

# Using Virtual Reality to Elicit the PLAY Emotion

## Project Proposal

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### Abstract

Emotions are primary brain processes central to human existence, yet traditional elicitation techniques lack the ecological validity and interactivity needed to evoke primary-process emotions in controlled settings. Panksepp's Theory of Affective Neuroscience identifies PLAY as a distinct subcortical primary emotional system with significant implications for cognitive and therapeutic applications. Despite this, to our knowledge, no prior work has targeted PLAY elicitation in Virtual Reality (VR) [56]. This paper addresses that gap by proposing a framework for eliciting PLAY through VR. We adapt Dozio et al.'s affective VE design framework to incorporate Pankseppian emotion theory, mapping PLAY to high valence, arousal, and dominance, and introducing an affective framing component to capture PLAY's defining social qualities. Three independently designed VR environments, a snowball rally, a tug of war, and an apple interaction are presented. Evaluation uses a triangulated multimodal approach combining physiological measures (ECG and GSR), self-report instruments (SAM, PANAS-X Joviality subscale, IPQ, and social presence subscales), and behavioural observation across 90 participants in a between-subjects design. This work will contribute a replicable design framework for Pankseppian VR emotion elicitation and a measurement model for validating state-level PLAY activation.

### Keywords

Virtual Reality, Emotion Elicitation, Affective Neuroscience, PLAY Emotion, Primary-Process Emotions, Multimodal Measurement, Presence

## 1 Introduction

Given the importance of emotions to human existence, scientists have refined methods for eliciting, assessing and analysing emotions in order to improve their understanding [52]. Discrete models (which categorise emotions into distinct states) and the Dimensional models (which place emotions on scales such as arousal, valence, and dominance) are the main ways emotions are classified [21, 49].

Jaak Panksepp's Theory of Affective Neuroscience proposes that animals possess innate emotional circuits activated by localised electrical stimulation of the brain (ESB) in sub-cortical regions [40]. He identifies seven emotions, PLAY, CARE, LUST, SEEKING, RAGE/ANGER, FEAR and GRIEF. Positive emotions serve as ESB rewards, while animals actively avoid stimulation evoking negative emotions [40].

PLAY is a non-serious, highly pleasurable interaction between entities [7]. Panksepp's rat experiments demonstrated playful pinning behaviour accompanied by 50kHz ultrasonic vocalisations [42]. Since touch is PLAY's primary sensory system and the neocortex is not required, PLAY constitutes a primary process emotion [41].

Emotion elicitation techniques allow emotions to be studied in controlled settings [10]. Passive methods, including International Affective Picture System images, film clips, music, and autobiographical recall are the widely-used standard for controlled emotion elicitation in laboratory settings [6, 23, 62]. Although these methods successfully elicit emotions, the position of the participant is as an observer. This limits immersion and ecological validity (the degree to which findings generalise to real-world settings) [22, 30]. Hence they are poorly suited to eliciting interactive emotions requiring active participation [10, 58].

Active techniques produce more intense emotions through direct engagement, including computer-generated avatar interactions, Virtual Reality (VR) and games. VR is particularly promising due to high engagement, arousal, and strong positive affect [10, 56]. Since PLAY requires environment engagement, VR is an appropriate elicitation medium [7].

When designing affective VR content, presence, immersion and agency all influence emotion elicitation success. Presence, the subjective sense of "being there" occurs when the user's awareness of the physical world recedes [36, 47, 54]. Agency is the capacity for meaningful action within the VE granting narrative ownership and enhancing engagement [20, 29, 35]. Immersion reflects the degree of sensory isolation the technology delivers [1, 8, 14].

We propose a design framework for eliciting PLAY in VR by adapting existing methodologies to incorporate Pankseppian theory. We present three independently designed virtual environments and a multimodal approach to validate the system's success.

## 2 Related Work

This chapter examines prior work to identify what has and has not been accomplished. No prior work targets PLAY as a distinct neurobiological system in VR. Limitations in framing, interaction design, and measurement reveal the significant gap that this research addresses.

