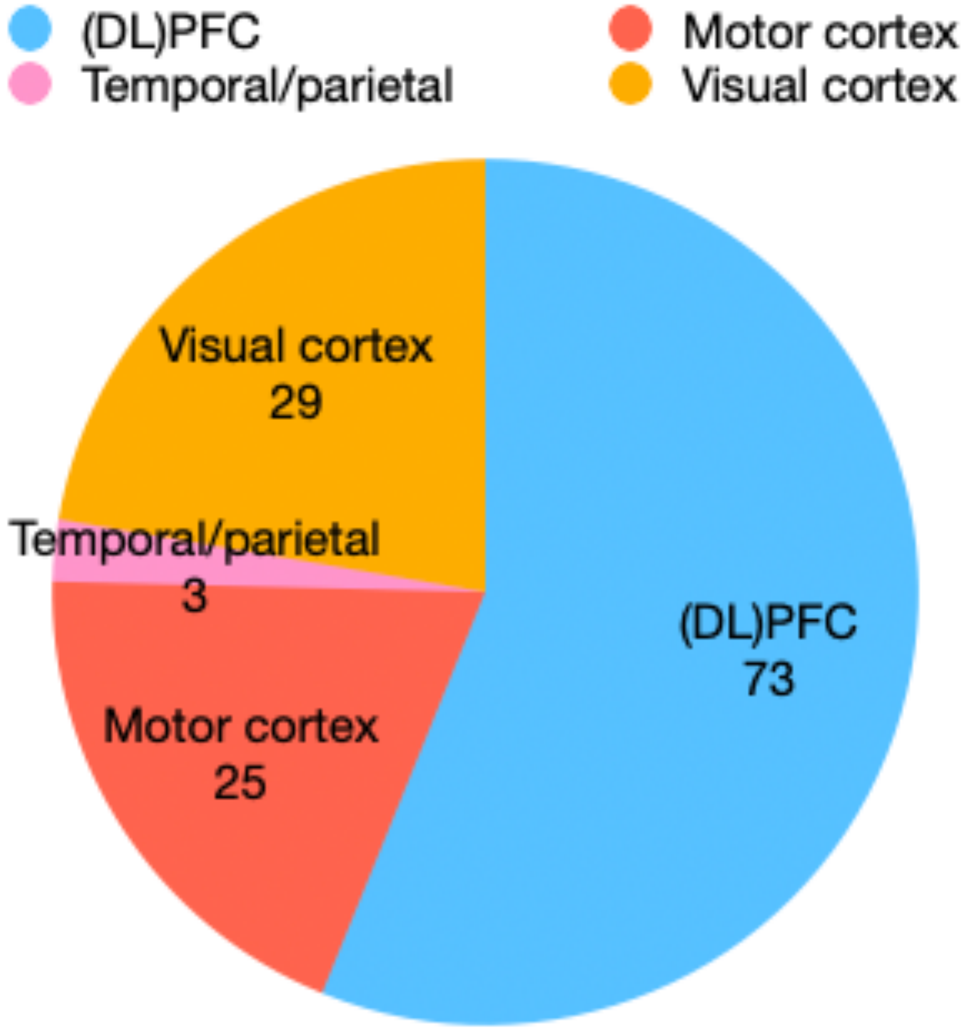
fNIRS with other neuroimaging methods

Number of fNIRS studies for year the 2023

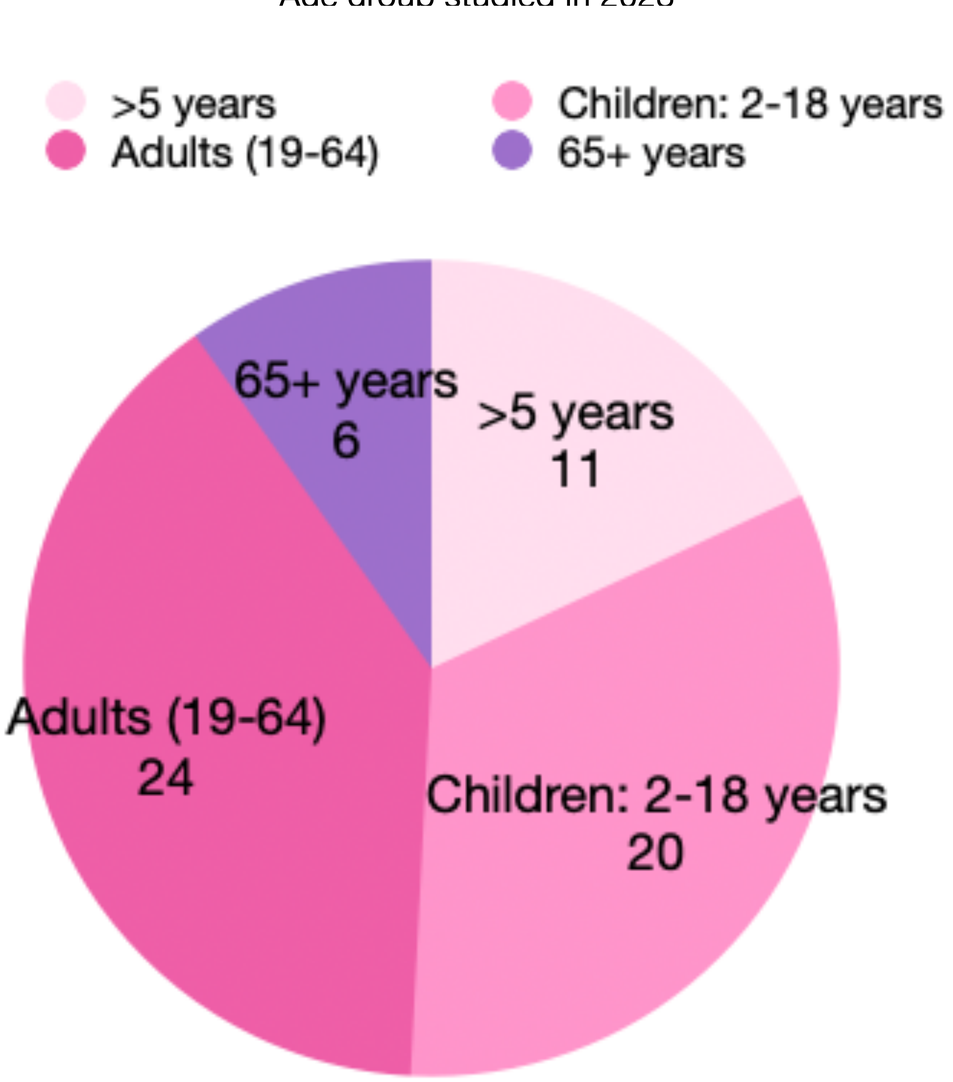


Brain areas studied

Brain areas studied with fNIRS in 2023



Participant age groups



BCI studies:

