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Neurophysiological and Subjective Analysis of VR Emotion Induction Paradigm

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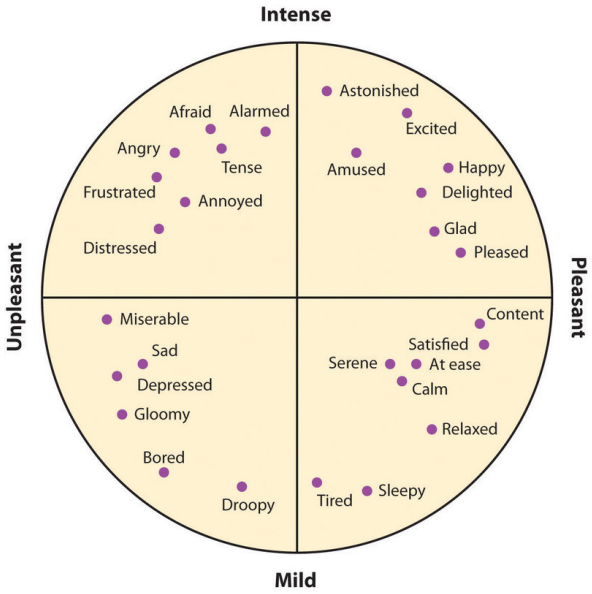
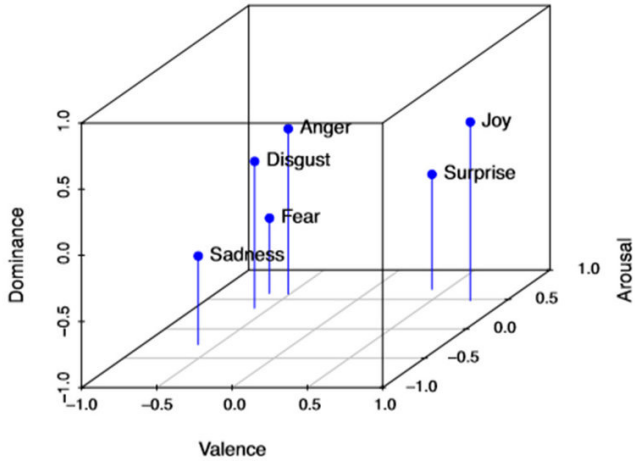
虚拟现实技术与系统国家重点实验室

Background

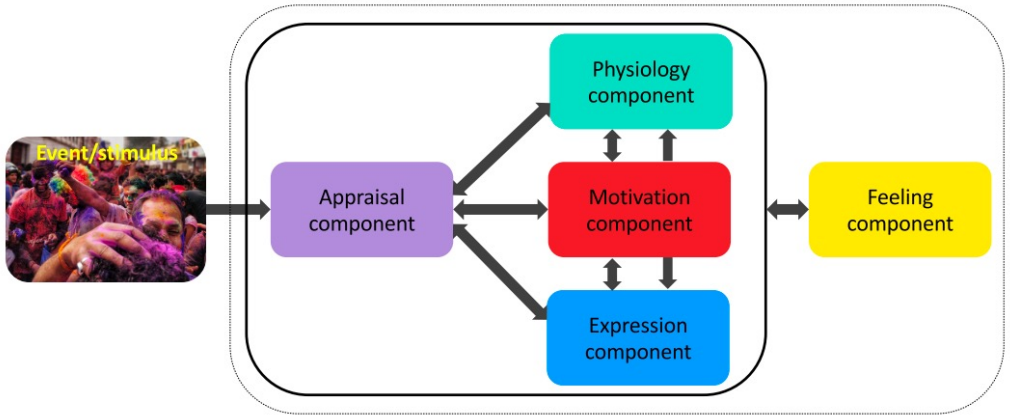
Models of Emotion



2-D representation of emotions
Anger, Happiness, Fear, Surprise, Disgust, Sadness
(Valence-Arousal, VA)



