

# **Standard Operating Procedures of the HCPh project**



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# The Human Connectome PHantom (HCPH) study: Standard Operating Procedures

## Summary

Unveiling how the brain's structure defines its distributed function and modulates the dynamics of processing holds the promise of triggering a revolution in neuroscience and applications to mental health and neurodegenerative diseases. Magnetic resonance imaging (MRI) has proven a valuable, non-invasive way of probing both the architecture and activity of the brain in-vivo, with sufficient spatial and temporal resolution to understand many aspects of its function. Although a large body of literature has shown strong correlations between structural and functional networks at the larger scales [1-4], the accumulated unreliability of MRI measurements from the scanner and through further steps of the research workflow impedes the link between structure, function, and dynamics at clinically relevant spatial and temporal scales. In particular, the measurements obtained with MRI are highly indirect, spatiotemporally uncertain, and confounded by other sources of MR signal. This complexity provides an immense informatics challenge that crosses multiple imaging modalities, including structural, functional, and dynamic connectivity approaches to understanding the human brain. Nonetheless, functional and structural networks extracted from MRI have proven sufficient levels of reliability to discriminate between individuals [4-7], and such reliability has proven stable from months to years [8]. Therefore, it is critical to characterize the reliability of this network's phenotyping before these analytical approaches may be applied clinically [9, 10]. In this project, we will first optimize the research workflow of MR network analyses to maximize the reliability of functional and structural connectivity matrices (so-called connectomes). Indeed, these matrices have been shown to contain large ratios of false positives and false negatives in both the functional [11] and the structural [12, 13] cases. We hypothesize that such improvements in sensitivity and specificity of functional and structural networks generalize across scanners and subjects, allowing the univocal identification of individuals from their brain's networks ("fingerprinting"). In order to be able to statistically separate and characterize the sources of signal variation, the project involves acquiring large amounts of repeated data on a small number of individuals. This approach has recently been dubbed "precision MRI" [14] and focuses on individual differences rather than group differences. The data acquisition approach is structured in three efforts with varying numbers of subjects, repetitions, and scanning devices. The first two, called "Cohort I" and "Cohort II" are sequential in time, and collected on three different devices. Cohort I involves a single individual who will undergo a total of 60 scanning sessions. Subsequently, Cohort II involves six (6) individuals and a total of twelve (12) sessions each. Finally, "Cohort III" is a quality control set involving 18 individuals and a total of two sessions each in a single scanner. In total, the project plans for repeated MRI acquisition on 25 healthy, adult human subjects, across three different 3.0 Tesla (T) MRI scanners available at CHUV. In addition to the new data, the project will reuse existing, open-access data to pilot various aspects of the MRI processing and analysis workflow to further support the overall reliability of the findings.

# Impact

Overall, this project will equip researchers with a framework for the extraction of reliable and precise structural, functional and dynamic networks that permit their joint modeling and analysis with interpretable and reproducible methods. The project will publicly release two highly valuable datasets necessary for the improvement of the workflow for structural and functional network extraction under open access and reuse terms. Upon conclusion, this study will mark a turning point for MRI research as a fundamental resource for academic training and a necessary assessment to unlock clinical applications in the long-term with the improvement of the reliability of MRI-network analyses. At a local scale, the project will substantially contribute to ensuring the reliability of the MRI clinical workflow that routinely aids medical decisions at CHUV.

# Pre-registration

The experiments and hypotheses associated to the collection of Cohorts I and II will be pre-registered to further guarantee research rigor and seek early scrutiny and feedback from experts in the field, thereby generating consensus on data collection and analysis. Researchers increasingly perceive pre-registration as a tool to maximize research transparency, improve study planning, and eliminate incentives conducive to dubious practices in the search for positive outcomes. By pre-registering the study, we will maximize the impact and usefulness of this work. A report on the Cohort I collection is undergoing pre-registration. Similarly, a report on Cohort II will be similarly submitted to suitable journal or organization (such as the Peer Community in Registered Reports, PCIRR) for peer-review. Additional reports and public communications of results of this project will be pre-registered whenever that is possible.

# References

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- [12]: A. Zalesky, A. Fornito, L. Cocchi, L. L. Gollo, M. P. van den Heuvel, and M. Breakspear, "Connectome sensitivity or specificity: which is more important?," *NeuroImage*, vol. 142, pp. 407–420, Nov. 2016, doi: 10.1016/j.neuroimage.2016.06.035.
- [13]: K. H. Maier-Hein et al., "The challenge of mapping the human connectome based on diffusion tractography," *Nat. Comm.*, vol. 8, no. 1, p. 1349, Nov. 2017, doi: 10.1038/s41467-017-01285-x.
- [14]: E. M. Gordon et al., "Precision Functional Mapping of Individual Human Brains," *Neuron*, vol. 95, no. 4, pp. 791-807.e7, Aug. 2017, doi: 10.1016/j.neuron.2017.07.011.

# Change History

All notable changes to these SOPs are documented below, starting with the most recent version of the document.

## You found an error

If you want to check the list of open issues, please proceed to our [issue tracker](https://github.com/TheAxonLab/hcph-protocol/issues) (<https://github.com/TheAxonLab/hcph-protocol/issues>).

If you have identified a problem, a typo, or something missing, and you know it is not in our tracker, please report it by [creating a new issue](https://github.com/TheAxonLab/hcph-protocol/issues/new) (<https://github.com/TheAxonLab/hcph-protocol/issues/new>).

## 0.1.0 (<https://github.com/TheAxonLab/hcph-protocol/releases/tag/0.1.0>) (June 29, 2023)

The first release of these SOPs. Currently, the document is still a work in progress, with the [Data management](#), [Preprocessing](#), and [Release of data](#) yet to be written.

Compare with first commit (<https://github.com/TheAxonLab/hcph-protocol/compare/51fb53f255aa8ee25b1ecb38b3429c400fabea3...0.1.0>)

## Enhancements, new features, and additions

- Rename study-settings file ([f53526ecec5cbe26679f8bbcfea134306571cde7](https://github.com/TheAxonLab/hcph-protocol/commit/f53526ecec5cbe26679f8bbcfea134306571cde7)) by [Oscar Esteban](https://github.com/oesteban) (<https://github.com/oesteban>)).
- Add task timings and references ([b21c7171139a4a19060fc648e41cf1dc019a05e7](https://github.com/TheAxonLab/hcph-protocol/commit/b21c7171139a4a19060fc648e41cf1dc019a05e7)) by [Oscar Esteban](https://github.com/oesteban) (<https://github.com/oesteban>)). Related issues/PRs: #73 (<https://github.com/TheAxonLab/hcph-protocol/issues/73>) Co-authored-by: [Elodie Savary](https://github.com/esavary) (<https://github.com/esavary>)
- Add phys2bids commandline ([0d22fd71d28f59c405b5f01fab18127780be6ea2](https://github.com/TheAxonLab/hcph-protocol/commit/0d22fd71d28f59c405b5f01fab18127780be6ea2)) by [Oscar Esteban](https://github.com/oesteban) (<https://github.com/oesteban>)).
- Change theme, add chuv logo, update data-storage ([a00e83325f02110c0c1a7a3389def10339475115](https://github.com/TheAxonLab/hcph-protocol/commit/a00e83325f02110c0c1a7a3389def10339475115)) by [Oscar Esteban](https://github.com/oesteban) (<https://github.com/oesteban>)).
- Refining the participant preparation ([f450fd208ceb83fa0c800be6e71e6231c2a0a25a](https://github.com/TheAxonLab/hcph-protocol/commit/f450fd208ceb83fa0c800be6e71e6231c2a0a25a)) by [Oscar Esteban](https://github.com/oesteban) (<https://github.com/oesteban>)).

- Sectioning the participant preparation ([84a4ee1](https://github.com/TheAxonLab/hcph-protocol/commit/84a4ee1b6a306fafda8e7c7332db423003986d0b) (<https://github.com/TheAxonLab/hcph-protocol/commit/84a4ee1b6a306fafda8e7c7332db423003986d0b>) by Oscar Esteban (<https://github.com/oesteban>)).
- Revise @celprov (<https://github.com/celprov>)'s code ([a011894](https://github.com/TheAxonLab/hcph-protocol/commit/a0118947eb563bfdc6e329d73a82abe7702c76c2) (<https://github.com/TheAxonLab/hcph-protocol/commit/a0118947eb563bfdc6e329d73a82abe7702c76c2>) by Oscar Esteban (<https://github.com/oesteban>)).
- Minimal, stylistic changes ([030a9ca](https://github.com/TheAxonLab/hcph-protocol/commit/030a9ca) (<https://github.com/TheAxonLab/hcph-protocol/commit/030a9ca>) by Oscar Esteban (<https://github.com/oesteban>)).
- Remove comment about starting recordings as it is now covered by #71 (<https://github.com/TheAxonLab/hcph-protocol/issues/71>) ([e4fa2cf](https://github.com/TheAxonLab/hcph-protocol/commit/e4fa2cf301ad7b7b8a7f35ddc0a6bb37f412278e) (<https://github.com/TheAxonLab/hcph-protocol/commit/e4fa2cf301ad7b7b8a7f35ddc0a6bb37f412278e>) by Oscar Esteban (<https://github.com/oesteban>)).
- Overhaul of the scanning section of the SOPs ([732c963](https://github.com/TheAxonLab/hcph-protocol/commit/732c963d91a6f537af026227e178d10c48030c7) (<https://github.com/TheAxonLab/hcph-protocol/commit/732c963d91a6f537af026227e178d10c48030c7>) by Oscar Esteban (<https://github.com/oesteban>)).
- Add emergency procedures ([fc52766](https://github.com/TheAxonLab/hcph-protocol/commit/fc52766e9793ad516155df01d54b57f27f1e94c1) (<https://github.com/TheAxonLab/hcph-protocol/commit/fc52766e9793ad516155df01d54b57f27f1e94c1>) by Céline Provins (<https://github.com/celprov>)).
- Miscellaneous improvements and picture addition ([b9b74c0](https://github.com/TheAxonLab/hcph-protocol/commit/b9b74c05a5bc697bd8c43cd8513dc0b057fde53) (<https://github.com/TheAxonLab/hcph-protocol/commit/b9b74c05a5bc697bd8c43cd8513dc0b057fde53>) by Céline Provins (<https://github.com/celprov>)).
- Add info on how to configure the Acknowledge software and record physiologocal signals ([f321875](https://github.com/TheAxonLab/hcph-protocol/commit/f32187555b9a399b5cafab56530318bd29a38d84) (<https://github.com/TheAxonLab/hcph-protocol/commit/f32187555b9a399b5cafab56530318bd29a38d84>) by Céline Provins (<https://github.com/celprov>)).
- Add information about the outputs of the different sequences to better explain the procedure ([c7db90a](https://github.com/TheAxonLab/hcph-protocol/commit/c7db90a) (<https://github.com/TheAxonLab/hcph-protocol/commit/c7db90a>) by Hélène Lajous (<https://github.com/helenelajous>)).
- Add info about cleaning procedure ([f15155a](https://github.com/TheAxonLab/hcph-protocol/commit/f15155a5103b53c6f6526d6a9e07aca03f3b0388) (<https://github.com/TheAxonLab/hcph-protocol/commit/f15155a5103b53c6f6526d6a9e07aca03f3b0388>) by Hélène Lajous (<https://github.com/helenelajous>)).
- Correct typos and add info in case you know which exam will be run next ([3d82aee](https://github.com/TheAxonLab/hcph-protocol/commit/3d82aee5b703eb812e6c23ecd4bca84b05eb173f) (<https://github.com/TheAxonLab/hcph-protocol/commit/3d82aee5b703eb812e6c23ecd4bca84b05eb173f>) by Hélène Lajous (<https://github.com/helenelajous>)).
- Add details about how to switch to advanced user mode to save a protocol ([8e5c46a](https://github.com/TheAxonLab/hcph-protocol/commit/8e5c46a02ea0f725b3e2404329b3428ce31df3a7) (<https://github.com/TheAxonLab/hcph-protocol/commit/8e5c46a02ea0f725b3e2404329b3428ce31df3a7>) by Hélène Lajous (<https://github.com/helenelajous>)).
- Add details and correct a few typos ([fdd742d](https://github.com/TheAxonLab/hcph-protocol/commit/fdd742d) (<https://github.com/TheAxonLab/hcph-protocol/commit/fdd742d>) by Hélène Lajous (<https://github.com/helenelajous>)).

- Review comments ([1745329924878c5dc81b6b7d1697b93029a1f61b](https://github.com/TheAxonLab/hcph-protocol/commit/1745329924878c5dc81b6b7d1697b93029a1f61b)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add picture of the ET attached ([eaa3a8a3b7b8a9f6e18ef1b5b469ab04de516fee](https://github.com/TheAxonLab/hcph-protocol/commit/eaa3a8a3b7b8a9f6e18ef1b5b469ab04de516fee)) by Oscar Esteban (<https://github.com/oesteban>)).
- Setup *mkipdfs* plugin ([2d6f9fd1d7819943adb0312bf397945a0be5ac19](https://github.com/TheAxonLab/hcph-protocol/commit/2d6f9fd1d7819943adb0312bf397945a0be5ac19)) by Oscar Esteban (<https://github.com/oesteban>)).
- Make it louder ([6d6cce44cfcd39b00af88617c45a9bebd48050d3](https://github.com/TheAxonLab/hcph-protocol/commit/6d6cce44cfcd39b00af88617c45a9bebd48050d3)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add info box about moving the mirror slightly to the right ([589fd6387dc4c6a35b1a0ec94cbd57c8d3400297](https://github.com/TheAxonLab/hcph-protocol/commit/589fd6387dc4c6a35b1a0ec94cbd57c8d3400297)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add warning about attachment of infrared mirror ([00c214d26232700293199788b40615422ddab683](https://github.com/TheAxonLab/hcph-protocol/commit/00c214d26232700293199788b40615422ddab683)) by Oscar Esteban (<https://github.com/oesteban>)).
- Miscellaneous improvements and image additions ([a74aa6d4989b3bcf600086140fa79788ca53b6cb](https://github.com/TheAxonLab/hcph-protocol/commit/a74aa6d4989b3bcf600086140fa79788ca53b6cb)) by Céline Provins (<https://github.com/celprov>)).
- Give instructions on how to switch on the scanner ([c83ad232a763e7aaf7ce427f1ceb98d6d4a3b29e](https://github.com/TheAxonLab/hcph-protocol/commit/c83ad232a763e7aaf7ce427f1ceb98d6d4a3b29e)) by Hélène Lajous (<https://github.com/helenelajous>)).
- Improve how the scanner is switched off ([f95d5590c4106d8e6b19b2bf0693ab7536830b7](https://github.com/TheAxonLab/hcph-protocol/commit/f95d5590c4106d8e6b19b2bf0693ab7536830b7)) by Hélène Lajous (<https://github.com/helenelajous>)).
- Say you want to turn the key ([85180b44d3b0d825e245cb3baac8e3da1d9703de](https://github.com/TheAxonLab/hcph-protocol/commit/85180b44d3b0d825e245cb3baac8e3da1d9703de)) by Hélène Lajous (<https://github.com/helenelajous>)).
- [heudiconv heuristic] Do not deduplicate if run is found ([5f15cca59aa974b56a98de2b94be571e4562e15](https://github.com/TheAxonLab/hcph-protocol/commit/5f15cca59aa974b56a98de2b94be571e4562e15)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add phone call script ([8b10d1c96cb8fd1e0bb3a3233e53e329f2443584](https://github.com/TheAxonLab/hcph-protocol/commit/8b10d1c96cb8fd1e0bb3a3233e53e329f2443584)) by Céline Provins (<https://github.com/celprov>)).
- Add what to do if the alarm rings ([f89e39977e01aa39866742c66b3ff473182dd586](https://github.com/TheAxonLab/hcph-protocol/commit/f89e39977e01aa39866742c66b3ff473182dd586)) by Céline Provins (<https://github.com/celprov>)).
- Replace BIOPAC setup photo with Ines' annotated one ([8e97af771d0bf7758cf86468d551248e5f8e0d14](https://github.com/TheAxonLab/hcph-protocol/commit/8e97af771d0bf7758cf86468d551248e5f8e0d14)) by Céline Provins (<https://github.com/celprov>)).

- Add missing bibliography ([a667955e1f7a604ffda222c73bd4062d04be9d2](https://github.com/TheAxonLab/hcph-protocol/commit/a667955e1f7a604ffda222c73bd4062d04be9d2)) by Céline Provins (<https://github.com/celprov> ).
- Addition of miscalleneous information and of many missing pictures ([20ad2bd88603b6e84ca82e045fb9227d12fda17c](https://github.com/TheAxonLab/hcph-protocol/commit/20ad2bd88603b6e84ca82e045fb9227d12fda17c)) by Céline Provins (<https://github.com/celprov> ).
- Add link to reproin ([dd4978f5bcc6aa323cbe1e97f5a2986c6760e042](https://github.com/TheAxonLab/hcph-protocol/commit/dd4978f5bcc6aa323cbe1e97f5a2986c6760e042)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add a filter to show missing secrets as REDACTED or replace values ([61451c847c3553d85c9c406f3df317400314ea69](https://github.com/TheAxonLab/hcph-protocol/commit/61451c847c3553d85c9c406f3df317400314ea69)) by Oscar Esteban (<https://github.com/oesteban>)).
- Improvements to the data management section ([2a176c15d3bba5fc06f177b4b42af7f011de8c2f](https://github.com/TheAxonLab/hcph-protocol/commit/2a176c15d3bba5fc06f177b4b42af7f011de8c2f)) by Oscar Esteban (<https://github.com/oesteban>)).
- Minimal improvements to clean-up ([d20edf3e87360d8dce1280c669edb6bc4559a3de](https://github.com/TheAxonLab/hcph-protocol/commit/d20edf3e87360d8dce1280c669edb6bc4559a3de)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add pictures and improve new exam description ([c02291f82d784bfa006c101cb20bce8c913851df](https://github.com/TheAxonLab/hcph-protocol/commit/c02291f82d784bfa006c101cb20bce8c913851df)) by Oscar Esteban (<https://github.com/oesteban>)).
- Split data collection ([516c388cb1a38c699eb381b2f0586b617e16b73b](https://github.com/TheAxonLab/hcph-protocol/commit/516c388cb1a38c699eb381b2f0586b617e16b73b)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add GA video ([944a525880b2263f7c6b6b719fcf7f33f1fe4d3e](https://github.com/TheAxonLab/hcph-protocol/commit/944a525880b2263f7c6b6b719fcf7f33f1fe4d3e)) by Oscar Esteban (<https://github.com/oesteban>)).
- Reorder misplaced steps, improve rendering ([3ede838775d3437c4fe377e47cf34a4d7e2e38f3](https://github.com/TheAxonLab/hcph-protocol/commit/3ede838775d3437c4fe377e47cf34a4d7e2e38f3)) by Oscar Esteban (<https://github.com/oesteban>)).
- Ensuring it looks good when rendered ([07b0f04bf2298d818b97eb535885f9a4fe33ef02](https://github.com/TheAxonLab/hcph-protocol/commit/07b0f04bf2298d818b97eb535885f9a4fe33ef02)) by Oscar Esteban (<https://github.com/oesteban>)).
- Added some files, restructure and fix some items ([3fa2c85215c1881ed84cfa30c357f33847e84a07](https://github.com/TheAxonLab/hcph-protocol/commit/3fa2c85215c1881ed84cfa30c357f33847e84a07)) by Oscar Esteban (<https://github.com/oesteban>)).
- Fix typos and overhaul of data collection ([00e3daf2c844e274f6902220c05263a169c878](https://github.com/TheAxonLab/hcph-protocol/commit/00e3daf2c844e274f6902220c05263a169c878)) by Oscar Esteban (<https://github.com/oesteban>)).
- Add images of gas analyzer ([6032ed01e4dfe354e8a2d3a59c6a6d5a957247f7](https://github.com/TheAxonLab/hcph-protocol/commit/6032ed01e4dfe354e8a2d3a59c6a6d5a957247f7)) by Céline Provins (<https://github.com/celprov> ).

- Add info how to setup the respiration belt and the gas analyzer ([62bf6fd](https://github.com/TheAxonLab/hcph-protocol/commit/62bf6fd2c7ab4a26396834432c752ef4cd436775) (<https://github.com/TheAxonLab/hcph-protocol/commit/62bf6fd2c7ab4a26396834432c752ef4cd436775>) by Céline Provins (<https://github.com/celprov>)).
- Add info to setup BIOPAC ([3719eca](https://github.com/TheAxonLab/hcph-protocol/commit/3719eca) (<https://github.com/TheAxonLab/hcph-protocol/commit/3719eca>) by Céline Provins (<https://github.com/celprov>)).
- Add info to turn off computer ([3e66ec85861eab28338081da436aa0286a0fa9c8](https://github.com/TheAxonLab/hcph-protocol/commit/3e66ec85861eab28338081da436aa0286a0fa9c8) (<https://github.com/TheAxonLab/hcph-protocol/commit/3e66ec85861eab28338081da436aa0286a0fa9c8>) by Céline Provins (<https://github.com/celprov>)).
- Add info about plugging the coil after the exam has been open ([1d5b501](https://github.com/TheAxonLab/hcph-protocol/commit/1d5b501) (<https://github.com/TheAxonLab/hcph-protocol/commit/1d5b501>) by Céline Provins (<https://github.com/celprov>)).
- Add info about how to save the magnitude image of the fmap ([d3efc7d](https://github.com/TheAxonLab/hcph-protocol/commit/d3efc7dc2b6eed9e5dd8662fe545d100102f66cb) (<https://github.com/TheAxonLab/hcph-protocol/commit/d3efc7dc2b6eed9e5dd8662fe545d100102f66cb>) by Céline Provins (<https://github.com/celprov>)).
- Add ack, edit/reorder some sections ([46e41fa](https://github.com/TheAxonLab/hcph-protocol/commit/46e41fa) (<https://github.com/TheAxonLab/hcph-protocol/commit/46e41fa>) by Oscar Esteban (<https://github.com/oesteban>)).
- First pass at data collection checklist ([2ab93f7](https://github.com/TheAxonLab/hcph-protocol/commit/2ab93f7e3e908f66a28ec124500c57853cf82e37) (<https://github.com/TheAxonLab/hcph-protocol/commit/2ab93f7e3e908f66a28ec124500c57853cf82e37>) by Oscar Esteban (<https://github.com/oesteban>)).
- Update README ([3833e370c8d15e8263e34ae66d3a530dec13a2d7](https://github.com/TheAxonLab/hcph-protocol/commit/3833e370c8d15e8263e34ae66d3a530dec13a2d7) (<https://github.com/TheAxonLab/hcph-protocol/commit/3833e370c8d15e8263e34ae66d3a530dec13a2d7>) by Oscar Esteban (<https://github.com/oesteban>)).

## Bug Fixes

- Add missing settings file ([0d4d3f8](https://github.com/TheAxonLab/hcph-protocol/commit/0d4d3f8ce7490657f0517595a71103996eb14615) (<https://github.com/TheAxonLab/hcph-protocol/commit/0d4d3f8ce7490657f0517595a71103996eb14615>) by Oscar Esteban (<https://github.com/oesteban>)).
- [heudiconv heuristic] Identify phase and mag in func and fmap-epi ([e1e3170](https://github.com/TheAxonLab/hcph-protocol/commit/e1e3170d8da31a55d1a7b7cf1b53d9d7ed953844) (<https://github.com/TheAxonLab/hcph-protocol/commit/e1e3170d8da31a55d1a7b7cf1b53d9d7ed953844>) by Oscar Esteban (<https://github.com/oesteban>)).
- [heudiconv heuristic] Robuster detection of phase/mag in GRE fieldmaps ([e65f0d2](https://github.com/TheAxonLab/hcph-protocol/commit/e65f0d2a6e26dcf3a96d21cce34d9febef727ec6) (<https://github.com/TheAxonLab/hcph-protocol/commit/e65f0d2a6e26dcf3a96d21cce34d9febef727ec6>) by Oscar Esteban (<https://github.com/oesteban>)).
- Wrong path of mathjax ([731dfddd89f49ef5980e7c3da9b3ea77f84e9a14](https://github.com/TheAxonLab/hcph-protocol/commit/731dfddd89f49ef5980e7c3da9b3ea77f84e9a14) (<https://github.com/TheAxonLab/hcph-protocol/commit/731dfddd89f49ef5980e7c3da9b3ea77f84e9a14>) by Oscar Esteban (<https://github.com/oesteban>)).
- Reorder scanning protocol to match sequences order in the manuscript ([80ee8f4](https://github.com/TheAxonLab/hcph-protocol/commit/80ee8f4) (<https://github.com/TheAxonLab/hcph-protocol/commit/80ee8f4>))

- 80ee8f4002cdd9ed003e9296b11355a2b18582ed) by Céline Provins (<https://github.com/celprov> ).
- Correct console parameter name for reconstruction ([dd1f3cf](https://github.com/TheAxonLab/hcp-ph-protocol/commit/dd1f3cf) (<https://github.com/TheAxonLab/hcp-ph-protocol/commit/dd1f3cff78eb02521b7d73d91a3dc1770eea75f>) by Céline Provins (<https://github.com/celprov> )).
  - Fix layout ([3facec988c160ffda362e71df55e6840b886d273](https://github.com/TheAxonLab/hcp-ph-protocol/commit/3facec988c160ffda362e71df55e6840b886d273)) by Céline Provins (<https://github.com/celprov> ).
  - Wrong link to psychopy git repo ([33ed5e5bc9610bb660f448550903e145da221389](https://github.com/TheAxonLab/hcp-ph-protocol/commit/33ed5e5bc9610bb660f448550903e145da221389)) by Céline Provins (<https://github.com/celprov> ).
  - Missing picture ([7eb7f42f37d064252f3ee2884d7d1017fc9db0ea](https://github.com/TheAxonLab/hcp-ph-protocol/commit/7eb7f42f37d064252f3ee2884d7d1017fc9db0ea)) by Céline Provins (<https://github.com/celprov> ).
  - Update RR figure 1 ([387722b35f7e93a0f67b5dadd32468d2e7e62fa2](https://github.com/TheAxonLab/hcp-ph-protocol/commit/387722b35f7e93a0f67b5dadd32468d2e7e62fa2)) by Oscar Esteban (<https://github.com/oesteban>)).
  - Add missing dependency ([976ae4cc269e1d5b82d9dcebf2087912379de9d3](https://github.com/TheAxonLab/hcp-ph-protocol/commit/976ae4cc269e1d5b82d9dcebf2087912379de9d3)) by Oscar Esteban (<https://github.com/oesteban>)).
  - Correct errors I introduced in @helenelajous (<https://github.com/helenelajous>)' PR ([3b656f2](https://github.com/TheAxonLab/hcp-ph-protocol/commit/3b656f2) (<https://github.com/TheAxonLab/hcp-ph-protocol/commit/3b656f27fe6185b9e1af0c0fc84528895b748d91>) by Oscar Esteban (<https://github.com/oesteban>)).
  - [heudiconv heuristic] More sensible decision for phasediff fieldmaps ([3d9b73e73f6fb4735eb73bfbde084cf1346e9e8a](https://github.com/TheAxonLab/hcp-ph-protocol/commit/3d9b73e73f6fb4735eb73bfbde084cf1346e9e8a)) by Oscar Esteban (<https://github.com/oesteban>)).
  - [heudiconv heuristic] Set run when duplicates of a sequence are found ([504e2170dc92b607bcfd7d356d6bb5a02cb7f8ca](https://github.com/TheAxonLab/hcp-ph-protocol/commit/504e2170dc92b607bcfd7d356d6bb5a02cb7f8ca)) by Oscar Esteban (<https://github.com/oesteban>)).
  - [heudiconv heuristic] Overhaul of the reproin heuristic ([6576b32](https://github.com/TheAxonLab/hcp-ph-protocol/commit/6576b321ec641c1eaea3e0800ea865a37ad8061a) (<https://github.com/TheAxonLab/hcp-ph-protocol/commit/6576b321ec641c1eaea3e0800ea865a37ad8061a>) by Oscar Esteban (<https://github.com/oesteban>)).
  - Minimal amends ([9e9d56f6d8cb0318b3ed382a0e31381f762fb311](https://github.com/TheAxonLab/hcp-ph-protocol/commit/9e9d56f6d8cb0318b3ed382a0e31381f762fb311)) by Oscar Esteban (<https://github.com/oesteban>)).
  - PACSMAN instructions ([b5623725f97e5832e1cb1bcb7da0c91c71cd5ed6](https://github.com/TheAxonLab/hcp-ph-protocol/commit/b5623725f97e5832e1cb1bcb7da0c91c71cd5ed6)) by Oscar Esteban (<https://github.com/oesteban>)).
  - PACSMAN csv file example ([e0a8f66](https://github.com/TheAxonLab/hcp-ph-protocol/commit/e0a8f66725c2048235b7ea6a6357e5982890b53f) (<https://github.com/TheAxonLab/hcp-ph-protocol/commit/e0a8f66725c2048235b7ea6a6357e5982890b53f>) by Oscar Esteban (<https://github.com/oesteban>)).

- Images with wrong paths, and names ([5260d62](https://github.com/TheAxonLab/hcph-protocol/commit/5260d62) (<https://github.com/TheAxonLab/hcph-protocol/commit/5260d62>) by Oscar Esteban (<https://github.com/oesteban>)).
- Miscellaneous stuff ([df5a300](https://github.com/TheAxonLab/hcph-protocol/commit/df5a300) (<https://github.com/TheAxonLab/hcph-protocol/commit/df5a300>) by Oscar Esteban (<https://github.com/oesteban>)).
- Update version of gha/checkout and fix path second time ([ccfc19c](https://github.com/TheAxonLab/hcph-protocol/commit/cfcc19c) (<https://github.com/TheAxonLab/hcph-protocol/commit/cfcc19c>) by Oscar Esteban (<https://github.com/oesteban>)).
- Still setting up path ([dfe542c](https://github.com/TheAxonLab/hcph-protocol/commit/dfe542c) (<https://github.com/TheAxonLab/hcph-protocol/commit/dfe542c>) by Oscar Esteban (<https://github.com/oesteban>)).
- Roll-back the path option ([ac2661f](https://github.com/TheAxonLab/hcph-protocol/commit/ac2661f) (<https://github.com/TheAxonLab/hcph-protocol/commit/ac2661f>) by Oscar Esteban (<https://github.com/oesteban>)).
- Checkout action ([1a149b2](https://github.com/TheAxonLab/hcph-protocol/commit/1a149b2) (<https://github.com/TheAxonLab/hcph-protocol/commit/1a149b2>) by Oscar Esteban (<https://github.com/oesteban>)).
- Remove toc plugin ([3861174](https://github.com/TheAxonLab/hcph-protocol/commit/3861174) (<https://github.com/TheAxonLab/hcph-protocol/commit/3861174>) by Oscar Esteban (<https://github.com/oesteban>)).

## Maintenance and Continuous Integration

- Set --in-place editing of the changelog ([48f8acd](https://github.com/TheAxonLab/hcph-protocol/commit/48f8acd) (<https://github.com/TheAxonLab/hcph-protocol/commit/48f8acd>) by Oscar Esteban (<https://github.com/oesteban>)).
- Refine changelog update with git-changelog ([e4ea298](https://github.com/TheAxonLab/hcph-protocol/commit/e4ea298) (<https://github.com/TheAxonLab/hcph-protocol/commit/e4ea298>) by Oscar Esteban (<https://github.com/oesteban>)).
- Use git-changelog to update the changelog ([856e58a](https://github.com/TheAxonLab/hcph-protocol/commit/856e58a) (<https://github.com/TheAxonLab/hcph-protocol/commit/856e58a>) by Oscar Esteban (<https://github.com/oesteban>)).
- Remove old exemplary code ([2e5697c](https://github.com/TheAxonLab/hcph-protocol/commit/2e5697c) (<https://github.com/TheAxonLab/hcph-protocol/commit/2e5697c>) by Oscar Esteban (<https://github.com/oesteban>)).