Title	First author	Notes
It takes two (seconds): decreasing encoding time for two-choice functional near-infrared spectroscopy brain-computer interface communication	**Vorreuther A**	**2 second task**
Impacts of simplifying articulation movements imagery to speech imagery BCI performance	**Guo & Chen**	**Mental task comparison**
Rethinking Delayed Hemodynamic Responses for fNIRS Classification	Wang Z	MVPA, Deep Neural Networks
Multimodal pre-screening can predict BCI performance variability: A novel subject-specific experimental scheme	Borgheai SB	MCPA, feature selection, EEG
Metaheuristic Optimization-Based Feature Selection for Imagery and Arithmetic Tasks: An fNIRS Study	Zafar A	MCPA, feature selection
Multimodal motor imagery decoding method based on temporal spatial feature alignment and fusion	Zhang Y	Neural network, EEG-fNIRS
Driving risk cognition of passengers in highly automated driving based on the prefrontal cortex activity via fNIRS	Wang H	:(
Exploring the effects of different BCI-based attention training games on the brain: A functional near-infrared spectroscopy study	Chen A	:(

BCI studies: #1 Vorreuther et al. (2023)

- Anna's paper: "It takes two (seconds).
- Encodes binary answers to 10 biographical questions in 10 healthy adults.
- Motor-speech imagery task of 2 seconds.
- Used temporal features.
- Results:
  - Mean run-based accuracy: 86%.
  - Mean single-trial accuracy: 68%

NEUROPHOTONICS

RESEARCH PAPER

It takes two (seconds): decreasing encoding time for two-choice functional near-infrared spectroscopy brain–computer interface communication

Anna Vorreuther,[a,b,*] Lisa Bastian,[a,c,d] Amaia Benitez Andonegui,[a,e] Danielle Evenblij,[a] Lars Riecke,[a] Michael Lührs,[a,f] and Bettina Sorger[a]

[a]Maastricht University, Department of Cognitive Neuroscience, Maastricht, The Netherlands
[b]University of Stuttgart, Institute of Human Factors and Technology Management IAT, Applied Neurocognitive Systems, Stuttgart, Germany
[c]University of Tübingen, Institute of Medical Psychology and Behavioral Neurobiology, Tübingen, Germany
[d]International Max Planck Research School, Graduate Training Centre of Neuroscience, Tübingen, Germany
[e]NIH, MEG Core Facility National Institute of Mental Health, Bethesda, Maryland, United States
[f]Brain Innovation B.V., Research Department, Maastricht, The Netherlands

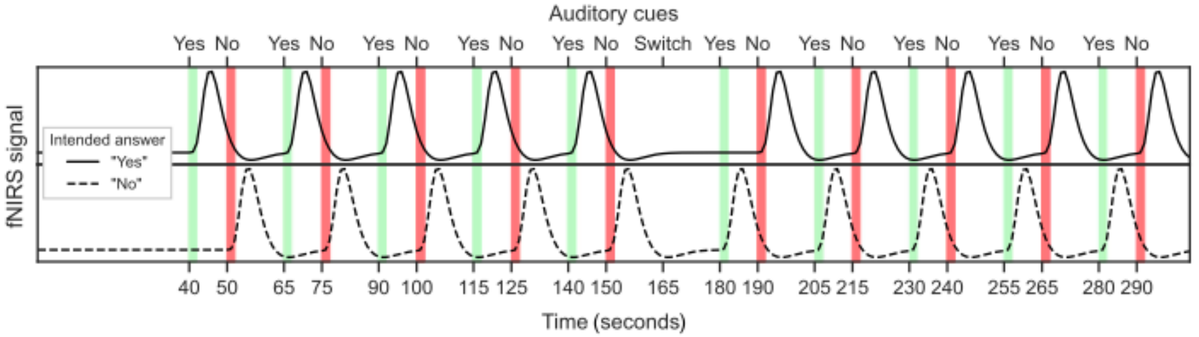


Fig. 2 Answer encoding scheme. The figure shows the two possible answer-encoding scenarios for both a "yes" (top) and "no" (bottom) answer. Expected oxyhemoglobin (HbO) time courses

BCI studies: #2 Guo & Chen (2023)

- Combined 10s motor imagery with speech imagery, using articulation of “yes” and “no”.
- They compared this to ‘default’ inner speech.
- LDA classifier using slope, mean and max valueof HbO, and min value of Hb.
- 3-class: “Yes”, “No” and “rest”.
- Results:
  - **Articulated inner speech**: 70% and 60%.
  - **Default inner speech**: 60% and 55%

Journal of Neural Engineering

PAPER

Impacts of simplifying articulation movements imagery to speech imagery BCI performance

Zengzhi Guo[1,2] and Fei Chen[2,*]

[1] School of Electronics and Information Engineering, Harbin Institute of Technology, Harbin, People’s Republic of China
[2] Department of Electrical and Electronic Engineering, Southern University of Science and Technology, Shenzhen, People’s Republic of China
[*] Author to whom any correspondence should be addressed.

E-mail: fchen@sustech.edu.cn

Keywords: brain-computer interface, functional near-infrared spectroscopy, speech imagery, simplifying articulation movements imagery

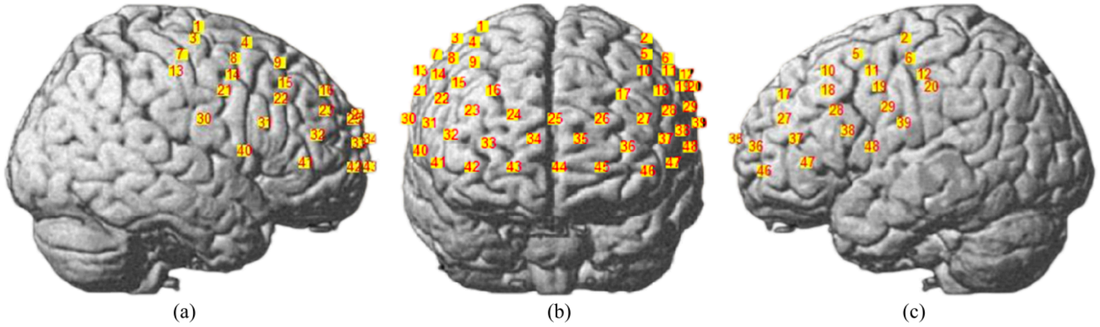


Figure 1. The positions of light channels. (a) Right view. (b) Frontal view. (c) Left view.

