F01_mci_emotion_preprocessing.R

2021-02-19

```r
## MCI EMO PREPROCESSING SCRIPT ##

# Reads behavioral log files for all participants and binds them together. Performs EEG preprocessing including
# re-refercing, ocular artifact correction, filtering, epoching, baseline correction, and automatic artifact rejection,
# for both verb- and picture-related potentials. Computes single-trial mean ERP amplitudes for the verb- and picture-
# related N400-component and the verb-related P600-component (see Methods and Appendix of the paper).

## SETUP ## ---------------------------------------------------------------------------------------------------

# Load packages
library(naturalsort)  # Version 0.1.3
library(tidyverse)    # Version 1.3.0
```

```
## -- Attaching packages ---------------------------------------- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.2      v purrr   0.3.4
## v tibble  3.0.3      v dplyr   1.0.0
## v tidyr   1.1.0      v stringr 1.4.0
## v readr   1.3.1      v forcats 0.5.0
```

```
## -- Conflicts ------------------------------------------- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```r
library(magrittr)     # Version 1.5
```

```
##
## Attaching package: 'magrittr'
```

```
## The following object is masked from 'package:purrr':
##
##     set_names


## The following object is masked from 'package:tidyr':
##
##     extract
```

```r
library(eeguana)      # Version 0.1.4.9000
```

```
##
## Attaching package: 'eeguana'


## The following object is masked from 'package:dplyr':
##
##     between
```

```r
# Make sure we have enough RAM available (note that your computer does not *actually* have so much RAM physically)
memory.limit(size = 128000)
```

```
## [1] 128000
```

```r
## BEHAVIORAL DATA ## ---------------------------------------------------------------------------------

# List behavioral log files
filenames_rt <- list.files("RT", pattern = ".txt", full.names = TRUE) %>% naturalsort()

# Read behavioral data into one data frame (if umlaute can't be read, try: Sys.setlocale("LC_ALL", "C"))
a1 <- map(filenames_rt, read.delim2) %>% bind_rows()

# Remove empty lines
a1 %<>% na.omit()

# Factorize columns for semantics and context (fixed effects) and participants and items (random variables)
a1 %<>% mutate(semantics = factor(SatzBed, levels = c("neutral", "sem", "mci"), labels = c("int", "vio", "mci")),
              context = factor(EmoBed, levels = c(1, 2), labels = c("neu", "neg")),
              participant = factor(VP_nr, levels = as.character(1:length(unique(VP_nr)))),
```

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                item = factor(Verb))

# For exploratory analyses: Add factorized columns for semantics and context manipulations at lag 1
# - Fillers are coded as belonging to the intuitive semantic and neutral context condition
a1 %<>% mutate(lag1Semantics = factor(lag(SatzBed, n = 1),levels = c("filler", "neutral", "sem", "mci"),
                                      labels = c("int", "int", "vio", "mci")))
a1 %<>% mutate(lag1Context = factor(lag(EmoBed, n = 1), levels =c(1,2), labels = c("neu", "neg")))

# Remove filler trials
a1 %<>% filter(SatzBed != "filler")

# Add a column which checks if participants made an error or if the RT was unrealistically short (< 200 ms)
a1 %<>% mutate(error = Errors == 99 | BildRT < 200)

# Remove trials with missing EEG (due to technical issues)
a1 <- a1[-c(4002:4011),]
a1 <- a1[-7013,]
a1 <- a1[-c(9488:9492),]
a1 <- a1[-c(10300:10303),]

## EEG DATA ## --------------------------------------------------------------------------

# List EEG header files and BESA matrices (for ocular correction)
filenames_eeg <- list.files("EEG/raw", pattern = ".vhdr", full.names = TRUE)
filenames_besa <- list.files("EEG/cali", pattern = ".matrix", full.names = TRUE)

