Do posterior EEG asymmetries also correlate to short-term subjective well-being?

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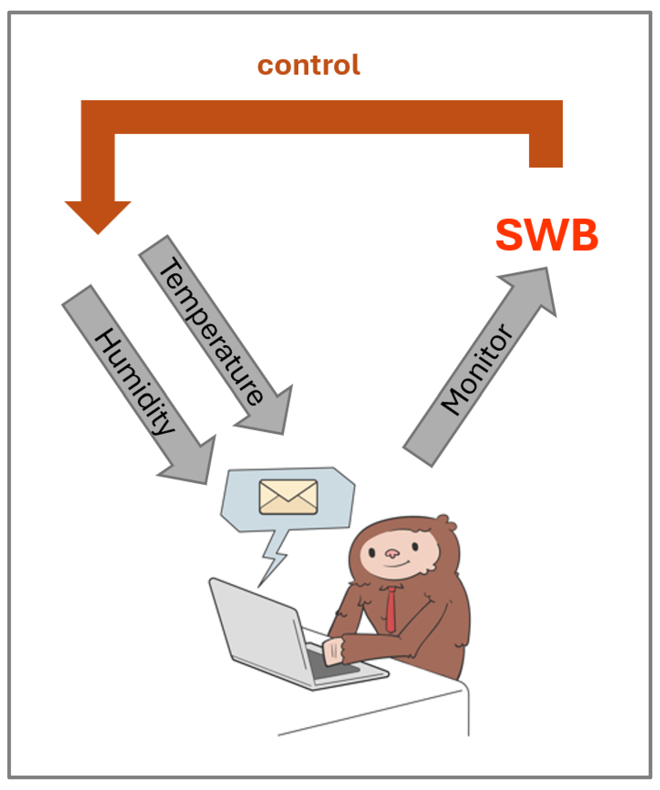
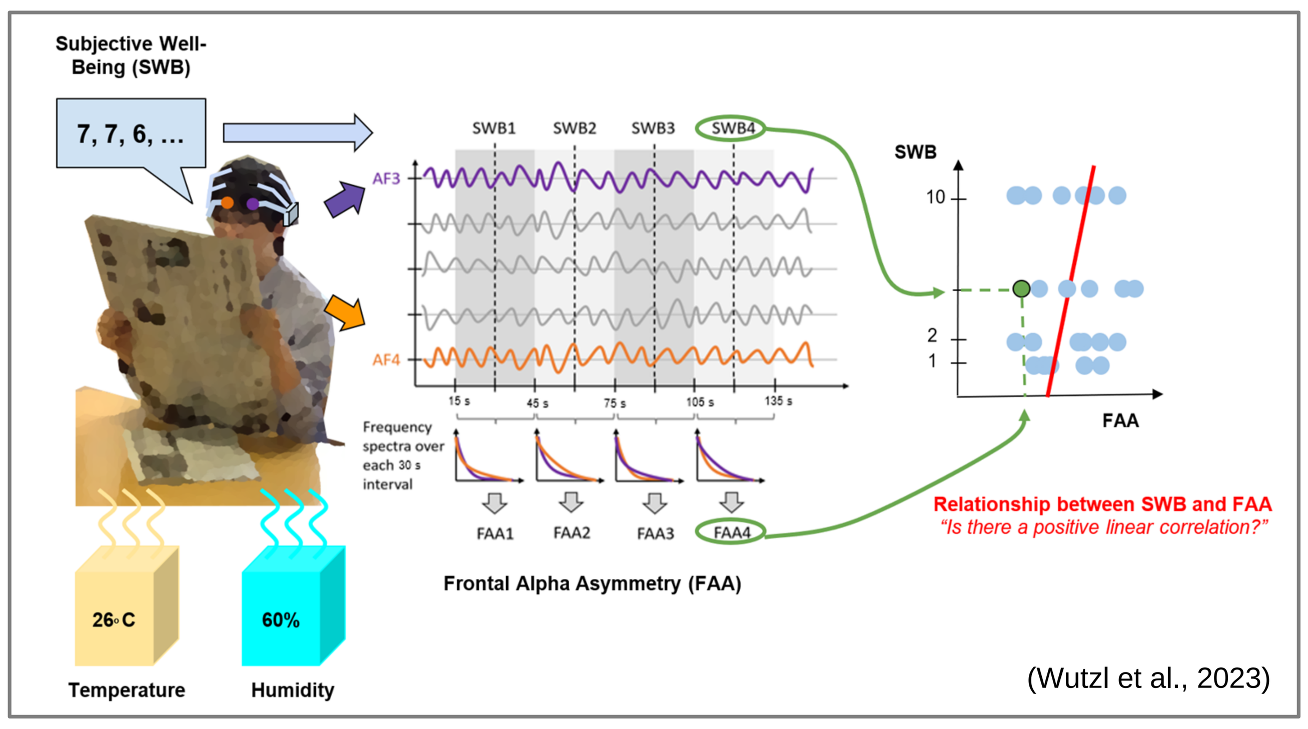
Subjective Well-Being (SWB)