BCI studies: #2 Guo & Chen (2023)

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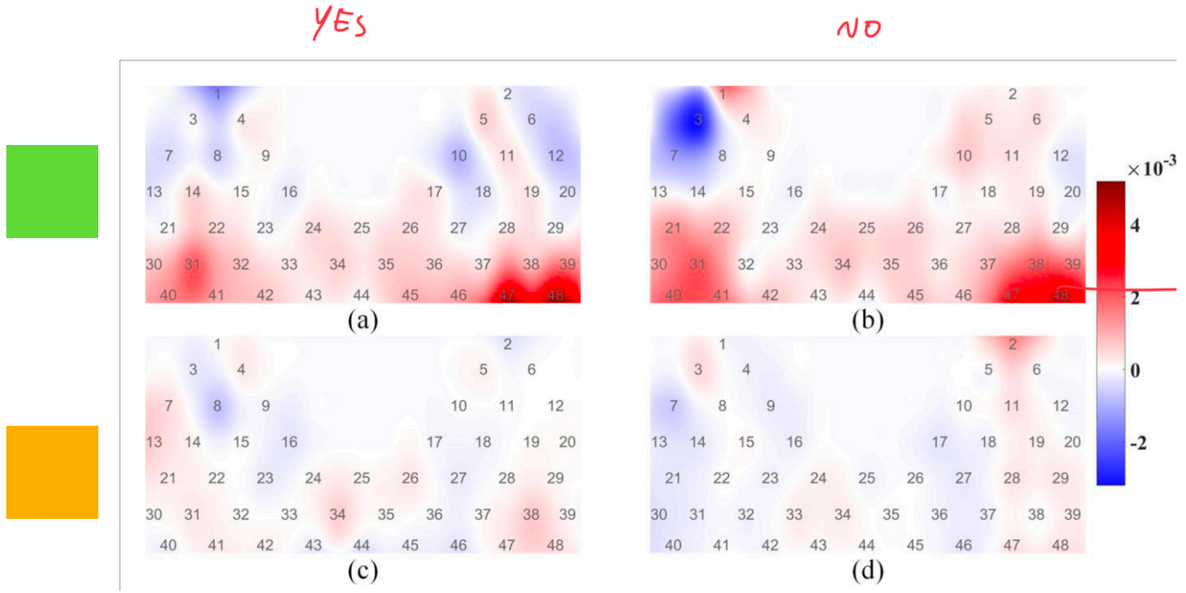


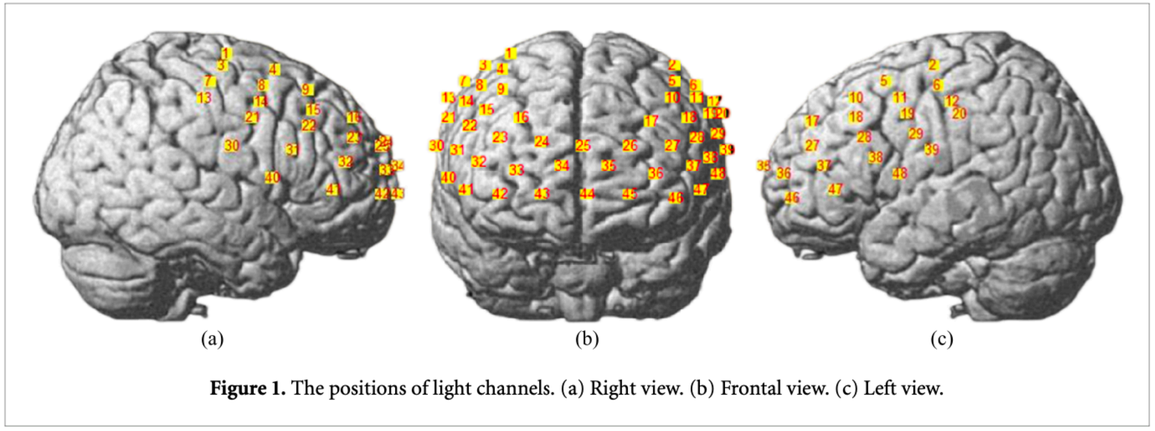


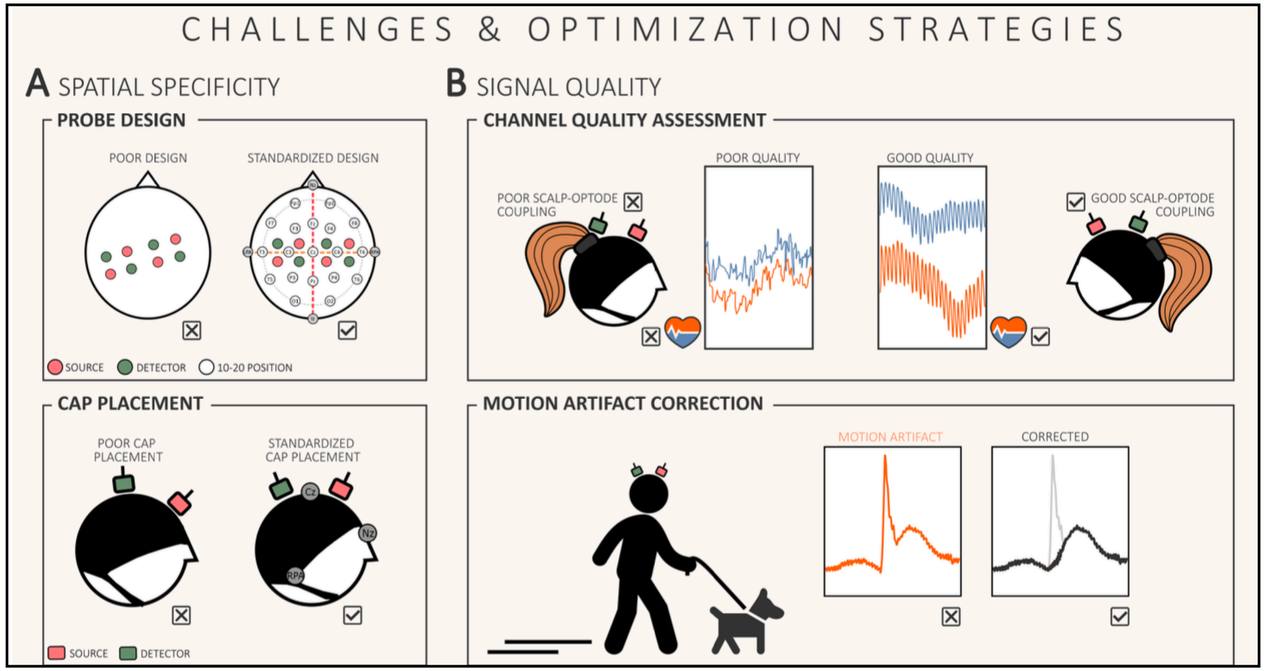
Figure 1. The positions of light channels. (a) Right view. (b) Frontal view. (c) Left view.