# Preprocessing
eeg <- map2(filenames_eeg, filenames_besa, function(vhdr_filename, besa_filename){
  message(paste("## PREPROCESSING", vhdr_filename, "WITH", besa_filename, "(VERB-RELATED)"))
  dat <- read_vhdr(vhdr_filename)
  message("## FIXING CHANNEL SETUP...")
  eog <- dat$.signal$Auge_u
  dat$.signal$Auge_u <- 0
  dat %<>% rename(A2 = Mastoid, A1 = Auge_u)
  message("## RE-REFERENCING...")
  channames <- dat %>% channel_names(.)
  dat %<>% eeg_rereference(ref = channames)
  message("## OCULAR CORRECTION...")
```

```r
  besa <- as.matrix(read.delim(besa_filename, row.names = 1))
  tmp <- t(dat$.signal %>% select(all_of(channames)))
  tmp <- besa %*% tmp # This is the actual OC; lines above and below are just transforming the signal table
  tmp <- split(tmp, row(tmp))
  tmp <- map(tmp, channel_dbl)
  dat$.signal[,channames] <- tmp[1:length(channames)]
  dat$.signal$IO1 <- eog
  message("## FILTERING...")
  dat %<>% eeg_filt_band_pass(freq = c(0.1, 30))
  message("## EPOCHING...")
  dat %<>% eeg_segment(.description %in% c("S211", "S212", "S213", "S221", "S222", "S223",
                                          "S181", "S182", "S183", "S191", "S192", "S193"),
                       lim = c(-200, 998), unit = "ms")
  message("## BASELINE CORRECTION...")
  dat %<>% eeg_baseline()
  message("## ARTIFACT REJECTION...")
  dat %<>%
    eeg_artif_amplitude(-IO1, threshold = c(-200, 200)) %>%
    eeg_artif_minmax(-IO1, threshold = 50, window = 2, unit = "ms") %>%
    eeg_artif_minmax(-IO1, threshold = 200, window = 200, unit = "ms") %>%
    eeg_events_to_NA(.type == "artifact", all_chs = TRUE)
  message("## DONE\n")
  return(dat)
})
```

```
## ## PREPROCESSING EEG/raw/Vp0001.vhdr WITH EEG/cali/Vp0001.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0001.vhdr...

## # Data from EEG/raw/Vp0001.eeg was read.

## # Data from 5 segment(s) and 64 channels was loaded.

## # Object size in memory 3.2 Gb

## ## FIXING CHANNEL SETUP...
```

4

```
## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 4

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 5

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0002.vhdr WITH EEG/cali/Vp0002.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0002.vhdr...

## # Data from EEG/raw/Vp0002.eeg was read.
```

```
## # Data from 4 segment(s) and 64 channels was loaded.

## # Object size in memory 3.2 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 1

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 4

## ## DONE
```

```
## ## PREPROCESSING EEG/raw/Vp0003.vhdr WITH EEG/cali/Vp0003.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0003.vhdr...

## # Data from EEG/raw/Vp0003.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.9 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...
```

```
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0


## ## DONE


## ## PREPROCESSING EEG/raw/Vp0004.vhdr WITH EEG/cali/Vp0004.matrix (VERB-RELATED)


## Reading file EEG/raw/Vp0004.vhdr...


## # Data from EEG/raw/Vp0004.eeg was read.


## # Data from 3 segment(s) and 64 channels was loaded.


## # Object size in memory 2.8 Gb


## ## FIXING CHANNEL SETUP...


## ## RE-REFERENCING...


## ## OCCULAR CORRECTION...


## ## FILTERING...


## Width of the transition band at the low cut-off frequency is 0.1 Hz


## Width of the transition band at the high cut-off frequency is 7.5 Hz


## Setting up band-pass filter from 0.1 - 30 Hz


## ## EPOCHING...


## # Total of 732 segments found.


## # Object size in memory 221.3 Mb after segmentation.
```

```
## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0005.vhdr WITH EEG/cali/Vp0005.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0005.vhdr...

## # Data from EEG/raw/Vp0005.eeg was read.

## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 3 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...
```

```
## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 10

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0006.vhdr WITH EEG/cali/Vp0006.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0006.vhdr...