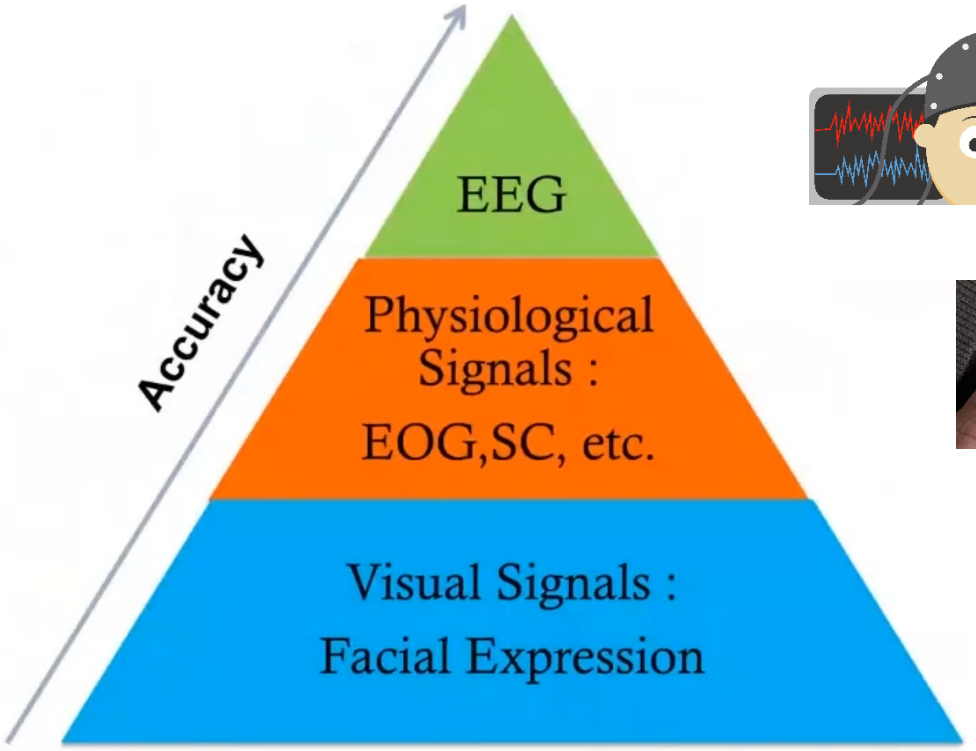
3-D representation of emotions
VAD

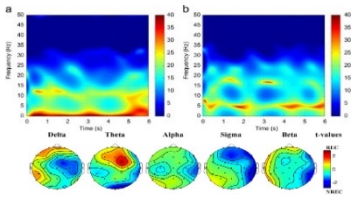


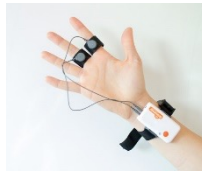
Appraisal theory of emotion

Background

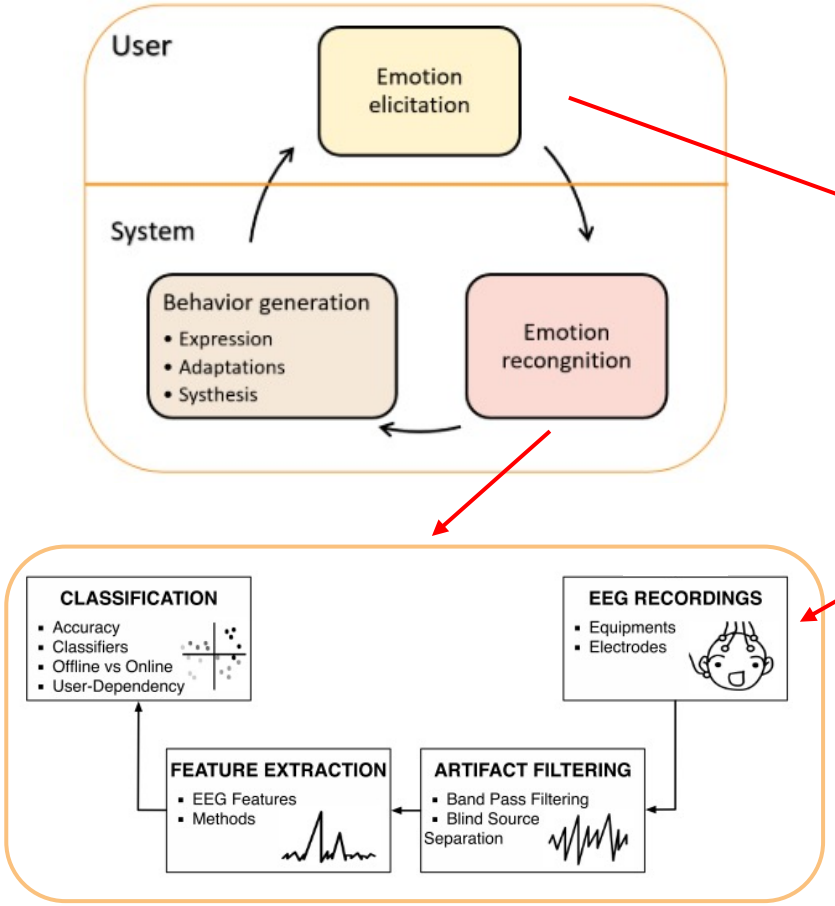
Why EEG ?







Motivation



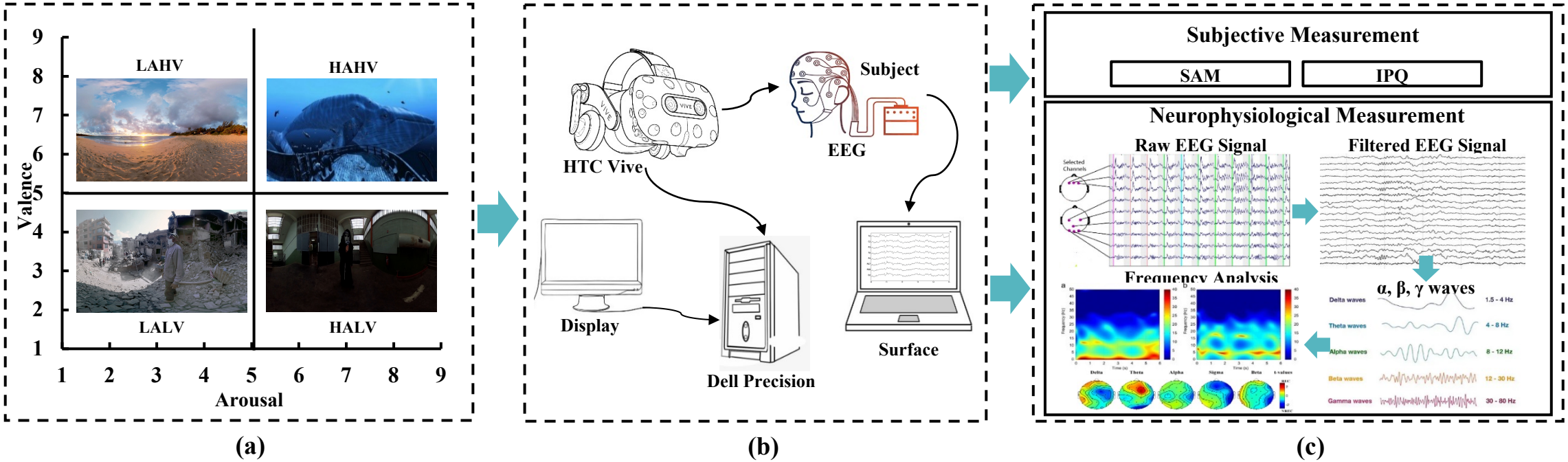
Datasets such as: DEAP, MAHNOB-HCI, SEED, and AMIGOS.
It is a passive emotion induction in the laboratory, and lacks sufficient ecological validity.

Motivation

VR Emotion-Induction Paradigms

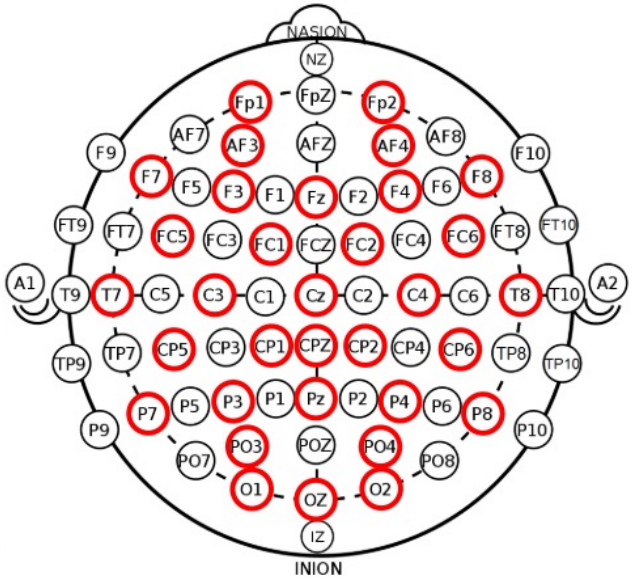
VR could remedies the gap between the laboratory and authentic environments