- What is SWB?
  - “A broad category of phenomena that includes people’s emotional responses, domain satisfactions, and global judgements of life satisfaction” (Diener et al. 1999, p. 277)
  - Also known as “psychological well-being” (Ryff 1989), “quality of life” (Frisch et al. 1992), or “subjective happiness” (Lyubomirsky and Lepper 1999), and similar to “comfort” (Pinto et al. 2017)
  - SWB can be influenced by environmental conditions (e.g., too hot or too cold causes discomfort)
- Electroencephalography (EEG) and SWB
  - Focus of the literature is on frontal alpha asymmetry (FAA) (Reznik and Allen 2018)
  - Correlation between SWB and Frontal Alpha Asymmetry (FAA) using EEG, e.g., (Urry et al. 2004; Xu et al. 2018)
  - SWB usually measured as a static metric or with psychological/psychiatric interventions over weeks, months, or longer
  - Correlation between FAA and SWB also holds for short-term times, i.e., 60 or 30 seconds (Wutzl et al. 2023)
- Research Question:
  - Do posterior EEG asymmetries also correlate to short-term subjective well-being?

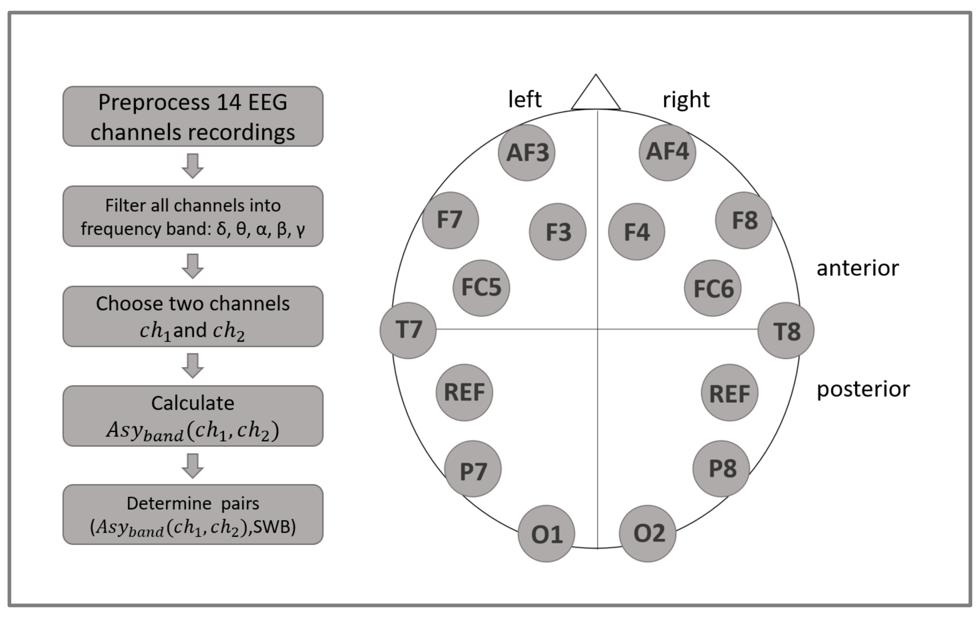


Methods

- 30 university students (28 right-handed, 2 left-handed, 16 males, 14 females, ages 22.3 ± 4.2 years) participated in the experiment
- Variation of SWB via temperature and humidity by changing the environment to different combinations of temperature-humidity values (low, medium, and high)
- EEG recording for up to 9 minutes with the Emotiv EPOC X headset (EMOTIV, San Francisco, USA)
- SWB was given verbally every 30 seconds by the participant on a scale from 1 (worst) to 10 (best)
- EEG preprocessing (each subject and session individually): EEGLAB (Delorme and Makeig 2004), HAPPE (Gabard-Durnam et al. 2018), MARA (Winkler et al. 2011, 2014)
- Filter EEG data into different frequency bands, i.e., delta band (0.5–3 Hz), theta band (4-7 Hz), alpha band (8-13 Hz), beta band (14-30 Hz), gamma band (> 31 Hz) and selection of specific time windows, i.e., 10 seconds before the SWB was recorded
- Calculate asymmetries $Asym$ from power spectrum $Asym_{band}(ch_1, ch_2) = mean(log\ pow_{band}(ch_1) - log\ pow_{band}(ch_2))$
- Several $(Asym_{band}(ch_1, ch_2)$, SWB) for each combination of bands and EEG channels
- Many samples for SWB values 6, 7, or 8 and only few for SWB values 1, 2, 3, or 10
- Balancing of data set with SMOTE (Synthetic Minority Over-Sampling Technique) (Chawla 2002)
- Output of SMOTE is random ⇒ we run the same analysis 10 times per participant
- 10 slopes and intercepts per individual participant ⇒ average slope