# **Recruitment, Scheduling, and Screening**

# Recruitment and screening

## Cohort I

Recruitment, screening and informed consent do not apply to Cohort I because the participant is the Principal Investigator himself.

## Cohort III

Recruitment, screening and informed consent do not apply to Cohort III because the sessions have already been acquired.

## Recruitment shortlist

- Distribute the [recruitment flyers](#) at CHUV, as well as on EPFL and UNIL campuses, both physically and electronically (e.g., e-mail lists).
- Insert any new potential participant who shows interest by calling █, whatsapp, SMS, email, etc. in [our recruits spreadsheet \(/redacted.html\)](#). Make sure you get an e-mail contact to send documents.

## Recruits shortlist

- Remove all flyers and indicate that recruitment is not open anymore once the shortlist quotas have been reached (5 males and 5 females for Cohort II).

## First contact

### Important

- Write an email to them within the next 24h.
- Use [the email template](#) and make sure you attach the MRI Safety and Screening Questionnaire and the Informed Consent Form.
- Confirm the reception of the email AND the documents over the phone.

## Phone call

### Info

The study coordinator (█, Assistante doctorante) will call the potential participant after at least three days of having sent the information in the case of cohort II (HRA, art. 16-3 (<https://www.fedlex.admin.ch/eli/cc/2013/642/en>)).

- Use the **phone script** to drive the conversation and record participant responses to questions.
- If participant consents to the phone screen, conduct it and mark the results (screener date, if responded "yes" to any medical questions, whether or not passed screener) in the appropriate columns of the recruitment spreadsheet.
- Confirm whether the potential participant understood the MRI Safety & Screening Questionnaire, and discuss with them any questions or potential reasons that may disqualify them to participate.

#### Carefully screen the subject

- In case of any doubts emerging from the MRI safety screening, indicate the potential participant that you will call them back within three days, after contacting the responsible physician.
  - Collect as much information as possible about their case.
  - Contact █ with all the information.
  - In case of negative assessment by the medical contact, the volunteer MUST NOT participate in the study.
  - Otherwise, call back the participant as soon as possible to confirm participation.
- 
- Female participants will be informed and must acknowledge that they must take a pregnancy test before the first scanning session.
  - If the candidate participant does not pass the phone screen, then end the interview, informing them that they do not meet our inclusion criteria, and mark the screen fail in the recruitment spreadsheet.
  - Make sure that the participant's questions about the study are all addressed and answered.
  - Request the potential participant to confirm they are willing to continue.
    - Indicate in the shortlist of recruits that the participant is ready to schedule the first session.
    - Tell the participant that they will be called back to set up the first session.
    - Remind them that they can ask further questions at any time before the MRI scan session.

## Templates

### First contact email (FR)

Remember to attach the MRI Safety and Screening Questionnaire and the ICF.

**Objet: Invitation à participer à une étude d'acquisition IRM du cerveau : informations et documents joints**

Cher/Chère [nom],

Nous vous remercions vivement pour l'intérêt que vous portez à notre étude de recherche sur l'imagerie IRM du cerveau.

Notre équipe mène actuellement une étude visant à mieux comprendre les différentes sources de variabilité lors d'un examen IRM.

Nous recherchons des participants·tes âgés de 24 à 55 ans, en bonne santé et sans antécédents de maladies neurologiques. Les participants·tes doivent consentir à la publication de leurs données dans le cadre du projet. Des mesures de confidentialité sont rigoureusement mises en place pour garantir l'anonymat des données. Elles impliquent notamment la suppression de toute information permettant l'identification des participants, telles que la date de naissance ou le nom.

Participer à cette étude implique une présence à 12 séances d'acquisition IRM du cerveau, d'environ 1h30 chacune. Ceci représente un temps de participation total d'environ 18 heures. Vous recevrez une indemnité financière pour votre participation. Veuillez noter que si des découvertes fortuites concernant votre santé étaient faites au cours de l'expérience, vous consentez à en être informé·e.

Nous vous invitons à prendre connaissance des documents joints afin d'obtenir un aperçu de l'étude. Le premier document détaille les implications d'une participation à l'étude, l'organisation des séances d'acquisition et fournit un résumé des objectifs du projet. Le second document concerne les éventuelles contre-indications à passer un examen IRM. Veuillez le remplir soigneusement et nous le retourner.

Si après lecture des informations ci-dessus vous acceptez de participer, nous souhaiterions convenir d'un entretien téléphonique avec vous afin de récapituler les points importants de votre participation. Cet entretien nous permettra également de vérifier votre éligibilité à participer à l'étude et de répondre à toutes vos éventuelles questions. Nous vous prions de nous retourner votre réponse dans un délai de 3 jours ouvrables. Afin que nous puissions planifier l'entretien téléphonique, veuillez également nous indiquer les plages horaires dans lesquelles nous pourrions vous contacter.

Entre-temps, si vous avez des questions, n'hésitez pas à nous contacter par e-mail ou par téléphone au █. Nous serons ravis de répondre à toutes vos questions.

Nous vous remercions encore une fois pour votre intérêt.

Cordialement,  
Céline PROVINS  
Assistante-doctorante

## First contact call (FR)

### First contact call script in French

Bonjour ici Céline Provins,

Je vous appelle concernant l'étude d'acquisition IRM du cerveau. Le but de cet appel est de vous répéter les éléments importants concernant le projet. Ensuite nous allons vérifier ensemble que vous êtes d'accord avec toutes les exigences pour participer à ce projet et nous allons vérifier que vous n'avez pas de contre-indications qui vous empêchent de passer des sessions IRM. De plus, je suis aussi là pour répondre à toutes vos questions, donc n'hésitez pas à m'interrompre si vous comprenez pas quelque chose ou si vous avez des doutes.

Est-ce que vous avez des questions jusque là ?

Je vais maintenant vous présenter les éléments essentiels concernant votre participation à notre étude. La participation à ce projet comprend 12 séances d'environ 1h30 qui se dérouleront au CHUV. Chaque séance durera environ 1h30. On commencera par remplir un bref questionnaire pour assurer la sécurité de la procédure, ça prendra environ 15 minutes ensuite, nous vous prépareront, nous vous expliquerons l'examen et nous nous assurerons que vous ne portez rien qui puisse causer des perturbations magnétiques. Nous

vérifierons également avec une liste de contrôle que toutes les mesures de sécurité sont prises et que vous n'avez pas un élément métalliques sur vous. Ensuite vous passerez environ 1h15 dans le scanner.

Dans chaque séance nous allons non seulement acquérir des images IRM mais nous allons aussi enregistrer des signaux physiologiques au moyen de quatres appareils supplémentaires. Ces appareils sont compatibles avec l'IRM et ils n'affectent pas votre santé.

Le premier appareil est une ceinture respiratoire pour suivre votre respiration. C'est simplement une ceinture autour de votre ventre ou autour de votre thorax qui mesure le déplacement de votre ventre.

Ensuite nous allons placer trois d'électrodes au sommet de votre thorax. Ceux-ci sont placés avec un gel conducteur sur la peau pour mesurer vos pulsations cardiaques.

Le troisième appareil est une canule respiratoire pour mesurer la concentration de dioxyde de carbone expiré. Une canule respiratoire c'est le tube que les personnes âgées ont pour respirer de l'oxygène. La différence c'est que nous n'allons pas vous donner du gaz, mais simplement que vous expirez pendant votre respiration.

Le 4ème appareil est un appareil pour mesurer le mouvement de vos pupilles. Cet appareil ne sera pas sur vous et n'a aucun effet ni sur votre santé ni sur votre confort. Durant toute la séance d'IRM, vous tiendrez un bouton alarme dans votre main, c'est-à-dire qu'à n'importe quel moment si vous avez un problème vous pouvez appuyer sur ce bouton d'alarme et nous interrompons l'examen immédiatement et venons vous chercher à l'intérieur du scanner pour voir avec vous ce qui ne va pas. Vous pouvez interrompre une session à tout moment sans explication.

Est-ce que vous avez des questions? Non, alors continuons.

Les risques liés à l'IRM sont les suivants.

l'IRM est un fort champ magnétique, il est donc dangereux de rentrer dans la salle avec des objets à susceptibilité magnétique. C'est pourquoi plus tard nous allons minutieusement vérifier ensemble la liste du questionnaire de sécurité IRM. Toutefois en l'absence d'object à susceptibilité magnétique, l'IRM est complètement sans danger car il n'utilise pas de rayonnement ionisant. Il n'y a pas de danger même si on fait beaucoup de séances.

Sachez que le tunnel est relativement étroit donc on peut se sentir un peu claustrophobique.

Si vous êtes une femme, je dois vous informer qu'avant la première session vous allez devoir faire un test de grossesse. C'est pour vérifier que vous n'êtes pas enceinte, car éthiquement nous n'avons pas le droit de scanner des femmes enceintes car les effets des IRM sur le fœtus n'ont pas encore été étudiés en détail. Avant chaque séance vous devrez également donner des informations sur vos règles comme le dernier jour des règles ainsi que la régularité de vos règles ceci est important car le cycle menstruel a un effet sur le cerveau et pour la fiabilité de notre étude nous avons besoin de savoir ces informations. Toutefois sachez que vous pouvez décider d'exclure les informations sur vos règles quand nous allons publier les données publiquement.

Les séances IRM seront programmées en fonction de la disponibilité des appareils et des préférences et de votre agenda. La durée de participation maximale est de 20 semaines consécutive, c'est-à-dire 5 mois, mais idéalement les sessions seront programmées à un interval régulier Est-ce que vous avez des questions jusqu-là ?

Ok donc maintenant je veux juste vérifier avec vous que vous êtes d'accord avec toutes les exigences concernant la participation à ce projet. Est-ce que vous êtes âgés entre 24 et 55 ans ? Vous n'êtes pas diagnostiquer avec un trouble ou une maladie neurologique ? Vous acceptez d'être informé des découvertes fortuites concernant votre santé? Parce que on a l'obligation éthique d'envoyer les images de la première session à un radiologue qui va vérifier ces images et vous informer s'il découvre quelque chose d'anormal dans votre cerveau. Ensuite un élément très important, c'est que vous devez accepter que vos données soient publier ouvertement, mais bien sûr après que nous ayons appliqué des mesures adéquates de protection de la confidentialité des données. Par exemple, nous allons enlever toute informations qui permettraient de vous reconnaître comme votre nom, votre date de naissance ou la date de l'examen afin de protéger votre confidentialité. Etes-vous d'accord avec ce terme ? Un autre élément important est que la participation à cette

étude implique de nombreuses sessions IRM. Comme je vous ai dit 12 sessions d'environ 1h30. Donc s'il vous plaît, veuillez vous demander si l'engagement pour le projet n'est pas excessif ou pourrait devenir lourd avec le temps et que vous avez amplement le temps pour finir le projet. Vous devez aussi accepter de nous informer si vous prenez des médicaments, si vous consommez de l'alcool ou de la drogue car ces substances ont un effet important sur le cerveau et nous avons besoin de savoir pour pouvoir quantifier ces effets.

Une autre contrainte c'est que vous devez éviter de boire du café 4h avant les séances car le café aussi est connu pour avoir des effets notables sur le cerveau.

Maintenant qu'on a confirmé que vous êtes d'accord avec toutes ces exigences, je vous rappelle que votre participation est entièrement libre et que vous pouvez vous retirer à tout moment sans explication. Toutefois pour nous c'est important que les participants finissent les 12 sessions pour la complétude de nos données et donc pour nous c'est mieux si vous êtes déterminés à finir les 12 sessions et que c'est seulement si il y a quelque chose d'urgent ou d'imprévu que vous interrompez votre participation.

Chaque séance sera rémunéré 45 francs plus les frais de transport.

Des questions ?

OK maintenant nous pouvons regarder ensemble le questionnaire de contrôle de sécurité et vérifier que vous avez répondu non à toutes les questions.

Avez-vous répondu oui à une des questions ? Non ok parfait.

Je veux juste revérifier avec vous que vous n'avez bien pas d'aide auditive.

Vous n'avez pas de bac dentaire, de prothèse dentaire, de fausses dents etc. Vous n'avez pas non plus de piercing de tatouage ou de maquillage permanent ni d'implant capillaire. Vous n'avez jamais été blessé par un objet métallique. Vous n'avez pas subi des opérations dans lesquelles il y aurait des métaux qui restent dans votre corps comme des clips chirurgicaux, des agrafes, des fixations vertébrale, un stimulateur de la moelle épinière, des extendeurs de tissu. Vous ne portez pas de valve cardiaque. Vous portez pas de biostimulateur, de pompe à médicament interne ou externe, de cathétér ou d'articulation artificielle.

C'est parfait, vous êtes éligible à participer.

Encore quelques instructions à suivre avant chaque la séance. Il faut retirer tous les bijoux, piercing compris, et tous les accessoires de cheveux. Veuillez aussi retirer vos prothèses dentaires, les fausses dents etc. Il faut également retirer les aides auditives et les lunettes. Si vous êtes un homme, veuillez s'il vous plaît vous raser la partie supérieure du torse car nous avons besoin de placer les électrodes à même la peau pour bien enregistrer le signal.

Voilà c'est toutes les informations que j'ai à vous partager. Est-ce que vous avez des questions?

En tout cas merci beaucoup pour votre participation! Si vous avez des questions, des doutes, n'hésitez pas à me rappeler à ce numéro et je vous rappelle dans quelques jours afin de fixer la première session.

Bonne journée.

Au revoir.

# Scheduling

- Iteratively draw participants from the recruitment shortlist and call them back to set their first session.

## Stop calling potential participants when the sample size has been achieved

Once the sample size is filled (e.g., 3M/3F for Cohort II), call the remainder of the participants in the shortlist to let them know that they have been moved into the wait list.

- The first session will always happen at MRI 1 (Prisma<sup>Fit</sup>, █)

## Scheduling of the Prisma<sup>Fit</sup> system (█)

### Contact █, MRI Operational Manager, for any doubts/problems regarding this system

- Open the █ scheduling system ([URL \(/redacted.html\)](#)) on a browser.
- With the participant on the phone, find a suitable, empty slot by scrolling the calendar.
- Click on the preferred slot, make sure that selected resource is █
- Select █ in the Operator dropdown menu.
- Select the adequate length for the session (120 minutes)
- Select *Research on healthy subjects* in the Type of Scan box.
- Select *true* in Technician Required if you are not a certified operator of the system.

## Scheduling of the Vida<sup>Fit</sup> system (█)

### Contact █, Technical MRI Coordinator, for any doubts/problems regarding this system

- Open the █ scheduling system ([URL \(/redacted.html\)](#)) on a browser.
- With the participant on the phone, find a suitable, empty slot by scrolling the calendar.

## Clinical scanner hours are very restricted

The study can only be executed on Fridays after 18h00

- Click on the preferred slot, make sure that selected resource is █
- Select █ in the Operator dropdown menu.
- Select the adequate length for the session (60 minutes)
- Select *Research on healthy subjects* in the Type of Scan box.

Select true in Technician Required.

## Scheduling of the Vida system (■■■)

Only ■■■, Technical MRI Coordinator, can book this system.

# Data collection

# Preliminary work

## Once, at the beginning of the project

### Emergency procedures

It is critical you fully understand and study the [emergency procedures to run an MRI scan at CHUV](#).

## Install the gas analyzer (GA)

- Watch the gas analyzer (GA) video:  
<https://mkpdfs.comwes.euhttps://embed-ssl.wistia.com/deliveries/5e08ccab25ab45382329671a82dfe5123f6e840e/file.mp4> Your browser does not support the video. [Click here to download it](#)

## Install the BIOPAC

### BIOPAC documentation

Get familiar with the BIOPAC setup and read through the [hardware documentation \(\[https://www.biopac.com/wp-content/uploads/MP\\\_Hardware\\\_Guide.pdf\]\(https://www.biopac.com/wp-content/uploads/MP\_Hardware\_Guide.pdf\)\)](#)

- Set up the line frequency switches on the back of the BIOPAC amplifier depending on your country frequency to reduce noise. Both switches should be DOWN if your country's line

frequency is 50Hz. Both switches should be UP if your country's line frequency line is 60Hz.

**AcqKnowledge - Set Line Frequency**

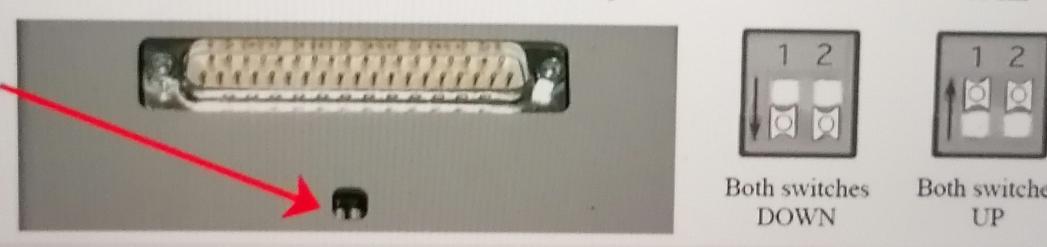
Select your country's line frequency:

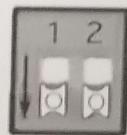
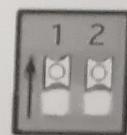
50 Hz (use for most of Europe)  
 60 Hz (use for United States)

Note: Line frequency determines filter settings, which can greatly reduce noise in some data files.

Also remember to set the line frequency switches on your amplifiers to reduce noise:

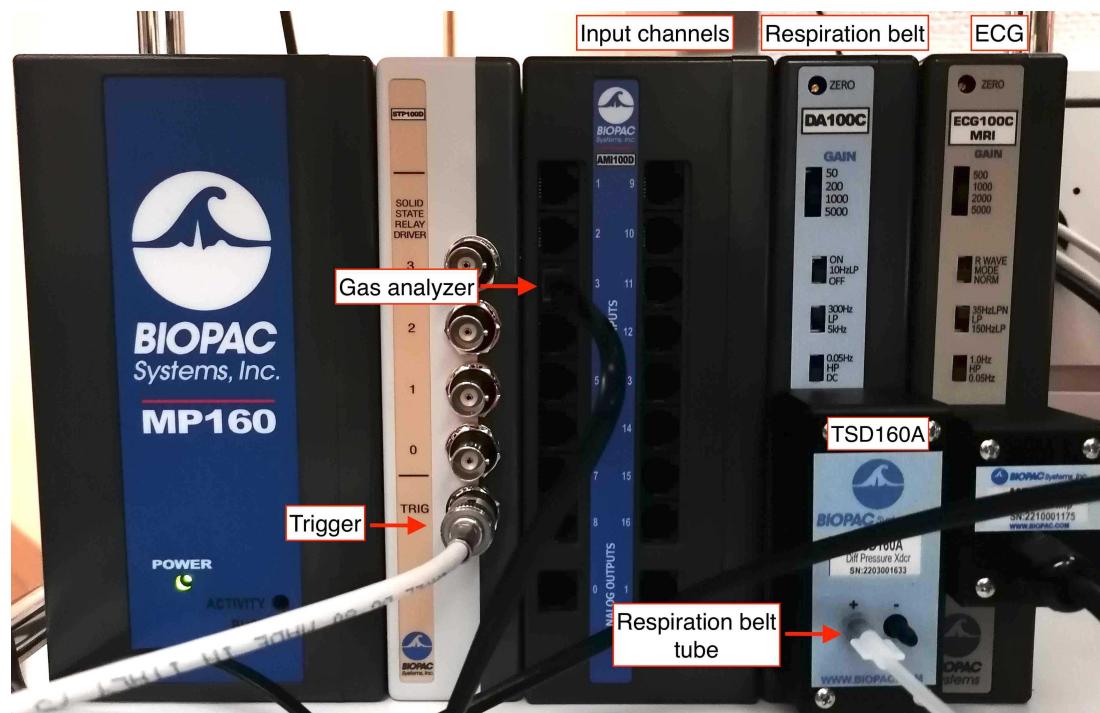
**Line Frequency switch bank is on the back of the amplifier**



<b>50 Hz</b>	<b>60 Hz</b>
	
Both switches DOWN	Both switches UP

**OK**

- Plug the different units of the BIOPAC together if it has not been done yet.
- Get familiar with the BIOPAC system:
  - We use the BIOPAC to synchronize and output in a single file all the physiological recordings: cardiac pulsation, respiration and CO<sub>2</sub> concentration.



- The AMI100C unit can receive up to 16 analog signals.

- The DA100C unit records the signal coming from the respiration belt. Plug the TSD160A unit on the DA100C.
- The ECG100C MRI unit records the electrical signal coming from the heart via the ECG. Plug the MECMRI-2 unit on the ECG100C unit.
- The [SPT100D \(solid state relay driver unit\)](#) is used to input digital signals that must be recorded (e.g., the trigger signals from the scanner)
- Ensure that the *Mode* switch of the [MMBT-S Trigger Interface Box adapter \(pink color box\)](#) is set on the P position.
- Install the BIOPAC recording software (*AcqKnowledge*).
- Create a template *graph file* ([EXP\\_BASE.gtl](#))

#### Creating the *AcqKnowledge*'s template graph file

- Creating a graph file requires the BIOPAC system powered up and connected to the computer.
- Add the RB module
  - Check the channel on top switch of the unit: the [DA100C](#) MUST be set on channel 1.
  - Under the tab *Analog*, click on *Add new module*.
  - Find the name of the BIOPAC unit corresponding to the [DA100C](#).
  - Set the module settings (gain, filters, etc.) corresponding to those of the configuration switches in the front of the module.
  - When prompted to enter the calibration points, map the interval [-5, 0] to [0, 10]. You invert the sign of the interval for the interpretation to be more clear.
- Add the ECG module
  - Check the channel on top switch of the unit: the [ECG100C MRI](#) MUST be set on channel 2.
  - Under the tab *Analog*, click on *Add new module*.
  - Find the name of the BIOPAC unit corresponding to the [ECG100C](#).
  - Set the module settings (gain, filters, etc.) corresponding to those of the configuration switches in the front of the module.
  - When prompted to enter [calibration?], for the ECG you should map the interval ?? to ??.
- Add the GA module
  - Confirm that the CO<sub>2</sub> output of the GA is connected through the ANISO filter to the channel 3 of the AMI100C module.
  - Under the tab *Analog*, click on *Add new module*.
  - Select *Custom* and then indicate it is connected to channel 3 by selecting *AMI/HLT - in3*.
  - When prompted to enter the calibration points, map the interval [0.03, 1.0] to [0, 10.0].
- Add the Digital inputs
  - Under the tab *Digital*, click on *Add new module*.
  - The parallel cable feeds into ports [D8-D15](#).
- Configure the sampling frequency
- Configure the experiment length (at least 2.5 hours)
- Configure whether you want to collect directly to hard disk and autosave settings
- Save the experiment, making sure you choose a "graph template file" (with extension .gtl)

#### Setting up the Connection between the Biopac and the Psychopy Laptop:

##### It's fundamental to have a reliable means of communication with the BIOPAC digital inputs

The following guidelines set up a little service on a linux box that keeps listening for key presses (mainly, the s trigger from the trigger box), and RPC (remote procedure calls) from typically *Psychopy* or similar software.

The service is spun up automatically when you connect the MMBT-S modem interface that communicates with the BIOPAC (that is, the *N-shaped pink box*)

- Copy the [latest version of the code to send triggers \(<https://github.com/TheAxonLab/hcph-sops/blob/mkdocs/code/synchronization/forward-trigger-service.py>\)](https://github.com/TheAxonLab/hcph-sops/blob/mkdocs/code/synchronization/forward-trigger-service.py)
- To automatically start the program when the BIOPAC is connected, create a udev rule as follows:

```
sudo nano /etc/udev/rules.d/99-forward-trigger.rules
```

- Add the following rule to the file:

```
ACTION=="add", KERNEL=="ttyACM0", SUBSYSTEM=="tty", TAG+="systemd"
```

- Save the file and exit the editor.
- Run the following command to reload the udev rules:

```
sudo udevadm control --reload-rules
```

- Create a systemd service unit file:

```
sudo nano /etc/systemd/system/forward-trigger.service
```

- Add the following content to the file (Adapt the path to forward-trigger.py to the location on your computer):

```
[Unit]
Description=Forward Trigger Service
After=network.target

[Service]
ExecStart=/usr/bin/python3 /path/to/forward-trigger.py
WorkingDirectory=/path/to/forward-trigger/directory
StandardOutput=null

[Install]
WantedBy=multi-user.target
```

- Save the file and exit the text editor.
- Run the following command to enable the service to start at boot:

```
sudo systemctl enable forward-trigger
```

- Run the following command to reload the systemd daemon:

```
sudo systemctl daemon-reload
```

### Verifying Trigger Transfer Without BIOPAC Connection:

- Ensure socat and screen are installed (if not already):

```
sudo apt-get update  
sudo apt-get install socat screen
```

- Create a virtual serial port and establish a symbolic link to /dev/ttyACM0 using the following command:

```
sudo socat PTY,link=/tmp/virtual_serial_port PTY,link=/dev/tty/
```

- With screen, listen to the new virtual serial port:

```
screen /dev/ttyACM0
```

- Press s and verify that ^A appears in the screen terminal.

### Stimuli presentation: *psychopy*

- Prepare a laptop with a running Psychopy 3 installation AND the EyeTracker software. For these SOPs, the designated laptop for the experiments is █.
- Fork the HCPh-fMRI-tasks repository (<https://github.com/TheAxonLab/HCPh-fMRI-tasks/fork>) under your user on GitHub.
- Clone the HCPh-fMRI-tasks repository (<https://github.com/TheAxonLab/HCPh-fMRI-tasks>):

```
git clone git@github.com:<your-gh-username>/HCPh-fMRI-tasks.git
```

- Set-up the original repository as upstream remote:

```
git remote add upstream git@github.com:theaxonlab/HCPh-fMRI-tas
```

- Log on █ with the username █ and password █.

- Clone the [Psychopy repository](https://github.com/psychopy/psychopy.git) (<https://github.com/psychopy/psychopy.git>):

```
git clone git@github.com:psychopy/psychopy.git
```

- Navigate to the Psychopy directory:

```
cd psychopy
```

- Psychopy should not be installed with anaconda. If an anaconda environment is activated, run the following command to deactivate it:

```
conda deactivate
```

- Update pip to the latest version:

```
pip3 install --upgrade pip
```

- Install bdist\_mpkg, py2app and attrdict:

```
pip3 attrdict py2app bdist_mpkg
```

- Install Psychopy using the following command:

```
pip3 install -e .
```

- Open Psychopy, open the experiment-files corresponding to each task:

- task-rest\_bold.psyexp (resting-state fMRI):
  - time it to confirm the length, and
  - check that the movie is played.
- task-bht\_bold.psyexp (breath-holding task, BHT):
  - time it to confirm the length, and
  - check that the movie is played.
- task-pct\_bold.psyexp (positive-control task, PCT) :
  - time it to confirm the length, and
  - check that the movie is played.

Remember to time the three functional MRI runs (rest, qct, bht)

The lengths of the three runs should be:

- task-rest\_bold.psyexp → 20min 0s,
- task-bht\_bold.psyexp → 5min 41s, and
- task-pct\_bold.psyexp → 2min 38s.

## Eye-tracker: *EyeLink Software* installation

- Log on [REDACTED] with the username [REDACTED] and password [REDACTED].
- Enable Canonical's universe repository with the following command:

```
sudo add-apt-repository universe  
sudo apt update
```

- Install and update the ca-certificates package:

```
sudo apt update  
sudo apt install ca-certificates
```

- Add the SR Research Software Repository signing key:

```
sudo apt-key adv --fetch-keys https://apt.sr-research.com/SRRes
```

- Install the EyeLink Developers Kit:

```
sudo apt install eyelink-display-software
```

- Install the EyeLink Data Viewer:

```
sudo apt install eyelink-dataviewer
```

## Setting up the scanner protocol at the MR console

### Important: follow Reproin conventions

When assigning names to the MR sequences in the protocol, make sure to follow the [Reproin conventions](https://dbic-handbook.readthedocs.io/en/latest/mri/reproin.html) (<https://dbic-handbook.readthedocs.io/en/latest/mri/reproin.html>) to maximally facilitate the conversion into BIDS.

Once the protocol is decided upon, and after any updates, make sure of storing the protocol.

### Login as an advanced user to save protocol

As a good practice, always work as the standard user janedoe. Change for *advanced user mode* if you want to save the protocol.

- Simultaneously press the Tab + Delete + [→ on the control-computer's keyboard:

Username: superjanedoe

Password: \*\*\*\*\*

**After three wrong password entries, access will be denied, and only a Siemens engineer will be able to unlock the MR scanner.**

- Update the *Number of measurements* in all *func-bold\_task-\** sequences, according to the [previously recorded timings](#):

$$[N_{\text{measurements}}] = L_t / \text{TR}, \quad \text{where } L_t \text{ is the length of a particular task } t \text{ in } \{\text{BHT}, \text{PCT}\}, \text{ and } \text{TR} \text{ is the repetition time of the BOLD sequence, in seconds.}$$

where  $L_t$  is the length of a particular task  $t$  (either BHT, PCT, or resting state) in seconds as timed before, and  $\text{TR}$  is the repetition time of the BOLD sequence, in seconds.