## # Data from EEG/raw/Vp0006.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.6 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz
```

```
## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0007.vhdr WITH EEG/cali/Vp0007.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0007.vhdr...

## # Data from EEG/raw/Vp0007.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.8 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...
```

```
## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0008.vhdr WITH EEG/cali/Vp0008.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0008.vhdr...

## # Data from EEG/raw/Vp0008.eeg was read.

## # Data from 4 segment(s) and 64 channels was loaded.

## # Object size in memory 2.9 Gb

## ## FIXING CHANNEL SETUP...
```

```
## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 4

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0009.vhdr WITH EEG/cali/Vp0009.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0009.vhdr...

## # Data from EEG/raw/Vp0009.eeg was read.
```

```
## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 3.3 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0010.vhdr WITH EEG/cali/Vp0010.matrix (VERB-RELATED)
```

```
## Reading file EEG/raw/Vp0010.vhdr...

## # Data from EEG/raw/Vp0010.eeg was read.

## # Data from 4 segment(s) and 64 channels was loaded.

## # Object size in memory 3 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
```

```
## ## DONE

## ## PREPROCESSING EEG/raw/Vp0011.vhdr WITH EEG/cali/Vp0011.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0011.vhdr...

## # Data from EEG/raw/Vp0011.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.8 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 682 segments found.

## # Object size in memory 206.2 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...
```

```
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0


## # Number of intervals with artifacts: 1


## ## DONE


## ## PREPROCESSING EEG/raw/Vp0011bis.vhdr WITH EEG/cali/Vp0011bis.matrix (VERB-RELATED)


## Reading file EEG/raw/Vp0011bis.vhdr...


## # Data from EEG/raw/Vp0011bis.eeg was read.


## # Data from 1 segment(s) and 64 channels was loaded.


## # Object size in memory 105.9 Mb


## ## FIXING CHANNEL SETUP...


## ## RE-REFERENCING...


## ## OCCULAR CORRECTION...


## ## FILTERING...


## Width of the transition band at the low cut-off frequency is 0.1 Hz


## Width of the transition band at the high cut-off frequency is 7.5 Hz


## Setting up band-pass filter from 0.1 - 30 Hz


## ## EPOCHING...


## # Total of 30 segments found.
```

```
## # Object size in memory 9.1 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 1

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0012.vhdr WITH EEG/cali/Vp0012.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0012.vhdr...

## # Data from EEG/raw/Vp0012.eeg was read.

## # Data from 4 segment(s) and 64 channels was loaded.

## # Object size in memory 2.9 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz
```

```
## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 1

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0013.vhdr WITH EEG/cali/Vp0013.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0013.vhdr...

## # Data from EEG/raw/Vp0013.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.7 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...
```

```
## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 2

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 6

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0014.vhdr WITH EEG/cali/Vp0014.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0014.vhdr...

## # Data from EEG/raw/Vp0014.eeg was read.

## # Data from 7 segment(s) and 64 channels was loaded.

## # Object size in memory 2.8 Gb
```

```
## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0015.vhdr WITH EEG/cali/Vp0015.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0015.vhdr...

## # Data from EEG/raw/Vp0015.eeg was read.
```

```
## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 2.8 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 3

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 8

## ## DONE
```

PREPROCESSING EEG/raw/Vp0016.vhdr WITH EEG/cali/Vp0016.matrix (VERB-RELATED)

Reading file EEG/raw/Vp0016.vhdr...

Data from EEG/raw/Vp0016.eeg was read.

Data from 4 segment(s) and 64 channels was loaded.

Object size in memory 2.8 Gb

FIXING CHANNEL SETUP...

RE-REFERENCING...

OCCULAR CORRECTION...

FILTERING...

Width of the transition band at the low cut-off frequency is 0.1 Hz

Width of the transition band at the high cut-off frequency is 7.5 Hz

Setting up band-pass filter from 0.1 - 30 Hz

EPOCHING...

Total of 732 segments found.

Object size in memory 221.3 Mb after segmentation.

BASELINE CORRECTION...

ARTIFACT REJECTION...

