The auditory hemodynamic response & Loudness modulation

Parzijn Majid 1:50 AM
good afternoon teammates, I am a clinical linguist and founder of earlab co. Earlab is a start-up company. we want to develop a medical diagnostic instrument for measuring hearing test. the instrument is based on measuring brain activity using EEG in combination with fnirs. this has also been the reason for me to join this group.

I don't know much about BCI or programming and no experiense with fnirs jet!.

Parzijn Majid 1:56 AM
We are in the early Development phase(POC)

One of our assumptions that we are working on is Loudness modulation for different frequency bands (between 100 Hz to 20kHz) in an interval of a third (1/3 octave)

Lawrence Neal 3:42 AM
FYI, I'm a Retired Telecommunications Engineer - 71yo, active as an Embedded Systems Developer, Hardware/Software, currently working on a project titled 'EpiSense' to anticipate Aura/Seizures for Epilepsy, A. Generalized tonic-clonic, B. Dyscognitive, C. Generalized tonic-clonic, and D. Dyscognitive seizures.

Yes, we need "Hardware", preferably the Nautilus fNIRS at minimum.

Parzijn Majid 4:00 AM
Most studies performed with fMRI have demonstrated that the auditory hemodynamic re- sponse is sensitive to variations in sound level. Some authors have indicated a positive, nearly linear re- lationship between the strength of the BOLD signal and sound intensity. It appears that auditory cortical re- sponses measured with fNIRS show such a linear relation- ship for perceived loudness, rather than for the (physical) intensity of the sound. This potential discrepancy between intensity vs. loudness might suggest that fNIRS does not primarily target primary auditory cortex, where intensity effects seem more clear, but mainly relate to activity generated in secondary auditory areas

Greeshma Sharma 4:11 AM
So we are developing BCI application for auditory stimulation.

What protocol should we look after

https://www.frontiersin.org/articles/10.3389/fnins.2014.00373/full
FrontiersFrontiers
Hybrid fNIRS-EEG based classification of auditory and visual perception processes

For multimodal Human-Computer Interaction (HCI), it is very useful to identify the modalities on which the user is currently processing information. This would enable a system to select complementary output modalities to reduce the user's workload. In this paper, we develop a hybrid Brain-Computer Interface (BCI) which uses Electroencephalography (EEG) and functional Near Infrared Spectroscopy (fNIRS) to discriminate and detect visual and auditory stimulus processing. We describe the experimental setup we used for collection of our data corpus with 12 subjects. On this data, we performed cross-validation evaluation, of which we report accuracy for different classification conditions. The results show that the subject-dependent systems achieved a classification accuracy of 97.8% for discriminating visual and auditory perception processes from each other and a classification accuracy of up to 94.8% for detecting modality-specific processes independently of other cognitive activity. The same classification conditions could also be discriminated in a subject-independent fashion with accuracy of up to 94.6 and 86.7%, respectively. We also look at the contributions of the two signal types and show that the fusion of classifiers using different features significantly increases accuracy.

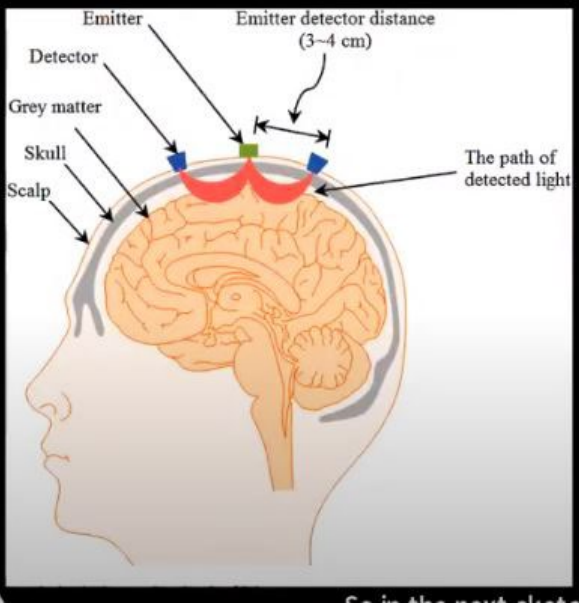
Parzijn Majid 4:15 AM
https://www.degruyter.com/document/doi/10.1515/cdbme-2016-0051/html
De GruyterDe Gruyter
fNIRS for future use in auditory diagnostics
Functional near-infrared spectroscopy (fNIRS) is an emerging technique for the assessment of functional activity of the cerebral cortex. Recently fNIRS was also envisaged as a novel neuroimaging approach for measuring the auditory cortex (AC) activity in cochlear implant (CI) users. In the present study we report on initial measurements of AC activation due to spatial sound presentation with a first target to generate data for comparison with CI user and the future use in auditory diagnostics.

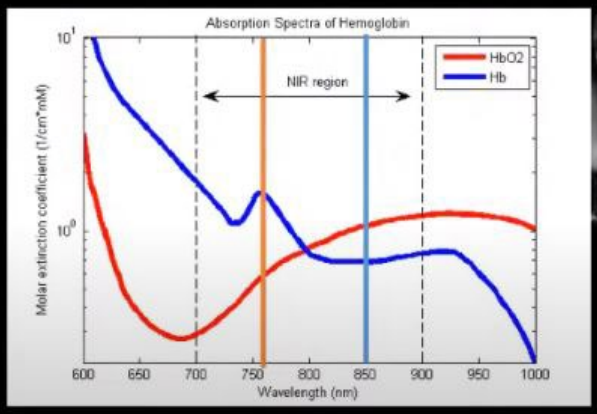
Parzijn Majid 6:02 AM
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6394942/
PubMed Central (PMC)PubMed Central (PMC)
Assessing hearing by measuring heartbeat: The effect of sound level
Functional near-infrared spectroscopy (fNIRS) is a non-invasive brain imaging technique that measures changes in oxygenated and de-oxygenated hemoglobin concentration and can provide a measure of brain activity. In addition to neural activity, fNIRS signals ...

Default Setting		fNIRS Project	
OFF TIME rest	30 sec	30 sec	30 sec
random off time	Do, Re, Mi,..... 15 sec	Do, Re, Mi,..... 15 sec	Do, Re, Mi,..... 15 sec
rest	10 ms	10 ms	10 ms
tone length signal	5 sec Pure tone	5 sec Pure tone	5 sec Pure tone
Rest	15 ms	15 ms	15 ms
test frequencies	50 Hz 63 Hz 80 Hz 100 Hz 125 Hz 160 Hz 200 Hz 250 Hz 315 Hz	400 Hz 500 Hz 630 Hz 800 Hz 1000 Hz 1250 Hz 1600 Hz 2000 Hz 2500 Hz	3150 Hz 4000 Hz 5000 Hz 6300 Hz 8000 Hz 10000 Hz 12500 Hz 16000 Hz 20000 Hz
start frequency	50 Hz	400 Hz	3150 Hz
straat test ear side	right	right	right
intensity	15 dB, 30 dB, 45 dB, 60 dB,75 dB, 90 dB, 105 dB	15 dB, 30 dB, 45 dB, 60 dB,75 dB, 90 dB, 105 dB	15 dB, 30 dB, 45 dB, 60 dB,75 dB, 90 dB, 105 dB
step size	15 dB	15 dB	15 dB

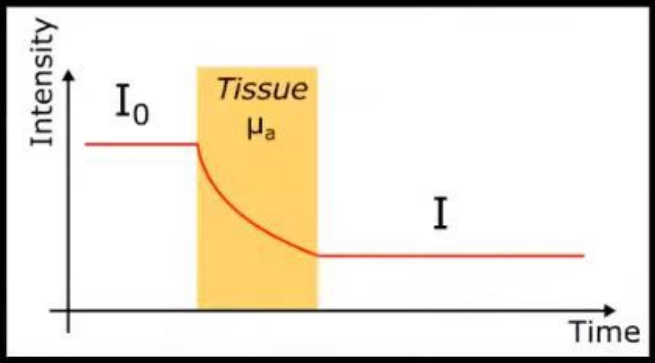
Lawrence Neal 5:24 PM
Hey all, FYI, YouTube URL (https://www.youtube.com/watch?v=tXJj61EptSk) for DAY 4 - APRIL 28 BCIs WITH FNIRS, STIMULATION & ERROR POTENTIALS - 19:00 | Wireless EEG and fNIRS recordings Patrick Reitner.. starts @ 9:51:42, I think it's worth watching again.

