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Webinar Material

# Combined EEG-fNIRS

Mobile recordings

Brain Products / Brain Vision Webinar

# OUTLINE

• **BACKGROUND & THEORY**

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• **PARADIGM**

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• **EQUIPMENT**

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• **EEG-fNIRS SPECIFIC SETUP**

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• **DEMONSTRATION**

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• **WRAP UP QUESTIONS**

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# BACKGROUND & THEORY

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# NEUROSCIENCE METHODS

**Human Behavior** | Questionnaire

**Physiological responses** | GSR/EDA  
Eye tracking  
ECG  
EMG

**Neural activity correlates** | fMRI  
fNIRS  
PET

**Neural activity (indirect)** | EEG  
MEG

**Neural activity (direct)** | Single unit recordings  
LFP



**External Validity** + / -





**EEG**

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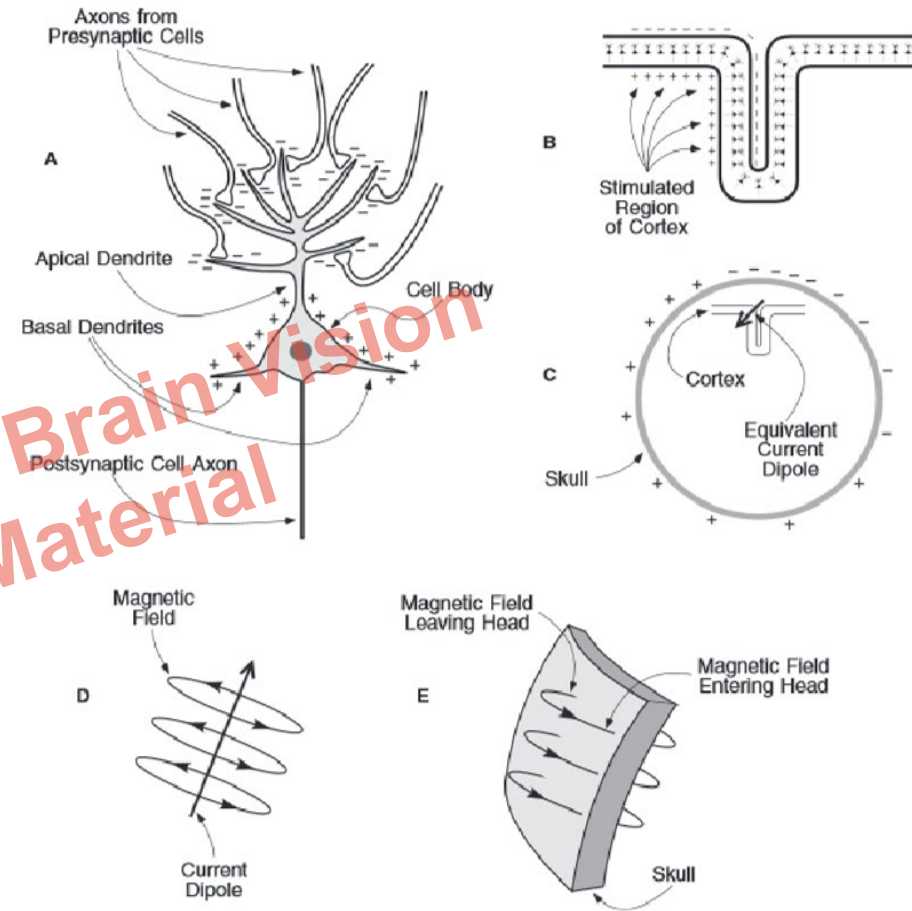
# EEG – WORKING NEURAL ACTIVITY MODEL

- **Excitatory neurotransmitter** is released from the presynaptic terminal

- **Positive ion flow** into the postsynaptic neuron

  - Results in small dipole

- **Dipole summation** from individual neurons, on the folded cortical regions

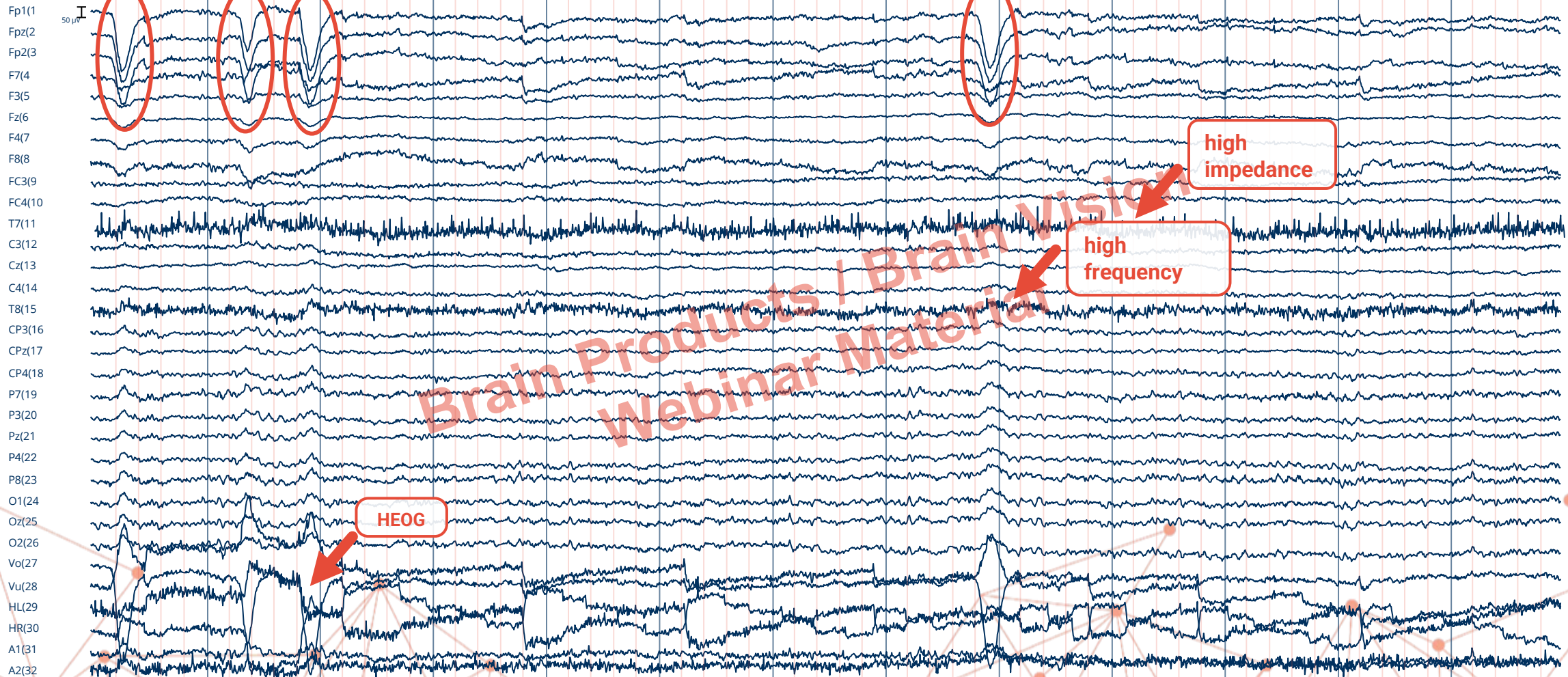


Source: Luck (2005). Introduction to the Event-Related Potential Technique. Cambridge: MIT Press.

# EEG – SIGNAL (OUTSIDE SCANNER)

REF  
signal

VEOG – Blink



# EEG EQUIPMENT - APPLICATIONS

Sleep



EEG-TMS



EEG with eye tracking



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# EEG EQUIPMENT - APPLICATIONS

EEG-fMRI

Kids



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# EEG EQUIPMENT - APPLICATIONS

EEG-fNIRS



EEG-tDCS



MoBI



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# EEG EQUIPMENT - ELECTRODE TYPES

actiCAP  
slim

R-Net

BrainCap

actiCAP  
Xpress  
Twist

Quick-20r



Gel active  
electrode



Passive  
saline/sponge



Passive gel  
electrode



Dry active  
electrode



Dry active  
electrode

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# EEG EQUIPMENT - AMPLIFIERS

BrainAmp

LiveAmp

actiCHamp  
Plus



Specialized  
conditions



Wearable



Lab portable

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# EEG – QUALITIES

## Pro

- Timing (<1ms)
- Cost efficient collection
- Indirect measure of neural activity

## Con

- Poor 3D spatial resolution (inverse problem of source localization)

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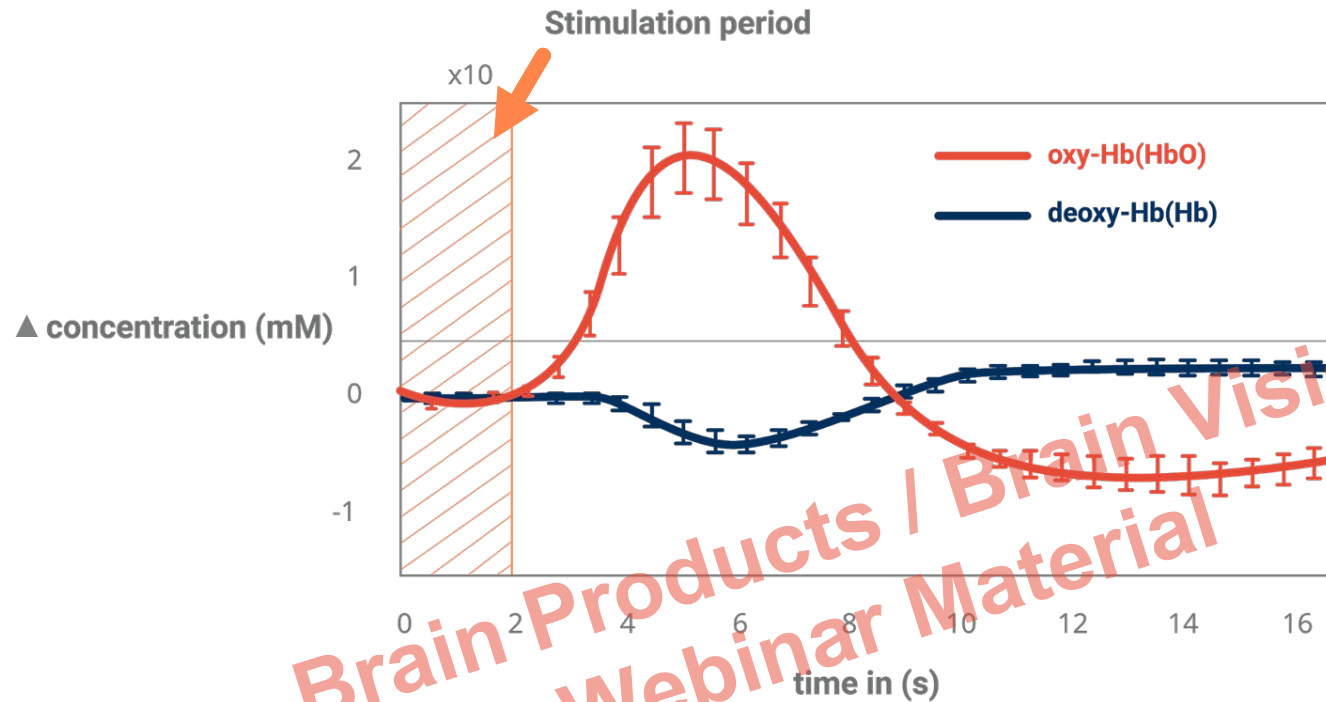


**fNIRS**

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# fNIRS – WORKING NEURAL ACTIVITY MODEL



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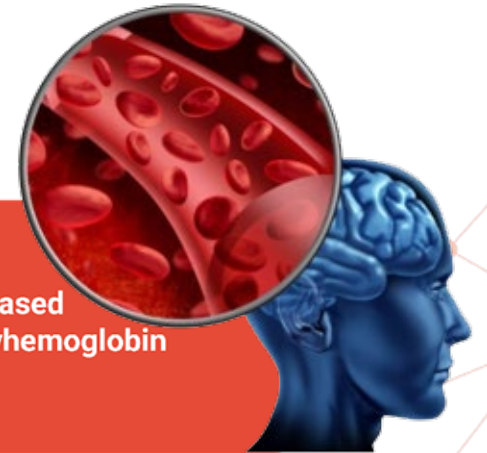
Neuronal Activity