### 2.1 VR as an active elicitation medium

VR is the most effective medium for controlled emotion elicitation. It produces higher arousal and positive affect than 2D displays [37]. Head Mounted Displays outperform 360-degree video on valence and arousal [43]. Yang and Zhang [65] found a clear gradient: VR outperforms 360-degree video, which outperforms 2D video on presence, enjoyment, and emotional engagement. VR-elicited

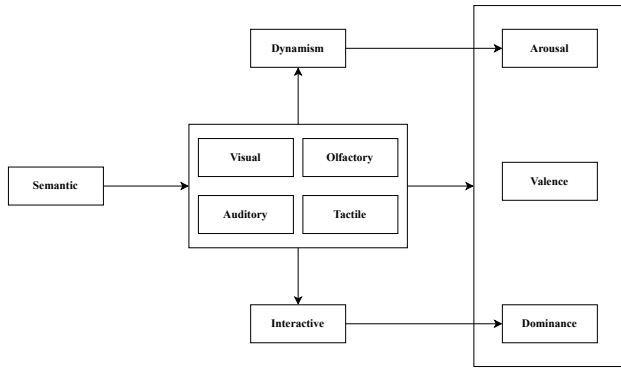


**Figure 1: Affective VE design procedure adapted from Dozio et al. [16]**

responses are comparable in intensity and temporal pattern to real-world experiences [9, 48]. Interactive VR produces stronger effects than passive viewing, mediated by presence [3, 66].

This efficacy is grounded in the bidirectional relationship between presence and emotion [1, 14, 47]: emotionally charged environments increase presence, and higher presence amplifies arousal [18, 47]. This establishes VR as the appropriate platform for investigating complex emotional states, including primary-process emotions.

## 2.2 Designing for Affective VEs

Researchers have developed design frameworks for affective VR, but these target dimensional or discrete emotions. Active tasks are typically goal-directed, and social VR research focuses on task-oriented collaboration rather than non-serious play.

**2.2.1 Design frameworks for affective virtual environments.** Design choices in a virtual environment directly shape the emotion it elicits. Dozio et al. [16] formalised a four-layer methodology, validated across 10 VEs targeting different emotions. Multiple studies converge on these four key design categories, which provide the generalisable framework for affective scene design seen in Figure 1. Steinhilber et al. [57] identified themes, colours/textures, and lighting as central. The sensory dimension is especially well-corroborated: lighting, sound, colour, and haptics consistently modulate emotional responses [18, 26, 27].

A key limitation is that these frameworks have only been validated against dimensional or discrete emotion models. None incorporate reciprocal social interaction or role-reversal (behavioural signatures of PLAY) and the "interactive" layer emphasises user control rather than social reciprocity with an agent. Nevertheless, they offer a validated outline of affective design elements applicable to a PLAY-eliciting VE.

**2.2.2 Social, active, and collaborative VR.** VR supports meaningful social and emotional engagement, but existing research focuses on task-oriented collaboration rather than non-serious play. Cooperative tasks enhance social presence and positive affect [12, 63], and authentic avatar interaction facilitates presence [46]. Stylised non-human characters are rated more positively than realistic avatars

[15]. The type of social presence matters: a collaborative companion enhances experience [12] while an evaluative observer may reduce positive affect [60].

Active tasks enhance emotional intensity and produce a wider spread of arousal responses than passive viewing [64]. PLAY, however, requires non-serious activity done for its own sake. Existing active VR tasks are goal-directed (escaping a room, sorting objects), which is incompatible with the autotelic nature of PLAY.

## 2.3 Measurement Approaches

Self-report and physiological measures dominate affective VR evaluation, yet are poorly suited to capturing state-level PLAY. Self-report instruments lack specificity for state-level PLAY. For example, the SAM [2] conflates PLAY with SEEKING within a high-valence, high-arousal space; the PANAS-X Joviality subscale [61] reflects positive engagement but is not a validated PLAY measure; and the IPQ [50] assesses presence rather than affect. More broadly, self-report is susceptible to cognitive bias and demand characteristics [28, 56]. Physiological measures (e.g., ECG, GSR) provide continuous, objective indicators of arousal, but cannot distinguish PLAY from general excitement or SEEKING. Consequently, even a well-designed PLAY VE cannot be adequately validated with existing measures, highlighting a fundamental methodological gap that necessitates a multi-modal, triangulated approach.