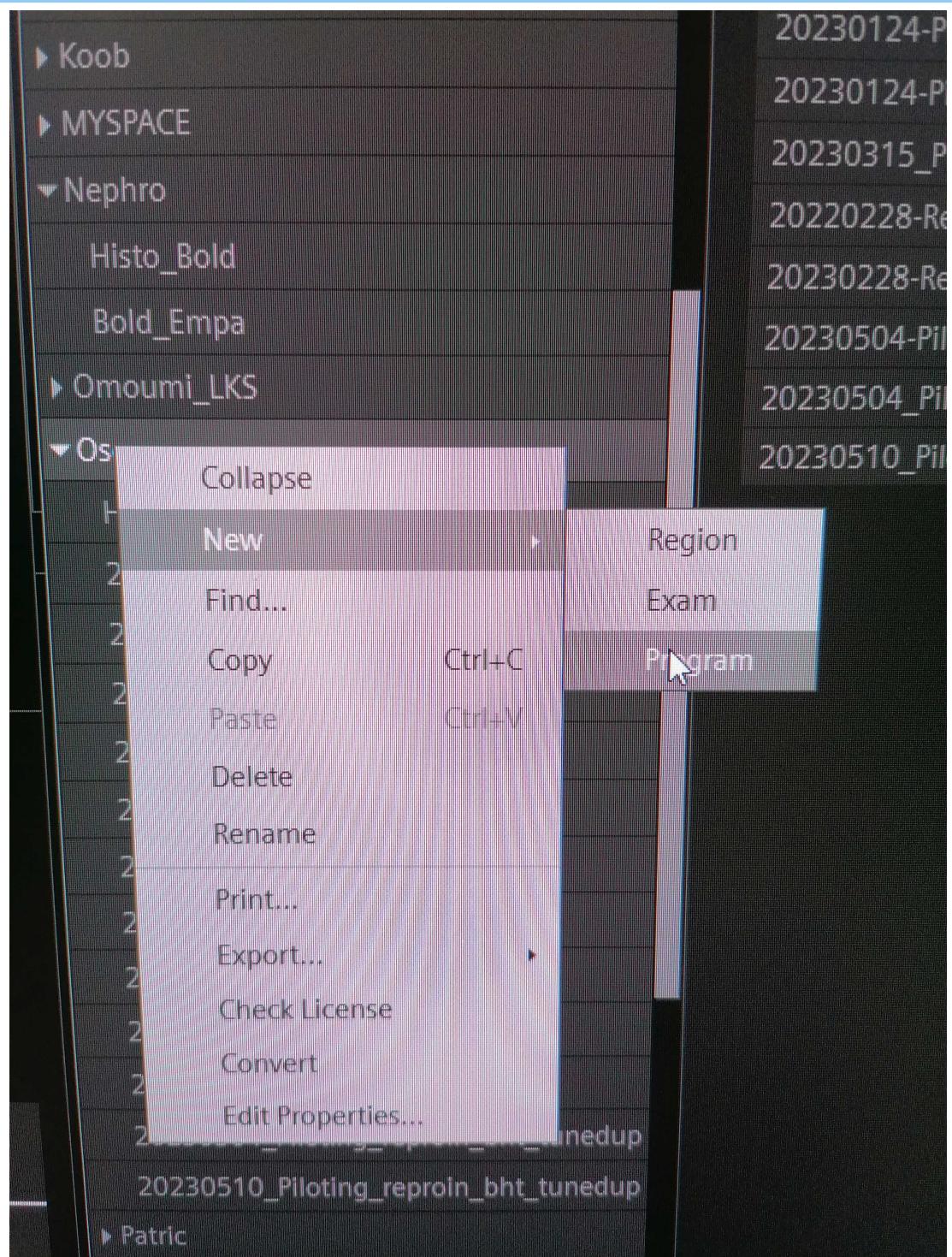
- Now that you are logged in as an advanced user, save your protocol:

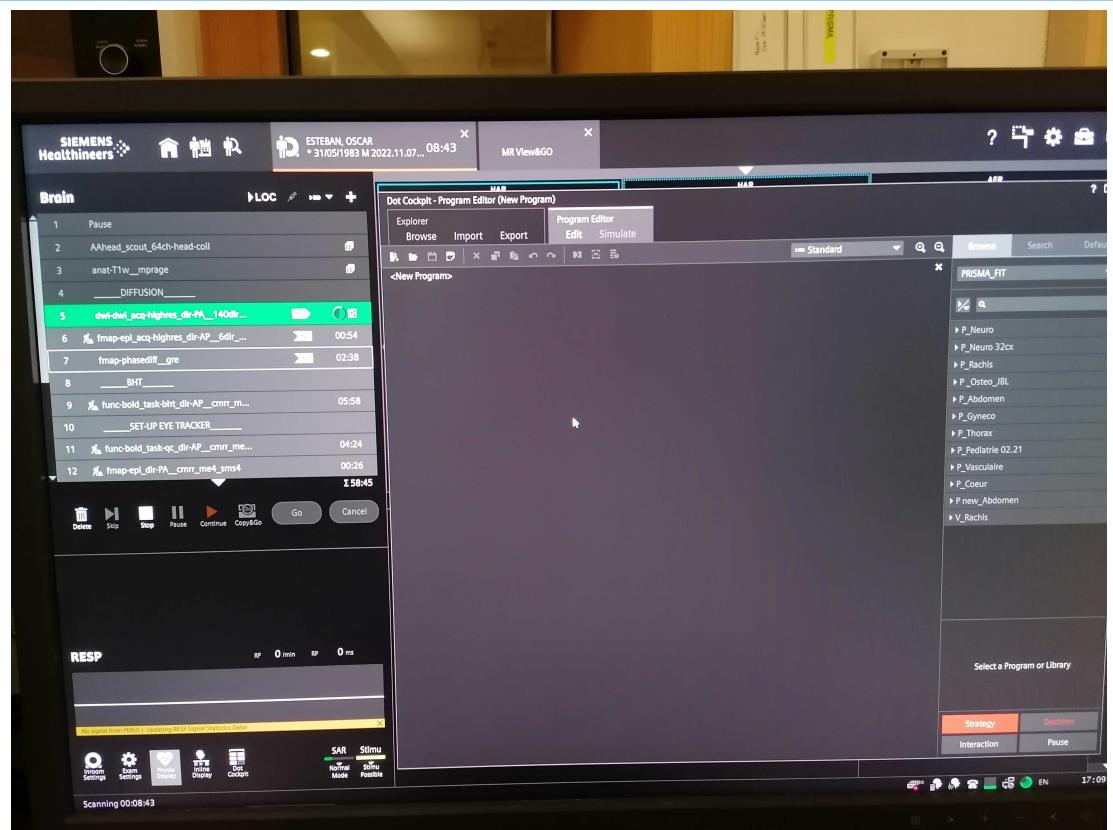
- Open the Dot-Cockpit window



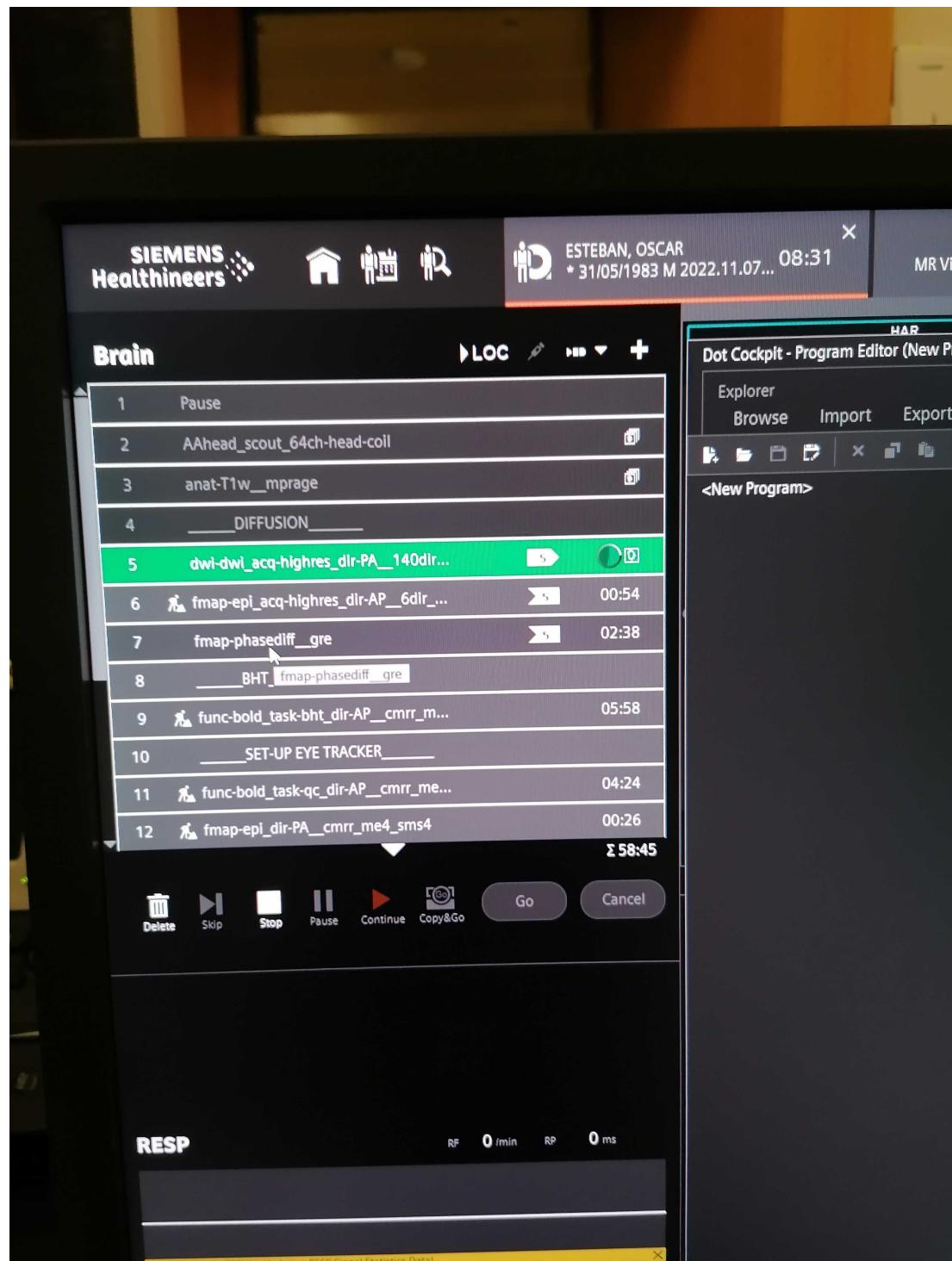
- In Browse, find the right folder to save the protocol in (*RESEARCH ↳ Oscar*).

- Right click on the folder and select *New ↗ Program*. This opens an empty page in the program editor

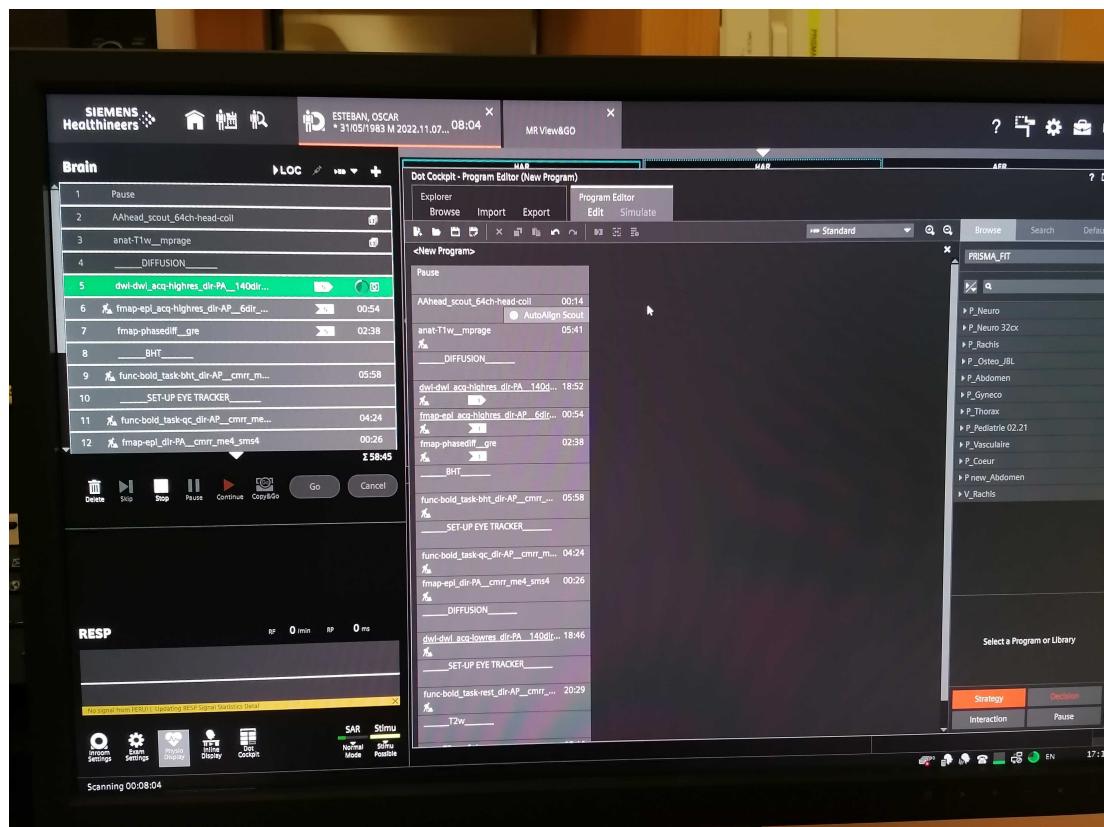




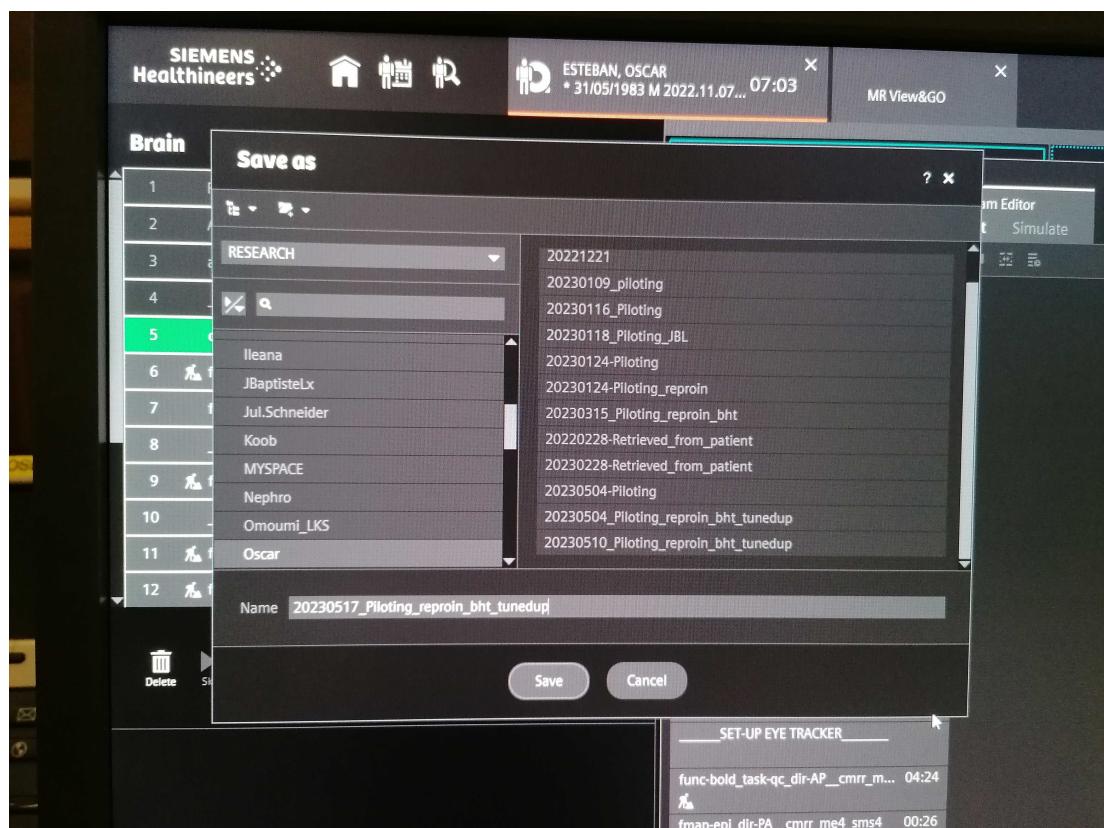
- Select all the sequences you want to run from the sequence list and click right to copy.



- Drag or paste the copied sequences in the program editor.



- Once finished, click on the floppy disk icon () in the upper left to save.  
 Give the protocol a relevant name starting with the date of acquisition in the format YYYYMMDD and click Save.



- If desired, the protocol details can also be downloaded as a pdf on a peripheral USB key.
  - Right-click on the protocol and select *Print*
  - Save the PDF in your USB key.
- Make sure you save a different protocol for each of the four PE directions (i.e., AP, PA, LR, RL).

## Every two months

### Calibrate the GA

- Get a gas bottle with a known CO<sub>2</sub> concentration between 5% and 10%.
- Connect the GA to the BIOPAC as described below and start recording signal.
- In the *AcqKnoledge* software, edit the configuration of the inputs, making sure you update the voltage range for input 3 (the GA), estimated as described in [the GA's manual](#)
- Update the template *graph file* ([EXP\\_BASE.gtl](#)) with the calibrated input.

## Three days BEFORE THE FIRST SESSION

- Verify that as part of the [recruitment and screening procedure](#), you have sent a copy of the MRI Safety and screening form ([EN|FR](#)) to the participant over email and confirm reception by checking the 'First contact email sent' column in [our recruits spreadsheet \(/redacted.html\)](#).
- Verify also that you confirmed that the participant has read and understood the document, and in particular, you double-checked that they do not have any MRI contraindications, by checking the 'Phone interview done' and 'Participant volunteer and eligible' column in [our recruits spreadsheet \(/redacted.html\)](#).
- If the phone call interview was more than three days before the first session, call the participant again to reconfirm the following information:
  - Remind the participant that any jewelry should be removed prior to the scan.
  - Indicate that they MUST shave the upper area of their chest where the ECG electrodes will be placed, if there is hair. The ECG electrodes MUST directly contact the skin.
  - Confirm clothing:
    - if allowed to wear street clothes, remind the participant to avoid clothing with metal or that would uncomfortable to lie in for the duration of the scan; otherwise
    - remark the participant they will be given a gown and they will need to change before every session.
  - Repeat at what time and where will you meet the participant.
  - Verify that the participant has your phone number [REDACTED] to call you in case he gets lost.

- FEMALE PARTICIPANTS ONLY: Remind the participant that pregnant women cannot undergo our MRI protocols. Therefore, they will take a pregnancy test (which we will have prepared) before the first session.
- If participant has indicated nervousness or history of claustrophobia, organize a session to use the mock scanner.

## BEFORE DAY OF SCAN

- Print [the informed consent form](#) (first session only), an MRI safety screener ([EN|FR](#)) and a receipt form for each participant that will get scanned.
- Make sure you have internet access, and update the [HCPH-fMRI-tasks repository](https://github.com/TheAxonLab/HCPH-fMRI-tasks) (<https://github.com/TheAxonLab/HCPH-fMRI-tasks>) on [REDACTED]:

```
git fetch upstream
git checkout main
git rebase upstream/main
```

- On the [REDACTED] laptop, open a terminal and execute `conda deactivate`.
- Open psychopy 3 by typing `psychopy`
- Load in the different experiments and check for proper functioning:
  - `task-rest_bold.psyexp` (resting-state fMRI):
    - time it to [confirm the length](#), and
    - check that the movie is played.
  - `task-bht_bold.psyexp` (breath-holding task, BHT):
    - time it to [confirm the length](#), and
    - check that the movie is played.
  - `task-pct_bold.psyexp` (positive-control task, PCT):
    - time it to [confirm the length](#), and
    - check that the movie is played.

# Before each session

## Thanks

All the documentation about the eye-tracker is derived from Benedetta Franceschiello's user guide. We greatly appreciate her help with the eye-tracker.

Instructions of operations to be performed before the participant arrival, before EACH session (i.e., DAY OF SCAN)

## Documentation and other non-experimental devices

- Prepare [the informed consent form](#) (first session only)
- Prepare an MRI safety screener ([EN|FR](#))
- Prepare a pen and a receipt form that the participant will sign when they are given the compensation
- Check you have the AcqKnowledge software USB license key
- Prepare a pregnancy test (Only female participants on their first session)
- Prepare a thermometer
- Prepare a blood pressure meter
- Prepare scrubs and MR-compatible glasses if applicable
- Prepare a pack of sterile cotton gauze, a bottle of medical alcohol, the *Nuprep* skin preparation gel (white/blue tubes), and three new electrodes.



- Verify that your phone is on ringing mode so the participants can reach you
- Check the time regularly to be on time to meet with the participant at the predefined location

Boot the scanner up if it is shut down

Please wait for all systems to finalize their boot-up (about 10 minutes), even if only the satellite station is to be used.



- Turn the key of the System ON/OFF Station Box into the *open lock* position (🔒)
- Push the blue button with the sun symbol (⌚) and the SYSTEM ON label underneath, which is found right above the key

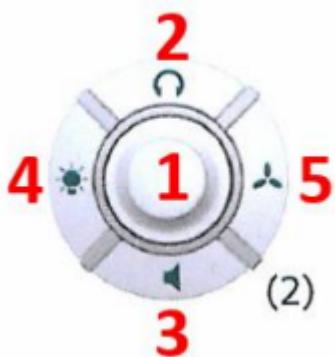
## Basic preparations in the scanning room

- If any head coil from the last exam is still plugged, remove it:
  - If it is the 64-channel coil, you can just temporarily move it into the scanner's bore.
  - Otherwise, store it on the shelf where the other coils are and bring the 64-channel one in the proximity of the bed (e.g., inside the scanner's bore). Make sure to remove other coil's fitting element.
- Remove the spine coil by lifting the corresponding latch, then sliding it toward the head of the bed, lift it from the bed, and place it on the floor ensuring it is not obstructing any passage or unstable.
- Place the two back padding elements filling the spine coil socket.
- Cover the MRI bed with a sheet.
- Connect the 64-channel head-and-neck coil to the head end of the bed.
- After positioning the participant, connect the anterior part of the coil using the terminal cable.
- Check that both the posterior and anterior parts of the head-and-neck coil are now detected by the scanner. To do so, ensure their names ("Head Neck 64 Posterior", and "Head Neck 64 Anterior", respectively) appear on the scanner's monitor screen.
- Remove the light inside the scanner bore (button 4) and the ventilation (button 5) for a better performance of the ET.

- Use buttons 2 and 3 to adjust the volume of the speaker in the scanner room, and of the earphones, respectively.

The central knob (button 1) will turn off the alarm if necessary

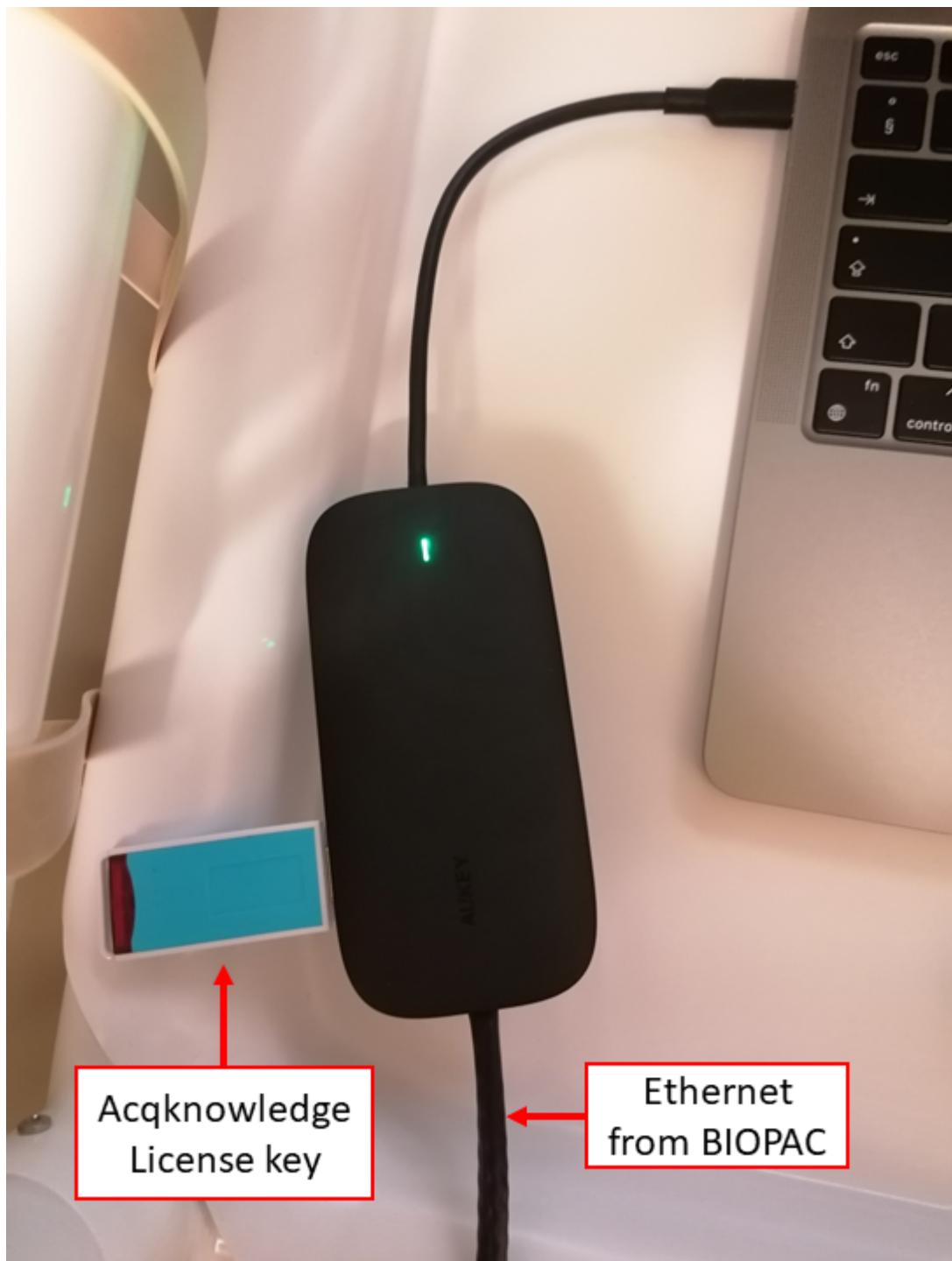
- Press the respective button and rotate the central knob to adjust the corresponding settings to the desired level.



## Setting up the BIOPAC system and physiological recording sensors

- Ensure you have the *AcqKnowledge* software USB license key. Plug the USB key to the multiport adapter for Mac and plug that adapter to the computer █ as shown in the picture below. It needs to stay plugged at all times during the acquisition.
- Open the *AcqKnowledge* software
- Initiate an *Amphetamine* session to avoid the computer to go to sleep/lock the screen:
  - Click on the pill icon on the Mac's status bar
  - Select *New session* ↴ *While is running* ↴ *Acqknowledge*.
- Plug the power cord of the BIOPAC and of the GA into suitable power sockets.
- Plug in the Ethernet (the plug is on the back side of the BIOPAC) to the multiport adapter connected to the computer █.





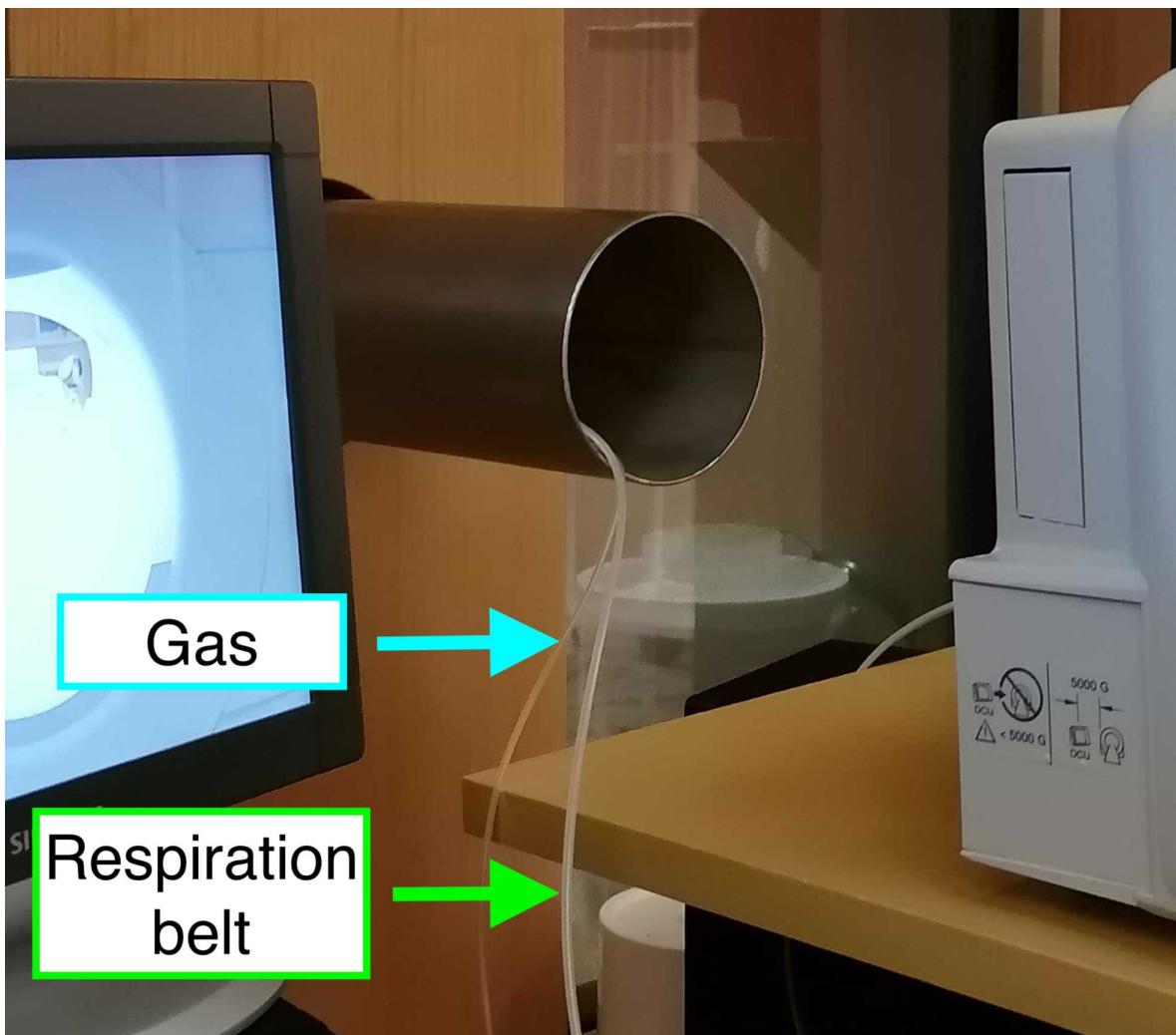
- Connect the parallel cable to the 25-pin socket at the back of the SPT100D of the BIOPAC and to the parallel port of the MMBT-S Trigger Interface Box adapter (N-shaped pink box).





- Plug the power cords of the BIOPAC and the GA into suitable power sockets.
- Go inside the scanning room, unscrew the wood cap that covers the hole in front of the MR.
- Check that the extension tube for the nasal cannula does not contain any bubbles.

- Delicately pass the extension tube that will be connected to the nasal cannula and the extension tube from the respiration-belt (RB) through the front access tube.



- Connect the distal end of the extension tube to the cannula and leave the cannula ready on the bed ready for the participant. To connect the extension tube to the cannula, you need to insert with force the end into the cannula.

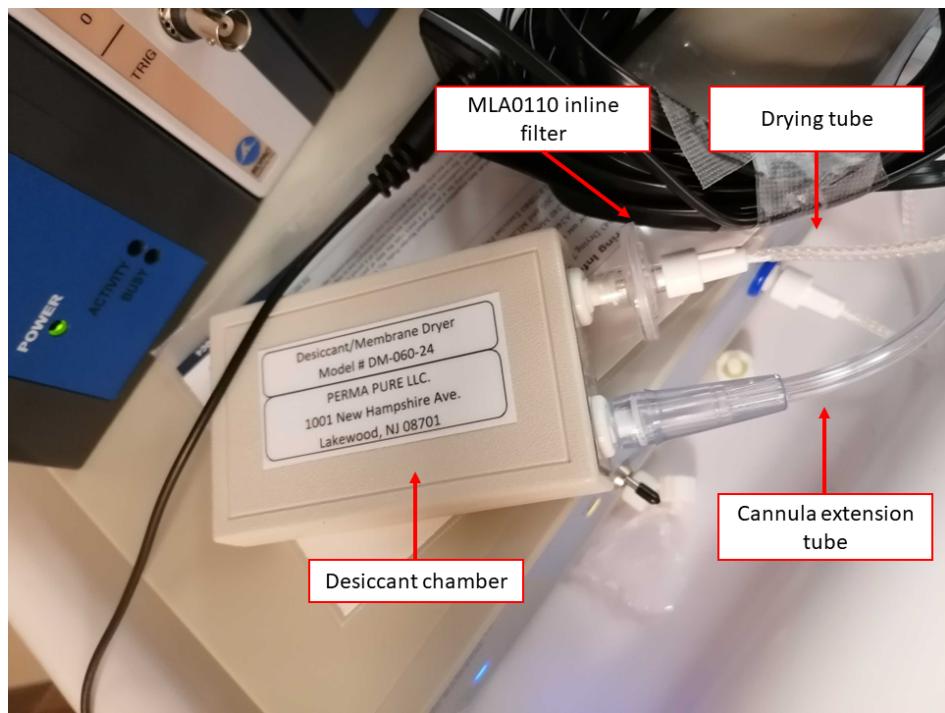
**Ensure that the length of the tubing inside the MR room is sufficient so that it can lie on the floor.**

When the tubing is hanging, pressure waves may alter the recorded gas concentration.

