Individual Brain Charting project

Documentation

Version 3.1

Individual Brain Charting

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This document presents the organization, content and accessibility of the *Individual Brain Charting* (IBC) dataset.

If you use the IBC dataset in a scientific publication, we would appreciate citations to the following paper:

Pinho, A. L. et al. Individual Brain Charting, a high-resolution fMRI dataset for cognitive mapping. Sci Data 5 , 180105. DOI: 10.1038/sdata.2018.105 (2018).

Contents

1 Participants

The cohort of the IBC dataset consists in a permanent group of twelve adults with neither psychiatric and neurologic disorders nor specific psychometric profile. Participants are numbered from 1 to 15, by which participants 3 and 10 are not part of the group.

Table 1 contains demographic information of the participants. Data from *sub-02* were only acquired for the ARCHI tasks, HCP tasks plus RSVP Language task and, thus, the cohort is exceptionally composed of thirteen participants for these particular tasks. For further details about exclusion criteria and experimental procedures concerned with the handling of the participants, please consult [Pinho et al., 2018].

Subject ID	Year of recruitment	Age	Sex	Handedness score
sub-01	2015	39.5	M	0.3
sub-02	2015	32.8	M	1
sub-04	2015	26.9	M	0.8
sub-05	2015	27.4	M	0.6
sub-06	2015	33.1	M	0.7
sub-07	2015	38.8	M	1
sub-08	2015	36.5	F	1
sub-09	2015	38.5	F	1
sub-11	2016	35.8	M	1
sub-12	2016	40.8	M	1
sub-13	2016	28.2	M	0.6
sub-14	2016	28.3	M	0.7
sub-15	2017	30.3	M	0.9

Table 1: **Demographic data of the participants.** Age stands for the participants' age upon recruitment.

2 MRI acquisitions

This section contains details about the overall organization of the MRI sessions across participants. It provides details about session IDs for every participant, the MRI sequences employed in every session and their imaging parameters. A description about data anomalies is also provided per participant for every session.

For more information about the technical specifications of the MRI equipment used, please consult Section 2.2.2 of [Pinho et al., 2018].

2.1 Organization of the MRI sessions

Figure 1 depicts the temporal organization of runs in terms of MRI sequences within sessions:

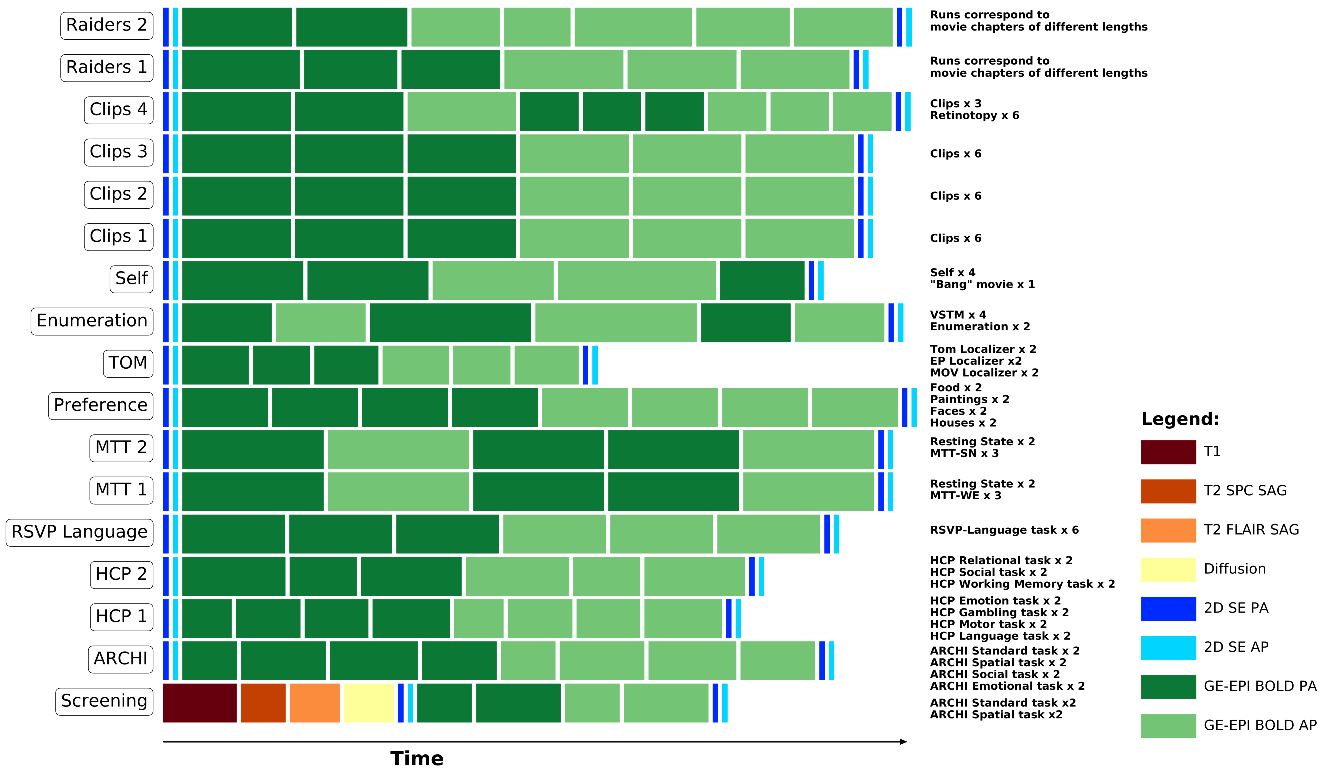

Figure 1: **Structure of the IBC-MRI sessions in terms of number, type and duration of the runs performed.** Each rectangle represents one run; its width visually quantifies the duration of that run and the color indicates the type of sequence employed. Rows of rectangles depict the chronological organization of every session. Labels on the left side identify the session represented by each row. For every session, the tasks employed during the EPI sequences are specified on the right side of the corresponding row.

Besides, a plan of the MRI sessions undertaken per participant can be found in Table 51 and a summary of the fMRI-data anomalies over sessions and participants can be found in Table 52.

2.2 Parameters of the MRI sequences

A detailed description of the imaging parameters set up for every MRI sequence is provided over the following subsections.

2.2.1 2D Spin-Echo

The 2D Spin-Echo maps are used to obtain a model of distortions for EPI images: a pair of AP/PA images are acquired jointly with each EPI (BOLD or diffusion-weighted) acquisition.

Parameter	Value
Sequence	Spin-echo EPI
TR	9500 ms
TE	37.00 ms
Flip angle	90 deg
Refocusing flip angle	180 deg
FOV	240 x 240 mm
Matrix	128 x 128
Slice thickness	1.30 mm
Multiband accel. factor	1
Echo spacing	0,71 ms
BW	1598 Hz/Px
Phase partial Fourier	6/8
b-values	0 s/mm^2

Table 2: **Acquisition parameters for Spin-Echo.**

2.2.2 Diffusion

Three types of diffusion sequences were employed in three different runs, respectively:

- High-resolution (1.3mm isotropic, 60 directions) acquisitions with $B = 1500$ or $B = 3000$.
- Multi-shell (1.3mm isotropic, 20 directions) acquisitions for multiple B-values ranging from 300 to 3000 in steps of 300.

Parameter	Value
Sequence	diff_dw60_TE76
TR	7000 ms
TE	76 ms
Flip angle	90 deg
Refocusing flip angle	180 deg
FOV	240 x 240 mm
Matrix	128 x 128
Slice thickness	1.30 mm, 112 slices, 1.30 mm isotropic
Multiband accel. factor	2
Echo spacing	0.71 ms
BW	1598 Hz/Px
Phase partial Fourier	6/8
b-values	[1500, 3000] s/mm^2

Table 3: **Acquisition parameters for high-resolution diffusion imaging.**

Parameter	Value
Sequence	diff_dw26_TE76
TR	7000 ms
TE	76 ms
Flip angle	90 deg
Refocusing flip angle	180 deg
FOV	240 x 240 mm
Matrix	128 x 128
Slice thickness	1.30 mm, 112 slices, 1.30 mm isotropic
Multiband accel. factor	2
Echo spacing	0.71 ms
BW	1598 Hz/Px
Phase partial Fourier	6/8
b-values	[0, 300, 600, 900, 1200, 1500, 1800, 2100, 1400, 2700, 3000] s/mm^2

Table 4: **Acquisition parameters for multi-shell diffusion imaging.**

- Two low-resolution acquisitions (2mm, 20 directions) used for screening.

Parameter	Value	Parameter	Value
Sequence	diff_screening_2mmiso	*Sequence*	diff_dw20_MB
TR	9000 ms	*TR*	5700 ms
TE	66,00 ms	*TE*	79,40 ms
Flip angle	90 deg	*Flip angle*	90 deg
Refocusing flip angle	180 deg	*Refocusing flip angle*	180 deg
FOV	240 x 240 mm	*FOV*	240 x 240 mm
Matrix	128 x 128	*Matrix*	160 x 160
Slice thickness	2 mm isotropic, 70 slices	*Slice thickness*	1,5 mm isotropic, 94 slices
Multiband accel. factor	1	*Multiband accel. factor*	2
Echo spacing	0,54 ms	*Echo spacing*	0,65 ms
BW	2192 Hz/Px	*BW*	1838 Hz/Px
Phase partial Fourier	6/8	*Phase partial Fourier*	6/8
b-values	0, 1500 s/mm^2	*b-values*	0, 1500 s/mm^2

Table 5: **Acquisition parameters for screening.**

2.2.3 T1

Two types of T1 images were acquired:

- High-resolution (0.75mm) anatomical images.

Parameter	Value
Sequence	Anatomy_T1_0.75mm
TR	2300 ms
TE	3.16 ms
Flip angle	9 deg
FOV	240 x 240 mm
Matrix	128x128
Slice thickness	0.75 mm, 224 slices, 0.75 mm isotropic
Multiband accel. factor	1
Echo spacing	7.8 ms
BW	240 Hz/Px
Phase partial Fourier	7/8
b-values	0 s/mm^2

Table 6: **Acquisition parameters for high-resolution T1 images.**

- MPRAGE T1 image in sagittal view.

Parameter	Value
Sequence	mprage_sag_T1_160sl
TR	2300 ms
TE	2.98 ms
Flip angle	9 deg
FOV	256 x 256 mm
Matrix	256 x 256
Slice thickness	1 mm, 160 slices, 1 mm isotropic
Multiband accel. factor	1
Echo spacing	7.1 ms
BW	240 Hz/Px
Phase partial Fourier	7/8
b-values	0 s/mm^2

Table 7: **Acquisition parameters for MPRAGE sagittal T1.**

T1 relaxometry Three different runs were performed:

- A B1 map for T1 mapping.

Parameter	Value
Sequence	B1Map_for_T1_map
TR	20000 ms
TE	2.59 ms
Flip angle	8 deg
FOV	256 x 256 mm
Matrix	128 x 128
Slice thickness	2 mm, 44 slices, 2 mm isotropic
Multiband accel. factor	1
Echo spacing	4.5 ms
BW	800 Hz/Px
Phase partial Fourier	None
b-values	0 s/mm^2

Table 8: **Acquisition parameters for B1 maps.**

- T1 maps with FA from 3 to 19 in steps of two.

Parameter	Value
Sequence	T1Map_1mm
TR	10 ms
TE	3 ms
Flip angle	3 deg
FOV	256 x 256 mm
Matrix	128 x 128
Slice thickness	1 mm, 176 slices, 1 mm isotropic
Multiband accel. factor	1
BW	240 Hz/Px
Phase partial Fourier	7/8
b-values	0 s/mm^2

Table 9: **Acquisition parameters for T1 maps.**

2.2.4 T2

Several types of images were acquired under this category:

- T2 SPC sagittal images.

Parameter	Value
Sequence	T2_SPC_SAG_FOV230
TR	3200 ms
TE	419 ms
Flip angle mode	T2 var
FOV	230 x 230 mm
Matrix	256 x 256
Slice thickness	0.90 mm, 176 slices, 0.90 mm isotropic
Multiband accel. factor	1
Echo spacing	3.52 ms
BW	698 Hz/Px
Phase partial Fourier	None
b-values	0 s/mm^2

Table 10: **Acquisition parameters for T2 sagittal images.**

- T2 FLAIR sagittal.

Parameter	Value
Sequence	T2_FLAIR_SAG_FOV230
TR	5000 ms
TE	396 ms
Flip angle mode	T2 var
FOV	230 x 230 mm
Matrix	256 x 256
Slice thickness	0.81 mm, 192 slices, 0.81 mm isotropic
Multiband accel. factor	1
Echo spacing	3,36 ms
BW	781 Hz/Px
Phase partial Fourier	0
b-values	0 s/mm^2

Table 11: **Acquisition parameters for T2 FLAIR sagittal images.**

- T2 sagittal with fat saturation.

Parameter	Value
Sequence	T2_SPC_SAG_fatsat
TR	3200 ms
TE	420 ms
Flip angle mode	T2 var
FOV	270 x 270 mm
Matrix	384 x 384
Slice thickness	0.70 mm, 240 slices, 0.70 mm isotropic
Echo spacing	3.68 ms
BW	723 Hz/Px
Phase partial Fourier	None
b-values	0 s/mm^2

Table 12: **Acquisition parameters for T2 images with Fat-Sat.**

- T2 sagittal (0.7mm).

Parameter	Value
Sequence	T2_SPC_SAG_0.7mm
TR	3200 ms
TE	420 ms
Flip angle mode	T2 var
FOV	270 x 270 mm
Matrix	384 x 384
Slice thickness	0.70 mm, 240 slices, 0.70 mm isotropic
Multiband accel. factor	1
Echo spacing	3.68 ms
BW	723 Hz/Px
Phase partial Fourier	None
b-values	0 s/mm^2

Table 13: **Acquisition parameters for high-resolution sagittal T2 images.**

T2 relaxometry Two types of relaxometry images were acquired:

- T2* sagittal (relaxometry).