Neurofeedback reviews: #1 Klein et al. (2023)

- Practical review on fNIRS neurofeedback for new users.
- Advantages and challenges of fNIRS NF.
- Possibilities and outlooks

From Lab to Life: Challenges and Perspectives of fNIRS for Hemodynamic Neurofeedback in Real-World Environments

Franziska Klein[1,2], Simon H. Kohl[3,4], Michael Lührs[5,6], David M.A. Mehler[2,7,8] and Bettina Sorger[5]



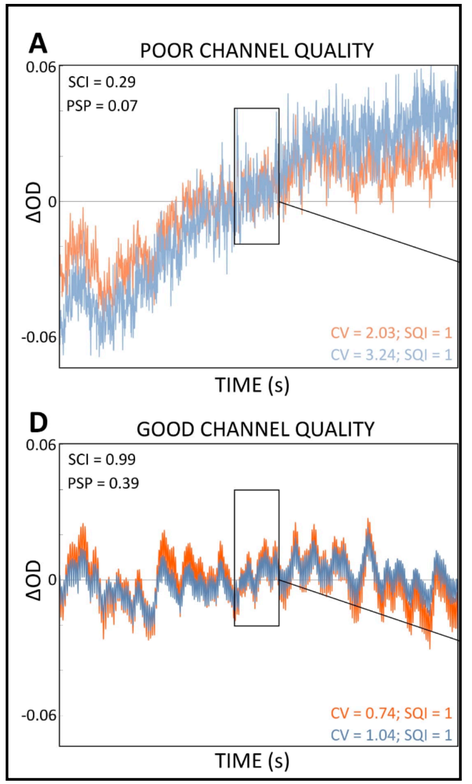
Neurofeedback reviews: #2 Klein (2023)

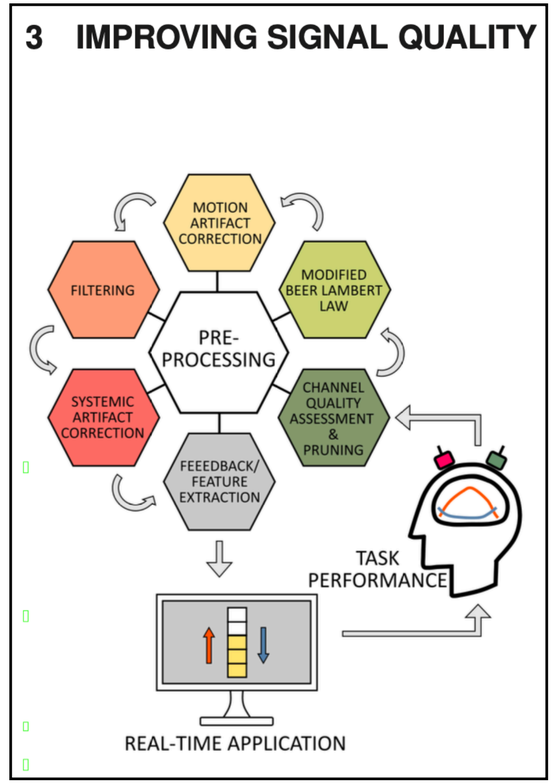
- Practical recommendations on improving real-time fNIRS signal for BCIs and neurofeedback.
- Recommendations for:
  - Optode and cap placement
  - Assessing channel signal quality.
  - Filter use.
  - Motion-correction techniques

1

Optimizing real-time fNIRS in BCI and neurofeedback: A comprehensive overview of strategies to improve reliability, spatial specificity, and signal quality

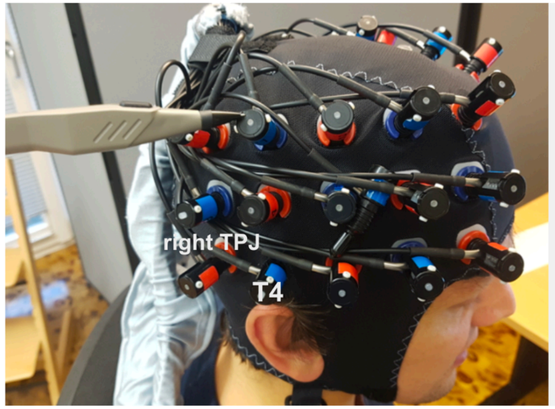
Franziska Klein [1,2,3*]

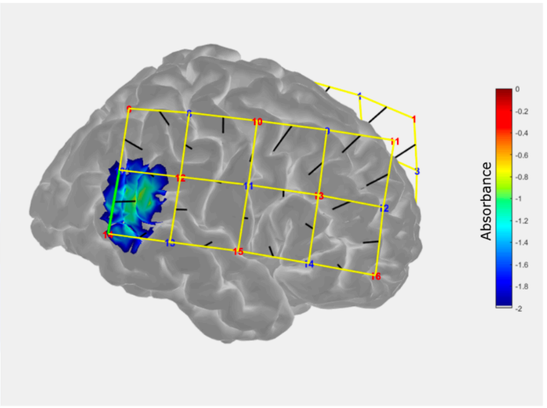




Neurofeedback studies: Kohl et al. (2023)

- 50 participants, 4 days of training.
- Bidirectional regulation control group design.
- Only the up regulation group maintained increase in rTPJ activity over sessions.