- Connect the distal end of the RB tube to the RB and leave it on the bed.

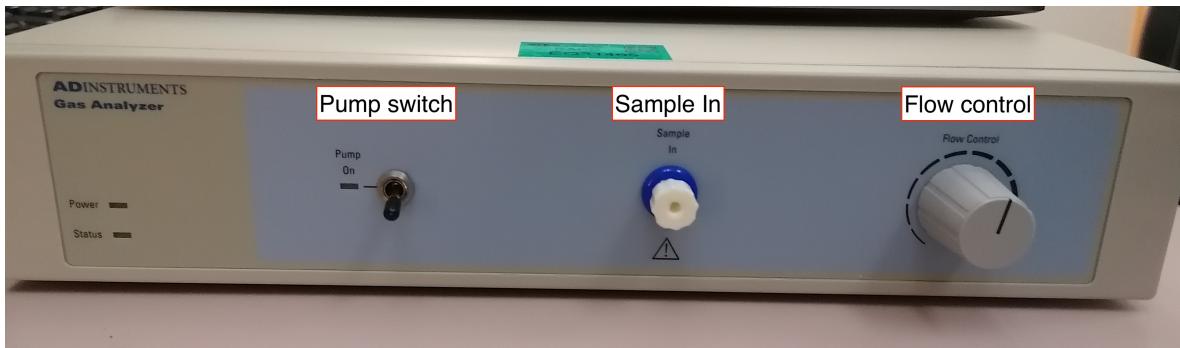


- Go back to the control room and connect the proximal end of the cannula extension tube to one plug of the desiccant chamber (which one is not important). Connect the MLA0110 inline filter to the other plug of the desiccant chamber. Connect the MLA0343 drying tube to the MLA0110 inline filter.

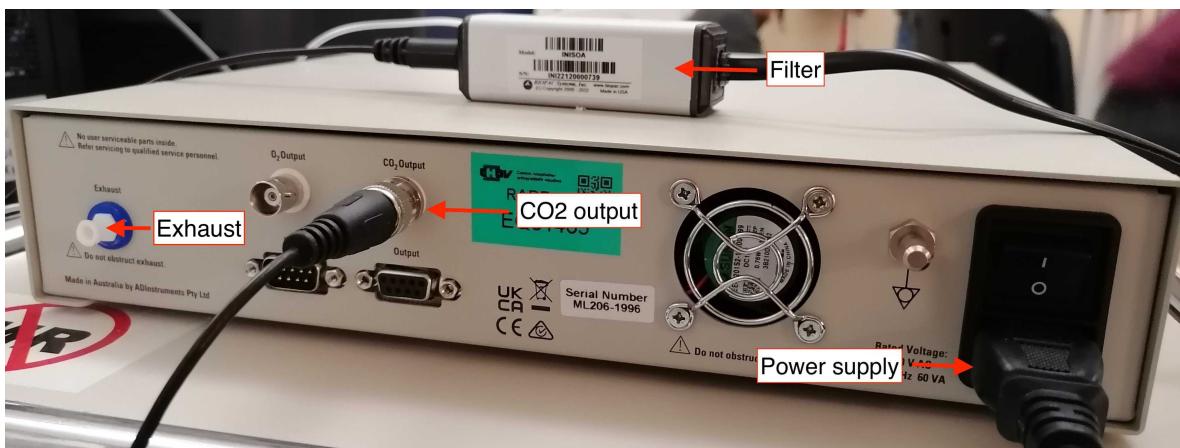


If the color of the drying tube changes, it should be replaced.

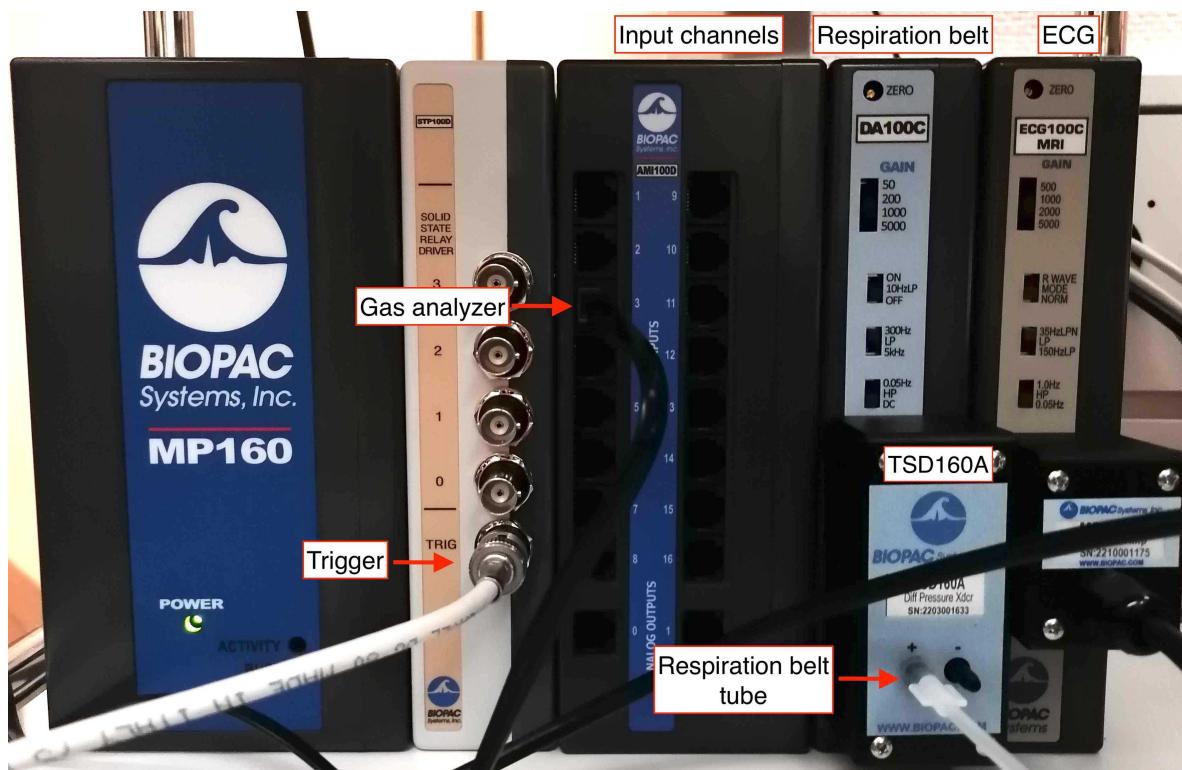
- Remove the cap of the gas input (Sample In, front panel of the GA) and connect the MLA0110 inline filter to it. The inline filter MUST be replaced after some ten sessions.



- Connect the coaxial end of the BNC-BNC cable to the CO<sub>2</sub> output in the back of the GA and connect the other end (jack plug) into the input end of the INISO/A filter.



- Connect one end (RJ-11 to RJ-11) to the output of the INISO/A filter, and the other into channel 3 of the AMI100D BIOPAC module.



- Check that the RB (DA100C) and ECG (ECG100C MRI) channels are set to channel 1 and channel 2.



**Important**

- Check that the exhaust pipe (back of the GA) is free of obstruction. An obstructed exhaust can damage the device!



- Check that the cap on Sample In is removed and that the MLA0110 inline filter is connected to it. The pump switch MUST BE OFF when the cap is on and when switching on the GA. Turn the GA on using the on/off switch located at the front of the GA. The GA MUST be ON for 20-30 min to warm-up before measuring.



- Check that the flow control wheel (front of the GA) is set to the maximum.
- Connect the proximal end of the RB tube to the TSD160A BIOPAC unit, using the plug marked negative (- symbol).
- Connect the cable from the RJ-45 output of the syncbox to the first filter (BNC connector; has a label "External signal") in the cupboard covering the access panel to the Faraday cage. The cable might be stored in the lower left cupboard of office █. Make sure you will have access to the cable with sufficient time ahead. [INSERT PICTURE]

- Connect the syncbox to the Biopac via the white trigger cable. [TOCHECK]

## Setting up the eye-tracker

- The eye-tracker (ET) computer is kept on its designated rolling table, which is stored under the projector in room █. Behind the rolling table, there is a transparent panel (the *plexiglas* in the following) where the ET camera will stand inside the scanner bore.
- Verify that the monitor and the cable, as well as the ET over the PC tower are fixed to the rolling table with scotch tape.
- Bring the table with the ET computer to the control room, and place it next to the access closet. Be very attentive during the displacement and lift the front wheels when passing steps or cables. The plexiglas panel can also be brought to the scanning room simultaneously, if done with care.
- From room █ (first cabinet on the left), take the blue box labeled *Eye-Tracker only for fMRI*, containing the ET camera, lenses, and the special infrared mirror.
- Take the MR-compatible lens out of the lenses box. It is easy to recognize it as it is the only one with two golden screws.



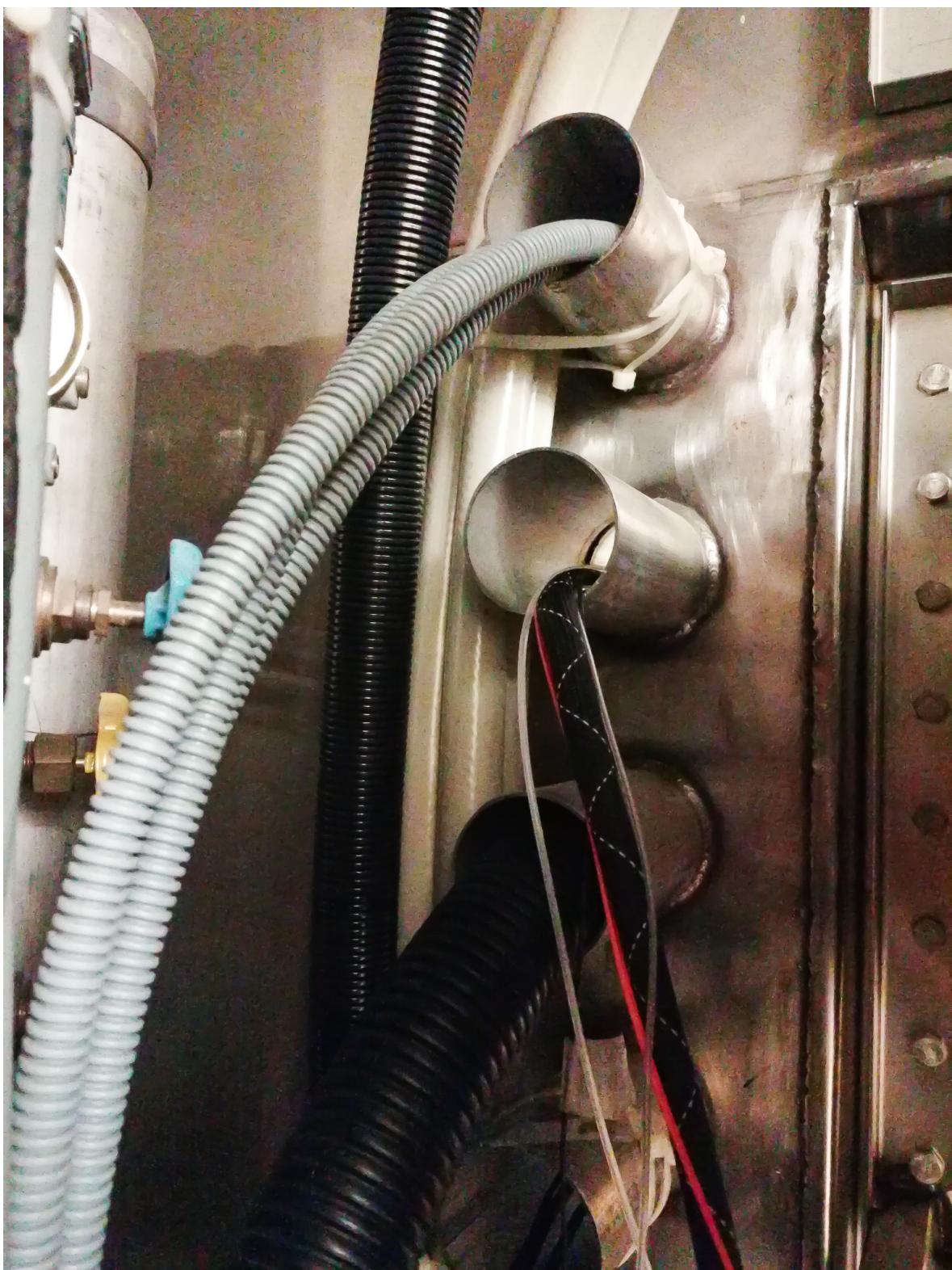
- Install the MR-compatible lens, after removing any other present lens. If other lens is present, put it back to its plastic bag inside the lenses box after unscrewing and removal. To avoid accidentally dropping a lens, one hand MUST be under the lens at all times while screwing/unscrewing it. The lens MUST BE INSTALLED before bringing the ET inside the Scanner Room.



## INSIDE the scanner room

- Place the plexiglas standing panel inside the scanner bore, following the indications stuck on the panel (a sign notes the top side that faces up, and two tape markers designate the position of the ET). The plastic feet must face down to avoid the panel to slide. To ensure the repeatable positioning of the ET, place the end of the plexiglas such that its edge coincide with the edge of the illuminated MRI rails.
- Bring the ET inside the scanner room, and put it on top of the plexiglas panel. The two posterior feet of the ET stand have to be within the two corner signs made of scotch tape.  
**HOLD THE ET STAND STRONGLY, BECAUSE THE MAGNETIC FIELD GENERATES RESISTANCES.**
- Open the door of the cable section between the recording room and the scanner room.
- First, pass the optic fiber (orange wire) and the power cable (the one with a fabric sheet) through the access point. This operation requires two people, one handling the cables from outside the scanner, and the other gently pulling them from inside. Both people will lift the cable to avoid its abrasion with the edges of the metallic cylinder, which is the passage between exterior and interior of the scanner room. Once the sliding of the cable is finished, leave the extremities inside the scanner room in the left-top corner, far from the scanner.

These parts are magnetic.



- Connect the cables (two plugs for the black, one plug for the orange).



- Take the half-circle one-direction screen from the table behind the scanner and put it on the back of the scanner, behind the ET system (don't push the plexiglas yet)



- Place the infrared mirror:

- Detach the mirror frame from the head coil, if it is placed there. Remove unnecessary items from the scanning bed, and prepare the mirror to attach the infrared mirror of the ET at a later step.
- Prepare two long strips of scotch tape and leave them in a convenient place to attach the ET mirror later. E.g., attach the corner of each strip to the back part of the mirror frame.
- Go back to the control room and take the infrared mirror out of the «fMRI usage» box. **DO NOT EXTRACT THE MIRROR OUT FROM ITS BOX YET**. The mirror's box is labeled as *RELIQUIA DI SAN GENNARO* ([https://it.wikipedia.org/wiki/San\\_Gennaro#La\\_reliquia](https://it.wikipedia.org/wiki/San_Gennaro#La_reliquia)) to emphasize that THIS IS THE MOST DELICATE PART, BECAUSE THE MIRROR CANNOT BE REPLACED **NOR CLEANED**. This mirror is EXTREMELY EXPENSIVE.



- Get two gloves (e.g., from the box hanging at the entrance of the scanner room), then approach the scanner bed. Put the gloves on, and DON'T TOUCH ANYTHING. You MUST have the standard mirror dismounted and in front of you at this point. WITH THE GLOVES proceed to extract the infra-red mirror from its box, being extremely careful. YOU CAN ONLY TOUCH THE MIRROR WITH GLOVES, because it cannot be cleaned up. Watch out for FINGERPRINTS and once taken out of its box, IMMEDIATELY PROCEED TO ATTACH IT to the standard coil mirror. The mirror MUST NOT be placed anywhere else if not in its box.
- WITH YOUR GLOVES ON, attach the ET mirror to the standard coil mirror (the larger mirror that points toward projector's screen at the back of the scanning room) using the scotch tape strips you prepared before. Put it more or less in the center, although **this position may need to be adjusted** (being careful and with the same precautions explained before). Do not touch the surface of the ET mirror.



**The infrared mirror MUST be airtight attached**

It is critical that there is no air gap between the infrared mirror and the standard mirror. Also, make sure the scotch tape is firmly glued to the standard mirror because the infrared mirror will be hanging when placed on the coil and may loosen up creating a gap with the standard mirror.

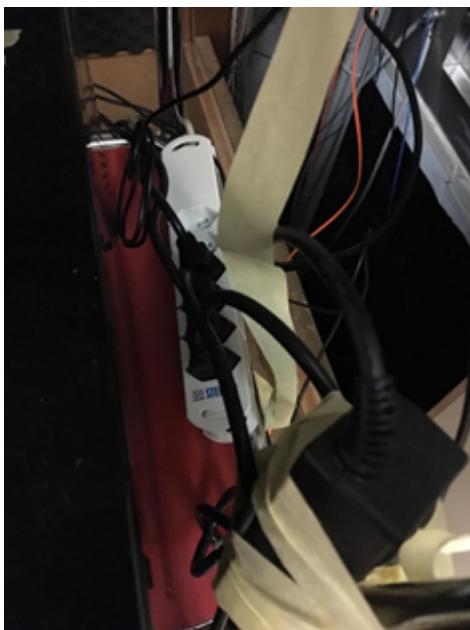
**Suggestion**

Since we are going to track the right eye only, it is useful to displace the infrared mirror to the right from the participant's standpoint and cut the scotch tape narrower to occlude less surface of the mirrors on the right side.

- Place the mirror frame back on the head coil. As always, DO NOT TOUCH THE MIRROR.

## Back OUTSIDE THE SCANNER ROOM (control room)

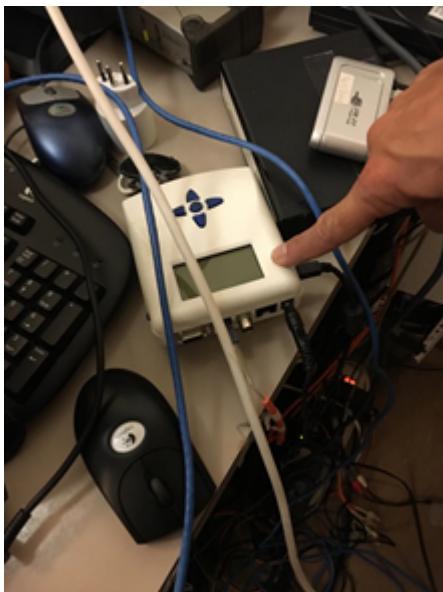
- Plug in the Power strip containing the ET Power Cable, the PC-tower power, etc



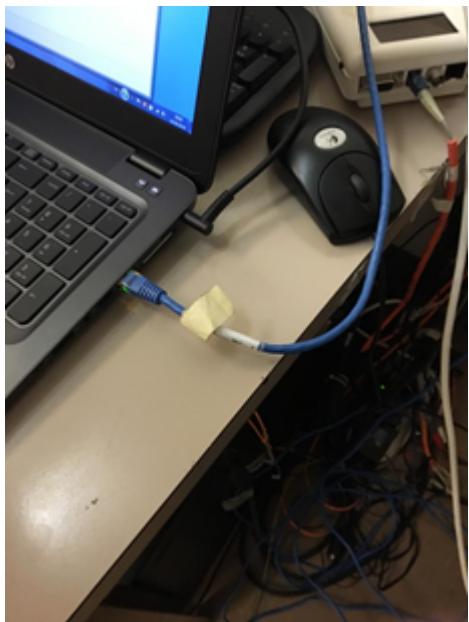
- Switch on the ET PC-tower. Select "Eyelink" when given the option of which operating system to launch.



- This is the sync box of the scanner, allowing a synchronization of the triggers between the scanner sequence and the ET recordings.



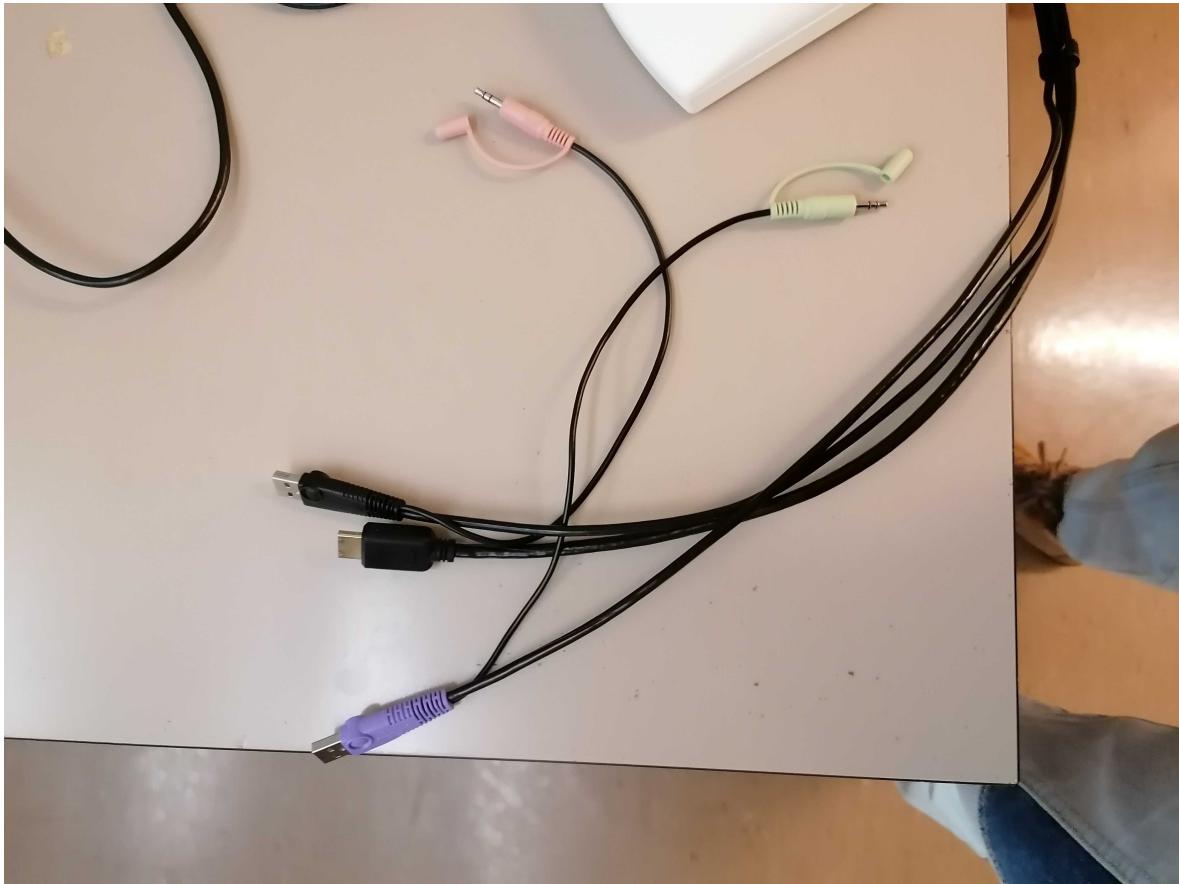
- Switch on █ and login with the username █ and password █.
- Connect to the ET to the █ laptop with the ethernet cable (blue color).



- Connect the sync box to the laptop with the USB cable. It is normally plugged into the [REDACTED], it must be re-plugged in after usage.



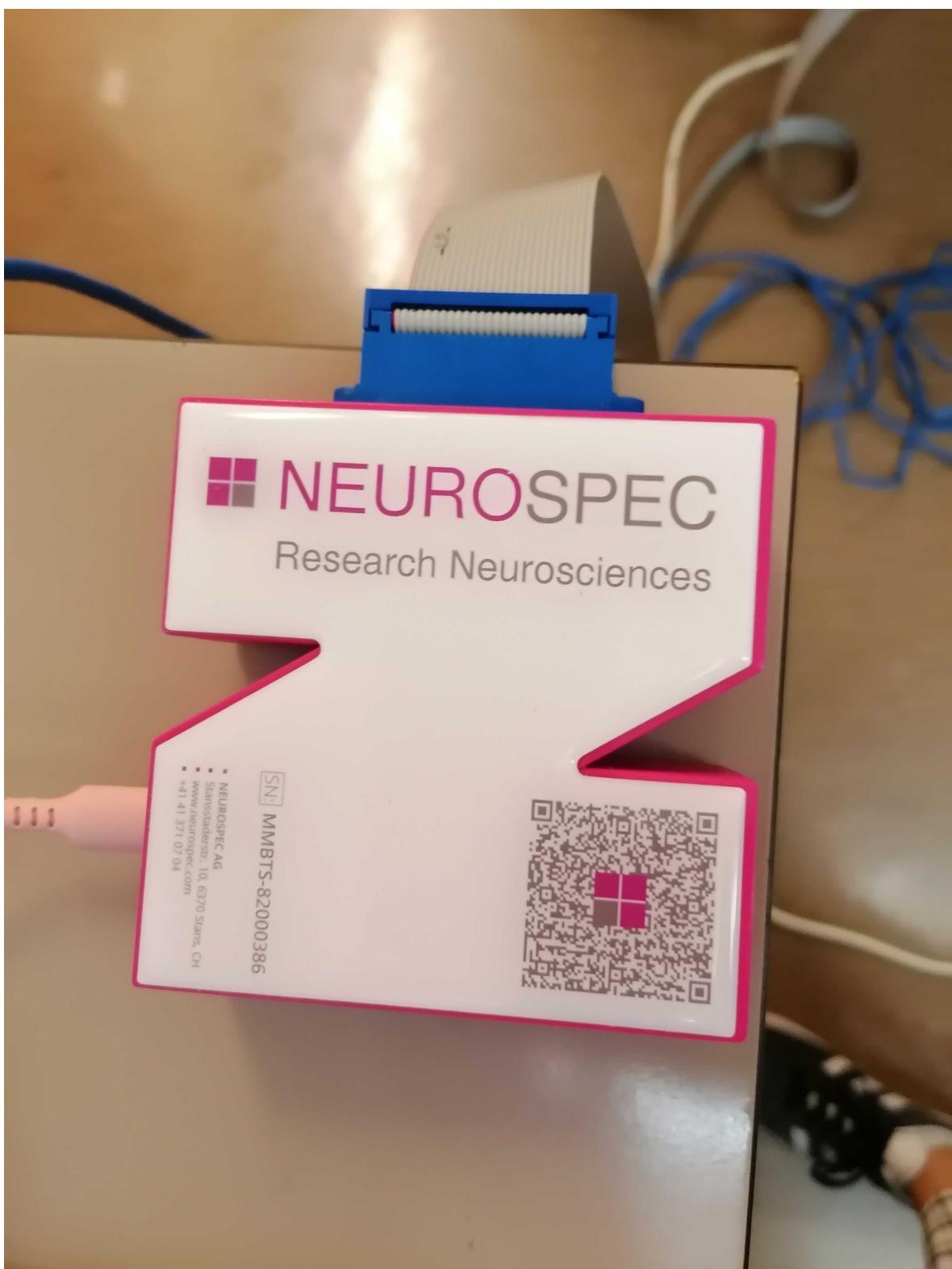
- Connect the [REDACTED] laptop to the screen switch box (see picture below) with the corresponding HDMI cable. This should project your screen on the screen of CHUV's tower [REDACTED].



If the monitor does not automatically switch the source of the screen, you can use the button below to switch it.

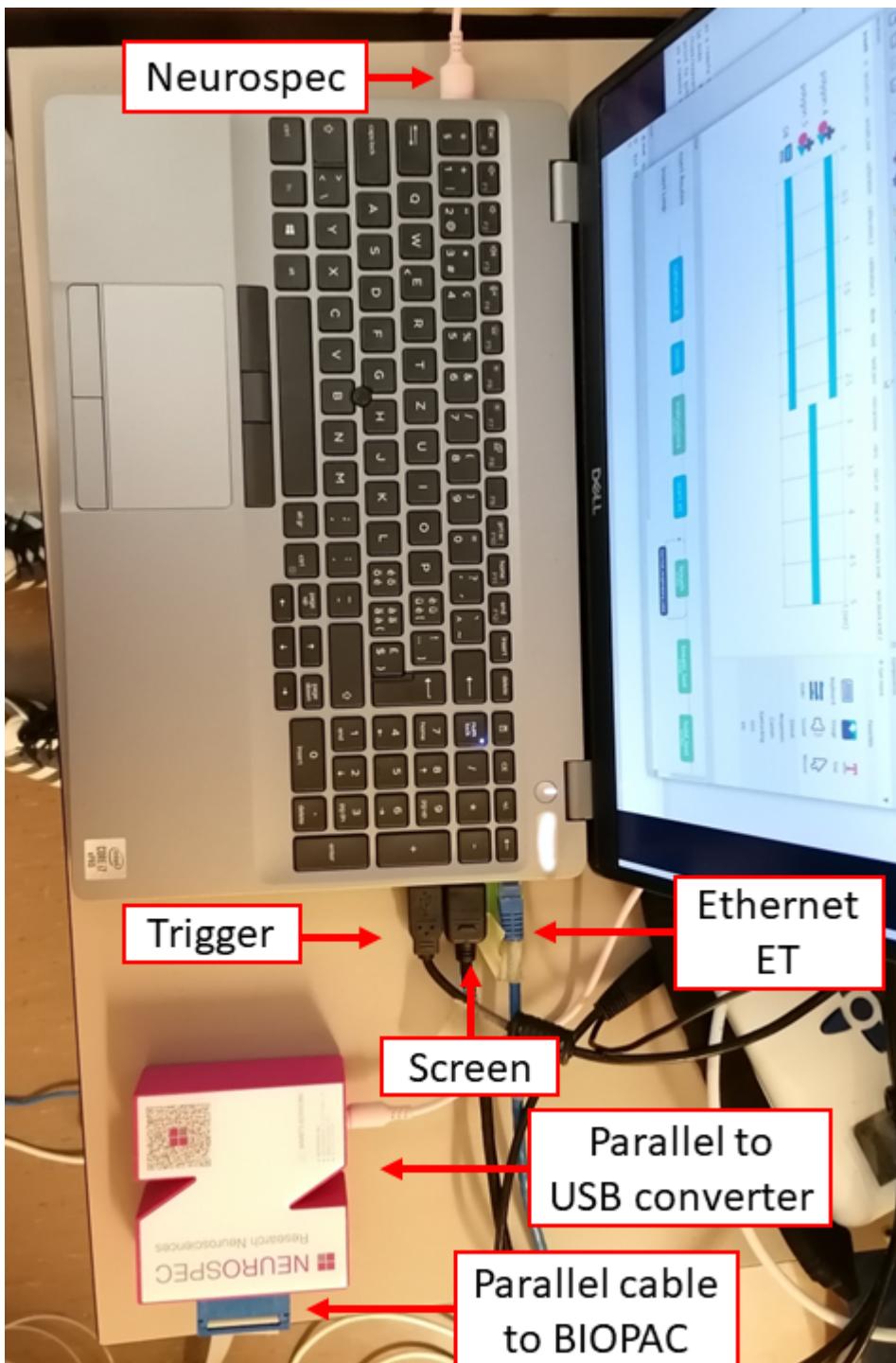


- Connect the MMBT-S Trigger Interface Box adapter (pink USB cable) to one of the USB ports of the laptop.