fNIRS Principal



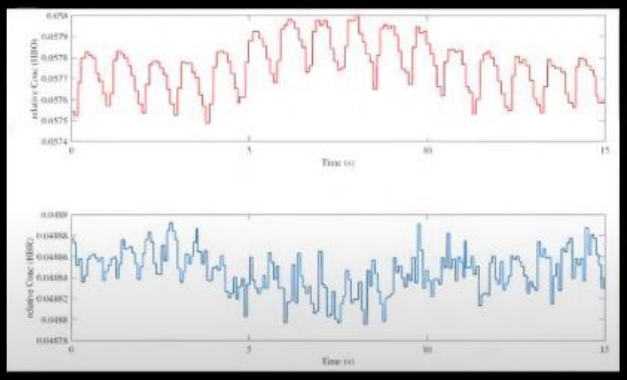


Continous Wave fNIRS Principal



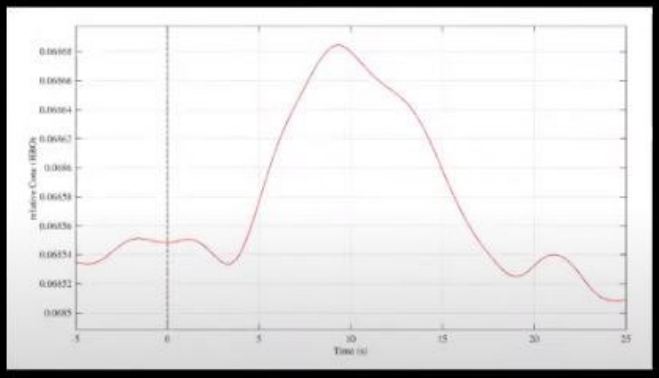
$$\begin{bmatrix} \Delta[HHb] \\ \Delta[O_2Hb] \end{bmatrix} = (d)^{-1} \begin{bmatrix} \varepsilon_{HHb,\lambda_1} & \varepsilon_{O_2Hb,\lambda_1} \\ \varepsilon_{HHb,\lambda_2} & \varepsilon_{O_2Hb,\lambda_2} \end{bmatrix}^{-1} \begin{bmatrix} \frac{\Delta OD(\Delta t,\lambda_1)}{DPF(\lambda_1)} \\ \frac{\Delta OD(\Delta t,\lambda_2)}{DPF(\lambda_2)} \end{bmatrix}$$

HBO and HBR



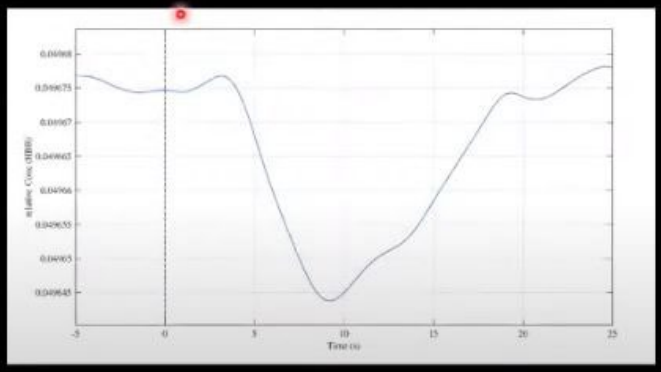
- oxygenated hemoglobine (HBO)
- deoxygenated hemoglobine (HBR)
- SNR in general better for HBO
- clear visible pulsatile fluctuations (quality indication)

HBO Response



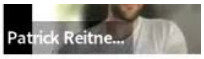
- averaged HBO respones from MI experiment:
  - dotted line: task onset
  - task duration: 10s
- initial dip (~2-3s)
- peak (~8s)
- undershoot

HBR Response



- averaged HBR respones from MI experiment:
  - dotted line: task onset
  - task duration: 10s

fNIRS and EEG Placement

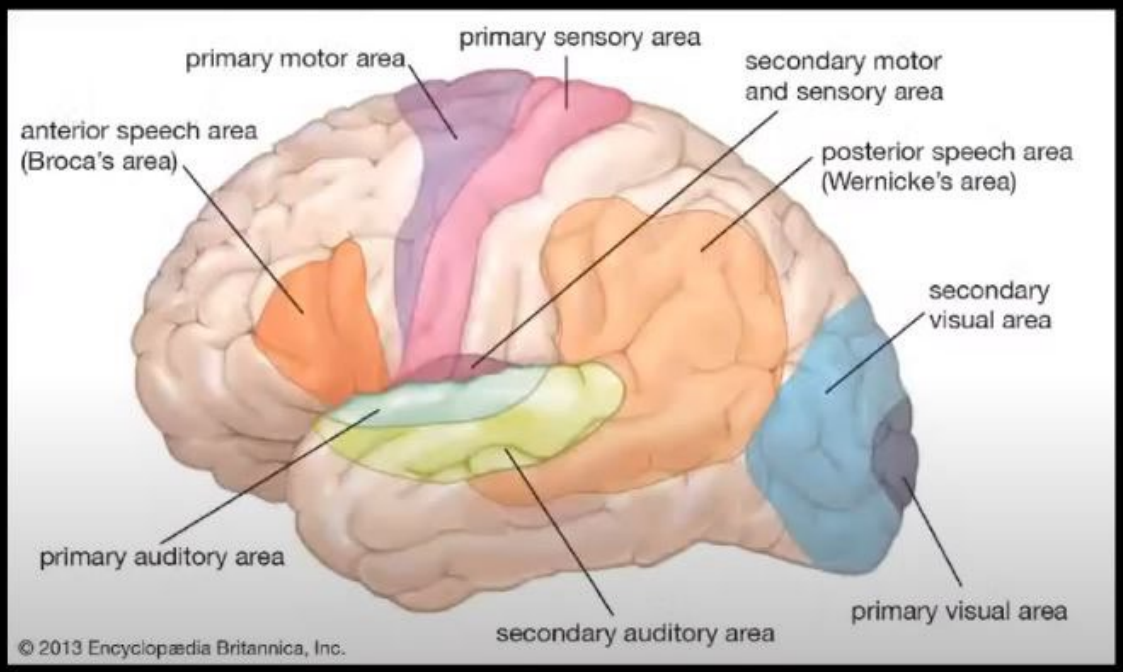


g.Nautilus fNIRS: Hard Facts

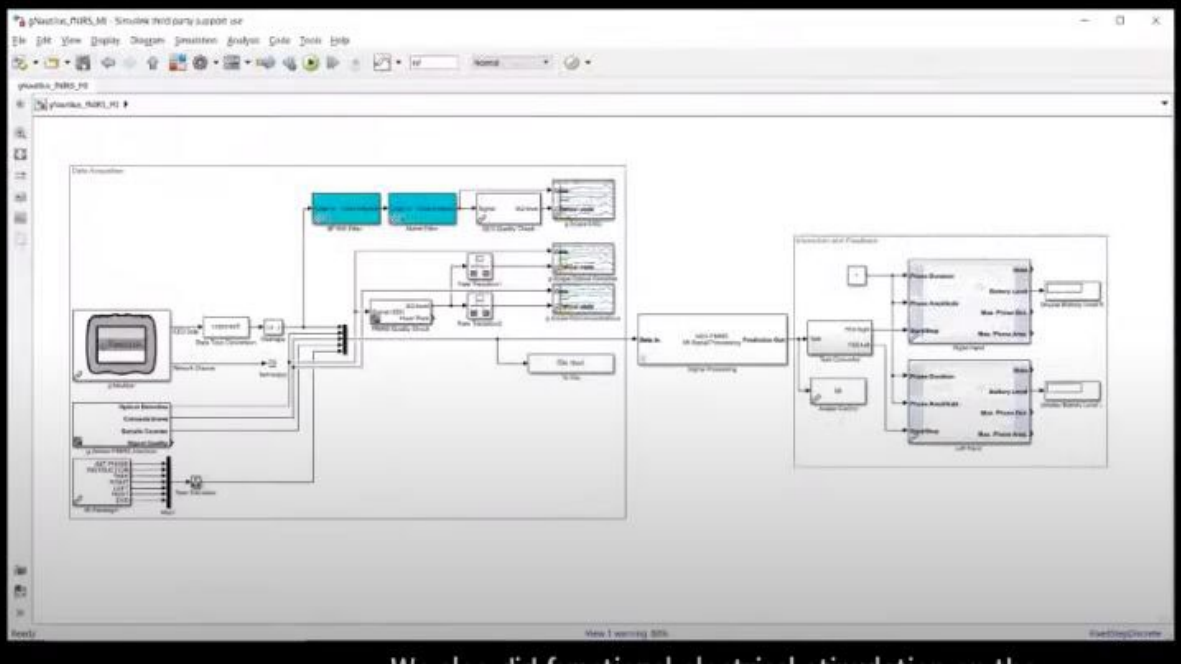
- EEG: g.Nautilus
  - up to 64 channels
  - 24 bit
  - up to 500Hz sampling rate

- fNIRS: Artinis OctaMon
  - 8 channels
  - 50Hz sampling rate
  - 760nm and 850nm