Parameter	Value
Sequence	relaxometry_T2star_sag
TR	50 ms
TE1	1.77 ms
TE2	5.06 ms
TE3	8.35 ms
TE4	11.64 ms
TE5	14.93 ms
TE6	18.22 ms
TE7	21.51 ms
TE8	24.80 ms
TE9	28.09 ms
TE10	32.50 ms
TE11	38.90 ms
TE12	47.00 ms
Flip angle	20 deg
FOV	288 x 288 mm
Matrix	196 x 196
Slice thickness	1.50 mm, 120 slices, 1.50 mm isotropic
Multiband accel. factor	1
BW	420 Hz/Px
Phase partial Fourier	7/8
b-values	0 s/mm^2

Table 14: **Acquisition parameters for T2 relaxometry images.**

- T2 relaxometry with 12 contrasts.

Parameter	Value
Sequence	relaxometry_T2_tra_12contrastes
TR	7600 ms
TE1	14 ms
Flip angle	180 deg
FOV	256 x 256 mm
Matrix	256 x 256
Slice thickness	1,1 mm, 128 slices, 1,1 mm isotropic
GRAPPA accel. factor	3
Echo spacing	14 ms
BW	215 Hz/Px
Phase partial Fourier	None
b-values	0 s/mm^2

Table 15: **Acquisition parameters for 12-contrast T2 images.**

2.2.5 EPI T2* with BOLD contrast

The same acquisition parameters were used in all task-fMRI runs, except the number of repetitions (TRs) as each run had a different duration. Table 16 contains the acquisition parameters for the ARCHI Standard task. Table 17 contains the number of TRs for every task:

Parameter	Value
Sequence	Archi_STD
TR	2000 ms
TE	27 ms
Flip angle mode	74 def
FOV	192 x 192 mm
Matrix	128 x 128
Slice thickness	1.50 mm, 93 slices, 1.50 mm isotropic
Multiband accel. factor	3
Echo spacing	0,65 ms
BW	1776 Hz/Px
Phase partial Fourier	None
B-values	0 s/mm^2

Table 16: **Acquisition parameters for BOLD-contrast images.**

Task	Repetitions (TR)	Duration: ss (mm:ss)
ARCHI Standard	156	312 (5:12)
ARCHI Spatial	252	504 (8:24)
ARCHI Social	262	524 (8:44)
ARCHI Emotional	220	442 (7:22)
HCP Language	229	458 (7:38)
HCP Emotion	139	278 (4:38)
HCP Gambling	188	376 (6:16)
HCP Motor	185	370 (6:10)
HCP Social	196	392 (6:32)
HCP Relational	311	622 (10:22)
HCP WM	303	606 (10:06)
RSVP Language	310	620 (10:20)
Mental Time Travel	394	788 (13:08)
Preference	248	496 (8:16)
Theory-of-Mind localizer	186	372 (6:12)
Theory-of-Mind and Pain-Matrix Narrative localizer	156	312 (5:12)
Theory-of-Mind and Pain-Matrix Movie localizer	178	356 (5:56)
Visual Short-Term Memory	260	520 (8:40)
Enumeration	490	980 (16:20)
Self (runs 1, 2, 3)	360	720 (12:00)
Self (run 4)	480	960 (16:00)
Bang	243	486 (8:06)

Table 17: **Number of repetitions (TR) for each task.**

3 Tasks

The IBC dataset aims at providing a comprehensive characterization of brain systems under the neuroimaging framework and within the scope of cognitive neuroscience. To this end, an extensive collection of task-fMRI data concerned with a large class of behavioral protocols –covering a diversity of psychological domains– have been collected in a permanent cohort.

Over the next sections, a detailed description about the experimental paradigms of these tasks, namely their conditions and corresponding effects-of-interest, are provided together with the specification of the main contrasts derived from such conditions. For all tasks, the stimuli were delivered through protocols based on custom-made scripts that ensured a fully automated environment and computer-controlled collection of the behavioral data. Details about materials and experimental settings specifically employed to run each task are also included, together with its design description.

Protocols of all tasks are public available in the "Public protocols" repository on GitHub (see Section 6 for more information) along with general instructions on how to run them, including the correct display of the stimuli and obtainment of log files of the experiments; the corresponding code is open source and adaptations of the current designs are also possible. Additionally, for a better understanding of the stimuli as well as the chronological sequence of events composing the paradigm of each task, video records (*aka* video annotations) of complete runs are also provided on this GitHub repository.

3.1 ARCHI tasks

The ARCHI tasks are a battery of localizers comprising a wide range of psychological domains. A description about each task and its corresponding conditions and contrasts are presented over the next sections.

3.1.1 ARCHI Standard

Quick Info:

- Paradigm: fast event-related design
- Duration: 307s
- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: in-house custom-made sticks featuring one-top button, each one to be used in each hand

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This task, described in [Pinel et al., 2007] probes basic functions, such as button presses with the left or right hand, viewing horizontal and vertical checkerboards, reading and listening to short sentences, and mental computations (subtractions). Visual stimuli were displayed in four 250-ms epochs, separated by 100ms intervals (i.e., 1.3s in total). Auditory stimuli were generated from a recorded male voice (i.e., a total of 1.6s for motor instructions, 1.2-1.7s for sentences, and 1.2-1.3s for subtraction). The auditory or visual stimuli were shown to the participants for passive viewing or button response in event-related paradigms. Informal inquiries undertaken after the MRI session confirmed that the experimental tasks were understood and followed correctly. This task comprises 10 conditions described in Table 18 and represented in Figure 3.

Condition	Description
• *audio left-button press*	left-hand three-times button press, indicated by auditory instruction
• *audio right-button press*	right-hand three-times button press, indicated by auditory instruction
• *video left-button press*	left-hand three-times button press, indicated by visual instruction
• *video right-button press*	right-hand three-times button press, indicated by visual instruction
• *horizontal checkerboard*	visualization of flashing horizontal checkerboards
• *vertical checkerboard*	visualization of flashing vertical checkerboards
• *listen to sentence*	listen to narrative sentences
• *read sentence*	read narrative sentences
• *audio subtraction*	mental subtraction, indicated by auditory instruction
• *video subtraction*	mental subtraction, indicated by visual instruction

Table 18: **Conditions of the ARCHI Standard task.**

The main contrasts derived from the conditions of this task are described in Table 19.

Contrast id	Specification
• *left – right button press*	left hand vs. right hand
• *reading – listening*	sentence reading vs. sentence listening
• *motor – cognitive*	button presses vs. narrative/computation
• *reading – checkerboard*	sentence reading vs. checkerboard
• *computation – sentences*	mental subtraction vs. sentence reading
• *horizontal – vertical*	horizontal checkerboard vs. vertical checkerboard

Table 19: **Main contrasts of the ARCHI Standard task.**

3.1.2 ARCHI Spatial

Quick Info:

- Paradigm: block-design (block duration: 5 to 7s)
- Duration: 489s
- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)

This task includes the performance of *(1)* ocular saccade, *(2)* grasping and *(3)* orientation judgments on objects (the two different tasks were actually made on the same visual stimuli in order to characterize grasping-specific activity), *(4)* judging whether a hand photograph was the left or right hand or *(5)* was displaying the front or back. The same input stimuli were presented twice in order to characterize specific reponse to hand side judgment. This task comprises 5 conditions described in Table 20 and represented in Figure 4.

Condition	Description
• *saccades*	ocular movements were performed according to the displacement of a fixation cross from the center towards peripheral points in the image displayed
• *guess which hand*	mental judgment on whether the hand displayed on the image is a left or a right hand
• *hand palm or back*	mental judgment on the palmar-dorsal direction of a hand displayed as visual stimulus
• *object grasping*	mimicry of object grasping with right hand, in which the corresponding object was displayed on the screen
• *mimic orientation*	mimic orientation of rhombus, displayed as image background on the screen[1], using right hand along with fingers

Table 20: **Conditions of the ARCHI Spatial task.**

The main contrasts derived from the conditions of this task are described in Table 21.

Contrast id	Specification
• *saccades*	saccades vs. fixation
• *hand – side*	left or right hand vs. hand palm or back
• *grasp – orientation*	object grasping vs. orientation judgment
• *rotation side*	rotation side vs. fixation
• *object orientation*	object orientation vs. fixation

Table 21: **Main contrasts of the ARCHI Spatial task.**

3.1.3 ARCHI Social

Quick Info:

- Paradigm: block-design (block duration: 5 to 7s)
- Duration: 516s
- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)

This task relies on *(1)* the interpretation of short stories involving false beliefs or not, *(2)* observation of moving objects with or without a putative intention, and *(3)* listening to speech and non-speech sounds. The conditions are described in Table 22 and represented in Figure 5.

Condition	Description
• *mechanistic tale*	interpret short stories (presented as auditory stimuli) through mental reply (no active response was involved), featuring a cause-consequence plot
• *mechanistic story*	interpret short stories (presented as visual stimuli) through mental reply (no active response was involved), featuring a cause-consequence plot
• *false-belief tale*	interpret short stories (presented as auditory stimuli) through mental reply (no active response was involved), featuring a *false-belief* plot
• *false-belief story*	interpret short stories (presented as visual stimuli) through mental reply (no active response was involved), featuring a *false-belief* plot
• *mental motion*	watch short movies of triangles, which exhibit a putative interaction
• *random motion*	watch short movies of triangles, which exhibit a random movement
• *voice sound*	listen passively to short samples of human voices
• *natural sound*	listen passively to short samples of natural sounds

Table 22: **Conditions of the ARCHI Social task.**

The main contrasts derived from the conditions of this task are described in Table 23.

Contrast id	Specification
• *mechanistic audio*	listening to a mechanistic tale
• *mechanistic video*	reading a mechanistic story
• *false belief – mechanistic audio*	false-belief tale vs. mechanistic tale (audio)
• *false belief – mechanistic video*	false-belief story vs. mechanistic story (video)
• *triangle mental – random*	social-interaction motion vs. random motion
• *triangle random*	randomly drifting figures
• *non speech sound*	listen to natural sound
• *speech sound – non speech sound*	listen to voice sound vs. natural sound

Table 23: **Main contrasts of the ARCHI Social task.**

3.1.4 ARCHI Emotional

Quick Info:

- Paradigm: block-design (block duration: 5 to 7s)
- Duration: 436s
- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)

This task includes *(1)* facial judgments of gender, and *(2)* trustworthiness plus expression based on complete portraits or photos of eyes' expressions. The conditions are described in Table 24 and represented in Figure 6.

Condition	Description
• *face gender*	gender evaluation of the presented human faces
• *face control*	mental assessment on the slope of a gray-scale grid image (obtained from scrambling a face's image) that may be tilted or not
• *face trusty*	trustworthy evaluation of the presented human faces
• *expression intention*	trustworthy evaluation of the presented human eye images
• *expression gender*	gender evaluation of the presented human eye images
• *scrambled image*	mental assessment on the slope of a gray-scale grid image (obtained from scrambling an eyes' image) that may be tilted or not

Table 24: **Conditions of the ARCHI Emotional task.**

The main contrasts derived from the conditions of this task are described in Table 25.

Contrast id	Specification
• *expression gender – control*	gender assessment from eyes' expression
• *expression intention – gender*	expression intention vs. gender assessment
• *face gender – control*	gender assessment from face image
• *face trusty – gender*	face trusty vs. gender assessment

Table 25: **Main contrasts of the ARCHI Emotional task.**

3.2 HCP tasks

The HCP tasks used herein were reproductions made in a subset of task-fMRI paradigms originally developed for the Human Connectome Project (HCP, [Barch et al., 2013]), but with minor changes. The adjustments mainly concerned to the translation of all stimuli plus instructions into french, the increment of the number of blocks[2] or the amount of events within blocks[3], among other technical adaptations with respect to the environment in the scanner. No conceptual modifications on the tasks and alterations in the temporal sequence of the conditions were undertaken.

Data from each task were acquired in two runs, within the same session and using different phase-encoding directions.

For sake of clarity, a short description about conditions in the applied tasks is briefly presented over the next sections. Table 26 summarizes all conditions for this set of tasks.

3.2.1 HCP Emotion

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)

The main purpose of *HCP Emotion* task was to capture neural activity arising from fear- or angry-response processes. To elicit stronger effects, affective facial expressions were used as visual stimuli due to their importance in adaptive social behavior [Hariri et al., 2002].

The paradigm was thus composed by two categories of blocks: *(1)* the face block, and *(2)* the shape block. All blocks consisted of a series of events, in which images with faces or shapes were displayed, respectively. There were always three faces/shapes per image;

[2] The number of blocks was doubled in the majority of the tasks.
[3] This adjustement was only performed for the HCP Relational task.

one face/shape was shown at the top and two faces/shapes were shown at the bottom. The participants were then asked to decide which face/shape at the bottom, i.e. left or right face/shape, matched the one displayed at the top, by pressing respectively the index or middle finger's button of the response box.

The task was formed by twelve blocks per run, i.e. six face blocks and six shape blocks. The two block categories were alternately presented for each run. All blocks contained six trials and they were always initiated by a cue of three seconds. In turn, the trials included a visual-stimulus period of two seconds and a fixation-cross period of one second; the total duration of the trial was thus three seconds. The experimental design of this task is represented in Figure 7.

3.2.2 HCP Gambling

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)

This task was adapted from the *Incentive processing* task-fMRI paradigm of the HCP and its aim was to localize brain structures that take part to the reward system, namely the basal ganglia complex.

The paradigm included eight blocks and each block was composed by eight events. For every event, the participants were asked to play a game. The goal was to guess whether the next number to be displayed, which ranged from one to nine, would be more or less than five while a question mark was shown on the screen. The answer was given by pressing the index or middle finger's button of the response box, respectively. Feedback on the correct number was provided afterwards. There was an equal amount of blocks in which the participants experienced either *reward* or *loss*, for most of the events. Concretely, six out of the eight events within a block pertained to one of these two outcomes; the remaining events corresponded to the antagonist or a neutral outcome, i.e. when the correct number was five.

The task was constituted by eight blocks per run, in which each half related to reward and loss experience, respectively. The order of the two block categories were pseudo-randomized during a single run, but fixed for all participants. A fixation-cross period of fifteen seconds was displayed between blocks. All blocks contained eight trials. The trials included a question-mark visual stimulus lasting up to 1.5 seconds, a feedback period of one second and a fixation-cross period of one second, as well; the total duration of the trial was then 3.5 seconds, approximately. The experimental design of this task is represented in Figure 8.

