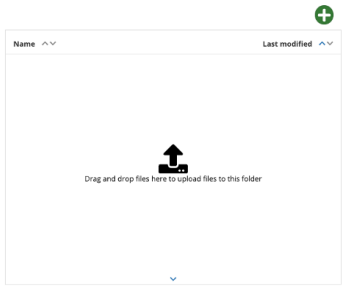
Instructions

This document includes the questions that will be when completing this registration template on OSF. Make a copy of this document and use it to plan and prepare for submitting your registration.

Questions with a red asterisk (*) are required.

Questions will offer one of the following input options:

●	Radio button	You will be provided with a series of options and may select only one.
☐	Check box	You will be provided with a series of options and may select as many as necessary.
Text box	Text box (short or long)	You will type in your response.
	File upload widget	You can upload a file as a response to this question. You may attach up to 5 files and cannot total over 5GB in size.

Metadata

Title

Description

Contributors

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Subject

Our system uses the bepress taxonomy. Please select as many subjects as you please. Note, the more detailed and inclusive you are in your response makes it easier for others to find your work.

Tags (Optional)

Design Plan

Hypotheses

List specific, concise, and testable hypotheses. Please state if the hypotheses are directional or non-directional. If directional, state the direction. A predicted effect size is also appropriate here. If a specific interaction or moderation is important to your research, you can list that as a separate hypothesis. State the specific ERP component for which an experimental manipulation is (or is not) expected.

Example.

H1 (directional). We predict that, behaviourally, people with musical training would be more accurate at discriminating small pitch differences compared to those without musical training, as evidenced by statistically more accurate performance in the behavioral discrimination task for the small pitch difference among musically trained individuals.

H2 (directional). We predict that, at the electrophysiological level, people with musical training would show a stronger discrimination response to both small and large pitch differences compared to people without musical training. This would be reflected in a larger mean amplitude of the MMN to both the smaller and the larger pitch difference for the musically trained individuals.

Stimuli

Describe the stimuli used in the experiment.

Example. The pitch difference for the small difference is 4 Hz (standard 400 Hz, deviant 404 Hz), and for the large difference is 8 Hz (standard 400 Hz,deviant 408 Hz). There will be 300 trials per block, 80% of which are standards (N = 240; 400 Hz), and 20% are deviants (N = 60, either 404 Hz or 408 Hz). The stimuli will be created as pure sine tones (mono, sampling frequency of 44100 Hz, amplitude of 0.2 Pa and Fade-in and fade-out durations of 0.01 sec).

Study design

Describe your study design. Is it a between-subject, within-subject, or mixed design

Example: We will employ a mixed 2x2 design, with one between-subject factor musical training (two levels: musicians -non-musicians) and one within-subject factor pitch difference (two levels: small difference, large difference).

Experimental design

Describe the experimental design. Consider adding the following: Stimulus presentation duration, Inter-stimulus interval, Trial duration, Inter-trial interval, Number of trials, Blocked or randomized trial presentation, Participant's task, Duration of the study, Response window.

Example: Stimuli will be presented for 400 ms, with an ISI of 500 ms. Participants will be presented with 4 blocks (two with small pitch difference, two with large pitch difference) of 300 trials each, separated by short self-paced pauses. The total duration of the experiment will be about 20 minutes. Participants will be instructed to press the spacebar when they detect the deviant (i.e., stimulus that has a higher pitch).

Randomization

If you are doing a randomized study, how will you randomize, and at what level? What kind of counterbalancing will you use?

Example: We will pseudo-randomize the stimuli such that there will be at least 3 consecutive standards between each deviant. Participants' group assignment is based on pre-set musicality criteria and therefore cannot be randomized. Non-musicians will be age-matched to musicians. Block order will be counterbalanced: within each group, participants assigned with an odd number will be presented with the small difference block first, whereas participants assigned with an even number will be presented with the large difference block first.

Blinding

Blinding describes who is aware of the experimental manipulations within a study. You can specify whether the study was blind for subjects, experimenters or double blind. You can also specify whether the analysis was performed in a blind way.

Example: Group assignment is based on pre-set musicality criteria, and will not be blinded for the experimenter. The experimenter will not be blinded to block order either, since this is a perceivable pitch difference (at least for a trained listener). Preprocessing will be blinded, that is, the researcher performing the preprocessing will not be aware of the participant's group, or of the pitch difference of the block.