Pipeline



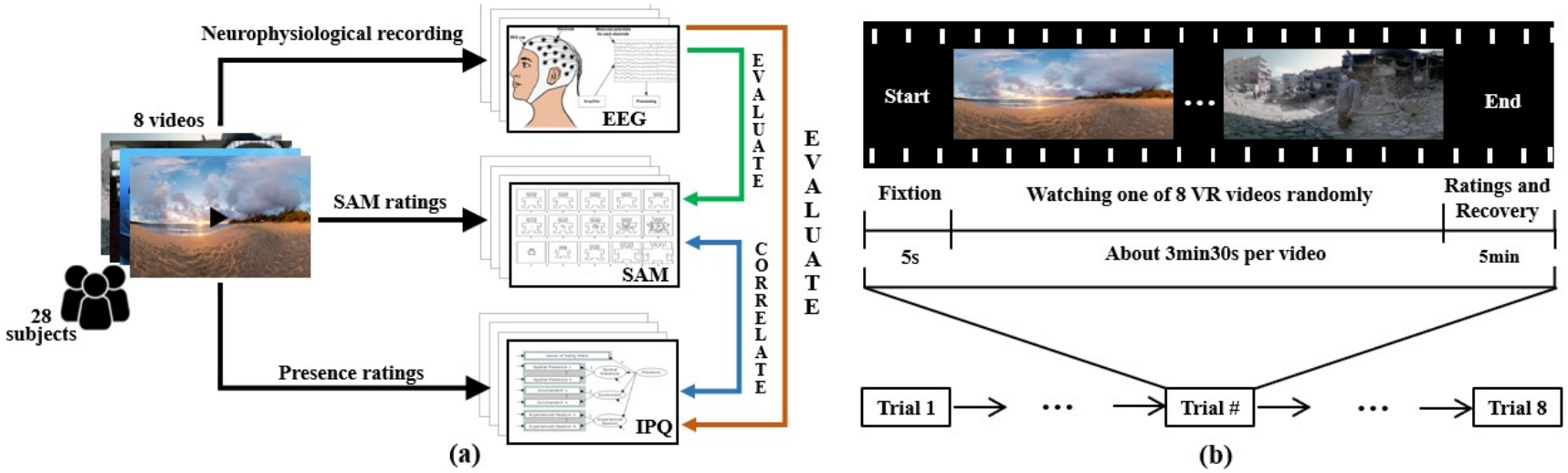
An overview of our framework for VR emotion induction and analysis.
(a): The expected emotional state and emotion induction materials;
(b): The experiment set-up;
(c): The subjective and neurophysiological data process and analysis

Methods



EEG equipment and HMD used in our study

Methods



(a) The study overview in our experiment. (b) Experiment process for each trial.

Methods

VR-based emotion-inducing materials

VIRTUAL HUMAN INTERACTION LAB
Stanford University

ABOUT US THE TEAM PUBLICATIONS CONTENT NEWS

A Public Database of 360 Videos with Corresponding Ratings of Arousal and Valence

Below is a comprehensive list of all immersive VR clips from the paper "A Public Database of 360 Videos with Corresponding Ratings of Arousal, Valence, and Correlations between Head Movements and Self Report Measures"

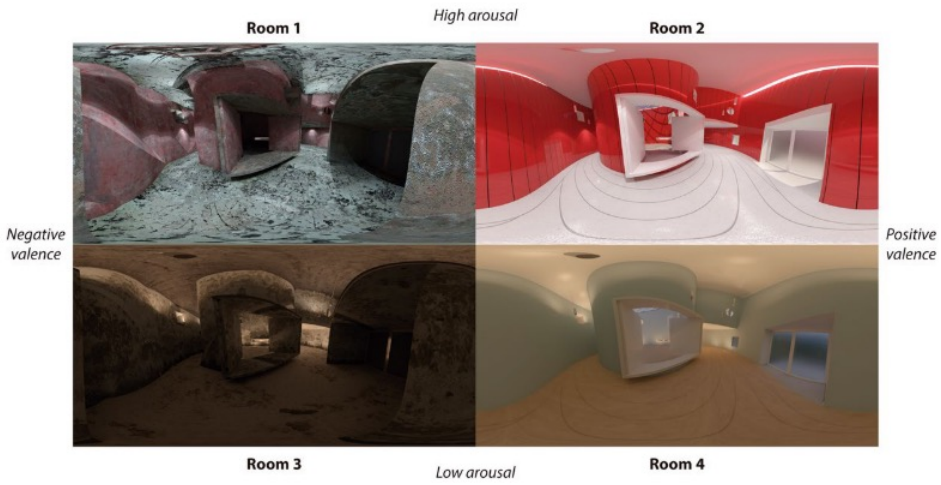
Clicking on the title of the video will lead you to the video content.

* Videos are no longer available online

	Title	Valence	Arousal	Total time (s)	Description
1	Abandoned building	4.39	2.77	120	Daytime shot of an alley in between two abandoned buildings, with ambient music
2	A Mumbai Summer	5.87	4.6	199	Tour of the Mumbai, India, various shots of urban and suburban locations
3	Abandoned City	3.33	3.33	50	Virtual environment of a post-apocalyptic abandoned city
4	Jared Leto Tour Guides Alaska's Melting Glaciers	4.73	3.33	234	Educational clip about the effects of climate change on Alaska's glaciers
	Chernobyl VR 360	3.06	4.18	548	Educational clip on the effects of the Chernobyl nuclear disaster on the town of Pripyat

&spfreload=5

Stanford Virtual Human Interaction LAB (Frontiers in Psychology 2017)



Universitat Politècnica de València (Scientific Reports 2018)