3.2.3 HCP Motor

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)

HCP Motor task was designed with the intent of extracting maps on gross motor topography, in particular motor skills associated with movements of the foot, hand and tongue.

There were thus five categories of blocks with respect to motor tasks involving *(1)* the left foot, *(2)* the right foot, *(3)* the left hand, *(4)* the right hand, and *(5)* the tongue, respectively. The blocks always started with visual cues referring to which part of the body should be moved. The cues were then followed by a set of events, which were in turn indicated by flashing arrows on the screen. The events pertained to the corresponding movements performed by the participants.

The task was formed by five blocks per category, with a total of twenty blocks per run. The order of the block categories were pseudo-randomized during each run, but fixed for all participants. A fixation-dot period of fifteen seconds was inserted between some blocks. All blocks contained ten trials. Every trial included a cue of one second and a period of performance of twelve seconds[4]; the total duration of the trial was then thirteen seconds. The experimental design of this task is represented in Figure 9.

3.2.4 HCP Language

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)

HCP Language task was used as a localizer of brain regions involved in semantic processing, with special focus on the anterior temporal lobe (ATL) [Binder et al., 2011].

The paradigm comprised two categories of blocks: *(1)* story blocks, and *(2)* math blocks. The math block served as a control task in this context, since it was likely to adress other brain regions during the attentional demands. Both type of blocks exhibited auditory stimuli in short epochs, which in turn finished with a final question followed by two possible answers. During story blocks, participants were presented with stories, whose question targeted their respective topics. Conversely, math blocks showed arithmetic problems for which the correct solution must be selected. The answer was provided after the two possible options were displayed, through pressing the corresponding button of the

[4]During the period of performance, arrows flashed ten times on the screen, as an indication of the number of movements that should be performed.

response box, i.e. the button for the index or middle finger of the response box for the first or second option, respectively. The difficulty levels of the problems, presented for both categories, were adjusted throughout the experiment, in order to keep the participants engaged in the task and, thus, assure accurate performances [Binder et al., 2011].

The task was composed by eleven blocks per run. For the first run, six story blocks and five math blocks were interleaved, respectively. The reverse amount and order of blocks were used during the second run. The number of trials per block varied between one and four. Nevertheless, it was assured that both block categories matched their length of presentation at every run. There was a cue of two seconds in the beginning of each block, indicating its category. The duration of the trials within a block varied between ten and thirty seconds. Finally, the presentation of the auditory stimuli was always accompanied by the display of a fixation cross on the screen throughout the entire run. The experimental design of this task is represented in Figure 10.

3.2.5 HCP Relational

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)

HCP Relational task employed a relational matching-to-sample paradigm, featuring a second-order comparison of relations between two pairs of objects. It served primarily as a localizer of the rostrolateral prefrontal cortex, since *relational matching* mechanisms were shown to elicit activation on this region [Smith et al., 2007].

Similarly to some previous tasks, two categories of blocks described the paradigm: *(1)* the *relational-processing* block, and *(2)* the *control-matching* block. All blocks were constituted by a set of events. In the relational-processing block, visual stimuli consisted of images representing two pairs of objects, in which one pair was placed at the top and the other one at the bottom of the image, respectively. Objects within a pair may differ in two dimensions: shape and texture. The participants had to identify whether the pair of objects from the top differed in a specific dimension and, subsequently, they were asked to determine whether the pair from the bottom changed along the same dimension. For the control block, one pair of objects was displayed at the top of the image and a single object at the bottom of the same image. In addition, a cue was shown in the middle of that image referring to one of the two possible dimensions. The participants had thus to indicate whether the object from the bottom was matching either of the two objects from the top, according to the dimension specified as a cue. If there was a match they had to press with the index finger on the corresponding button of the button box; otherwise, they had to press with the middle finger on the corresponding one.

This task was formed by twelve blocks per run. Two groups of six blocks referred to the two block categories, respectively. Block categories were, in turn, interleaved for display within a run. A fixation-cross period of sixteen seconds was inserted between some blocks. All blocks contained six trials and they were always initiated by a cue of two seconds. The trials were described by a visual-stimulus plus response period followed by a fixation-cross period, lasting up to ten seconds. The duration of the former differed in agreement with the type of block, i.e. it lasted nine seconds and 7.6 seconds during the relational-processing block and control-matching block, respectively. The experimental design of this task is represented in Figure 11.

3.2.6 HCP Social

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)

HCP Social task intended to provide evidence for task-specific activation in brain structures presumably implicated in social cognition.

The paradigm included two categories of blocks, in which movies were presented during short epochs. The movies consisted in triangle-shape clip art, moving in a predetermined fashion. Putative social interactions could be drawn from movements referring to the block category on the effect-of-interest. In contrast, objects appeared to be randomly moving the other category, i.e. the control-effect block. Participants were to decide whether the movements of the objects appeared to represent a social interaction (by pressing with the index finger in the corresponding button of the response box) or not (by pressing with the ring finger in the corresponding button of the response box; in case of uncertainty, they had to press with the middle finger.

The task was constituted by ten blocks per run. Each half of the blocks corresponded to one of the aforementioned block categories, whose order was pseudo-randomized for every run, but fixed for all participants. There was only one trial present per block. It consisted of a twenty-second period of video-clip presentation plus three seconds maximum of a response period, indicated by a momentary instruction on the screen. Thus, the total duration of a block was approximately twenty three seconds. A fixation-cross period of fifteen seconds was always displayed between blocks. The experimental design of this task is represented in Figure 12.

3.2.7 HCP Working Memory

Quick Info:

- Protocol software: E-Prime 2.0 Professional (Psychological Software Tools, Inc.)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)

HCP Working Memory task was adapted from the classical *n-back* task to serve as functional localizer for evaluation of working-memory (WM) capacity and related processes.

The paradigm integrated two categories of blocks: *(1)* the "0-back" WM-task block, and *(2)* the "2-back" WM-task block. They were both equally presented within a run. A cue was always displayed at the beginning of each block, indicating its task-related type. Blocks were formed by set of events, during which pictures of faces, places, tools or body parts were shown on the screen. One block was always dedicated to one specific category of pictures and the four categories were always presented at every run. At each event, the participant were to decide whether the image matched with the reference or not, by pressing respectively on the index or middle finger's button of the response box.

The task was constituted by sixteen blocks per run, splitted into two block categories. Besides, there were four pairs of blocks per category, referring respectively to the four classes of pictures mentioned above. The order of the blocks, regardless their category and corresponding class of pictures, was pseudo-randomized for every run, but fixed for all participants. A fixation-cross period of fifteen seconds was introduced between some blocks. All blocks contained ten trials and they were always initiated by a cue of 2.5 seconds. Trials included in turn the presentation of a picture for two seconds and a very short fixation-cross period for half of a second; the total duration of one trial was thus 2.5 seconds. The experimental design of this task is represented in Figure 13.

The conditions of the HCP battery of tasks are described in Table 26.

Task	Conditions	Task	Conditions
HCP Language	tale mental addition	*HCP Social*	mental motion random motion
HCP Emotion	face image shape outline	*HCP Relational*	relational processing visual matching
HCP Gambling	punishment reward	*HCP WM*	0-back body image 2-back body image
HCP Motor	left hand right hand left foot right foot tongue cue		0-back face image 2-back face image 0-back tool image 2-back tool image 0-back place image 2-back place image

Table 26: **Conditions of the HCP tasks.**

The main contrasts derived from the conditions of this task are described in Table 27.

Task	Contrast id	Specification
HCP Language	story – math	tale vs. mental addition
	math	mental addition vs. fixation
HCP Social	mental – random	mental motion vs. random motion
	random	random motion vs. fixation
HCP Emotion	face – shape	face image vs. shape outline
	shape	shape outline vs. fixation
HCP Relational	relational – match	relational processing vs. visual matching
	match	visual matching
HCP Gambling	punishment – reward	punishment vs. reward outcome
	reward	reward vs. fixation
HCP WM	2back – 0back	2-back vs. 0-back
	body – avg	body image vs. any motion
	face – avg	face image vs. any motion
	place – avg	place image vs. any motion
	tools – avg	tool image vs. any motion
HCP Motor	left hand – avg	left hand vs. any motion
	right hand – avg	right hand vs. any motion
	left foot – avg	left foot vs. any motion
	right foot – avg	right foot vs. any motion
	tongue – avg	tongue vs. any motion

Table 27: **Main contrasts of the HCP tasks.**

3.3 RSVP Language task

Quick Info:

- Protocol software: Expyriment 0.7.0 (Python 2.7)
- Response device: in-house custom-made sticks featuring one-top button, each one to be used in each hand
- Preset resolution of the screen: 1920×1080

The *Rapid-Serial-Visual-Presentation (RSVP) Language* task was adapted from the study undertaken by [Humphries et al., 2006] on syntactic and semantic processing during auditory sentence comprehension. Specifically, the task herein described targeted the same syntactic and semantic modules, but in the context of reading. It thus allowed for capturing further associations with regard to e.g. visual (pseudo) word recognition and sublexical route, among other aspects related to active reading.

Condition	Description
• *simple sentence*	constituents, i.e. words, formed syntactically and semantically congruent sentences of one single clause (low_sentence-structure_complexity)
• *complex sentence*	constituents, i.e words, formed syntactically and semantically congruent sentences with more than one clause grid image that may be tilted or not (high sentence-structure complexity)
• *read jabberwocky*	syntactically congruent sentences composed by non-lexical vocable constituents
• *read words*	syntactically non-congruent sentences but with semantic content
• *read pseudowords*	syntactically and semantically non-congruent sentences composed by non-lexical vocable constituents
• *consonant strings*	syntactically and semantically non-congruent sentences composed by non-vocable constituents

Table 28: **Conditions of the RSVP Language task.**

The paradigm consisted in a block-design presentation strategy of the stimuli. One block was defined as an epoch within a trial and epochs corresponded in turn to experimental conditions. Such conditions stood for the consecutive visual presentation of ten constituents composed by letters. There were six different conditions; they are described in Table 28.

All linguistic content elicited from the conditions except "consonant strings", such as grammar rules, lexicon and phonemes, were part of the french language. In order to ensure continuous engagement during task performance, participants were asked, straight afterwards the visualization of every sentence, to ascertain whether the current constituent displayed on the screen, *aka* "the probe", was part of the previous sentence or not. The corresponding answer was provided immediately after the probe, by pressing the button in the left hand if "yes" or the one in the right hand if "no".

Data were collected in six runs during one single session. Every run was composed by sixty trials, in which subsets of ten trials were dedicated to each condition, respectively. The order of the trials was pseudo-randomized within and between runs, such that there were no repeated trials during a full session. Moreover, a different pseudo-randomized order for the presentation of the trials was always employed across participants. One trial comprised several experimental manipulations, other than a block integrating one specific condition. It was sequentially formed by a period of fixation-cross display (two seconds), another short period of a blank screen (0.5 seconds), a block containing the linguistic stimuli (0.4 seconds $\times$ 10 = 4 seconds), a jittered blank screen (varying from one to 1.5 seconds), a period of a second fixation-cross display (0.5 seconds), a period for the probe display (0.5 seconds), and, finally, a response period (varying up to two seconds). The total duration of one single trial was thus ten seconds. Three extra seconds of blank screen were added at the beginning of every run, i.e. before the presentation of the first trial. The experimental design of this task is represented in Figure 14.

Two opposite phase-encoding directions were respectively applied during acquisition of each half of the total amount of runs.

The main contrasts derived from the conditions of this task are described in Table 29.

Contrast id	Specification
• *complex – simple*	read sentence with complex vs. simple syntax
• *sentence – jabberwocky*	read sentence vs. read *jabberwocky*
• *sentence – word*	read sentence vs. read words
• *word – consonant string*	read words vs. consonant strings
• *jabberwocky – pseudo*	read *jabberwocky* vs. read pseudowords
• *word – pseudo*	read words vs. read pseudowords
• *pseudo – consonant string*	read pseudowords vs. consonant strings
• *consonant string*	read and encode consonant strings

Table 29: **Main contrasts of the RSVP Language task.**

3.4 Mental Time Travel tasks

Quick Info:

- Protocol software: Expyriment 0.7.0 / pygame 1.9.3
- Response device: in-house custom-made sticks featuring one-top button, each one to be used in each hand
- Preset resolution of the screen: 1024×768

The *Mental Time Travel* (MTT) task battery was developed following previous studies conducted at the NeuroSpin platform on chronosthesia and mental space navigation [Gauthier and van Wassenhove, 2016a, Gauthier and van Wassenhove, 2016b, Gauthier et al., 2018]. In these studies, participants were to judge the ordinality of real historical events in time and space by mentally project oneself, i.e. through egocentric mapping. In contrast, the present task was intended to assess the neural correlates underlying both mental time and space judgment involved in allocentric mapping implemented in narratives. To this end, and in order to remove confounds associated with prior subject-specific mental representations linked to the historical events, fictional scenarios were created with fabricated stories and characters.

Concretely, this battery is composed of two tasks –*MTT WE* and *MTT SN*– that were employed, each of them, in two different sessions. The stimuli of each task referred to a different island plotting different stories and characters. There were two stories per island and they were created based on a two-dimensional mesh of nodes. Each node corresponded to a specific action. The stories of each island evolved both in time and in one single cardinal direction. The cardinal directions, cued in the task, differed between sessions. Thus, space judgment was performed according to the cardinal directions *West-East* and *South-North* for tasks MTT WE and MTT SN, respectively. In addition, the stories of each island evolved spatially in opposite ways. For instance, the two stories plotted in the West-East island evolved across time from west to east and east to west, respectively.

Prior to each session, participants were to learn the story of the corresponding session. To prevent any retrieval of graphical memories referring to the schematic representation of the stories, they were presented as audio narratives. Additionally, the participants were also instructed to learn the stories chronographically, i.e. as they were progressively referred to in the narrative, and to refrain from doing (visual) notes, which could be encoded as mental judgments.