Manipulation check

Describe whether you are going to do any manipulation checks.

Example: We will check whether the participants are, independent of our manipulation, able to hear the tones. Therefore, we will assess whether all individual participants show a P100 averaged across conditions.

Sampling Plan

Foreknowledge of data or evidence

Preregistration clarifies the difference between planned analyses, specified prior to observing the data or evidence, and unplanned analyses conducted after observing the data or evidence. However, for pre-existing data, how much is known about the data and evidence could introduce unintended influences on analysis and conclusions. Please choose the situation which best resembles your understanding about your foreknowledge of the data and evidence for this study and analysis plan.

- Data does not yet exist. No part of the data that will be used for this analysis plan exists, and no part will be generated until after this plan is registered.
- Data exists but the authors cannot observe it yet. At least some of the data that will be used for this analysis plan exists but is inaccessible to the authors and will remain so until after this plan is registered.
- Data exists but the authors have not observed it yet. At least some of the data that will be used for this analysis plan exists and is possible for the authors to access. However, the authors certify that they have not accessed any of that data and will not do so until after this plan is registered.
- Only people other than the authors have observed the data. At least some of the data that will be used for this analysis plan has been accessed by people other than the authors. However, the authors certify that they have not observed any of that data and will not do so until after this plan is registered.
- Authors' limited observation of the data could not influence their analysis decisions. At least some of the data that will be used for this analysis plan has been accessed and

observed by the authors. However, the authors certify that they have not sufficiently observed relevant evidence to influence their analysis decisions for this analysis plan and will not do so until after this plan is registered.

- Authors have observed the data, but have not performed the proposed analyses. At least some of the data that will be used for this analysis plan has been accessed and observed by the authors. The authors have sufficiently observed relevant evidence to influence their analysis decisions or conclusions. However, the authors have not yet performed any of the proposed analyses in this plan and will not do so until after this plan is registered.
- Authors have observed the data. The authors cannot certify meeting any of the levels above given prior access and observation of the data relevant to this analysis plan.
- Analyses in this plan have been conducted already. At least some of the analyses described in this analysis plan have been conducted by the authors making this a retrospective registration.

Explanation of foreknowledge and managing unintended influences

If the data for this study exist already, the prior item summarizes what is known about the data. Use this response box to add clarifying detail as needed. Having some foreknowledge of the data is a risk for making data independent decisions about analysis plans that could affect confidence in the conclusions. Regardless of the amount of foreknowledge, there are many ways to reduce risk of unintended influences on analysis plans and conclusions. Report any specific actions taken to reduce risks of unintended influences.

Participant recruitment procedure

Please describe the process by which you will collect (or have collected, see Existing Data) your data. If you are using human participants, this should include the sampling population, recruitment efforts, payment/reimbursement for participation, inclusion and exclusion criteria, and study timeline.

Example: Participants will be recruited through advertisements at the local university and the conservatory. Participants will be paid €10 or receive course credit for their participation. Participants must be at least 18 years old, have normal hearing, with no history of neurological diseases. We will exclude participants that speak a tone language as L1/L2 (acquired before the age of 12). Participants will be considered musicians if they have received at least 12 years of formal music training. Participants will be considered non-musicians if they have never had any formal music training, except for group lessons in primary school.

Sample size

Describe the sample size of your study. How many participants will be recruited?

Example: Within the data collection phase of the study (three months), we aim to collect clean datasets from 80 participants (40 per group: with vs. without musical training).

Sample size rationale

This gives you an opportunity to specifically state how the sample size will be determined. This could include a power analysis or an arbitrary constraint such as time, money, or personnel. If there is more than one hypothesis, choose the largest estimated sample size that is required from the power analyses corresponding to your hypotheses.

Example: We used MOREpower software (Campbell & Thompson, 2012) to calculate the necessary sample size to detect an effect size of η 2 = 0.15 with alpha level set at .05 for the interaction term (H1) in the 2 x 2 mixed ANOVA design to obtain .90 power. The target effect size is taken from a recent study by X et al. (2016) and accounted for a potential effect size inflation by taking 75% of the original effect size.

Rationale for number of trials

Provide a justification for how the number of trials was determined. This could be a power analysis, time and resource constraints or based on previous experiments in the literature.