Increased  
Metabolic  
Demand

Increased  
Blood  
Flow

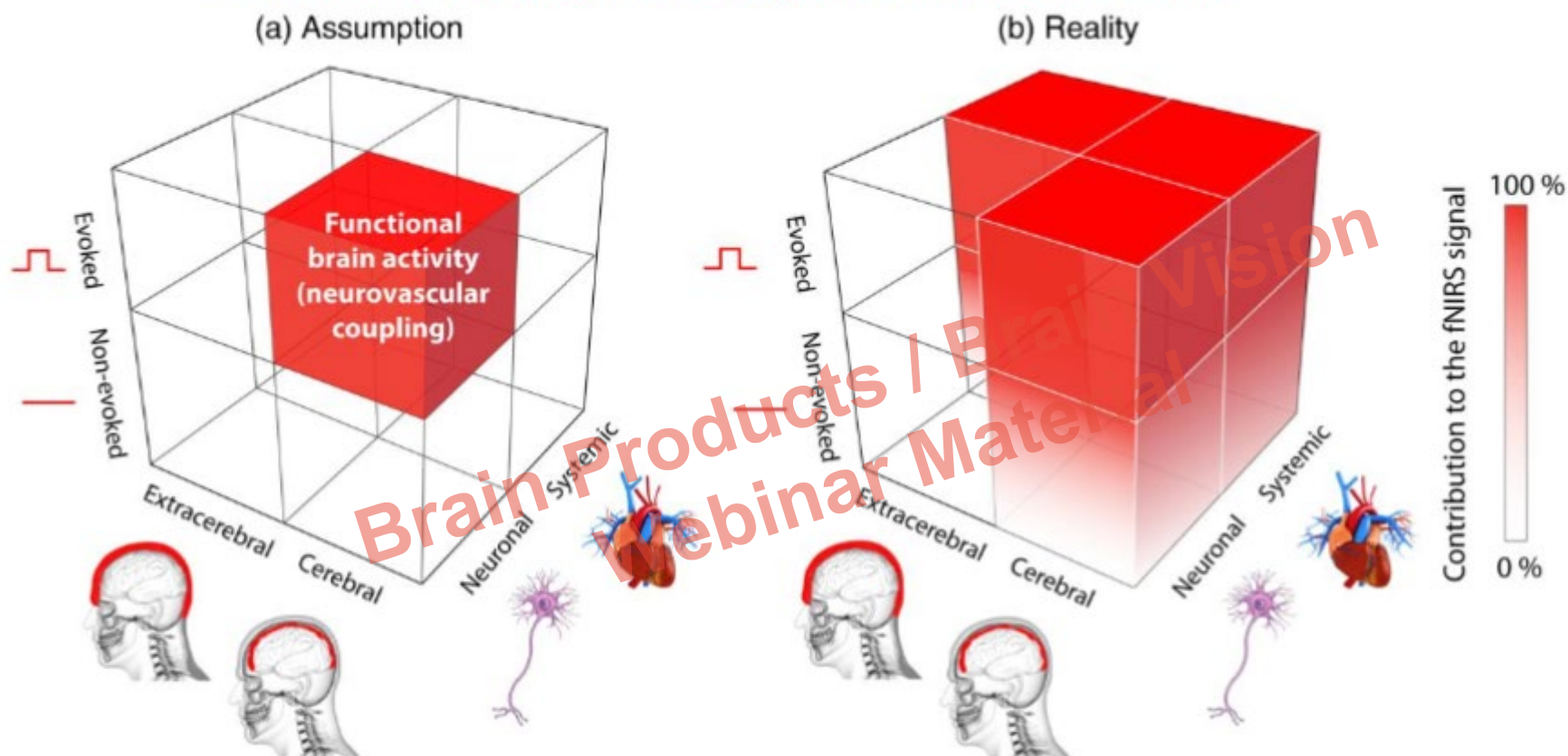
Increased  
Oxyhemoglobin

Decreased  
Deoxyhemoglobin



# fNIRS – WORKING NEURAL ACTIVITY MODEL

## Sources of the hemodynamic response measured with fNIRS



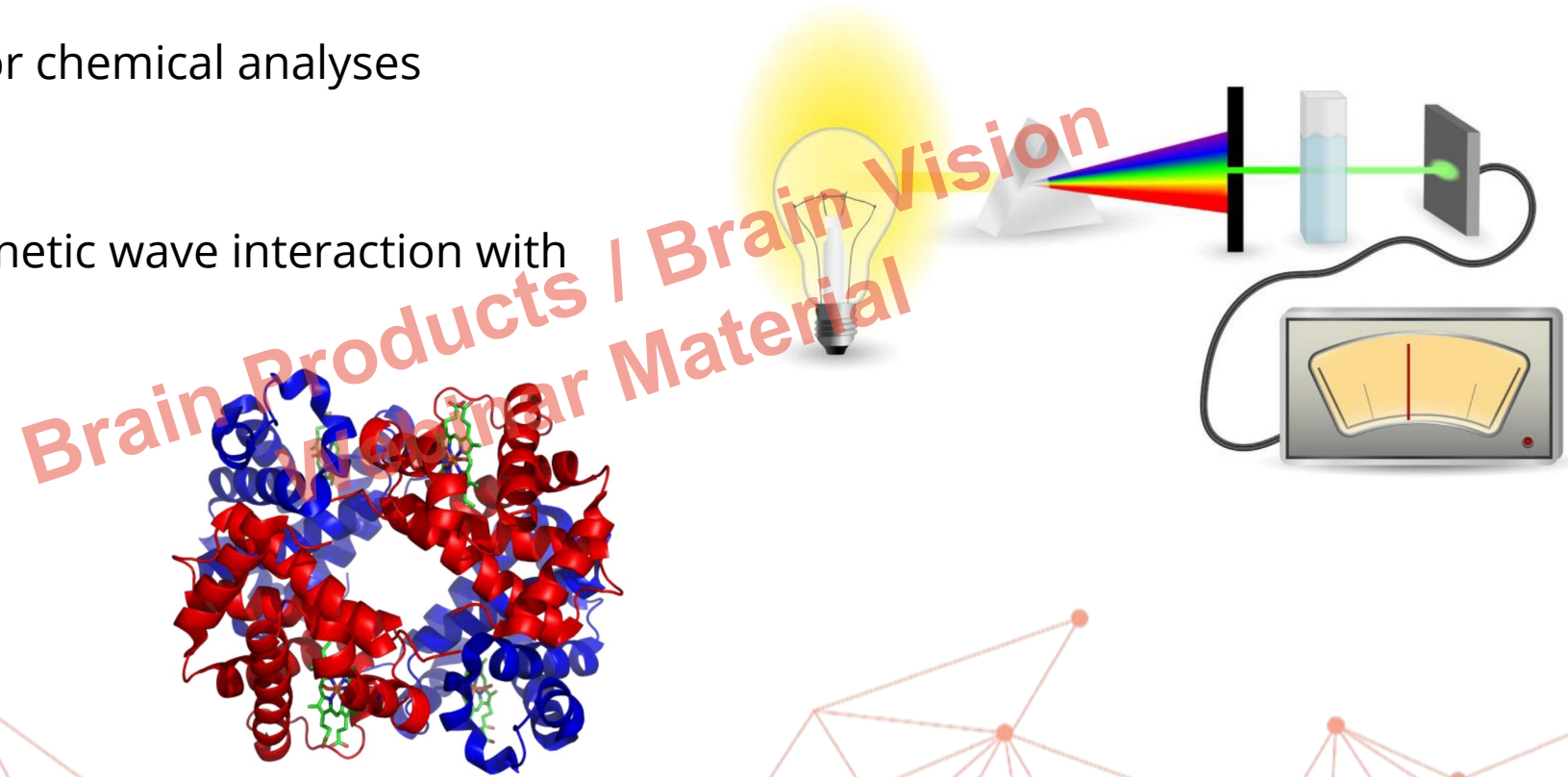
from Tachtsidis and Scholkmann 2016



# FUNCTIONAL NEAR-INFRARED SPECTROSCOPY

- Technique common for chemical analyses

- Leverages electromagnetic wave interaction with matter



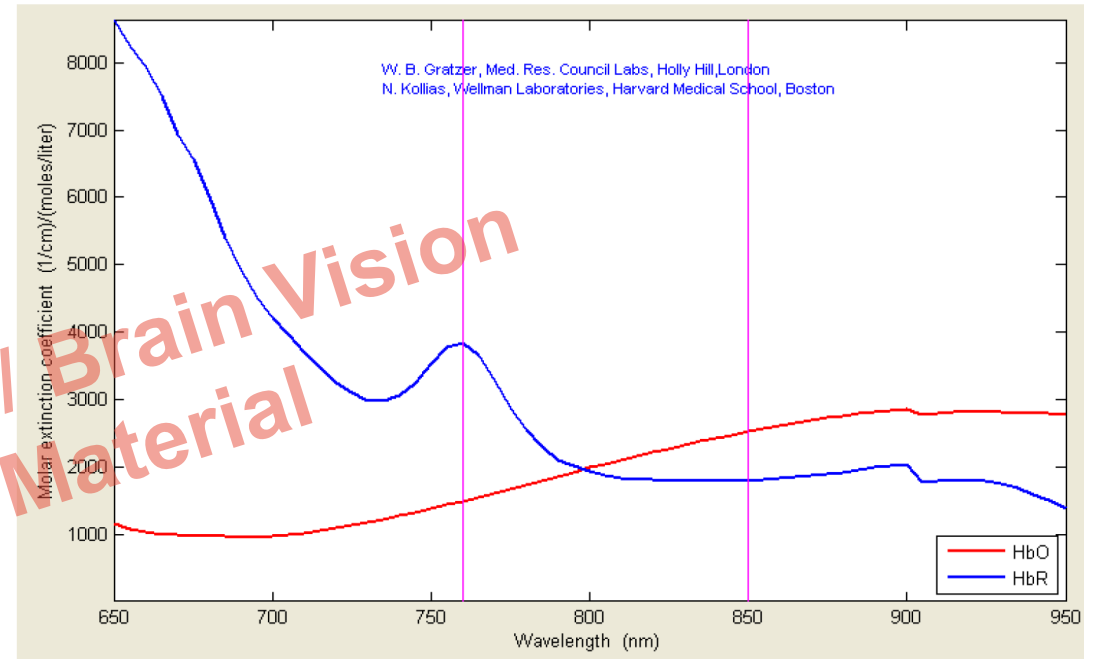
# fNIRS FOR HEMOGLOBIN

## Molar Extinction Coefficients

- How strongly a substance absorbs a light at a given wavelength

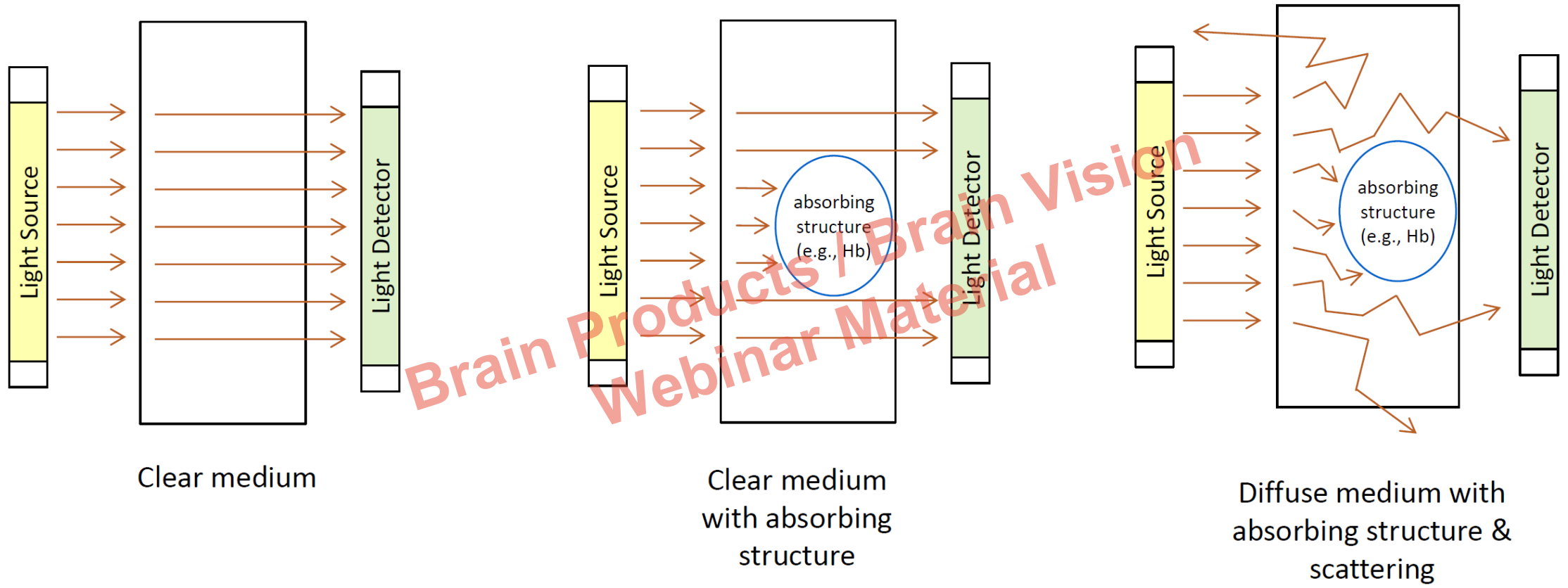
- NIRS systems use multiple wavelengths (at least 2) to distinguish oxy and deoxy-hemoglobin

