

Breath hold task: gas analyzer and respiration belt

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Introduction

In this report, we will explain how to set up a fMRI breath holding task with the ML206 Gas Analyzer, ADINSTRUMENTS and the RX-TSD221-MRI BIOPAC Systems, Inc. [3]. respiration belt. All the inputs are sent to the MP160 BIOPAC Systems, Inc.^[2] and displayed with the AcqKnowledge software.

CO₂/O₂ Gas analyzer

Before using the gas analyzer (GA) system, calibrate it with O₂ every 2 to 3 months.

- Get a gas bottle with a known CO₂ concentration between 5% and 10%.
- Connect the GA to the BIOPAC as described below and start recording signal.
- 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[4].

To setup the system, follow the steps written below.

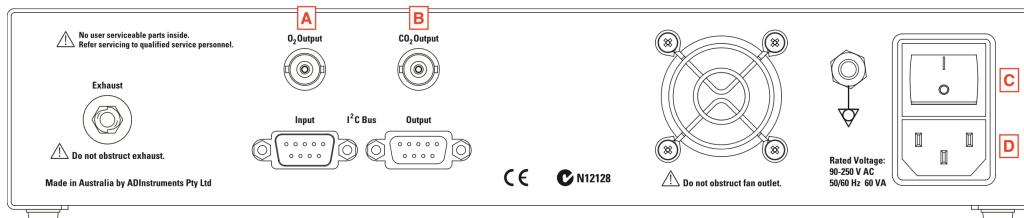


Figure 1: Schemes of the back/rear panel of the ML206 Gas Analyzer, ADINSTRUMENTS^[4]

1. Branch the power supply (Fig. 1, D).
2. Branch the *BNC-BNC cables*^[4] to the CO₂ and/or O₂ output of the gas analyzer (rear panel, Fig. 1, A and B).
3. Connect the *BNC-BNC cable* to the INISOA BIOPAC Systems Inc.[1] filter (Fig. 2). This step prevents the noise to go back from Biopac^[2] to the gas analyzer.
4. Connect the *RJ-11-RJ-11 cable* from the filter to the Biopac^[2] (Gas analyzer, Fig. 5a). You can choose your favorite channel (e.g. channel 3). **Be careful not to use the channel of the respiration belt or the ECG (Fig. 5c).**
5. Connect the nasal cannula to the *MLA0343 drying tube*^[4] (Fig. 4a), to prevent any moisture damage to the analyzer. After some time, it will change color and will need to be changed. The cannula should also be changed regularly to prevent bubbles from forming. **TODO: buy the piece to connect it.**
6. Connect this tube to a "flexible" extension tube and to a *MLA0110 in-line filter*^[4] (Fig. 4b).
7. Pass the cable through the hole to reach the MRI room (Fig. 4c). **You should have enough extension tube so that it can lie on the floor.** If the tube is stretched, it will induce waves on the signal !
8. Connect the in-line filter^[4] to the *Sample In* (Fig. 3 B).

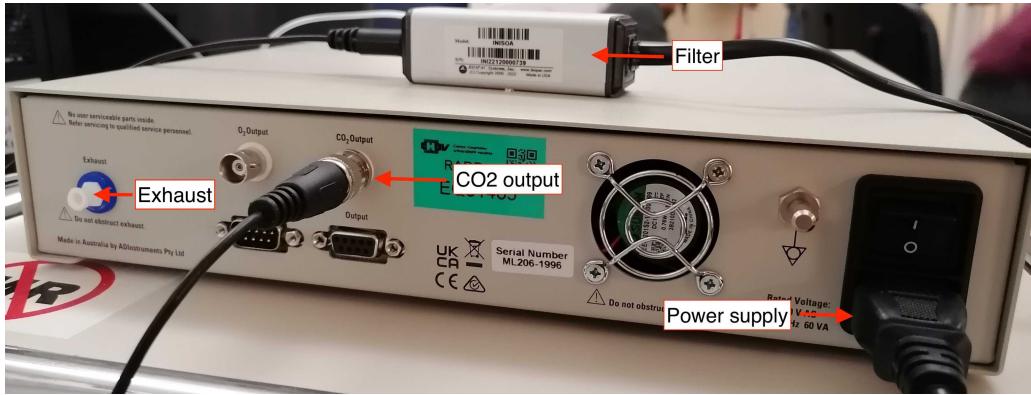


Figure 2: CO₂ cable and Biopac filter, back panel of the ML206 Gas Analyzer, ADINSTRUMENTS^[4]

