A functional connectome phenotyping dataset including cognitive state and personality measures

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Abstract

The dataset enables exploration of higher-order cognitive faculties, self-generated mental experience, and personality features in relation to the intrinsic functional architecture of the brain. We provide multimodal magnetic resonance imaging (MRI) data and a broad set of state and trait phenotypic assessments: mind-wandering, personality traits, and cognitive abilities. Specifically, 194 healthy participants (between 20 and 75 years of age) filled out 31 questionnaires, performed 7 tasks, and reported 4 probes of in-scanner mind-wandering. The scanning session included four 15.5-min resting-state functional MRI runs using a multiband EPI sequence and a high-resolution structural scan using a 3D MP2RAGE sequence. This dataset constitutes one part of the MPI-Leipzig Mind-Brain-Body database.

Background & Summary

Understanding the unique features of brain organization giving rise to distinct patterns of behavior, cognition, and mental experience remains one of the key research questions in the emerging field of human functional connectomics (Kelly et al., 2012). Functional connectivity has become a prominent method for investigating phenotypic differences across individuals (Vaidya & Gordon, 2013; Smith et al., 2015). However, there is ever greater need for validation of findings across independent datasets. The dataset presented here joins several others in contributing to this research agenda (e.g., Nooner et al., 2012; Holmes et al., 2015; Van Essen et al., 2013) and provides an additional resource for cross-site validation studies.

We acquired a wide range of self-reported personality measures as well as features of self-generated mental experience. In addition, a core magnetic resonance imaging (MRI) dataset—including one-hour of resting-state fMRI data—was acquired on 194 healthy participants. Questionnaires and behavioral measures were acquired over several follow-up sessions.

This dataset constitutes one part of the MPI-Leipzig Mind-Brain-Body database (manuscript forthcoming). It enables exploration of individual variance across cognitive and emotional phenotypes in relation to the brain. All MRI data were acquired on the same 3T Siemens Verio MRI scanner.

Methods

Participants

In total, datasets from 194 native German-speaking participants are included (94 female, mean age = 34 years, median age = 27, SD = 16 years; Figure 1). All participants were scanned on a 3 Tesla magnetic resonance imaging (MRI) scanner (Siemens Verio 3T) for the acquisition of one structural and four resting-state functional MRI scans. In addition, extensive questionnaire and task performance data were acquired from each participant. A subset of participants (N=109) were also included in the complementary data acquisition by Babayan et al. (manuscript forthcoming).

[Figure 1 about here]

Recruitment and inclusion criteria

Prospective participants were initially recruited by the Leipzig Study for Mind-Body-Emotion Interactions project (manuscript forthcoming). Additional participants were recruited through online and poster advertisements. All participants were prescreened via telephone to determine their eligibility for the current study (Table 1). Participants fulfilling the eligibility criteria (including medical screening for MRI-scanning and neurological history) were invited to Max Planck Institute for Human Cognitive and Brain Sciences (MPI-CBS) where they were screened for past and present psychiatric disorders using the Structured Clinical Interview for DSM-IV (SCID-I; Wittchen et al., 1995). After meeting eligibility criteria, participants received detailed information regarding the study.

All participants fulfilled the MRI safety requirements of the MPI-CBS (Supplementary Table 1), provided written informed consent (including agreement to their data being shared anonymously) prior to their participation in the study. Participants received monetary compensation for their participation. The study protocol was approved by the ethics committee of the University of Leipzig (097/15-ff).

[Table 1 about here]

Data acquisition and protocol overview

Participants were required to complete: 1) four functional MRI scans within one scanning session and, if not previously acquired in the study by Babayan et al (manuscript forthcoming), one structural scan; 2) a battery of cognitive, behavioral, and personality questionnaires spread over five appointments, and 3) a set of cognitive and creativity tasks spread over two appointments.

[Table 2 about here]

The data acquisition took place over five appointments over a two-year period (see Table 2):

- Day 1: We acquired data on a set of questionnaires that were completed at MPI-CBS (Tables 2 and 3).
- Day 2: We sent personalized links to participants, who could complete the set of online questionnaires at their convenience (Tables 2 and 3).
- Day 3: Participants were scanned at the Day Clinic for Cognitive Neurology, University of Leipzig. Before entering the scanner, participants completed a pen-and-paper practice trial of the short version of the New York Questionnaire (Ruby et al., 2013). While in the scanner, and immediately after each of the four resting state runs, participants received the computerized version of the same questionnaire. Immediately after the scanning session participants received additional questionnaires and a set of tasks (Tables 2, 3, and 4).
- Day 4: The Abbreviated Math Anxiety Scale and the NEO Personality Inventory-Revised were completed online at the participant's convenience.
- Day 5: We acquired data on a set of questionnaires and tasks that were administered at MPI-CBS. Tasks were conducted using pen-and-paper, computer-administered, as well as Limesurvey interfaces (Tables 2, 3, and 4).

Within each set of questionnaires and tasks, the order of presentation of questionnaires and tasks was randomized across participants. If participants failed to complete a given questionnaire it was excluded from data analysis. Due to dropout, not all participants completed the full set of questionnaires and tasks.