Methods

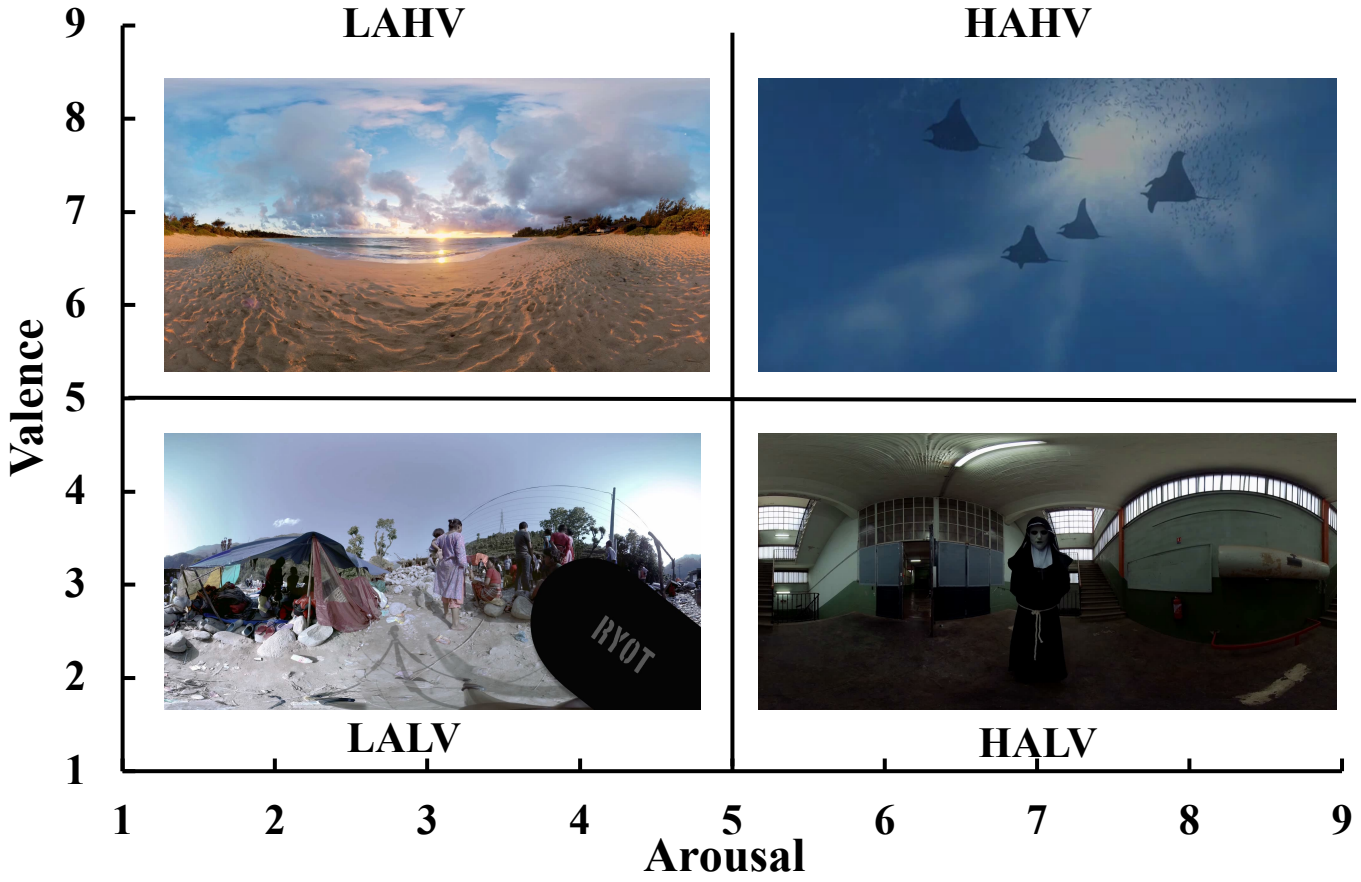
(a) LALV (b) HALV (c) LAHV (d) HAHV

Sample screenshots of participants and VR videos with different emotions
Four from Stanford immersive VR video public database
Two from Youtube, HALV
Two from Steam, HAHV

Methods

VR Stimulate videos used in our experiment:

The Nepal Earthquake Aftermath (LAHV)



The Whale Encounter (HAHV)

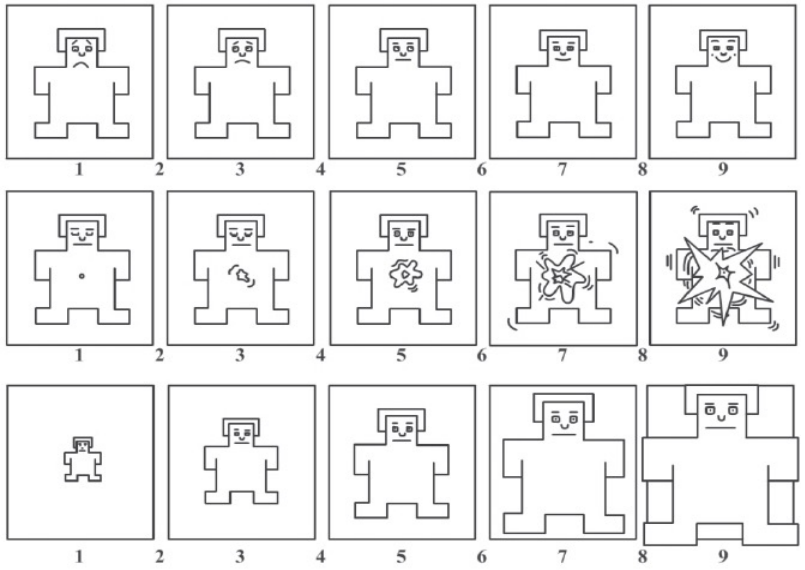
The Malaekahana Sunrise (LALV)

The Real Run (HALV)

Methods

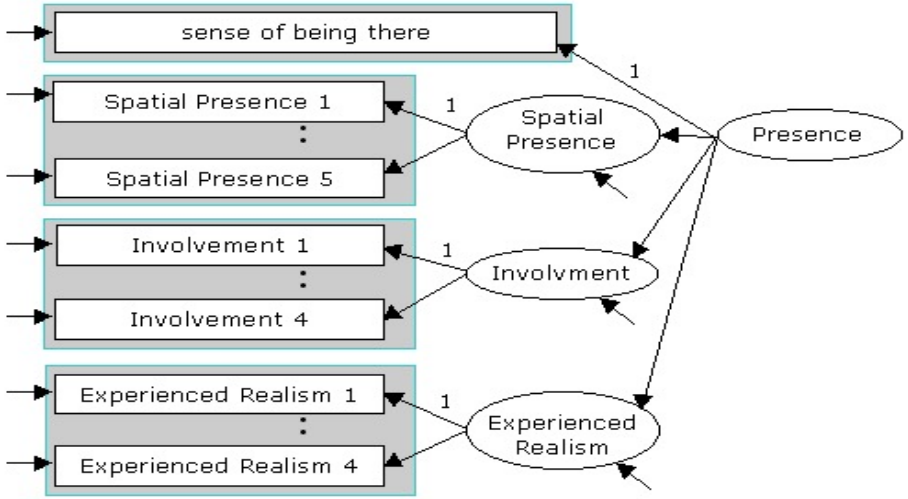
Subjective Scale

Self-Assessment Manekin (SAM)



Arousal, Valence, Dominance (1-9 points)

Igroup Presence Questionnaire (IPQ)