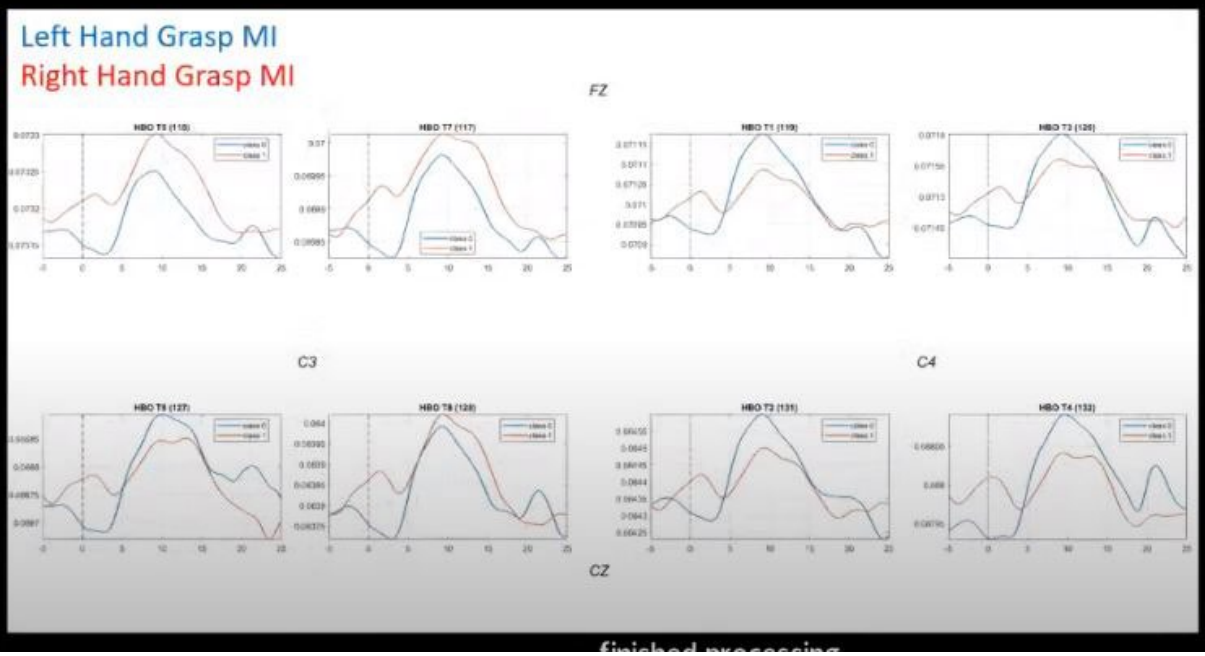
MI Experiment



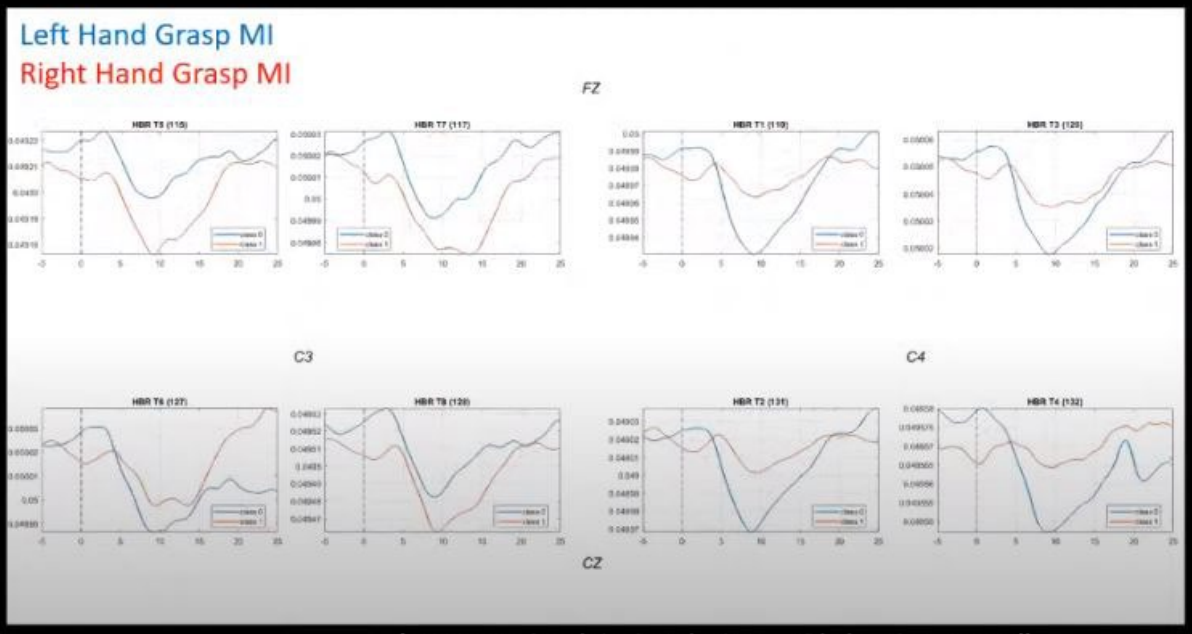
MI Experiment – Simulink Model



MI Experiment – HBO Response

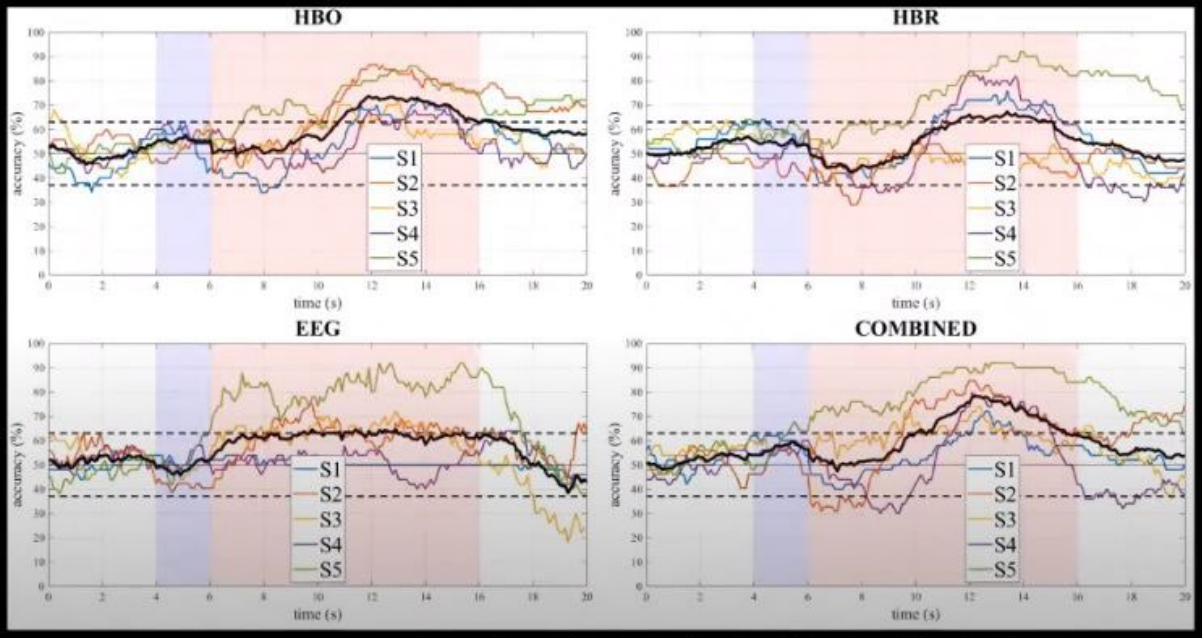


MI Experiment – HBR Response



