Poster number: 1629

The correlation between Subjective Well-Being and EEG Frontal Asymmetry in different frequency bands

Betty Wutzl [1], Kenji Leibnitz [2,1], Masayuki Murata [1,2]

[1] Graduate School of Information Science and Technology, Osaka University, Suita, Japan

[2] Center for Information and Neural Networks (CiNet), National Institute of Information and Communications Technology, and Osaka University, Suita, Japan

Email: b-wutzl@ist.osaka-u.ac.jp, Twitter: @BettyWutzl

Subjective Well-Being (SWB)

- SWB is “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
- SWB was 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)
- Inner state of SWB can be influenced by environmental conditions (e.g., too hot or too cold causes discomfort)
- SWB increases productivity and efficiency
- **Our goal**
  Adapt the subject’s environment (temperature, humidity) in an office room to increase SWB
- **Our approach**
  Utilize brain measurements with electroencephalography (EEG) and identify SWB of a person to regulate their environment

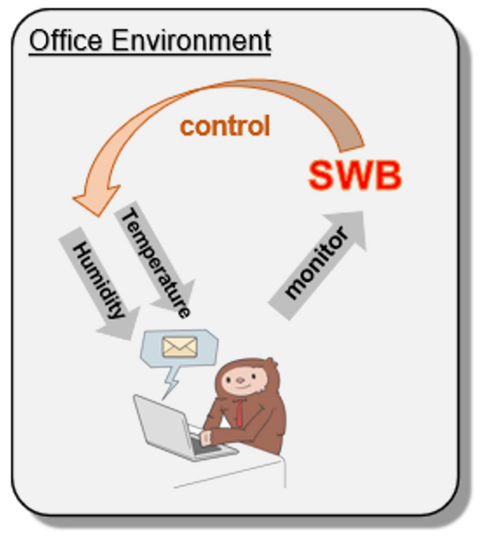


Fig. 1: Schematic representation of our study

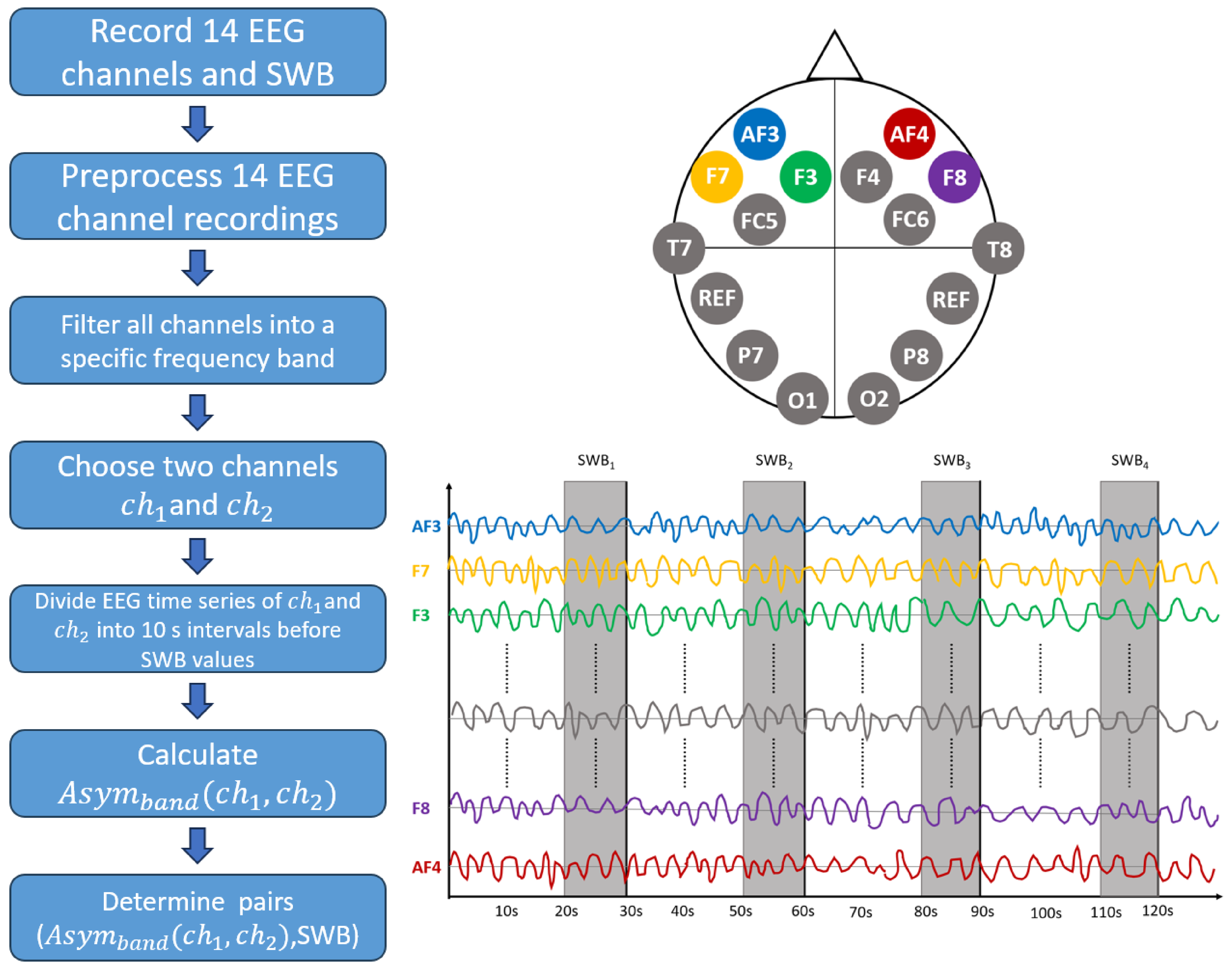
- **Frontal Alpha Asymmetry** (FAA) has been shown to have a direct correlation to SWB (Urry et al. 2004; Xu et al. 2018), but not as a dynamic value that changes during one EEG session
- Our previous work (Wutzl et al. 2023), showed a similar result when SWB is changed on short time scales (60 or 30 seconds) via the environment
- We also focused on the asymmetry of different frontal sensors, as these sensor locations were reported to influence the asymmetry scores (Metzen et al. 2022)
- **Now**, we expand this research to include the asymmetries between all frontal sensors, as well as different EEG frequency bands