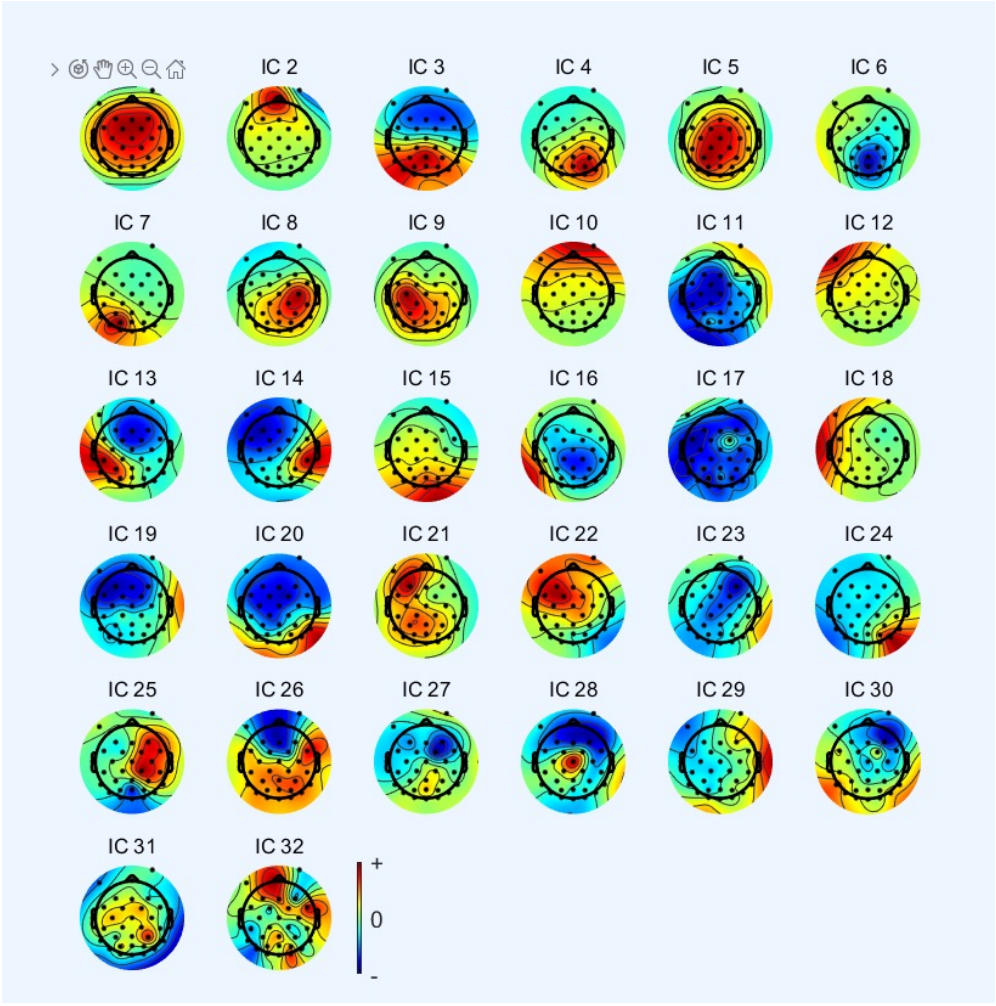


INV, SP, REAL

EEG Processing (EEGLAB)

Body movements, VR displays, EOG, ECG, and EMG can easily interfere with EEG signals

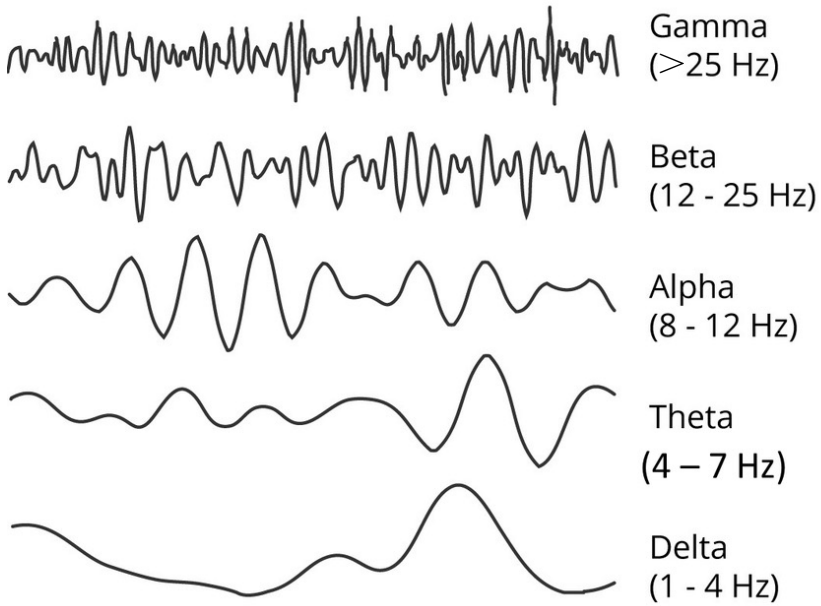
- **512Hz Raw data, resampled to 128Hz**
- **FIR Filter (4-47Hz)**
- **Independent Component Analysis (ICA): decompose EEG to 32 independent components (ICs).**
- **Finally, we remove an average of 9.37 components per subject.**



EEG Feature Extraction

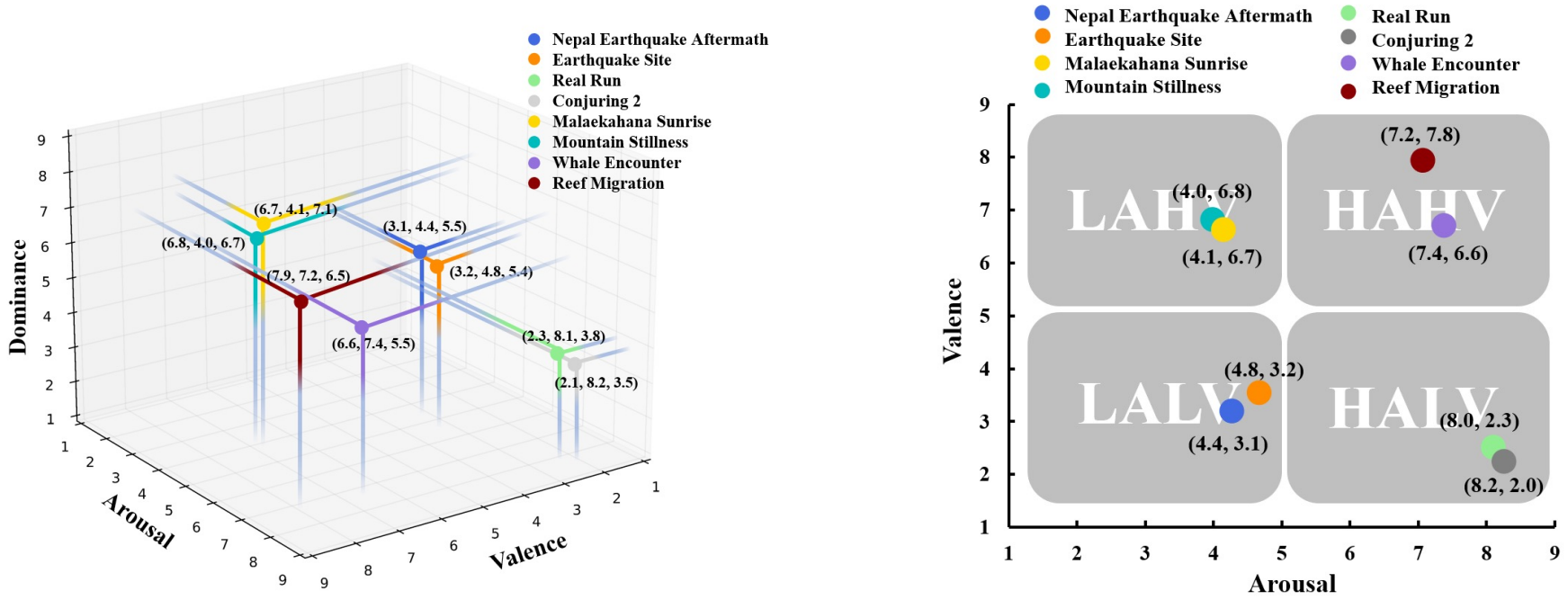
Most significant feature related to emotion usually exists in the frequency domain.