[Tables 3 and 4 about here]

Drug screening prior to MRI data acquisition

Each of the participants was instructed not to use illicit drugs within two weeks of the scanning appointment. Participants were also requested to abstain from alcohol and caffeine consumption, as well as nicotine on the night prior to the scanning day and on the day of scanning. Before the beginning of the MRI session, participants' urine was biochemically screened with a MULTI 8/2 strip test (Diagnostik Nord, Schwerin, Germany) for the presence of buprenorphine (cutoff 10ng/mL), amphetamine (cutoff 1000ng/mL), benzodiazepine (300ng/mL), cocaine (cutoff 300ng/mL), methamphetamine (1000ng/mL), morphine/heroine (cutoff 300ng/mL), methadone (cutoff 300ng/mL), THC (cutoff 50ng/mL). Cutoff levels are those recommended by the American National Institute on Drug Abuse (NIDA; Hawks & Chiang, 1986). Participants provided informed consent on the use of the urine strip test and agreed to its anonymous data sharing, prior to their participation in the study.

MRI data acquisition

All magnetic resonance imaging (MRI) data was acquired using a whole-body 3 Tesla scanner (Magnetom Verio, Siemens Healthcare, Erlangen, Germany) equipped with a 32-channel Siemens head coil at the Day Clinic for Cognitive Neurology, University of Leipzig. For each participant the following scans were obtained: 1) a high-resolution structural scan, 2) four resting-state functional MRI (rs-fMRI) scans, 3) two gradient echo fieldmaps and, 4) two pairs of spin echo images with reversed phase encoding direction. A low-resolution structural image of each participant was acquired using a FLAIR sequence for clinical screening.

Structural scan

The high-resolution structural image was acquired using a 3D MP2RAGE sequence (Marques et al., 2010) with the following parameters: voxel size = 1.0 mm isotropic, FOV = 256 x 240 x 176 mm , TR = 5000 ms, TE = 2.92 ms, TI1 = 700 ms, TI2 = 2500 ms, flip angle 1 = 4°, flip angle 2 = 5°, bandwidth = 240 Hz/Px, GRAPPA acceleration with iPAT factor 3 (32 reference lines), pre-scan normalization, duration = 8.22 min. From the two images produced by the MP2RAGE sequence at different inversion times (inv1 and inv2), a quantitative T1 map (t1map), and a uniform T1-weighted image (t1w) were generated. Importantly, the latter image is purely T1-weighted, whereas standard T1-weighted image, for example acquired with the MPRAGE sequence, also contain contributions of proton density and T2*. It should be taken into account that such differences can affect morphometric measures (Lorio et al., 2016).

For one participant, the structural scan is MPRAGE instead of MP2RAGE (the T1-weighted image file names contain the sequence type) with voxel size = 1 mm isotropic, FoV = 256 x 240 x 176, TR = 2300 ms, TE = 2.98 ms, TI = 900 ms, flip angle = 9°, bandwidth = 238 Hz/Px.

Resting-state scans

Four rs-fMRI scans were acquired in axial orientation using T2*-weighted gradient-echo echo planar imaging (GE-EPI) with multiband acceleration, sensitive to blood oxygen level-dependent (BOLD) contrast (Feinberg et al., 2010; Moeller et al., 2010). Sequences were identical across the four runs, with the exception of alternating slice orientation and phase-encoding direction, to vary the spatial distribution of distortions and signal loss. Thus, the y-axis was aligned parallel to the AC-PC axis for runs 1 and 2, and parallel to orbitofrontal cortex for runs 2 and 4. The phase-encoding direction was A–P for runs 1 and 3, and P–A for runs 2 and 4. Further parameters were set as follows for all four runs: voxel size = 2.3 mm isotropic, FOV = 202 x 202 mm², imaging matrix = 88 x 88, 64 slices with 2.3 mm thickness, TR = 1400 ms, TE = 39.4 ms, flip angle = 69°, echo spacing = 0.67 ms, bandwidth = 1776 Hz/Px, partial fourier 7/8, no pre-scan normalization, multiband acceleration factor = 4, 657 volumes, duration = 15 min 30 s. During the resting-state scans, participants were instructed to remain awake with their eyes open and to fixate on a crosshair.

Scans for distortion correction

Two prominent methods exist to correct for geometric distortions in EPI images: fieldmaps, which represent the degree of distortion as calculated from two phase images with different echo times (Jezzard & Balaban 1995; Reber et al., 1998), and reverse phase encoding, in which pairs of “blip-up blip-down” images are acquired with opposite phase encoding direction — thus opposite distortions — and used to model a middle distortion-free image (Chang & Fitzpatrick, 1992; Andersson et al., 2003). This datasets contains scans required for both methods to accommodate different preprocessing approaches and facilitate method comparison. Before each pair of resting-state runs with the same y-axis orientation (see above), the following scans were acquired in the same orientation as the subsequent resting-state scans: a pair of spin echo images (voxel size = 2.3 mm isotropic, FOV = 202 x 202 mm², imaging matrix = 88 x 88, 64 slices with 2.3 mm thickness, TR = 2200 ms, TE = 52 ms, flip angle = 90°, echo spacing = 0.67 ms, phase encoding = AP / PA, bandwidth = 1776 Hz/Px, partial fourier 6/8, no pre-scan normalization, duration = 0.20 min each), and a gradient echo fieldmap (voxel size = 2.3 mm isotropic, FOV = 202 x 202 mm², imaging matrix = 88 x 88, 64 slices with 2.3 mm thickness, TR = 680 ms, TE1 = 5.19 ms, TE2 = 7.65 ms, flip angle = 60°, bandwidth = 389 Hz/Px, prescan normalization, no partial fourier, duration = 2.03 min).

