

## Music Memory

In this repository, you will find the implementation of experimental paradigms investigating musical memory and imagery with intracranial EEG and MEG. The experiment consists of three tasks, with versions in English (for psychopy 3.1.2 and 2021.2.3) and Spanish (for psychopy 2021.2.3). For Knight-lab laptops, **Psychopy 3.1.2** version should be used (launched from the conda environment “david” – see below). The tasks are also implemented in BCI2000 (currently set in Loma Linda and Wash U – see below).

### Taks:

1- A recognition memory task in which participants listen to a short musical excerpt (from a J.S. Bach work) and afterwards are presented with short melodies which could belong or not to the musical excerpt. Participants decide whether each melody is "old" or "new".

2- A localizer block in which participants are presented each of the three tones used in task 3 in random order (avoiding consecutive repetitions). After each sound, participants are asked to imagine it very vividly in their minds without singing or moving otherwise.

3- A working memory and imagery task (maintenance) in which participants are presented with a short three-note melody, then are asked to imagine it vividly on cue (without singing or moving), and finally are required to decide if the second melody is the same or different from the first. In this task, there is a second block (manipulation) in which participants need to mentally invert the melody in their minds (e.g., ABC becomes CBA) and judge whether the second melody is an inverted version of the first or not. The two blocks (maintenance and manipulation) are counterbalanced across subjects.

### Background questionnaire

In addition, before the task is implemented, a musical background and imagery questionnaire should be completed by the participants. English and Spanish versions of the questionnaire can be found in these links:

- In English:

<https://survey.au.dk/LinkCollector?key=FH7L913WUNC1>

- In Spanish:

<https://survey.au.dk/LinkCollector?key=PF3V793FLP1N>

A physical copy of the questionnaires can also be used (see PDFs in the folder).

### Task versions and scripts

For tasks 2 and 3 we have both MEG and iEEG versions in English (psychopy 2021.3.2 only). These are the corresponding implementations of each task, for different Psychopy versions and different languages:

Implementations in English using Psychopy 3.1.2:

- task 1 scripts/LerningBach\_iEEG\_3.1.2.py
- task 2 scripts/localizer\_iEEG\_3.1.2.py
- task 3 scripts/manipulation\_task\_iEEG\_3.1.2.py

Implementations in English using Psychopy 2021.2.3

- task 1 scripts/LerningBach\_iEEG\_spanish.py
- task 2 scripts/localizer\_iEEG\_spanish.py (for iEEG) and scripts/localizer\_MEG.py (for MEG)
- task 3 scripts/manipulation\_task\_iEEG\_spanish.py (for iEEG) and scripts/manipulation\_task\_MEG.py (for MEG)

Implementations in Spanish using Psychopy 2021.2.3

- task 1 scripts/LerningBach\_iEEG.py
- task 2 scripts/localizer\_iEEG.py
- task 3 scripts/manipulation\_task\_iEEG.py

The three tasks should be presented in this order: 1, 2, 3 or this order: 2, 3, 1; so that the localizer always precedes the maintenance/manipulation task. These two orders may be counterbalanced across participants.

### **Master scripts**

To facilitate running the tasks, master scripts have been created in which the order is predetermined. However, if desired, blocks can be run individually and / or in a custom order as specified in a prompt dialogue at the beginning:

Task run in English using Psychopy 3.1.2 (default for Knight-lab laptops).

- scripts/task\_run\_iEEG\_3.1.2.py

Task run in English using Psychopy 2021.2.3

- scripts/task\_run\_iEEG.py

Task run in Spanish using Psychopy 2021.2.3

- scripts/task\_run\_iEEG\_spanish.py

### **Task durations**

These are the approximate durations and number of trials in each task:

For iEEG

- task 1: 42 trials (21 old, 21 new) (5 minutes)

- task 2: 120 trials (40 for each tone) (5 minutes)
- task 3: 96 trials (48 maintenance: 24 same, 24 different; 48 manipulation: 24 inverted, 24 not inverted/other) (17 minutes)

For MEG:

- task 2: 180 trials (60 for each tone) (8 minutes)
- task 3: 120 trials (60 maintenance: 30 same, 30 different; 60 manipulation: 30 inverted, 30 not inverted/other) (21 minutes)

Stimuli found under the "stimuli" folder. Log files stored in the "logs" folder.

### Software requirements

**Linux** and **Psychopy 3** (versions above 2021 if triggers are needed or v3.1.2 if sound onsets or photodiode are recorded otherwise).

### Externals

- Keyboard for participant responses.
- Photodiode to record screen onsets. This may be crucial if information about sound onsets is not obtained otherwise.
- Either headphones or loudspeakers to present the stimuli.

### Instructions to run the tasks (Psychopy)

- 1- Open the link to the online questionnaire provided above and make sure the participant answers all the questions.
- 2- To run the task, open Psychopy 3.1.2 (alternatively 2021.2.3 if appropriate):
  - Open the bash terminal and write 'conda activate david' (works for Knight-lab laptops)
  - Then type 'psychopy'
  - Alternatively, you can run the task directly from the command line (only for knight-lab laptops):
    - Open the bash terminal and write "conda activate david"
    - Navigate (cd) to the scripts folder and type "python task\_run\_iEEG\_3.1.2.py".
    - Skip step 3 and go to step 4
  - For non-Knight-lab laptops, Psychopy may be installed in different places. Ask around.
- 3- In the coder, open the script "scripts/task\_run\_iEEG\_3.1.2.py" (or alternative task-run version; see above), click on the "run" button and write the subject code in the pop-up window. Also specify the tasks to run in the desired order (leaving blank the field will run all the tasks in a pseudorandom order).
- 4- At the beginning of each task, you will be asked to confirm participant info, whether a photodiode is used and other information. Usually the default settings are correct, but double check just in case.
- 5- After the tasks finish, make sure to retrieve and store the corresponding log files. Tasks 2 and 3 have both a default and a custom log file. Task 1 has only a custom log file.

## BCI2000 instructions

In BCI2000, all the tasks can be run by opening one of the batch files located under the batch.ECoG folder of the local BCI2000 installation. There are four different versions of the task, each one corresponding to a different task order, which should ideally be counterbalanced across subjects:

- 1- fragment\_music\_memory\_task1
- 2- fragment\_music\_memory\_task2
- 3- fragment\_music\_memory\_task3
- 4- fragment\_music\_memory\_task4

For each subject, run **only one** of the four versions and try to make sure this version hasn't been used with the last three subjects. However, if you are in doubt or if things get messy, feel free to run any of the four versions at will.

### Tips and caveats:

Make sure that the participant fully understands the nature of the task. Emphasize that they should imagine the sounds vividly in their minds when indicated to do so. Also emphasize that they shouldn't overtly sing or otherwise reproduce the sounds with their bodies.

If your system requires sending triggers, please make sure to update the parallel port address to match your local machine in the script "triggers.py". If your system does not record triggers, please make sure to record sound onsets otherwise (e.g., recording the sound signal, recording the photodiode). Make sure the photodiode fully covers the white square in the bottom left corner of the screen.

Task 1 on one hand, and task 2-3 on the other hand can be run independently, for example if there is little time or the participant is tired. Task 1 can be a nice and easy addition to any data collection as it only takes 5 minutes.

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