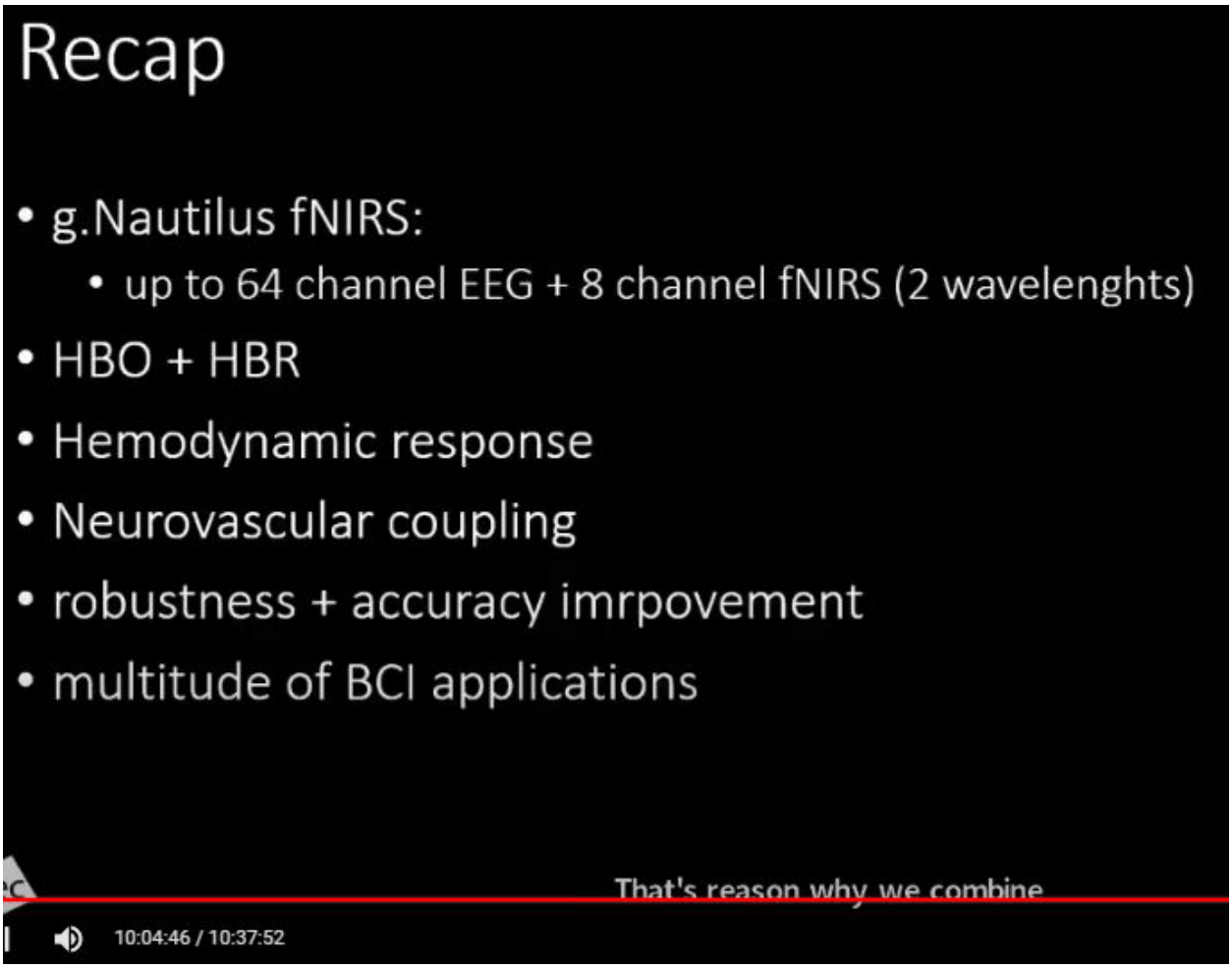
lower on the right hemisphere, this is what we call

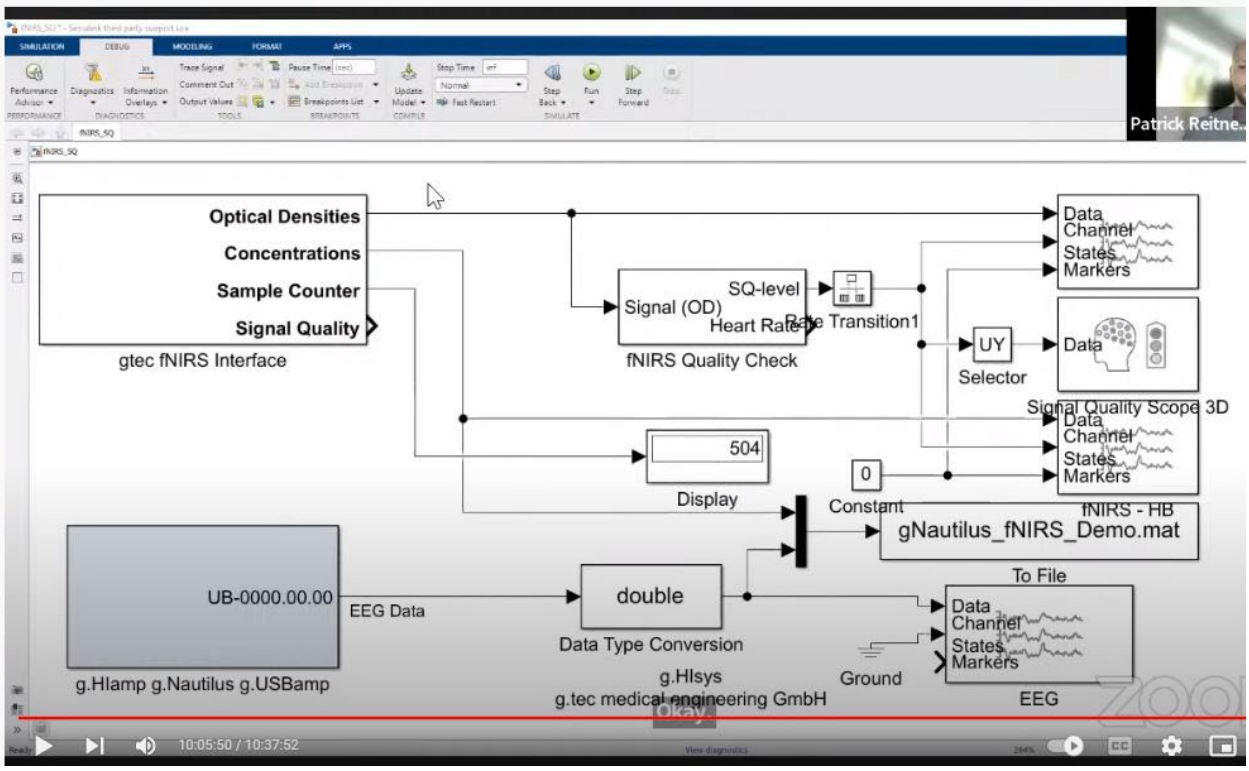
MI Experiment - Results



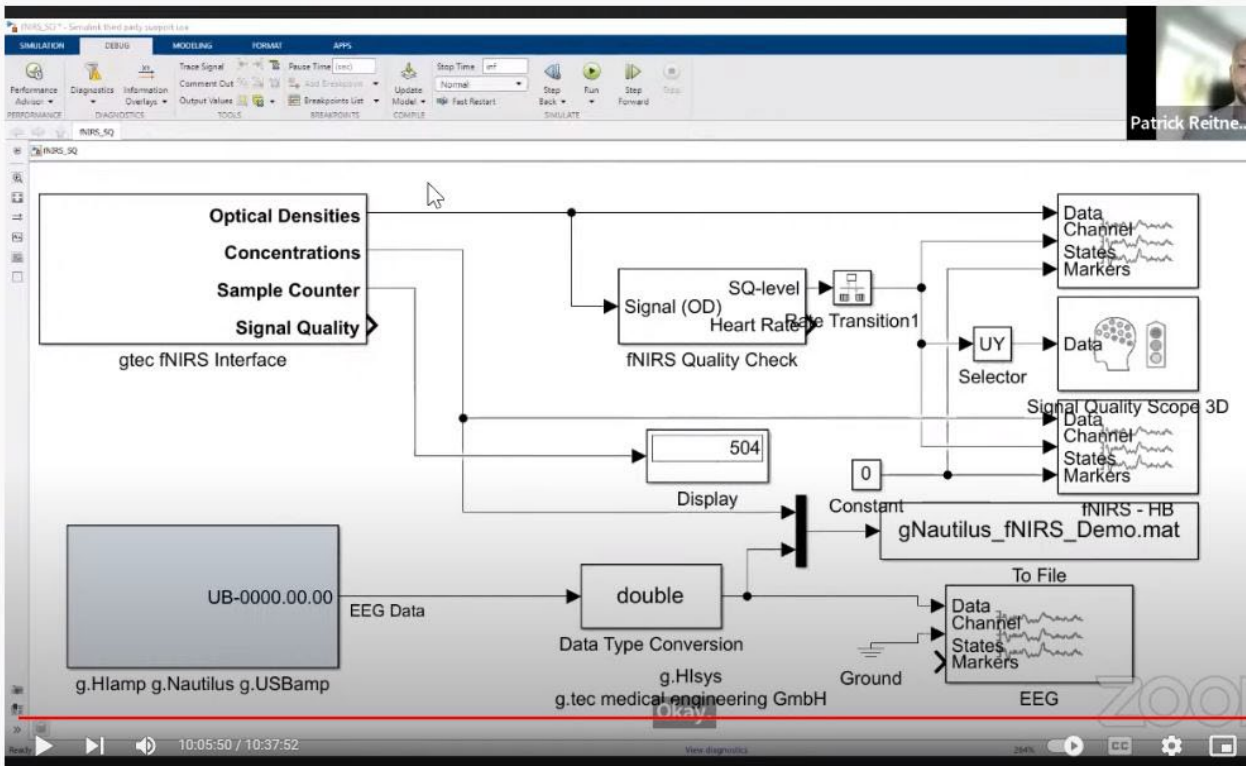
So, and now I'm going to show you a slide, which