Additional scans

109 subjects also took part in the protocol by Babayan et al. (manuscript forthcoming). Therefore, additional modalities might be available for these subjects. Modalities include high-resolution T2-weighted (108 subjects), diffusion-weighted (109), 3D FLAIR (47), phases and magnitudes of gradient-echo images suitable for Susceptibility-Weighted Imaging (SWI) and Quantitative Susceptibility Mapping (QSM) (45 subjects), as well as an additional 15-minute resting-state scan for all 109 subjects.

MRI data preprocessing

To enhance data usability we provide preprocessed data from 189 subjects.[1] Data from five participants were further excluded due to failure at the preprocessing stage. The raw MRI data of these subjects are not corrupted, and are therefore available in the main database. Preprocessing pipelines were implemented using Nipype (Gorgolewski et al., 2011) and are described in more detail below. All code is openly available.[2]

[1] Five participants did not have all four resting-state scans are available, and were excluded from preprocessing.
[2] https://github.com/NeuroanatomyAndConnectivity/pipelines/tree/master/src/lsd_lemon

Importantly, the preprocessing performed here is just one out of a multitude of possible pipelines that could be conceived for this dataset. The decisions taken at individual processing steps will not be suitable for every application. Users are strongly advised to familiarize themselves with the details of the workflow before adopting the preprocessed data for their study. We also encourage users to subscribe to the mailing list for updates and discussions regarding the preprocessing pipelines used here.[3]

Structural data

The background of the uniform T1-weighted image was removed using CBS Tools (Bazin et al., 2014), and the masked image was used for cortical surface reconstruction using FreeSurfer's full version of recon-all (Dale et al., 1999; Fischl et al., 1999). A brain mask was created based on the FreeSurfer segmentation results. Diffeomorphic nonlinear registration as implemented in ANTs SyN algorithm (Avants et al., 2011) was used to compute a spatial transformation between the individual's T1-weighted image and the MNI152 1mm standard space.

To remove identifying information from the structural MRI scans, a mask for defacing was created from the MP2RAGE images using CBS Tools (Bazin et al. 2014). This mask was subsequently applied to all anatomical scans.

Functional data

The first five volumes of each resting-state run were excluded. Transformation parameters for motion correction were obtained by rigid-body realignment to the first volume of the shortened time series using FSL MCFLIRT (Jenkinson et al., 2002). The fieldmap images were preprocessed using the fsl_prepare_fieldmap script. A temporal mean image of the realigned time series was rigidly registered to the fieldmap magnitude image using FSL FLIRT (Jenkinson & Smith 2001) and unwarped using FSL FUGUE (Jenkinson et al. 2012) to estimate transformation parameters for distortion correction. The unwarped temporal mean was rigidly coregistered to the subject's structural scan using FreeSurfer's boundary-based registration algorithm (Greve & Fischl 2009), yielding transformation parameters for coregistration. The spatial transformations from motion correction, distortion correction, and coregistration were then combined and applied to each volume of the original time series in a single interpolation step. The time series were masked using the brain mask created from the structural image (see above). The six motion parameters and their first derivatives were included as nuisance regressors in a general linear model (GLM), along with regressors representing outliers as identified by Nipype's rapidart algorithm[4], as well as linear and quadratic trends. To remove physiological noise from the residual time series, we followed the aCompCor approach as described by Behzadi et al. (2007). Masks of the white matter and cerebrospinal fluid were created by applying FSL FAST (Zhang et al., 2001) to the T1-weighted image, thresholding the resulting probability images at 99%, eroding by one voxel and combining them to a single mask. Of the signal of all voxels included in this mask, the first six principal components were included as additional regressors in a second GLM, run on the residual time series from the first GLM. The denoised time series were temporally filtered to a frequency range between 0.01 and 0.1

[3] http://groups.google.com/group/resting_state_preprocessing
[4] http://nipy.org/nipype/interfaces/generated/nipype.algorithms.rapidart.html

Hz using FSL, mean centered and variance normalized using Nitime (Rokem et al., 2009). The fully preprocessed time series of all for runs were temporally concatenated. To facilitate analysis in standard space, the previously derived transformation was used to project the full-length time series into MNI152 2mm space. The preprocessed data are made available in the subjects' native structural space and MNI standard space, along with the subject's brain mask and all regressors used for denoising.

Data security and data anonymization procedures

Data for all participants was stored on our instance of the eXtensible Neuroimaging Archive Toolkit (XNAT, Marcus et al. 2007) v.1.6.5. at the MPI-CBS. Access to the initial project was restricted (via XNAT's private project mode) to members of the Neuroanatomy & Connectivity Group at MPI-CBS for initial curation and quality assessment of data. All data comprised in the MPI-Leipzig Mind-Brain-Body database were derived from MPI-CBS so data import into XNAT was done from a local secured network.