- NIRx uses **760nm** and **850nm** wavelengths shown in pink



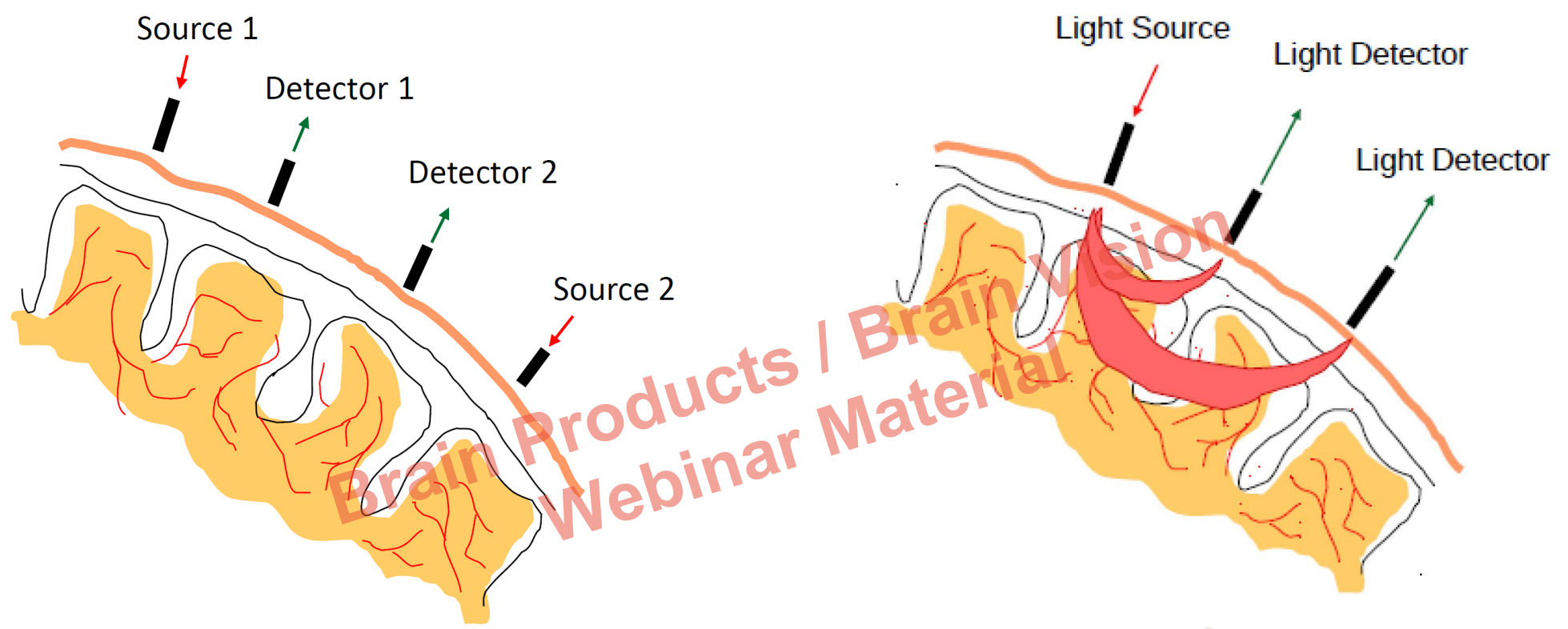


# fNIRS – HOW DOES IT WORK?

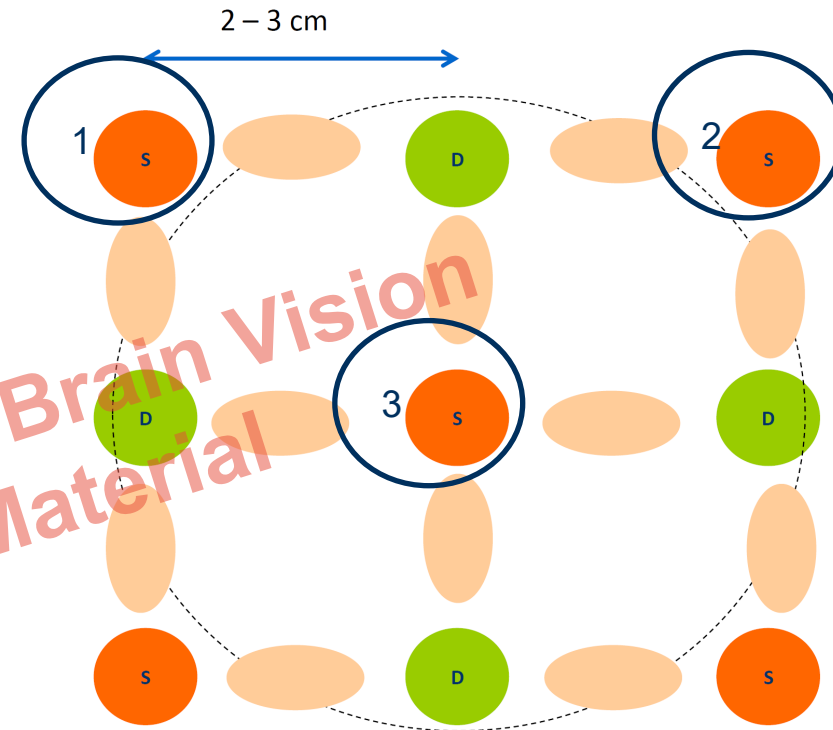
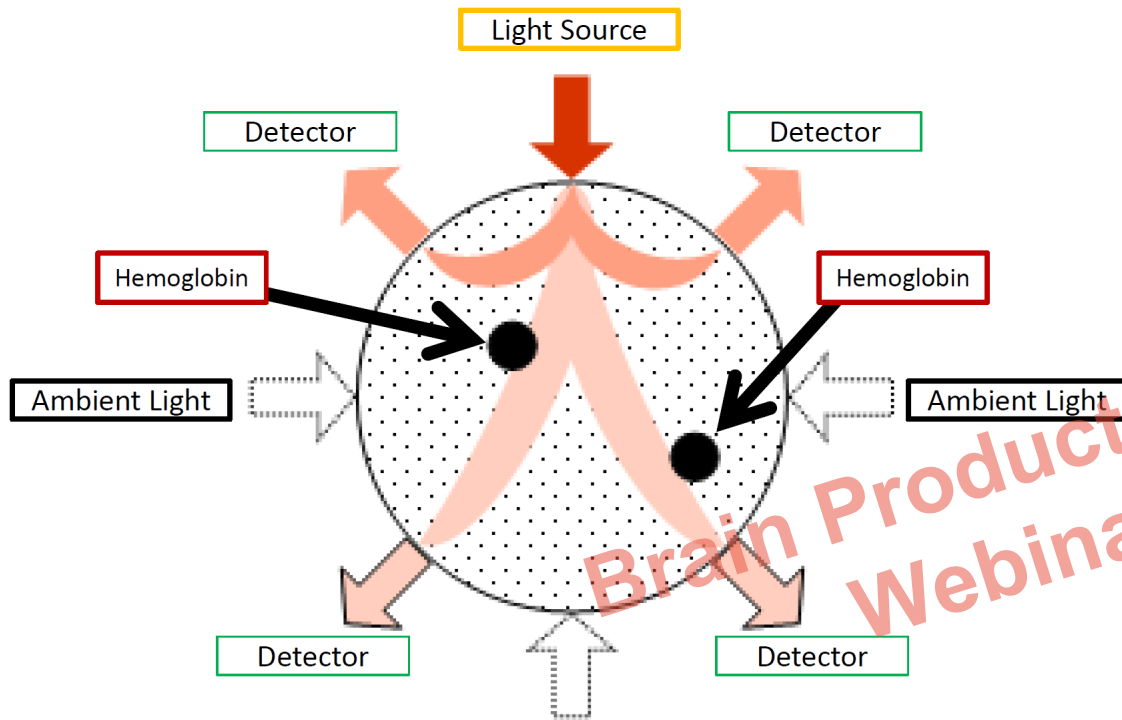


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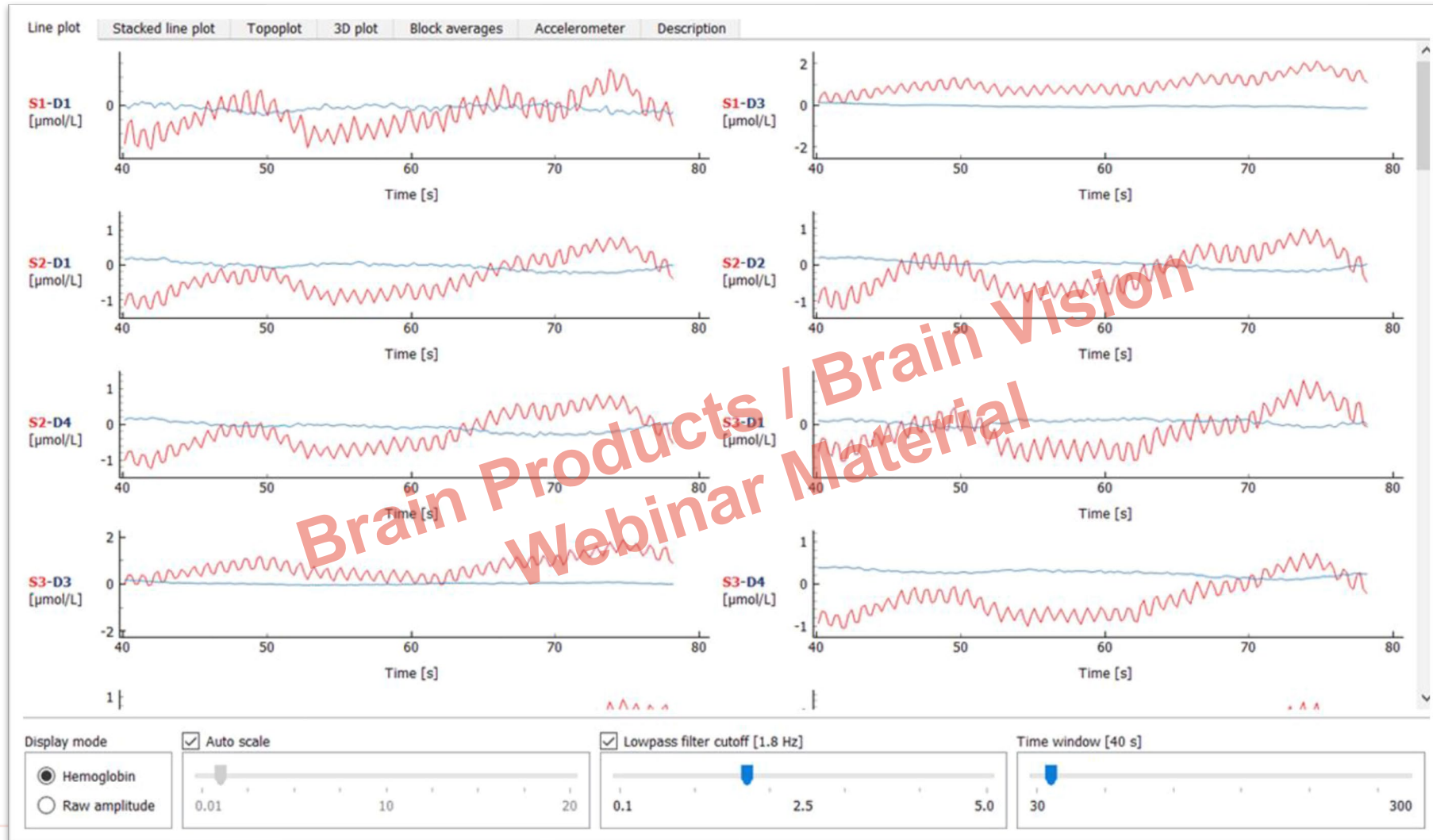
# fNIRS – HOW DOES IT WORK?