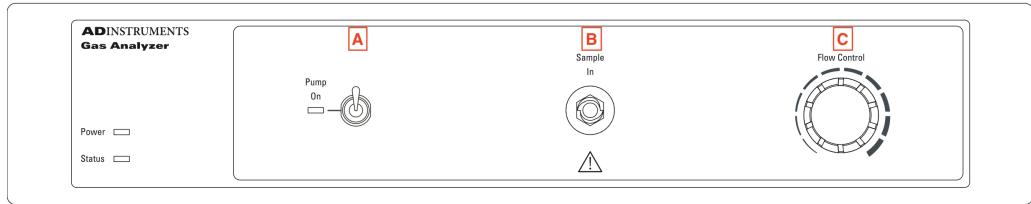


Figure 3: Schemes of the front panel of the ML206 Gas Analyzer, ADINSTRUMENTS^[4]

9. Switch the power on (Fig. 1 C).
10. Before switching the *Pump On*, make sure that the in-line filter is fixed to the *Sample In* or that no cap is on the *Sample In*. **Don't start if the cap is on, this would damage the system !!**
11. Switch the *Pump On* 30 minutes before your experiment to let the device warm up (front panel, Fig. 3 B).
12. Put the *Flow control* to the maximum aspiration strength to decrease the noise in the signal (front panel, Fig. 3 C).
13. Set up your subject (Fig. 4d).
14. Before starting the acquisition, check that everything works as expected. To do so, ask your subject to do the following task: breathing in during 3s, then out during 3s. Do this 3 times. The last time, ask your subject to hold his/her breath for 3s and then breath out again.

Respiration belt

1. Pass the rigid tube (AFT30XL - 10m) through the hole to enter the MRI room (Fig. 4c).
2. Connect the respiration belt tube to the belt.
3. Connect the other extremity of the tube to the Biopac TSD160A ^[2] (respiration tube, Fig. 5a). Plug the tube to the “-” input if you want the signal to decrease when breathing out.
4. Set up the subject (Fig. 4d). Be careful to put the belt at the correct height: some subjects breathe more at the chest level, some at the abdominal level. Tighten the belt enough (but don't suffocate him/her either). Don't put any pressure on the tube: no arm or leg on it.

Biopac

The Biopac^[2] systems integrates all the signals together (Fig. 5a).

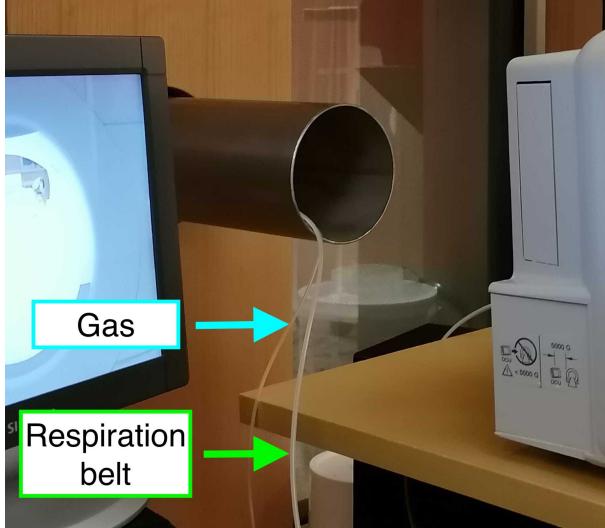
1. Connect the power supply (Fig. 5b).
2. Connect the Gas analyzer cable to one channel. This should have already been done in previous section.



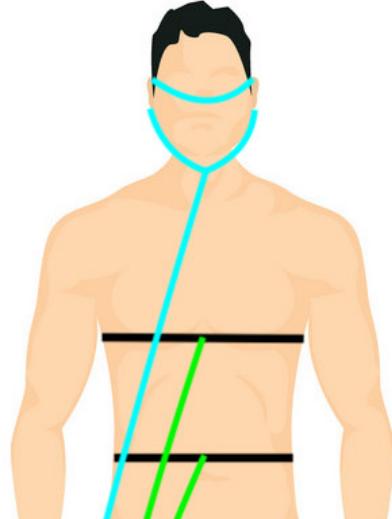
(a) MLA0343 Drying Tube



(b) MLA0110 in-line filter^[4]