The MMBT-S Trigger Interface MUST be connected to the laptop AFTER the trigger USB cable coming from the SyncBox.

- Your laptop connections should now look like this.



- Configure the display settings of the laptop to mirror outputs and set a resolution of 800x600 for both screens. That step and that exact resolution is crucial for the eye-tracker calibration to work.
- Configure the display settings of the laptop to mirror outputs and set a resolution of 800x600 for both screens.
- Double check that the IP address corresponding to the ethernet interface of the [REDACTED] laptop is correct. You can either run `ifconfig -a` or use the GUI. Make sure the IP/mask is 100.1.1.2/24, and the protocol is IP version 4. Execute `ping 100.1.1.1` to see if the ET is responding to echoes.

- Check that the service to synchronize the triggers is up with `sudo systemctl status forward-trigger`.

**If the service is down, manually force its start**

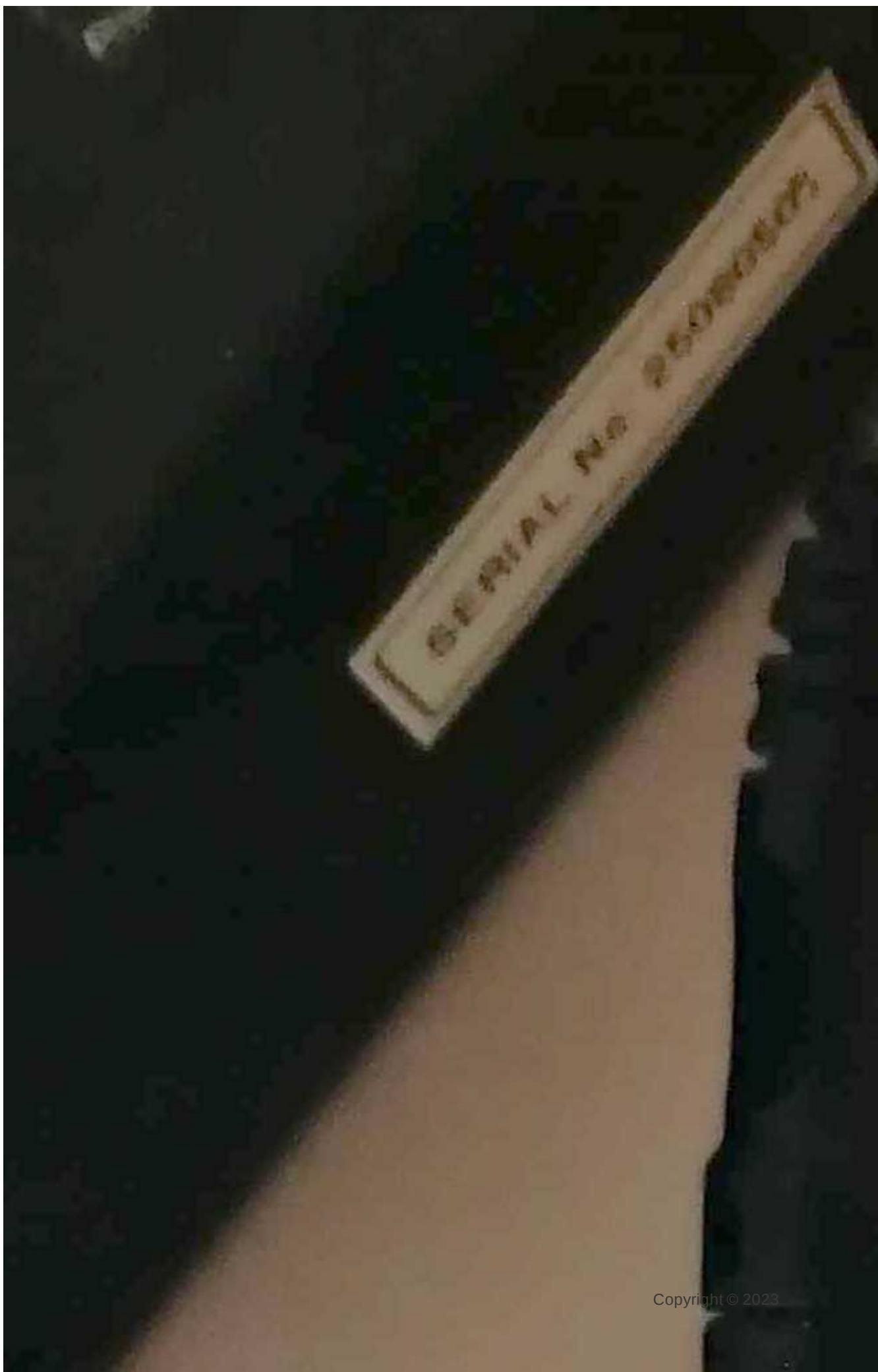
- Run `sudo systemctl start forward-trigger`
- Recheck the status with `sudo systemctl status forward-trigger`.

**These commands are executed with sudo**

The console will prompt you for the common user password: \*\*\*\*

- Check that you can send trigger events manually:
  - Enter the "Synchronization" menu by selecting it and pushing the enter button (●).
  - Hit the down arrow button (▼) until you find "Send trigger"
  - Push the enter button (●) every time you want to send an s character.
  - Check that the [REDACTED] laptop types those triggers (e.g., on an open editor receiving keypresses, or the shell prompt).
  - Check that the BIOPAC is properly registering the trigger too. Every trigger sent should be seen in the *AcqKnowledge* GUI.
- Start the syncbox session:
  - Push the up arrow button (▲) until you find "Start session"
  - Push the enter button (●) and the syncbox will be now waiting for the scanner's trigger signal to forward it.





- Switch the projector on by hitting the power button on its right side. The projector is found in room █. Adjust the projector tilt and centering if the projection does not properly aim the panel inside the scanner's bore. E.g., change the height of the paper pile that supports it (see images, FENS papers).



*The hole is the part through which you should check the quality of*

- Verify that the projector projects your laptop screen by looking through the window of the console room.
- Go back to the █ laptop, open a terminal and execute `conda deactivate`.
- Open psychopy 3 by typing `psychopy`
- Open the PCT experiment in *Psychopy* (`task-pct_bold.psyexp` file).
  - Run the experiment by pressing the green play button.
  - Enter the session and participant number in the pop up window. The Eyelink system setup page opens.
  - Press enter to begin the *camera setup mode*.
  - The camera setup mode contains a view of one eye, and you can switch that view between two modes: one is the field-of-view of the ET, the second is an automatic zoom on the eye itself (or a random part if the eye is not visible).
  - To ease the setup of the ET, switch to the full view in the camera setup mode by pressing the left or right arrow. This will allow you to adjust the ET position as the infrared camera is providing feedback inside the scanning room through the projector.
  - On the ET computer, verify that the calibration selected is the 9-points one.
    - Click on *Set Options* on the right of the screen.

- On top left under Calibration type, choose the image containing 9 points.



## Final checks inside the scanning room

- Prepare padding: under-knee padding, neck padding, inflatable head-padding.
  - Wrap a sanitary cover around each padding.
  - The head padding should be chosen and adjusted to each participant depending on their head size so that their nose is only 1-2mm away from the anterior part of the coil. The anterior part of the head coil will be tight around the participant's nose, so ensure they are nonetheless comfortable.
- Prepare a blanket.
- Prepare a new pair of earplugs.
- Check the RB, ECG, and nasal cannula are prepared.

# Preparing the participant

## Procedures for when the participant has arrived

It is critical to stay alert and anticipate any potential risk to the participant to avert them. This is particularly important for the first session.

## Preparation of the participant in the CONTROL ROOM

### Participant reception

- Meet the participant at an easily locatable place (e.g., the reception desk of the Radiology Unit) and show them the way into the control room. **Allow sufficient time before the experiment for the preparation (min. 30 minutes).**
- Show the participant the scanning room and explain to them how the device is controlled from outside.
- Ask the participant to fill out the consent form and MRI safety screener, and verbally confirm responses, paying attention to frequently forgotten devices and implants, like orthodontia.

### DO NOT subject the participant to any risk

- In case of any doubts emerging from the MRI safety screening, contact [ ] immediately at [ ].  
**DO NOT PROCEED if the medical contact cannot be reached.**
  - In case of discovering any previously undisclosed contraindication, the volunteer MUST NOT participate in the study.
- Remind the participant to use the bathroom at this moment if they need ([ ]).

### Only female participants, only the first session

- Remind the participant that for their safety, pregnant women cannot participate:

Hey [NAME], I have to remind you that pregnant women cannot participate for their safety. To be absolutely sure that you are not scanned while being pregnant, the ethical review board requests us that you take a pregnancy test before the first session. Here you have a test, and this is the urine sample cup. I'm going to show you the bathroom now so that you can do the test with the necessary privacy.

  - Provide the participant with a pregnancy test and a urine sample cup.
  - Go over the instructions with them.
  - Accompany them to the bathroom (situated at [ ]), and ask whether there is anything else they anticipate they will need.
  - If the test is positive, the person CANNOT PARTICIPATE in the study. **You MUST be understanding of the situation as most likely the person will not be aware of the circumstance.**

- Tell the participant they will be holding an alarm button throughout the session, and that they may use it any time whenever they need to stop the experiment.

During the duration of the exam, you'll have an alarm button on your hand. You can use it at any moment. We will first talk with you to check everything is fine, and we will stop the session whenever you need to stop the experiment. There is no need for you to endure uncomfortable experiences or anxiety (for instance, if you feel claustrophobic)

## Describing the development of the session

- Describe the participant how the session will develop, with special attention to tasks. In the first session, show the task while explaining them for clarity. Let them interrupt you to ask for clarifications and answer all the questions that may arise.

### Script for the first session

We are going to acquire three types of images. The first type is anatomical imaging that we use to study the morphology of the brain. The second type is diffusion MRI, which we use to infer the pathways of major fiber bundles showing how the different regions of the brain may be interconnected. Finally, we collect functional MRI, which we use to understand how the brain activates as a response to stimuli we will present to you. During the whole duration of the exam, please do not create closed loops by crossing your legs or holding your hands together. It is possible that your peripheral nerves get stimulated at some points, so you will feel twitching of muscles, for instance, of your pectorals. Do not panic, it is okay, but if it feels too uncomfortable, please squeeze the alarm button.

For the anatomical and the diffusion MRI we just ask you to relax and try to stay as still and comfortable as possible. Like a photographic camera, the largest problem making analyses difficult is motion. As opposed to a photo camera, the imaging of the brain happens very slow so there is a lot of opportunity for involuntary movements (e.g., when you blink or you take a deeper breath) or semi-voluntary (e.g., you need to swallow).

The functional MRI is a bit more entertaining, as we will ask you to engage in different behavioral activities. The first functional block is what we call a positive-control task, that will tell us little about your brain but will help us determine if there are confounding signals intermixed with your data. In this positive-control task, you will be shown a fixation point with the shape of a circle. Whenever you see that fixation point, please focus your gaze at the center of it. At points the fixation point will browse around the screen. When that happens, please follow it with your eyes taking care of not moving your head with the eye movement. Other times it will be fixed on the center, and have a blank gray background or a flickering or grating circular area behind it. The last element of this block will show the words LEFT or RIGHT. When either appears, please tap your thumb on each of the your other four fingers of the hand designated by the word, sequentially with all fingers and reversing the direction at the extremes (your pointer and your pinkie). This positive-control task has a length of 2min 38s. During this task, please leave the alarm button on your tummy, where you can recover it when it finishes.

Then there is a long block of 20min 0s that we call *resting state*. During this block, all you have to do is stay still and look at the movie. Please do not close your eyes.

Finally, a breath-holding task will help us understand the signals elicited by your breathing that are detected by the scanner. This block has a length of 5min 41s. You will watch five repeats of the same block. Each block will show you a colored rectangle in the middle. The green rectangle means *breathe in*, the yellow rectangle means *breathe out*, and the red rectangle means *hold your breath*. The last two green and yellow rectangle will be shown on a lighter green and orange color respectively to signal you

that a hold will follow immediately after the breathe-out. The red rectangle will turn pink to indicate that you will soon be able to breathe-out any remaining air in your lungs and breathe in again. Please remember to breathe out after the breath-hold. When no rectangle is presented, you can breathe as it feels more comfortable to you. The first of the blocks is a mock. That will be reminded to you at the beginning of the task on the screen. During the mock block, please look at the stimuli on the screen but keep your habitual breathing pace disregarding the task instructions. At the end of this mock block, a message will remind you must follow the task instructions from that moment on. that you must adapt your breathing to the pace indicated by the color-changing rectangle in the center of the screen for the remaining four repetitions of the block.

Is everything clear to you? Do you have any questions?

#### Script for the following sessions ^

As you probably remember, we acquire three types of images. For two of them you just stay still in the scanner, but we will also require your collaboration for the third, which is functional MRI. During the whole duration of the exam, please do not create closed loops by crossing your legs or holding your hands together. It is possible that your peripheral nerves get stimulated at some points, so you will feel twitching of muscles, for instance, of your pectorals. Do not panic, it is okay, but if it feels too uncomfortable, please squeeze the alarm button.

Let's quickly recap the functional MRI tasks. The first is the positive-control task, you will be shown a fixation point with the shape of a circle that you must follow with your gaze wherever it goes and then the words LEFT or RIGHT while which you tap your fingers like this (remind to them). During this task, please leave the alarm button on your tummy, where you can recover it when it finishes.

Then there is a long block of about 20 minutes that we call *resting state*, where you will be watching a movie. During this block, all you have to do is stay still and please do not close your eyes.

Finally, the breath-holding task where you will watch five repeats of the same block with colored rectangles in the middle. The green rectangle means *breathe in*, the yellow rectangle means *breathe out*, and the red rectangle means *hold your breath*. The last two green and yellow rectangle will be shown on a lighter green and orange color respectively to signal you that a hold will follow immediately after the breathe-out. The red rectangle will turn pink to indicate that you will soon be able to breathe-out any remaining air in your lungs and breathe in again. Please remember to breathe out after the breath-hold. When no rectangle is presented, you can breathe as it feels more comfortable to you. The first of the blocks is a mock. That will be reminded to you at the beginning of the task on the screen. During the mock block, please look at the stimuli on the screen but keep your habitual breathing pace disregarding the task instructions. At the end of this mock block, a message will remind you must follow the task instructions from that moment on. that you must adapt your breathing to the pace indicated by the color-changing rectangle in the center of the screen for the remaining four repetitions of the block.

Is everything clear to you? Do you have any questions?

## Finalizing the preparation

- Indicate the participant where the door to the changing room is if changing into scrubs is necessary. Otherwise, offer them a box to deposit everything they have in their pockets and all jewelry/hair accessories.

Before we continue, we need to make sure we do not introduce any dangerous object in the magnet room.

[IF THEY NEED TO CHANGE INTO SCRUBS] Here you will find a changing room, I have prepared some scrubs for you. Please remove all your clothes and leave them in the changing room. Please keep your underwear on (if a woman, double check that their undergarment DOES NOT contain any large metallic part such as shaping guides, and request their removal if they do).

[IF THEY CAN WEAR THEIR CLOTHES] Please deposit here all your belongings, your belt, your glasses, your jewelry and any accessories, piercings, etc. that you have on you.

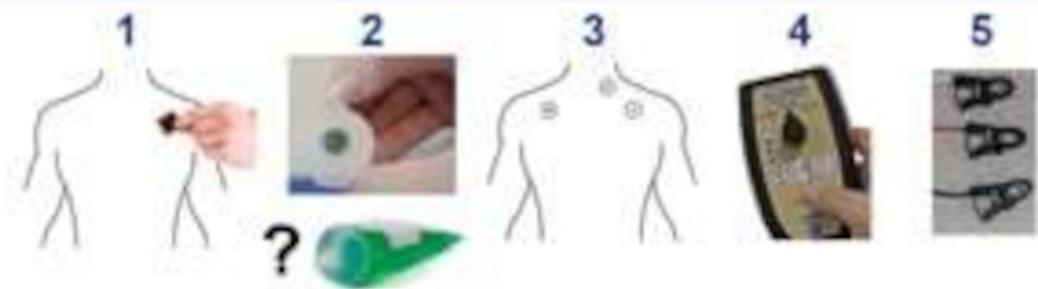
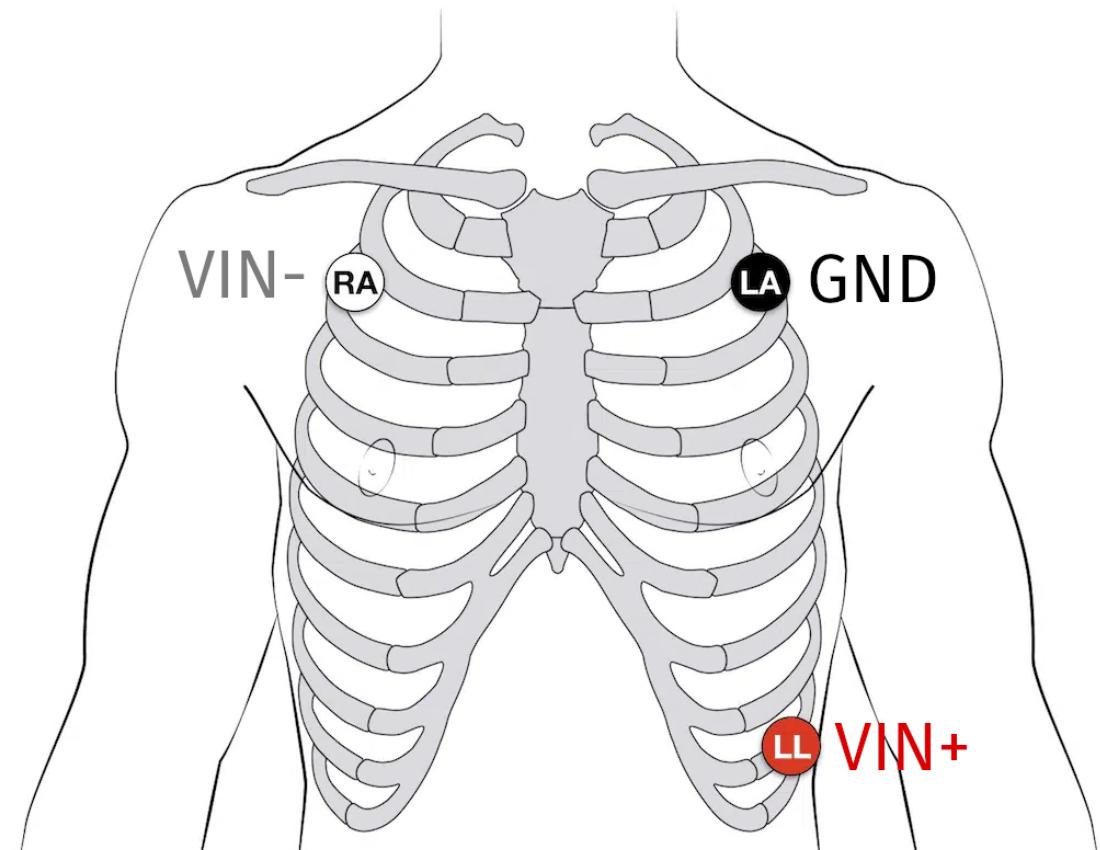
- Help the participant to prepare their skin and place the ECG electrodes:

**Ask the participant if they have atopic skin or other skin problems**

If the participant reports having skin issues, be careful with the following process and do not unnecessarily irritate their skin (e.g., skip the alcohol cleaning and perhaps the abrasion with the preparation gel)

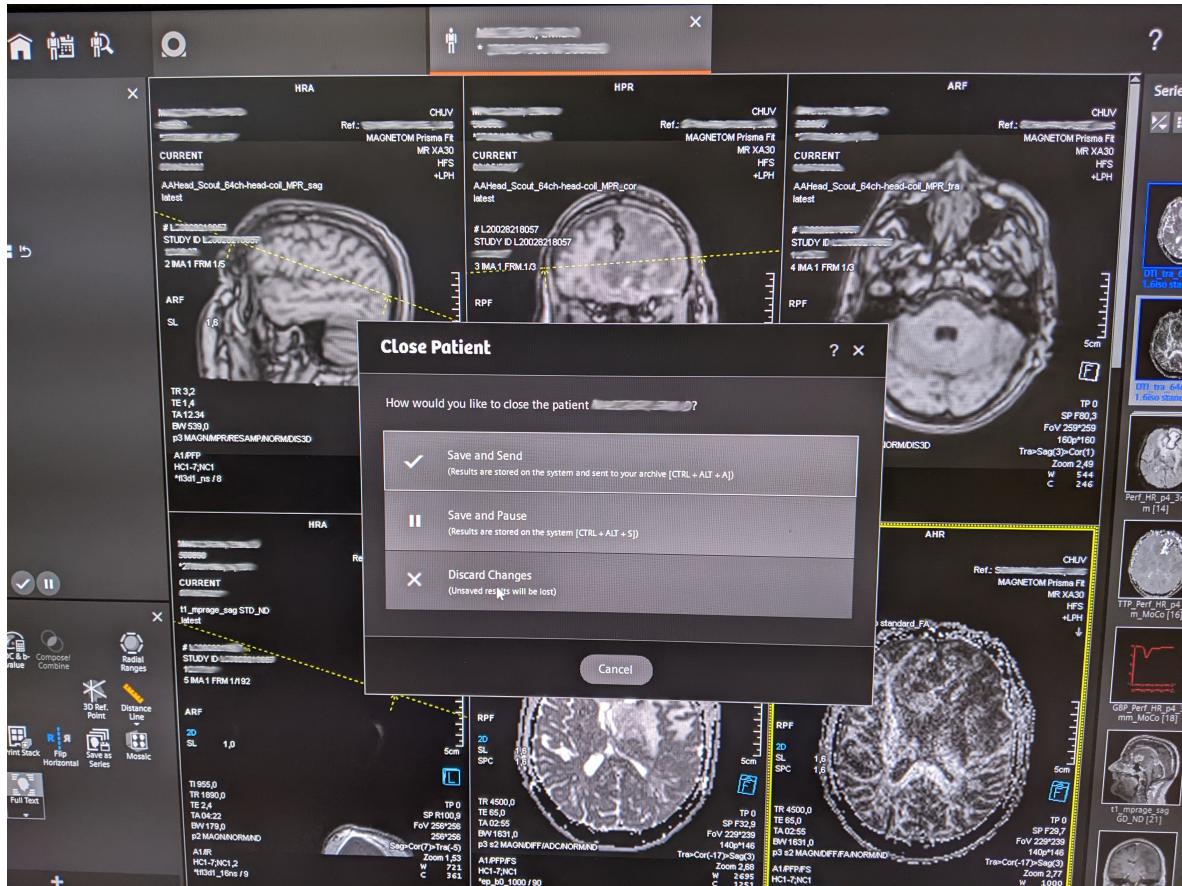
- Open the sterile cotton gauze pads package, take one and moisten it with alcohol.
- Clean the skin around the three areas with the alcohol-soaked pad with circular movements.
- Get a second cotton gauze pad and put some *Nuprep* preparation gel and gently abrade the skin by rubbing it onto the skin with four or five circular movements.
- Remove gel excess with a clean cotton gauze.
- Remove the protective film from the electrode.
- Stick the electrode on the participant's skin by starting in one side and ironing the rest of the electrode. This procedure ensures that no air is trapped between the electrode

and your skin and that no wrinkles form at the edges. Repeat for the three electrodes.

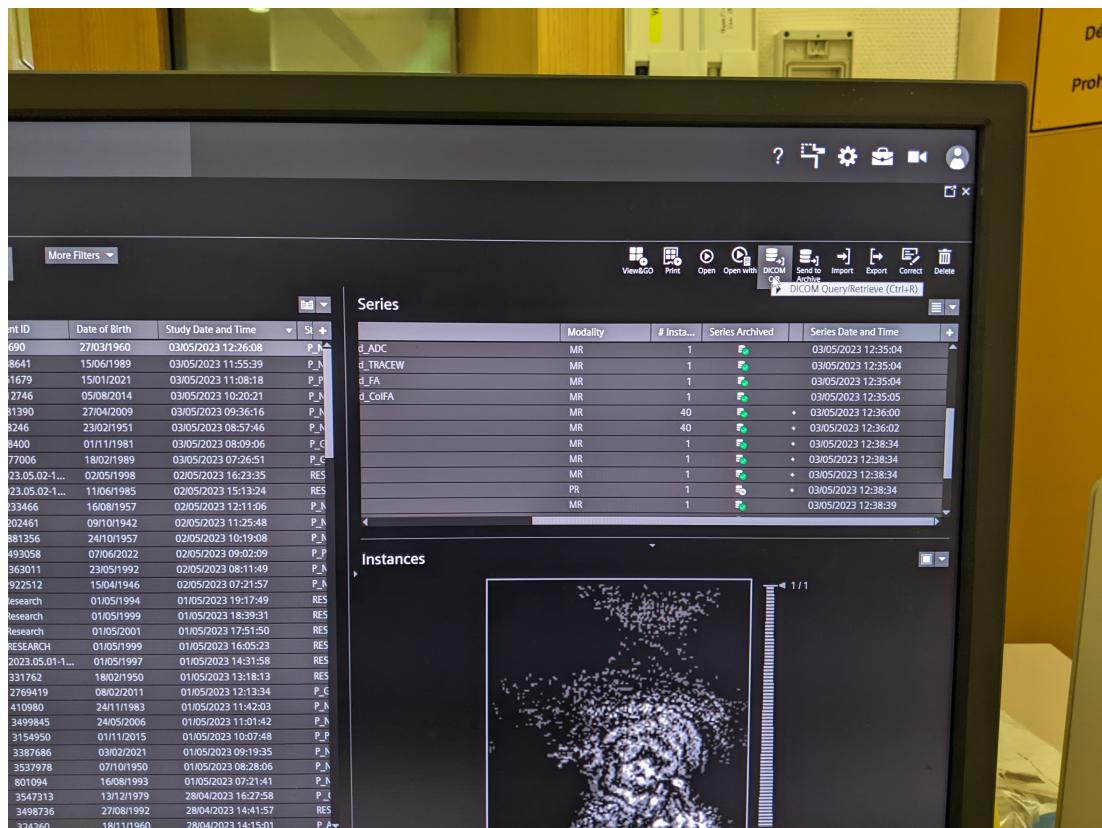


## Preparation of the scanning protocol (control console)

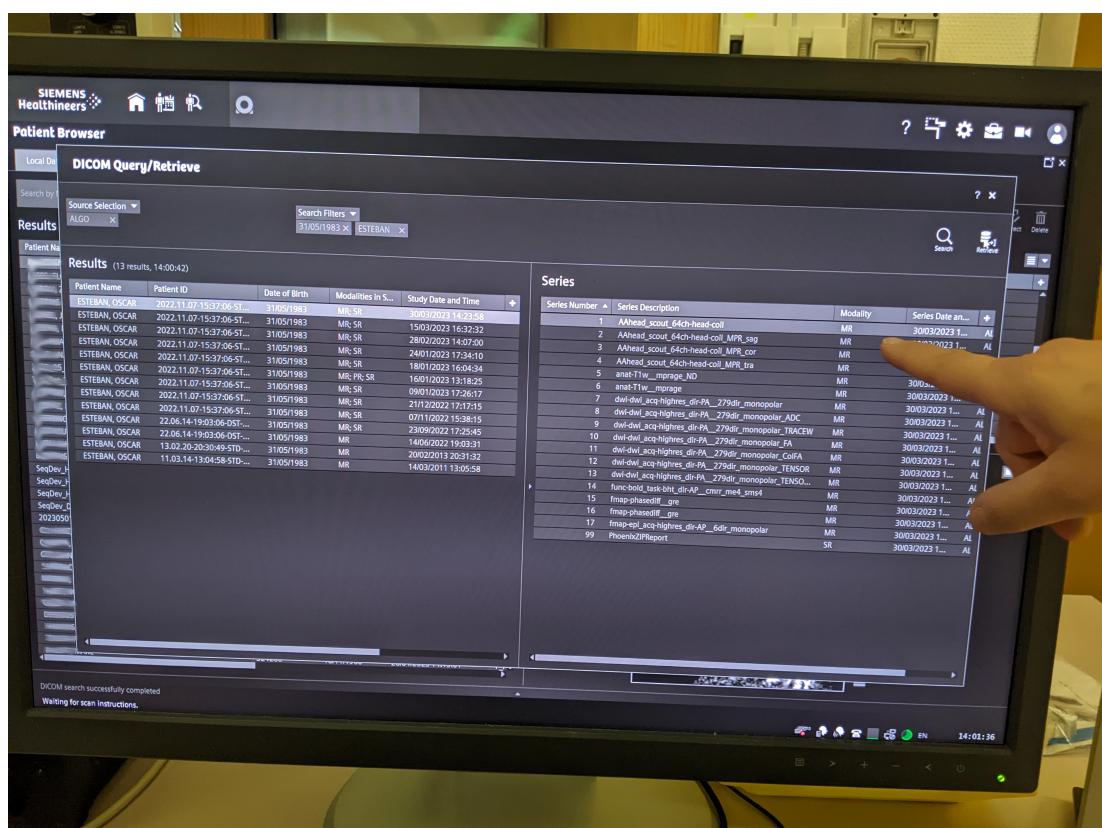
- Close open patients discarding changes.



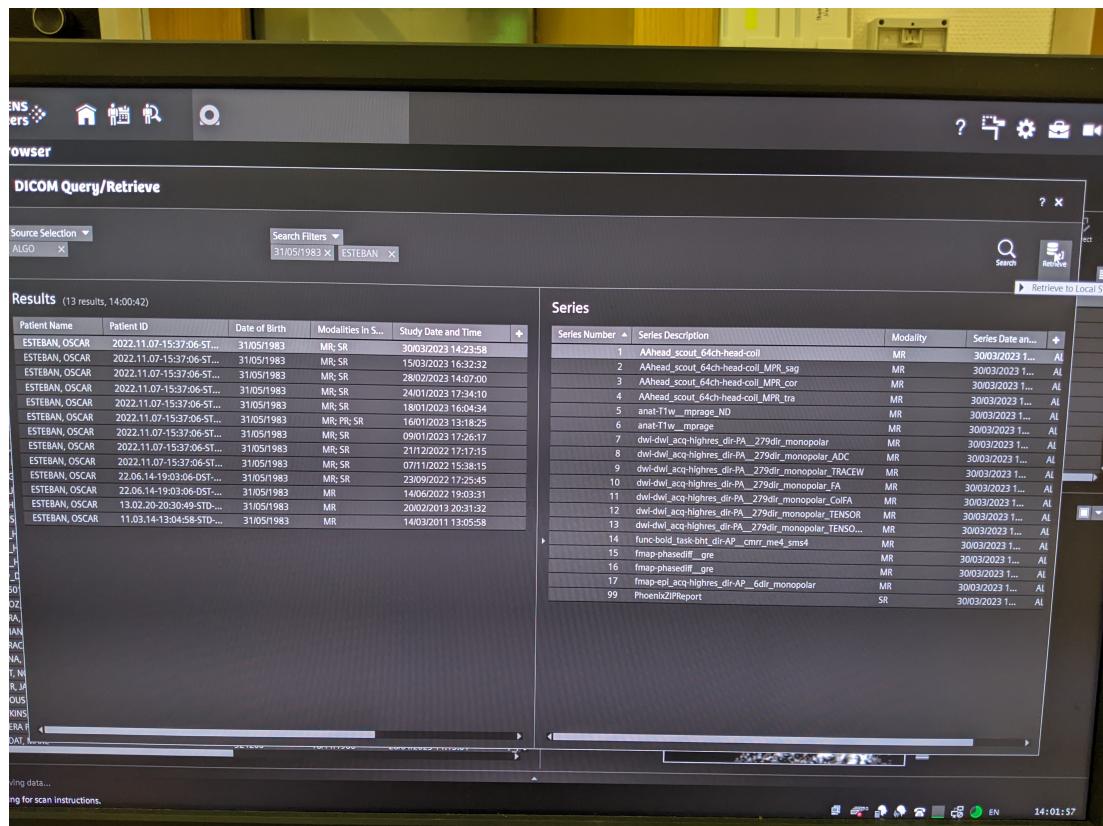
- Search for the participant by clicking on the "Patient Browser" in the top left corner. If the participant is not shown (because it is archived and hence not locally found):
  - Click on the *DICOM Q/R* button on the top-right area.