# fNIRS – HOW DOES IT WORK?



# fNIRS – SIGNAL





# fNIRS – EQUIPMENT



**DYNOT 232 (2004)**

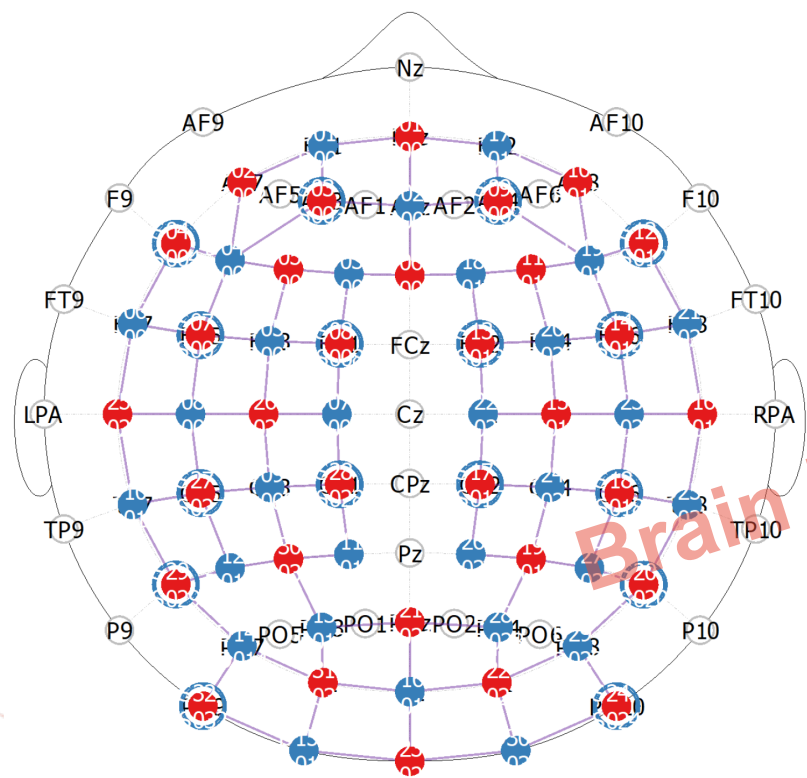


**NIRScout Extended Plus with  
lasers (2015)**



**NIRSport2 16x16 with LEDs (2018)**

# fNIRS – EQUIPMENT



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Source: NIRx

# fNIRS – QUALITIES

## Pro

- Better (than EEG) 3D spatial resolution
- Cost efficient collection
- Comparable to BOLD fMRI

## Con

- **BOLD** is a correlate to neuronal activity
- Lower timing resolution
- Time lagged signal

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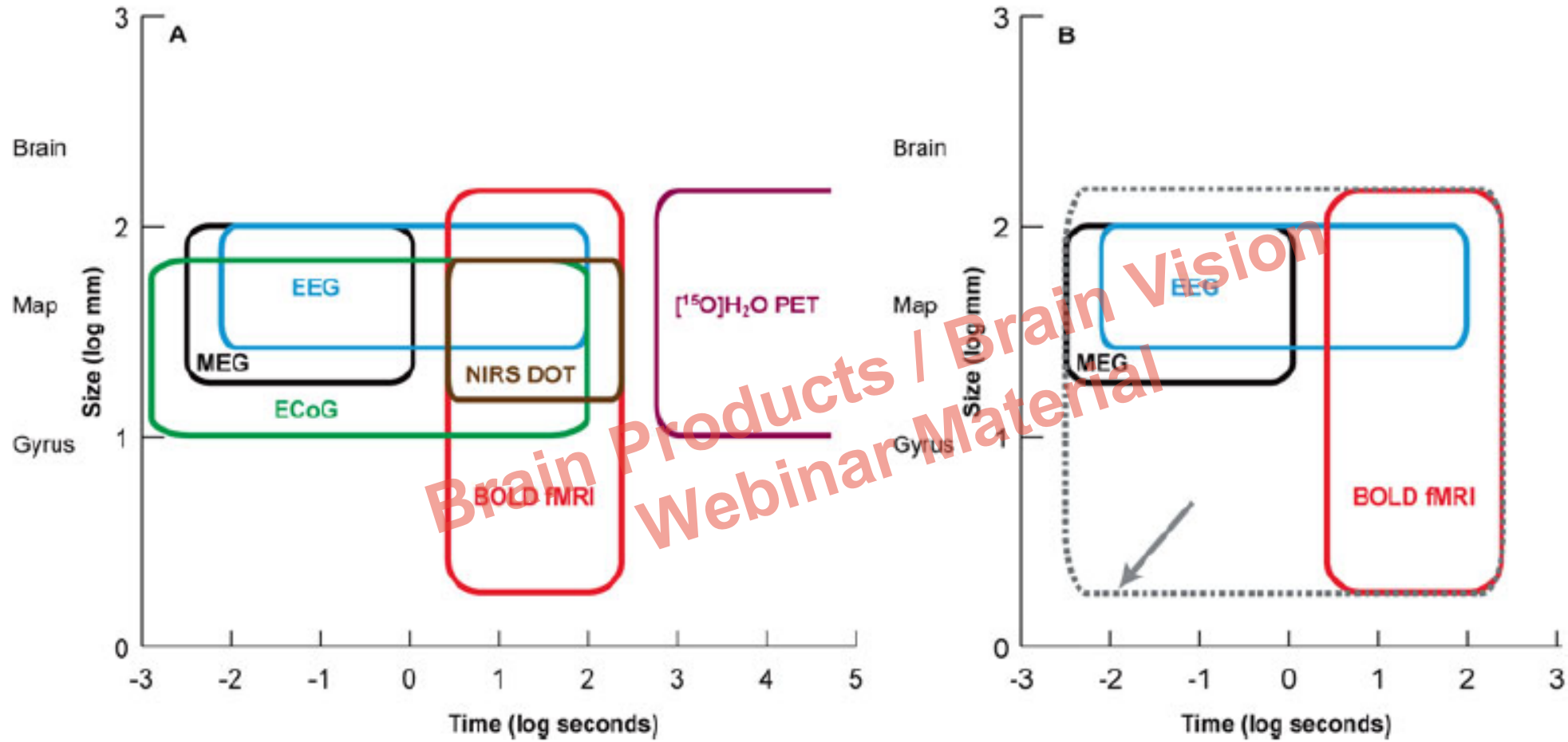


# COMBINING MODALITIES

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# COMBINING MODALITIES

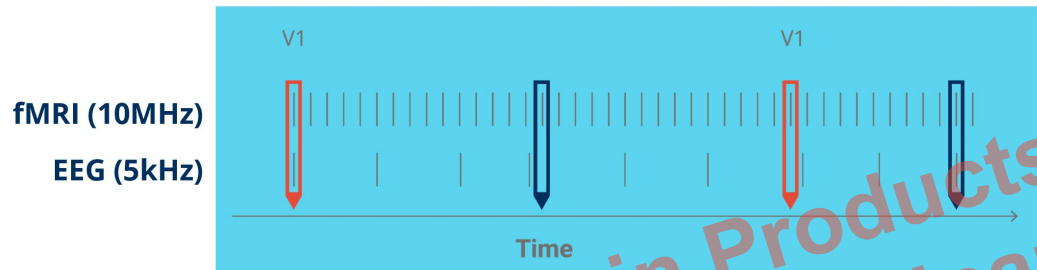


Source: Huettel, Song, McCarthy (2014). Functional Magnetic Resonance Imaging. Oxford University Press.

# COMBINING MODALITIES

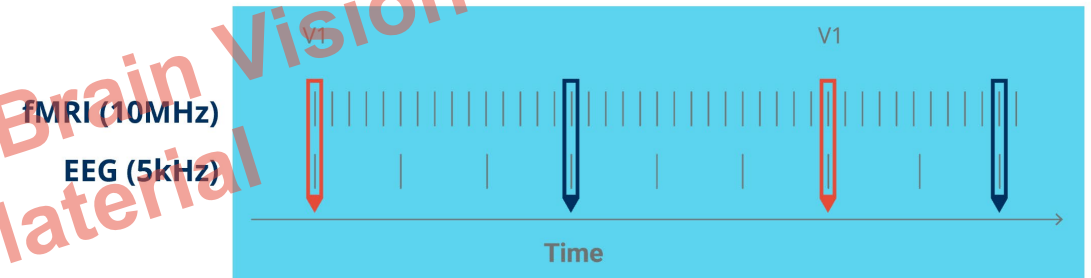
## Joint Event Markers

- a. **Event matching between modalities**  
(Independent clocks)  
*Hardware or software based*

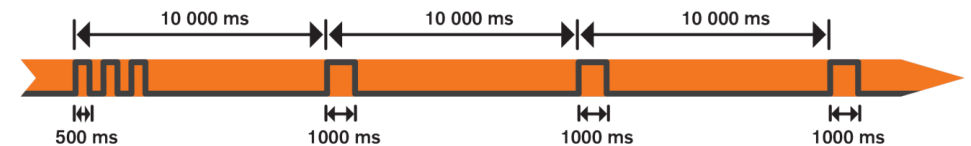


## Synchronized Clocks

- a. **Fully phase synchronized**  
(Clock Source/Sink pair)  
*Hardware based*



- b. **Resampling**  
(Independent clocks, may base on periodic markers)  
*Software based*



Source: Tobii Pro Glasses 3 User Manual

<https://pressrelease.brainproducts.com/eeg-eyetracking-mobile/>  
<https://www.gotostage.com/channel/brainproducts>



# PARADIGM

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# PARADIGM



- EEG-fNIRS while golfing (putting)
  - Let's investigate brain state before/during/after the act of putting
  - Example of Mobile Body Imaging (MoBI)
  - We'll ask our subject to putt when they are ready
  - Setup our systems to insert markers timed to this subject paced recording

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# EQUIPMENT

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# EEG SOLUTIONS

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## ● LiveAmp32

Wireless EEG amplifier

Compatible with passive gel, active gel, or active dry electrodes

Expandable from 8, 16, 32, or 64 channels

Expandable for ExG and sensors and triggers

Record onboard and/or via wireless transmission

## ● actiCAP slim electrodes

Active gel electrodes

Easy to prep, robust against noise

Come in bundles of 32-ch

# EEG SOLUTIONS

- actiCAP snap holders

Use these to populate combined EEG-fNIRS caps to accept actiCAP slim electrodes at designated EEG positions

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# fNIRS SOLUTIONS

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- **NIRSport2**
  - Wearable and expandable fNIRS imager (8x8 to 80x80)
  - Battery powered
  - Record via Wifi or onboard
  - 8-bit TTL input
- **Dual tip LED sources**
  - Light-weight LEDs
  - 760nm/850nm wavelengths
  - Dual tip for comfort and easier hair parting
- **Dual tip SiPD detectors**
  - Lightweight active SiPD sensor
  - Dual tip for comfort and easier hair parting

# fNIRS SOLUTIONS

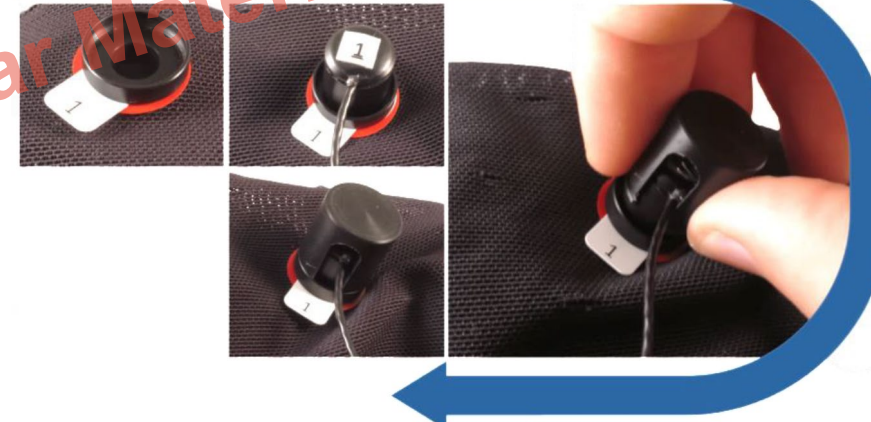
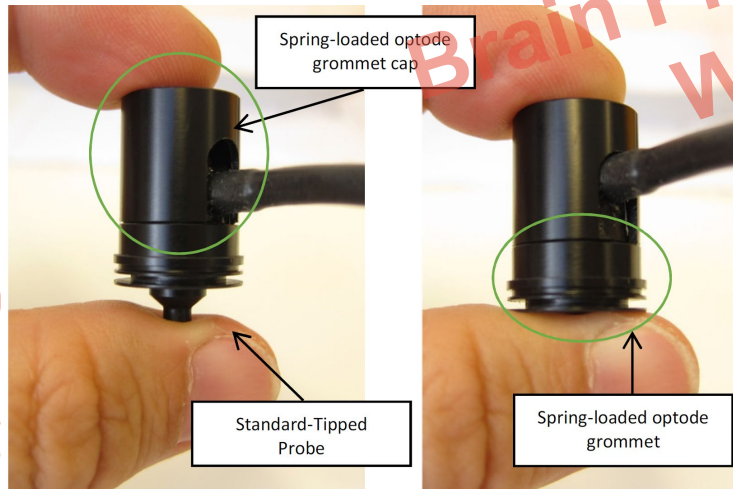


- NIRx spring loaded grommets

Leave grommets in cap (labeled) according to montage

Insert optodes into them and apply grommet tops with appropriate spring strength level

Spring levels 0, 1, 2, and 3



Source: NIRx





# JOINT HEADGEAR

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# JOINT HEADGEAR



- Black EasyCap cap
  - Standard 10/5 positions cut, marked, and labeled
  - High precision fabric for increased stability