```
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0


## # Number of intervals with artifacts: 1


## ## DONE


## ## PREPROCESSING EEG/raw/Vp0017.vhdr WITH EEG/cali/Vp0017.matrix (VERB-RELATED)


## Reading file EEG/raw/Vp0017.vhdr...


## # Data from EEG/raw/Vp0017.eeg was read.


## # Data from 5 segment(s) and 64 channels was loaded.


## # Object size in memory 2.9 Gb


## ## FIXING CHANNEL SETUP...


## ## RE-REFERENCING...


## ## OCCULAR CORRECTION...


## ## FILTERING...


## Width of the transition band at the low cut-off frequency is 0.1 Hz


## Width of the transition band at the high cut-off frequency is 7.5 Hz


## Setting up band-pass filter from 0.1 - 30 Hz


## ## EPOCHING...


## # Total of 732 segments found.
```

```
## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 1

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0018.vhdr WITH EEG/cali/Vp0018.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0018.vhdr...

## # Data from EEG/raw/Vp0018.eeg was read.

## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 3.1 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz
```

```
## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0019.vhdr WITH EEG/cali/Vp0019.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0019.vhdr...

## # Data from EEG/raw/Vp0019.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.9 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...
```

Width of the transition band at the low cut-off frequency is 0.1 Hz

Width of the transition band at the high cut-off frequency is 7.5 Hz

Setting up band-pass filter from 0.1 - 30 Hz

EPOCHING...

Total of 732 segments found.

Object size in memory 221.3 Mb after segmentation.

BASELINE CORRECTION...

ARTIFACT REJECTION...

Number of intervals with artifacts: 0
Number of intervals with artifacts: 0

Number of intervals with artifacts: 3

DONE

PREPROCESSING EEG/raw/Vp0020.vhdr WITH EEG/cali/Vp0020.matrix (VERB-RELATED)

Reading file EEG/raw/Vp0020.vhdr...

Data from EEG/raw/Vp0020.eeg was read.

Data from 4 segment(s) and 64 channels was loaded.

Object size in memory 2.9 Gb

FIXING CHANNEL SETUP...

```
## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 730 segments found.

## # Object size in memory 220.7 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 15

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 64

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0021.vhdr WITH EEG/cali/Vp0021.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0021.vhdr...

## # Data from EEG/raw/Vp0021.eeg was read.
```

```
## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 2.8 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 4

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 2

## ## DONE
```

```
## ## PREPROCESSING EEG/raw/Vp0022.vhdr WITH EEG/cali/Vp0022.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0022.vhdr...

## # Data from EEG/raw/Vp0022.eeg was read.

## # Data from 5 segment(s) and 64 channels was loaded.

## # Object size in memory 2.7 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 26
```

```
## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 18

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0023.vhdr WITH EEG/cali/Vp0023.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0023.vhdr...

## # Data from EEG/raw/Vp0023.eeg was read.

## # Data from 5 segment(s) and 64 channels was loaded.

## # Object size in memory 3.4 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.
```

```
## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0024.vhdr WITH EEG/cali/Vp0024.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0024.vhdr...

## # Data from EEG/raw/Vp0024.eeg was read.

## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 2.9 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...
```

```
## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0025.vhdr WITH EEG/cali/Vp0025.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0025.vhdr...

## # Data from EEG/raw/Vp0025.eeg was read.

## # Data from 4 segment(s) and 64 channels was loaded.

## # Object size in memory 2.7 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz
```

```
## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0026.vhdr WITH EEG/cali/Vp0026.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0026.vhdr...

## # Data from EEG/raw/Vp0026.eeg was read.

## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 2.6 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...
```

```
## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 696 segments found.

## # Object size in memory 210.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0026a.vhdr WITH EEG/cali/Vp0026a.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0026a.vhdr...

