Mobile EEG and eye tracking

Dr. Sara Pizzamiglio, Michael Hoppstädter

Scientific Consultants at Brain Products

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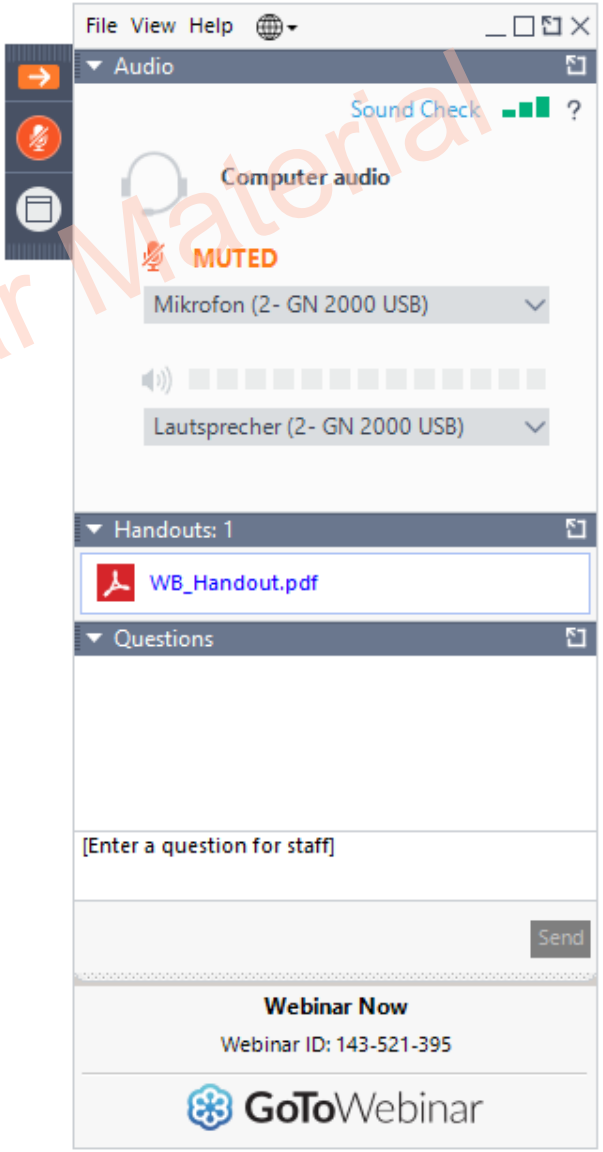
Starting in a few minutes

A few things to keep in mind:

- Please note that your microphones are **muted**. All attendees will stay in ***listen-only mode*** throughout the webinar.

- Please ask questions only via the **Questions pane** and ***address them to staff***. My colleagues will either answer them directly / save them for the Q&A session at the end of the webinar.



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BRAIN PRODUCTS
Solutions for neurophysiological research

Today's Webinar Team

Presenter

Dr Sara Pizzamiglio

Presenter

Michael Hoppstädter

Host

Dr Laura Leuchs

Moderator

Dr Bastian Schledde

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Overview

- Combined EEG / eye tracking measurements: why and how
- Mobile EEG and eye tracking: Hardware and Software overview
- The “photo gallery”: a mobile EEG and eye tracking recording
- Analysis and combination of mobile EEG & eye tracking data

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Combined EEG / eye tracking measurements

Why and How

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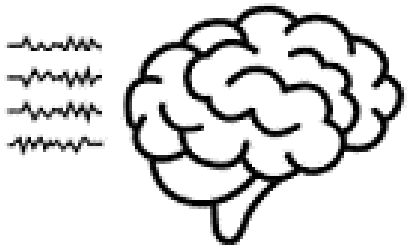
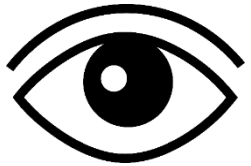
Combined EEG / eye tracking measurements – Why?



- Neural activity



- Gaze position
- Pupil size

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Example applications:

- Use the **pupil size** as physiological measure
- Use the **gaze position** to check the participant's focus
- Use timing of fixations to calculate **fixation-related potentials**

Combined EEG / eye tracking measurements – Why?

https://www.houstonpublicmedia.org/articles/news/2016/01/21/134834/what-do-our-brains-look-like-when-art-gets-involved/

Jesus G. Cruz-Garza, Justin A Brantley, Sho Nakagome, Kim Kontson, Dario Robleto, Jose L. Contreras-Vidal, December 20, 2017, "Mobile EEG Recordings in an Art Museum Setting", IEEE Dataport, doi: https://dx.doi.org/10.21227/H2TM00.