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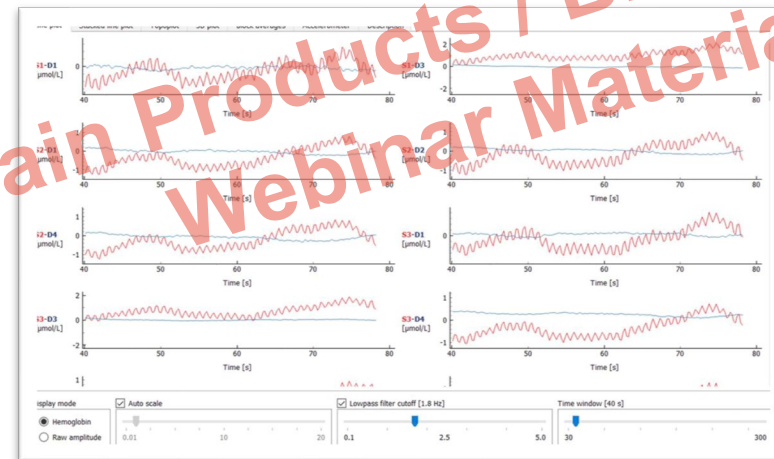
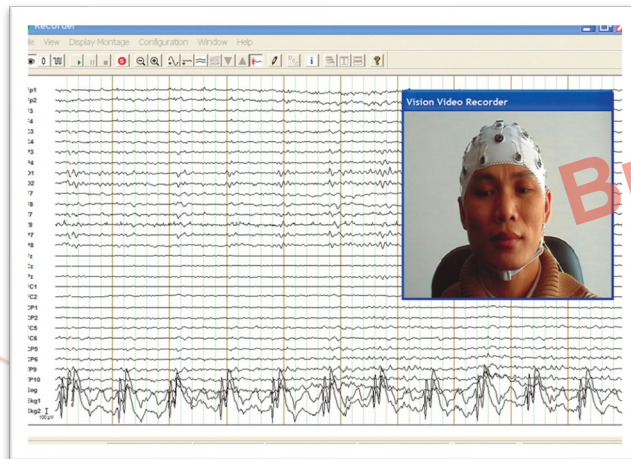
# EEG-fNIRS SPECIFIC SETUP

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# EEG-fNIRS SPECIFIC SETUP

- Caps
- Event marker generation
- Cabling between systems
- Recording Computers



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**CAPS**

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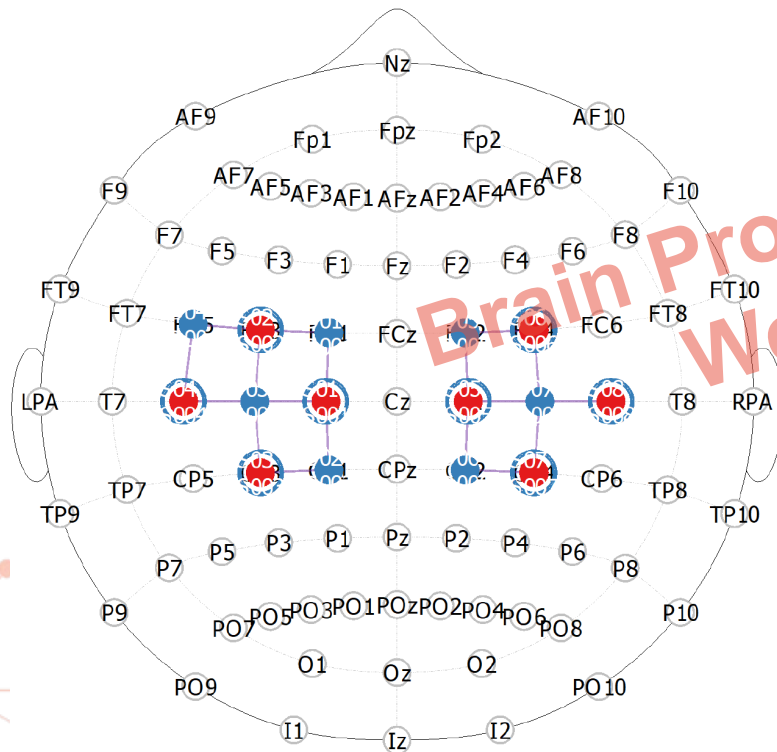




- NIRx spring loaded grommets  
Placed according to fNIRS montage of interest
- BP actiCAP snap holders  
Placed around the fNIRS montage to provide as even of distribution coverage as possible

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Name: MotorShort\_8x7  
 Channels: 26  
 Optodes: 23  
 Sources: 8  
 Detectors: 15  
 S.D. detectors: 8



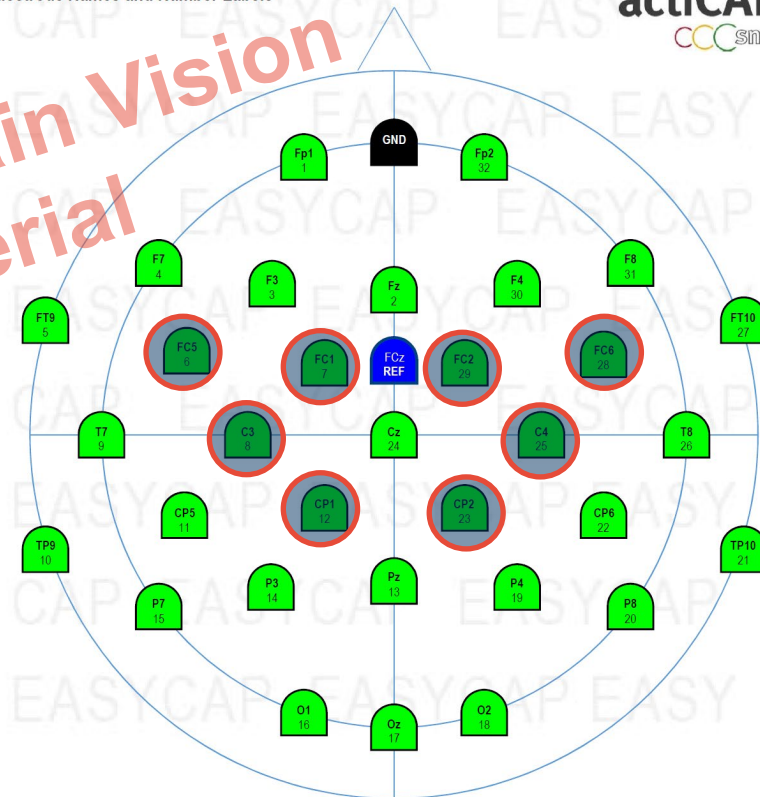
### Standard 32Ch actiCAP snap

Cap with holders for actiCAP slim electrodes

- Green holders: Label 1-32, Hardware Channel 1 – 32
- Blue holder: Label & hard-wired REF
- Black holder: Label & hard-wired GND

Electrode Names and Number Labels

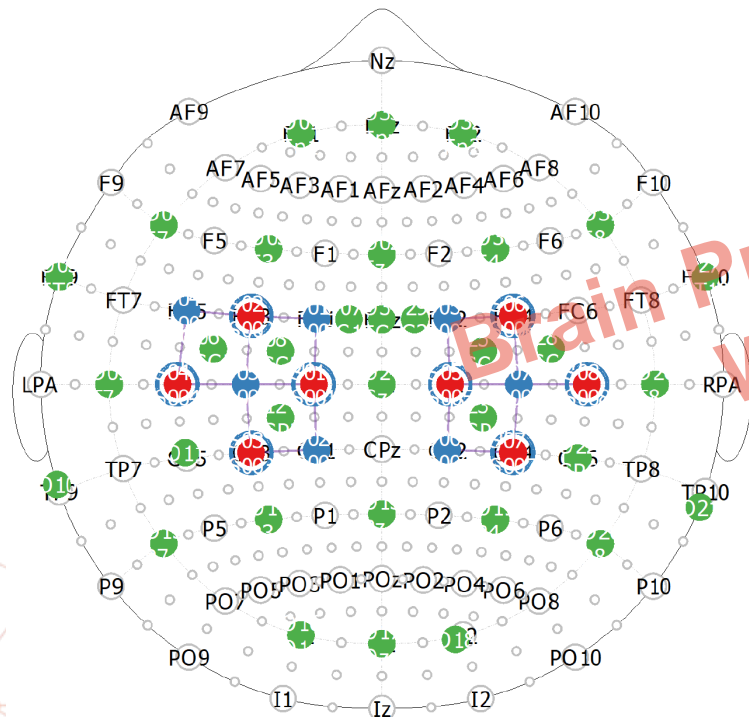
actiCAP  
 CCCsnap



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# CAPS

Name: Motor8x8EEG32  
 Channels: 26  
 Optodes: 57  
 Sources: 8  
 Detectors: 15  
 S.D. detectors: 8

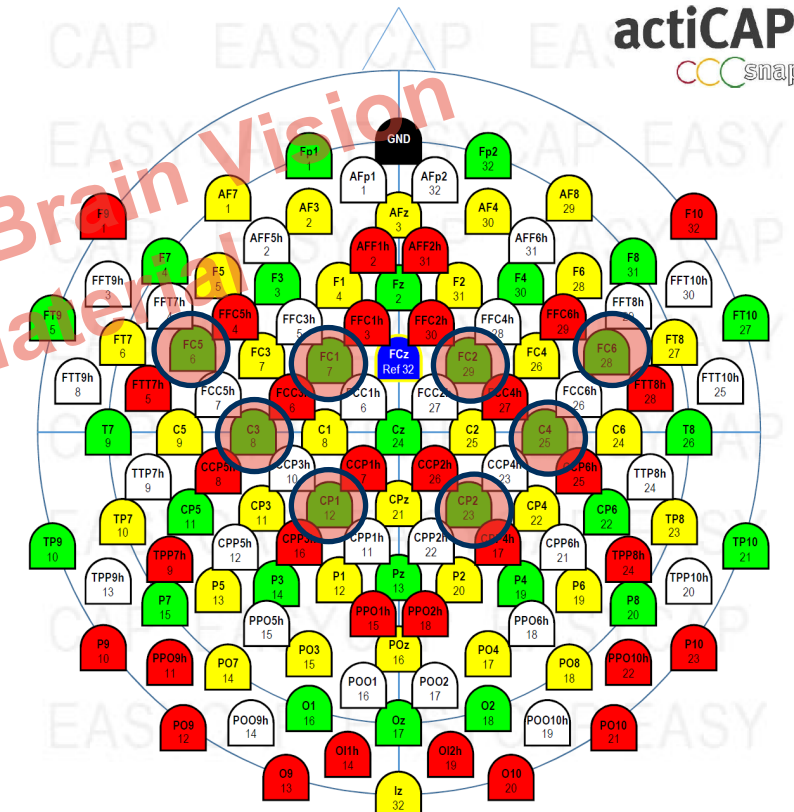


## Standard 128Ch actiCAP snap

Cap with holders for acticap slim electrodes

- Green Holders: Label 1-32, Hardware Channel 1 – 32
- Yellow Holders: Label 1-32, Hardware Channel 33 – 64
- Red Holder: Label 1-32, Hardware Channel 65 – 96
- White Holders: Label 1-32, Hardware Channel 97 – 128
- Blue Holder: For REF or Ch64 (yellow 32)
- Black Holder: Label & hard-wired GND

### Electrode Names and Number Labels



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# EVENT MARKER GENERATION

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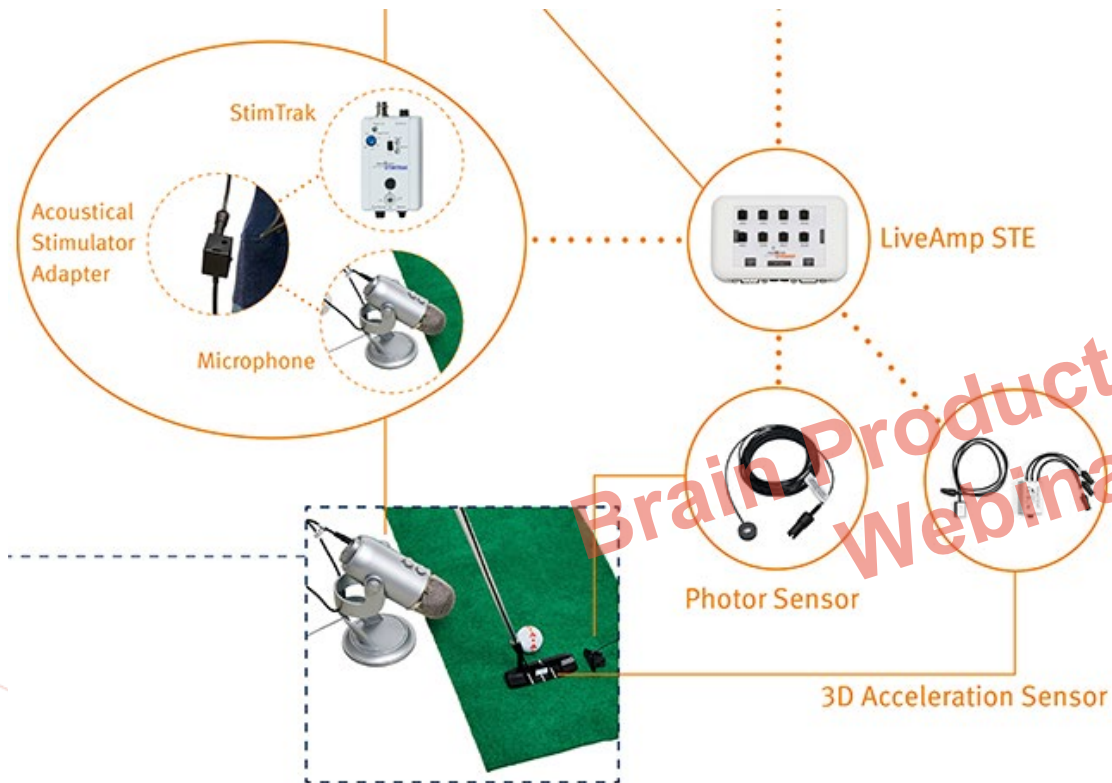