The task was organized as a block-design paradigm, composed of trials with three conditions of audio stimuli: *(1) Reference*, statement of an action in the story to serve as reference for the time or space judgment in the same trial; *(2) Cue*, question concerning the type of mental judgment to be performed in the same trial, i.e. *"Before or After?"* for the time judgment or *"West or East?"* and *"South or North?"* for the space judgment in the first and second sessions, respectively; and *(3) Event*, statement of an action to be judged with respect to the Reference and according to the Cue. A list of all conditions can be found in Table 30.

Condition	Description
• *all references in we/sn island*	action in the story to serve as reference for the time or space judgment in the same trial in the west-east/south-north island
• *space cue on all references in we/sn island*	cue indicating a question about spatial orientation in the west-east/south-north island
• *time cue on all references in we/sn island*	cue indicating a question about time orientation in the west-east/south-north island
• *westside/southside events*	action to be judged whether it takes place west/-south or east/north from this reference, that actually takes place west/south from this reference
• *eastside/northside events*	action to be judged whether it takes place west/-south or east/north from this reference, that actually takes place east/north from this reference
• *past events in we/sn island*	action to be judged whether it takes place before or after this reference, that actually takes place before this reference, in the west-east/south-north island
• *future events in we/sn island*	action to be judged whether it takes place before or after this reference, that actually takes place before this reference, in the west-east/south-north island
• *responses to events in we/sn island*	motor responses performed after every event condition in the west-east/south-north island

Table 30: **Conditions of the Mental Time Travel tasks.**

Every trial started with an audio presentation of the Reference followed by silence, with a duration of two and four seconds, respectively. The audio presentation of the Cue came next, followed by a silence period; they had respectively a duration of two and four seconds. Afterwards, a series of four Events were presented for two seconds each; all of them were interspersed by a *Response* condition of three seconds. Every trial ended with a silent period of seven seconds, thus lasting thirty nine seconds in total.

A black fixation cross was permanently displayed on the screen across conditions and the participants were instructed to never close their eyes. At the very end of each trial, the cross turned to red during half of a second in order to signal the beginning of the next trial; such cue facilitated the identification of the next audio stimulus as the upcoming Reference to be judged.

During the Response period, the participants had to press one of the two possible buttons, placed in their respective left and right hand. If the Cue presented in the given trial hinted at time judgment, the participants were to judge whether the previous Event occurred before the Reference, by pressing the button of the left hand, or after the Reference, by pressing the button of the right hand. If the Cue concerned with space judgment, the participants were to judge, in the same way, whether the Event occurred west or east of the Reference in the first session and south or north of the Reference in the second session.

One session of data collection comprised three runs; each of them included twenty trials. Half of the trials for a given run were about time navigation and the other half, space navigation. Five different references were shared by both types of navigation and, thus, there were two trials with the same reference for each type of navigation. In turn, these two trials differed in terms of distance in the mesh between the node of the Reference and the node of each Event, i.e. *close* referred to two consecutive nodes whereas *far* referred to two nodes interspersed by another node. Within trials, half of the Events related to past or western/southern actions and the other half to future or eastern/northen actions with respect to the Reference. A list with the relevant contrasts for this task can be found in Table 31.

The order of the trials was shuffled within runs, only to ensure that each run would feature a unique sequence of trials according to type of reference (both in time and space) and cue. No pseudo-randomization criterion was imposed as the trials' characterization was already very rich. Since there were only two types of answers, we also randomized events according to their correct answer within each trial. The same randomized sequence for each run was employed for all participants. The code of this randomization is provided together with the protocol of the task on Github: `https://github.com/hbp-brain-charting/public_protocols/tree/master/mtt/mtt_protocol/randomization`. Note that the randomized sequence of trials for all runs is pre-determined and, thus, provided as inputs to the protocol for a specific session.

Contrast id	Specification
• *we/sn average reference*	all references in we/sn island vs. fixation
• *we/sn all space – time cue*	space vs. time cue on all references in we/sn island
• *we/sn average event*	events from all references in we/sn island
• *we/sn space – time event*	space vs. time events from all references in we/sn island
• *westside – eastside event*	westside vs. eastside events
• *southside – northside event*	southside vs. northside events
• *we/sn before – after event*	past vs. future events in we/sn island

Table 31: **Main contrasts of the Mental Time Travel tasks.**

3.5 Preference tasks

Quick Info:

- Protocol software: Psychophysics Toolbox Version 3 (PTB-3), aka Psychtoolbox-3, for GNU Octave
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)
- Preset resolution of the screen: 1920×1080

The *Preference* task battery was adapted from the *Pleasantness Rating task* (Study 1a) described in [Lebreton et al., 2015], in order to capture the neural correlates underlying the decision-making for potentially rewarding outcomes (*aka* "positive-incentive value") as well as the level of confidence of such type of action.

The whole task battery is composed of four tasks, each of them pertaining to the presentation of items of a certain kind. Therefore, *Food*, *Painting*, *Face* and *House* tasks were dedicated to "food items", "paintings", "human faces" and "houses", respectively.

All tasks were organized as a block-design experiment with one condition per trial. The description of the condition corresponding to each task can be found in Table 32. Every trial started with a fixation cross, whose duration was jittered between 0.5 seconds and 4.5 seconds, after which a picture of an item was displayed on the screen together with a rating scale and a cursor. Participants were to indicate how pleasant the presented stimulus was, by sliding the cursor along the scale. Index and ring finger's of the response box were to move respectively with low and high speed to the left whereas the middle and little fingers were to move respectively with low and high speed to the right; thumb's button was used to validate the answer. The scale ranged between 1 and 100. The value 1 corresponded to the choices "unpleasant" or "indifferent"; the middle of the scale corresponded to the choice "pleasant"; and the value 100 corresponded to the choice "very pleasant". Therefore, the ratings related only to the estimation of the positive-incentive value of the items displayed.

Condition	Description
	***Food* task**
• *food evaluation*	classify the level of pleasantness of a food item displayed on the screen in terms of willingness to eat it
	***Painting* task**
• *painting evaluation*	classify the level of pleasantness of a painting displayed on the screen in terms of willingness to possess it
	***Face* task**
• *face evaluation*	classify the level of pleasantness of a human face displayed on the screen in terms of willingness to meet the person portrayed
	***House* task**
• *house evaluation*	classify the level of pleasantness of a house displayed on the screen in terms of willingness to live in that house

Table 32: **Conditions of the Preference tasks.**

One full session was dedicated to the data collection of all tasks. It comprised eight runs with sixty trials each. Although each trial had a variable duration, according to the time spent by the participant in the assessment, no run lasted longer than eight minutes and sixteen seconds. Every task was presented twice in two fully dedicated runs. The stimuli were always different between runs of the same task. As a consequence, no stimulus was ever repeated in any trial and, thus, no item was ever assessed more than once by the participants. The main contrasts can be found in Table 33. To avoid any selection bias in the sequence of stimuli, the order of their presentation was shuffled across trials and between runs of the same type. This shuffle is embedded in the code of the protocol and, thus, the sequence was determined upon launching it. Consequently, the sequence of stimuli was also random across subjects. For each run (of each session), this sequence was properly registered in the logfile generated by the protocol.

Contrast id	Specification
• *preference constant*	visual evaluation of an item vs. fixation
• *preference linear*	visual preference vs. no preference
• *preference quadratic*	confidence in preference vs. no confidence

Table 33: **Main contrasts of the Preference tasks.** They account for conditions from the four tasks all together.

3.6 Theory-of-Mind and Pain Matrices tasks

This battery of tasks was adapted from the original task-fMRI localizers of Saxe Lab, intended to identify functional regions-of-interest in the *Theory-of-Mind* network and *Pain Matrix* regions. These localizers rely on a set of protocols along with verbal and non-verbal stimuli, whose material was obtained from https://saxelab.mit.edu/localizers.

Minor changes were employed in the present versions of the tasks herein described. Because the cohort of this dataset is composed solely of native French speakers, the verbal stimuli were thus translated to French. Therefore, the durations of the reading period and the response period within conditions were slightly increased.

3.6.1 Theory-of-Mind Localizer

Quick Info:

- Protocol software: Psychophysics Toolbox Version 3 (PTB-3), aka Psychtoolbox-3, for GNU Octave
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)
- Preset resolution of the screen: (main session) 1920×1080; (training session) 3200×1800

The *Theory-of-Mind Localizer* (TOM localizer) was intended to identify brain regions involved in theory-of-mind and social cognition, by contrasting activation during two distinct story conditions: *(1) belief judgments*, reading a *false-belief* story that portrayed characters with false beliefs about their own reality; and *(2) fact judgments*, reading a story about a false photograph, map or sign [Dodell-Feder et al., 2011]. Conditions of this task are listed in Table 34.

Condition	Description
• *belief judgments*	read a *false-belief* story
• *fact judgments*	read a false-photograph story

Table 34: **Conditions of the TOM localizer.**

The task was organized as a block-design experiment with one condition per trial. Every trial started with a fixation cross of twelve seconds, followed by the main condition that comprised a reading period of eighteen seconds and a response period of six seconds. During this response period, participants were to judge whether a statement about the story previously displayed is true or false by pressing respectively with the index or middle finger in the corresponding button of the response box. The total duration of the trial amounted to thirty six seconds. There were ten trials in a run, followed by an extra-period of fixation cross for twelve seconds at the end of the run. Two runs were dedicated to this task in one single session.

The designs, i.e. the sequence of conditions across trials, for two possible runs were pre-determined by the authors of the original study and *hard-coded* in the original protocol (see Section 3.6). The IBC-adapted protocols contain the exactly same designs. For all subjects, design #1 was employed for the PA-run and design #2 for the AP-run.

The main contrasts for this task are listed in Table 35.

Contrast id	Specification
• *belief – photo*	belief vs. fact judgments
• *photo*	fact judgments vs. fixation

Table 35: **Main contrasts of the TOM localizer.**

3.6.2 Theory-of-Mind and Pain-Matrix Narrative Localizer

Quick Info:

- Protocol software: Psychophysics Toolbox Version 3 (PTB-3), aka Psychtoolbox-3, for GNU Octave
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)
- Preset resolution of the screen: (main session) 1920×1080; (training session) 3200×1800

The *Theory-of-Mind and Pain-Matrix Narrative Localizer* (Emotional Pain localizer) was intended to identify brain regions involved in theory-of-mind and Pain Matrix areas, by contrasting activation during two distinct story conditions: reading a story that portrayed characters suffering from *(1) emotional pain* and *(2) physical pain* [Jacoby et al., 2016]. Conditions of this task are listed in Table 36.

Condition	Description
• *emotional-pain story*	read story about fictional characters suffering from emotional pain
• *physical-pain story*	read story about fictional characters suffering from physical pain

Table 36: **Conditions of the Emotional Pain localizer.**

The experimental design of this task is identical to the one employed for the TOM localizer, except that the reading period lasted twelve seconds instead of eighteen seconds. Two different designs were pre-determined by the authors of the original study and they were employed across runs and participants, also in the same way as described for the TOM localizer (see Section 3.6.1).

During the response period, the participant had to the judge the amount of pain experienced by the character(s) portrayed in the previous story. For no pain, they had to press with their thumb on the corresponding button of the response box; for mild pain, they had to press with their index finger; for moderate pain, they had to press with the middle finger; and for a strong pain, they had to press with the ring finger.

The main contrasts for this task are listed in Table 37.

Contrast id	Specification
• *emotional – physical pain*	emotional-pain story vs. physical-pain story
• *physical pain*	physical-pain story vs. fixation

Table 37: **Main contrasts of the Emotional Pain localizer.**

3.6.3 Theory-of-Mind and Pain-Matrix Movie Localizer

Quick Info:

- Protocol software: Psychophysics Toolbox Version 3 (PTB-3), aka Psychtoolbox-3, for GNU Octave
- Preset resolution of the screen: 1920×1080

The *Theory-of-Mind and Pain Matrix Movie Localizer* (Pain Movie localizer) consisted in the display of "Partly Cloud", a 6 minutes movie from Disney Pixar, in order to study the responses implicated in theory-of-mind and Pain Matrix brain regions [Jacoby et al., 2016, Richardson et al., 2018]. Conditions of this task are listed in 38.

Condition	Description
• *mental movie*	watch movie-scene wherein characters experience changes in beliefs, desires, and/or emotions
• *physical-pain movie*	watch movie-scene wherein characters experience physical pain

Table 38: **Conditions of the Pain Movie localizer.**

Two main conditions were thus hand-coded in the movie, according to [Richardson et al., 2018], as follows: *(1) mental movie*, in which characters were "mentalizing"; and *(2) physical pain movie*, in which characters were experiencing physical pain. Such conditions were intended to evoke brain responses from theory-of-mind and pain-matrix networks, respectively. All moments in the movie not focused on the direct interaction of the main characters were considered as a baseline period. The main contrasts for this task are listed in Table 39.

Contrast id	Specification
• *movie mental – pain*	mental-pain movie vs. physical-pain movie
• *movie pain*	physical-pain movie vs. fixation

Table 39: **Main contrasts of the Pain Movie localizer.**

3.7 Visual Short-Term Memory and Enumeration tasks

Quick Info:

- Protocol software: Psychophysics Toolbox Version 3 (PTB-3), aka Psychtoolbox-3, for GNU Octave
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)
- Preset resolution of the screen: 1024×768

This battery of tasks was adapted from the control experiment described in [Knops et al., 2014].

For both tasks, the stimuli consisted of sets of tilted dark-gray bars displayed on a light-gray background. Minor changes were employed in their present versions herein described: *(1)* both the response period and the period of the fixation dot at the end of each trial were made constant in both tasks; and *(2)* for the Enumeration task, answers were registered via a button-press response box instead of an audio registration of oral responses as in the original study.

Each task featured one main condition only and they are summarized in Table 40. A complete description of the paradigms of both tasks is presented in the following sections.

Condition	Description
	Visual Short-Term Memory **(VSTM) task**
• *vstm response to constant numerosity*	judge whether any bar changed orientation within two consecutive displays of bar sets on the screen
	Enumeration **task**
• *enumeration response to constant numerosity*	judge the number of bars displayed on the screen

Table 40: **Conditions of the Visual Short-Term Memory (VSTM) and Enumeration tasks.**

3.7.1 Visual Short-Term Memory task

In the *Visual Short-Term Memory* (VSTM) task, participants were presented with a certain number of bars, varying from one to six.

