# AffectTracker: Real-time continuous rating of affective experience in immersive Virtual Reality.

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## Introduction

### Background

- ***Subjective experience**: A core component of **affective states (AS)**, typically assessed through self-reports, such as the Affect Grid expressed with **Valence**: pleasantness (pleasant-unpleasant); and **Arousal**: intensity (low-high).*
- ***Summary ratings (SR)**: Retrospective, single-point affect ratings after stimulus exposure. Commonly used after stimulus presentation, but may fail to capture emotional dynamics.*
- ***Continuous rating (CR)**: Real-time, moment-to-moment affect tracking, allowing finer temporal resolution of AS, but may introduce invasiveness and alter the experience itself.*
- ***Immersive virtual reality (iVR)**: Offers rich, interactive environments that elicit emotions more naturally. Allows precise experimental control, improving replicability.*

### Study 1 summary: AffectTracker

Real-time tool for **simultaneous valence-arousal ratings in iVR**, featuring **Flubber feedback—a dynamic, abstract shape visually representing affect.** In an under-review study (Study 1), AffectTracker's CR **strongly correlated with SR for low-variability stimuli**.

Different feedback modalities (Flubber, Grid, Proprioceptive) tested in short 360° iVR videos. **Flubber showed high usability, low distraction, and minimal interference**. CR mean correlated strongly with SR for valence, while CR variability was most informative for arousal.


### Aims

**Compare Study 1 and Study 2:** Examine whether the findings from short, repeated videos (Study 1) hold for a longer, more varied stimulus (Study 2) to validate AffectTracker in a **longer (23 min) iVR experience.**

Analyze the **relationship between CR and SR** to determine how well CR reflect SR, especially for **arousal** fluctuations.

Assess **user experience** (usability, distraction, emotion representation, sense of presence) in a longer iVR exposure.

## Methods

### Participants

- **Inclusion criteria:** ≥18 years old, normal/corrected vision.
- **Exclusion criteria:** neurological/psychiatric disorders, substance abuse, severe phobias (e.g., spiders, blood, heights).
- **N = 62**
- **Age 29.8**±6.7
- General **good interoceptive awareness** (MAIA scores) and within the **non-alexithymic range** (TAS-20 scores).
- Testing sites:

Berlin Torino

### Experimental setup

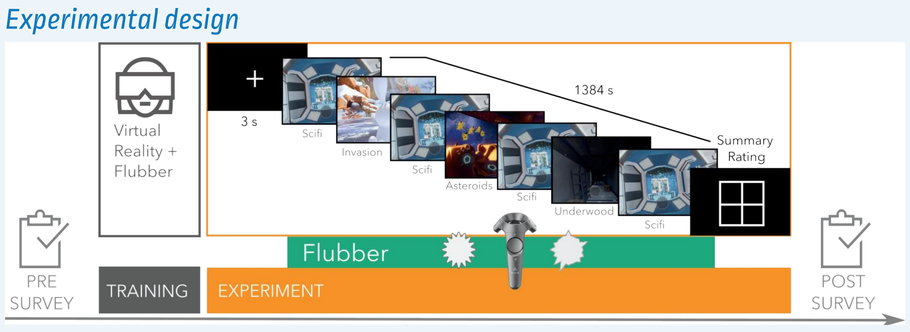

### Questionnaires

- **Pre-experiment:** SSQ (motion sickness), TAS (emotional awareness), MAIA (bodily awareness), demographics (age, gender, education, VR/gaming experience).
- **Post-experiment:** SUS (usability), Distraction (feedback interference), Emotion Representation (alignment with experience), Sense of Presence (VR immersion), SSQ, open-ended feedback on CR experience.

SCAN ME

Watch the **video** showing the iVR experiment and access **data**, **codes**, and our **preprint**.

### Experimental design




### Data analysis

**Relationship between CR and SR:** Pearson correlations between CR indices (mean, standard deviation, range, skewness, kurtosis) and SR for valence and arousal. Fisher r-to-z transformation to compare CR-SR correlations between Study 1 (Selection) and Study 2 (Evaluation).

**Impact of CR on user experience:** One-way ANOVA (Type 3) on System Usability Scale (SUS), Distraction, Sense of Presence, Emotion Representation, and Satisfaction scores. Post-hoc t-tests (Bonferroni correction) for pairwise comparisons.