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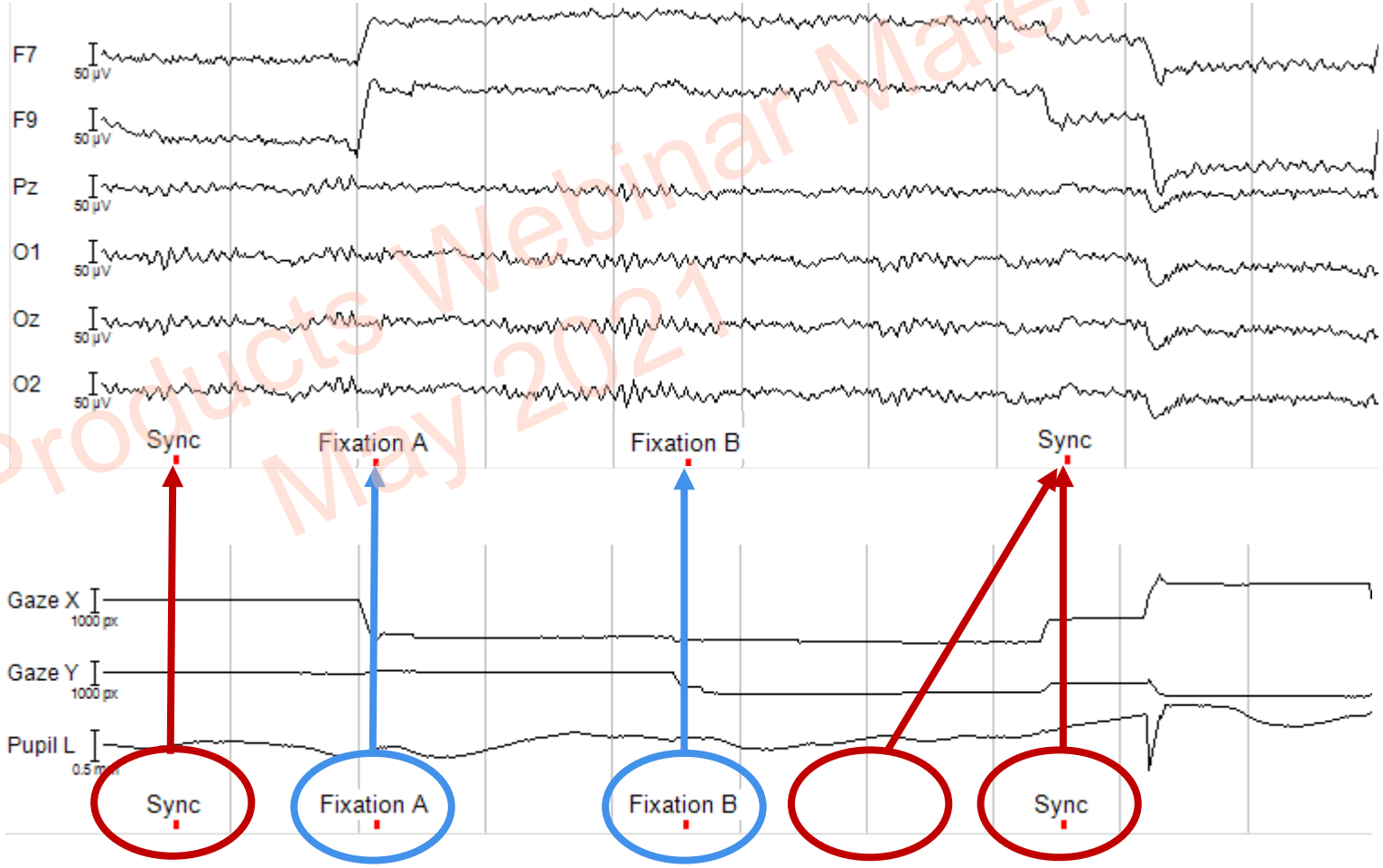
Combined EEG / eye tracking measurements – How?

For combined analysis, we need to **align EEG** and **eye tracking** data on the same time scale!

EEG

Eye tracking



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Workflow

Eye tracking hardware

Glasses 3 Controller Application

Eye tracking recording

tobii pro lab

Analyze & export eye tracking data

Sync events

EEG hardware

EEG recording

Merge EEG & eye tracking data for combined analysis

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BRAINVISION professional ANALYZER 2

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Mobile EEG and eye tracking

Hardware & Software Overview

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Wearable eye tracking: the Tobii Pro Glasses 3

Tobii Pro Glasses 3

- Wearable eye tracker integrated into glasses, connected to recording unit
- Track gaze during natural viewing, not bound to a screen
- Up to 100 Hz sampling rate allows to investigate fixations

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Wearable eye tracking: the Tobii Pro Glasses 3

Tobii Pro Glasses 3

- Wearable eye tracker integrated into glasses, connected to recording unit
- Track gaze during natural viewing, not bound to a screen
- Up to 100 Hz sampling rate allows to investigate fixations
- 16 illuminators and 4 eye cameras integrated into scratch-resistant lenses
- Scene camera with a wide field of view (106° H: 95°, V: 63°)
- Microphone for recording the environment
- Gyroscope, Accelerometer, Magnetometer to detect motion
- Wireless or Ethernet communication
- 3.5mm jack Sync In/Out Port available

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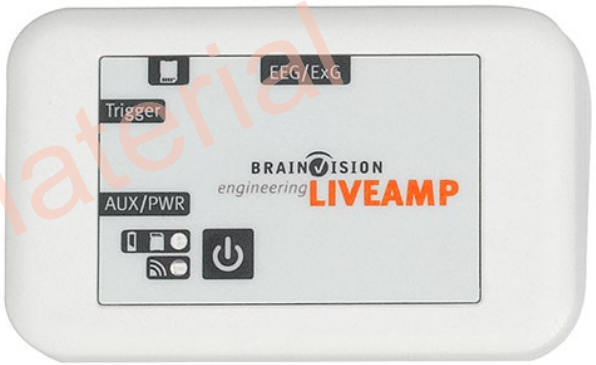
Wireless EEG amplifier: the LiveAmp

Amplifier

- **Ultra-light**
- **Wireless**: Recording via Bluetooth (range ~ 10 m) and/or on SD card within amplifier
  → SD card recording most recommended for mobile applications!
- 2.5 mm jack for **1-bit trigger signals**
- Integrated **3D accelerometer**
- **Compatible** with all our active and passive electrode systems
- 8, 16, 32 or 64 channel



Battery

- Integrated, rechargeable lithium-ion battery
- Power supply for ~4 hours, duration extendable with a USB power bank

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Electrode system: actiCAP

Active electrode technology

- amplification & signal conversion is performed at the scalp inside the electrodes
- Reduced influence of noise → ideal for real-world settings!