Every trial started with the presentation of a black fixation dot in the center of the screen for 0.5 seconds. While still on the screen, the black fixation dot was then displayed together with a certain number of tilted bars –variable between trials from one to six– for 0.15 seconds. Afterwards, a white fixation dot was shown for 1 second. It was next replaced by the presentation of the test stimulus for 1.7 seconds, displaying identical number of tilted bars in identical positions together with a green fixation dot. The participants were to remember the orientation of the bars from the previous sample and answer with one of the two possible button presses, i.e. respectively with the index or middle finger, depending on whether one of the bars in the current display had changed orientation by 90° or not, which was the case in half of the trials. The test display was replaced by another black fixation dot for a fixed duration of 3.8 seconds. Thus, the trial was 7.15 seconds long. There were seventy two trials in a run and four runs in one single session. Pairs of runs were launched consecutively. To avoid selection bias in the sequence of stimuli, the order of the trials was shuffled according to numerosity and change of orientation within runs and across participants.

The main contrasts of this task are presented in Table 41.

Contrast id	Specification
• *vtsm constant*	VSTM response to constant numerosity vs. fixation
• *vtsm linear*	VSTM response to numerosity vs. fixation
• *vtsm quadratic*	VSTM response to numerosity interaction vs. fixation

Table 41: **Main contrasts of the Visual Short-Term Memory (VSTM) task.**

3.7.2 Enumeration task

In the Enumeration task, participants were presented with a certain number of bars, varying from one to eight.

Every trial started with the presentation of a black fixation dot in the center of the screen for 0.5 seconds. While still on the screen, the black fixation dot was then displayed together with a certain number of tilted bars –variable between trials from one to eight– for 0.15 seconds. It was followed by a response period of 1.7s, in which only a green fixation dot was being displayed on the screen. The participants were to remember the number of the bars that were shown right before and answer accordingly, by pressing the corresponding button:

- once with the thumb's button for one bar;
- once with the index finger's button for two bars;
- once with the middle finger's button for three bars;
- once with the ring finger's button for four bars;
- twice with the thumb's button for five bars;
- twice with the index finger's button for six bars;
- twice with the middle finger's button for seven bars;
- twice with the ring finger's button for eight bars.

Afterwards, another black fixation dot was displayed for a fixed duration of 7.8 seconds. The trial length was thus 9.95 seconds. There were ninety six trials in a run and two (consecutive) runs in one single session. To avoid selection bias in the sequence of stimuli, the order of the trials was shuffled according to numerosity within runs and across participants.

The main contrasts of this task are presented in Table 42.

Contrast id	Specification
• *enumeration constant*	enumeration response to constant numerosity vs. fixation
• *enumeration linear*	enumeration response to numerosity vs. fixation
• *enumeration quadratic*	enumeration response to numerosity interaction vs. fixation

Table 42: **Main contrasts of the Enumeration task.**

3.8 Self task

Quick Info:

- Protocol software: Expyriment 0.7.0 (Python 2.7)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)
- Preset resolution of the screen: 1024×768

The *Self* task was adapted from the study [Genon et al., 2014], originally developed to investigate the *Self-Reference Effect* in older adults. This effect pertains to the encoding mechanism of information referring to the self, characterized as a memory-advantaged process. Consequently, memory-retrieval performance is also better for information encoded in reference to the self than to other people, objects or concepts.

The present task was thus composed of two phases, each of them relying on encoding and recognition procedures. The encoding phase was intended to map brain regions related to the encoding of items in reference to the self, whereas the recognition one was conceived to isolate the memory network specifically involved in the retrieval of those items. The phases were interspersed, so that the recognition phase was always related to the encoding phase presented immediately before.

The encoding phase had two blocks. Each block was composed of a set of trials pertaining to the same condition. For both conditions, a different adjective was presented at every trial on the screen. The participants were to judge whether or not the adjective described themselves –*self-reference encoding* condition– or another person –*other-reference encoding* condition– by pressing with the index finger on the corresponding button of the response box for "yes" and with the middle finger for "no". The other person was a public figure in France around the same age range as the cohort, whose gender matched the gender of every participant. Two public figures were mentioned, one at the time, across all runs; four public figures –two of each gender– were selected beforehand. By this way, we ensured that all participants were able to successfully characterize the same individuals, holding equal the levels of familiarity and affective attributes with respect to these individuals.

In the recognition phase, participants were to remember whether or not the adjectives had also been displayed during the previous encoding phase, by pressing with the index finger on the corresponding button of the response box for “yes” and with the middle finger for “no”. This phase was composed of a single block of trials, pertaining to three categories of conditions. *New* adjectives were presented during one half of the trials whereas the other half were in reference to the adjectives displayed in the previous phase. Thus, trials referring to the adjectives from “self-reference encoding” were part of the *self-reference recognition* category and trials referring to the “other-reference encoding” were part of the *other-reference recognition* category. Conditions were then defined according to the type of answer provided by the participant for each of these categories (see Table 43 for details).

Condition	Description
• *instruction*	presentation of a question related to the succeeding block†
Encoding phase	
• *self-reference encoding*	judge with overt response whether or not a certain adjective, displayed on the screen, qualifies oneself
• *other-reference encoding*	judging with overt response whether a certain adjective, displayed on the screen, qualifies someone else
• *self-reference encoding no-response**	no overt response provided during a “self-reference encoding” trial
• *other-reference encoding no-response**	no overt response provided during a “other-reference encoding” trial
Recognition phase	
• *self-reference recognition*	successful recognition with an overt response of an adjective, displayed on the screen, as having been already presented during one “self-reference encoding” trial of the preceding encoding phase
• *other-reference recognition*	successful recognition with an overt response of an adjective, displayed on the screen, as having been already presented during one “other-reference encoding” trial of the preceding encoding phase
• *memory*	successful identification with an overt response that a *new* adjective has never been presented before

• *no recognition*	unsuccessful identification with an overt response that a *new* adjective has been presented before
• *self-reference recognition miss**	unsuccessful recognition with an overt response of an adjective, displayed on the screen, as having been already presented during one "self-reference recognition" trial of the preceding encoding phase
• *other-reference recognition miss**	unsuccessful recognition with an overt response of an adjective, displayed on the screen, as having been already presented during one "other-reference recognition" trial of the preceding encoding phase
• *self-reference recognition no-response**	no overt response provided during a "self-reference recognition" trial
• *other-reference recognition no-response**	no overt response provided during a "other-reference recognition" trial

Table 43: **Conditions of the Self task.** Conditions marked with an asterisk (*) were modeled as regressors-of-no-interest.
† Questions were according to the type of the succeeding block. Thus, "encode_self" blocks were preceded by the question *"Are you?"*; "encode_other" blocks were preceded by the question *"Is <name_of_famous_person>?"*; and recognition-phase blocks were preceded by the question *"Have you seen?"*.

There were four runs in one session. The first three ones had three phases; the fourth and last run had four phases. Their total durations were twelve and 15.97 seconds, respectively. Blocks of both phases started with an *instruction* condition of five seconds, containing a visual cue. The cue was related to the judgment that should be performed next, according to the type of condition featured in that block. A set of trials, showing different adjectives, were presented afterwards. Each trial had a duration of five seconds, in which a response was to be provided by the participant. During the trials of the encoding blocks, participants had to press the button with their left or right hand, depending on whether they believed or not the adjective on display described someone (i.e. self or other, respectively for "self-reference encoding" or "other-reference encoding" conditions). During the trials of the recognition block, participants had to answer in the same way, depending on whether they believed or not the adjective had been presented before. A fixation cross was always presented between trials, whose duration was jittered between 0.3 seconds and 0.5 seconds. A rest period was introduced between encoding and recognition phases, whose duration was also jittered between ten and fourteen seconds. Long intervals between these two phases, i.e. longer than ten seconds, ensured the measurement of long-term memory processes during the recognition phase, at the age range of the cohort [Newell and Simon, 1972, Ericsson and Kintsch, 1995]. Fixation-cross periods of three and fifteen seconds were also introduced in the beginning and end of each run, respectively.

Lastly, all adjectives were presented in the lexical form according to the gender of the participant. There were also two sets of adjectives. One set was presented as new adjectives during the recognition phase and the other set for all remaining conditions of both phases. To avoid cognitive bias across the cohort, sets were switched for the other half of the participants. Plus, adjectives never repeated across runs but their sequence was fixed for the same runs and across participants from the same set. Yet, pseudo-randomization of the trials for the recognition phase was pre-determined by the authors of the original study, according to their category (i.e. "self-reference recognition", "other-reference recognition" or "new"), such that no more than three consecutive trials of the same category were presented within a block.

The main contrasts for this task can be found in Table 44.

Contrast id	Specification
• *encode self – other*	self-reference encoding vs. other-reference encoding
• *encode other*	other-reference encoding vs. fixation
• *recognition self – other*	self-reference recognition vs. other-reference recognition
• *recognition other hit*	other-reference recognition vs. fixation
• *recognition hit – correct rejection*	recognition vs. memory
• *correct rejection*	memory vs. fixation

Table 44: **Main contrasts of the Self task.**

3.9 *Bang* task

Quick Info:

- Protocol software: Expyriment 0.9.0 (Python 2.7)
- Preset resolution of the screen: 1024×768

The *Bang* task was adapted from the study [Campbell et al., 2015], dedicated to investigate aging effects on neural responsiveness during naturalistic viewing.

The task relies on watching –viewing and listening– of an edited version of the episode "Bang! You're Dead" from the TV series "Alfred Hitchcock Presents". The original black-and-white, 25-minute episode was condensed to seven minutes and fifty five seconds while preserving its narrative. The plot of the final movie includes scenes with characters talking to each other as well as scenes with no verbal communication. Conditions of this task were thus set by contiguous scenes of speech and no speech (45).

Condition	Description
• *speech*	watch contiguous scenes of speech
• *no speech*	watch contiguous scenes with no speech

Table 45: **Conditions of the Bang movie task.**

This task was performed during a single run in one unique session. Participants were never informed of the title of the movie before the end of the session. Ten seconds of acquisition were added at the end of the run. The total duration of the run was thus eight minutes and five seconds. Description about the main contrasts featuring this task can be found in Table 46.

Contrast id	Specification
• *talk – no talk*	speech vs. no speech
• *no talk*	no speech vs. fixation

Table 46: **Main contrasts of the Bang movie task.**

3.10 Clips task

Quick Info:

- Protocol compatibility: Python 2.7
- Preset resolution of the screen: 800×600

The *Clips* task stands for an adaptation of [Nishimoto et al., 2011], in which participants were to visualize naturalistic scenes edited as video clips of ten and a half minutes each.

Each run was always dedicated to the data collection of one video clip at a time. As in the original study, runs were grouped in two categories pertaining to the acquisition of training data and test data, respectively. Scenes from training clips were shown only once. Contrariwise, scenes from the test clips were composed of approximately one-minute-long excerpts extracted from the clips presented during training. Excerpts were concatenated to construct the sequence of every test run; each sequence was predetermined by randomly permuting many excerpts that were repeated ten times each across all runs. The same randomized sequences, employed across test runs, were used to collect data from all participants.

There were twelve and nine runs dedicated to the collection of training data and test data, respectively. Data from nine runs of each category were interspersedly acquired in three full sessions; the three remaining runs devoted to train-data collection were acquired in half of one last session, before the *Retinotopy* tasks (see Section 3.11 for complete description of this task).

To assure the same topographic reference of the visual field for all participants, a colored fixation point was always presented at the center of the images. Such point was changing three times per second to ensure that it was visible regardless the color of the movie. To account for stabilization of the BOLD signal, ten extra seconds of acquisition were added at the beginning and end of every run. The total duration of each run was thus ten minutes and fifty seconds.

3.11 Retinotopy tasks

Quick Info:

- Protocol software: Psychopy (Python 2.7)
- Response device: five-button ergonomic pad (Current Designs, Package 932 with Pyka HHSC-1x5-N4)
- Preset resolution of the screen: 1920×1080

The *Retinotopy* tasks refer to the classic retinotopic paradigms –the *Wedge* and the *Ring* tasks– consisting of four kinds of visual stimuli: *(1-2)* a slowly rotating clockwise or counterclockwise, semicircular checkerboard stimulus, as part of the Wedge task; and *(3-4)* a thick, dilating or contracting Ring, as part of the ring task. The phase of the periodic response at the rotation or dilation/contraction frequency measured at each voxel relates to the measurement of the perimetric parameters concerning polar angle and eccentricity, respectively [Sereno et al., 1995].

In the present study, six runs were devoted to these two tasks. Each of them were five-and-a-half minutes long. They were programmed for the same session following the last three "training-data" runs of the Clips task (see Section 3.10 for complete description of this task.) Four runs were dedicated to the Wedge task (two runs for each direction) and the remaining two were dedicated to the Ring task (the dilating ring in the first run and the contracting in the second run).

Similarly to the Clips task, a point was displayed at the center of the visual stimulus in order to keep constant the perimetric origin in all participants. Participants were thus to fixate continuously this point whose color flickered between red, green, blue and yellow throughout the entire run. To keep the participants engaged in the task, they were instructed that, after each run, they would be asked which color had most often been presented. They had thus to press on the response box with:

- thumb for red
- index finger for green
- middle finger for blue
- ring finger for yellow

Additionally, ten seconds of a non-flickering, red fixation cross were displayed at the end of every run.

The lists of conditions for the Wedge and Ring tasks together with their descriptions can be found in Tables 47 and 48, respectively.