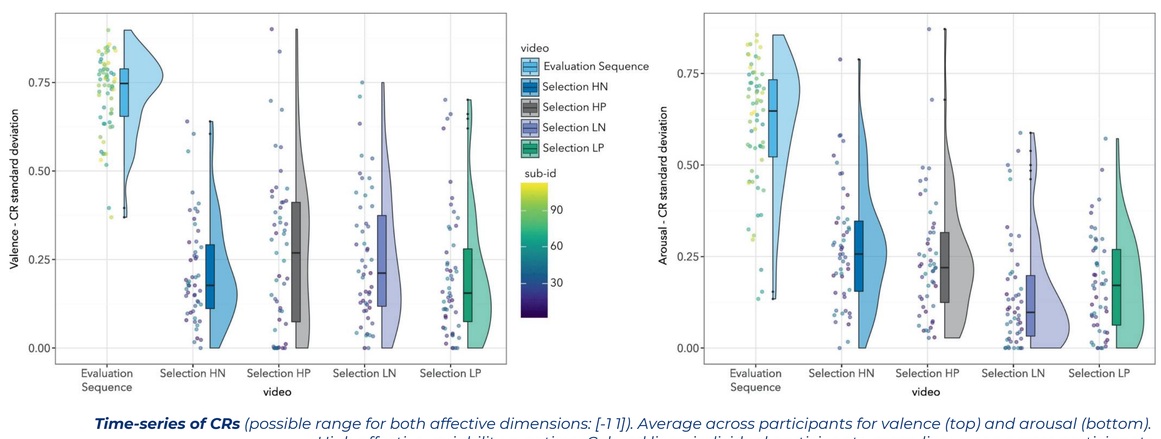
## Results

### CR Variability and CR-SR Relationship

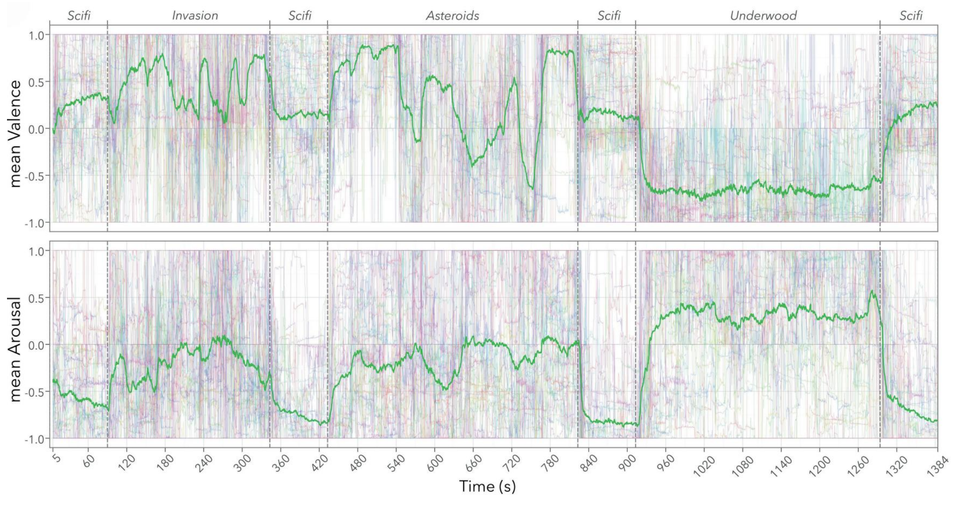
- **CR variability** was significantly **higher in Study 2** than in Study 1, indicating **greater moment-to-moment emotional fluctuations**.
- **CR standard deviation** showed the **strongest correlation with SR** for **arousal** ($r = .591$, $p < .001$), while CR mean had a weaker correlation ($r = .186$, $p = .147$).

### User experience

- **High usability** (SUS = 81.2), confirming that AffectTracker was easy to use.
- No significant interference in Sense of Presence: **Participants remained immersed** in the iVR experience.
- **Emotion Representation was lower in Study 2** vs. Study 1 ($p < .001$), possibly due to the prolonged duration.




***Time-series of CRs** (possible range for both affective dimensions: [-1 1]). Average across participants for valence (top) and arousal (bottom). High affective variability over time. Colored lines: individual participants; green line: mean across participants.*




***Comparison of variability of continuous ratings (CRs) between Stud1 and Study 2.** Standard deviation (std) of the CRs for each video in the two studies, for valence (left) and arousal (right). CRs during Study 2 Sequence showed higher variability than during the four Study 1 videos (all $|t| > 10.4$, $p < .001$).*

## Discussion

**AFFECTTRACKER**

A reliable tool for affective neuroscience and clinical psychology research.

Enhances moment-to-moment affect tracking, addressing the limitations of SR in prolonged immersive VR experiences.

**SR VS. CR DIFFERENCES**

SR good for brief stimuli.
CR captures richer affective dynamics.

**FUTURE RESEARCH DIRECTIONS**

Multimodal applications (EEG and ECG).
Deeper insights into emotional dynamics.