- Statistical significance of the mean of these averaged slopes from all participants via one-sided t-test, i.e., slope (of linear regression $Asym$ and SWB) > 0



(Wutzl et al., 2023)



Results (Wutzl et al. 2024)

Table 1. Results of the analyses with the original reference electrode for sensor combinations in the posterior regions and unadjusted $p < 0.1$: The first column shows the considered frequency band. Entries in the second and third columns give the EEG channels used for ch_1 and ch_2 in Equation (1). The fourth column shows the unadjusted p-value of the two-sided t-test. The last two columns give the lower and upper bounds of the CI of the slope of the linear correlation, respectively.

Band	ch_1	ch_2	p-Value	CI_{low}	CI_{high}
Theta	T8	P7	0.067	−0.47	0.02
Theta	P8	O1	0.063	−0.72	0.02
Beta	O2	P7	0.054	−0.95	0.01
Gamma	O2	P7	0.042	−1.05	−0.02
Gamma	T8	O1	0.046	0.01	1.43
Non	O2	P7	0.031	−1.25	−0.07
Non	T8	O1	0.052	−0.00	1.05

Table 2. Results of the analyses with AF3 as reference electrode for sensor combinations in the posterior regions and unadjusted $p < 0.1$: The first column shows the considered frequency band. Entries in the second and third columns give the EEG channels used for ch_1 and ch_2 in Equation (1). The fourth column shows the unadjusted p-value of the two-sided t-test. The last two columns give the lower and upper bounds of the CI of the slope of the linear correlation, respectively.

Band	ch_1	ch_2	p-Value	CI_{low}	CI_{high}
Delta	O2	T7	0.048	−0.55	−0.00
Theta	P8	P7	0.096	−0.66	0.06
Theta	P8	O1	0.026	−0.62	−0.04
Alpha	O2	P7	0.011	−0.93	−0.13
Alpha	T8	P7	0.026	−0.71	−0.05
Beta	T8	T7	0.094	−1.08	0.09
Beta	O2	P7	0.014	−1.52	−0.19
Gamma	O2	T7	0.078	−0.92	0.05
Gamma	O2	P7	0.047	−1.30	−0.01
Non	O2	T7	0.056	−1.10	0.02
Non	O2	P7	0.024	−1.84	−0.14

Conclusion

- The experimental setup did not allow for the demonstration of a statistically significant correlation between the asymmetry calculated over any EEG sensor of the posterior regions when filtered in any possible EEG frequency band
- We observed trends, with the most prominent resulting from filtering in the beta band and asymmetry calculations in the reverse direction compared to the anterior regions
- Focusing on FAA when analyzing SWB may not provide a comprehensive understanding of the underlying brain mechanisms
- While FAA demonstrates a stronger correlation with short-term SWB, posterior regions also exhibit effects that should not be overlooked

Recent paper: (Wutzl et al., 2024)

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