Quick cap preparation

- Active electrodes (organized in 32 channel bundles) to populate the cap
- Snap caps come with color-coded snap holders in 10-20 layout
- **Visual feedback** from LED lights on impedance level
- Impedance levels of **25 kOhm** already deliver great signal quality

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Eye tracking & EEG software overview

Eye tracking

Glasses 3 Controller application

- Eye tracking recording software
- Calibration, Recording and Live View
- Available for Windows 10 and Android 10, 9 tablets

Tobii Pro Lab

- Eye tracking analysis software
- Replay, gaze mapping, visualizations, graphics
- Export result metrics and data

EEG

BrainVision Recorder

- EEG Recording software
- Set up electrodes & trigger ports

BrainVision Analyzer 2

- EEG analysis software
- Add Channels module to import eye tracking data

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Mobile EEG & eye tracking setup and synchronization

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The “photo gallery”

A mobile EEG and eye tracking settings

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The “photo gallery”

Settings
Mobile and computer-free

Goal
Perform Fixation-Related Potentials based on the first fixations upon images of objects/faces

Challenge
No markers available in the EEG

Solution
Identify and mark timings of fixations within the eye tracking data and import them in the EEG

… let’s have a look!

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The “photo gallery”

Wearable eye tracking analyses steps in Tobii Pro Lab

1. Map all fixations on “snapshots” (i.e., static images of the real objects) via Assisted or Manual Mapping

2. Define the Areas of Interest on the snapshots to extract info on just the relevant fixations (i.e., fixations within the Area of Interest)

3. Export times of each fixations within the AOI (i.e., “AOI Hit”) and import them into BrainVision Analyzer (use .plof file format)

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Mobile EEG and eye tracking

Data handling session with BrainVision Analyzer 2.2.1 and Add Channels

Sara Pizzamiglio & Michael Hoppstädter

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Objectives

- How to import and synchronize your eye tracking data recorded simultaneously with EEG?

- What to do with the synchronized modalities? Examples would be…
  - Eye tracking data guided ERP analysis.
  - Fixation event-related potential (fERP).

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Prerequisites

- For using Add Channels:
  - Add-on license.
- For offline synchronization:
  - Common markers sent to EEG and eye tracking devices at the same time.
- Supported data formats:

Data format	Versions	Manufacturer
Tobii Pro Lab Output Format (PLOF)	2	Tobii Pro AB
Tobii Studio	2.2.3 & 3.0.1	Tobii Pro AB
EyeLink 1000 Plus	1	SR Research Ltd
BeGaze	3.0.0	SensoMotoric Instruments (SMI)
ASL Eye-Trac Data	6	Applied Science Laboratories (ASL)

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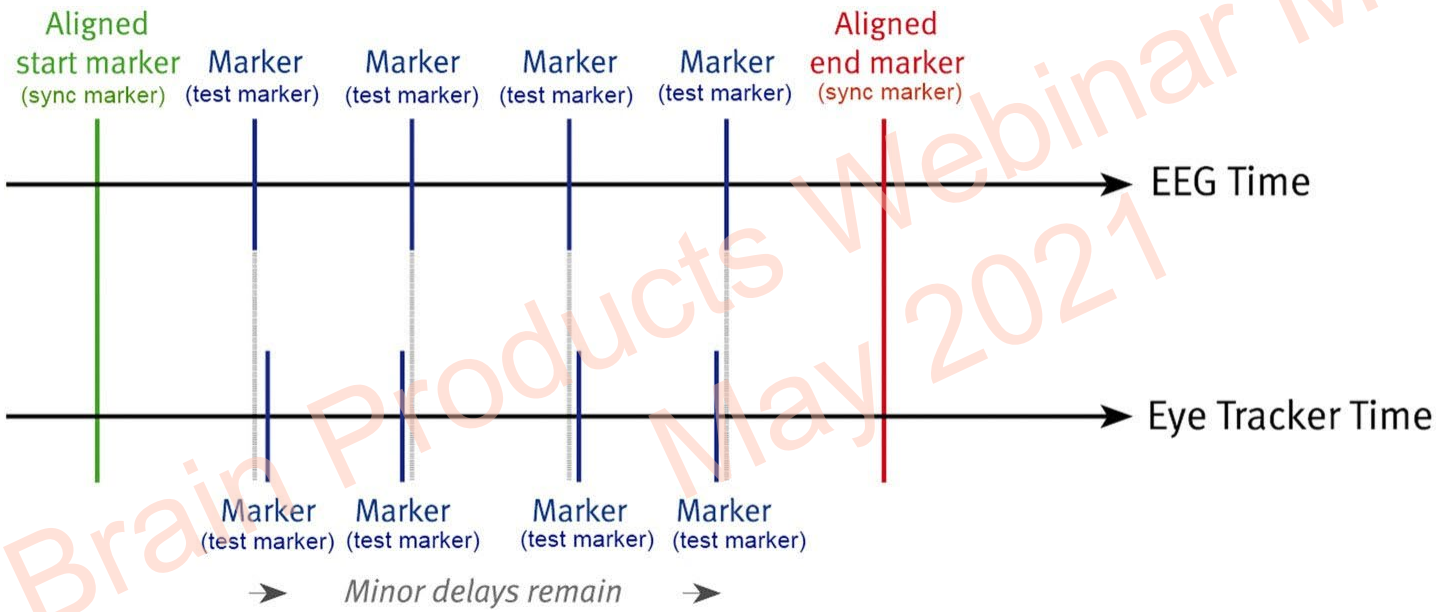
Method to synchronize the two modalities

- First and Last Marker method
  - Start and end marker available at the beginning and end of the data are used to correct clock offset and drift effects.



