F01_mci_style_neu_preprocessing.R

2020-09-19

```
## MCI_STYLE_NEU PREPROCESSING SCRIPT ##

# Reads behavioral log files for all participants and binds them together. Performs EEG preprocessing including
# re-referencing, 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 N400
# component and exports by-participant averaged waveforms for plotting.

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

# Load packages
library(naturalsort)  # Version 0.1.3
library(tidyverse)    # Version 1.3.0
library(magrittr)     # Version 1.5
library(eeguana)      # Version 0.1.4.9000

# Make sure we have enough (virtual) RAM available
memory.limit(size = 64000)
```

```
## [1] 64000
```

```
## 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 filler trials and empty lines
```

```r
a1 %<>% filter(SatzBed != "filler") %>% na.omit()

# Factorize columns for semantics and context (fixed effects) and participants and items (random variables)
a1 %<>% mutate(semantics = factor(SatzBed, levels = c("correct", "sev", "mci"), labels = c("int", "vio", "mci")),
               style = factor(Version, levels = c(1, 2), labels = c("nor", "ftl")),
               participant = factor(VP_nr, levels = as.character(1:length(unique(VP_nr)))),
               item = factor(Verb))

# 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)

## 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("## OCCULAR CORRECTION...")
  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 2 segment(s) and 64 channels was loaded.

## # Object size in memory 4.9 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 8

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 4

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

## # Object size in memory 4.1 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 4

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 6

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

```
## # Object size in memory 4.3 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 161

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 206

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

## # Object size in memory 4.1 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 600 segments found.

## # Object size in memory 181.4 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/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 3 segment(s) and 64 channels was loaded.

## # Object size in memory 4.2 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 600 segments found.

## # Object size in memory 181.4 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/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 3.8 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.
```

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

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 2

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 5

## ## 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 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 600 segments found.

## # Object size in memory 181.4 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/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 4.2 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

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

## # Number of intervals with artifacts: 1

## ## 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 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 600 segments found.

## # Object size in memory 181.4 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

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

```
## # Object size in memory 1.9 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 280 segments found.

## # Object size in memory 84.7 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 11

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 22

## ## DONE

## ## PREPROCESSING EEG/raw/Vp0010b.vhdr WITH EEG/cali/Vp0010b.matrix (VERB-RELATED)
```

```
## Reading file EEG/raw/Vp0010b.vhdr...

## # Data from EEG/raw/Vp0010b.eeg was read.

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

## # Object size in memory 2.1 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 320 segments found.

## # Object size in memory 96.8 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 13

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

```
## # Number of intervals with artifacts: 34

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

## # Object size in memory 4.2 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 600 segments found.

## # Object size in memory 181.4 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/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 3 segment(s) and 64 channels was loaded.

## # Object size in memory 4.2 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 600 segments found.
```

```
## # Object size in memory 181.4 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/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 4.5 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 600 segments found.

## # Object size in memory 181.4 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/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 4 segment(s) and 64 channels was loaded.

## # Object size in memory 3.8 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 7

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 6

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

## # Object size in memory 3.7 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 600 segments found.

## # Object size in memory 181.4 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/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 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 3

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 5

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

## # Object size in memory 4.9 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 600 segments found.

## # Object size in memory 181.4 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/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 3 segment(s) and 64 channels was loaded.
## # Object size in memory 4.3 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 600 segments found.
## # Object size in memory 181.4 Mb after segmentation.
## ## BASELINE CORRECTION...
## ## ARTIFACT REJECTION...
## # Number of intervals with artifacts: 8
```

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

## # Number of intervals with artifacts: 16

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

## # Object size in memory 3.9 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.
```

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

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 25

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 89

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

## # Object size in memory 3.9 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 2

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 4

## ## 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 3.9 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 14

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 12

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

## # Object size in memory 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 34

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 20

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

## # Object size in memory 3.9 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 600 segments found.

## # Object size in memory 181.4 Mb after segmentation.

## ## BASELINE CORRECTION...

## ## ARTIFACT REJECTION...

## # Number of intervals with artifacts: 2

## # Number of intervals with artifacts: 0

## # Number of intervals with artifacts: 2

## ## 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 5 segment(s) and 64 channels was loaded.
## # Object size in memory 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 600 segments found.
## # Object size in memory 181.4 Mb after segmentation.
## ## BASELINE CORRECTION...
## ## ARTIFACT REJECTION...
## # Number of intervals with artifacts: 51
```