- **Power Spectral Density (PSD) and Hemispherical Asymmetry through Welch's method**
- **Hanning window of 256 samples with an overlap of 128 samples.**
- **The fixed stage of five seconds before each video as the baseline for baseline correction.**
- **Finally, PSD values are averaged over θ (4 - 7 Hz), α (7 - 13 Hz), β (14 - 29 Hz), and γ (30 - 47 Hz) bands**



Result & Discussion

Analysis of Subjective SAM Ratings



(a) The distribution of 8 VR videos in the valance-arousal-dominance space;
(b) The distribution of 8 VR videos in the valance-arousal plane.

Analysis of Subjective SAM Ratings

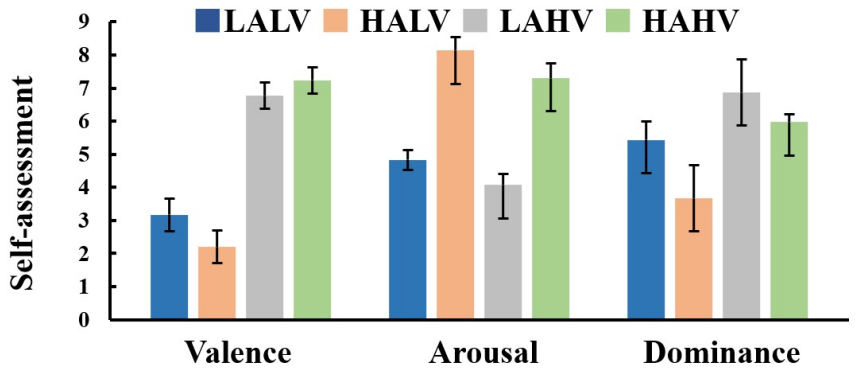


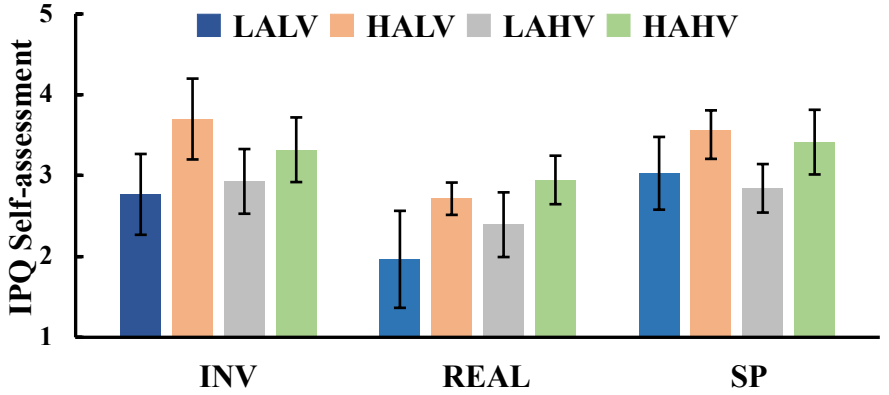
Table 2. The inter-correlation between three scales of valence, arousal, and dominance (* = $p < 0.05$).

Scale	Valence	Arousal	Dominance
Valence	1	0.12	0.43*
Arousal		1	0.19
Dominance			1

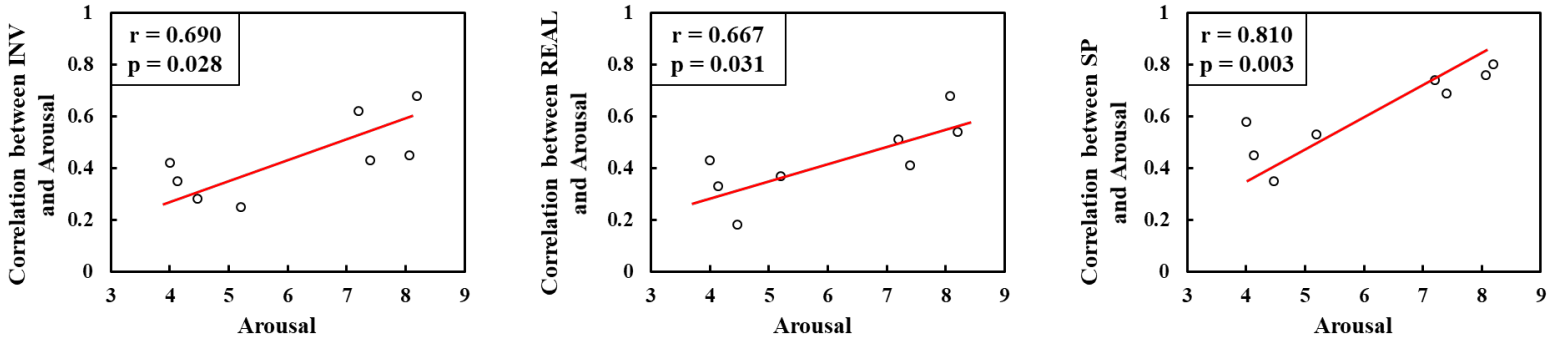
The mean ratings of participants for valence, arousal and dominance under the 4 emotion induction conditions. The rating is averaged for each subject and each condition.