Imaging Neuroscience
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Research Article

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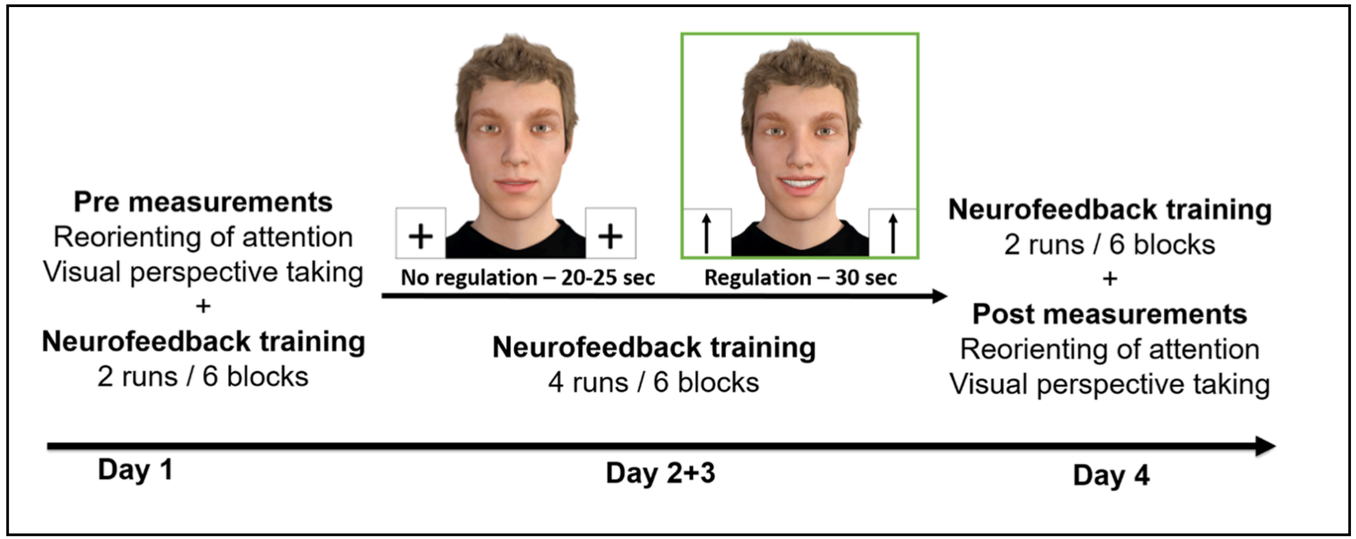
Successful modulation of temporoparietal junction activity and stimulus-driven attention by fNIRS-based neurofeedback—A randomized controlled proof-of-concept study

Simon H. Kohl[a,b], Pia Melies[b], Johannes Uttecht[b], Michael Lührs[c,d], Laura Bell[b,e], David M. A. Mehler[f,g], Surjo R. Soekadar[h], Shivakumar Viswanathan[i], Kerstin Konrad[a,b]



Neurofeedback studies: DLPFC & working memory

Title	First author	Nr of participants	Control
Subjective feeling of control during fNIRS-based neurofeedback targeting the DL-PFC is related to neural activation determined with short-channel correction	**Godet et al. (2023)**	**30**	**NA**
A brief real-time fNIRS-informed neurofeedback training of the prefrontal cortex changes brain activity and connectivity during subsequent working memory challenge	**Yang et al. (2023)**	**62**	**Yoked**
Functional near-infrared spectroscopy neurofeedback of dorsolateral prefrontal cortex enhances human spatial working memory	Keshuang et al. (2023)	60	Yoked
Cognitive training based on functional near-infrared spectroscopy neurofeedback for the elderly with mild cognitive impairment: a preliminary study	Lee et al. (2023)	13	None
Higher prefrontal activity based on short-term neurofeedback training can prevent working memory decline in acute stroke	Tetsuka M	30 stroke patients	Yoked
Mechanisms underlying fNIRS-neurofeedback over the prefrontal cortex for participants with binge-eating disorder	**Rosch et al. (2023)**	**22 BED patients**	

Neurofeedback studies: Godet et al. (2023)

- Single session.
- Compared two bandpass filters: 0.01-0.09 Hz and 0.01-0.2 Hz
- Compared short-channel correction vs none.
- 60% managed to control their DLPFC, which dropped to 43% with short-channel correction.
  - Control = “significant activation in at least 1 out of 4 NF channels covering the DLPFC”

PLOS ONE

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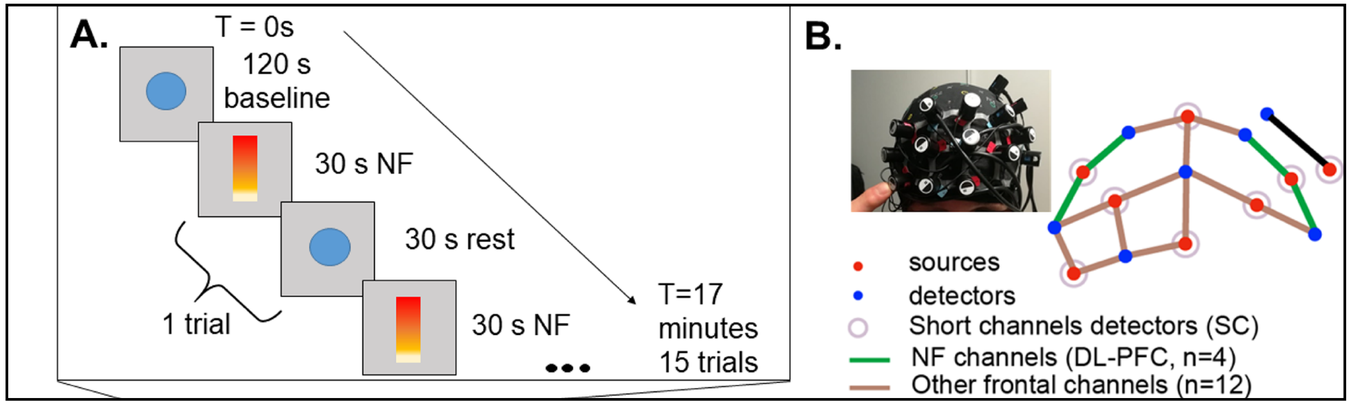
RESEARCH ARTICLE

Subjective feeling of control during fNIRS-based neurofeedback targeting the DL-PFC is related to neural activation determined with short-channel correction

Ambre Godet, Yann Serrand, Alexandra Fortier, Brieuc Léger, Elise Bannier, David Val-Laillet, Nicolas Coquery



Neurofeedback studies: Rösch et al. (2023)

- 22 participants with binge-eating disorder (BED).
- Control group = delayed rtfNIRS-NF