Example: Previous studies in the literature (e.g., X et al, 2016; X et al., 2012) have collected 600 trials per condition, and we have kept that consistent here.

Starting and stopping rules

For studies generating new data or research using a portion of a larger existing dataset, specify how you will decide when pilot testing ends and data collection for the study begins, and how you will decide when to terminate data collection.

Example: If we have to exclude participants due to data quality issues (specify the criteria in the section "Data exclusion"), we will recruit additional participants to replace the excluded datasets. The minimum acceptable sample size within the scheduled data collection phase is 60 (30 per group). Due to budgetary constraints, we will terminate data collection after reaching a total of 100 participants.

Variables

Manipulated variables

Describe all variables you plan to manipulate in your experimental paradigm.

Example: Between-subject variable: Variable musical training, with two levels: musicians and non-musicians. Within-subject variable: Variable pitch difference, with two levels: 4 Hz (small difference) and 8 Hz.

Measured variables

Describe each variable that you will measure. This will include behavioral and EEG outcome measures, as well as any predictors or covariates that you will collect. In case of the EEG variables, please specify how you subselect your data in time and sensor space.

Example; EEG outcome measure: The EEG outcome variable will be the difference wave, i.e., the mean amplitude in response to the deviant minus the mean amplitude in response to the previous standard, in a time-window of 50-250 ms at electrodes Fz, FCz, and Cz. Time window and electrodes were chosen based on recommendations by X et al. (2014).

Behavioral outcome measure: Behavioral outcome will be measured by calculating the hit rate. An accurate response is defined as a button-press during the response window: between 100 ms after the start of the oddball until the start of the following standard.

Indices

If any measurements are going to be combined into an index (or even a mean), what measures will you use and how will they be combined? Include either a formula or a precise description of your method. If you are using a more complicated statistical method to combine measures (e.g., factor analysis, z-standardization within conditions/participants), you can note that here but describe the exact method in the analysis plan section. Also include the time window and region of interest over which the index will be computed.

Example: We will compute the mean amplitude based on the above specified time window (50-250 ms) and electrodes (Fz, FCz, Cz) (See Measured Variables)

Acquisition

Computer Screen

Screen type

Type (e.g., LCD, CRT), resolution, refresh rate.

Example: LED screen, 1920 × 1080 resolution, 59 Hz refresh rate.

Distance and constraints

Distance between screen and participant, use of chinrest or other constraints

Example: 1 m distance between screen and participant, no chinrest or constraints.

EEG hardware and acquisition settings

Amplifier

Manufacturer and model.

Example: EEG activity will be recorded using a BioSemi Active-Two system (BioSemi, Inc., Netherlands).

Electrode cap

Manufacturer and model.

Example: Brain Products (BrainVision) BrainCap.

Electrodes

Pre-amplifiers

Do scalp electrodes have pre-amplifiers?

- Active (yes)
- Passive (no)

Number and location

Number and location of electrodes, including reference and ground, but excluding EOG and other non-EEG electrodes.

Examples: 35 electrodes in total, including mastoid electrodes, ground at AFz, and 32 standard electrodes: F7, F8, FC5, FC6, T7, T8, CP5, CP6, P7, P8, FP1, FP2, AF3, AF4, FC1, FC2, F3, F4, C3, C4, CP1, CP2, P3, P4, PO3, PO4, Oz, Fz, Cz, Pz.

Electrode material

Example: Ag/AgCl

Conductive medium

Example: Gel / dry / saline / adhesive paste

Montage

Example: We will use the standard 10-5 international electrode montage (Oostenveld & Praamstra, 2001).

Online reference and ground placement

Example: The BioSemi ActiveTwo system has two electrodes, the common mode sense (CMS) active electrode and the driven right leg (DRL) passive electrode, which will be used as reference and ground electrodes, respectively.

Impedance level
Impedance level deemed acceptable for data collection or alternative data quality indicator for high input impedance amplifiers.

Example: Electrode impedances on all recording sites will be kept below 5 kΩ at the beginning of data collection for all participants.

Sampling rate and filter settings
Example: EEG activity will be recorded at a 1024 Hz sampling rate with a 100 Hz low-pass filter and a 0.16 Hz high-pass filter.

Local power line frequency
This is usually 60 Hz in America and parts of Asia or 50 Hz in other parts of the world.