A specially customized XNAT uploader was used to upload all participants' data to XNAT. The native DICOM format was used for MRI data, whilst a standard ASCII (*.csv, *.txt) format was employed to upload all other experimental data such as surveys, test batteries, and demographical data.

The anonymization measures applied to the MRI data consisted of removal of DICOM header tags containing information which could lead to the identification of test subjects as well as the defacing of all structural (NIFTI) scans. Specific surveys and test batteries containing sensitive information are only available via the restricted project in XNAT for which access needs to be applied for (see the Usage Notes section below).

Code availability

All code that was implemented for data acquisition and processing is available online.[5] Data handling and computation of summary measures were implemented in Python. The pipeline used for MRI preprocessing is also available.[6]

The tasks that the participants received were implemented using the Python package PsychoPy2 Experiment Builder v1.81.03 (Peirce, 2007, 2008), OpenSesame 0.27.4 (Mathôt & Theeuwes, 2012) and Presentation® software (Version 16.5, Neurobehavioral Systems, Inc., Berkeley, CA, www.neurobs.com). We provide the respective source codes of the adaptive visual and auditory oddball task (oddball)[7], conjunctive continuous performance task (CCPT)[8], and emotional task switching task (ETS)[7].

Data Records

[5] https://neuroanatomyandconnectivity.github.io/opendata/
[6] https://github.com/NeuroanatomyAndConnectivity/pipelines/tree/v2.0/src/lsd_lemon (release v2.0)
[7] https://github.com/NeuroanatomyAndConnectivity/opendata/tree/master/scripts
[8] https://github.com/NeuroanatomyAndConnectivity/ConjunctiveContinuousPerformanceTask

Survey and task data

A comprehensive list of behavioral and questionnaire data are given in Supplementary Table 2. Data from all questionnaires are released as summary scores. Results of questionnaires without summary scores are released as raw item scores, namely: Multi-Gender Identity (MGIQ), Mobile phone usage (MPU), FBI (Facebook intensity scale), New York cognition (NYC-Q), and the short version of the New York cognition (Short-NYC-Q) questionnaires. Task data for the CCPT, ETS, and oddball task are available via subject-specific csv files. Accompanying specifications and information for each questionnaire and task are given in txt file format.

A basic demographic summary is provided together with general information on data acquisition. The metafile includes gender, age (5-year bins), current or past diagnosed psychiatric disorder(s), result of the drug test on day of scanning, and formal education.

MRI data

The dataset is organized in concordance with the Brain Imaging Data Structure (BIDS) format (Gorgolewski et al., 2016a). This facilitates data analysis, for example with BIDS-Apps (Gorgolewski et al., 2016b).[9] BIDS-Apps encapsulate standard MRI analysis tools within an application that understands the BIDS format and allows to automatically access relevant data and metadata.

MRI data are currently available from two locations:

1. OpenfMRI.org platform also hosts the raw data.[10]
2. Gesellschaft für wissenschaftliche Datenverarbeitung mbH Göttingen (GWDG).[11] The data at this location is accessible through web browser and fast FTP connection. It contains both raw and preprocessed data. Currently, preprocessed resting-state fMRI data is available.[12] In the case the location of the data changes in the future, the location of the dataset can be resolved with PID 21.11101/0000-0004-2CD6-A.[13]

Technical Validation

All datasets were manually assessed for missing or corrupt data. Further quality control of the data was applied to the MRI and behavioral measures, as described below.

MRI data quality assessment

[9] http://bids-apps.neuroimaging.io
[10] https://www.openfmri.org/dataset/ds000221/
[11] https://www.gwdg.de/
[12] The current URL for the dataset is ftp://ftp.gwdg.de/pub/misc/MPI-Leipzig_Mind-Brain-Body/ or https://ftp.gwdg.de/pub/misc/MPI-Leipzig_Mind-Brain-Body/
[13] e.g., https://hdl.handle.net/21.11101/0000-0004-2CD6-A

Preprocessed MRI data were assessed for quality using the mriqc package[14] (Esteban et al. 2017), implemented in Python. mriqc creates a report for each individual scan based on assessment of movement parameters, coregistration, and temporal signal-to-noise (tSNR) calculations. For comparison, all individual-level scores are displayed with respect to the group-level distribution. We visually inspected the quality assessment reports for each subject to ensure adequate coregistration and fieldmap correction.

As motion during the resting-state fMRI scan poses a substantial source of noise (Power et al., 2014), we characterized motion for each run as the mean and maximum framewise displacement (Figure 2). Overall, the summary of motion parameters demonstrates that the data are largely of sufficient quality, with 89.2% of runs showing less than one voxel (2.3 mm) maximum framewise displacement, and a mean framewise displacement of 0.18 mm (SD = 0.08 mm).

[Figure 2 about here]

Fieldmap correction provides an approach to correct for distortions due to susceptibility artifacts. While unable to recover signal loss, the correction of such nonlinear distortions improves coregistration between scan types, and group-level alignment (Jezzard, 2012). As an example, we present a single dataset, pre- and post-fieldmap correction, in Figure 3. As expected, fieldmap correction primarily shifted voxels within ventral regions.