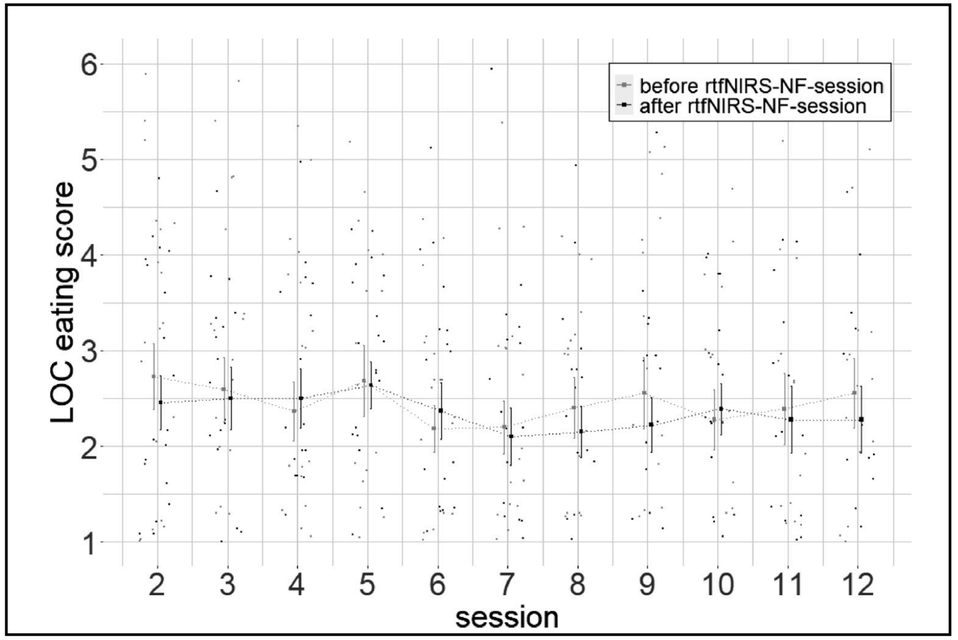
Contents lists available at ScienceDirect

Clinical Neurophysiology

journal homepage: www.elsevier.com/locate/clinph

Mechanisms underlying fNIRS-neurofeedback over the prefrontal cortex for participants with binge-eating disorder

Sarah A. Rösch [a,b,*], Ricarda Schmidt [a], Jytte Wimmer [a], Michael Lührs [c,d], Ann-Christine Ehlis [e], Anja Hilbert [a]



Neurofeedback studies: Rösch et al. (2023)

- Was preregistered ->

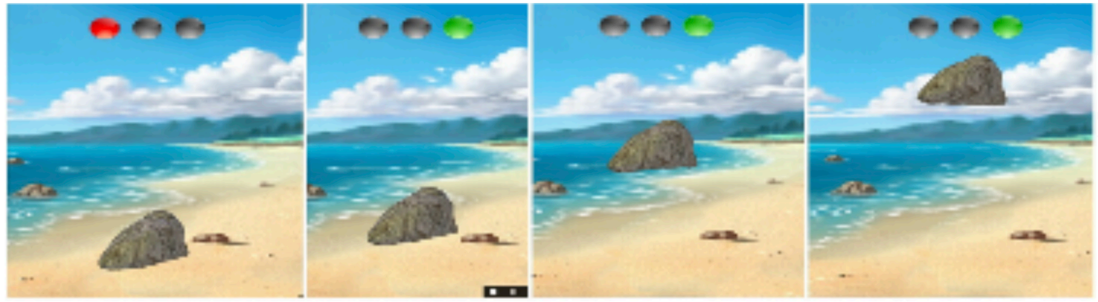
Table 1
Overview of Hypotheses and Analyses.

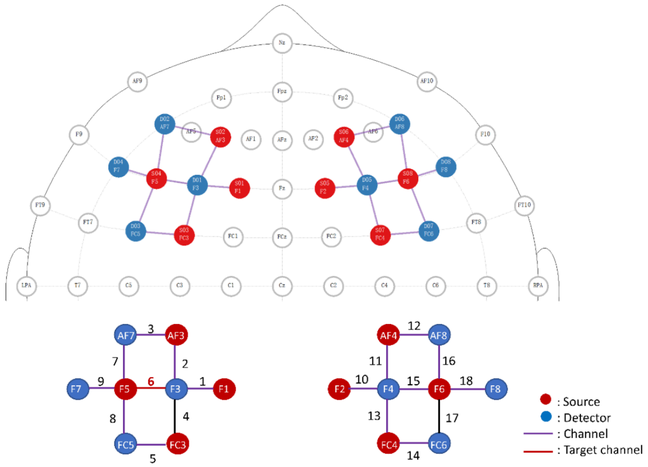
Hypothesis	Model	Predictor variables	Outcome variables
H_1, *directional hypothesis*: Better online visual feedback signals (smaller picture sizes on the screen) positively predict subjective, but not offline, regulation success	Linear mixed models	Measures for online visual feedback: (1) Mean picture size (2) Percentage of successful trials (3) Transfer picture size	Measures for regulation success: (1) Subjective success, measured via self-report on a 7-point Likert scale ranging from 1 = *not at all* to 7 = *very strong* (2 – 4) Offline NF regulation success, measured via the difference in GLM betas in regulation vs. mirror in the individually selected ROI, DLPFC, and IFG (5 – 8) Offline transfer regulation success, measured via the difference in GLM betas in regulation vs. mirror in the individually selected ROI, DLPFC, and IFG
$H_{2\text{-}3}$, *directional hypotheses*: Decreases in LOC eating after vs. before and with increasing number of rtfNIRS-NF-sessions	Cumulative link mixed models	(1) session (levels: 1 – 12) (2) assessment (levels: pre, post)	Score for LOC eating, measured via self-report on a 7-point Likert scale ranging from 1 = *not at all* to 7 = *very strong*
$H_{4\text{-}6}$, *directional hypotheses*: Decreases in LOC eating correlate positively with higher online and offline regulation success in the individually selected ROI, DLPFC, and IFG	Partial correlations, controlling for the effect of session	Changes in self-reported LOC eating after vs. before sessions	Measures for regulation success: (1) Mean picture size (online regulation success) (2) Percentage of successful trials (online regulation success) (3) Transfer picture size (transfer regulation success) (4) Subjective success, measured via self-report on a 7-point Likert scale ranging from 1 = *not at all* to 7 = *very strong* (5 – 7) Offline NF regulation success, measured via the difference in GLM betas in regulation vs. mirror in the individually selected ROI, DLPFC, and IFG (8 – 11) Offline transfer regulation success, measured via the difference in GLM betas in transfer regulation vs. mirror in the individually selected ROI, DLPFC, and IFG
Exploratory analyses	Linear mixed models	Categories of strategies (levels: applied in the respective session, not applied in the respective session): (1) "Behavior" (2) "Concentration" (3) "Distraction" (4) "Emotion" (5) "Imagination" (6) "Self-Talk" (7) "Thought"	Measures for regulation success: (1) Subjective success, measured via self-report on a 7-point Likert scale ranging from 1 = *not at all* to 7 = *very strong* (2) Online regulation success, measured via the mean picture size, percentage of successful trials and transfer picture size (3 – 5) Offline NF regulation success, measured via the difference in GLM betas in regulation vs. mirror in the individually selected ROI, DLPFC, and IFG (6 – 8) Offline transfer regulation success, measured via the difference in GLM betas in transfer regulation vs. mirror in the individually selected ROI, DLPFC, and IFG

Note. DLPFC: dorsolateral prefrontal cortex, fNIRS: functional near-infrared spectroscopy, GLM: general linear model, IFG: inferior frontal gyrus, LOC: loss of control, NF: neurofeedback, ROI: region of interest.