- Introduce some unambiguous search criteria:

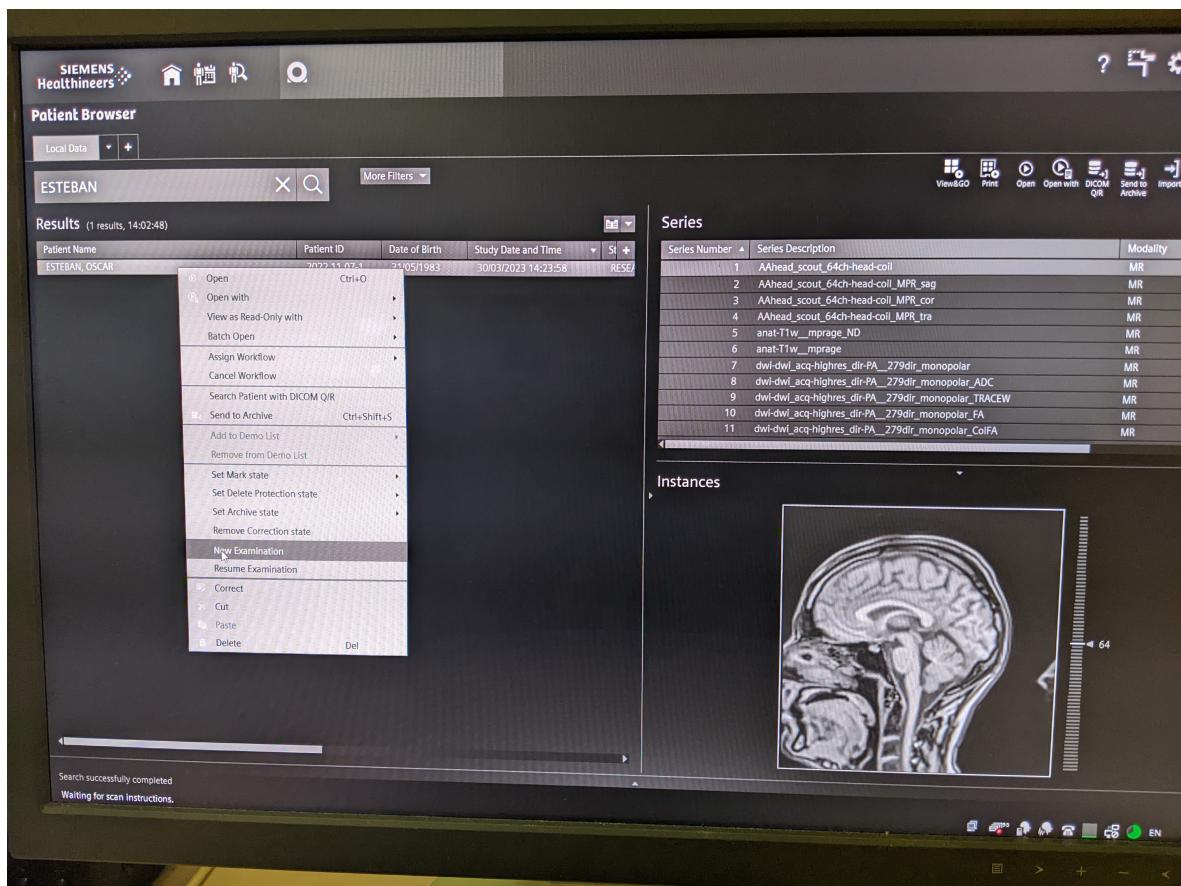


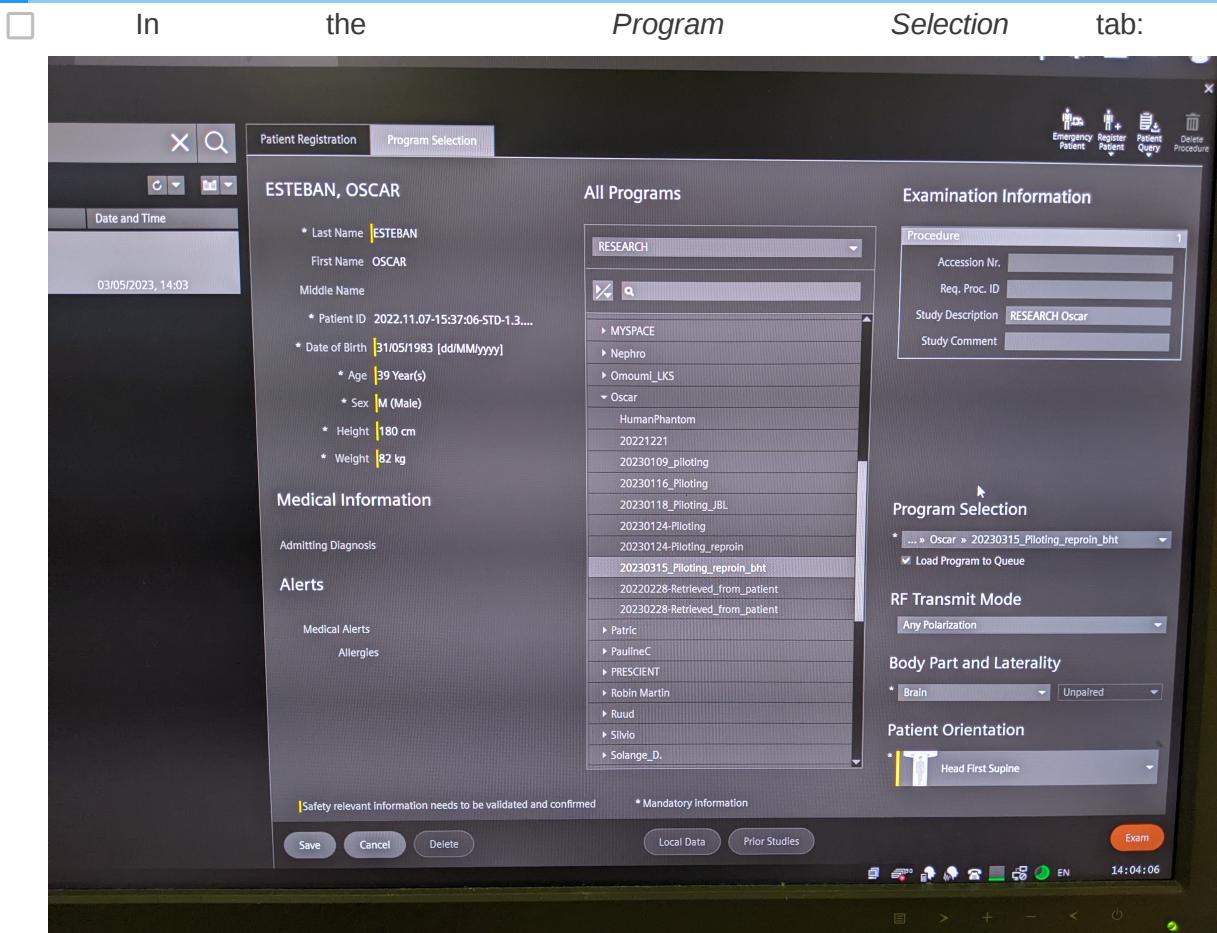
- Select the subject (left column) or the sequence (right column) you want to retrieve and hit *Retrieve*. Be careful, you probably want to retrieve a subject, that means make sure you have selected a row on the left column:



- Go back to the "Patient Browser" and check that the patient now shows up in the local search.
- Check the head coil is not plugged before initiating a "New examination" to ensure good SNR of the localizer sequence.

- Right click and select "New examination".





- Enter the weight and height of the participant.
- Select the right protocol under *RESEARCH* ↴ *Oscar*.
- Select *Brain* as the organ.
- Select the *Position* as "Head First Supine".
- Before you hit Exam, you can edit general patient's data by changing to the *Patient Registration* tab if you need to edit general information about the patient.
- Click the Exam button (red background, rightmost-bottom).
  
- Load the adequate protocol, making sure of loading the right phase-encoding (PE) direction corresponding to the session.
  
- Double-check that all PE prescriptions are correct.

## Installing the participant in the SCANNING ROOM

Thanks to Stephanie Bogaert, MSc, Pieter Vandemaele, MSc and Pim Pullens, PhD

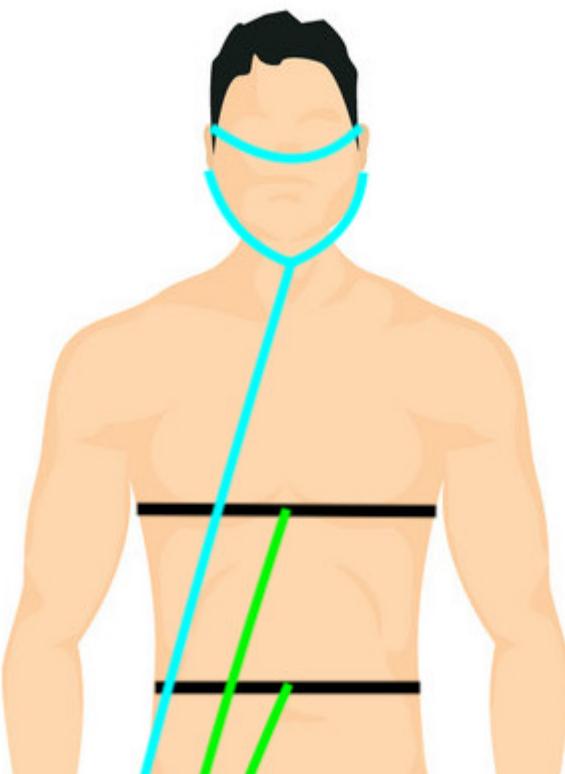
Some of the pictures in this section have been extracted from the [Ghent Institute for functional and Metabolic Imaging MRI User 2019 \(\[http://gifmi.ugent.be/drupal/system/files/documents/GifMI\\\_MRI%20User%20manual\\\_BASIC\\\_SiemensPrisma\\\_EN.pdf\]\(http://gifmi.ugent.be/drupal/system/files/documents/GifMI\_MRI%20User%20manual\_BASIC\_SiemensPrisma\_EN.pdf\)\)](http://gifmi.ugent.be/drupal/system/files/documents/GifMI_MRI%20User%20manual_BASIC_SiemensPrisma_EN.pdf) written by Stephanie Bogaert, MSc, Pieter

Vandemaele, MSc and Pim Pullens, PhD. We express our gratitude that they put together such a comprehensive guide.

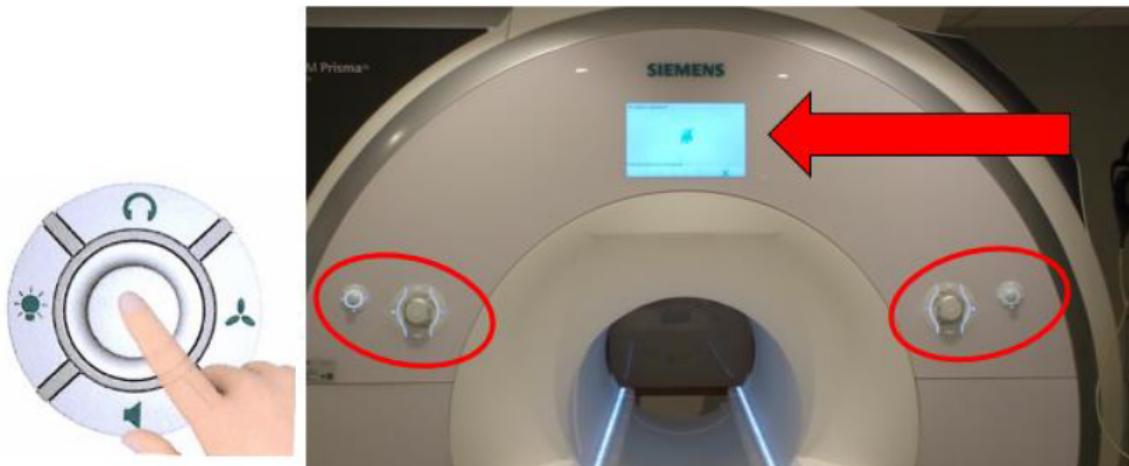
- Have the participant remove their shoes at the entrance of the scanning room.
- Show the alarm button to the participant and explain how they may use it.
- Give to the participant the emergency button. Make the participant try it, so they can see it works. To switch off the alarm, there's a button on the scanner (circular, both on the left and on the right of the hole)
- Give them the ear-plugs to protect their hearing during acquisition, allow time for them to place them.
- Instruct the participant to lay on the MRI bed.

## Connecting physiological recording sensors and probes

- Connect the ECG leads to the three electrodes. The electrodes MUST be connected following the color scheme shown in the picture above.
- Install the RB below the participant's chest and connect it to the tube as shown in the picture below. The RB measures the stretching induced by breathing, so it MUST surround the chest or stomach comfortably. Positioning the RB higher (chest) or lower (stomach) depends on the individual's preferential respiration mode (chest breathing or diaphragmatic, respectively).
- Place the nasal cannula in the nose of the participant making sure the two protrusions are aligned with the nostrils of the participant. Place the tube behind the ears and tighten under the chin for comfort and stability by sliding the ring as shown in the picture above.



- When completely laying down on the bed, tightly fasten the RB and check with the participant whether they are too uncomfortable.
- Solicit feedback on participant's comfort while positioning them on the scanner bed and suggest ergonomic positioning of their arms to avoid discomfort.
- Once the subject is lying on the MR bed, check that no arms/legs lie on the GA or the RB tubes.



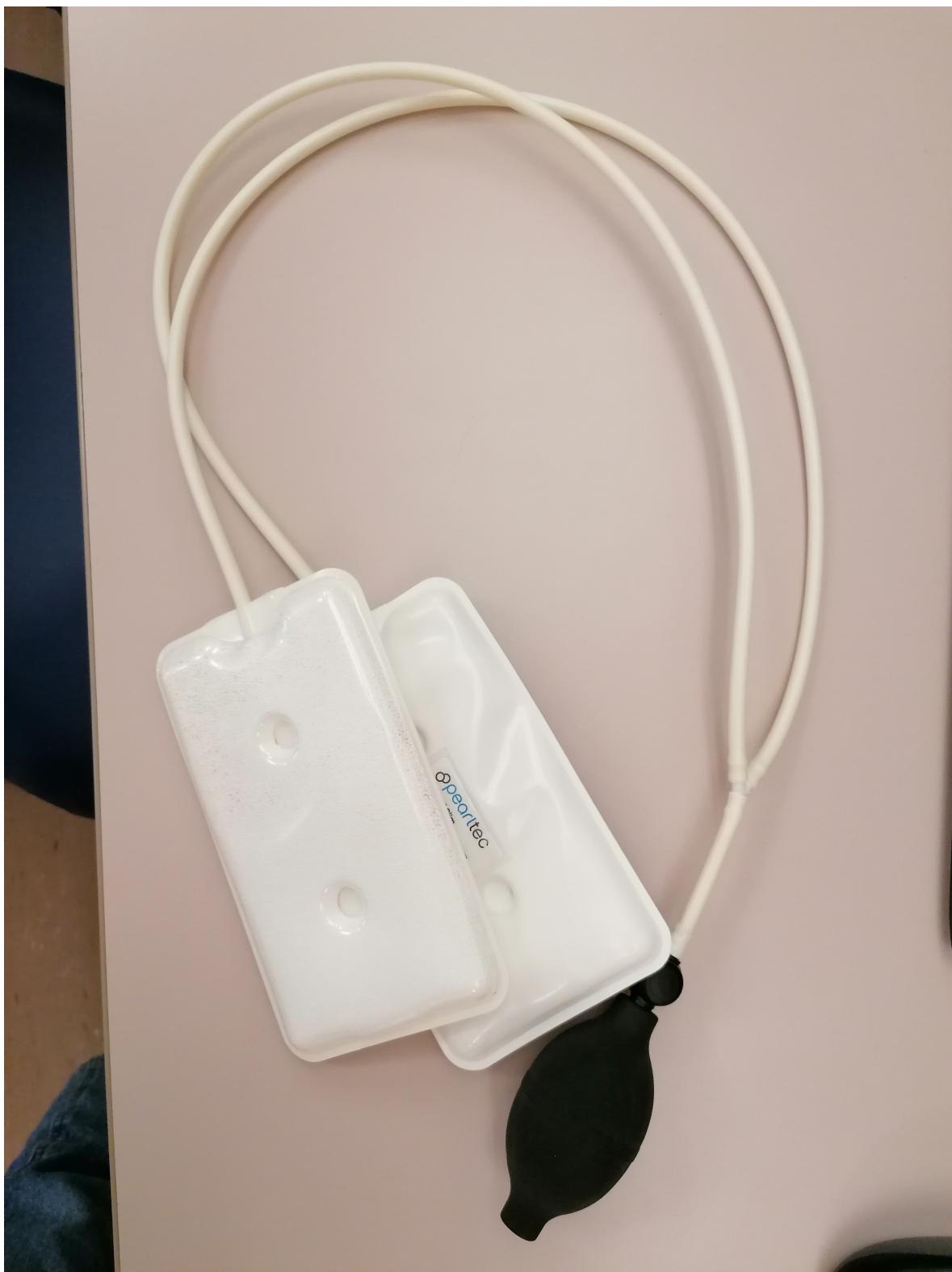
#### Accommodating the participant's head in the coil

- Adjust the participant inside. With the paddings, their head position MUST be adjusted and elevated so that the nose and the forehead of the participant are both close to the upper coil. This procedure ensures the ET has the clearest possible view of eye.
- This part must be repeated taking out and putting back the upper part of the head-coil, adjusting the pillow at every step, until the head is fixed and the nose and forehead of the participant almost touch the coil. In case of need, ask the participant to rotate their head like when saying yes until reaching an adequate position, place any remaining paddings.



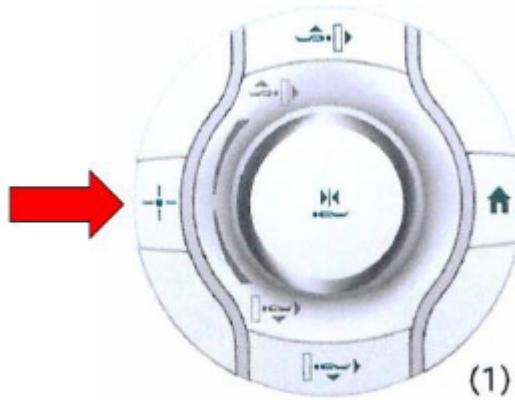
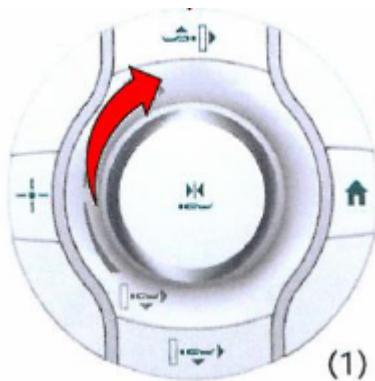


- Take the side paddings and fit them between each ear and the coil. If using the inflatable padding, pump air into them without making the participant uncomfortable (check with them).

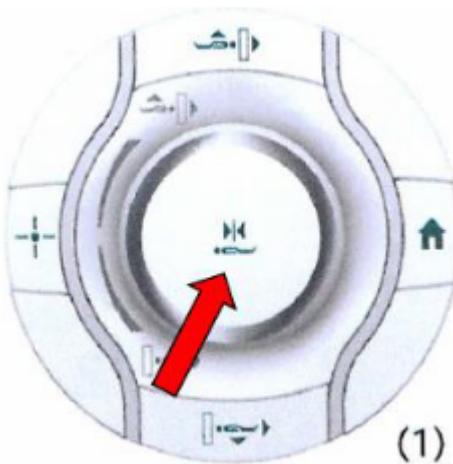


- Cut a long strip of medical auto-adhesive band and stick it at each side of the lower block of the head coil, across the participant's forehead and stick it to the participant's forehead. Indicate the participant that this band will tell them when they moved and help them recover the original position.

- Place the top block of the coil and check that the participants' front touches or is really close to the coil. Now the nose can also be a bit far from the coil. Tell the participant to relax the neck, so the nose should go a bit up and touch the coil.
- Connect the coil's cable to the corresponding socket on the table.
- Ask the participant if they are feeling cold. Cover them with a blanket if necessary.
- Place rectangular paddings at each side of the chest and help the participant accommodate their elbows on them.
- Remind the participant not to create closed loops by crossing their legs or holding their hands together.
- Gently move the participant with the manual regulation. Stop when the head is under the head-localizer. Ask the participant to close their eyes, press the laser alignment button and align the head-coil markers with the red light.



- Switch off the alignment light, now the participant can open their eyes. You can move the participant (always gently as before) inside the scanner manually, until the mm counter marks "Isometric" or you can press the rotary knob for two seconds. This will send the participant to the isocenter automatically.



### Final preparatory steps of the ET

- You should see the projection of the calibration mode as you left it open before.
- Adjust the ET position to point the camera to the right eye. Adjustment may be easier if you switch to *Head camera* mode, which has a wider angle.
  - The lens can be focused by rotating it, like a photo camera.
  - If the position of the ET is still inadequate, you can move the base.
  - As a last resort, you can also adjust the strength of the infrared light (emitter). This is the black box on the other side with respect to the lens. Under the emitter there are two little screws. Unscrew, move the emitter front/back, check the contrast of the face image, re-screw.
- Switch the ET to *Eye camera* mode (zoomed in) and check the eye is still well covered by the view and the pupil is segmented.
- Check that two crosses appear on the eye.



- If the pupil is correctly seen, as well as the eye (indicated by the crosses following their movement), inform the participant that you are leaving the room, and that you are going to first check with them whether the speaker works well, immediately.
- Exit the camera mode by pressing Enter.

Check the communication with the participant



**Important**

The red button (3) immediately stops the currently running sequence.

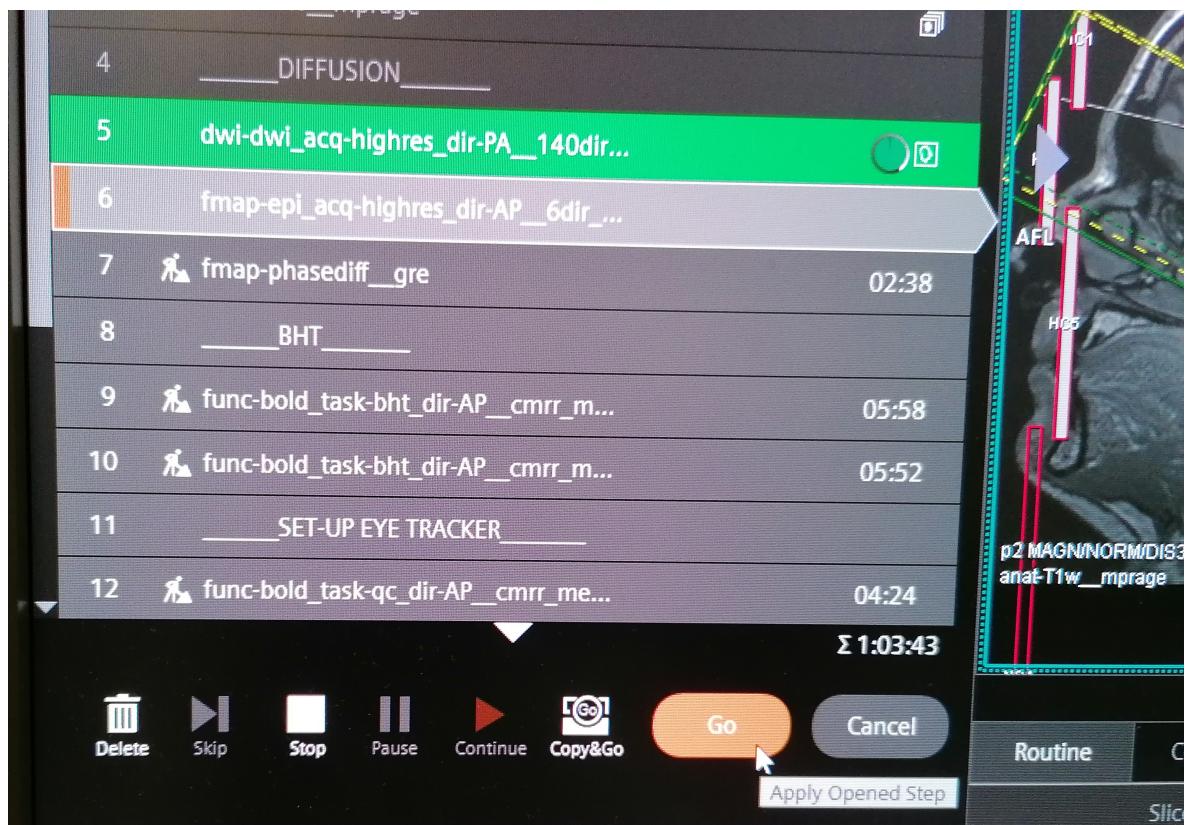
- Make sure the speaker is audible (and not annoying) and confirm the participant's feedback
- Keep on pressing the speak mode button to give instructions (1). Set the volume control of your microphone by pressing the +/- buttons.
  - Hey [NAME], can you hear me well?
- To listen to participant responses, make sure you release the speak mode button before you press the listen mode button once (2). Set the volume control of the participant's microphone by pressing the +/- buttons.
- If this volume increase is not enough for the participant to hear you well, proceed as follow:
  - In the Siemens program, click on Configuration represented by a gear wheel at the top right of the screen.
  - Click on *Configuration panel*
  - Under the section *Scan application*, locate the icon of the speaker and tune the volume to the maximum.
  - Click *Apply*

# Notes on the scanner's console and recording devices

## Quick guide to the protocol settings and configuration

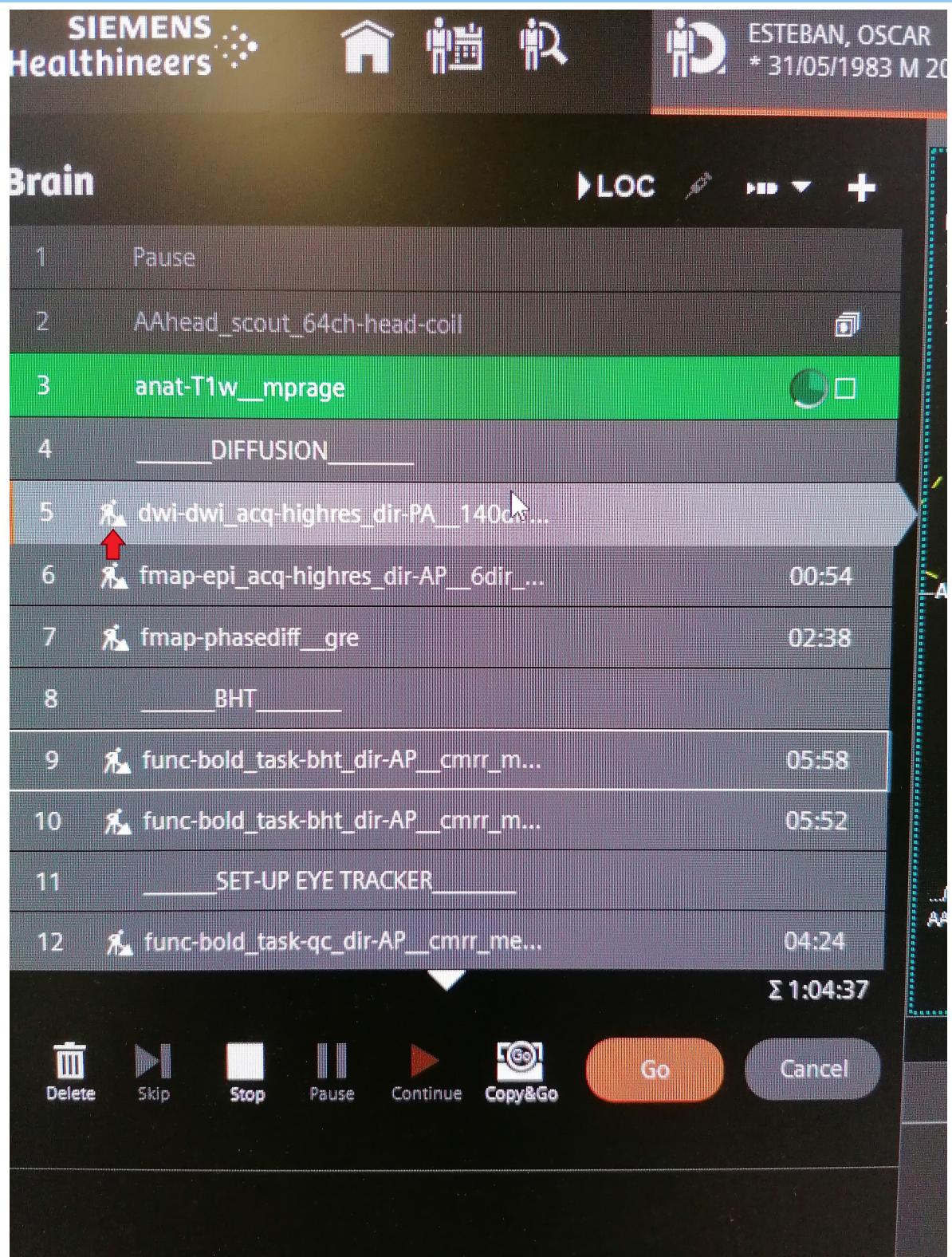
### Editing a sequence

- Double click on the sequence name.
- After editing the sequence, you MUST store the changes if you want them to be kept by clicking on the Go button:

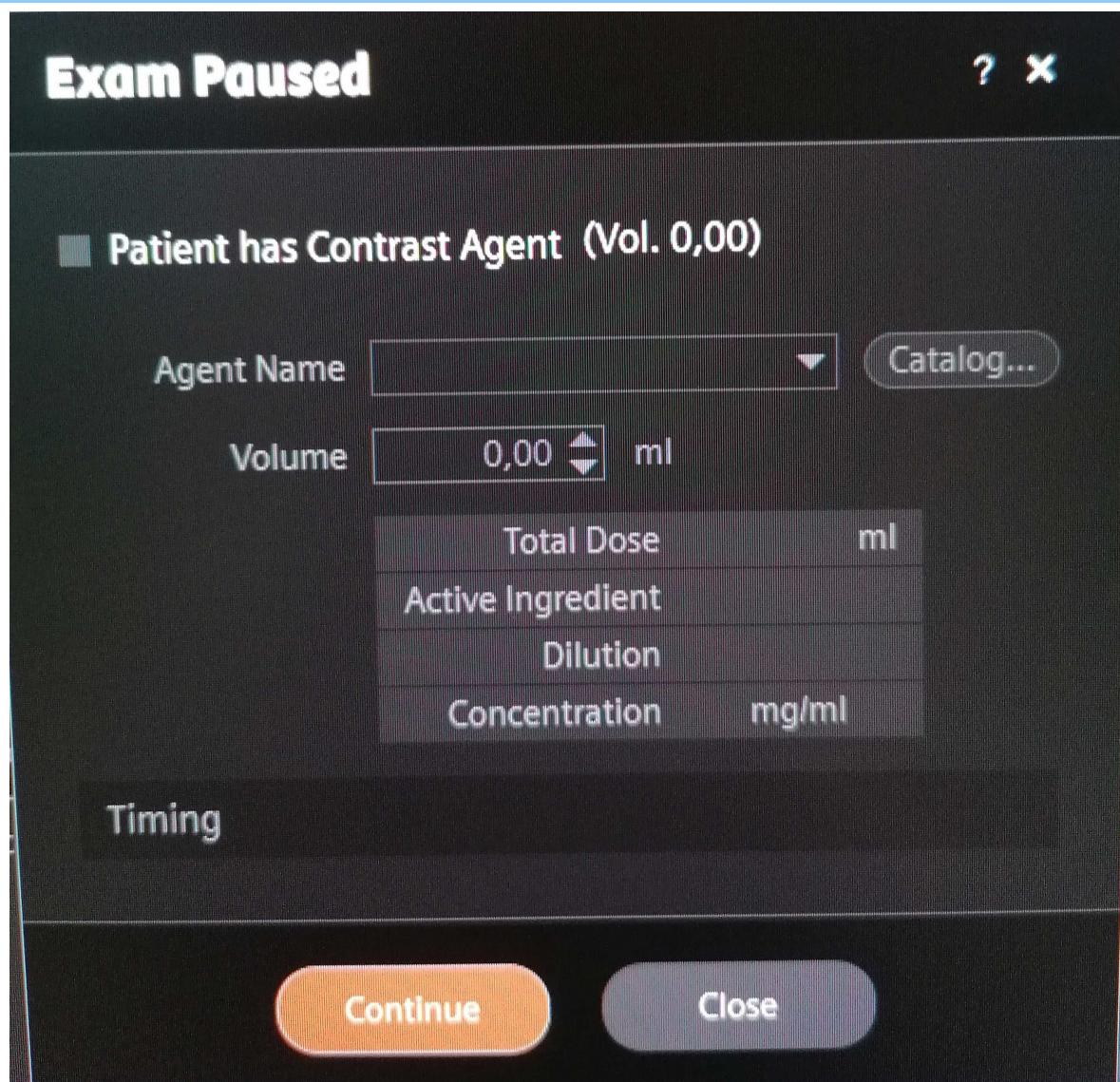


### Setting sequences for automatic start

- You can set the worker icon on the left of the sequence by clicking on it if you want to pause before starting that sequence. If the worker is not present, the sequence will launch automatically.



