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Data Article

The aging brain: A set of functional MRI data acquired at rest and during exposure to tactile or muscle proprioceptive stimulation in healthy young and older volunteers

Caroline Landelle[a,b], Julien Sein[c], Jean-Luc Anton[c], Bruno Nazarian[c], Olivier Felician[d], Anne Kavounoudias[a,*]

[a] *Aix Marseille Univ, CNRS, LNSC (Laboratoire de Neurosciences Sensorielles et Cognitives - UMR 7260), 3 place Victor Hugo 13331, Marseille, France*
[b] *McConnell Brain Imaging Centre, Montreal Neurological Institute, McGill University, Montreal, QC, Canada*
[c] *Aix Marseille Univ, CNRS, Centre IRM-INT@CERIMED (Institut des Neurosciences de la Timone – UMR 7289), Marseille, France*
[d] *Aix Marseille Univ, INSERM, INS (Institut des Neurosciences des Systèmes - UMR1106), Marseille, France*

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ABSTRACT

There is a growing interest in understanding functional brain decline with aging. The dataset provides raw anatomical and functional images recorded in a group of 20 young volunteers and in another group of 19 older volunteers during a 10-minute period of resting state followed by four consecutive task-related runs. During each task-related run, the participants were exposed to two types of sensory stimulation: a tactile stimulation consisting in a textured-disk rotation under the palm of their right hand or a muscle proprioceptive stimulation consisting in a mechanical vibration applied to the muscle tendon of their wrist abductor. These two stimulations are known to evoke illusory sensations of hand movement, while the hand remains actually still. Therefore, the dataset is meant to be used to assess age-related functional brain changes during the perception of hand movements based on muscle proprioception or touch individually. It also allows to explore any structural changes or functional

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* Corresponding author.
E-mail address: Anne.Kavounoudias@univ-amu.fr (A. Kavounoudias).

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resting connectivity alteration with aging. The dataset is a supplement to the research findings in the paper 'Functional brain changes in the elderly for the perception of hand movements: a greater impairment occurs in proprioception than touch published in NeuroImage.

Specifications Table

Subject	Cognitive Neuroscience
Specific subject area	Functional neuroimaging, resting-state functional connectivity, aging, sensory integration
Type of data	Images
How data were acquired	Magnetic Resonance Imaging (3T Prisma scanner; Siemens, Erlangen, Germany) with a body-coil for radio frequency excitation and the manufacturer's 64-channel phase-array head coil for reception
Data format	Raw NIFTI (Neuroimaging Informatics Technology Initiative) format
Parameters for data collection	Fieldmap images were acquired with a spin-echo EPI (Echo-planar imaging) sequence twice with opposite phase encode directions along the anterior-posterior: TR/TE = 7060/59 ms, voxel size = $2.5 \times 2.5 \times 2.5$ mm^3, slices = 54, FOV (Field of View) = 210×210 mm^2, flip angle = 90/180° BOLD images were acquired using a gradient-echo EPI with a multi-band gradient sequence with a factor of 3 that cover the whole brain and cerebellum: TR= 1224 ms, TE= 30 ms, flip angle = 65°, slices= 54, voxel size= $2.5 \times 2.5 \times 2.5$ mm^3, FOV= $256 \times 256 \times 204.8$ mm^3 T1-weighted anatomical image: 3D MPRAGE sequence TR/TI/TE = 2400/1010/2.28 ms, voxel size = $0.8 \times 0.8 \times 0.8$ mm3, slices = 256, FOV = $256 \times 256 \times 204.8$ mm3, flip angle = 8°
Description of data collection	Data were recorded in 39 subjects, 19 elderly (6 men/13 women; mean: 69.2 ± 3.3 years) and 20 young (7 men/ 13 women; mean: 23.7 ± 2.8 years) healthy volunteers. - T1-weighted anatomical image is available for each participant in this dataset. - A total of 284 T2*-weighted images were recorded during the 10 min of resting-state acquisition, while participants were asked to keep their eyes open and fix a foveal cross. - A total of 1136 T2*-weighted images were also recorded when participants underwent 4 successive task-related runs during which a random mixture of proprioceptive and tactile stimulations were delivered at two levels of intensity. Each stimulus lasted 10 s. A total of 20 stimuli of each modality and intensity were presented in each run (2 modalities x 2 intensities x 5 stimuli x 4 runs).
Data source location	Institution: Aix-Marseille University City/Town/Region: Marseille Country: France Latitude and longitude for collected samples/data: 43.288881, 5.403347
Data accessibility	Repository name: Aging Data identification number: OpenNeuro Accession Number: ds002872 Direct URL to data: https://doi.org/10.18112/openneuro.ds002872.v1.0.0
Related research article	C Landelle, JL Anton, B Nazarian, J Sein, A Gharbi, O Felician, A Kavounoudias. Functional brain changes in the elderly for the perception of hand movements: a greater impairment occurs in proprioception than touch. Neuroimage **220,** 2020, https://*doi.org/10.1016/j.neuroimage.2020.117056*