Condition	Description
• *lower meridian*	visual representation in the lower half-plane of the visual field delimited by its horizontal meridian
• *upper meridian*	visual representation in the upper half-plane of the visual field delimited by its horizontal meridian
• *left meridian*	visual representation in the left half-plane of the visual field delimited by its vertical meridian
• *right meridian*	visual representation in the right half-plane of the visual field delimited by its vertical meridian
• *lower left*	visual representation in the lower-left quadrant of the visual field delimited by its vertical and horizontal meridians
• *upper left*	visual representation in the upper-left quadrant of the visual field delimited by its vertical and horizontal meridians
• *lower right*	visual representation in the lower-right quadrant of the visual field delimited by its vertical and horizontal meridians
• *upper right*	visual representation in the upper-right quadrant of the visual field delimited by its vertical and horizontal meridians

Table 47: **Conditions of the Wedge task.**

Condition	Description
• *foveal*	visual representation in the fovea
• *middle*	visual representation in the mid-periphery of the visual field
• *peripheral*	visual representation in the far-periphery of the visual field

Table 48: **Conditions of the Ring task.**

Likewise, descriptions about the main contrasts featuring the Wedge and Ring tasks can be respectively found in Tables 49 and 50.

Contrast id	Specification
• *lower meridian*	lower meridian vs. fixation
• *upper meridian*	upper meridian vs. fixation
• *left meridian*	left meridian vs. fixation
• *right meridian*	right meridian vs. fixation
• *lower left*	lower left vs. fixation
• *upper left*	upper left vs. fixation
• *lower right*	lower right vs. fixation
• *upper right*	upper right vs. fixation

Table 49: **Main contrasts of the Wedge task.**

Contrast id	Specification
• *foveal*	foveal vs. fixation
• *middle*	middle vs. fixation
• *peripheral*	peripheral vs. fixation

Table 50: **Main contrasts of the Ring task.**

3.12 Raiders task

Quick Info:

- Protocol software: Expyriment 0.9.0 (Python 2.7)
- Preset resolution of the screen: 1024×768

The *Raiders* task was adapted from [Haxby et al., 2011], in which the full-length action movie *Raiders of the Lost Ark* was presented to the participants. The main goal of the original study was the estimation of the hyperalignment parameters that transform voxel space of functional data into feature space of brain responses, linked to the visual characteristics of the movie displayed.

Similarly, herein, the movie was shown to the IBC participants in contiguous runs determined according to the chapters of the movie defined in the DVD.

This task was completed in two sessions. In order to use the acquired fMRI data in train-test split and cross-validation experiments, we performed three extra-runs at the end of the second session in which the three first chapters of the movie were repeated.

To account for stabilization of the BOLD signal, ten seconds of acquisition were added at the end of the run.

4 Processing pipeline

4.1 Preprocessing pipeline

Source data were preprocessed using *PyPreprocess*. This library offers a collection of Python tools to facilitate pipeline runs, reporting and quality check (`https://github.com/neurospin/pypreprocess`). It is built upon the *Nipype* library [Gorgolewski et al., 2011] v0.12.1, that in turn launched various commands used to process neuroimaging data. These commands were taken from the *SPM12* software package (Wellcome Department of Imaging Neuroscience, London, UK) v6685, and the *FSL* library (Analysis Group, FMRIB, Oxford, UK) v5.0.

All fMRI images, i.e. GE-EPI volumes, were collected twice with reversed phase-encoding directions, resulting in pairs of images with distortions going in opposite directions. Susceptibility-induced off-resonance field was estimated from the two Spin-Echo EPI volumes in reversed phase-encoding directions. The images were corrected based on the estimated deformation model, using the *topup* tool [Andersson et al., 2003] implemented in FSL [Smith et al., 2004].

Further, the GE-EPI volumes were aligned to each other within each participant. A rigid body transformation was employed, in which the average volume of all images was used as reference [Friston et al., 1995]. The mean EPI volume was also co-registered onto the corresponding T1-weighted MPRAGE (anatomical) volume for every participant [Ashburner and Friston, 1997]. The individual anatomical volumes were then segmented into tissue types to finally allow for the normalization of both anatomical and functional data [Ashburner and Friston, 2005]. Concretely, the segmented volumes were used to compute the deformation field for normalization to the standard MNI152 space. The deformation field was then applied to the EPI data. In the end, all volumes were resampled to their original resolution, i.e. 1 mm isotropic for the T1-weighted MPRAGE images and 1.5 mm for the EPI images.

4.1.1 FMRI Model Specification

The fMRI data were analyzed using the *General Linear Model* (GLM). Regressors of the model were designed to capture variations in BOLD response strictly following stimulus timing specifications. They were estimated through the convolution of temporal representations referring to the task-conditions with the canonical *Hemodynamic Response Function* (HRF), defined according to [Friston et al., 1998a] and [Friston et al., 1998b].

The temporal profile of the conditions was characterized by boxcar functions. To build such models, paradigm descriptors grouped in triplets (i.e. onset time, duration and trial type according to BIDS Specification) were determined from the log files' registries generated by the stimulus-delivery software.

To account for small fluctuations in the latency of the HRF peak response, additional regressors were computed based on the convolution of the same task-conditions profile with the time derivative of the HRF.

Nuisance regressors were also added to the design matrix in order to minimize the final residual error. To remove signal variance associated with spurious effects arising from movements, six temporal regressors were defined for the motion parameters. Further, the first five principal components of the signal, extracted from voxels showing the 5% highest variance, were also regressed to capture physiological noise [Behzadi et al., 2007].

In addition, a discrete-cosine transform set was applied for high-pass filtering (cutoff=128 seconds). Model specification was implemented using *Nistats* library v0.0.1b, a Python module devoted to statistical analysis of fMRI data (`https://nistats.github.io`), which leverages *Nilearn* [Abraham et al., 2014], a Python library for statistical learning on neuroimaging data (`https://nilearn.github.io/`).

4.1.2 Model Estimation

In order to restrict GLM parameters estimation to voxels inside functional brain regions, a brain mask was extracted from the mean EPI volume. The procedure implemented in the Nilearn software simply thresholds the mean fMRI image of each subject in order to separate brain tissue from background, and performs then a morphological opening of the resulting image to remove spurious voxels.

Regarding noise modeling, a first-order autoregressive model was used in the maximum likelihood estimation procedure.

A mass-univariate GLM fit was applied separately to the preprocessed GE-EPI data of each run with respect to a specific task. Parameter estimates pertaining to the experimental conditions were thus computed, along with the respective covariance at every voxel. Various contrasts (linear combinations of the effects), were then defined, referring only to differences in evoked responses between either *(i)* two conditions-of-interest or *(ii)* one condition-of-interest and baseline. GLM estimation and subsequent statistical analyses were also implemented using Nistats v0.1. fMRI data analysis was first run on unsmoothed data and, afterwards, on data smoothed with a 5mm full-width-at-half-maximum kernel. Such procedure allows for increased *Signal-to-Noise Ratio* (SNR) and it facilitates between-image comparison.

5 MRI-data organization

The tree structure of the IBC dataset follows BIDS Specification (http://bids.neuroimaging.io/), as in Figure 2.

- The identifiers of the 13 participants are “sub-01”, “sub-02”, “sub-04”, ..., “sub-15”.
- The acquisitions are organized in sessions (“ses-00”, “ses-01”, ..., “ses-20”, etc.).
- Within each session, data is divided according to modality: “anat”, “dwi”, “fmap”, “func”.
- For each modality, files are stored in .nii.gz format, with a name that recapitulates subject, session and modality together with meta-information stored in .tsv and .json files.

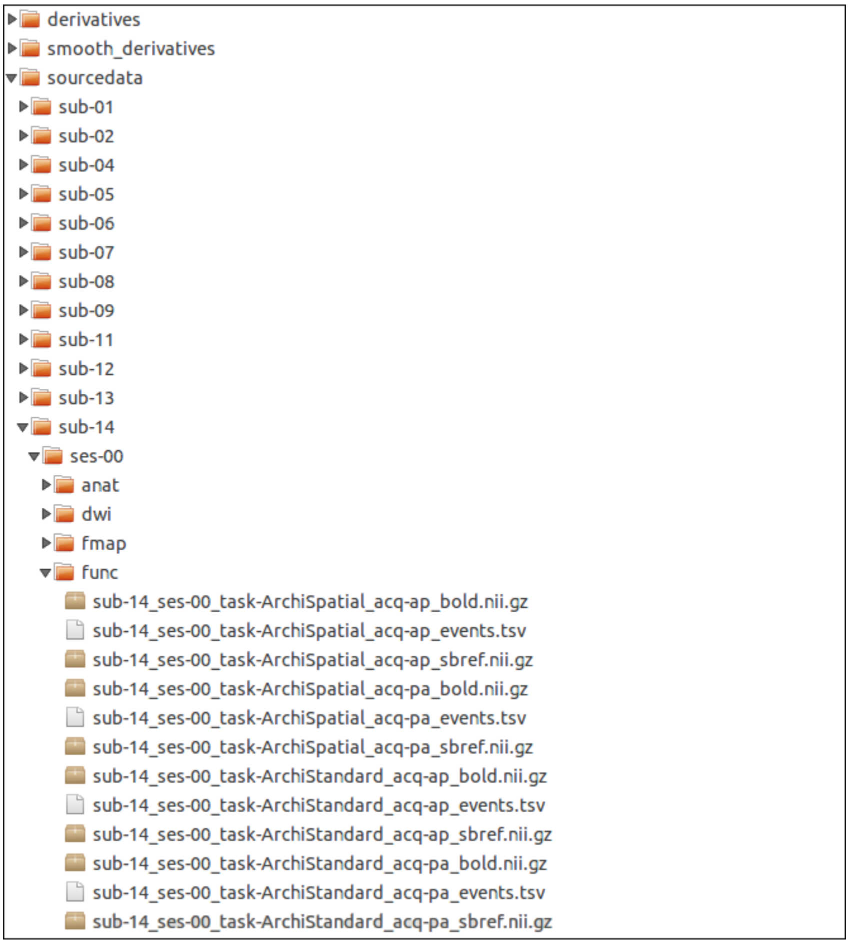

Figure 2: **Imaging modalities employed in each session.**

6 Accessibility

The online access of the raw data (*aka* source data) of the IBC dataset is assured by the *OpenNeuro* repository as well as the *EBRAINS* platform of the *Human Brain Project* (HBP), in the following DOIs:

OpenNeuro

all tasks: 10.18112/openneuro.ds002685.v1.0.0

EBRAINS

all tasks: 10.25493/XX28-VJ1
ARCHI Standard: 10.25493/YW4P-3U
ARCHI Spatial: 10.25493/P21W-NW5
ARCHI Social: 10.25493/78KJ-603
ARCHI Emotional: 10.25493/73GH-KET
HCP Emotion: 10.25493/ZXMK-AH0
HCP Gambling: 10.25493/Z8J1-1H3
HCP Motor: 10.25493/PR7B-HND
HCP Language: 10.25493/GDT6-BMK
HCP Relational: 10.25493/WQAG-ZDZ
HCP Social: 10.25493/3JXW-AFS
HCP Working Memory: 10.25493/PPE1-XNM
RSVP Language: 10.25493/PD28-TRA

Post-processed data are available in the collections of the NeuroVault repository with the id 6618:
`https://identifiers.org/neurovault.collection:6618`

Meta-data about the behavioral protocols, video annotations and paradigm descriptors' extraction are available in the public git repository:
`https://github.com/hbp-brain-charting/public_protocols`.

The scripts used for data analysis are available in the public git repository: `https://github.com/hbp-brain-charting/public_analysis_code`.

The first data-descriptor, peer-reviewed article of the IBC-dataset is open access and available under the following DOI: 10.1038/sdata.2018.105. In this article, you can find more information about: the overall scope of the IBC project; demographic data of the cohort; description of the experimental procedures undertaken; materials and methods used; and technical validation of the dataset.

References

[Abraham et al., 2014] Abraham, A., Pedregosa, F., Eickenberg, M., Gervais, P., Mueller, A., Kossaifi, J., Gramfort, A., Thirion, B., and Varoquaux, G. (2014). Machine learning for neuroimaging with scikit-learn. *Front Neuroinform*, 8:14.

[Andersson et al., 2003] Andersson, J. L., Skare, S., and Ashburner, J. (2003). How to correct susceptibility distortions in spin-echo echo-planar images: application to diffusion tensor imaging. *Neuroimage*, 20(2):870 – 888.

[Ashburner and Friston, 1997] Ashburner, J. and Friston, K. (1997). Multimodal Image Coregistration and Partitioning - A Unified Framework. *Neuroimage*, 6(3):209–217.

[Ashburner and Friston, 2005] Ashburner, J. and Friston, K. J. (2005). Unified segmentation. *Neuroimage*, 26(3):839–851.

[Barch et al., 2013] Barch, D. M., Burgess, G. C., Harms, M. P., Petersen, S. E., Schlaggar, B. L., Corbetta, M., Glasser, M. F., Curtiss, S., Dixit, S., Feldt, C., Nolan, D., Bryant, E., Hartley, T., Footer, O., Bjork, J. M., Poldrack, R., Smith, S., Johansen-Berg, H., Snyder, A. Z., and Van Essen, D. C. (2013). Function in the human connectome: Task-fMRI and individual differences in behavior. *Neuroimage*, 80:169–89.

[Behzadi et al., 2007] Behzadi, Y., Restom, K., Liau, J., and Liu, T. T. (2007). A component based noise correction method (compcor) for {BOLD} and perfusion based fMRI. *Neuroimage*, 37(1):90 – 101.

[Binder et al., 2011] Binder, J. R., Gross, W. L., Allendorfer, J. B., Bonilha, L., Chapin, J., Edwards, J. C., Grabowski, T. J., Langfitt, J. T., Loring, D. W., Lowe, M. J., Koenig, K., Morgan, P. S., Ojemann, J. G., Rorden, C., Szaflarski, J. P., Tivarus, M. E., and Weaver, K. E. (2011). Mapping anterior temporal lobe language areas with fMRI: A multicenter normative study. *Neuroimage*, 54(2):1465 – 1475.