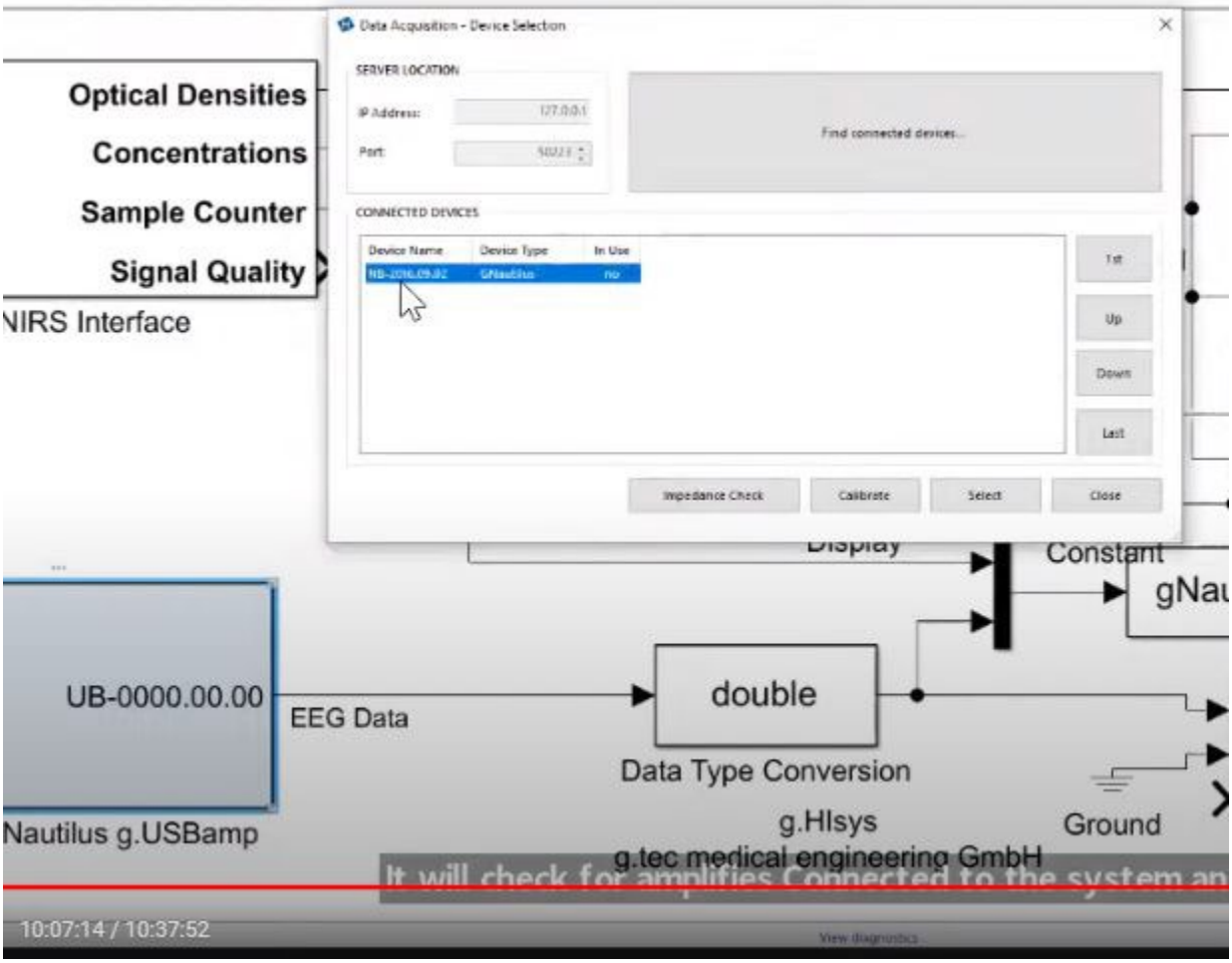
10:03:13 / 10:37:52

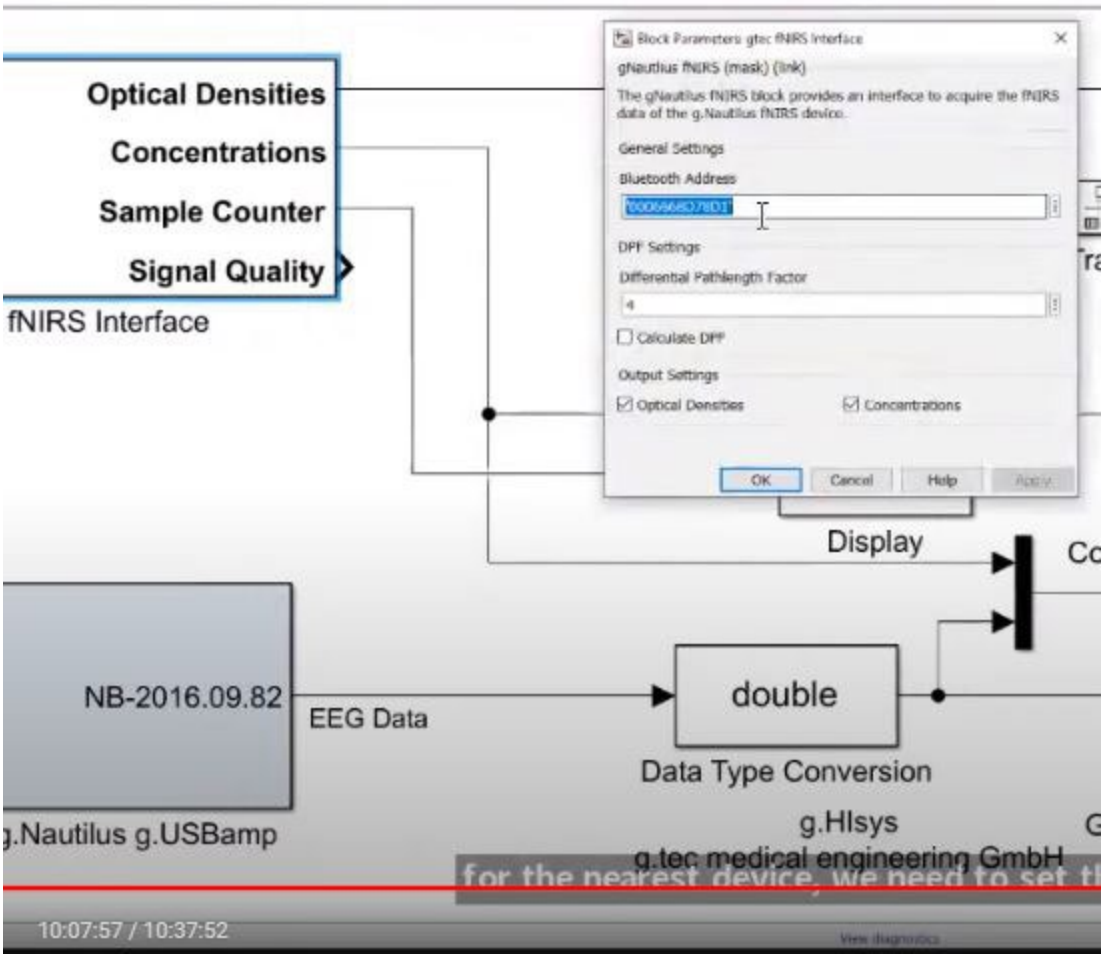

Recap
• g.Nautilus fNIRS:
• up to 64 channel EEG + 8 channel fNIRS (2 wavelenghts)
• HBO + HBR
• Hemodynamic response
• Neurovascular coupling
• robustness + accuracy imrpovement
• multitude of BCI applications
That's reason why we combine
10:04:46 / 10:37:52