- Synchronizing procedure implies interpolating (resampling) the eye tracking data in order to match the sampling rate of the EEG data.

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Planned analysis pipeline

- Only sync markers available in EEG
  - Import the markers from Eyetracker for visual stimuli and for AOI fixations to the preprocessed data node
  - Use those markers for trial selection

- Create fixation event-related potentials (fERPs)
  - Use the fixation marker
  - Make sure that only the first fixation after stimulus onset is used

- Separate the two conditions
  - Looking at inanimate objects
  - Looking at faces

- Compare the fERPs to both conditions

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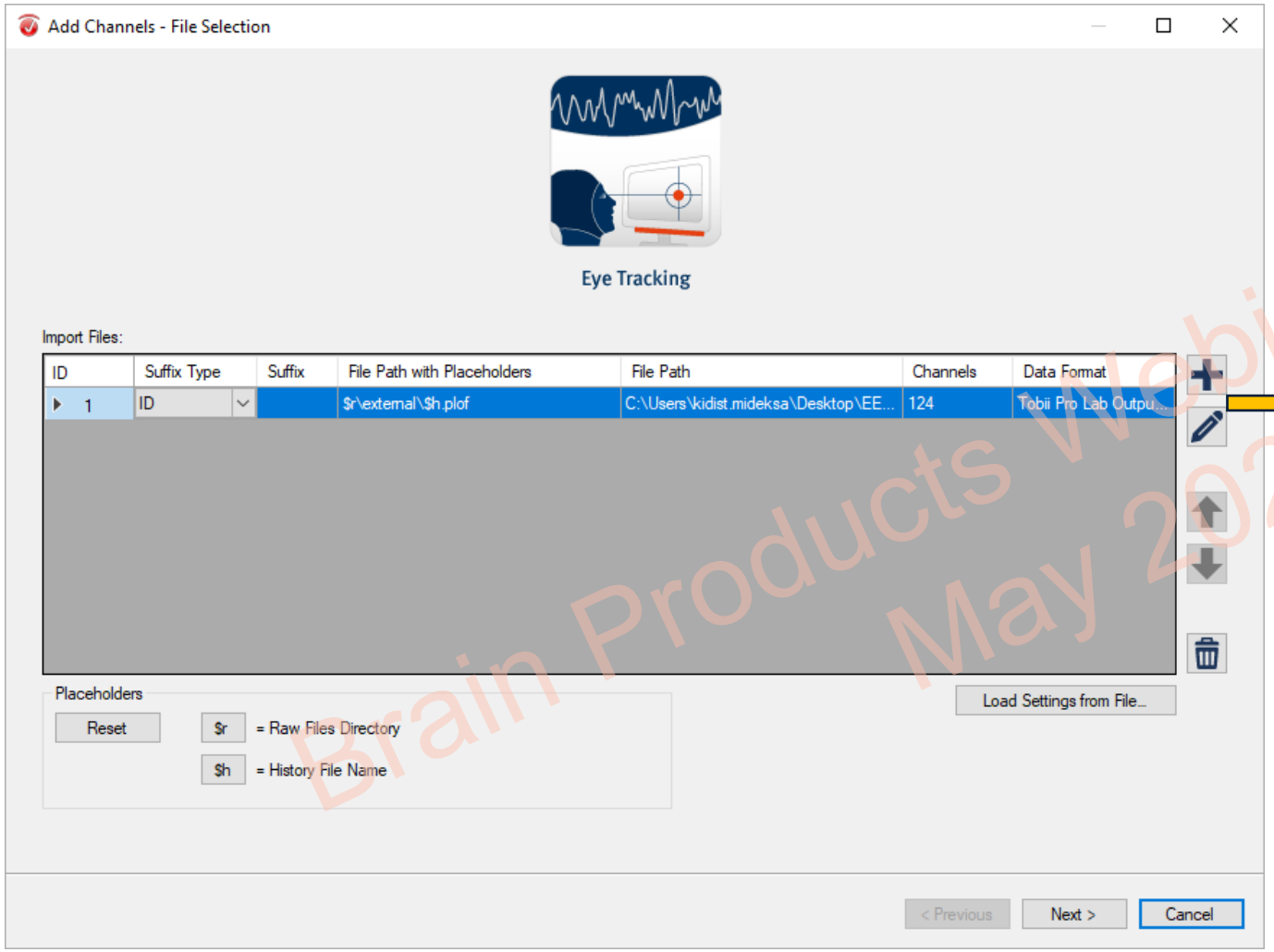
Import eye tracking data



Possibility to load multiple files of the same data format in one go.