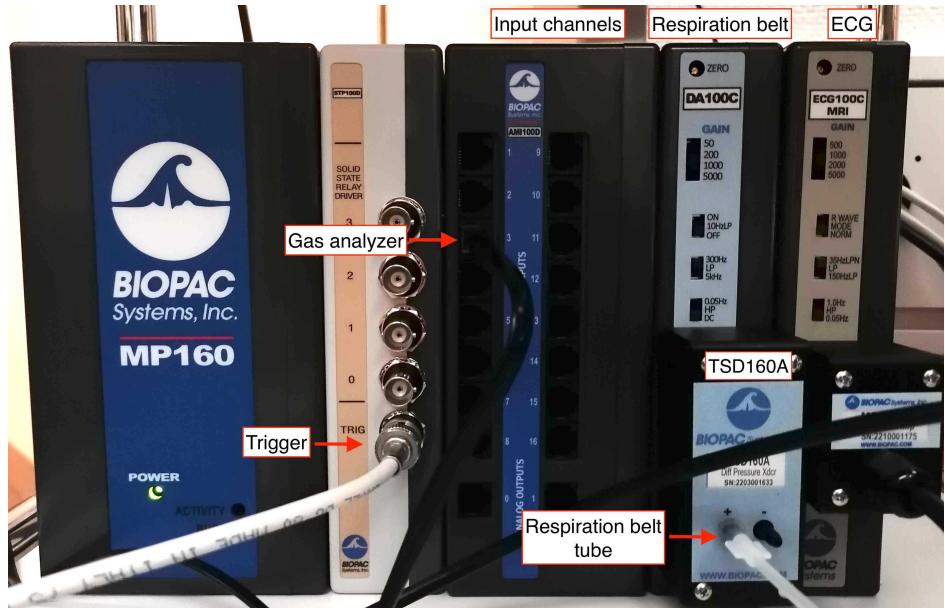
(c) Tubes setup



(d) Scheme of the subject setup

Figure 4: a) MLA0343 Drying tube, ADINSTRUMENTS^[4]. b) in-line filter. c) Gas and respiration belt tubes going from the MRI to the control room. The gas tube is more flexible than the respiration belt one. d) The nasal cannula is shown in blue. The respiration belt is depicted in black, at two different heights and the respiration belt tube is shown in green.

3. Connect the Respiration belt tube to the respiration belt unit. This should have already been done in previous section. On the top of the unit, you can choose its channel.
4. Connect the ethernet cable to the CHUV computer (Fig. 5b).
5. Switch on the power supply.



(a) Front panel



(b) Back panel



(c) Front panel, zoomed in

Figure 5: Front (a) and rear/back (b) panels of MP160 data acquisition systems, BIOPAC®systems inc.^[2], with STP100D unit, AMI100D input channel unit, DA100C respiration belt unit, ECG100C MRI ECG unit. (c) DA100C and ECG100C MRI zoomed in

Trigger

The fMRI trigger should be connected to the computer. Technically, the AcqKnowledge software could be linked to the trigger as well. **TODO: find how.**

1. Switch on the trigger box (Fig. 6c).
2. Check the connection with the MRI (optic fiber MRI, Fig. 6c).
3. Connect it to Biopac (trigger Biopac, Fig. 6c).
4. Connect it to the computer (trigger PC, Fig. 6c).
5. Choose mode (Fig. 6a).
6. Start session (Fig. 6b).



Figure 6: Trigger box

CHUV computer

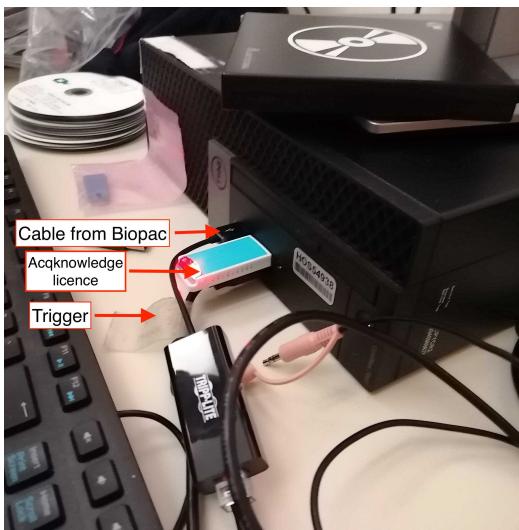
If you're using the CHUV computer:

1. Plug in the trigger cable (Fig. 7a).
2. Plug in the ethernet cable from Biopac (Fig. 7a).
3. Open AcqKnowledge software.