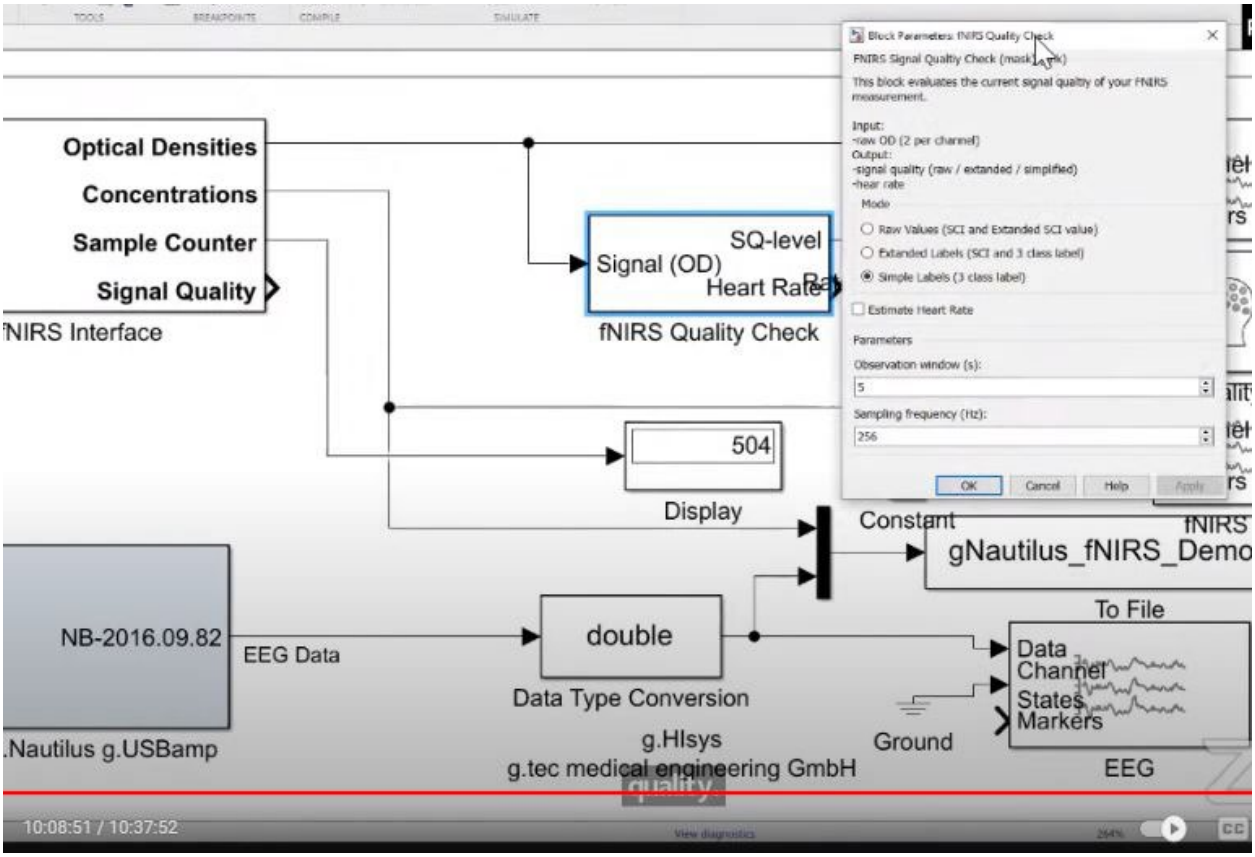


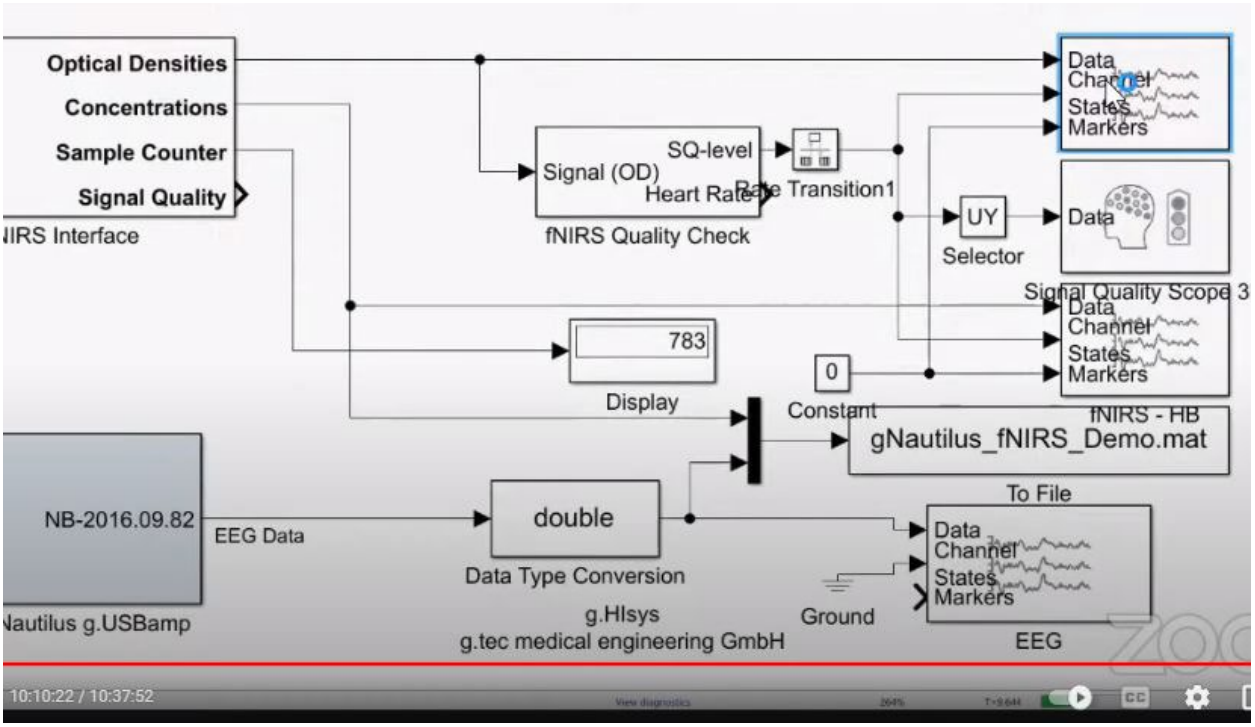
The next slide/info from Day 4…

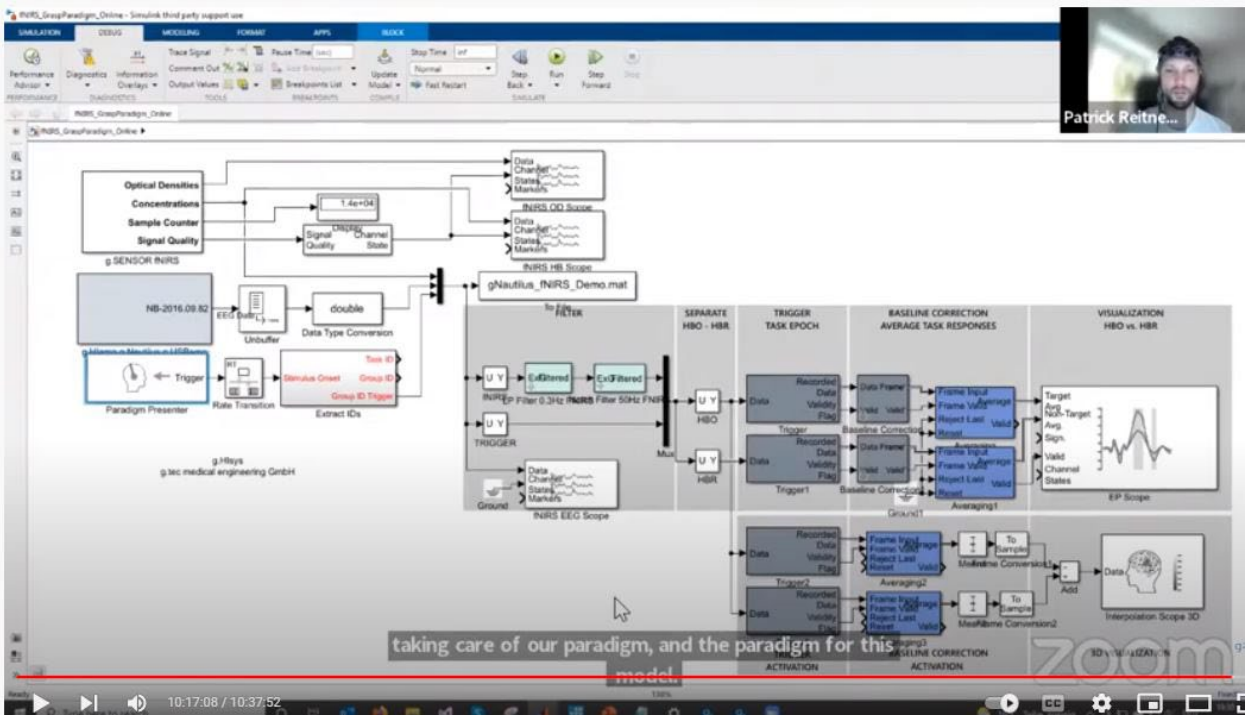


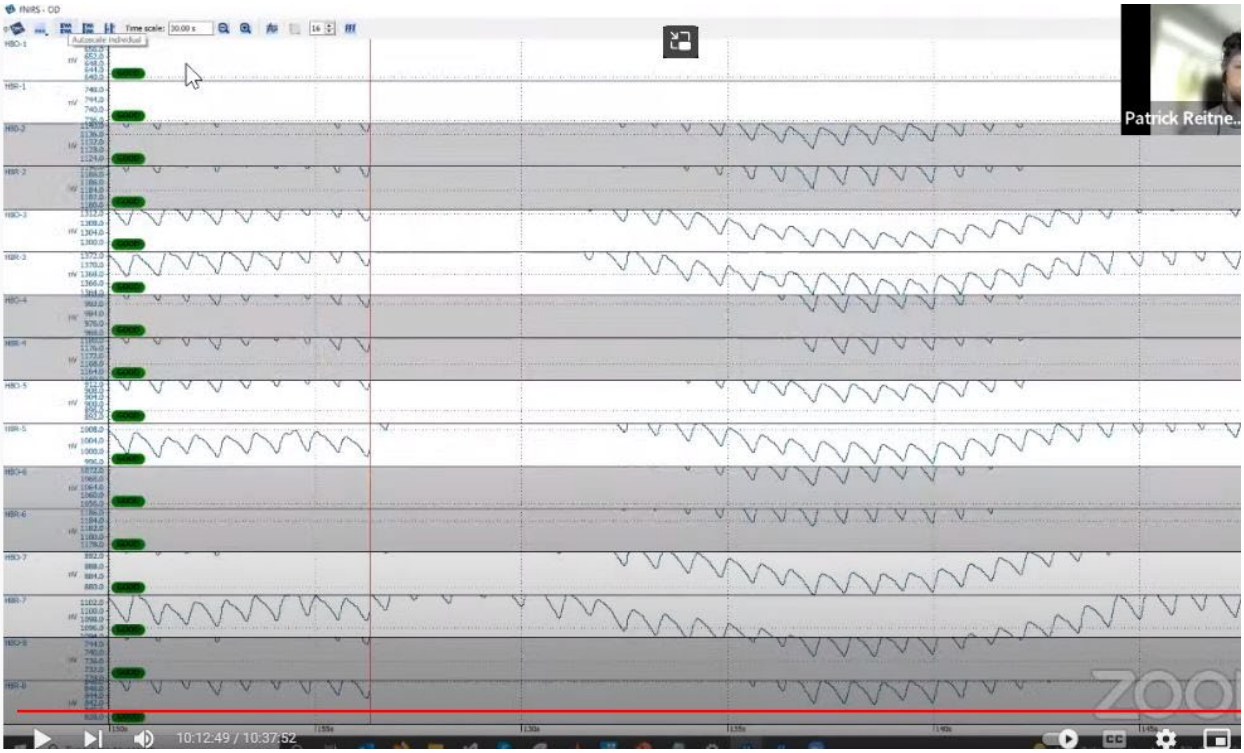

Optical Densities
Concentrations
Sample Counter
Signal Quality
NIRS Interface
Data Acquisition - Device Selection
SERVER LOCATION
IP Address:
Port:
Find connected devices...
CONNECTED DEVICES
Device Name
Device Type
In Use
Impedance Check
Calibrate
Select
Close
Display
Constant
UB-0000.00.00
EEG Data
double
Data Type Conversion
g.HIsys
Nautilus g.USBamp
g.tec medical engineering GmbH
Ground
10:07:14 / 10:37:52