# EVENT MARKER GENERATION

## BP Press Release 03/2020

Ideas on how to generate meaningful events markers in sport physiology

Tune into a future webinar to see more background on how these may be setup



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<https://pressrelease.brainproducts.com/eeg-sport-physiology>



# EVENT MARKER GENERATION



## StimTrak with photosensor

Photosensor covered by putter in resting position, uncovered when swing initiated

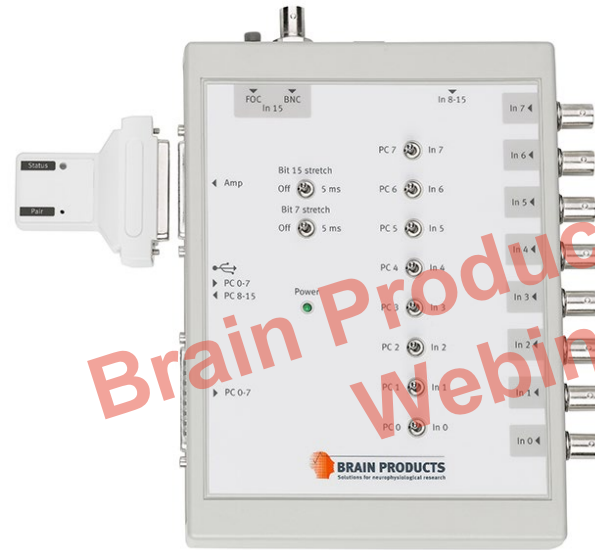
StimTrak generates event marker when input signal crosses user defined threshold

See BP Press Release 04/2014

(<https://pressrelease.brainproducts.com/photosensor/>)

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# EVENT MARKER GENERATION



## LiveAmp STE with wireless trigger receiver

Connect this to the LiveAmp to add

- 8x AUX channels for sensors
- 8-bit TTL input
- 8-bit TTL output

Wireless Trigger Receiver pairs with a transmitter to grab trigger markers wirelessly from a base station

## TriggerBox with wireless trigger transmitter

Wireless Trigger Transmitter pairs with a receiver to send trigger markers wirelessly to a LiveAmp

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# EVENT MARKER GENERATION



Increased voltage from sensed light





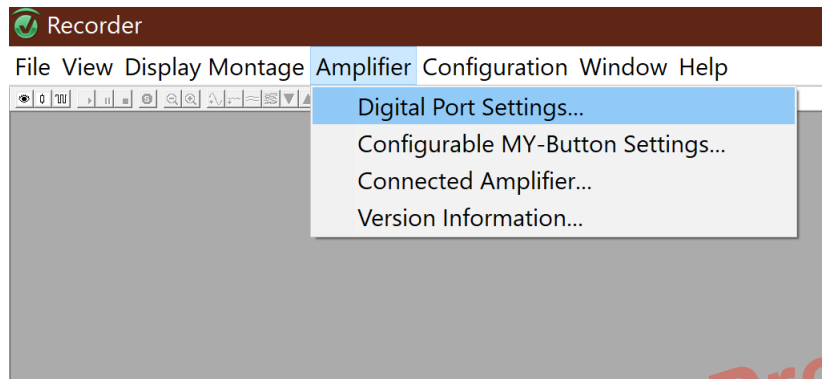


# CABLING BETWEEN SYSTEMS

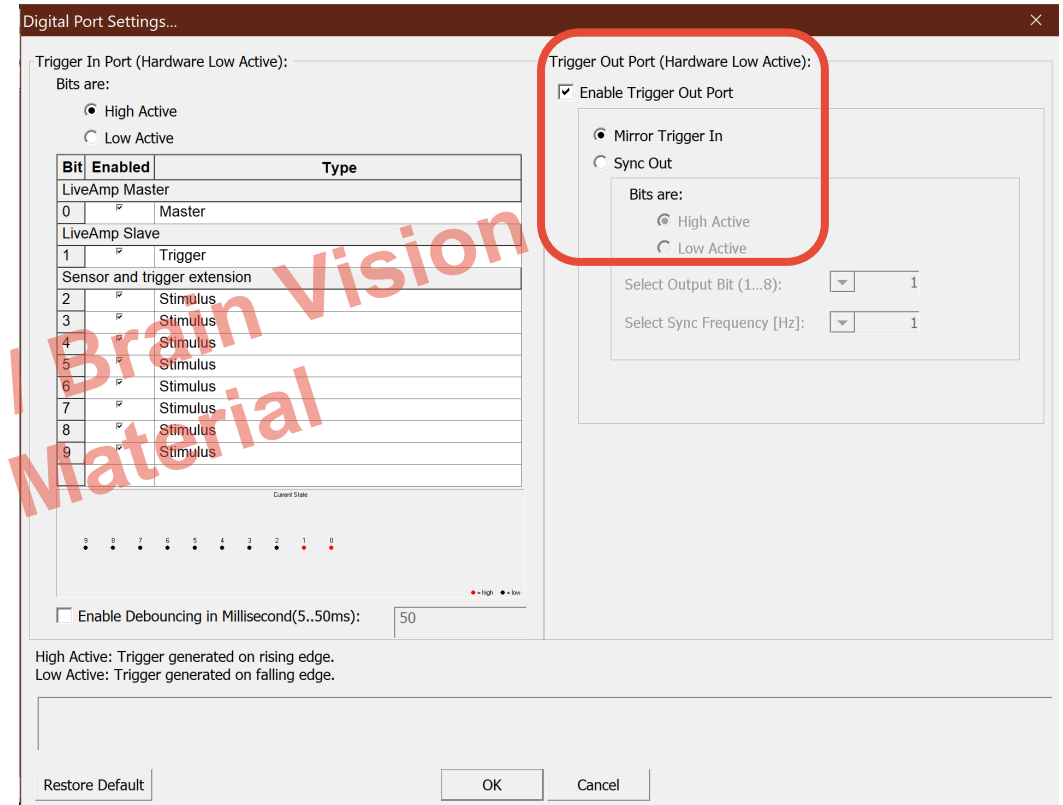
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# CABLING BETWEEN SYSTEMS



- Go to the menu bar and click "Amplifier" > "Digital Port Settings..."
- Enable TriggerOut Port, set to Mirroring





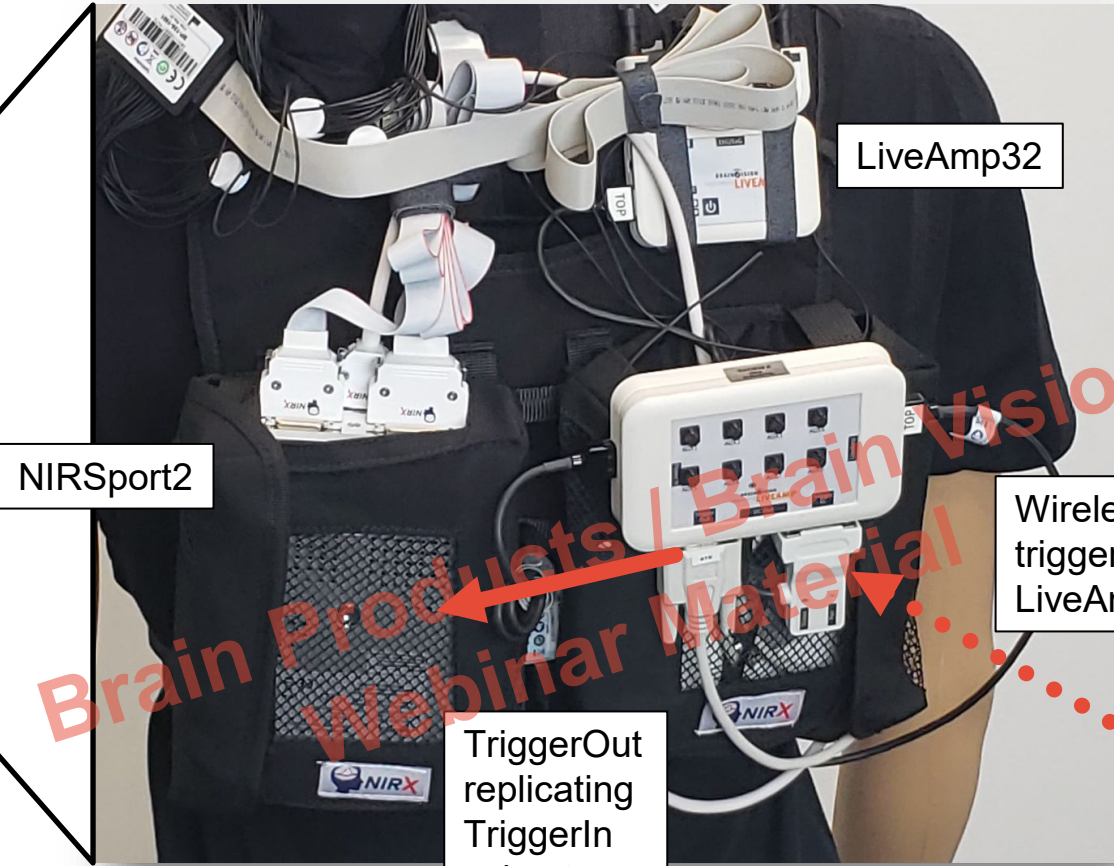
# CABLING BETWEEN SYSTEMS



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# CABLING BETWEEN SYSTEMS

Joint headgear with  
actiCAP active gel  
electrodes and NIRx  
fNIRS optodes



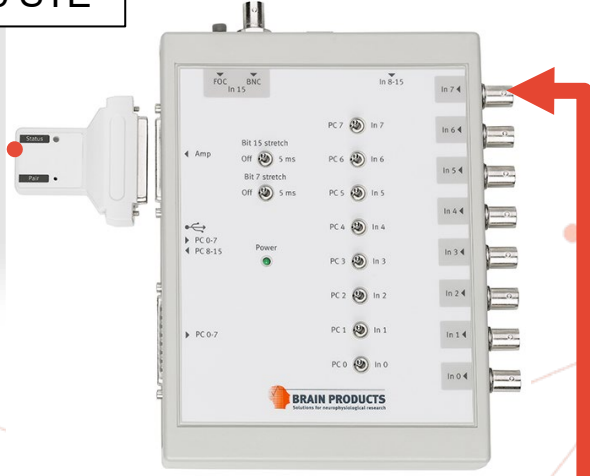
Wireless 8-bit  
trigger to  
LiveAmp STE

TriggerOut  
replicating  
TriggerIn  
value to  
NIRSport2

Light sensor  
voltage change  
after swing



5V TTL (BNC)  
to TriggerBox





# RECORDING COMPUTERS

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# RECORDING COMPUTERS



# RECORDING COMPUTERS WITH LSL





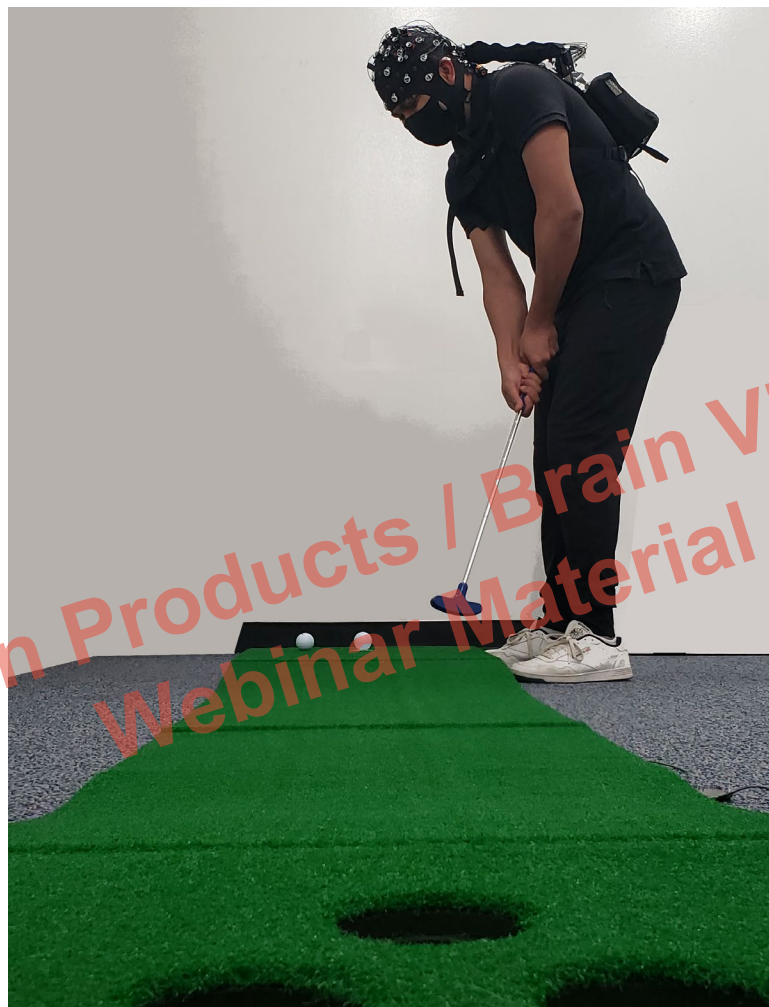


# DEMONSTRATION

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# DEMONSTRATION



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# WRAP UP QUESTIONS

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## WRAP UP QUESTIONS

- Thanks for joining, we are happy to address questions you may have now.