Example: 50 Hz

Additional equipment
Describe other equipment in addition to EEG in as much detail as appropriate (e.g., ECG/EMG/EOG/eye tracking).

Pre-processing
General Setup
Order of preprocessing steps
List the order in which you will apply the preprocessing steps.

Example: Resampling, re-referencing, offline-filtering, artifact correction/rejection, epoching, averaging, baseline correction.

Programs, toolboxes, and packages

Which program/toolbox/package are you going to use? Which version number?

Example: All EEG data preprocessing steps will be scripted and run in MATLAB (v. 2021b) and the FieldTrip toolbox using the version that will be the latest at the time pre-processing begins.

Preprocessing pipeline

Will you use a pre-existing/standardized preprocessing pipeline (e.g., PREP, BEAPP, HAPPE; remember to also report the version number) or develop your own?

Example: We will not use any pre-existing preprocessing pipelines. The planned preprocessing steps are described elsewhere in this template.

Data Import

Recording software

What software will be used to record the EEG data?

Example: EEG data will be recorded using BrainVision Recorder software (the latest available version at the start of data collection).

Recording file format

What file format will you use at recording? Are you planning to export the files to a different format for analyses (e.g., .edf, .cnt, .bnf)?

Example: The data will be recorded in .eeg format and exported to .edf for analyses.

Channels imported

Will you import all recorded channels or a subset?

Example: All recorded channels will be imported.

Resampling
Are you going to resample the continuous EEG signal? If so, to what sampling rate?

Example: The EEG data will be downsampled to 200 Hz to decrease file size and computational time.

Re-Referencing
Re-referencing
Are you going to re-reference your data? To what reference?

Example: Average reference, mean mastoids, Laplacian.

Channels to reference
Which channels are you going to re-reference?

Example: All EEG channels will be re-referenced.

Offline Filtering
Filters applied

Example: Will filters be applied to continuous or epoched data?

Filtered Data Process
How will data be filtered (e.g., high-pass, low-pass, band-pass)? Please report at least the following properties: filter type (e.g., FIR, IIR, Butterworth), filter order (e.g., 5th order), filter cut-off type and frequency (e.g., 40 Hz (−3 dB half-amplitude)), and filter roll-off (e.g., 12 dB/oct)

Example: "[A] 5th order infinite impulse response (IIR) Butterworth filter [will be] used for low-pass filtering on the continuous (nonsegmented data), with a cut-off frequency (3 dB point) of 40 Hz and 12 dB/octave roll-off." (Keil et al., 2014, p. 6).

Artifact rejection/correction

Noisy Channel Detection

How are you going to identify noisy channels for subsequent interpolation (e.g., visually or using automated algorithms)?

Example: EEG data will be inspected visually for flat channels which will be selected for interpolation. We will also use the FieldTrip semi-automatic ft_rejectvisual tool to identify noisy channels for interpolation.

Channel Interpolation

Will you use an interpolation algorithm for those bad channels? If so, what kind of algorithm will you use (e.g., spherical spline)?

Example: Selected channels will be interpolated from 4 neighboring electrodes using the spherical spline method based on 3D sensor locations.

Artifact Rejection Stage

Are you going to perform artifact rejection on continuous or epoched data?

Example: Artifact rejection will be performed on continuous data.

Rejection Method

Are you going to do artifact rejection automatically, semi-automatically, manually, or not at all?

Example: Artifact rejection will be performed automatically.

Rejection Criteria & Parameters

If artifacts are rejected automatically or semi-automatically, what kind of artifact rejection algorithm will you use (e.g., z-value approach implemented in FieldTrip, detect abrupt spikes or flat activity based on kurtosis, reject epochs using spectral estimates)? What parameter values will you use for your algorithm? If artifacts are rejected manually, which criteria will you apply (e.g., only blinks and horizontal eye movements)?)

Example: We will use the automatic artifact rejection algorithm implemented in Fieldtrip: we will reject from the analysis trials with a z-value > 3.

Artifact Correction Approach

What kind of artifact correction will you perform? For example, independent component analysis like FASTica as implemented in EEGLAB or Artifact Subspace Reconstruction (Mullen et al., 2013)? What parameter values will you use for your algorithm? Will you correct all artifacts (blinks, saccades, alpha, muscle, etc) or only a subset? For example, in infant research you might want to reject muscle artifacts from the neck but correct eye movement artifacts.