[Campbell et al., 2015] Campbell, K. L., Shafto, M. A., Wright, P., Tsvetanov, K. A., Geerligs, L., Cusack, R., Tyler, L. K., Brayne, C., Bullmore, E., Calder, A., Cusack, R., Dalgleish, T., Duncan, J., Henson, R., Matthews, F., Marslen-Wilson, W., Rowe, J., Shafto, M., Campbell, K., Cheung, T., Davis, S., Geerligs, L., Kievit, R., McCarrey, A., Price, D., Taylor, J., Tsvetanov, K., Williams, N., Bates, L., Emery, T., Erzinçlioglu, S., Gadie, A., Gerbase, S., Georgieva, S., Hanley, C., Parkin, B., Troy, D., Allen, J., Amery, G., Amunts, L., Barcroft, A., Castle, A., Dias, C., Dowrick, J., Fair, M., Fisher, H., Goulding, A., Grewal, A., Hale, G., Hilton, A., Johnson, F., Johnston, P., Kavanagh-Williamson, T., Kwasniewska, M., McMinn, A., Norman, K., Penrose, J., Roby, F., Rowland, D., Sargeant, J., Squire, M., Stevens, B., Stoddart, A., Stone, C., Thompson, T., Yazlik, O., Dixon, M., Barnes, D., Hillman, J., Mitchell, J., Villis, L., and Tyler, L. K. (2015). Idiosyncratic responding during movie-watching predicted by age differences in attentional control. *Neurobiol Aging*, 36(11):3045 – 3055.

[Dodell-Feder et al., 2011] Dodell-Feder, D., Koster-Hale, J., Bedny, M., and Saxe, R. (2011). fMRI item analysis in a theory of mind task. *Neuroimage*, 55(2):705 – 712.

[Ericsson and Kintsch, 1995] Ericsson, K. A. and Kintsch, W. (1995). Long-term working memory. *Psychol Rev*, 102(2):211–245.

[Friston et al., 1998a] Friston, K., Fletcher, P., Josephs, O., Holmes, A., Rugg, M., and Turner, R. (1998a). Event-related fMRI: Characterizing differential responses. *Neuroimage*, 7(1):30 – 40.

[Friston et al., 1995] Friston, K., Frith, C., Frackowiak, R., and Turner, R. (1995). Characterizing Dynamic Brain Responses with fMRI: a Multivariate Approach. *Neuroimage*, 2(2):166–172.

[Friston et al., 1998b] Friston, K., Josephs, O., Rees, G., and Turner, R. (1998b). Nonlinear event-related responses in fMRI. *Magn Reson Med*, 39(1):41–52.

[Gauthier et al., 2018] Gauthier, B., Pestke, K., and van Wassenhove, V. (2018). Building the Arrow of Time... Over Time: A Sequence of Brain Activity Mapping Imagined Events in Time and Space. *Cereb Cortex*, 29(10):4398–4414.

[Gauthier and van Wassenhove, 2016a] Gauthier, B. and van Wassenhove, V. (2016a). Cognitive mapping in mental time travel and mental space navigation. *Cognition*, 154:55 – 68.

[Gauthier and van Wassenhove, 2016b] Gauthier, B. and van Wassenhove, V. (2016b). Time Is Not Space: Core Computations and Domain-Specific Networks for Mental Travels. *J Neurosci*, 36(47):11891–11903.

[Genon et al., 2014] Genon, S., Bahri, M. A., Collette, F., Angel, L., d'Argembeau, A., Clarys, D., Kalenzaga, S., Salmon, E., and Bastin, C. (2014). Cognitive and neuroimaging evidence of impaired interaction between self and memory in Alzheimer's disease. *Cortex*, 51:11 – 24.

[Gorgolewski et al., 2011] Gorgolewski, K., Burns, C. D., Madison, C., Clark, D., Halchenko, Y. O., Waskom, M. L., and Ghosh, S. S. (2011). Nipype: A Flexible, Lightweight and Extensible Neuroimaging Data Processing Framework in Python. *Front Neuroinform*, 5:13.

[Hariri et al., 2002] Hariri, A. R., Tessitore, A., Mattay, V. S., Fera, F., and Weinberger, D. R. (2002). The Amygdala Response to Emotional Stimuli: A Comparison of Faces and Scenes. *Neuroimage*, 17(1):317 – 323.

[Haxby et al., 2011] Haxby, J., Guntupalli, J., Connolly, A., Halchenko, Y., Conroy, B., Gobbini, M., Hanke, M., and Ramadge, P. (2011). A Common, High-Dimensional Model of the Representational Space in Human Ventral Temporal Cortex. *Neuron*, 72(2):404 – 416.

[Humphries et al., 2006] Humphries, C., Binder, J. R., Medler, D. A., and Liebenthal, E. (2006). Syntactic and Semantic Modulation of Neural Activity During Auditory Sentence Comprehension. *J Cogn Neurosci*, 18(4):665–679.

[Jacoby et al., 2016] Jacoby, N., Bruneau, E., Koster-Hale, J., and Saxe, R. (2016). Localizing Pain Matrix and Theory of Mind networks with both verbal and non-verbal stimuli. *Neuroimage*, 126:39 – 48.

[Knops et al., 2014] Knops, A., Piazza, M., Sengupta, R., Eger, E., and Melcher, D. (2014). A Shared, Flexible Neural Map Architecture Reflects Capacity Limits in Both Visual Short-Term Memory and Enumeration. *J Neurosci*, 34(30):9857–9866.

[Lebreton et al., 2015] Lebreton, M., Abitbol, R., Daunizeau, J., and Pessiglione, M. (2015). Automatic integration of confidence in the brain valuation signal. *Nat Neurosci*, 18(8):1159–67.

[Newell and Simon, 1972] Newell, A. and Simon, H. A. (1972). *Human problem solving*. Prentice-Hall, NJ, 1st edition.

[Nishimoto et al., 2011] Nishimoto, S., Vu, A., Naselaris, T., Benjamini, Y., Yu, B., and Gallant, J. (2011). Reconstructing Visual Experiences from Brain Activity Evoked by Natural Movies. *Curr Biol*, 21:1641–6.

[Pinel et al., 2007] Pinel, P., Thirion, B., Meriaux, S., Jobert, A., Serres, J., Bihan, D. L., Poline, J.-B., and Dehaene, S. (2007). Fast reproducible identification and large-scale databasing of individual functional cognitive networks. *BMC Neurosci*, 8:91.

[Pinho et al., 2018] Pinho, A. L., Amadon, A., Ruest, T., Fabre, M., Dohmatob, E., Denghien, I., Ginisty, C., Séverine-Becuwe, Roger, S., Laurier, L., Joly-Testault, V., Médiouni-Cloarec, G., Doublé, C., Martins, B., Pinel, P., Eger, E., Varoquaux, G., Pallier, C., Dehaene, S., Hertz-Pannier, L., and Thirion, B. (2018). Individual Brain Charting, a high-resolution fMRI dataset for cognitive mapping. *Sci Data*, 5:180105.

[Richardson et al., 2018] Richardson, H., Lisandrelli, G., Riobueno-Naylor, A., and Saxe, R. (2018). Development of the social brain from age three to twelve years. *Nat Commun*, 9(1027).

[Sereno et al., 1995] Sereno, M., Dale, A., Reppas, J., Kwong, K., Belliveau, J., Brady, T., Rosen, B., and Tootell, R. (1995). Borders of multiple visual areas in humans revealed by functional magnetic resonance imaging. *Science*, 268(5212):889–893.

[Smith et al., 2007] Smith, R., Keramatian, K., and Christoff, K. (2007). Localizing the rostrolateral prefrontal cortex at the individual level. *Neuroimage*, 36(4):1387 – 1396.

[Smith et al., 2004] Smith, S., Jenkinson, M., Woolrich, M., Beckmann, C., Behrens, T. E., Johansen-Berg, H., Bannister, P. R., Luca, M. D., Drobnjak, I., Flitney, D. E., Niazy, R. K., Saunders, J., Vickers, J., Zhang, Y., Stefano, N. D., Brady, J. M., and Matthews, P. M. (2004). Advances in functional and structural {MR} image analysis and implementation as {FSL}. *Neuroimage*, 23, Supplement 1:S208 – S219.