## # Data from EEG/raw/Vp0026a.eeg was read.

## # Data from 1 segment(s) and 64 channels was loaded.

## # Object size in memory 103.5 Mb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...
```

```
## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 26 segments found.

## # Object size in memory 7.9 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0
## # Number of intervals with artifacts: 0

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0027.vhdr WITH EEG/cali/Vp0027.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0027.vhdr...

## # Data from EEG/raw/Vp0027.eeg was read.

## # Data from 2 segment(s) and 64 channels was loaded.

## # Object size in memory 3 Gb
```

```
## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 4

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 29

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0028.vhdr WITH EEG/cali/Vp0028.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0028.vhdr...
```

```
## # Data from EEG/raw/Vp0028.eeg was read.

## # Data from 5 segment(s) and 64 channels was loaded.

## # Object size in memory 3.2 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.

## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 5

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 17
```

```
## ## DONE

## ## PREPROCESSING EEG/raw/Vp0029.vhdr WITH EEG/cali/Vp0029.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0029.vhdr...

## # Data from EEG/raw/Vp0029.eeg was read.

## # Data from 6 segment(s) and 64 channels was loaded.

## # Object size in memory 3.4 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 724 segments found.

## # Object size in memory 218.9 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...
```

```
## # Number of intervals with artifacts: 9

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 3

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0030.vhdr WITH EEG/cali/Vp0030.matrix (VERB-RELATED)

## Reading file EEG/raw/Vp0030.vhdr...

## # Data from EEG/raw/Vp0030.eeg was read.

## # Data from 3 segment(s) and 64 channels was loaded.

## # Object size in memory 3 Gb

## ## FIXING CHANNEL SETUP...

## ## RE-REFERENCING...

## ## OCCULAR CORRECTION...

## ## FILTERING...

## Width of the transition band at the low cut-off frequency is 0.1 Hz

## Width of the transition band at the high cut-off frequency is 7.5 Hz

## Setting up band-pass filter from 0.1 - 30 Hz

## ## EPOCHING...

## # Total of 732 segments found.
```

```
## # Object size in memory 221.3 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 1

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 2

## ## DONE
```

```r
# Bind data from all participants together
eeg %<>% do.call(what = bind)
```

```
## # Object size in memory 6.5 Gb
```

```r
# Extract experimental factors from EEG triggers and factorize
eeg %<>%
  mutate(type = case_when(description %in% c("S211", "S212", "S213", "S221", "S222", "S223") ~ "Verb-related",
                          description %in% c("S181", "S182", "S183", "S191", "S192", "S193") ~ "Picture-related"),
         semantics = case_when(description %in% c("S211", "S221", "S181", "S191") ~ "int",
                               description %in% c("S212", "S222", "S182", "S192") ~ "vio",
                               description %in% c("S213", "S223", "S183", "S193") ~ "mci"),
         context = case_when(description %in% c("S211", "S212", "S213", "S181", "S182", "S183") ~ "neu",
                             description %in% c("S221", "S222", "S223", "S191", "S192", "S193") ~ "neg")) %>%
  mutate(type = factor (type, levels = c("Verb-related", "Picture-related")),
         semantics = factor(semantics, levels = c("int", "vio", "mci")),
         context = factor(context, levels = c("neu", "neg")))

# Compute mean amplitude across electrodes in the N400 ROI
eeg %<>% mutate(ROI = chs_mean(C1, C2, Cz, CP1, CP2, CPz))

# Average single trial ERPs in the ROI across the relevant time windows (and bind to behavioral data)
```

```r
a1 <- eeg %>%
  filter(type == "Verb-related", between(as_time(.sample), 0.300, 0.500)) %>%
  group_by(.id) %>%
  summarise(erps = mean(ROI)) %>%
  pull(erps) %>%
  as.numeric() %>%
  bind_cols(a1, N400_verb = .)
a1 <- eeg %>%
  filter(type == "Picture-related", between(as_time(.sample), 0.150, 0.350)) %>%
  group_by(.id) %>%
  summarise(erps = mean(ROI)) %>%
  pull(erps) %>%
  as.numeric() %>%
  bind_cols(a1, N400_pict = .)
a1 <- eeg %>%
  filter(type == "Verb-related", between(as_time(.sample), 0.500, 0.900)) %>%
  group_by(.id) %>%
  summarise(erps = mean(ROI)) %>%
  pull(erps) %>%
  as.numeric() %>%
  bind_cols(a1, P600_verb = .)