Neurofeedback studies: Yang et al. (2023)

- NF instruction: try to "lift the stone" on the beach as high as possible.





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New Results

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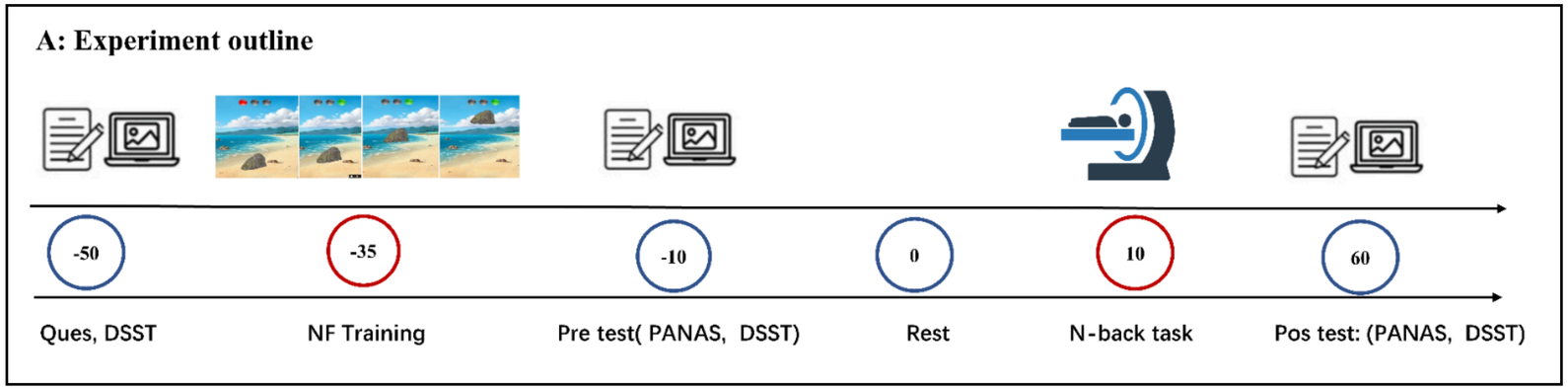
A brief real-time fNIRS-informed neurofeedback training of the prefrontal cortex changes brain activity and connectivity during subsequent working memory challenge

Xi Yang, Yixu Zeng, Guojuan Jiao, Xianyang Gan, David Linden, Dennis Hernaus, Chaozhe Zhu, Keshuang Li, Dezhong Yao, Shuxia Yao, Yihan Jiang, Benjamin Becker



Mindfulness/meditation studies

Title	First author	Nr of participants	Brain area
Brief mindfulness meditation intervention improves attentional control of athletes in virtual reality shooting competition: Evidence from fNIRS and eye tracking	Gao et al (2023)	34	DLPFC
Prefrontal cortical hemodynamics and functional network organization during Tai Chi standing meditation: an fNIRS study	Qi et al (2023)	24	DLPFC
In situ fNIRS measurements during cognitive behavioral emotion regulation training in rumination-focused therapy: A randomized-controlled trial	Laicher et al (2023)	42	DLPFC, IFG

Mindfulness/meditation studies: Qi et al. (2023)

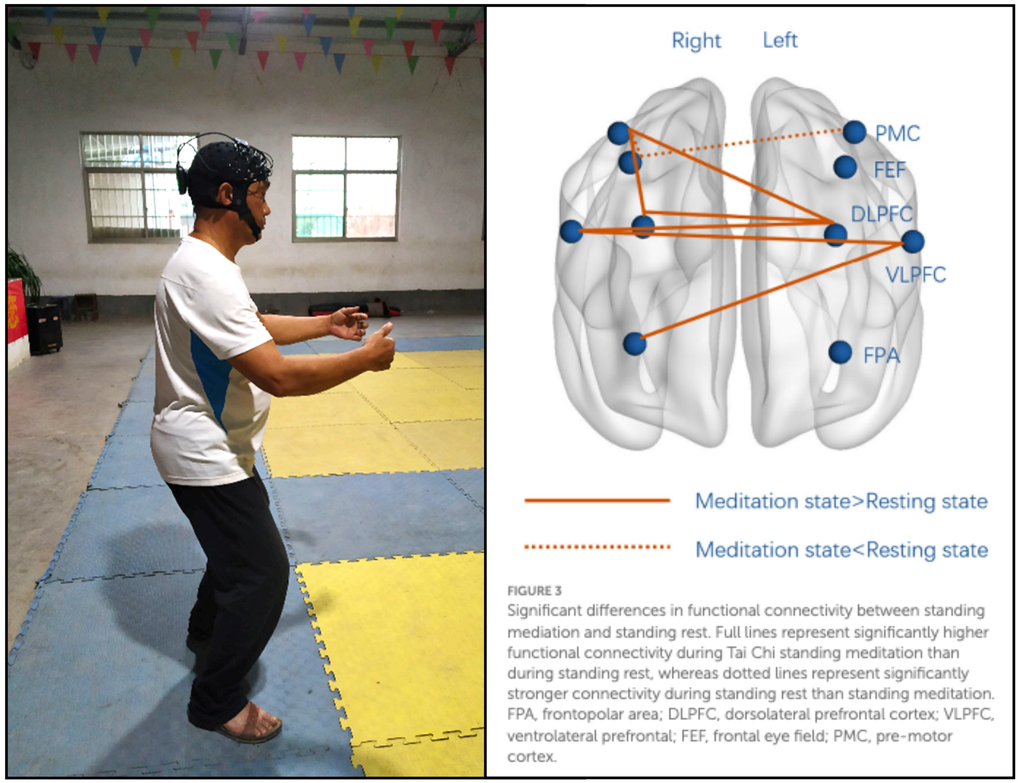


FIGURE 3
Significant differences in functional connectivity between standing mediation and standing rest. Full lines represent significantly higher functional connectivity during Tai Chi standing meditation than during standing rest, whereas dotted lines represent significantly stronger connectivity during standing rest than standing meditation. FPA, frontopolar area; DLPFC, dorsolateral prefrontal cortex; VLPFC, ventrolateral prefrontal; FEF, frontal eye field; PMC, pre-motor cortex.