Example: We will use AMICA algorithm (Palmer et al., 2012) (calculated data rank with 'pcakeep' option) for independent component analysis (ICA). The components corresponding to eye movements, blinks, heart activity will be identified and rejected semi-automatically with ICLabel (Pion-Tonachini et al., 2019): if a component is classified as eye movements or heart activity with > 60% and < 30% brain activity (and confirmed visually), then it will be rejected.

Epoching and averaging

Epoching Plan

Are you going to epoch data? If so, what will the epoch length be? What part of the stimulus/response will epochs be time-locked to?

Baseline Correction

Will you apply baseline correction? If so, how long will the baseline time window be and how did you come to this decision? Will you calculate a separate baseline per trial, condition, block, participant? What procedure will you use (subtraction, division, covariate in statistical model)?

ERP Averaging Method

How will these epochs be averaged to create ERPs? Include information about which stimuli and/or responses will be included in each average.

Analysis Plan

Statistical models

What statistical model will you use to test your hypotheses? Please include the type of model (e.g., ANOVA, cluster-based permutation test, linear mixed model, etc.) and the model specification (this includes each variable that will be included as predictors, outcomes, or covariates). Please specify any interactions, subgroup analyses, pairwise or complex contrasts, or follow-up tests from omnibus tests. Will you be using one- or two-tailed tests? If you are comparing multiple conditions or testing multiple hypotheses, how will you correct for multiple comparisons? Please also indicate which statistical model tests which hypothesis.

Example: To analyze the EEG data, we will use a 2 x 2 mixed ANOVA on MMN mean amplitude values. Based on our main hypothesis, we will only consider whether the pitch difference x musical training interaction is statistically significant. We will not consider the main effects and therefore will not correct for multiple testing for several comparisons within the ANOVA. If the interaction (in either or both ANOVAs) is statistically significant, we will run post-hoc t-tests for the given ANOVA.

Transformations

If you plan on transforming, centering, or recoding the data, please describe that process here. Transformations often are not necessary for ERP data, but other factors in your model may need recoding (see example below).

Example: We will compute the difference wave by subtracting the standard from the deviant waveform.

Inference criteria

What criteria will you use to make inferences (e.g., p-values, Bayes factors, specific model fit indices)? Where appropriate, please also report the cut-off criterion.

Example: We will use p <. 05 to determine statistical significance.

Data exclusion

How will you determine what data or samples, if any, to exclude from your analyses? How will outliers be handled? Will there be awareness checks? Is there a pre-specified minimum number of trials for

participants to be retained in the final analysis? If so, how did you come to this decision (e.g., prior work indicates that 30 trials are required to elicit a reliable MMN)?

Example: Participants will be excluded if there are less than 40 deviant trials per condition left after artifact rejection or due to technical failure; this cutoff is based on prior work by X et al. (2014).

Missing Data

How will you deal with incomplete or missing data?

Example: "In case of missing values in one or more conditions for a participant, we will employ Multiple imputation using Fully Conditional Specification (FCS) implemented by the MICE algorithm (Buuren & Groothuis-Oudshoorn, 2011), as implemented in the R package mice (Buuren & Groothuis-Oudshoorn, 2011)."

Exploring your data

You are obviously free to explore your data set to look for unexpected relationships. You may describe this procedure here. Describing this procedure here can serve as a reminder to meticulously log your analysis steps and decisions while performing your data exploration.

Example: We will explore relationships between age and handedness and MMN amplitude.

Other

References

Supplementary materials

Template Attribution

This registration follows the structure of a community-developed template. More information about the original template is available below.

Govaart, G. H., Schettino, A., Helbling, S., Mehler, D. M. A., Ngiam, W. X. Q., Moreau, D., Chiossi, F., Zanesco, A. P., Yang, Y.-F., Gau, R., Bartlett, J. E., García Alanis, J. C., Gutsell, J. N., Çetinçelik, M.,

Pavlov, Y. G., Šoškić, A., Ehinger, B. V., Mouseli, P., Algermissen, J., … Paul, M. (2025). EEG and ERP Methods - Preregistration Template. MetaArXiv. https://doi.org/10.31222/osf.io/4nvpt_v2