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# BRAIN VISION

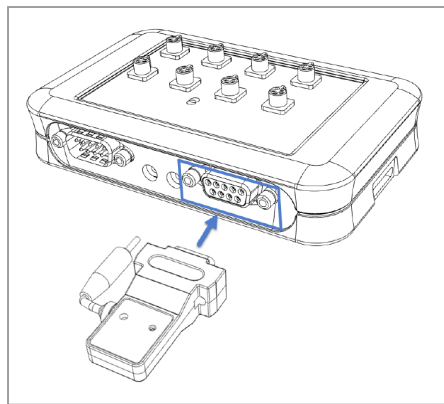
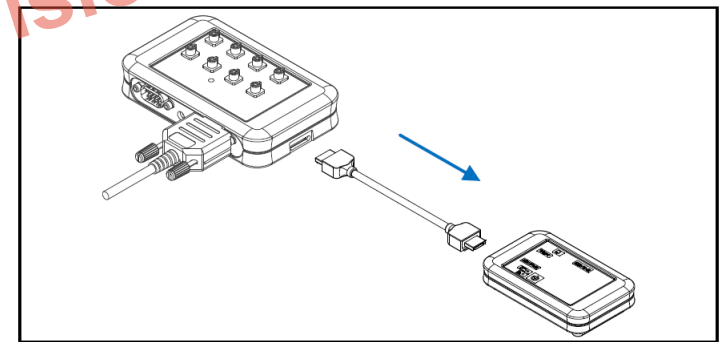
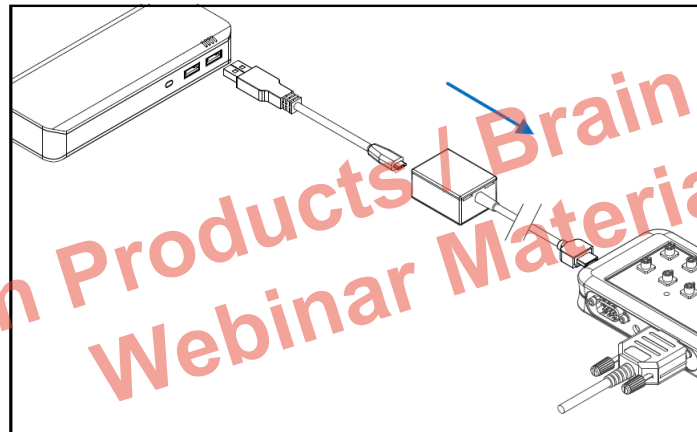
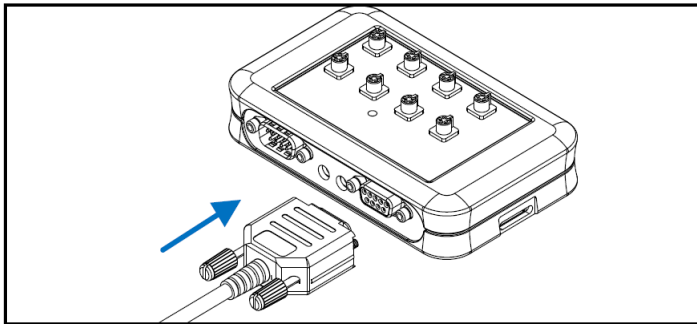
Solutions for neurophysiological research

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# AMPLIFIER AND CABLING

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engineering **LIVEAMP**



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# AMPLIFIER AND CABLING

**BRAIN VISION**  
engineering **LIVEAMP**

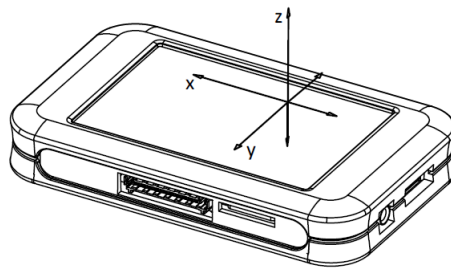
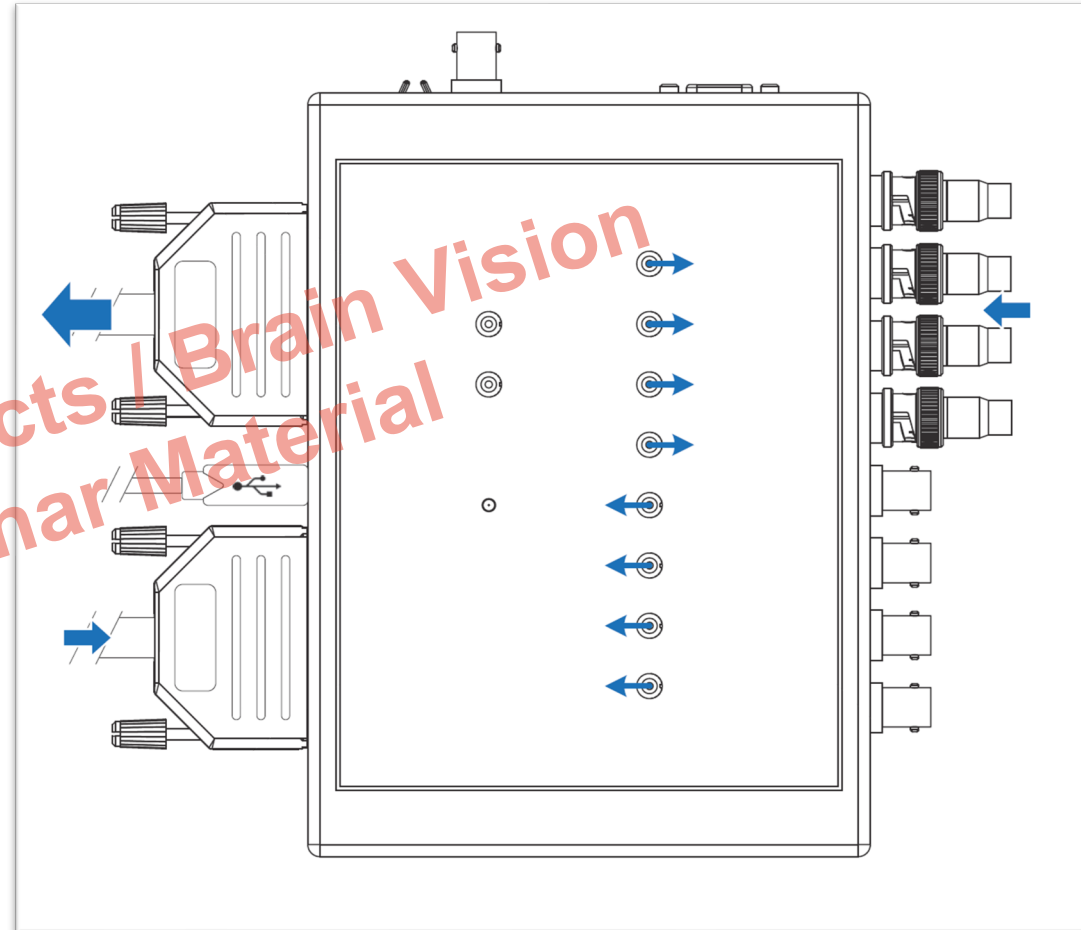


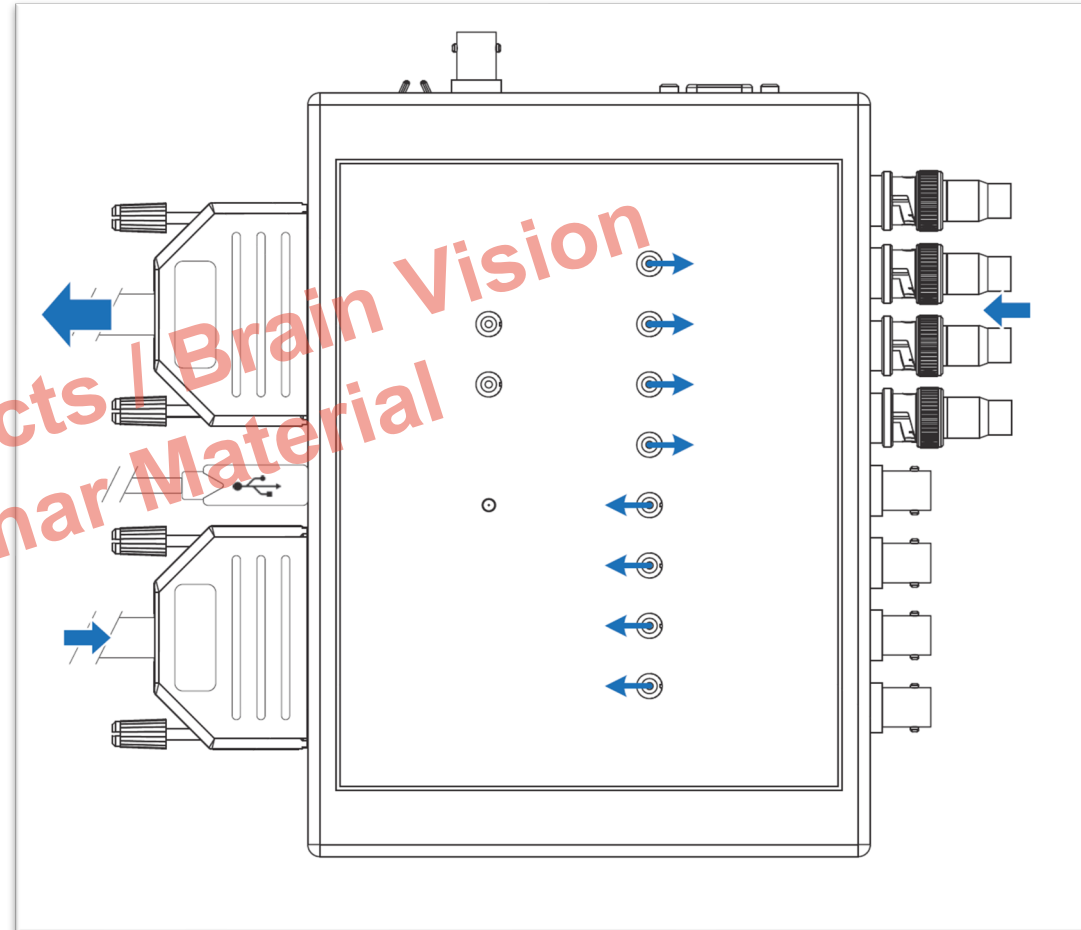
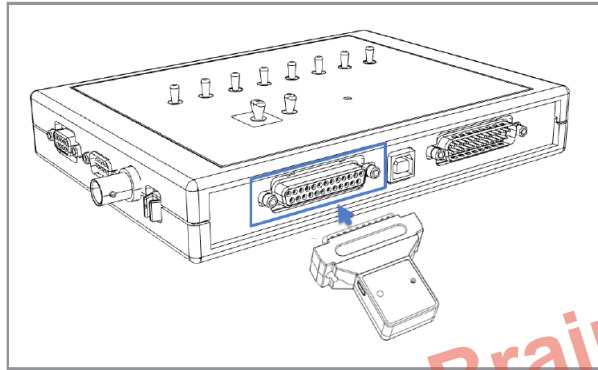
Figure 4-1. x, y, and z axes of the accelerometer



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# AMPLIFIER AND CABLING

**BRAIN VISION**  
engineering **LIVEAMP**





# INTRODUCTIONS

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# INTRODUCTIONS



## Brain Vision LLC

Brain Vision partners with scientists and institutions at the forefront of neurophysiological research, helping them select and effectively utilize state-of-the-art hardware and software from the world's leading manufacturers.