[Figure 3 about here]

Temporal signal-to-noise (tSNR), which is calculated on the voxel-level as the mean signal divided by the standard deviation, offers a general overview of the local differences across the brain. We observed lower tSNR in ventral regions, including the orbitofrontal and temporal cortex (Figure 4).

[Figure 4 about here]

Behavioral measures quality assessment

Fifteen questionnaires without a published German version were in-house translated (English-German). To ensure general usability of the translated questionnaires, their reliability was estimated using Cronbach's Alpha coefficient (see Table 5). For comparison, the Cronbach's Alpha coefficients from the original questionnaires are also reported in Table 5.
Internal consistency of the majority of questionnaires was acceptable, with an average Cronbach's Alpha of 0.78, thus showing that the German translations of those specific questionnaires are reproducible and valid. However, three questionnaires (Short Dark Triad, Body Consciousness questionnaires, and the Creative Achievement questionnaire) and four scales (two scales of the Five Facets of Mindfulness questionnaire, one scale of the Metacognition questionnaire, and one scale of the Involuntary Musical Imagery scale) showed modest reliability, with Cronbach's Alpha coefficient < 0.70, and should be interpreted with caution.

[14] The code was adapted from https://github.com/chrisfilo/mriqc and can be found at https://github.com/NeuroanatomyAndConnectivity/pipelines/tree/master/src/lsd_lemon (release v2.0)

[Table 5 about here]

Usage Notes

The MRI dataset can be accessed at www.openfmri.org, and the behavioral data is available at www.nitrc.org[15]. The following data are publicly available: 1) MRI data (structural and functional), 2) general demographic of the studied population, 3) summary scores and/or indexes of the questionnaires and tasks, and 4) raw scores of the measures that do not possess summary scores and have not been classified as sensitive. All MRI datasets are made available in NIFTI format, and all anatomical scans have been defaced.

The dataset, protocols, and software used in the acquisition and processing of the data are documented, curated, and available for research purposes. For access to the behavioral data, users must first agree to the terms of data usage.

Additional access to sensitive behavioral measures

Individual behavioral scores and sensitive phenotypic measures may be made available upon request.[16] The completion of additional data license and confidentiality forms will be required in advance of further data access.

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Author contributions

Conception, design, and preparation of the manuscript: D.S.M., J.G., J.M.H., M.E.L., M.F., N.M., S.O.
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All authors provided critical feedback and approval of the manuscript.

Competing interests

The authors declare no competing financial interests.

[15] http://nitrc.org/projects/mpilmbb/
[16] Contact corresponding authors.

Figure Legends

Figure 1. Age distribution. Age distribution (5-year bins) of the participants split by gender.

Figure 2. Quality assessment of resting-state fMRI scans. Distribution of motion (maximum and mean framewise displacement).

Figure 3. Example impact of fieldmap correction.

Figure 4. Temporal signal-to-noise (tSNR). Group-level variance in temporal signal-to-noise (tSNR) across the brain. tSNR values are lower in ventral regions including orbitofrontal and temporal cortex.

Table Legends

Table 1. Exclusion criteria. Exclusion criteria to prospective participants.

Table 2. Phases of the data acquisition. Overview of the different phases of the data acquisition.

Table 3. Behavioral measures: questionnaires. Overview of data available for each questionnaire.

Table 4. Behavioral measures: tasks. Overview of data available for each task.

Table 5. Reliability of translated questionnaires. Estimated reliability of the English-German translated questionnaires using Cronbach's Alpha coefficient (α).

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Figure 1. Age distribution (5-year bins) of the participants split by gender.

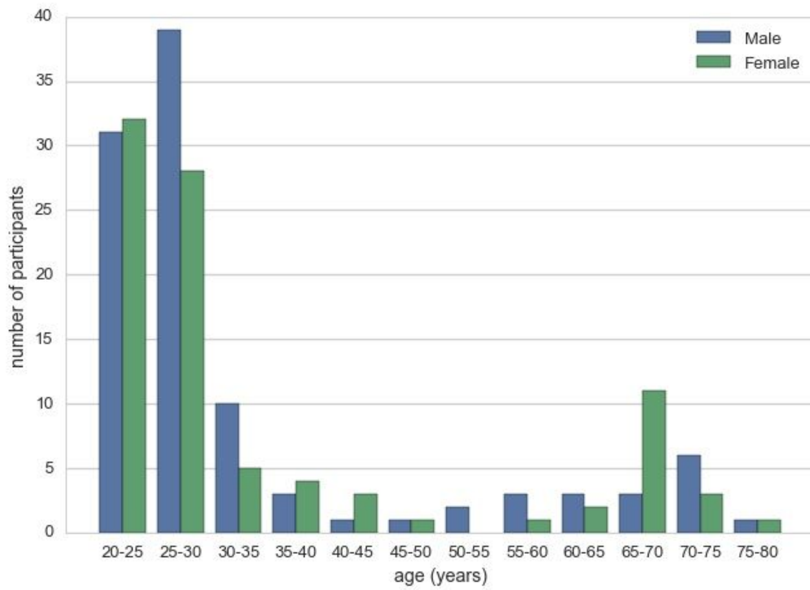

Figure 2. Quality assessment of resting-state fMRI scans.