1. Value of the data

- These data can be used to replicate the results of [1].
- These data can be used for investigating functional connectivity during resting-state in younger and older adults.
- These data can be analysed by cognitive neuroscientists to further understand the age-related changes in hand movement perception from proprioceptive and/or tactile information
- These data could be exploited for investigating brain anatomical changes with aging

2. Data description

The released dataset contains one directory for each participant called sub-XX where XX is the participant number. Each subject's directory is composed of 3 subdirectories named 'anat', 'fmap' and 'func' that respectively contains the anatomical, fieldmap and functional raw images recorded for each of the 39 participants who underwent the experiment (20 young and 19 older adults). The 'anat' folder contains T1-weighted ('sub-XX_T1w.nii.gz') anatomical image with skull stripped and the corresponding descriptive files with '.json' extension. The folder 'fmap' is composed of 6 fieldmap images and the corresponding descriptive files with '.json' extension. The 'func' directory regroups 4D functional images including the resting-state run ('XX_task-rest_bold.nii.gz') and the four task-related run acquisitions ('XX_task-illusion_runYY_bold.nii.gz', where YY is the run number), again with the corresponding descriptive files with '.json' extension. This 'func' folder also contains tabulated files of the events ('XX_task-illusion_runYY_events.tsv'). All brain images are compressed in NIFTI format and accompanied by a descriptive tabulated file.

The 'derivatives' folder contains automatic prediction of quality and visual reporting of raw MRI scans (MRIQC) [2]. Group and individual reports are available in the subfolder 'mriqc'.

A 'sourcedata' directory is composed of one directory for each participant and contains 4 event files (.txt) and 4 audio files (.wav), one for each run. Each event file gives precise information about the protocol in the following columns: 1- 'CONDITION': name of the onset, 2- 'DISK': the velocity of the disk rotation in volt (0 = no rotation; 3 volts = 10°/s; 8 volts= 30°/s), 3-: non-useful column, 4- 'Vib (SLOW/FAST)': the vibration condition (0= no vibration; SLOW = 30 Hz; FAST= 60 Hz), 5- 'DURATION (trigger)': the duration in trigger, 6 and 7: non-useful columns, 8- 'BIP': the auditory beeps (0: no beep, 1=beep), 9-'ONSETS_TRIGGERS': the onsets in trigger and 10- 'ONSETS_MS': the onsets in millisecond. Audio files correspond to the recording of participant's oral responses during each task-related run.

3. Experimental design, materials and methods

3.1. Participants

Twenty elderly volunteers (6 men; average age: 69.2 ± 3.3 years) and 20 gender-matched young volunteers (7 men; average age: 23.7 ± 2.8 years) were recruited for the experiment. One older participant was not included in the study because he was unable to complete the MRI scanning.

All participants were right-handed according to the Edinburgh handedness scale (Oldfield 1971). A systematic inclusion medical examination was conducted prior to the experiment to confirm that none of young and old participants had any sensory-muscular disease, neurological disorders or cardiovascular risk factors.

All participants gave their written informed consent in accordance with the guideline of the local ethics committee (CCP Marseille Sud 1 #RCB 2010-A00359-30) (Fig 1).

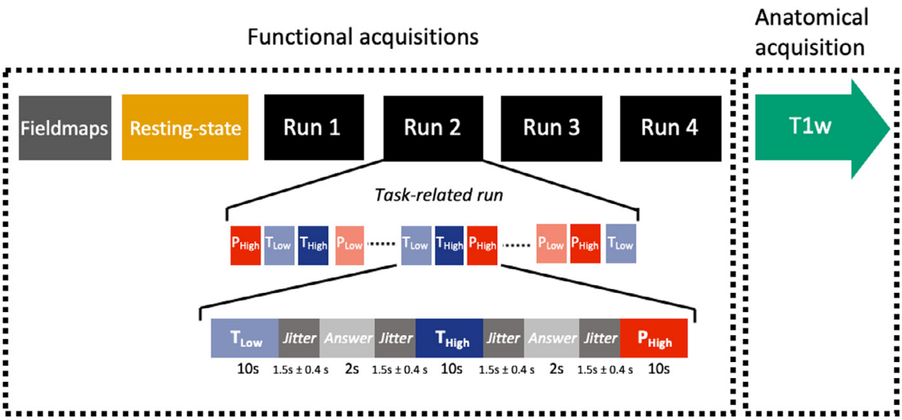

Fig. 1. Experimental design. Illustration of the scanning session including functional and anatomical brain acquisitions. Each task-related run (in black) included 4 stimulation conditions (P_{Low}, P_{High}, T_{Low}, T_{High}) pseudorandomly presented 5 times each for a total of 20 trials per run. Each trial consisted of a 10 s stimulation followed by a first jitter interval (1.5 ± 0.4 s), 2 s to answer the question "Did you feel the illusion?", and a second jitter interval (1.5 ± 0.4 s).