- Blocks with a name between double underscores   \*    introduce an *Exam Paused* break.  
Such breaks prompt a modal dialog with the *Exam Paused* title like this:



The *Patient has Contrast Agent* checkbox MUST always be unchecked, as this protocol does not involve a contrast agent"

- Click Continue when you are ready to proceed.

## Setting the FoV

Using the anatomical image to adjust the field-of-view (FoV) is RECOMMENDED

- Drag and drop the protocol's stack icon (MRI) corresponding to the anat-T1w\_mprage sequence into the image viewer. The icon will appear AFTER the image has been acquired.
- Make sure that the FOV (yellow square) includes the whole brain by tilting or translating the FOV. If the full brain, including the cerebellum, do not fit in the FOV, favorise making sure that the cortex is fully enclosed in the yellow square. For reproducibility, it is better if the FOV across sequences have a similar center and a similar tilt. However, if it is not possible, the priority remains to include the whole brain in the FOV.

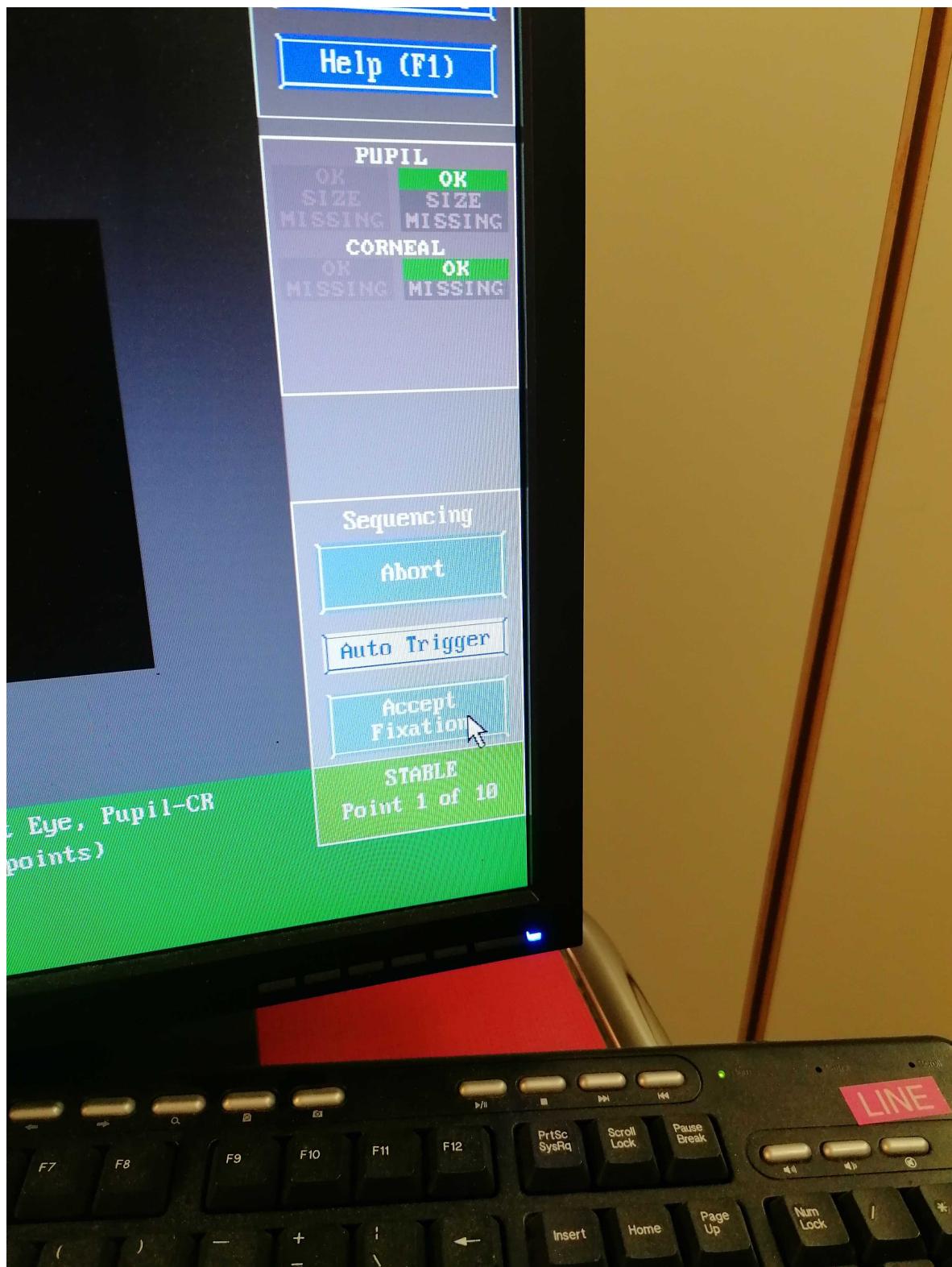
- If two sequences have the same resolution and the same number of slices, you can copy/paste the FOV
  - Open the sequence for which you want to adjust the FOV/geometry
  - Right click on the sequence for which the FOV has already been carefully positioned
  - Select Copy Parameters
  - Center of slice groups and saturation regions
- Once the FOV is well placed, store the new settings of the sequence by pressing Go.



## Eye-tracker calibration

- Inform the participant about the calibration process (the [scanning protocol](#) provides you with scripts)
- Run the experiment by pressing the green play button.
- Enter the session and participant number in the pop up window. The Eyelink system setup page opens.
- Press C to open the calibration mode to perform the calibration and validation.
- Exit the calibration mode by clicking on ESC .
- Once the calibration of the ET is concluded, hit the Esc key on the laptop  to exit the calibration mode continue the task's program.

- Launch the ET calibration by pressing C on the laptop keyboard or by clicking on Calibration on the ET interface:
  - When the gaze is stable, the button Accept fixation appears green, then you can manually click on it to validate the first position.



- The following positions should be validated automatically when the gaze is stable enough. If it is not the case, manually click on the validate button when it turns green

- The ET software MUST show a cross during the calibration. If it does not, try sequentially the following:
  - readjust the focus of the ET; and if it still doesn't show the cross,
  - readjust the mirror frame position sliding it along the rails attached to the coil; and if it still doesn't show the cross,
  - readjust the participant's head positioning inside the coil; and if it still doesn't show the cross,
  - move the mirror up or down (being careful as mentioned before). Just a few mm can ruin the calibration and the eye-position; and if it still doesn't show the cross,
  - iterate over the previous steps.
- When the calibration is successful, launch the validation by clicking on validation on the ET interface or clicking V on the keyboard of the laptop. Follow the same instructions as in the calibration to validate the positions.
- If the validation is not ok, iterate over previous steps restarting calibration. Otherwise, you can leave the calibration mode on and move forward.

# Running the scanning session

## Familiarize with emergency procedures

You MUST know the security procedures in case of problem and keep yourself updated with changes. Some of the emergency procedures are found here [here](#).

In addition to the brief guidelines given in these SOPs, further safety information is found in █.

## During the session

- Check in with the participant frequently, not necessarily only at the scripted points.
- Watch for motion and arousal state using the ET's camera. If you detect motion or the participant falls asleep at inadequate points, use the speaker to inform them.

## Check experimental setup

### DO NOT FORGET to check the readiness of the experimental setup at this point

- Check the trigger box:
  - the box is on,
  - Synchronization mode* is on,
  - session has been started,
  - USB cable to █ is connected.
- Check the GA:
  - the tubing coming from the scanning room is properly connected,
  - the CO<sub>2</sub> BNC output is plugged through the filter to the BIOPAC AMI200, on input channel 3,
  - the exhaust cap IS REMOVED
  - the GA is on (switch it on if necessary),
  - ensure the PUMP IS ON, and
  - turn the pump's power knob to MAXIMUM position.
- Check █:
  - has enough battery, and plug the power cord if necessary;
  - USB cable to the MMBT-S Trigger Interface Box is connected;
  - serial cable from the MMBT-S Trigger Interface Box is connected to the back of the SPT100D digital interface (gray block) of the BIOPAC;
  - computer is ready, with psychopy open, and with the appropriate version of experiments; and
  - leave the computer with a pleasant screen projecting (e.g., a gray background).

Check █:

- has enough battery, and plug the power cord if necessary;
- computer is ready, with the *AcqKnowledge* software open and collecting data;
- check the ECG and RB signals, and fix unanticipated problems (e.g., the respiration belt needs to be fastened tighter);
- the *Amphetamine* app is running and keeping the computer unlocked while *AcqKnoledge* is working.

## Acquire a localizer (AAhead\_scout)

Indicate the participant that the scanning will soon start:

Hey [NAME], we are about to start our first scan run.

This is going to be a long session, so please make sure you are feeling as comfortable as you possibly can in there. Remember not to cross your legs or hold your hands together and check your back is also comfortable. I'm going to ask you to take a deep breath now, so I can check the respiration belt is properly set up. If it is too tight, please let me know.

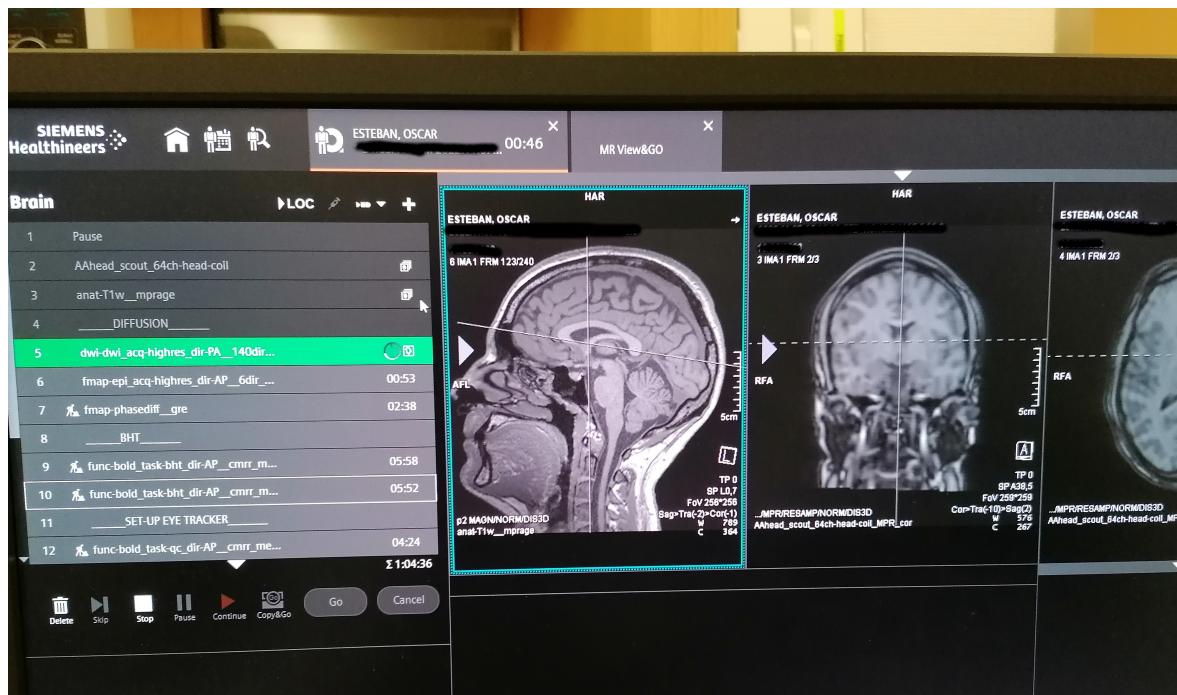
[Allow a few moments for the participant to breathe while you check the recordings]

Okay, we seem to be able to track your respiration. Is the respiration belt too restraining? This is also a good moment to swallow, and to check your neck and head are in a comfortable position.

For this first part, all you have to do is stay still; you can relax and close your eyes if it helps.

Are you ready?

- Wait for the participant confirmation and set the speaker off afterward.
- Launch the AAhead\_scout\_{32,64}ch-head-coil protocol by pressing *Continue* (█).
- Once the localizer is concluded, you can drag and drop the image stack icon (something like █, with an object on the top stack) onto the image viewer. That will open the localizer on the viewer.



If the localizer presents very low quality

The localizer may present very low quality if the head-coil has not been properly initiated by the scanner

- Enter the scanning room, extract the participant from the scanner by pressing the home (🏠) button.
- Tell the participant that you need to reset the head coil
- Unplug and replug the head coil
- Check that the coil has been properly detected in the scanner's monitor
- Re-insert the participant in the scanner
- Re-run the AAhead\_scout\_{32,64}ch-head-coil protocol.

## Acquire a high-resolution, anatomical image

- Launch the anat-T1w\_\_mprage protocol by pressing *Continue* (➡).

### While you are still running the MPRAGE sequence

- Open the parameters of the sequence named fmap-phasediff\_gre and ensure that under *Contrast ↴ Reconstruction* the option *Magnitude et phase* is selected. This is crucial so that both the magnitude and the phase difference field map images are saved.
- Repeat the configuration of *Magnitude et phase* for all sequences name fmap-epi\_acq-bold\_dir-{RL,LR,PA,AP}\_\*.
- Repeat the configuration of *Magnitude et phase* for all sequences name func-bold\_task-{bht,pct,rest}\_dir-{RL,LR,PA,AP}\_cmrr\_me4\_sms4.
- Open the dwi-dwi\_dir-{RL,LR,PA,AP}\_279dir\_monopolar sequence and under the section *Diff.*, uncheck all the derivatives except for *Diff. Weighted Image*.

## Acquire the diffusion MRI run

- [Adjust the FoV](#) of the dwi-dwi\_dir-{RL,LR,PA,AP}\_279dir\_monopolar sequence as indicated below.
- Verify again the dwi-dwi\_dir-{RL,LR,PA,AP}\_279dir\_monopolar parameters under section *Diff*. All the derivatives MUST be unchecked except for *Diff. Weighted Image*.
- Inform the participant that the diffusion scan will follow.

### Only for the participant of Cohort I

Hey Oscar, we are ready to proceed with the diffusion scan. The BIOPAC is functional and *AcqKnowledge* is properly registering the respiration belt and ECG. The gas analyzer is ON, but it is still warming up. The psychopy computer is ready. Are you ready?

### Participant of Cohort II

Hey [NAME], the next block is a bit long, around 30 minutes.

You can close your eyes and even sleep if you wish.

I'm going to give you a short time (ten seconds or so) to swallow, and perhaps accommodate your back or your arms. However, please try not to move your head.

It is critical that you don't move, especially at all at the very beginning and the next 20 seconds after you hear the first blipping sounds.

Try to minimize swallowing, and eye movements (for example, blinking) and try to maintain comfortable and shallow breathing.

Are you ready?

- Launch the diffusion dwi-dwi\_dir-{RL,LR,PA,AP}\_279dir\_monopolar sequence by pressing *Continue* (➡).
- While it is running, [adjust the FoV](#) for the following sequence.

### At this point, the GA should have finished the warm-up so you can verify it is working

- Ask the participant to take three deep breathes, to then go back to a comfortable, normal respiration pace. Check on the *AcqKnowledge* window that the three breathes are distinctly registered (taking into account that there may be 10-25 seconds of delay because of the tubing).

## Once the main diffusion MRI run is done, proceed with fieldmaps

- Launch the DWI-EPI sequence fmap-epi\_acq-b0\_dir-{RL,LR,PA,AP}\_6dir\_monopolar for  $B_0$  field mapping by pressing *Continue* (➡).
- While it is running, [adjust the FoV](#) for the following sequence.

- Launch the GRE (*phase difference*) sequence `fmap-phasediff_gre` for  $B_0$  field mapping by pressing *Continue* (➡).
- While it is running,
  - [Adjust the FoV](#) for the following sequence.
  - Verify that in the next sequence parameters under *Contrast>Reconstruction* the option *Magnitude et phase* is selected!
- Launch the BOLD-EPI sequence `fmap-epi_acq-bold_dir-[RL,LR,PA,AP]_cmrr_me4_sms4` for  $B_0$  field mapping by pressing *Continue* (➡).
- While the fieldmap sequence is running,
  - [Adjust the FoV](#) for the positive-control-task (`func-bold_task-pct_dir-[RL,LR,PA,AP]_cmrr_me4_sms4`) fMRI sequence following the abovementioned steps, and
  - verify the *Number of measurements* with respect to the [task's timing](#) (2min 38s).
  - Verify that the positive-control task `task-pct_bold.psyexp` is open in psychopy, that you calibrated the ET.

## Acquire the functional MRI block

- Inform the participant about the fMRI block

Hey [NAME], we are now to move into measuring the activity of your brain.

Is everything alright thus far?

[Allow some time for response]

Before we start, we need to calibrate the eye-tracker device, which follows your right eye during experiments.

Your are going to see a round fixation point, and the point is going to move randomly over the screen space. Please follow it with your gaze, trying to look at it as stable as possible and without moving your head.

Are you ready?

- Wait for confirmation, respond to follow-up comments, and [initiate the ET calibration \(instructions below\)](#)

## Positive-control task (PCT)

- Verify that the task's program is awaiting the scanner's trigger to start.
- Inform the participant that we will proceed with the positive control task (PCT). Repeat task instructions.

Hey [NAME], thanks for your collaboration with the eye tracking calibration.

The following block will collect some behavioral data and requires your collaboration. You will be exposed to several activities.

Whenever you see a red circle, please fix your gaze on it, wherever it is shown on the screen. If the red circle moves, we ask you to follow it with your eyes.

Some other times, you'll see either "RIGHT" or "LEFT" written on the screen. During those times, please tap your thumb and the other fingers of your right or left hand as indicated on the screen.

Before we start, please leave the alarm button on your tummy to free your hand for finger tapping. Please do not hesitate to grab it in case you need to squeeze it.

- Launch the `func-bold_task-pct_dir-{RL,LR,PA,AP}_cmrr_me4_sms4` protocol by pressing *Continue* (█).
- Wait for the calibration scans to be finished (the process is reported on the bottom left corner of the console) and verify that the first volume's trigger signal was received by █ (meaning CHECK that the task program was initiated).
- While it is running:
  - [Adjust the FoV](#) for the following sequence,
  - verify the [Number of measurements](#) with respect to the [task's timing](#) (20min 0s), and
  - double check that it has the setting [Magnitude et phase](#) selected in the drop-down menu under [Contrast>Reconstruction](#).
- Once the sequence is over, you need to stop manually the psychopy task by pressing the key t on the keyboard (as fast as possible to avoid collecting more data than needed).
- Once the sequence is over, close the current experiment on psychopy and open `task-rest_bold.psyexp`.

## Resting state fMRI

- Inform the participant:

Thanks [NAME], that was a short behavioral task.

Before moving on, we will run another calibration of the eye tracker, please follow the moving fixation point.

Is everything alright?

- Wait for confirmation, respond to follow-up comments, and [initiate the ET calibration \(instructions below\)](#)
- Once the ET is calibrated, verify that the task is left and awaiting for the sequence's trigger to start.
- Inform the participant that the next sequence is resting-state fMRI (rsfMRI).

Hey [NAME], we are about to start resting-state fMRI.

For this scan, all you have to do is stay still, and look at the movie. Please do not close your eyes, and it is particularly critical that you don't move at all in the initial moments of the acquisition block.

Are you ready?

- Launch the rsfMRI sequence `func-bold_task-rest_dir-{RL,LR,PA,AP}_cmrr_me4_sms4` by pressing *Continue* (☒).
- While it is running:
  - [Adjust the FoV](#) for the following sequence,
  - verify the *Number of measurements* with respect to the [task's timing](#) (5min 41s), and
  - double check that it has the setting *Magnitude et phase* selected in the drop-down menu under *Contrast>Reconstruction*.
- Once the sequence is over, close the current experiment on psychopy and open `task-bht_bold.psyexp`.

## Breath-holding task (BHT)

- Inform the participant:

Thanks [NAME], that was a long behavioral block.

Before moving on, we will run another calibration of the eye tracker, please follow the moving fixation point.

Is everything alright?

- Wait for confirmation, respond to follow-up comments, and [initiate the ET calibration \(instructions below\)](#)
- Once the ET is calibrated, verify that the task is left and awaiting for the sequence's trigger to start.
- Inform the participant that the next sequence is breath-holding task fMRI. Repeat the instructions for the task.

Hey [NAME], we will proceed now with a breath-holding task.

I remind you that you have to breathe following the cues of the colored rectangle.

Green means "BREATHE IN", orange means "BREATHE OUT" and red means "HOLD YOUR BREATH".

Remember to not follow the breathing instructions during the first block and to exhale the small amount of air you have remaining at the end of the hold.

Are you ready?

- Launch the `func-bold_task-bht_dir-{RL,LR,PA,AP}__cmrr_me4_sms4` sequence by pressing *Continue* (➡).
- While it is running, determine whether there is enough time to run the anatomical T2-weighted run. If so, [adjust the FoV](#) for the following sequence.
- Once the sequence is over, you need to stop manually the psychopy task by pressing the key t on the keyboard (as fast as possible to avoid collecting more data than needed).

## Concluding the session

### ONLY if time permits

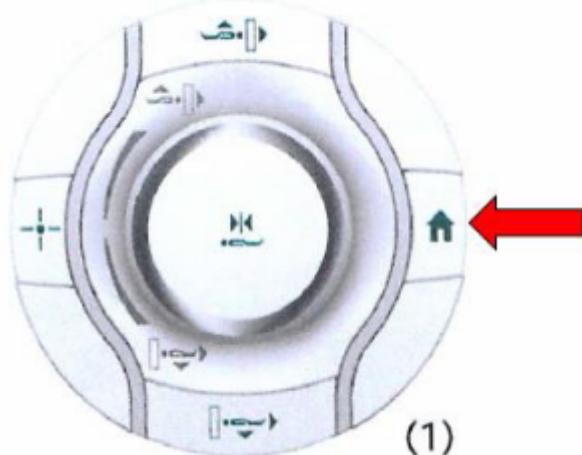
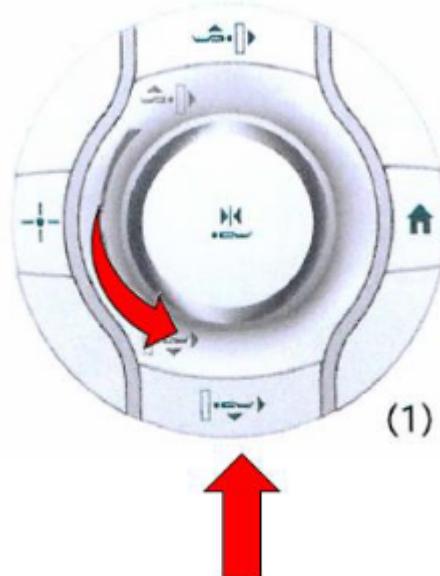
- Launch the `anat-T2w_flair` protocol by pressing *Continue* (➡)
- Inform the participant:

Thanks [NAME], the session has concluded and we will shortly let you out of the scanner.
- The exam is over, you can proceed with the [tear-down protocol](#).

## Session tear-down

### Showing the participant out

- Extract the bed from the scanner's bore using the scanner's control wheel. The home button can be used to bring the bed out.



- Unplug the head coil from the bed connector and then lift the lever that releases the upper part of the coil, put it aside (e.g., inside the bore or on a chair next to the scanner).
- Release the air from the inflatable padding pushing the release valve of the pump and take them away. Remove the disposable covers and throw them away in the trash container.
- Help the participant sit down.
- Instruct the participant to remove the earplugs and dispose of them. Ask them about the experience:

[NAME], how was your experience? Have you been able to feel comfortable throughout the session? What advice, indication do you feel we could've provided you for a better experience?

- Lift the nasal cannula and help the participant remove it from their head.
- Disconnect the tube from the RB and then lift the velcro attachmet to remove the RB.
- Disconnect the ECG leads
- Help the participant step down and accompany them out to the control room.
- Help the participant recover their personal belongings and change clothes if necessary.
- Solicit more feedback on participant's comfort for future sessions.
- Solicit tickets and receipts for transportation.
- Give the participant the corresponding compensation for the participation and transportation.
- Request a signed receipt of the amount of the financial compensation.

## AFTER SCAN, inside the scanner room

- Carefully remove the infrared mirror:
  - Enter again the scanner room with the plastic container of the mirror and leave it prepared on the bed.
  - Separate the mirror frame from the upper part of the head coil and lay it on the bed.
  - PUT ON A NEW PAIR OF GLOVES
  - Remove the scotch tape holding the infrared mirror and IMMEDIATELY insert the mirror in its plastic bag.
  - Take the mirror in its bag OUT OF THE SCANNING ROOM and place it back in the fMRI box, with extreme care.
  - Re-enter the scanning room and clean the standard mirror removing all residues of glue from the scotch tape. Re-attach the mirror to its coil's frame.
- Cleaning up instrumentation:
  - Take the projector's screen off and store it in its designated shelf.
  - Unplug the two cables connected to the ET (signal and power). Put those extremities aside far from the scanner.
  - Take the ET back outside and put it in a stable place.
  - Unscrew the ET lens, while ALWAYS keeping one hand under the lens while screwing/unscrewing it and put it back into its cover.



- Put the cover, the ET base back in the fMRI box, being extremely careful to not crush the mirror.
- Re-enter the scanning room.
  - Disconnect the ECG leads from the filter of the access panel, fold the cable and leave it prepared with the RB to take out of the room with other equipment.
  - Disconnect the last section of the cannula and dispose of it in the trash can.
  - Take the ECG electrodes, the RB, and the plexiglas base outside to the control room.
- With someone outside in the control room:
  - Careful extract the cables (fiber and power of the ET) back through the access tube. The person outside will carefully roll them around being extremely careful, and place them in the rolling table of the ET computer.
  - Extract the RB and the GA tubing from the room. Likewise, the person outside will carefully roll and store them.
- Clean-up of the scanning room:
  - Put the sheet and the blanket inside the dirty linen bag (in the trash if used plastic sheets).

- Dispose all single-use sanitary protections.
- Put the pillows back in place.
- Clean up the head coil (bottom and upper parts), and lock it back with its bottom part, do not plug the connectors.
- Remove the head coil and put it in the scanner's bore.
- Remove the back padding elements and put them back in their designated storage.
- Reinstall the spine coil.
- Plug back the head coil if you know the next exam will require that specific coil, or simply put it away with the other (head) coils on the shelf next to the scanner.
- Put the bed back in place = push the "home" button on the scanner
- Put the wooden stopper of the main access tube back on the tube.
- Everything that is removed for the experiment MUST be put back in place at the end of the experiment, i.e. position of the bed, coil, emergency button, ears padding.
- Take a glove, on the right there is some cleaning napkins. Use them to clean the bed.
- Exit and close the external door.