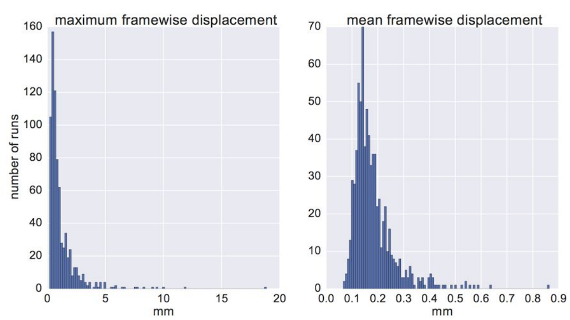

Figure 3. Example impact of fieldmap correction.

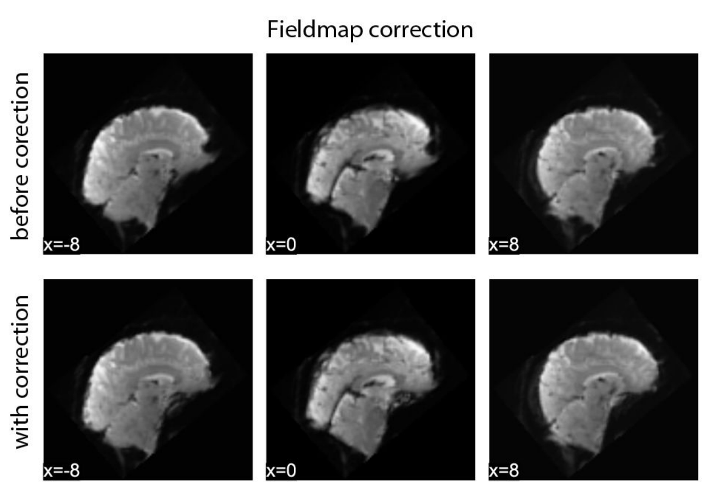

Figure 4. Temporal Signal-to-Noise (tSNR)

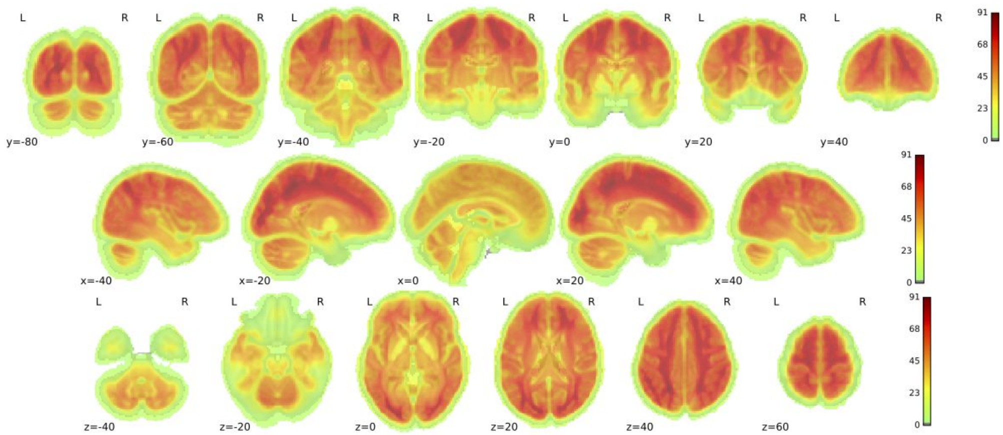

Table 1. Exclusion criteria to prospective participants.

Exclusion Criteria
● History of psychiatric diseases that required inpatient treatment for longer than 2 weeks within the last 10 years (e.g., psychosis, attempted suicide, post-traumatic stress disorder); ● History of neurological disorders (incl. multiple sclerosis, stroke, epilepsy, brain tumour, meningoencephalitis, severe concussion); ● History of malignant diseases; ● Intake of one of the following medications: ○ Any centrally active drugs (including *Hypericum perforatum*) ○ Beta- and alpha-blocker ○ Cortisol ○ Any chemotherapeutic or psychopharmacological medication; ● Positive drug anamnesis (extensive alcohol, MDMA, amphetamines, cocaine, opiates, benzodiazepine, cannabis); ● BMI < 18 or > 30 ; ● Extensive testing experience at the MPI-CBS or other academic institution; ● Past or present student of Psychology; ● MRI exclusion criteria (see Table 1 in Supplementary Material) ○ Any metallic implants, braces, non-removable piercings ○ Tattoos ○ Pregnancy ○ Claustrophobia ○ Tinnitus ○ Surgical operation in the last 3 months

Table 2. Overview of the different phases of the data acquisition.