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

## # Number of intervals with artifacts: 57

## ## DONE
```

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

```
## # Object size in memory 4.3 Gb
```

```
# 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"),
         style = case_when(description %in% c("S211", "S212", "S213", "S181", "S182", "S183") ~ "nor",
                           description %in% c("S221", "S222", "S223", "S191", "S192", "S193") ~ "ftl")) %>%
  mutate(type = factor (type, levels = c("Verb-related", "Picture-related")),
         semantics = factor(semantics, levels = c("int", "vio", "mci")),
         style = factor(style, levels = c("nor", "ftl")))

# Compute mean amplitude across electrodes in the N400 ROI
eeg %<>% mutate(ROI_verb = chs_mean(C1, C2, C3, C4, Cz, CP1, CP2, CP3, CP4, CPz, P3, P4),
                ROI_pict = chs_mean(Fz, Cz))

# Average single trial ERPs in the ROI across the relevant time window (and bind to behavioral data)
a1 <- eeg %>%
  filter(type == "Verb-related", between(as_time(.sample), 0.300, 0.500)) %>%
  group_by(.id) %>%
  summarise(erps = mean(ROI_verb)) %>%
  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_pict)) %>%
  pull(erps) %>%
  as.numeric() %>%
  bind_cols(a1, N400_pict = .)

# 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 %>%
  mutate(participant = rep(a1$participant, each = 2),
         error = rep(a1$error, each = 2)) %>%
  filter(!error) %>%
  group_by(.sample, type, semantics, style, 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 18362)
##
## 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
```

```
##  [8] tidyr_1.1.0        tibble_3.0.3       ggplot2_3.3.2      tidyverse_1.3.0    naturalsort_0.1.3
##
## loaded via a namespace (and not attached):
##  [1] nlme_3.1-148        matrixStats_0.56.0  fs_1.5.0            lubridate_1.7.9     httr_1.4.2          tools_4.0.2         backports_
##  [8] R6_2.4.1            lazyeval_0.2.2      mgcv_1.8-31         DBI_1.1.0           colorspace_1.4-1    withr_2.2.0         tidyselect
## [15] compiler_4.0.2      cli_2.0.2           rvest_0.3.6         eegUtils_0.5.0.9000 xml2_1.3.2          plotly_4.9.2.1      scales_1.1
## [22] digest_0.6.25       rmarkdown_2.3       R.utils_2.9.2       ini_0.3.1           pkgconfig_2.0.3     htmltools_0.5.0     dbplyr_1.4
## [29] fastmap_1.0.1       highr_0.8           htmlwidgets_1.5.1   Rmisc_1.5           rlang_0.4.7         readxl_1.3.1        rstudioapi
## [36] shiny_1.5.0         generics_0.0.2      jsonlite_1.7.0      R.oo_1.23.0         R.matlab_3.6.2      Matrix_1.2-18       Rcpp_1.0.5
## [43] munsell_0.5.0       fansi_0.4.1         abind_1.4-5         lifecycle_0.2.0     R.methodsS3_1.8.0   stringi_1.4.6       yaml_2.2.1
## [50] MASS_7.3-51.6       plyr_1.8.6          grid_4.0.2          blob_1.2.1          parallel_4.0.2      listenv_0.8.0       promises_1
## [57] crayon_1.3.4        miniUI_0.1.1.1      lattice_0.20-41     splines_4.0.2       haven_2.3.1         hms_0.5.3           knitr_1.29
## [64] pillar_1.4.6        codetools_0.2-16    future.apply_1.6.0  reprex_0.3.0        glue_1.4.1          evaluate_0.14       data.table
## [71] renv_0.12.0         modelr_0.1.8        vctrs_0.3.2         httpuv_1.5.4        cellranger_1.1.0    gtable_0.3.0        future_1.1
## [78] assertthat_0.2.1    xfun_0.16           mime_0.9            xtable_1.8-4        broom_0.7.0         pracma_2.2.9        later_1.1.
## [85] viridisLite_0.3.0   RcppRoll_0.3.0      signal_0.7-6        globals_0.12.5      ellipsis_0.3.1
```