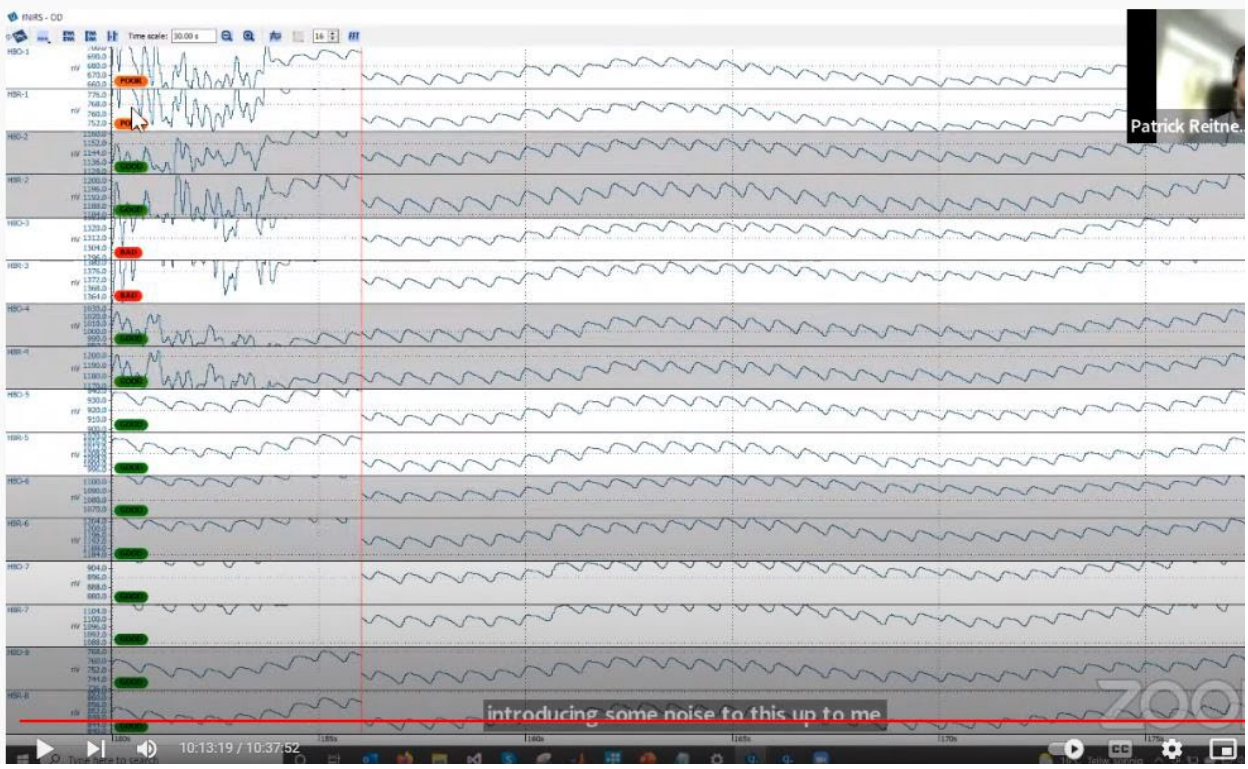

Optical Densities
Concentrations
Sample Counter
Signal Quality
fNIRS Interface
Block Parameters gtec fNIRS Interface
gNautilus fNIRS (mask) (link)
The gNautilus fNIRS block provides an interface to acquire the fNIRS data of the g.Nautilus fNIRS device.
General Settings
Bluetooth Address
DPF Settings
Differential Pathlength Factor
4
Calculate DPF
Output Settings
Optical Densities
Concentrations
OK
Cancel
Help
Apply
Display
NB-2016.09.82
EEG Data
double
Data Type Conversion
g.Nautilus g.USBamp
g.HIsys
g.tec medical engineering GmbH
for the nearest device, we need to set
10:07:57 / 10:37:52