Day 1 (MPI CBS)	Day 2 (Home)	Day 3 (Uni Clinic)	Day 4 (Home)	Day 5 (MPI CBS)
ASR	ACS	Scanning session	AMAS	BIS/BAS
God-MSI	BDI		NEO PI-R	CAQ
IAT	BP	FBI		MCQ-30
IMIS	ESS	S-D-MW		BCQ
MGIQ	HADS	Short-NYC-Q_inscan1-4		FFMQ
SCS	MMI	Short-NYC-Q_postETS		RAT
SD3	MPU	NYC-Q_postscan		SYN
SE	PSSI	ETS		AUT
TPS		CCPT		TCIA
VISQ		Oddball		
UPPS-P				
SDS				

Note. ACS = Attention Control Scale, **AMAS** = Abbreviated Math Anxiety Scale, **ASR** = Adult Self Report, **AUT** = Alternative Uses Task, **BCQ** = Body Consciousness Questionnaire, **BDI** = Beck Depression Inventar-II, **BIS/BAS** = Behavioral Inhibition and Approach System, **BP** = Boredom Proneness Scale, **CAQ** = Creative Achievement Questionnaire, **CCPT** = Conjunctive Continuous Performance Task, **ESS** = Epworth Sleepiness Scale, **ETS** = Emotional task switching task; **FBI** = Facebook Intensity Scale, **FFMQ** = Five Facets of Mindfulness Questionnaire, **Gold-MSI** = Goldsmiths Musical Sophistication Index, **HADS** = Hospital Anxiety and Depression Scale, **IAT** = Internet Addiction Test, **IMIS** = Involuntary Musical Imagery Scale, **MCQ-30** = Metacognition Questionnaire, **MGIQ** = Multi-Gender Identity Questionnaire, **MMI** = Multimedia Multitasking Index, **MPU** = Mobile Phone Usage, **NEO PI-R** = NEO Personality Inventory-Revised, **NYC-Q_postscan** = New York Cognition Questionnaire after scan, **Oddball** = Adaptive Visual and Auditory Oddball Target Detection Task, **PSSI** = Personality Style and Disorder Inventory, **RAT** = Remote Associates Test, **SCS** = Brief Self-Control Scale, **SD3** = Short Dark Triad, **S-D-MW** = Spontaneous and Deliberate Mind-Wandering, **SE** = Self-Esteem Scale, **Short-NYC-Q_inscan1-4** = Short Version of the New York Cognition Questionnaire in scanner, **Short-NYC-Q_postETS** = Short Version of the New York Cognition Questionnaire after tasks, **SYN** = Synesthesia Color Picker Test, **TCIA** = Test of Creative Imagery Abilities, **TPS** = Tuckman Procrastination Scale, **VISQ** = Varieties of Inner Speech Questionnaire, **UPPS-P** = UPPS-P Impulsive Behavior Scale, **SDS** = Social Desirability Scale-17.
MPI-CBS = Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig; **Uni Clinic** = Day Clinic for Cognitive Neurology, University of Leipzig.

Table 3. Overview of data available for each questionnaire.

Abbreviation	Behavioral Measure	N
ACS	Attention Control Scale (Derryberry & Reed, 2002)	210
AMAS	Abbreviated Math Anxiety Scale (Hopko et al., 2003)	145
ASR	Adult Self Report (adapted from Achenbach & Rescorla, 2003)	213
BCQ	Body Consciousness questionnaire (Miller et al., 1981)	79
BDI	Beck Depressions Inventar-II (Beck et al., 1961, 1996; German version: Hautzinger et al., 1995)	210
BIS/BAS	Behavioral Inhibition and Approach System (Carver & White, 1994; Strobel et al., 2001; Gray, 1981, 1982)	288
BP	Boredom Proneness Scale (Farmer & Sundberg, 1986)	209
CAQ	Creative achievement questionnaire (Carson et al., 2005)	79
CCPT	Conjunctive continuous performance task (Shalev et al., 2011)	169
ESS	Epworth Sleepiness Scale (Johns, 1991; German version: Bloch et al., 1999)	210
FBI	Facebook Intensity Scale (adapted from Ellison et al., 2007)	180
FFMQ	Five facets of mindfulness (Baer et al., 2006)	79
Gold-MSI	Goldsmiths Musical Sophistication Index (German version: Schaal et al. 2014; Müllensiefen et al. 2014)	214
HADS	Hospital Anxiety and Depression Scale (Zigmond & Snaith,1983; German version: Herrmann-Lingen, et al. 1995)	210
IAT	Internet Addiction Test (adapted from Young, 1998)	214
IMIS	Involuntary Musical Imagery Scale (adapted from Floridou et al., 2015)	214

MCQ-30	Metacognition (Wells & Cartwright-Hatton, 2004; Sadeghi et al., 2014)	79
MGIQ	Multi-Gender Identity Questionnaire (adapted from Joel et al., 2014)	159
MMI	Multimedia Multitasking Index (Ophir et al., 2009)	209
MPU	Mobile Phone Usage (Developed in-house.)	210
NEO PI-R	NEO Personality Inventory-Revised (Ostendorf & Angleitner, 2004; Costa & McCrae, 1985, 1992)	169
NYC-Q_posttasks NYC-Q_postscan NYC-Q	New York Cognition Scale (Gorgolewski et al., 2014)	202 188
PSSI	Personality Style and Disorder Inventory (Kuhl & Kazén, 2009).	209
SCS	Brief Self-Control Scale (Tangney et al., 2004; German version adapted from: Bertrams & Dickhäuser, 2009)	214
SD3	Short Dark Triad (adapted from Jones & Paulhus, 2014; Paulhus, 2013)	214
S-D-MW	Spontaneous and Deliberate Mind-Wandering (adapted from Carriere et al., 2013; see also Golchert et al. 2017)	214
SDS	Social Desirability Scale-17 (Crowne & Marlowe, 1960; German version: Stöber, 1999)	214
SE	Self-Esteem Scale (O'malley & Bachman, 1979)	214
Short-NYC-Q_inscan1 Short-NYC-Q_inscan2 Short-NYC-Q_inscan3 Short-NYC-Q_inscan4 Short-NYC-Q_postETS Short-NYC-Q_prescan	Short New York Cognition Scale (Ruby et al., 2013)	175 174 174 170 181 159
TPS	Tuckman Procrastination Scale (Stöber, 1995; Tuckman, 1991).	214
UPPS-P	UPPS-P Impulsive Behavior Scale (Whiteside & Lynam, 2001; Lynam et al., 2006; see also Golchert et al., 2017)	214