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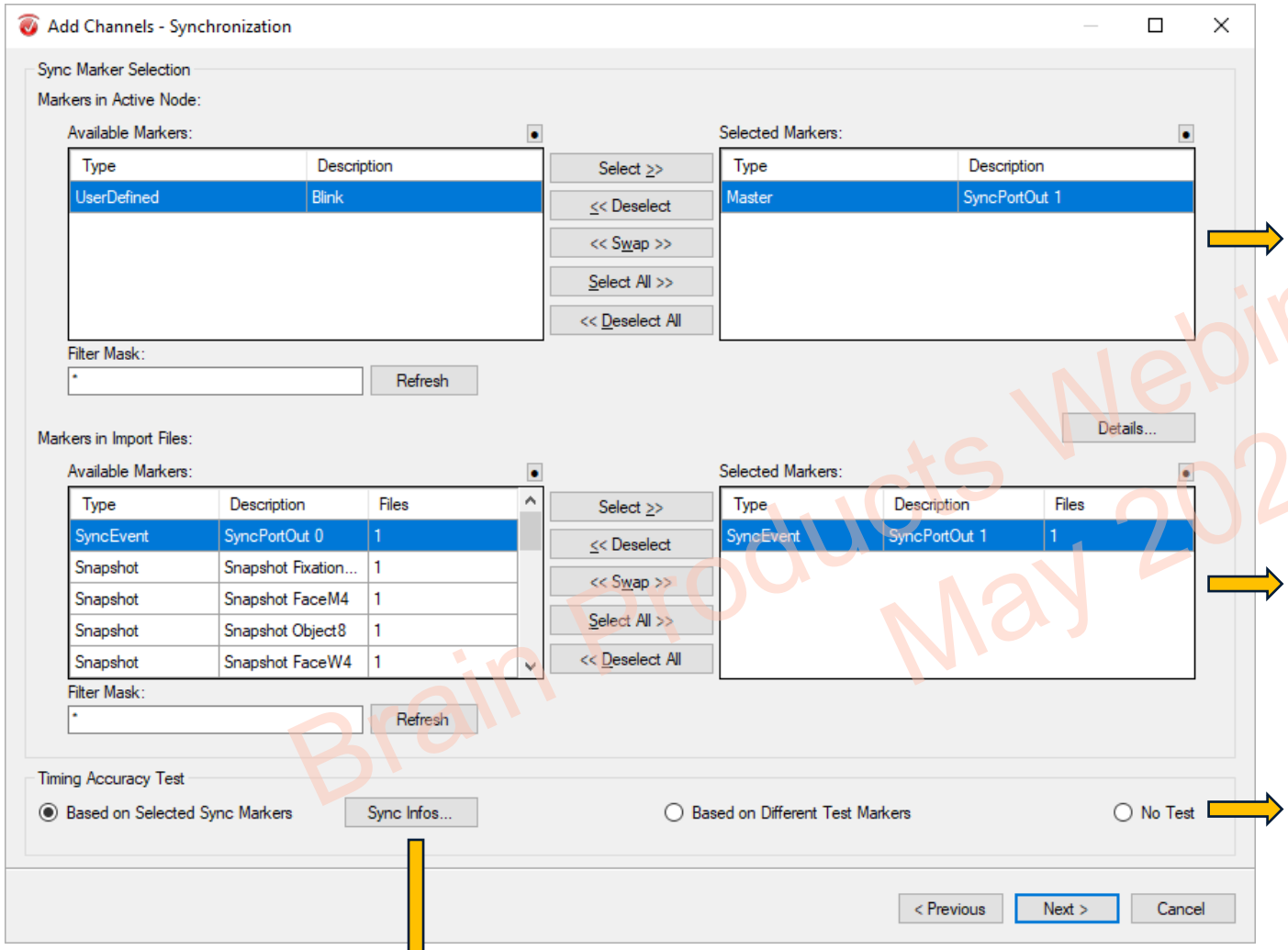
Sync marker selection



Select Sync markers from EEG data.

Select Sync markers from eye tracking data.

Select an option to estimate synchronization error.

Quantify residual synchronization error.

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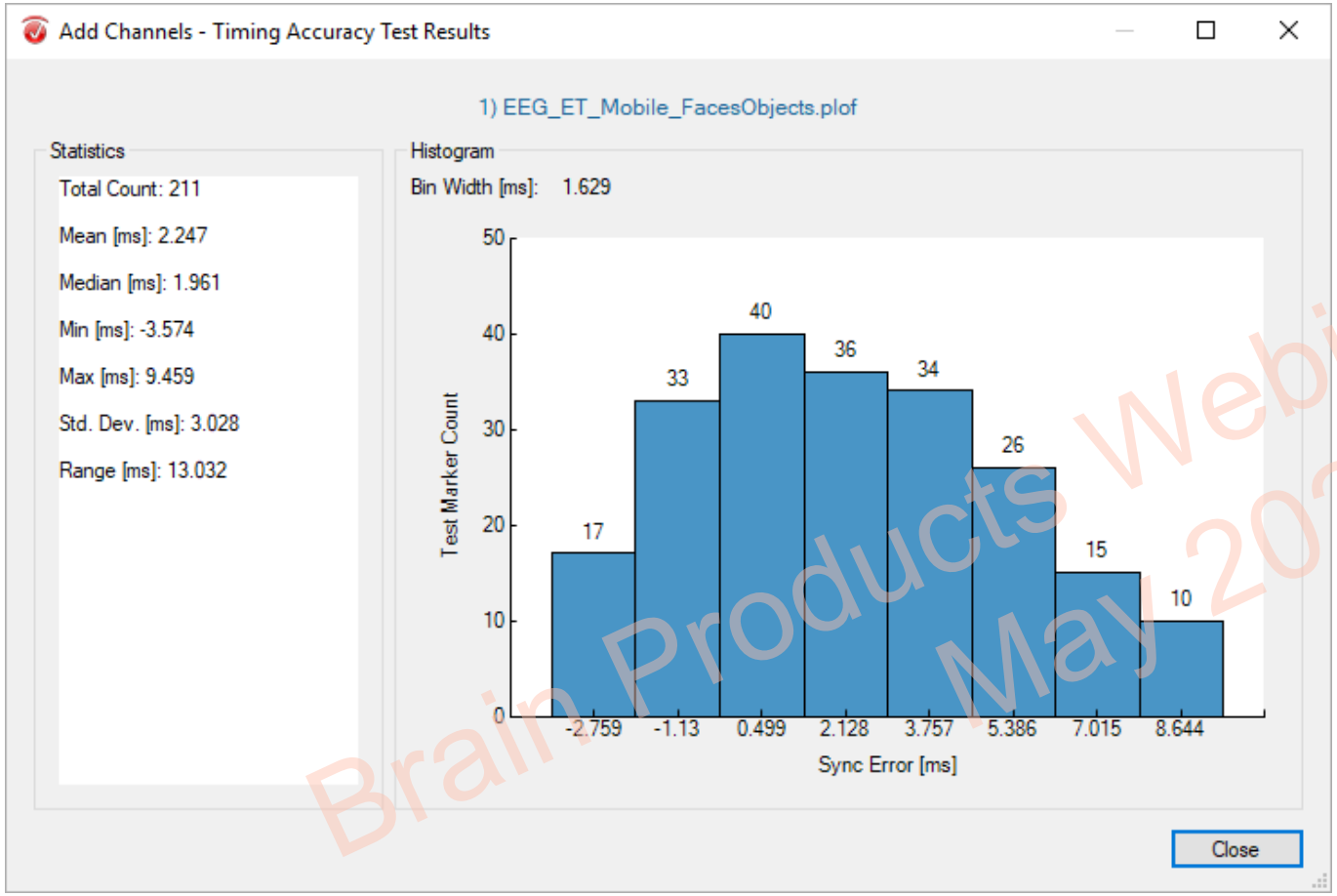
Timing accuracy test result