3.2. Experimental procedure (Fig 1)

The experiment began with the acquisition of two fieldmaps, followed by a 10-minute period of resting-state acquisition during which the participants were asked to fix a cross and to think about nothing in particular. Then, an event-related MRI protocol was presented, including four consecutive runs. During these task-related runs, participants were asked to close their eyes while undergoing a random mixture of tactile (disk rotation) and proprioceptive (muscle vibration) stimuli at low (P_{Low} or T_{Low}) or high (P_{High}or T_{High}) intensity level, each of which were repeated five times per run. Participants were instructed to focus on the movement sensation of their right hand that they could experience during both the tactile and proprioceptive stimulations. To make sure that participants remained awake and focused on the task, they were asked to answer orally ‘Yes' at the end of each stimulation if they perceived an illusory movement sensation and ‘No' if they did not. Two auditory beeps indicated the time interval of the response: one delivered on average 1.5 s after the sensory stimulus with a jitter interval of 1.5 ± 0.4 s, and the second, which announced the end of the response period, was delivered 2 s after the first beep followed by a jitter interval of 1.5 ± 0.4 s before the onset of the next stimulus. The 4 runs were presented in a random order between the participants.

3.3. Sensory stimuli

Proprioceptive and tactile stimuli were applied to the participant's right hand using MR-compatible devices already used in previous study from our group [3]. These two stimulations can evoke illusory sensations of hand movement rotations, while the hand remains actually still. The velocity of the movement illusion varies with the velocity rotation of the disk and with the vibration frequency of the vibrator applied to the muscle tendon [4].

Tactile stimulation (T) consisted of a textured-disk (40 cm in diameter, 7 cm height) rotating under the participant's right hand. A motor enclosed in a faradized box drove the disk remotely by means of plastic rotatory axes used to connect the two elements. The disk rotated at two constant velocities in the counterclockwise direction (T_{Low}: 10°/s and T_{High}: 30°/s).

The muscle proprioception stimulation (P) was delivered by pneumatic vibrators (cylinder 3 cm in diameter and 4 cm long) applied to the abductor muscle tendon of the participant's right wrist. Two constant vibration frequencies (P_{Low}: 30 Hz or P_{High}: 60 Hz) were applied using a SMC ITV2050 air pressure regulator, driven by a 0–10 V analog command.

A specific software developed for the current study in the LabVIEW environment (National Instruments) was implemented for the stimulation protocol. The software was synchronized with the MR acquisition using a NI-PXI 6289 multifunction I/O device. The hardware clock source of the whole protocol was defined by a digital input line connected to the TTL (Transistor-Transistor Logic) MR pulses and was described in a sequential text script, which included the analog commands of both tactile and proprioceptive stimulation devices.

During the task-related runs, participants were asked to focus on the illusion they perceived and to answer orally if they felt or not the illusion after each stimulation. MR-compatible earplugs (audio system S14, Sensimetrics) and microphone (microphone FOMRI-III, OptoAcoustics) were installed to communicate with the participants and to record their oral answers.

3.4. Data acquisition

MR scans were acquired using a 3-Tesla MRI Scanner (Magnetom-Prisma, Siemens) with an in-built body-coil for radio frequency excitation and the manufacturer's 64-channel phase-array head coil for reception. To estimate a map of the magnetic field, we first acquired a pair of phase-reversed fieldmap images with opposite phase encode directions along the anterior-posterior axis with the following parameters: TR (Repetition time) = 7060 ms, TE (Echo time) = 59 ms, voxel size = $2.5 \times 2.5 \times 2.5$ mm^3, slices = 54, flip angle = 90/180°, FOV (Field of View) = 210×210 mm^2. Then, BOLD images were acquired using a multi-band gradient-echo EPI sequence with a factor of 3 to cover the whole brain and cerebellum. 54 slices were acquired during the TR of 1224 ms, a of TE = 30 ms, an isotropic resolution 2.5 mm^3, a FOV of $256 \times 256 \times 204.8$ mm^3 and a flip angle of 65° This BOLD protocol was used for both resting-state and task-related runs, a total of 284 volumes were acquired for each run.

Then, a high-resolution T1-weighted anatomical image was acquired for each subject (3D MPRAGE sequence: TR/TI/TE = 2400/1010/2.28 ms, voxel size = $0.8 \times 0.8 \times 0.8$ mm^3, slices = 256, FOV = $256 \times 256 \times 204.8$ mm^3, flip angle = 8°).

Ethics statement

All participants gave their written informed consent, the study conformed to the Declaration of Helsinki was approved by the local ethics committee (CCP Marseille Sud 1 #RCB 2010-A00359-30).

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

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