Methods

- Environment was set to combinations of temperature-humidity values (low, medium, and high)
- **EEG recorded for 6 minutes** with 14-channel headset (EMOTIV EPOC X, EMOTIV, San Francisco, USA)
- **Subjects rated their SWB every 30 seconds** on a scale from 1 (worst) to 10 (best)
- Fig. 2 shows a graphical representation of the workflow and EEG sensor layout
- Standard preprocessing: EEGLAB (Delorme and Makeig 2004), HAPPE (The Harvard Automated Processing Pipeline for Electroencephalography) (Gabard-Durnam et al. 2018), MARA (Multiple Artifact Rejection Algorithm) (Winkler et al. 2011; Winkler et al. 2014), separately for each subject and temperature-humidity pair
- After cleaning and bandpass filtering, the data was filtered into one of the frequency bands: delta (0.5–3 Hz), theta (4–7 Hz), alpha (8–13 Hz), beta (14-30 Hz), or gamma (31-100 Hz)
- We also used the unfiltered signal as “non” (0.5-100 Hz)
- Calculation of the power spectrum of two channels ch_1 and ch_2 and determination of their asymmetry $Asym$ via

$$Asym_{band}(ch_1, ch_2) = mean(\log pow_{band}(ch_1) - \log pow_{band}(ch_2))$$

Fig. 2: Representation of our workflow on the left, channel locations and time series used for $Asym$ calculation on the right.



- $Asym$ was then combined with the reported SWB value as tuple $(Asym_{band}(ch_1, ch_2)$, SWB) for each subject and band
- Participants tend to report mid-ranged SWB values SWB (6–8) more frequently than very low or very high SWB values (1–3, 10) → we balanced the data set for each participant using SMOTE (Chawla et al. 2002) to have an equal number of samples per SWB
- Linear regression for each subject with $Asym$ as the independent and SWB as the dependent variable
- Then one-sided t-test to determine the statistical significance that the mean of the slopes of the linear regression from each subject is greater than zero

Results

- 30 students (28 right-handed, 2 left-handed, 16 males, 14 females, ages 22.3 ± 4.2 years)
- Results with p-values of less than 0.01 are shown in Table 1 (p < 0.001 in bold)
- As expected from reports in the literature and our previous results: alpha frequency band shows statistically significant results.
- However, filtering into the delta or theta bands, or not filtering at all (non), also yields a positive linear correlation between frontal sensors from contralateral brain hemispheres and SWB

band	*ch₁*	*ch₂*	p-value	CI	*band*	*ch₁*	*ch₂*	p-value	CI
Delta	AF3	AF4	0.002	[0.40, Inf)	**Alpha**	**FC5**	**AF4**	**<0.001**	**[0.45, Inf]**
Delta	**F7**	**AF4**	**<0.001**	**[0.39, Inf)**	Beta	F7	AF4	0.002	[0.34, Inf)
Delta	FC5	AF4	0.001	[0.30, Inf)	Gamma	AF3	AF4	0.003	[0.55, Inf)
Theta	**AF3**	**AF4**	**<0.001**	**[0.46, Inf)**	Gamma	F3	AF4	0.006	[0.38, Inf)
Theta	F7	F8	0.008	[0.17, Inf)	Gamma	FC5	AF4	0.004	[0.25, Inf)
Theta	**F7**	**AF4**	**<0.001**	**[0.41, Inf)**	Non	AF3	AF4	0.006	[0.54, Inf)
Alpha	AF3	AF4	0.002	[0.50, Inf)	**Non**	**F7**	**AF4**	**<0.001**	**[0.68, Inf)**
Alpha	**F7**	**AF4**	**<0.001**	**[0.47, Inf)**	Non	FC5	AF4	0.003	[0.34, Inf)

Table 1: The columns titled “band” show the frequency band considered. Entries ch_1 and ch_2 give the EEG channels in the calculation of $Asym_{band}(ch_1, ch_2)$. The columns p-value and CI specify the one-sided t-test and the confidence interval (CI) of the slope of the linear correlation. The results marked in bold are the ones with a p-value < 0.001.

Conclusion

- In our previous work, we focused on the alpha frequency band and the relationship between FAA and short-term SWB changes.
- Here, we present that also other frequency bands, i.e., delta or theta, or not filtering at all into a specific frequency band show similar results.
- Thus, we conclude that alpha is not the only EEG frequency band that should be investigated when focusing on short-term SWB changes.