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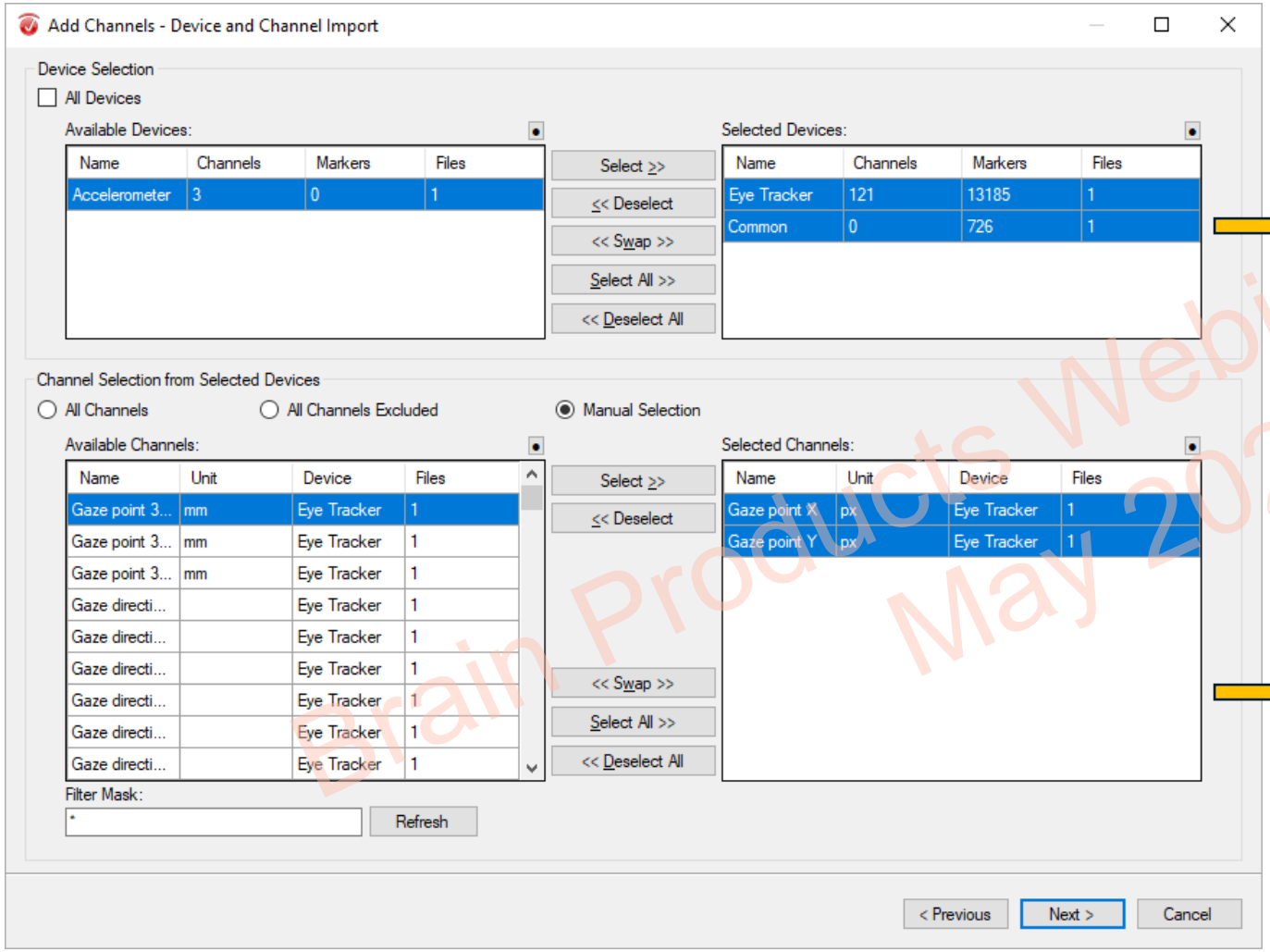
- Statistical measures based on the residual latency difference between test/sync markers in the EEG and eye tracking data per imported eye tracking file.