Result & Discussion

Analysis of Subjective IPQ Ratings



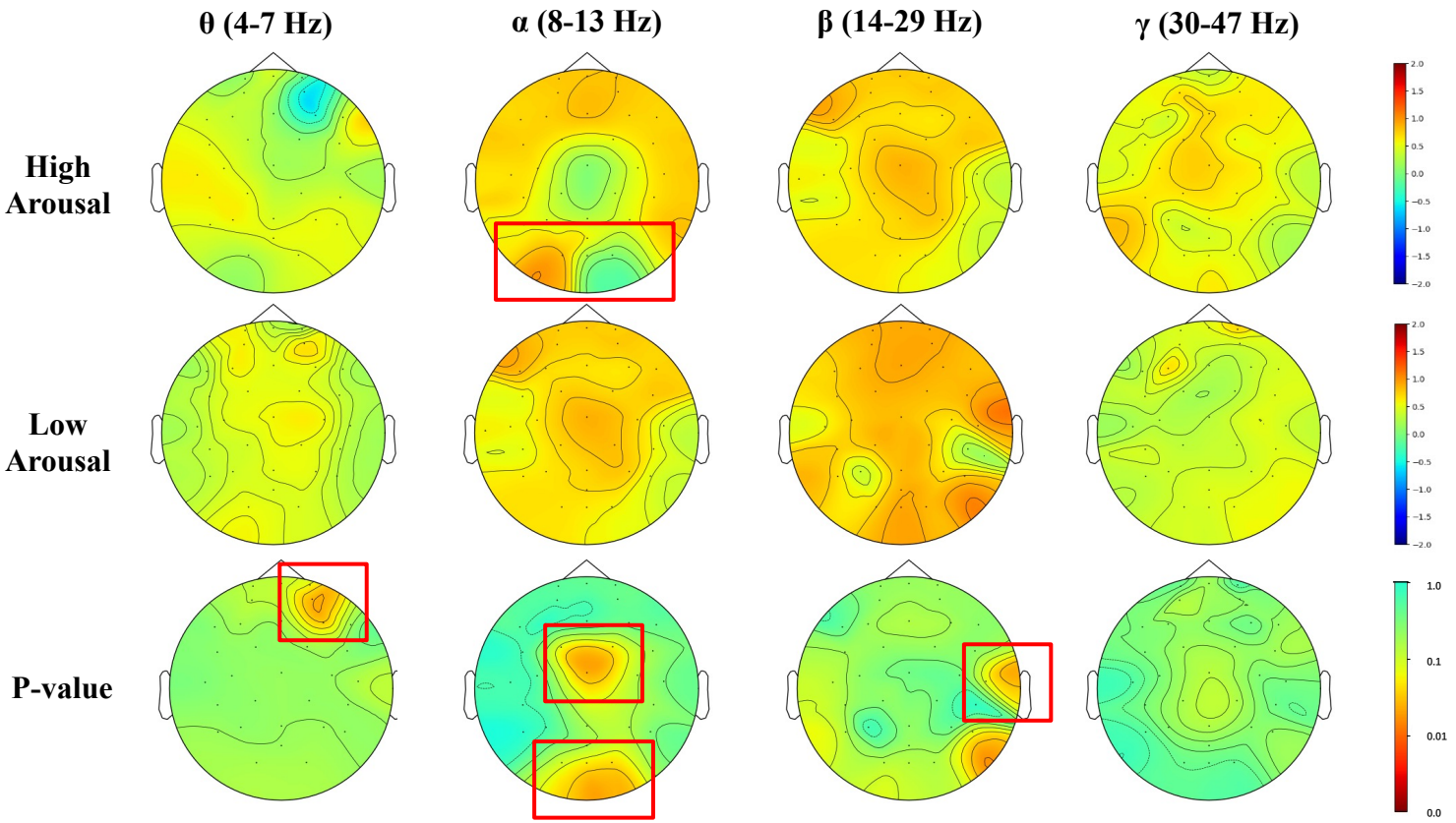
(a) The mean ratings of subjects for involvement (INV), sense of realness (REAL) and spatial presence (SP) under the 4 emotion induction conditions.



(b) The correlation between the global arousal score of 8 videos and the correlation between presence and arousal of videos.

Result & Discussion

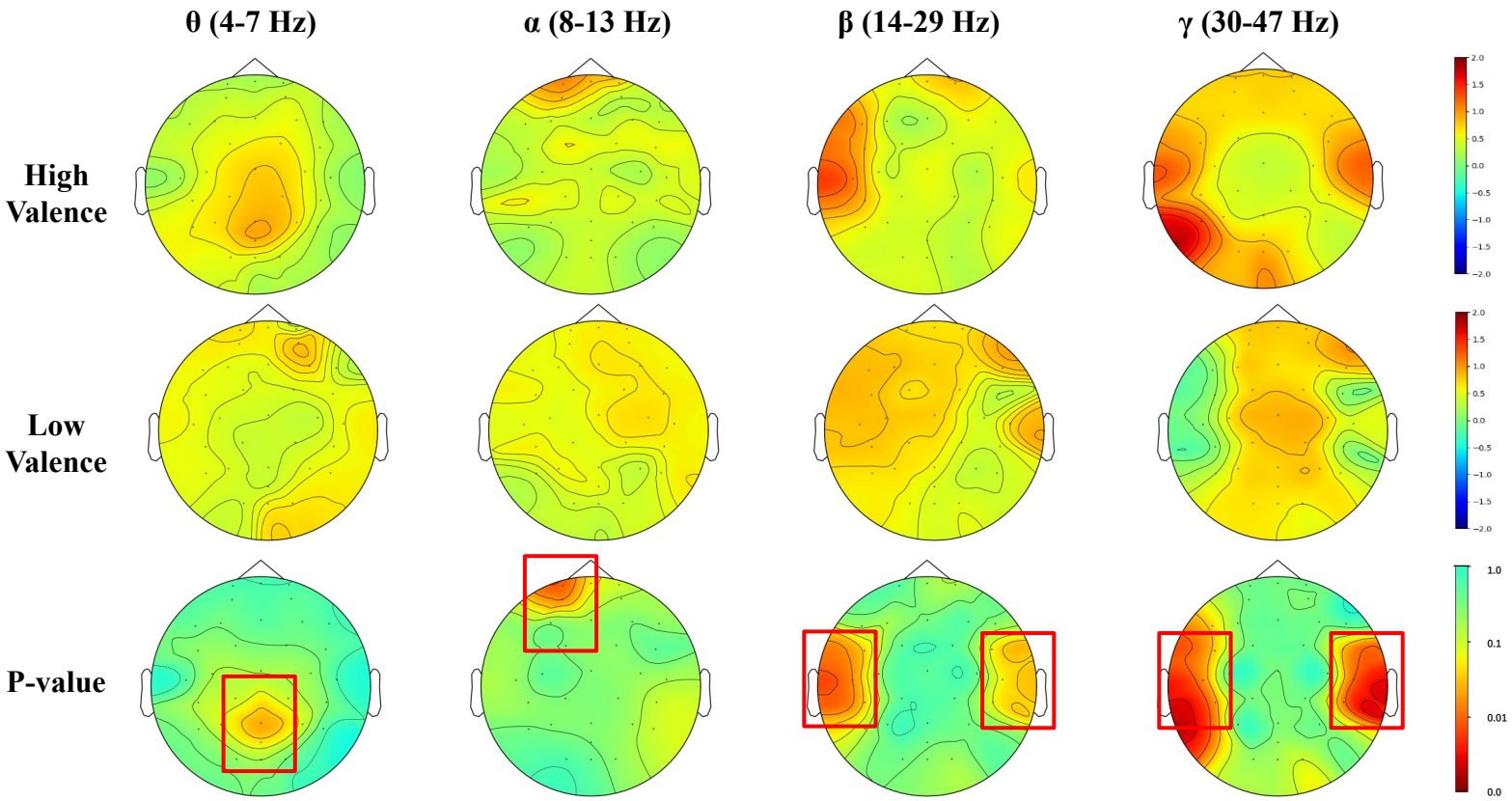
Analysis of EEG Power under High-Arousal/Low-Arousal



The average power of theta (4-7Hz), alpha (8-13Hz), beta (14-29Hz), and gamma (30-47Hz) over all subjects for high-arousal and low-arousal.