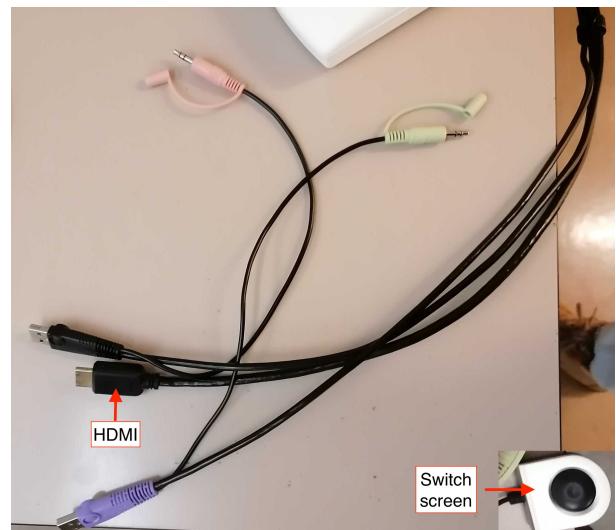
Laptop

If you're using your personal laptop:

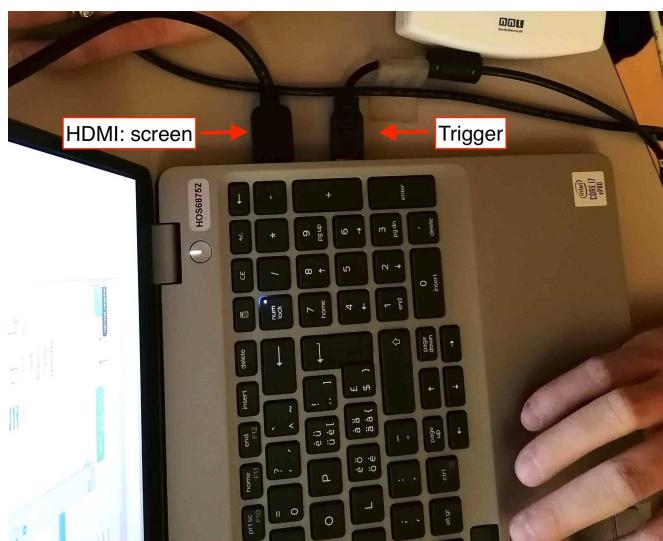
1. Plug in the hdmi cable (Fig. 7b, 7c).
2. Press the black button to display your laptop screen on the CHUV computer (Fig. 7b). Check if the display is correct.
3. Plug in the trigger cable (Fig. 7c).



(a) CHUV computer setup



(b) Screen cable and switch



(c) Laptop setup

Figure 7: Cable management. a) CHUV computer. b) Screen cable and switch. The HDMI for the screen is connected to the colored cables. c) Laptop setup.

AcqKnowledge software

When starting your experiment, choose a longer acquisition length to be sure everything is stored properly.

Data analysis

When analyzing the data, you should not detrend the CO₂ and the cardiac signal. Indeed, they can naturally increase with hypercapnia. Nevertheless, if the respiration belt has a drift, you can apply linear detrending on the signal. If doesn't move, the belt minimum should be stable.

The respiration belt and the gas analyzer signals display some delay, in the order of miliseconds and seconds, respectively. More precisely, the RB has a delay of 3 ms per meter of tubing [?]. To synchronize them with the acquisition, you should take the bold signal in the grey matter as a reference and register the signals with it. Use a grey matter mask or a cerebellum mask. The latter being surrounded by blood vessels, it is a good choice to have a strong bold signal.

References

- [1] Input Signal Isolation Adapter | INISOA, OUTISOA | Research | BIOPAC. URL: <https://www.biopac.com/product/signal-isolation-adapters/>.
- [2] Mp160 systems product sheet. URL: <https://www.biopac.com/wp-content/uploads/MP160-Systems.pdf>.
- [3] Respiration Transducer for MRI | TSD221-MRI | Research | BIOPAC. URL: <https://www.biopac.com/product/respiration-transducer-for-mri/>.
- [4] Adinstruments ml206 owner's manual pdf download, Aug 2020. URL: <https://www.manualslib.com/manual/1851941/Adinstruments-ML206.html>.