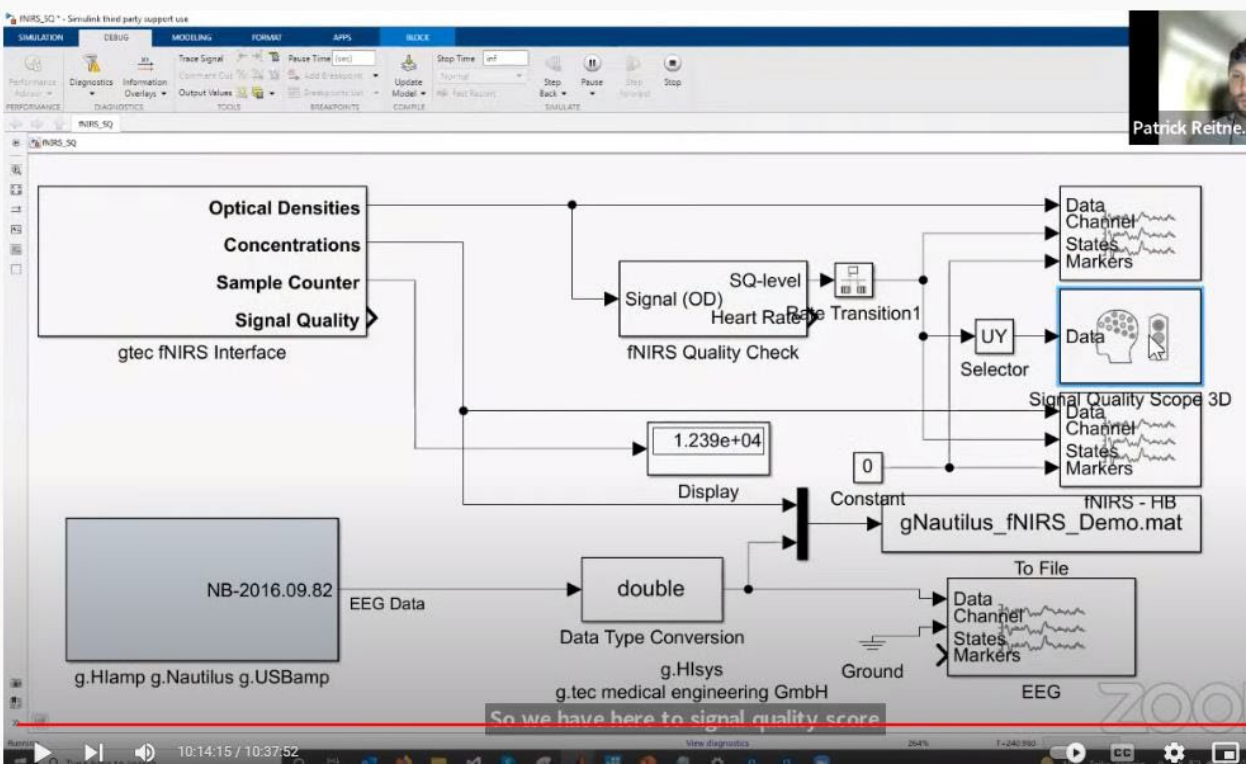

Optical Densities
Concentrations
Sample Counter
Signal Quality
NIRS Interface
Signal (OD)
SQ-level
Heart Rate
fNIRS Quality Check
Block Parameters: fNIRS Quality Check
fNIRS Signal Quality Check (mask)
This block evaluates the current signal quality of your fNIRS measurement.
Input:
-raw OD (2 per channel)
Output:
-signal quality (raw / extanded / simplified)
-hear rate
Mode
Raw Values (SCI and Extanded SCI value)
Extanded Labels (SCI and 3 class label)
Simple Labels (3 class label)
Estimate Heart Rate
Parameters
Observation window (s):
5
Sampling frequency (Hz):
256
OK
Cancel
Help
Apply
504
Display
Constant
gNautilus_fNIRS_Demo
To File
NB-2016.09.82
EEG Data
double
Data Type Conversion
Data
Channel
States
Markers
Ground
g.HIsys
g.tec medical engineering GmbH
EEG
10:08:51 / 10:37:52

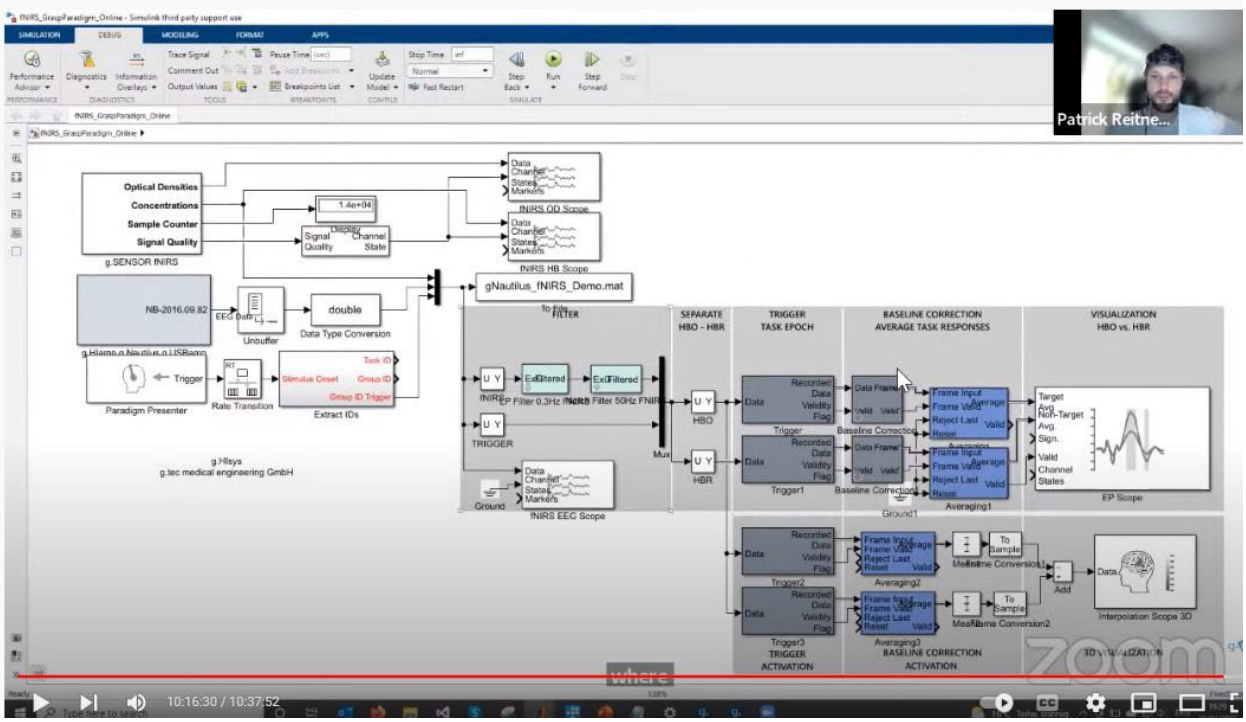

Optical Densities
Concentrations
Sample Counter
Signal Quality
IRS Interface
Signal (OD)
SQ-level
Heart Rate
Rate Transition1
fNIRS Quality Check
UY
Selector
Data
Signal Quality Scope 3
Data
Channel
States
Markers
783
Display
0
Constant
fNIRS - HB
gNautilus_fNIRS_Demo.mat
To File
NB-2016.09.82
EEG Data
double
Data Type Conversion
Data
Channel
States
Markers
Ground
g.HIsys
g.tec medical engineering GmbH
EEG
10:10:22 / 10:37:52


Patrick Reitne...
Optical Densities
Concentrations
Sample Counter
Signal Quality
g.SENSOR fNIRS
fNIRS OD Scope
fNIRS HB Scope
gNautilus_fNIRS_Demo.mat
NB-2016.09.82
Unbuffer
Data Type Conversion
Trigger
Paradigm Presenter
Rate Transition
Extract IDs
g.Hiamp
g.tec medical engineering GmbH
FILTER
SEPARATE HBO - HBR
TRIGGER TASK EPOCH
BASELINE CORRECTION AVERAGE TASK RESPONSES
VISUALIZATION HBO vs. HBR
HBO
HBR
TRIGGER
fNIRS EEG Scope
EP Scope
Interpolation Scope 3D
taking care of our paradigm, and the paradigm for this
model
10:17:08 / 10:37:52


fNIRS - OD
Patrick Reitne...
10:12:49 / 10:37:52


Patrick Reitne..
introducing some noise to this up to me
10:13:19 / 10:37:52


Patrick Reitne..
Optical Densities
Concentrations
Sample Counter
Signal Quality
gtec fNIRS Interface
Signal (OD)
SQ-level
Heart Rate
fNIRS Quality Check
Rate Transition1
UY
Selector
Data
Channel
States
Markers
Signal Quality Scope 3D
1.239e+04
Display
0
Constant
fNIRS - HB
gNautilus_fNIRS_Demo.mat
To File
NB-2016.09.82
EEG Data
g.HIamp g.Nautilus g.USBamp
double
Data Type Conversion
g.HIsys
g.tec medical engineering GmbH
Ground
EEG
So we have here to signal quality score
10:14:15 / 10:37:52


Patrick Reitne...
Optical Densities
Concentrations
Sample Counter
Signal Quality
g.SENSOR fNIRS
fNIRS OD Scope
fNIRS HB Scope
gNautilus_fNIRS_Demo.mat
NB-2016.09.82
Unbuffer
double
Data Type Conversion
Trigger
Paradigm Presenter
Rate Transition
Extract IDs
g.Hiamp g.Nautilus g.USBamp
g.Hiamp
g.tec medical engineering GmbH
FILTER
fNIRS
TRIGGER
Ground
fNIRS EEG Scope
SEPARATE HBO - HBR
HBO
HBR
TRIGGER TASK EPOCH
Trigger
Trigger1
Baseline Correction
Baseline Correction1
Averaging1
Ground1
BASELINE CORRECTION AVERAGE TASK RESPONSES
VISUALIZATION HBO vs. HBR
EP Scope
Trigger2
Trigger3
Averaging2
Averaging3
Add
Interpolation Scope 3D
TRIGGER ACTIVATION
BASELINE CORRECTION ACTIVATION
10:16:30 / 10:37:52