# Post-hoc analysis of a shorter time window for the verb-related N400
a1 <- eeg %>%
  filter(type == "Verb-related", between(as_time(.sample), 0.350, 0.450)) %>%
  group_by(.id) %>%
  summarise(erps = mean(ROI)) %>%
  pull(erps) %>%
  as.numeric() %>%
  bind_cols(a1, N400_posthoc = .)

# Export behavioral data and ERPs for mixed models
saveRDS(a1, file = "EEG/export/a1.RDS")

## PREPARE FOR PLOTTING ## --------------------------------------------------------------------------------

# Compute and export averaged waveforms for plotting
eeg %>%
```

```r
  mutate(participant = rep(a1$participant, each = 2),
         error = rep(a1$error, each = 2)) %>%
  filter(!error) %>%
  group_by(.sample, type, semantics, context, participant) %>%
  summarize_at(channel_names(.), mean, na.rm = TRUE) %>%
  saveRDS("EEG/export/avgs.RDS")

# System specs and package versions
sessionInfo()
```

```
## R version 4.0.2 (2020-06-22)
## Platform: x86_64-w64-mingw32/x64 (64-bit)
## Running under: Windows 10 x64 (build 19042)
##
## Matrix products: default
##
## locale:
## [1] LC_COLLATE=German_Germany.1252  LC_CTYPE=German_Germany.1252    LC_MONETARY=German_Germany.1252 LC_NUMERIC=C
## [5] LC_TIME=German_Germany.1252
##
## attached base packages:
## [1] stats     graphics  grDevices datasets  utils     methods   base
##
## other attached packages:
##  [1] eeguana_0.1.4.9000 magrittr_1.5       forcats_0.5.0      stringr_1.4.0      dplyr_1.0.0        purrr_0.3.4        readr_1.3.1
##  [9] tibble_3.0.3       ggplot2_3.3.2      tidyverse_1.3.0    naturalsort_0.1.3
##
## loaded via a namespace (and not attached):
##  [1] Rcpp_1.0.5        lubridate_1.7.9   assertthat_0.2.1  digest_0.6.25     R6_2.4.1          cellranger_1.1.0  backports_1.1.8   sign
##  [9] reprex_0.3.0      evaluate_0.14     httr_1.4.2        highr_0.8         pillar_1.4.6      rlang_0.4.7       readxl_1.3.1      rstu
## [17] data.table_1.13.0 blob_1.2.1        rmarkdown_2.3     munsell_0.5.0     tinytex_0.25      broom_0.7.0.9001  compiler_4.0.2    mode
## [25] xfun_0.16         pkgconfig_2.0.3   htmltools_0.5.0   tidyselect_1.1.0  RcppRoll_0.3.0    fansi_0.4.1       crayon_1.3.4      dbpl
## [33] withr_2.2.0       MASS_7.3-51.6     grid_4.0.2        jsonlite_1.7.0    gtable_0.3.0      lifecycle_0.2.0   DBI_1.1.0         scal
## [41] cli_2.0.2         stringi_1.4.6     renv_0.12.0       fs_1.4.2          ini_0.3.1         xml2_1.3.2        ellipsis_0.3.1    gene
## [49] vctrs_0.3.2       tools_4.0.2       glue_1.4.1        hms_0.5.3         yaml_2.2.1        colorspace_1.4-1  rvest_0.3.5       knit
## [57] haven_2.3.1
```