We deliver personalized, full-service support to further our primary goal of assisting our customers as they strive to attain their maximum research potential and advance the field of neuroscience.



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# INTRODUCTIONS



**Brain Products GmbH**  
(manufacturer)



**BrainVision**  
(brand name)



**Brain Vision LLC**  
(US partner in research, distributor)



**Brain Vision Solutions, Inc.**  
(Canadian partner in research, distributor)



# INTRODUCTIONS

## Brain Vision LLC and Brain Vision Solutions



**Judy Cini**  
CEO



**David Kadlec**  
SENIOR SCIENTIFIC  
CONSULTANT,  
SUPPORT MANAGER



**Edward Lau**  
SCIENTIFIC SALES DIRECTOR,  
SENIOR SCIENTIFIC CONSULTANT



**Tamara Spence, PhD**  
SCIENTIFIC CONSULTANT,  
TECHSUP TEAM LEAD



**Franziska Keller, MSc**  
JUNIOR SCIENTIFIC CONSULTANT



**Brett Bays, PhD**  
SCIENTIFIC CONSULTANT,  
SCISUP TEAM LEAD



**Stanley Donahoo,  
PhD**  
ASSOCIATE SCIENTIFIC  
CONSULTANT

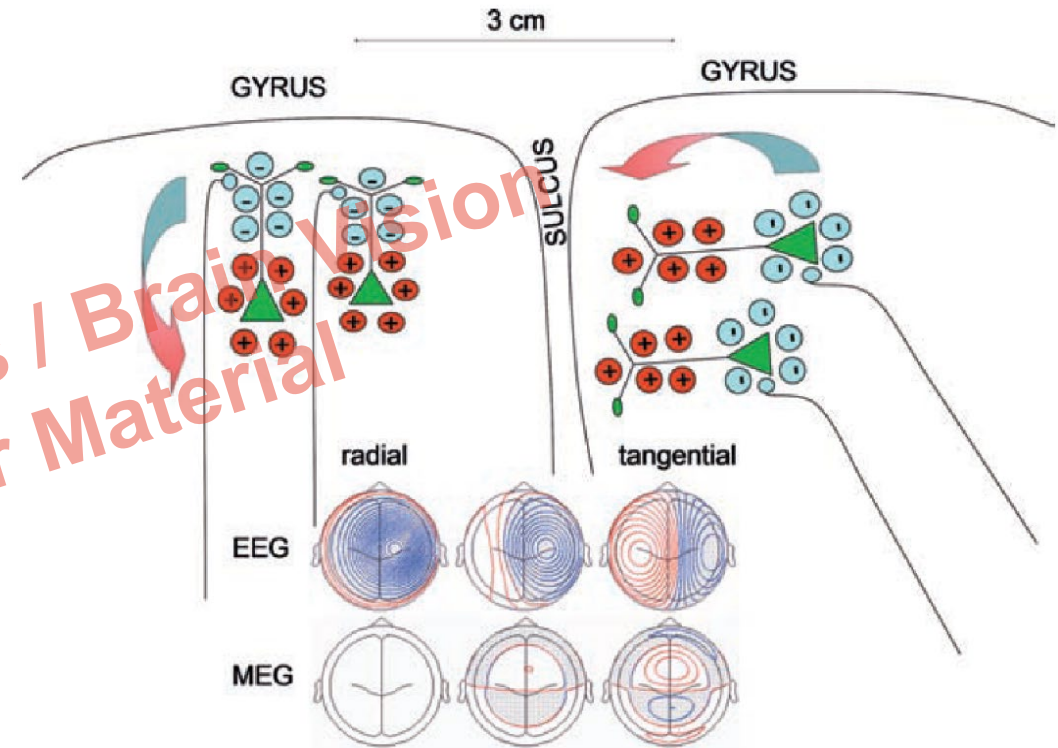


**Biraj Shrestha**  
ASSOCIATE TECHNICAL SUPPORT  
ENGINEER

# EEG – WORKING NEURAL ACTIVITY MODEL

- The summated dipoles can be approximated by a **single equivalent current dipole**

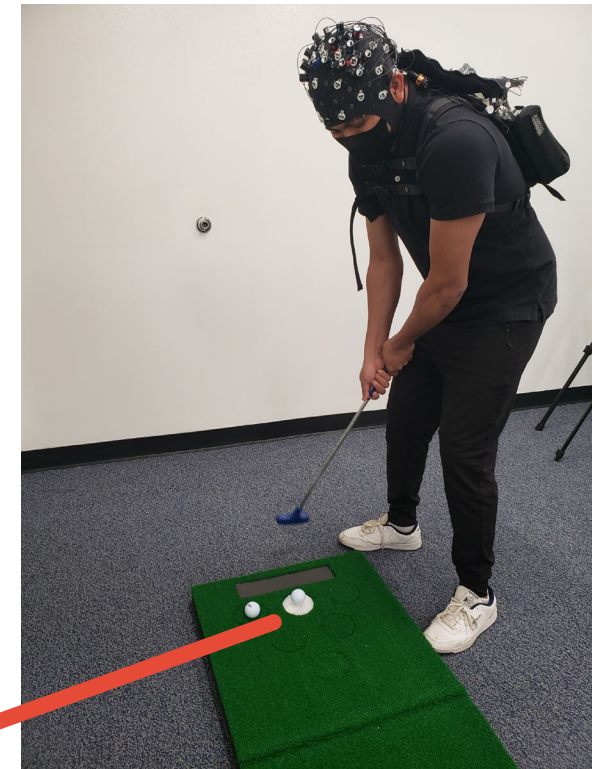
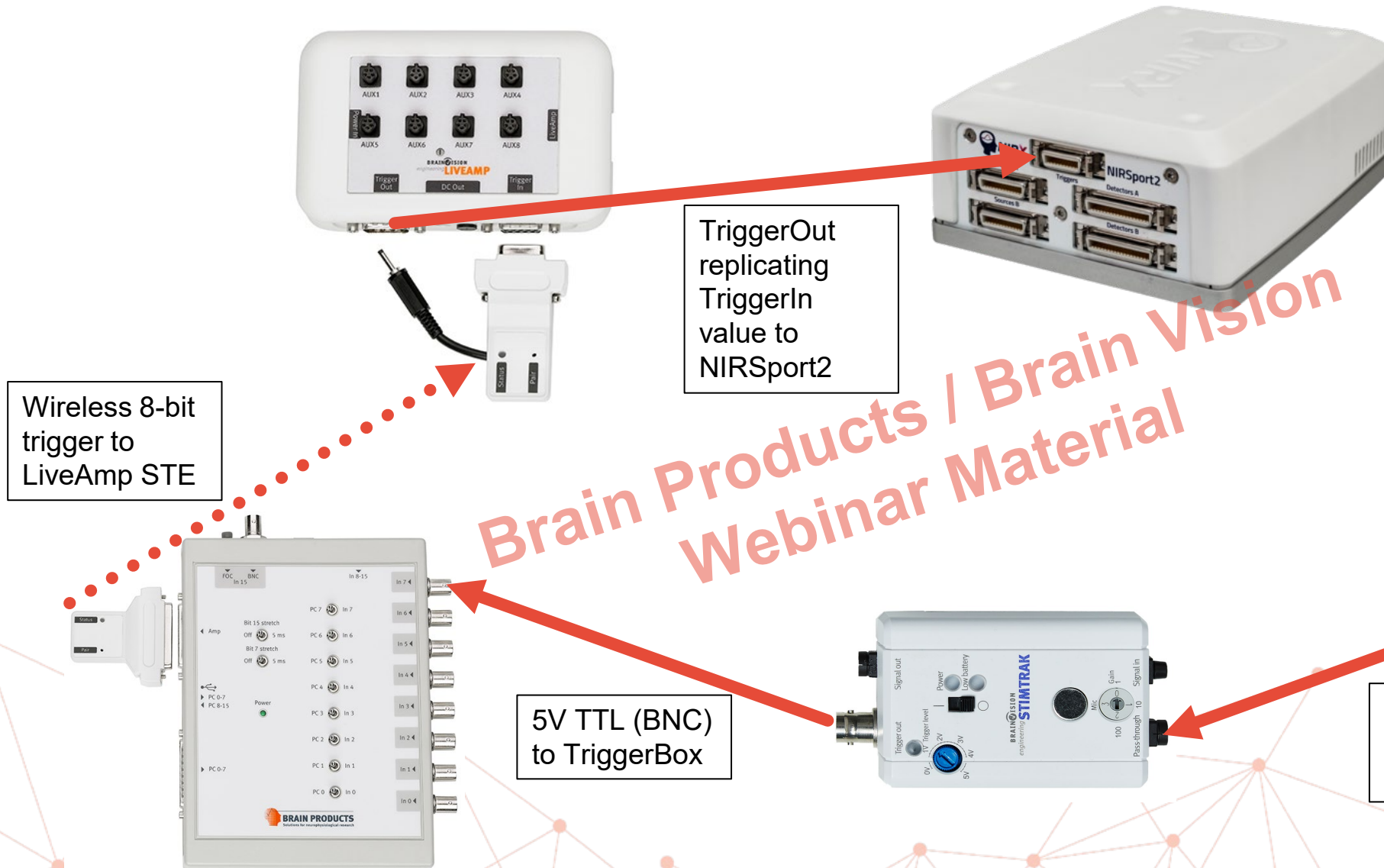
- **The position and orientation** (positive or negative) can be recorded



Source: Michel et. al (2009). Electrical Neuroimaging. Cambridge University Press.



# CABLING BETWEEN SYSTEMS



Light sensor change in voltage after swing



# PREPARING A SUBJECT

## Right fit of the actiCAP

1. Measure the head circumference with the measurement tape (Starter Kit) in centimeters
2. Choose the appropriate cap size (last two digits on label, 2cm increments)
3. Wipe forehead with alcohol wipes and/or makeup remover
4. Measure from Nasion to Inion, and mark the first 10% from the Nasion
5. Add electrodes into snap holders
6. Apply actiCAP snap cap on the participants head, frontal electrodes first
7. Measure the location of Vertex (Cz) to verify the cap is centrally placed halfway between nasion/inion and left/right preauriculars
8. Close the chinstrap. If a long recording session will happen, you can consider fixing certain electrodes with addition double-side adhesive rings (i.e. Fp1-2, Mastoids)

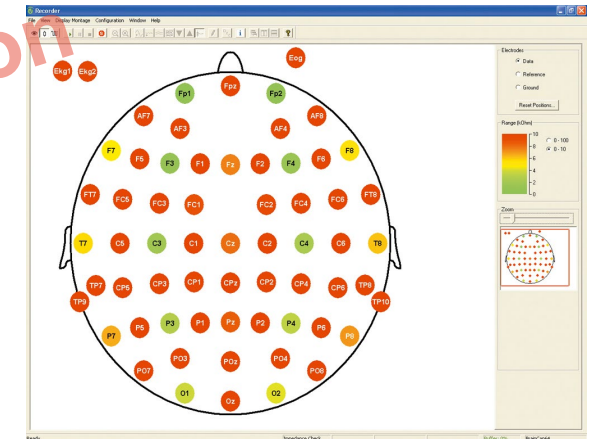
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# PREPARING A SUBJECT

## All impedances below 25kOhm or lower (signal quality)

1. Applying gel, follow these considerations:
  1. Add only a little (0.5mL or less) at a time. You can't put toothpaste back in the tube!
  2. Remember to point the needle tip back toward the electrode. The recording surface is under the LED.
  3. Apply some gel, then swirl the needle tip in big circles to mix the gel with the hair and get contact with the scalp.
  4. Remember to add a little gel as you remove the needle tip to backfill any gaps and prevent an air bubble.
2. Apply gel to Ground and Channel 1 of the first module.
  1. Ensure they have good (low) impedance values before moving on.
3. After that, start with electrodes at the back of the head and move forward.
  1. If two people are helping prepare the subject, consider splitting the hemispheres.
  2. Don't get stuck on an electrode that won't turn green. Add gel, swirl, and move on in your first pass. The gel will sink in and make a better connection in time while you prepare other electrodes.



# CABLING BETWEEN SYSTEMS

Subject is completely wireless and ready for MoBI recordings!



Joint headgear with actiCAP active gel electrodes and NIRx fNIRS optodes

LiveAmp32

LiveAmp STE with wireless trigger

NIRSport2

TriggerOut cable between LiveAmp and NIRSport2

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