## AFTER SCAN, outside scanner room

- Switch off the projector.
- Retrieve ET recordings (from [ ]):
  - Insert a USB key into [ ] and save the experiment from AcqKnowledge.
  - Upload to a pre-designated drop-box (e.g., using Dropbox)
- Switch off laptop and ET PC Tower. Plug back the sync box and the VGA projector where they were.
- Fix the rolled cable with the scotch on the PC Tower base.
- Turn off the pump of the GA, then switch the GA off. DO NOT PUT THE CAP IN WHILE THE PUMP IS ON.
- Remove the cables connected to the BIOPAC and the GA and store them in the boxes in their original bags.
- Take the ET, Remove (always with and hand under the lens) the MRI compatible LENS. Put it back to its contained inside the box.
- Put back the regular Lens.
- Bring back the box and the base at CIBM EEG lab. Put the keys back under old Nora's desk.
- Fix the ET with the scotch at the chariot.
- Bring back the chariot and the TMS laptop at the TMS lab

Turn off the MRI system if no more sessions are scheduled afterward

It is critical to follow the steps in order, ensuring each step is completed before proceeding further



- Turn off the satellite station (█████, the computer on the left side of the control desk)
- Turn off the control station (█████, the computer on the right side of the control desk)
- Push the blue button (circle and a dot outside) with the SYSTEM OFF label underneath, which is found right above the key
- Turn the key into the *closed lock* position (🔒)

# Emergency procedures

**Reminder:** Phone number of internal emergency services can be found in the agenda of all the phones of the hospital.

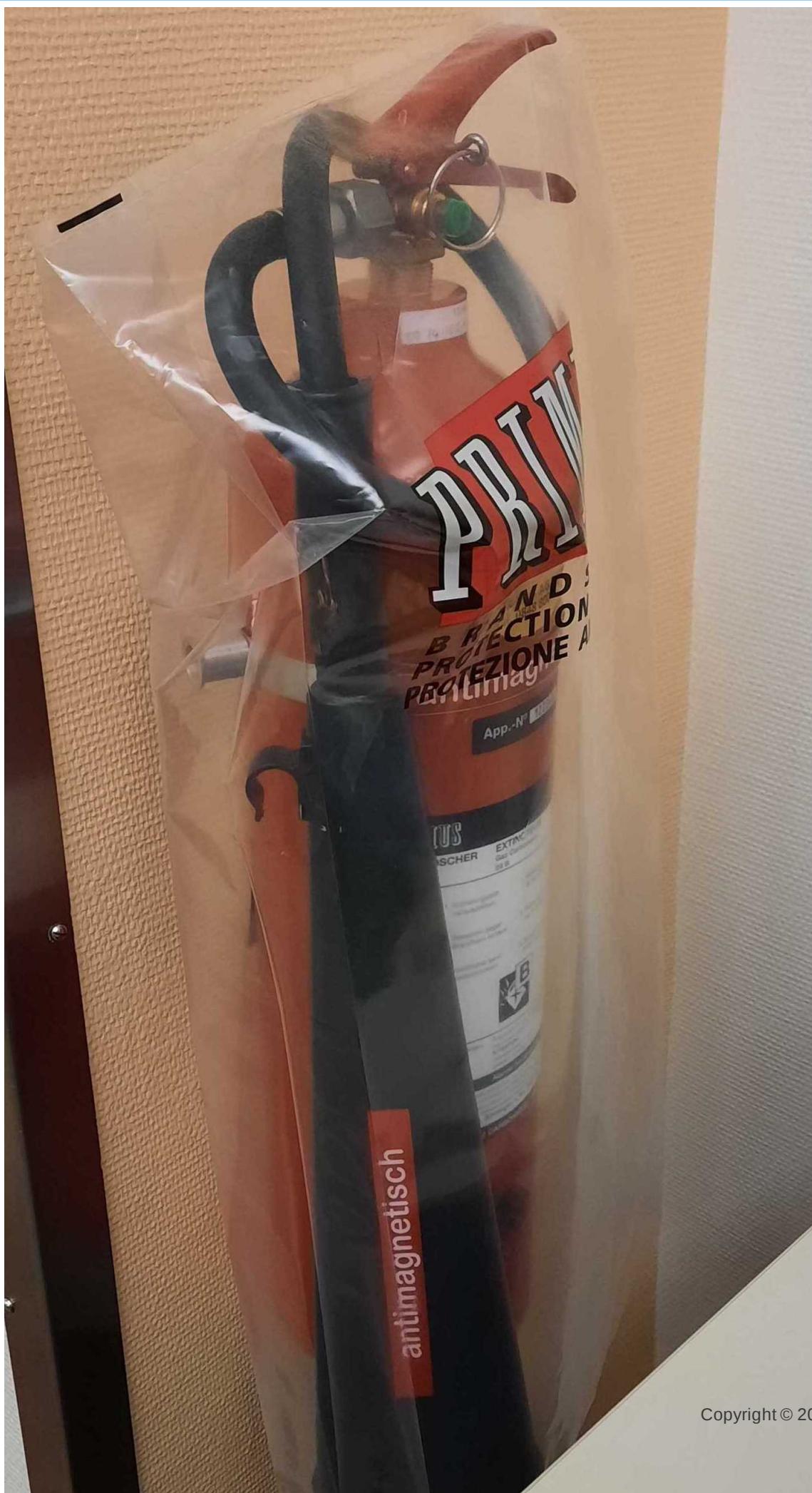
## Fire in the scanning room

- Immediately call the internal firefighter service at [REDACTED].
- Enter in the MRI room and cut the electricity in the MRI room by pressing the red button next to the entrance.

**Cutting electricity will NOT turn off the magnetic field!**

- Remove the subject from the scanner's room, applying the [manual extraction procedure described below](#).
- Close the scanner's room.
- Retrieve the MR-compatible extinguisher from its designated corner of the control room (see picture below) and put it in front of the scanning room.

**Conventional extinguishers MUST NOT be entered in the scanning room because the magnetic field is still active**



## Emergency quench

The quench button is to be used only in the case of an emergency in which a person is injured and the only safe way to avoid further injury is to decrease the magnetic field strength of the magnet.

- Lift the security cover to free the *red, mushroom-shaped button* with the STOP word written on it, and push it.



Fire in the scanner's room does not justify quenching unless the high field poses a direct threat to a person's health

Participant set the alarm

If at any point the participant rings the alarm, you MUST check on the participant IMMEDIATELY with the scanner's speaker system.

- Press the speaker button (1 in the picture below) and ask if everything is alright. It is possible that the participant triggered the alarm by mistake.



Pressing the speaker button (1) or the crossed-bell button (4) will turn the alarm off and open the speaker line to talk to the participant.

- Assess the participant and the situation by asking them what is wrong and checking the camera inside the room and the scanner's console.

#### If you can anticipate that the participant will need to be retrieved

Initiate the extraction of the bed from the scanner console using the *Room in* menu (lower left corner of the screen), and then click on the *home* (🏠) button.

### Alarm event requires further safety procedures

- Enter the scanning room if you do not get a response or the answer is unclear.

If there is an impending risk to the participant's health and it is safe for you and other operators to intervene, take actions to avert the dangerous situation.

For example, if the participant is choking because of the accidental occlusion of their respiratory ways after the displacement of some experimental instrument or sensor, immediately extract them from the scanner's bore with the fastest procedure available to you and remove the occluding instruments.

Similarly, suppose the participant suffers an acute panic attack and starts violently and uncontrollably shaking on the table. In that case, you will first lift the security side rails of the bed and securely restrain the participant further within the scanning table if necessary. This is critical to preempt their body from falling off the table while the head coil is still attached. Only when you can safely do so, extract them from the bore and remove the head coil.

### Participant possibly needs to be retrieved but there isn't impending risk to their health

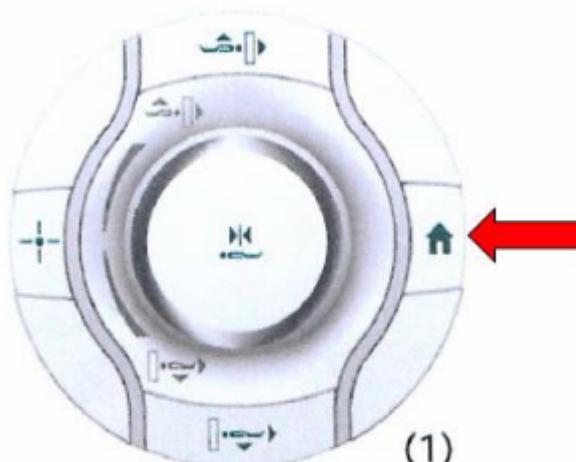
- If the alarm is still blaring, press the large, circular button at either side of the scanner's bore.



- Make the participant aware that you entered the room and ask them what is wrong.

If the participant is unresponsive, extract them from the scanner's bore using the standard procedure (the *Home* button). In case you previously cut the electricity or failure of the standard procedure, follow the manual procedure described in the first steps of [manual extraction protocol](#).

- Determine whether the participant can continue the session after some comforting or information or if it must be stopped at that point (e.g., the participant is feeling claustrophobic and cannot continue).
- If the session must be stopped, or you determine it is necessary to extract the participant before making that decision, hit the "Home" button to bring the participant outside the



scanner's bore quickly.

## In case you feel unsafe

If you feel unsafe for any reason (for example, because a patient behaves aggressively or threatens you), CALL SECURITY at [REDACTED].

## Technical difficulties

### If you are facing technical difficulties:

- Seek help from anyone on the BH7 floor.
- If you still have problems or didn't find anyone (e.g., scanning on a weekend), call the ER's MRI staff at [REDACTED].

## A person requires medical attention

At any moment, you may determine that the participant will require medical attention:

- The participant's health has been threatened or is actively at risk (e.g., elevated heart frequency, lack of pulse, respiratory issues, unconsciousness, dizziness, unsteadiness, etc.)

- The participant is unresponsive
- The participant reports feeling unwell and needs attention
- You think they may need medical attention but you are unsure.

#### If you determine that someone needs medical attention, call the resuscitation unit ( █ )

The resuscitation unit ( █ ) is the person to call in any case, even if the participant is not in life-threatening condition.

The phone number of the emergency services can be found on all the phones at CHUV.

After you called the resuscitation unit:

- Press on the heart button [INSERT PICTURE] on the wall, after lifting the security lid. This will guide the intensive care team to the place where they need to intervene. !!! important "In case you pressed the heart button by mistake, turn it off by pressing the adjacent green button."
- If the participant remains in the scanning room, re-enter the room and proceed with the [manual extraction protocol](#).

#### Danger

If the resuscitation team needs to shock the participant for cardiac resuscitation, it must never be done on the MR table.

## Manual extraction procedure

- If the bed is inside the bore:
  - Unlock the manual retrieval of the scanner's bed
  - Pull the bed all the way out of the bore
  - Lock the manual retrieval back
- Lift the table's breaks locking the wheels
- Lift the manual lock of the table's attachment to the bore.
- Pull the bed out of the scanning room
- Reassess the participant's health in the control room and determine a course of action.

#### Resetting the scanner's table after it's been manually detached

- Dock the table onto the scanner's bore by insert the arrow-shaped prong into the docking bay.
- Wait for the MRI screen to indicate it is ready for docking, push down the right attachment pedal with your foot for locking.
- Simultaneously press the up and down buttons to activate the automatic recalibration of the table.

## Immediately report incidents

### **MRI coordinators must be informed**

Once the situation is resolved, and before anything else, send an email to [ ] and [ ]. Make sure to report any potential risk you can anticipate to clinical activity the following day.

# **Data management**

# Post-session retrieval and BIDS

## Within 48h after the FIRST session

### Anatomical images must be screened for incidental findings within 48h after the first session

- Send the T1-weighted and T2-weighted scan to [REDACTED] for screening and incidental findings.
- Indicate on [our recruits spreadsheet \(/redacted.html\)](#) that the participant's first session has been submitted for screening.
- Wait for response from [REDACTED] and note down the result of the screening in our [our recruits spreadsheet \(/redacted.html\)](#).

To do so, you'll need to first [download the data from PACS](#) and then [convert the data into BIDS](#) as indicated below.

### What to do when there are incidental findings

- Discuss with [REDACTED] how to proceed with the participant.
- Exclude the participant from the study if [REDACTED] evaluates they don't meet the participation (inclusion and exclusion) criteria.

## Within one week after the completed session

### Download the data from the PACS with PACSMAN (only authorized users)

- Login into the PACSMAN computer (\*\*)
- Mount a remote filesystem through sshfs:

```
sshfs <hostname>:/data/datasets/hcp-h-pilot/sourcedata \
      $HOME/data/hcp-h-pilot \
      <args>
```

- Edit the query file vim \$HOME/queries/last-session.csv (most likely, just update with the session's date)

mydata-onesession.csv

```
PatientID,StudyDate
2022_11_07*,20230503
```

- Prepare and run PACSMAN, pointing the output to the mounted directory.

```
pacsmen --save -q $HOME/queries/last-session.csv \
--out_directory $HOME/data/hcph-pilot/ \
--config /opt/PACSMAN/files/config.json
```

- Remove write permissions on the newly downloaded data:

```
chmod -R a-w $HOME/data/hcph-pilot/sub-01/ses-*
```

- Unmount the remote filesystem:

```
sudo umount $HOME/data/hcph-pilot
```

Retrieve physiological recordings (from [ ])

Copy original DICOMs into the archive of Stockage HOrUs

- Setup a cron job to execute automatically the synchronization:

```
crontab -e
[ within your file editor add the following line ]
0 2 * * * rsync -avurP /data/datasets/hcph-pilot/* <user>@<host>
```

Within two weeks after the completed session

Convert data to BIDS with HeudiConv

- Careful to change the number of the session ! Note that we use the heuristic -f reproin, because we have name the sequences at the console following ReproIn convention.

Executing HeudiConv

```
#!/bin/bash
heudiconv -s "pilot" -ss "08" -f heuristic_reproin.py -b \
-o /data/datasets/hcph-pilot/ \
--files /data/datasets/hcph-pilot/sourcedata/\
sub-01/\
ses-18950702/ \
-l .
```

The output of *HeuDiConv* with our current heuristics and reproin conventions should be like:

```
└── ses-15
    ├── anat
    │   ├── sub-pilot_ses-15_acq-original_T1w.json
    │   ├── sub-pilot_ses-15_acq-original_T1w.nii.gz
    │   ├── sub-pilot_ses-15_acq-undistorted_T1w.json
    │   ├── sub-pilot_ses-15_acq-undistorted_T1w.nii.gz
    │   ├── sub-pilot_ses-15_T2w.json
    │   └── sub-pilot_ses-15_T2w.nii.gz
    ├── dwi
    │   ├── sub-pilot_ses-15_acq-highres_dir-LR_dwi.bval
    │   ├── sub-pilot_ses-15_acq-highres_dir-LR_dwi.bvec
    │   ├── sub-pilot_ses-15_acq-highres_dir-LR_dwi.json
    │   └── sub-pilot_ses-15_acq-highres_dir-LR_dwi.nii.gz
    ├── fmap
    │   ├── sub-pilot_ses-15_acq-b0_dir-RL_epi.json
    │   ├── sub-pilot_ses-15_acq-b0_dir-RL_epi.nii.gz
    │   ├── sub-pilot_ses-15_acq-bold_dir-RL_part-mag_epi.json
    │   ├── sub-pilot_ses-15_acq-bold_dir-RL_part-mag_epi.nii.gz
    │   ├── sub-pilot_ses-15_acq-bold_dir-RL_part-phase_epi.json
    │   ├── sub-pilot_ses-15_acq-bold_dir-RL_part-phase_epi.nii.gz
    │   ├── sub-pilot_ses-15_magnitude1.json
    │   ├── sub-pilot_ses-15_magnitude1.nii.gz
    │   ├── sub-pilot_ses-15_magnitude2.json
    │   ├── sub-pilot_ses-15_magnitude2.nii.gz
    │   ├── sub-pilot_ses-15_phasediff.json
    │   └── sub-pilot_ses-15_phasediff.nii.gz
    ├── func
    │   ├── sub-pilot_ses-15_task-bht_echo-1_part-mag_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-1_part-mag_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-1_part-phase_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-1_part-phase_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-2_part-mag_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-2_part-mag_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-2_part-phase_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-2_part-phase_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-3_part-mag_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-3_part-mag_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-3_part-phase_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-3_part-phase_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-4_part-mag_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-4_part-mag_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_echo-4_part-phase_bold.json
    │   ├── sub-pilot_ses-15_task-bht_echo-4_part-phase_bold.nii.gz
    │   ├── sub-pilot_ses-15_task-bht_part-mag_events.tsv
    │   ├── sub-pilot_ses-15_task-bht_part-phase_events.tsv
    │   └── sub-pilot_ses-15_task-qct_echo-1_part-mag_bold.json
```

```
    └── sub-pilot_ses-15_task-qct_echo-1_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-1_part-phase_bold.json
    └── sub-pilot_ses-15_task-qct_echo-1_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-2_part-mag_bold.json
    └── sub-pilot_ses-15_task-qct_echo-2_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-2_part-phase_bold.json
    └── sub-pilot_ses-15_task-qct_echo-2_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-3_part-mag_bold.json
    └── sub-pilot_ses-15_task-qct_echo-3_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-3_part-phase_bold.json
    └── sub-pilot_ses-15_task-qct_echo-3_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-4_part-mag_bold.json
    └── sub-pilot_ses-15_task-qct_echo-4_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_echo-4_part-phase_bold.json
    └── sub-pilot_ses-15_task-qct_echo-4_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-qct_part-mag_events.tsv
    └── sub-pilot_ses-15_task-qct_part-phase_events.tsv
    └── sub-pilot_ses-15_task-rest_echo-1_part-mag_bold.json
    └── sub-pilot_ses-15_task-rest_echo-1_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-1_part-phase_bold.json
    └── sub-pilot_ses-15_task-rest_echo-1_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-2_part-mag_bold.json
    └── sub-pilot_ses-15_task-rest_echo-2_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-2_part-phase_bold.json
    └── sub-pilot_ses-15_task-rest_echo-2_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-3_part-mag_bold.json
    └── sub-pilot_ses-15_task-rest_echo-3_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-3_part-phase_bold.json
    └── sub-pilot_ses-15_task-rest_echo-3_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-4_part-mag_bold.json
    └── sub-pilot_ses-15_task-rest_echo-4_part-mag_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_echo-4_part-phase_bold.json
    └── sub-pilot_ses-15_task-rest_echo-4_part-phase_bold.nii.gz
    └── sub-pilot_ses-15_task-rest_part-mag_events.tsv
    └── sub-pilot_ses-15_task-rest_part-phase_events.tsv
    └── sub-pilot_ses-15_scans.tsv
ses-16
└── anat
    ├── sub-pilot_ses-16_acq-original_T1w.json
    ├── sub-pilot_ses-16_acq-original_T1w.nii.gz
    ├── sub-pilot_ses-16_acq-undistorted_T1w.json
    ├── sub-pilot_ses-16_acq-undistorted_T1w.nii.gz
    └── sub-pilot_ses-16_T2w.json
    └── sub-pilot_ses-16_T2w.nii.gz
└── dwi
    ├── sub-pilot_ses-16_acq-highres_dir-RL_dwi.bval
    └── sub-pilot_ses-16_acq-highres_dir-RL_dwi.bvec
```

```
    └── sub-pilot_ses-16_acq-highres_dir-RL_dwi.json
    └── sub-pilot_ses-16_acq-highres_dir-RL_dwi.nii.gz
  fmap
    ├── sub-pilot_ses-16_acq-b0_dir-AP_epi.json
    ├── sub-pilot_ses-16_acq-b0_dir-AP_epi.nii.gz
    ├── sub-pilot_ses-16_acq-b0_dir-LR_epi.json
    ├── sub-pilot_ses-16_acq-b0_dir-LR_epi.nii.gz
    ├── sub-pilot_ses-16_acq-b0_dir-PA_epi.json
    ├── sub-pilot_ses-16_acq-b0_dir-PA_epi.nii.gz
    ├── sub-pilot_ses-16_acq-b0_dir-RL_epi.json
    ├── sub-pilot_ses-16_acq-b0_dir-RL_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-AP_part-mag_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-AP_part-mag_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-AP_part-phase_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-AP_part-phase_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-LR_part-mag_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-LR_part-mag_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-LR_part-phase_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-LR_part-phase_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-PA_part-mag_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-PA_part-mag_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-PA_part-phase_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-PA_part-phase_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-RL_part-mag_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-RL_part-mag_epi.nii.gz
    ├── sub-pilot_ses-16_acq-bold_dir-RL_part-phase_epi.json
    ├── sub-pilot_ses-16_acq-bold_dir-RL_part-phase_epi.nii.gz
    ├── sub-pilot_ses-16_magnitude1.json
    ├── sub-pilot_ses-16_magnitude1.nii.gz
    ├── sub-pilot_ses-16_magnitude2.json
    ├── sub-pilot_ses-16_magnitude2.nii.gz
    ├── sub-pilot_ses-16_phasediff.json
    └── sub-pilot_ses-16_phasediff.nii.gz
  func
    ├── sub-pilot_ses-16_task-bht_echo-1_part-mag_bold.json
    ├── sub-pilot_ses-16_task-bht_echo-1_part-mag_bold.nii.gz
    ├── sub-pilot_ses-16_task-bht_echo-1_part-phase_bold.json
    ├── sub-pilot_ses-16_task-bht_echo-1_part-phase_bold.nii.gz
    ├── sub-pilot_ses-16_task-bht_echo-2_part-mag_bold.json
    ├── sub-pilot_ses-16_task-bht_echo-2_part-mag_bold.nii.gz
    ├── sub-pilot_ses-16_task-bht_echo-2_part-phase_bold.json
    ├── sub-pilot_ses-16_task-bht_echo-2_part-phase_bold.nii.gz
    ├── sub-pilot_ses-16_task-bht_echo-3_part-mag_bold.json
    ├── sub-pilot_ses-16_task-bht_echo-3_part-mag_bold.nii.gz
    ├── sub-pilot_ses-16_task-bht_echo-3_part-phase_bold.json
    ├── sub-pilot_ses-16_task-bht_echo-3_part-phase_bold.nii.gz
    └── sub-pilot_ses-16_task-bht_echo-4_part-mag_bold.json
```

```
    └── sub-pilot_ses-16_task-bht_echo-4_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-bht_echo-4_part-phase_bold.json
    └── sub-pilot_ses-16_task-bht_echo-4_part-phase_bold.nii.gz
    └── sub-pilot_ses-16_task-bht_part-mag_events.tsv
    └── sub-pilot_ses-16_task-bht_part-phase_events.tsv
    └── sub-pilot_ses-16_task-qct_echo-1_part-mag_bold.json
    └── sub-pilot_ses-16_task-qct_echo-1_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-1_part-phase_bold.json
    └── sub-pilot_ses-16_task-qct_echo-1_part-phase_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-2_part-mag_bold.json
    └── sub-pilot_ses-16_task-qct_echo-2_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-2_part-phase_bold.json
    └── sub-pilot_ses-16_task-qct_echo-2_part-phase_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-3_part-mag_bold.json
    └── sub-pilot_ses-16_task-qct_echo-3_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-3_part-phase_bold.json
    └── sub-pilot_ses-16_task-qct_echo-3_part-phase_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-4_part-mag_bold.json
    └── sub-pilot_ses-16_task-qct_echo-4_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_echo-4_part-phase_bold.json
    └── sub-pilot_ses-16_task-qct_echo-4_part-phase_bold.nii.gz
    └── sub-pilot_ses-16_task-qct_part-mag_events.tsv
    └── sub-pilot_ses-16_task-qct_part-phase_events.tsv
    └── sub-pilot_ses-16_task-rest_echo-1_part-mag_bold.json
    └── sub-pilot_ses-16_task-rest_echo-1_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-rest_echo-1_part-phase_bold.json
    └── sub-pilot_ses-16_task-rest_echo-1_part-phase_bold.nii.g
    └── sub-pilot_ses-16_task-rest_echo-2_part-mag_bold.json
    └── sub-pilot_ses-16_task-rest_echo-2_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-rest_echo-2_part-phase_bold.json
    └── sub-pilot_ses-16_task-rest_echo-2_part-phase_bold.nii.g
    └── sub-pilot_ses-16_task-rest_echo-3_part-mag_bold.json
    └── sub-pilot_ses-16_task-rest_echo-3_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-rest_echo-3_part-phase_bold.json
    └── sub-pilot_ses-16_task-rest_echo-3_part-phase_bold.nii.g
    └── sub-pilot_ses-16_task-rest_echo-4_part-mag_bold.json
    └── sub-pilot_ses-16_task-rest_echo-4_part-mag_bold.nii.gz
    └── sub-pilot_ses-16_task-rest_echo-4_part-phase_bold.json
    └── sub-pilot_ses-16_task-rest_echo-4_part-phase_bold.nii.g
    └── sub-pilot_ses-16_task-rest_part-mag_events.tsv
    └── sub-pilot_ses-16_task-rest_part-phase_events.tsv
└── sub-pilot_ses-16_scans.tsv
```

We started to generate phase and magnitude only after session 15

As a result, the piloting data up to session 14 will look more like:

```
ses-14
├── anat
│   ├── sub-pilot_ses-14_acq-original_T1w.json
│   ├── sub-pilot_ses-14_acq-original_T1w.nii.gz
│   ├── sub-pilot_ses-14_acq-undistorted_T1w.json
│   ├── sub-pilot_ses-14_acq-undistorted_T1w.nii.gz
│   ├── sub-pilot_ses-14_T2w.json
│   └── sub-pilot_ses-14_T2w.nii.gz
├── dwi
│   ├── sub-pilot_ses-14_acq-highres_dir-PA_dwi.bval
│   ├── sub-pilot_ses-14_acq-highres_dir-PA_dwi.bvec
│   ├── sub-pilot_ses-14_acq-highres_dir-PA_dwi.json
│   └── sub-pilot_ses-14_acq-highres_dir-PA_dwi.nii.gz
├── fmap
│   ├── sub-pilot_ses-14_acq-b0_dir-AP_epi.json
│   ├── sub-pilot_ses-14_acq-b0_dir-AP_epi.nii.gz
│   ├── sub-pilot_ses-14_acq-bold_dir-PA_run-1_epi.json
│   ├── sub-pilot_ses-14_acq-bold_dir-PA_run-1_epi.nii.gz
│   ├── sub-pilot_ses-14_acq-bold_dir-PA_run-2_epi.json
│   ├── sub-pilot_ses-14_acq-bold_dir-PA_run-2_epi.nii.gz
│   ├── sub-pilot_ses-14_magnitude1.json
│   ├── sub-pilot_ses-14_magnitude1.nii.gz
│   ├── sub-pilot_ses-14_magnitude2.json
│   ├── sub-pilot_ses-14_magnitude2.nii.gz
│   ├── sub-pilot_ses-14_phasediff.json
│   └── sub-pilot_ses-14_phasediff.nii.gz
└── func
    ├── sub-pilot_ses-14_task-bht_echo-1_bold.json
    ├── sub-pilot_ses-14_task-bht_echo-1_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_echo-2_bold.json
    ├── sub-pilot_ses-14_task-bht_echo-2_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_echo-3_bold.json
    ├── sub-pilot_ses-14_task-bht_echo-3_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_echo-4_bold.json
    ├── sub-pilot_ses-14_task-bht_echo-4_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_events.tsv
    ├── sub-pilot_ses-14_task-bht_run-1_echo-1_bold.json
    ├── sub-pilot_ses-14_task-bht_run-1_echo-1_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-1_echo-2_bold.json
    ├── sub-pilot_ses-14_task-bht_run-1_echo-2_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-1_echo-3_bold.json
    ├── sub-pilot_ses-14_task-bht_run-1_echo-3_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-1_echo-4_bold.json
    ├── sub-pilot_ses-14_task-bht_run-1_echo-4_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-1_events.tsv
    ├── sub-pilot_ses-14_task-bht_run-2_echo-1_bold.json
    ├── sub-pilot_ses-14_task-bht_run-2_echo-1_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-2_echo-2_bold.json
    ├── sub-pilot_ses-14_task-bht_run-2_echo-2_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-2_echo-3_bold.json
    ├── sub-pilot_ses-14_task-bht_run-2_echo-3_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-2_echo-4_bold.json
    ├── sub-pilot_ses-14_task-bht_run-2_echo-4_bold.nii.gz
    ├── sub-pilot_ses-14_task-bht_run-2_events.tsv
    ├── sub-pilot_ses-14_task-qc_echo-1_bold.json
    ├── sub-pilot_ses-14_task-qc_echo-1_bold.nii.gz
    ├── sub-pilot_ses-14_task-qc_echo-2_bold.json
    └── sub-pilot_ses-14_task-qc_echo-2_bold.nii.gz
```

```

    └── sub-pilot_ses-14_task-qc_echo-3_bold.json
    └── sub-pilot_ses-14_task-qc_echo-3_bold.nii.gz
    └── sub-pilot_ses-14_task-qc_echo-4_bold.json
    └── sub-pilot_ses-14_task-qc_echo-4_bold.nii.gz
    └── sub-pilot_ses-14_task-qc_events.tsv
    └── sub-pilot_ses-14_task-rest_echo-1_bold.json
    └── sub-pilot_ses-14_task-rest_echo-1_bold.nii.gz
    └── sub-pilot_ses-14_task-rest_echo-2_bold.json
    └── sub-pilot_ses-14_task-rest_echo-2_bold.nii.gz
    └── sub-pilot_ses-14_task-rest_echo-3_bold.json
    └── sub-pilot_ses-14_task-rest_echo-3_bold.nii.gz
    └── sub-pilot_ses-14_task-rest_echo-4_bold.json
    └── sub-pilot_ses-14_task-rest_echo-4_bold.nii.gz
    └── sub-pilot_ses-14_task-rest_events.tsv
└── sub-pilot_ses-14_scans.tsv

```

## Convert physiological recordings and eye-tracking data to BIDS

- Plot an overview of the data with the following command. This command generates a PNG plot of the data within the current directory without processing the data itself. The physiological data folder is specified via the `-in` command line argument.

```
phys2bids -in /data/datasets/hcppilot/sourcedata/physio/sess:
```

- Check that all the channels are present in the PNG plot.
- If this is the case, proceed to process the file using the subsequent command. Use the `-ntp` argument to specify the number of volumes for each task, and the `-tr` argument to indicate the task's repetition time. Define the output directory with `-outdir` and provide the path to the heuristic file using `-heur`. Adjust the subject and session numbers accordingly. Should scanner trigger transmission encounter issues and manual adjustments are made to the trigger data, it is possible to allocate one trigger per task. Set the repetition time duration as the task length, as demonstrated in the example below.

```
phys2bids -in modified-last-session_multiscan.txt -chtrig 4 -n1
```

- Execute the script `write_event_file.py` as shown below to generate task event files. This script creates JSON and TSV files containing event information and generates PNG plots for each task, displaying both physiological data and corresponding events. These plots are saved in the current directory. The script must be executed with the following command, where `outputdir` is the output directory of `phys2bids`:

```
python write_event_file.py --path ./outputdir/sub-pilot/ses-01,
```

Once the script is executed, the BIDS folder (consisting solely of physiological data in this case) will have the following structure:

```
ses-01
└── func
    ├── sub-pilot_ses-01_task-bht_events.json
    ├── sub-pilot_ses-01_task-bht_events.tsv
    ├── sub-pilot_ses-01_task-bht_physio.json
    ├── sub-pilot_ses-01_task-bht_physio.tsv.gz
    ├── sub-pilot_ses-01_task-qct_events.json
    ├── sub-pilot_ses-01_task-qct_events.tsv
    ├── sub-pilot_ses-01_task-qct_physio.json
    ├── sub-pilot_ses-01_task-qct_physio.tsv.gz
    ├── sub-pilot_ses-01_task-rest_events.json
    ├── sub-pilot_ses-01_task-rest_events.tsv
    ├── sub-pilot_ses-01_task-rest_physio.json
    └── sub-pilot_ses-01_task-rest_physio.tsv.gz
```

## Incorporate into version control with DataLad

### Initiating the version-controlled dataset

Once at the beginning of the project, the datalad dataset will be created:

- Add stockage horus as an SSH remote.

# QC of unprocessed data

## Executing MRIQC

- Register the MRIQC container with DataLad containers-run
- Run MRIQC:

```
datalad containers-run \
    --container-name containers/mriqc \
    --input sourcedata \
    --output . \
    '{inputs}' '{outputs}' participant --session lastsession -v
```

- Screen the T1w, DWI and BOLD visual reports, assign a quality assessment using Q'Kay
- If either the dMRI or the RSfMRI quality is insufficient, schedule an extra session after the initially-planned scanning period to reacquire it.

# Preprocessing

## Defacing

The first step before releasing the data is to deface the T1w and T2w images for all sessions. To perform defacing, we are using a software called PyDeface (Gulban et al. 2019). To proceed, run the following command in the command line:

```
bash ./code/defacing/run_pydeface.sh
```

## References

- [1]: Gulban, Omer Faruk, Dylan Nielson, Russ Poldrack, John Lee, Chris Gorgolewski, Vanessa Sochat, and Satrajit Ghosh. 2019. “Poldracklab/Pydeface: V2.0.0.” Zenodo. doi: 10.5281/zenodo.3524401.