frontiers | Frontiers in Human Neuroscience

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Prefrontal cortical hemodynamics and functional network organization during Tai Chi standing meditation: an fNIRS study

Liping Qi[1*†], Guo-Liang Wang[1], Zhi-Hao Tian[1], Shuo Guan[1], Shu-Ye Yang[2], Yu-Long Yang[2], Li-Qing Liu[2] and Yong-Zhong Lin[3*†]

Hyperscanning studies

Title	First author
Interpersonal Competition in Elderly Couples: A Functional Near-Infrared Spectroscopy Hyperscanning Study	Zhang Q
fMRI and fNIRS Methods for Social Brain Studies: Hyperscanning Possibilities	Bazán PR
New Framework for Understanding Cross-Brain Coherence in Functional Near-Infrared Spectroscopy (fNIRS) Hyperscanning Studies	Gvirts Provolovski HZ
The increased inter-brain neural synchronization in prefrontal cortex between simulated patient and acupuncturist during acupuncture stimulation: Evidence from functional near-infrared spectroscopy hyperscanning	Chen L
Gender differences in cognitive and affective interpersonal emotion regulation in couples: an fNIRS hyperscanning	Zhang W
Is neuroimaging ready for the classroom? A systematic review of hyperscanning studies in learning	Tan SHJ
Affective or cognitive interpersonal emotion regulation in couples: an fNIRS hyperscanning study	Zhang W
Inter-brain neural mechanism and influencing factors underlying different cooperative behaviors: a hyperscanning study	Liu Q
Quantification of inter-brain coupling: A review of current methods used in haemodynamic and electrophysiological hyperscanning studies	Hakim U
The hyper-brain neural couplings distinguishing high-creative group dynamics: an fNIRS hyperscanning study	Lu K
HyperOptoNet: a MATLAB-based toolbox for inter-brain neuronal synchrony analysis using fNIRS hyperscanning	Lee G
Brain-to-brain synchrony during dyadic action co-representation under acute stress: evidence from fNIRS-based hyperscanning	Lin S
Increased Interpersonal Brain Synchronization in Romantic Couples Is Associated with Higher Honesty: An fNIRS Hyperscanning Study	Shao C
Decreased inter-brain synchronization in the right middle frontal cortex in alcohol use disorder during social interaction: An fNIRS hyperscanning study	Guo L
Reduced interpersonal neural synchronization in right inferior frontal gyrus during social interaction in participants with clinical high risk of psychosis: An fNIRS-based hyperscanning study	Wei Y
Analyzing teacher-student interactions through graph theory applied to hyperscanning fNIRS data	Oku AYA
Hyperscanning fNIRS data analysis using multiregression dynamic models: an illustration in a violin duo	do Nascimento DC

Extra: Dolphins!

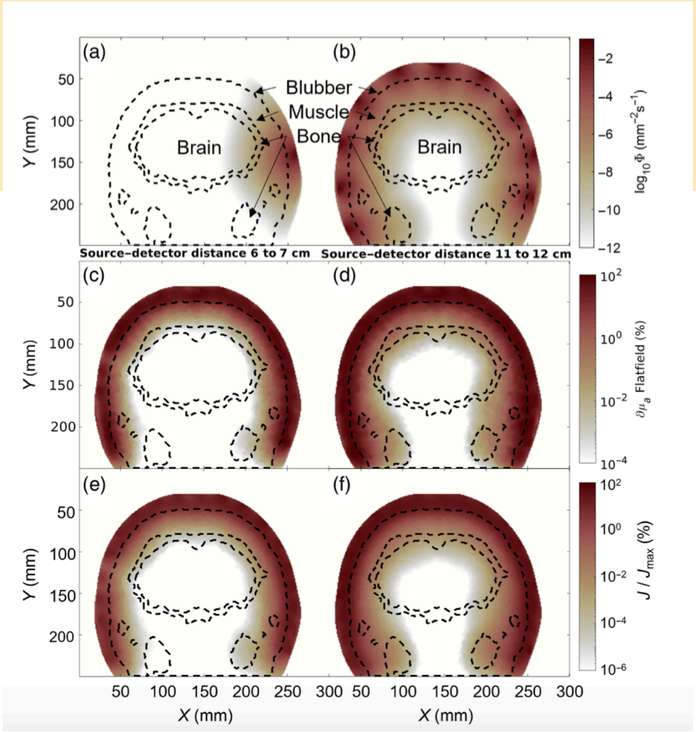
JBO Journal of Biomedical Optics

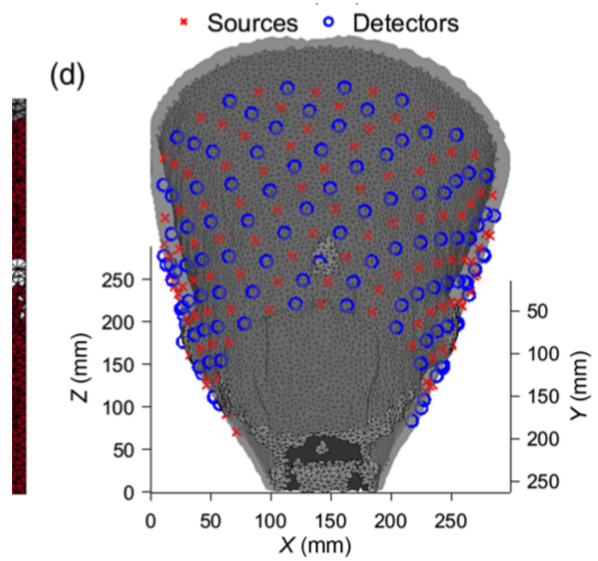
RESEARCH PAPER

Evaluating feasibility of functional near-infrared spectroscopy in dolphins

Alexander Ruesch,[a,b] Deepshikha Acharya,[b] Eli Bulger,[b] Jiaming Cao,[b] J. Christopher McKnight,[c] Mercy Manley,[d] Andreas Fahlman,[e,f,g] Barbara G. Shinn-Cunningham,[a,b] and Jana M. Kainerstorfer[a,b,*]

[a]Carnegie Mellon University, Neuroscience Institute, Pittsburgh, Pennsylvania, United States





Thanks for joining! :)

- You can find this presentation on the HBCI group **Github** page:
  - https://github.com/HBCIMaastricht
    - Data-analysis and stimulus presentation scripts.
    - Practical tips and tricks on fNIRS measurement.