Device and Channel selection



Select devices (e.g. Eye Tracker, Accelerometer, GSR, Mouse, Gyroscope) from which you intend to import channels and markers from.

Select channel(s) associated to the selected device(s).

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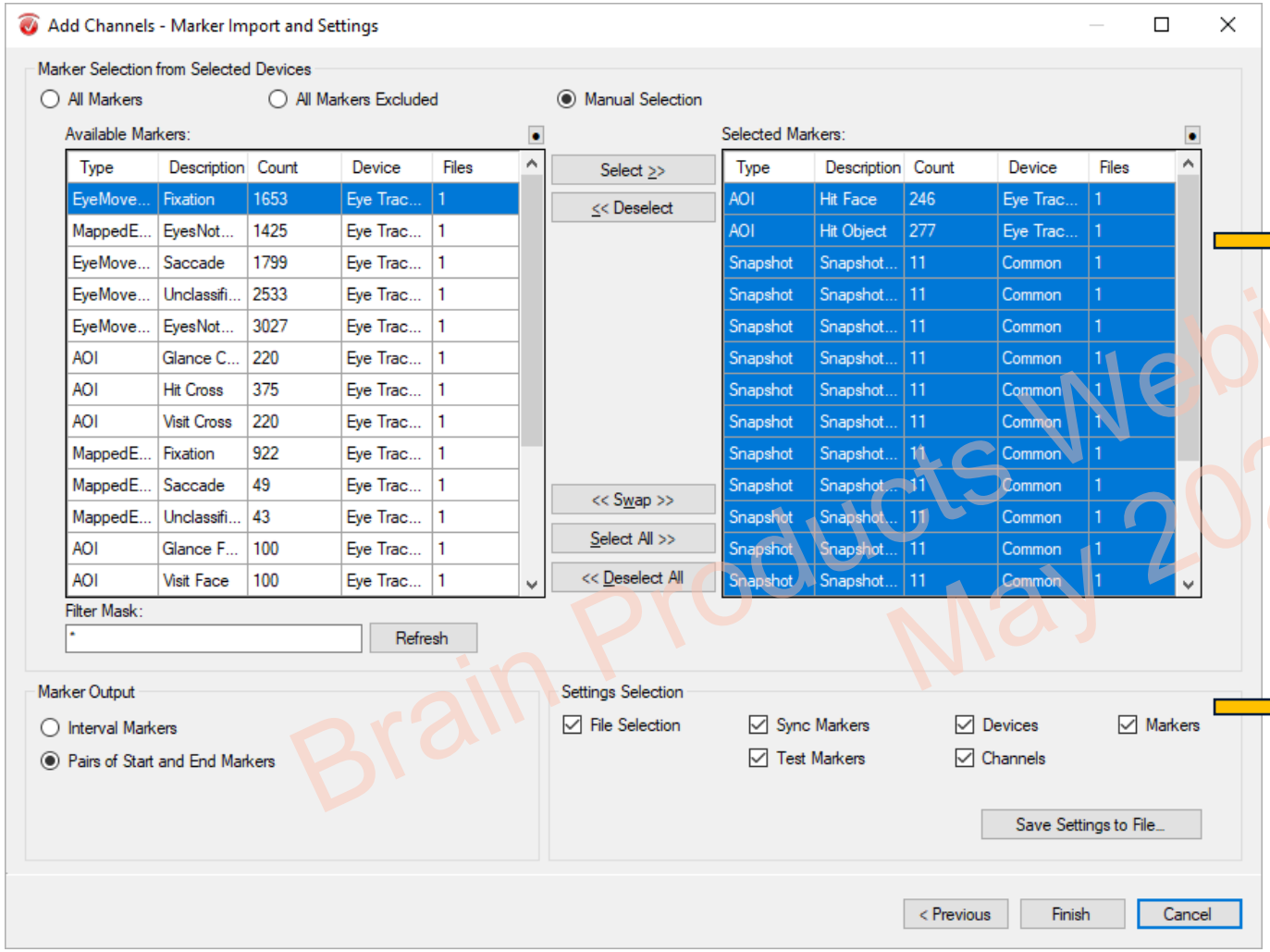
Marker selection and Settings



Select marker(s) associated to the selected device(s).

Save your current selection for future use.

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Recording Info

Recording Info

```
Eye Tracking Data:
Data Format: Tobii Pro Lab Output Format (PLOF)

Data:                    C:\Users\kidist.mideksa\Desktop\EEG-EYE\Raw\External\EEG_ET_Mobile_FacesObjects.plof
Data Format Version:     2.1

Project name                     Mobile_EEG_ET
Export date                      2021-05-03
Participant name                 SP
Recording name                   Recording 1
Recording date                   2021-04-27
Recording date UTC               2021-04-27
Recording start time             12:04:57.530
Recording start time UTC         10:04:57.530
Recording duration               2110759
Recording Fixation filter name   Tobii I-VT (Attention)
```

OK

Information about experimental setup (e.g., recording date, duration, name of the subject, calibration settings,….) can be easily accessed from the **Recording Info**.