Result & Discussion

Analysis of EEG Power under High-Valence/Low-Valence



The average power of theta (4-7Hz), alpha (8-13Hz), beta (14-29Hz), and gamma (30-47Hz) over all subjects for high-valence and low-valence.

Result & Discussion

Table 4. The channel list with significantly difference for high-arousal/valence compared with low-arousal/valence (* = $p < 0.05$, ** = $p < 0.01$).

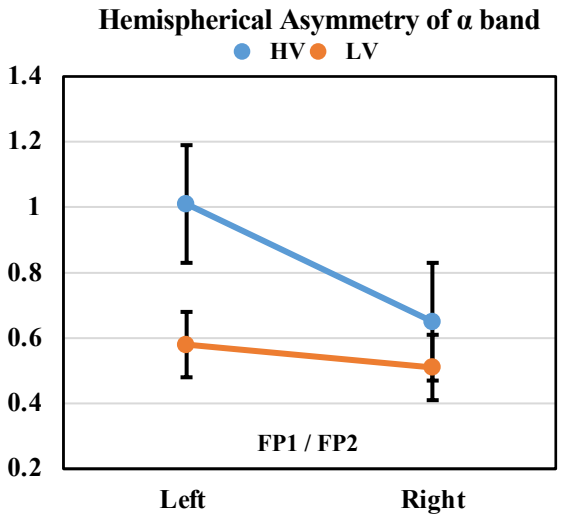
Band	Channel	HA	LA	HV	LV
θ	FP2**	-0.17	0.34		
	F4**	-0.43	0.51		
	AF4**	-0.55	0.65		
	Pz*			0.60	0.38
α	Cz**	0.07	0.87		
	FC1*	0.59	0.75		
	FC2*	0.55	0.71		
	Oz*	0.54	0.64		
	O2**	0.25	0.60		
	O1*	0.81	0.67		
	FP1**			1.01	0.51
	FP2*			0.65	0.58
β	T8*	0.47	0.82	0.50	0.69
	P8*	0.51	0.76		
	T7**			1.12	0.81
	FC5**			0.82	0.58
	CP5*			0.79	0.58
	FC6*			0.45	0.30
	CP6*			0.40	0.49
γ	FC5**			0.78	0.21
	T8**			1.03	0.47
	CP6**			0.58	0.24
	FC6**			0.81	0.33
	T7**			0.94	0.28
	P7**			1.21	0.43
	CP5**			0.65	0.27

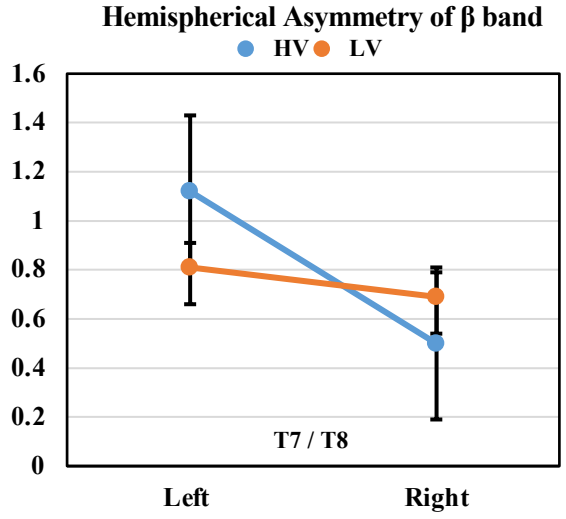
Table 1. 14 pairs of hemispheric asymmetry electrodes used in our experiment.

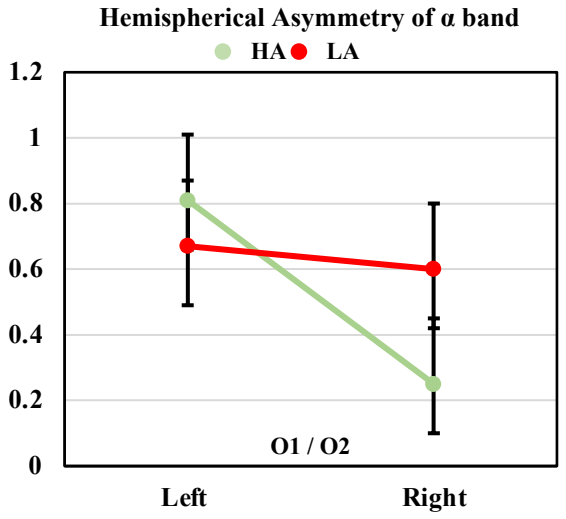
Pair No.	1	2	3	4	5	6	7
Left	Fp1	AF3	F7	F3	FC5	FC1	T7
Right	Fp2	AF4	F8	F4	FC6	FC2	T8
Pair No.	8	9	10	11	12	13	14
Left	C3	CP5	CP1	P7	P3	PO3	O1
Right	C4	CP6	CP2	P8	P4	PO4	O2

Result & Discussion

Effects Analyse of Hemisphere Asymmetry







Hemisphere Asymmetry Effect under High-Arousal / Low-Arousal and High-Valence / Low-Valence.

Limitations

- First, our dataset has a limited age distribution that exclusively collects EEG signals from college students.
- Second, subjects are not allowed to turn their heads excessively during the experiment, which may affect their experiences.
- Finally, due to the long time experiment could cause excessive fatigue to the subject, we only explored the validity of the VR emotion induction paradigm without comparison with the traditional 2D displays.

Conclusion

- We set a precedent by using VR videos to investigate the EEG features of diverse emotional states systematically, demonstrating the potential power of VR as stimulus material for emotion research from a neurophysiological perspective.
- We discover the crucial brain regions and frequency oscillations associated with emotional valence and arousal. It is, thereby, a critical step to extend emotion research towards real-world neuroscience.
- We find there is hemispheric lateralization of α waves in occipital regions for high-arousal emotions, which bring new insights for emotional arousal in affective computing.

Thank You!
Questions & Answers

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