VISQ	Varieties of Inner Speech (McCarthy-Jones & Fernyhough, 2011)	214

Table 4. Overview of data available for each task.

Abbreviation	**Behavioral Measure**	**N**
AUT	Alternative uses task (Silvia, 2008; Guilford et al. 1978)	77
CCPT	Conjunctive continuous performance task (Shalev et al., 2011)	169
ETS	Emotional task switching (adapted from Whitmer & Banich, 2007; see Hildebrandt et al., 2016)	189
Oddball	Adaptive visual and auditory oddball target detection task (modified from: Huettel & McCarthy, 2004)	137
RAT	Remote associates test (Landmann et al., 2014; see also Lee et al., 2014)	77
SYN	Synesthesia color picker test (synesthete.org; Eagleman et al., 2007)	73
TCIA	Test of creative imagery abilities (Jankowska & Karwowski, 2015)	77

Table 5. Estimated reliability of the English-German translated questionnaires using Cronbach's Alpha coefficient (α).

Translated Questionnaires	**Cronbach's alpha coefficient (α)**
Abbreviated math anxiety scale (Hopko et al., 2003)	α = .92 (English original: α = .90)
Attention control scale (Derryberry and Reed, 2002)	α = .74 (English original: not reported)
Body consciousness questionnaire (Miller and al., 1981)	*Private body scale*, α = .63 *Public body scale*, α = .62 *Body competence scale*, α = .62 Note. Cronbach's α coefficients of the original scales are not available
Boredom proneness scale (Farmer and Sundberg, 1986)	α = .84 (English original: α = .79)

Creative achievement questionnaire (Carson & Higgins, 2005)	α = .67 (English original: α = .96)
Five facets of mindfulness (Baer et al., 2006)	*Observing scale,* α = .68 (English original: α = .83) Describing scale, α = .89 (English original: α = .91) *Acting with Awareness scale,* α = .70 (English original: α = .87) *Nonjudging scale*, α = .87 (English original: α = .87) *Nonreactivity scale,* α = .69 (English original: α = .75)
Internet addiction test (Young, 1999)	α = .91 (item 3 was excluded from the analysis due to different scaling; values for English unavailable)
Involuntary musical imagery scale (Floridou et al., 2015)	*Negative valence*, α = .88 for (English original: α = .91) *Movement*, α = .92 (English original: α = .88) *Personal reflections*, α = .64 (English original: α = .76) *Help*, α = .90 (English original: α = .84)
Media-multitasking inventory (Ophir et al., 2009)	α = .97 (English original: not reported)
Metacognition (Wells and Cartwright-Hatton, 2004)	*Cognitive confidence,* α = .80 (English original: α = 0.93) *Positive beliefs,* α = .85 (English original: α = 0.92) *Cognitive self-consciousness,* α = .85 (English original: α = 0.92) *Uncontrollability and danger,* α = .80 (English original: α = 0.91) *Need to control thoughts,* α = .67 (English original: α = 0.72)
Self-esteem scale (O'malley and Bachman, 1979)	α = .88 (English original: α = .79 for males; α = .83 for females)
Short dark triad (Paulhus, 2013; Original by Jones and Paulhus, 2014)	*Machiavellianism*, α = .68 (English original: α = .78) *Narcissism*, α = .65 (English original: α = .77) *Psychopathy*, α = .59 for (English original: α = .80)
Spontaneous and deliberate mind-wandering	*Deliberate mind wandering*, α = .81 (English original: α = .90)

(Carriere et al., 2013)	*Spontaneous mind wandering*, α = .81 (English original: α = .88)
UPPS-P impulsive behavior scale (Whiteside and Lynam, 2001; Lynam et al., 2006)	*Negative urgency*, α = .83 (English original: α = .90) *Lack of premeditation*, α = .75 (English original: α = .91) *Lack of perseverance*, α = .84 (English original: α = .82) *Sensation seeking*, α = .82 (English original: α = .86) *Positive urgency*, α = .90 (English original: not reported)
Varieties of inner speech (McCarthy-Jones and Fernyhough, 2011)	*Dialogic inner speech*, α = .74 (English original: α = .83) *Condensed inner speech*, α = .79 (English original: α = .83) *Other people in inner speech*, α = .86 (English original: α = .88) *Evaluative inner speech*, α = .74 (English original: α = .80)