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fERP analysis

- Raw Data
  - Edit Markers_rename sync markers
  - Edit Channels_drop accelerometer
  - Filters_1-35 Hz + notch 50 Hz
  - Ocular Correction ICA
  - Add Channels
    - Segmentation_HITS OBJECTS -200..1000
      - Baseline Correction -200..-100
        - Average_HITS OBJECTS
    - Segmentation_HITS FACES -200..1000
      - Baseline Correction -200..-100
        - Average_HITS FACES

Pre-processing

fERP analysis

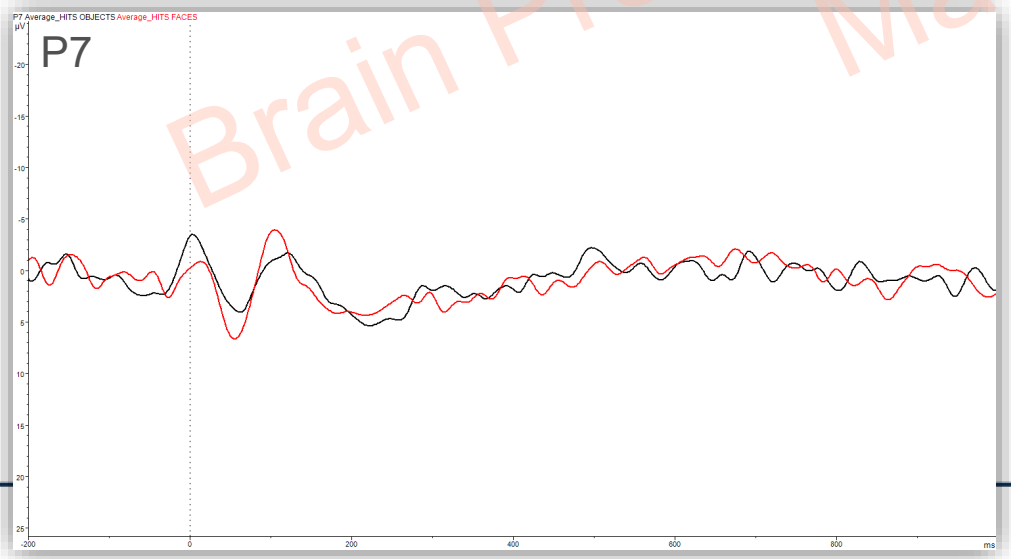
- Segmentation to all Hit Objects markers
- Use ABE in Segmentation
  - Use only the first fixation after the gaze has been directed onto the stimulus
- Baseline Correction
- Average: fERP of 87 trials (out of 88)

- Segmentation to all Hit Faces markers
- Use ABE in Segmentation
  - Use only the first fixation after the gaze has been directed onto the stimulus
- Baseline Correction
- Average: fERP of 86 trials (out of 88)

- Overlay of fERPs of both conditions

Objects

Faces



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Q & A Session

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Literature

References for stimuli used in the demo recording:

- Brodeur, M.B., Dionne-Dostie, E., Montreuil, T. and Lepage, M., 2010. The Bank of Standardized Stimuli (BOSS), a new set of 480 normative photos of objects to be used as visual stimuli in cognitive research. PloS one, 5(5), p.e10773.
- Lundqvist, D., Flykt, A., & Öhman, A., 1998. The Karolinska Directed Emotional Faces - KDEF, CD ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet, ISBN 91-630-7164-9

References for paradigm used in demo recording:

- Soto, V., Tyson-Carr, J., Kokmotou, K., Roberts, H., Cook, S., Fallon, N., Giesbrecht, T. and Stancak, A., 2018. Brain responses to emotional faces in natural settings: a wireless mobile EEG recording study. Frontiers in psychology, 9, p.2003.
- Roberts, H., Soto, V., Tyson-Carr, J., Kokmotou, K., Cook, S., Fallon, N., Giesbrecht, T. and Stancak, A., 2018. Tracking economic value of products in natural settings: a wireless EEG study. Frontiers in neuroscience, 12, p.910.

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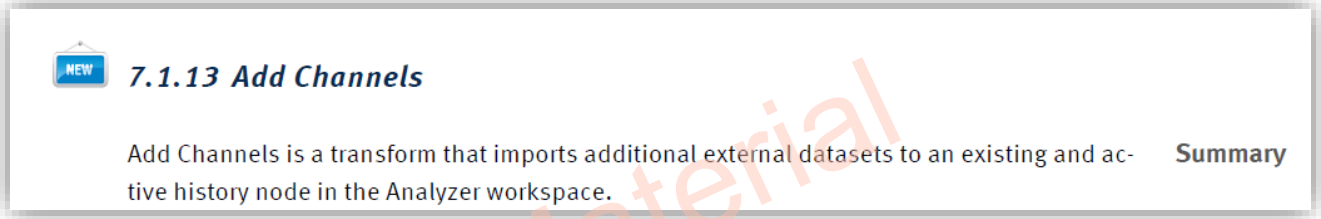
Additional information

Brain Products sources:

- BrainVision Analyzer 2.2.1 User Manual



- What's new in BrainVision Analyzer 2.2.1? – Integration of Tobii Pro Lab data in Add Channels & more: https://pressrelease.brainproducts.com/analyzer221

Tobii Pro sources:

- Installing Tobii Glasses Controller: https://www.tobiipro.com/learn-and-support/learn/steps-in-an-eye-tracking-study/setup/installing-tobii-glasses-controller/
- Wearable eye trackers: https://www.brainproducts.com/productdetails.php?id=30
- Tobii Pro landing page for eye tracking co-registrations https://www.tobiipro.com/product-listing/software/tobii-pro-lab/co-registrations/
- Learning article on „Solutions for co-registration of eye tracking and other biometric measures" https://www.tobiipro.com/learn-and-support/learn/steps-in-an-eye-tracking-study/design/solutions-for-co-registration-of-eye-tracking-and-other-biometric-measures/

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