Appendix A Experimental-design diagrams

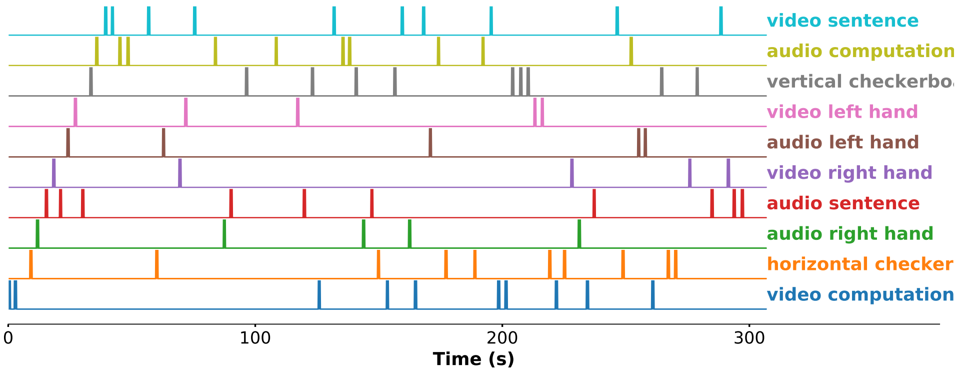

Figure 3: **Fast event-related design of the ARCHI Standard task.**

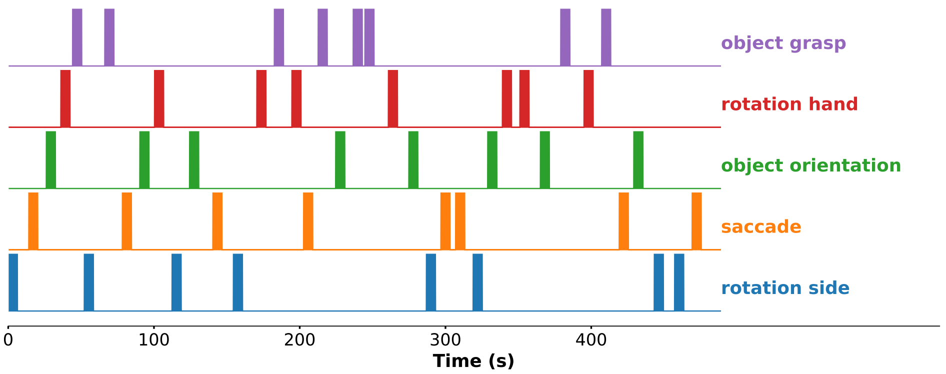

Figure 4: **Block-design of the ARCHI Spatial task.**

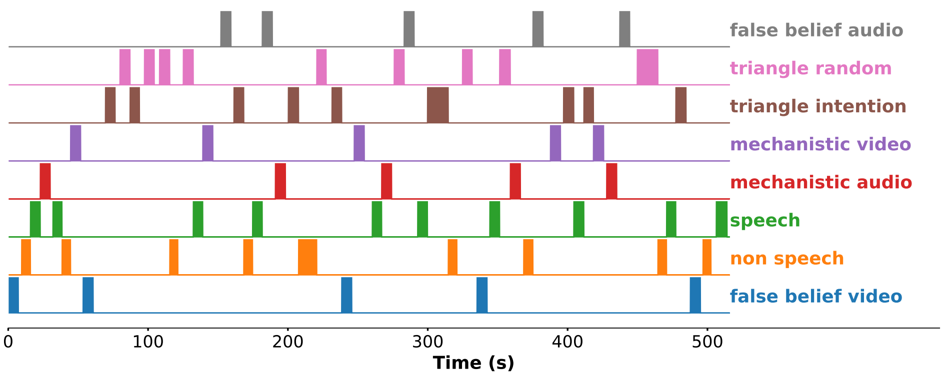

Figure 5: **Block-design of the ARCHI Social task.**

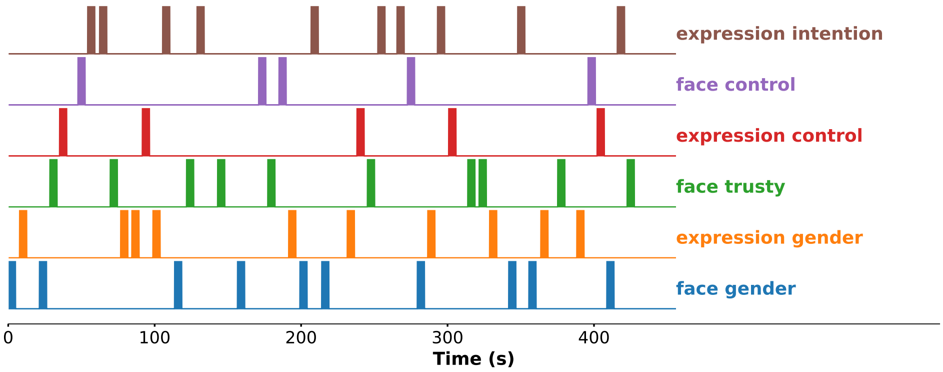

Figure 6: **Block-design of the ARCHI Emotional task.**

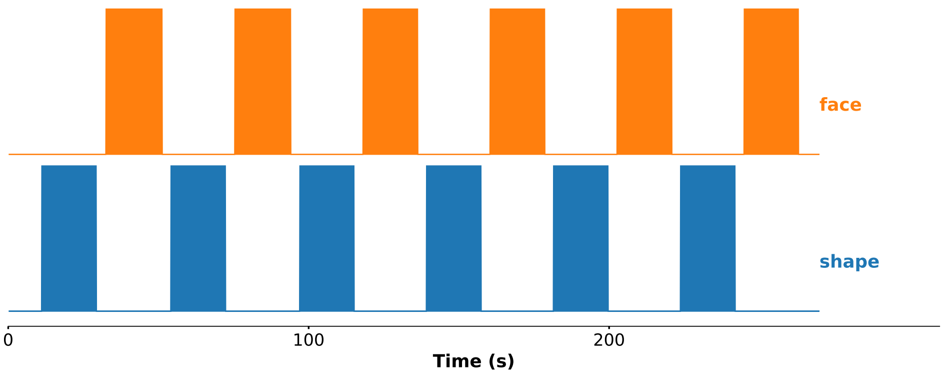

Figure 7: **Block-design of the HCP Emotion task.**

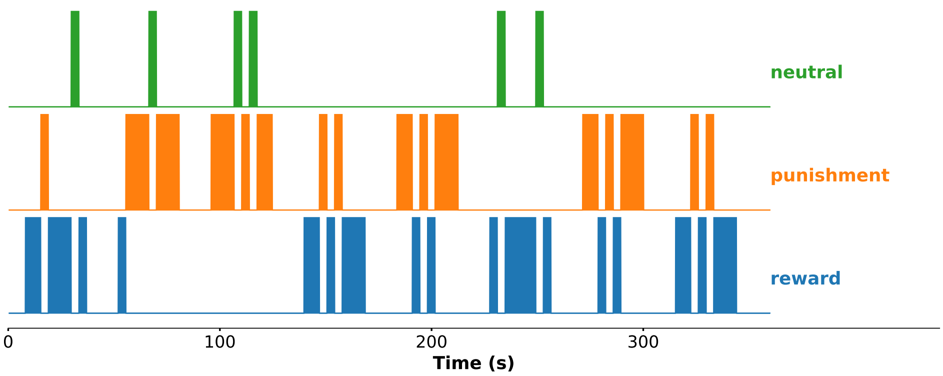

Figure 8: **Block-design of the HCP Gambling task.**

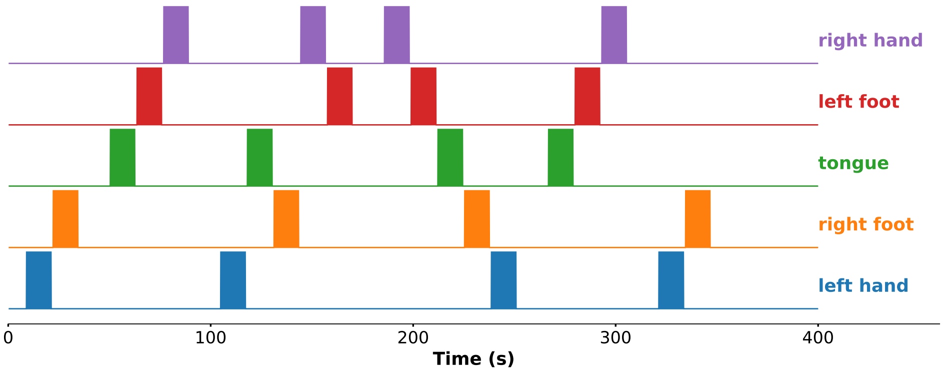

Figure 9: **Block-design of the HCP Motor task.**

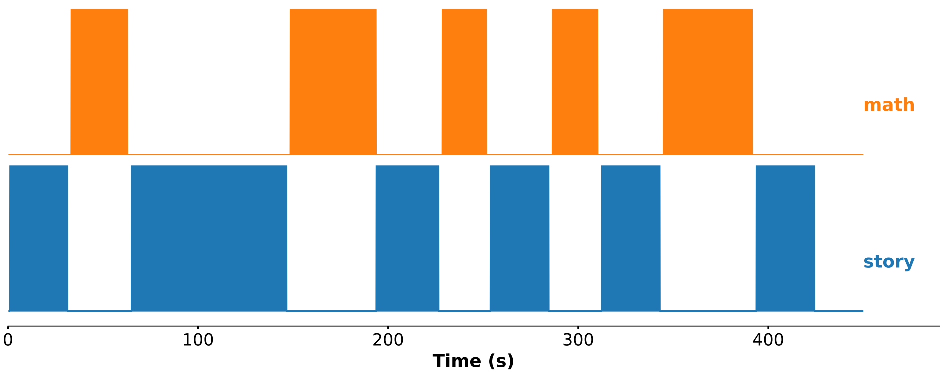

Figure 10: **Block-design of the HCP Language task.**

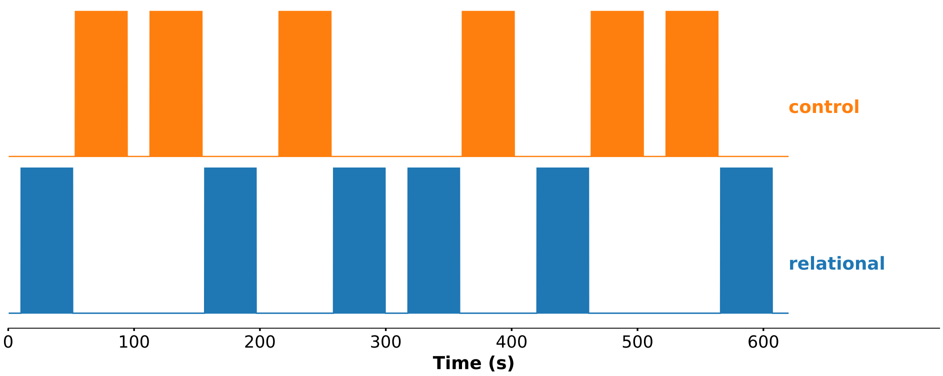

Figure 11: **Block-design of the HCP Relational task.**

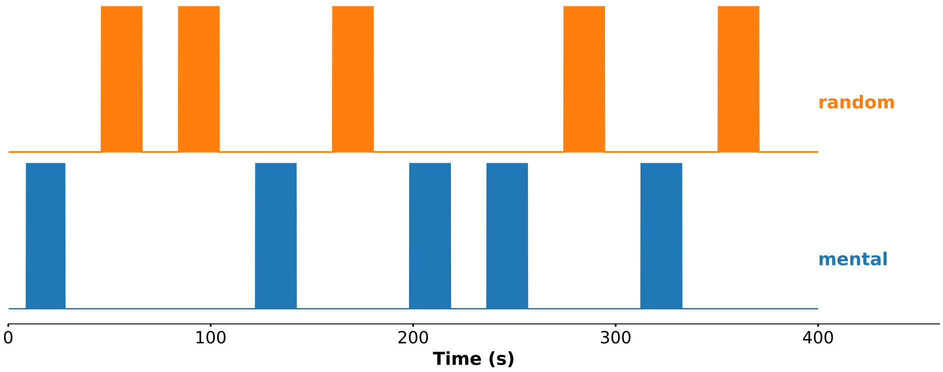

Figure 12: **Block-design of the HCP Social task.**

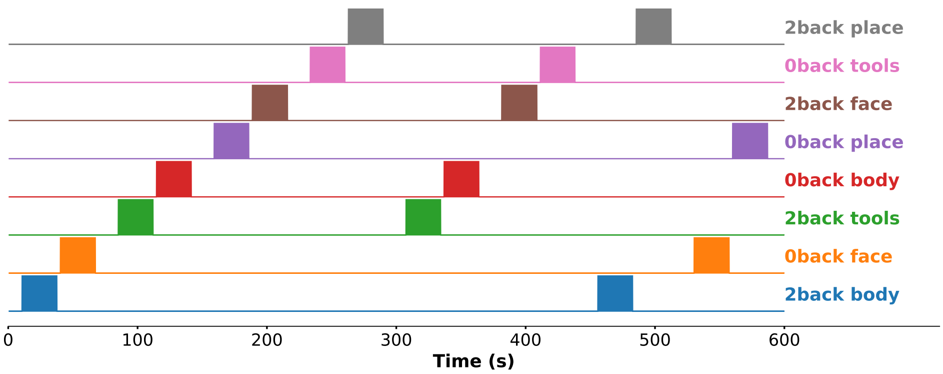

Figure 13: **Block-design of the HCP Working-Memory task.**

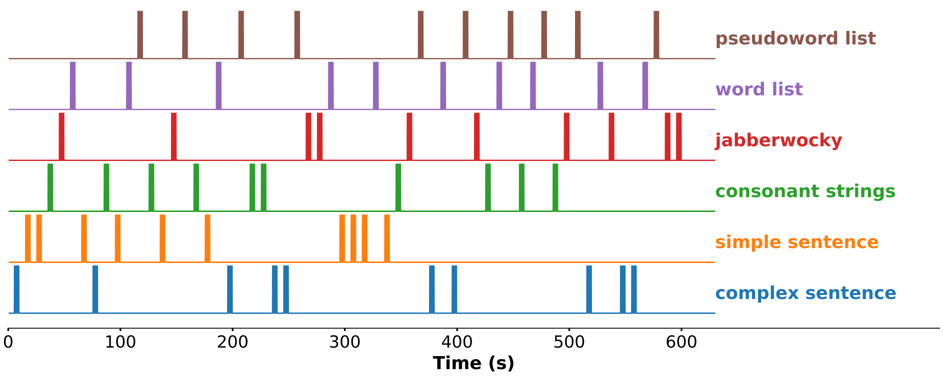

Figure 14: **Block-design of the RSVP Language task.**

Appendix B Acquisition table

	sub-01	**sub-02**	**sub-04**	**sub-05**	**sub-06**	**sub-07**	**sub-08**	**sub-09**	**sub-11**	**sub-12**	**sub-13**	**sub-14**	**sub-15**
ses-00	screening	screening	screening	screening	screening	screening	screening	screening	screening	screening	screening	screening	screening
ses-01	old_anat1	archi	hcp1	hcp1	hcp1	hcp1	archi	hcp1	hcp1	hcp1	hcp1	archi	archi
ses-02	old_anat2	old_anat1	hcp2	hcp2	hcp2	hcp2	hcp1	hcp2	hcp2	hcp2	hcp2	hcp1	hcp1
ses-03	hcp1	old_anat2	rsvp-language	rsvp-language	rsvp-language	rsvp-language	hcp2	old_anat1	rsvp-language	archi	rsvp-language	hcp2	hcp2
ses-04	hcp2	hcp1	archi	archi	archi	archi	rsvp-language	rsvp-language	clips1	rsvp-language	archi	rsvp-language	rsvp-language
ses-05	rsvp-language	hcp2	clips1	clips1	clips1	clips1	clips1	archi	archi	clips1	clips1	anat1	tom
ses-06	clips1	rsvp-language	clips2	clips2	clips2	clips2	clips2	clips1	clips2	clips2	clips2	anat2	preference
ses-07	archi	clips1	clips3	clips3	clips3	clips3	clips3	clips2	clips3	clips3	clips3	clips1	clips1
ses-08	clips2	clips2	anat1	anat1	clips4	clips4	clips4	clips3	clips4	clips4	clips4	clips2	clips2
ses-09	clips3	clips3	clips4	clips4	anat1	anat1	anat1	anat1	anat1	anat1	anat1	clips3	clips3
ses-10	anat1		anat2	anat2	anat2	anat2	anat2	clips4	anat2	anat2	anat2	clips4	enumeration
ses-11	clips4		mtt1	mtt1	mtt1	mtt1	mtt1	anat2	mtt1	mtt1	mtt1	mtt1	clips4
ses-12	anat1		mtt2	mtt2	mtt2	mtt2		mtt1	mtt2	mtt2	mtt2	mtt2	anat1
ses-13	anat2		raiders1	raiders1	raiders1	mtt2		mtt2	raiders1	raiders1	raiders1	preference	anat2
ses-14	mtt1		raiders2	raiders2	raiders2	raiders1		raiders1	raiders1	raiders1	raiders2	raiders1	mtt1
ses-15	mtt2		preference	preference	preference	raiders2		raiders2	raiders2	raiders2	preference	raiders2	mtt2
ses-16	raiders1		tom	tom	tom	preference		preference	preference	preference	tom	tom	raiders1
ses-17	raiders2		enumeration	enumeration	enumeration	tom		tom	relaxo	relaxo	enumeration	enumeration	anat1
ses-18	tom		lyon1	lyon1	lyon1	enumeration		enumeration	tom	tom	lyon1	lyon1	lyon1
ses-19	preference		lyon2	lyon2	lyon2	lyon1		relaxo	enumeration	enumeration	lyon2	lyon2	self
ses-20	enumeration		relaxo	self	relaxo	lyon2		lyon1	lyon1	lyon1	relaxo	relaxo	lyon2
ses-21	relaxo		self	audio1	self	relaxo		lyon2	lyon2	lyon2	self	self	audio1
ses-22	lyon1		audio1	relaxo	audio1	audio1		self	self	self	audio1	audio1	audio2
ses-23	lyon2		audio2	audio2	audio2	audio2		audio1	audio1	audio1	audio2	audio2	stanford1
ses-24	self		stanford1	stanford1	stanford1	self		audio2	audio2	audio2	stanford1	stanford1	
ses-25			stanford2	stanford2	stanford2	stanford1		stanford1	stanford1	stanford1	stanford2	stanford2	
ses-26			stanford3	stanford3	stanford3	stanford2		stanford2	stanford2	stanford2	stanford3	stanford3	
ses-27			lpp1	lpp1	lpp1	stanford3		stanford3	stanford3	stanford3		lpp1	
ses-28			lpp2	lpp2	lpp2	lpp1		lpp1	lpp1	lpp1		lpp2	
ses-29				biological-motion		lpp2			lpp2	lpp2		biological-motion	
ses-30									biological-motion	biological-motion			

Table 51: **Tasks per participant and session.** Latest sessions refer to tasks whose data haven't been released, yet.

Appendix C Data anomalies

	sub-01	sub-02	sub-04	sub-05	sub-06	sub-07	sub-08	sub-09	sub-11	sub-12	sub-13	sub-14	sub-15
screening													
archi													
hcp1													
hcp2													
rsvp-language													
clips1		No data											
clips2		No data											
clips3		No data											
clips4		No data											
mtt1	tSNR drop	No data								tSNR drop		tSNR drop	
mtt2	tSNR drop	No data	tSNR drop		tSNR drop								
raiders1		No data											
raiders2		No data											
preference		No data	tSNR drop		tSNR drop	tSNR drop		tSNR drop	tSNR drop + Paint/Face AP	tSNR drop	tSNR drop	tSNR drop	Food PA
tom		No data	tSNR drop										
enumeration		No data	tSNR drop									tSNR drop	tSNR drop
lyon1		No data											
lyon2		No data											
self		No data											
audio1		No data											
audio2		No data											
stanford1		No data											
stanford2		No data											
stanford3		No data											
lpp1		No data											
lpp2		No data											
biological-motion		No data											

Table 52: **Anomalies of neuroimaging data per participant and session.**
Decription of the anomalies:
tSNR drop: tSNR drop at the bottom of the cerebellum.
Paint/Face AP: Run "Painting-AP" is missing and Run "Faces-AP" was acquired twice.
Food PA: Run "Food-PA" contains only the first 50 trials.