## 2.4 The Research Gap

Prior work fails to elicit PLAY due to three interrelated gaps: dimensional framing cannot distinguish PLAY from other positive high-arousal states; existing affective VEs lack the behavioural affordances PLAY requires; and no state-level PLAY instrument exists. The convergence of these problems means targeted PLAY elicitation cannot be achieved by environments designed only to induce general positive affect.

## 3 Research Questions

### Problem Statement:

- Despite the therapeutic potential of PLAY and the established efficacy of VR as an emotion elicitation medium, it is unknown whether a Virtual Environment can be designed to specifically elicit the PLAY system.

### Primary Research Question:

**(RQ1):** To what extent do our virtual environments specifically designed to target PLAY successfully elicit this primary-process system?

### Secondary Research Questions:

- (RQ2):** What design elements are required to afford PLAY behaviours (reciprocity, role reversal, non-serious engagement) in VR?
- (RQ3):** Can triangulation of self-report, physiological, and behavioural measures infer state-level PLAY activation?

## 4 Methodology

This methodology tests whether the Panksepp's [39] PLAY emotion was elicited through an affective VE. In a between-subject design, participants will experience one of three affective VEs, all aiming

to elicit PLAY and designed independently by each author. However, the VEs are constrained by a shared design protocol which standardises evaluation criteria and mitigates confounds. Prior to the affective VE experience, participants will be guided through an emotionally-neutral VE which acts as a tutorial for navigating a VE. During this, their physiological measures will be recorded and upon completing the tutorial, subjective measures will be taken, which together captures their baseline measures. However, since the tutorial VE is not socially-charged, a baseline social presence is undefined and as such, no baseline social presence measures will be taken. Beyond baseline measures, the tutorial VE mitigates the novelty effect of VR which could have skewed results [44]. Participants will be randomly assigned to one affective VE in groups of 30 ( $n = 90$  total). During the affective experience, physiological measures will be recorded. Post-experience, subjective measures will too be taken. A between-subject design was chosen over a within-subject design to control for the carryover effect [31] and potential fatigue from repeated VE experiences.

#### 4.1 Adapted Affective VE Design Framework

Panksepp described the human emotion system as a three-tier hierarchy [39]. At the lowest level is the primary emotional system, including the Pankseppian emotions. Sitting above, is the secondary system which includes learned associations between external stimuli and primary emotions. Lastly, at the highest level is the tertiary emotional system which involves reflective thinking and rumination.

Panksepp [39] found a bidirectional relationship between these levels. Upon the primary system's activation, it cascades up, triggering the secondary and tertiary levels. The reverse exists as well, whereby activations at a higher level cascade down, triggering all levels beneath. With this dual cascade, once any level activates, all levels will follow suit. This provides us with multiple routes via which the primary emotion PLAY can be activated. Route one involves the direct activation of the system as a result of the present circumstance. Route two speaks to the secondary layer being triggered and causing the primary level to activate as well. Lastly, route three is whereby the tertiary level is activated, triggering both the secondary and primary levels as a result. This is visually depicted in Figure 2.

PLAY's direct elicitation requires social-physical contact with another living being [42], which is not possible in a VE and rules out route one. During PLAY, one is not reflecting or thinking deeply, but making instinctual responses to the rapidly changing environment [42]. Therefore, PLAY cannot be elicited via route three which requires reflective thinking. However, the learned associations required to activate the secondary layer in route two, can be included in a VE as assets. Hence, for our purposes we will use route two to elicit PLAY by activating the secondary level.

Section 2.2 outlined the generic affective VE design protocol proposed by Dozio et al. [16]. However, this framework selects design elements with specific valence, arousal and dominance (VAD) levels where the cumulative selections average to the VAD levels of the target emotion. This framework was designed for the cortical, Dimensional Model of Emotions, which would suggest that it cannot measure the subcortical Pankseppian emotions. However, according

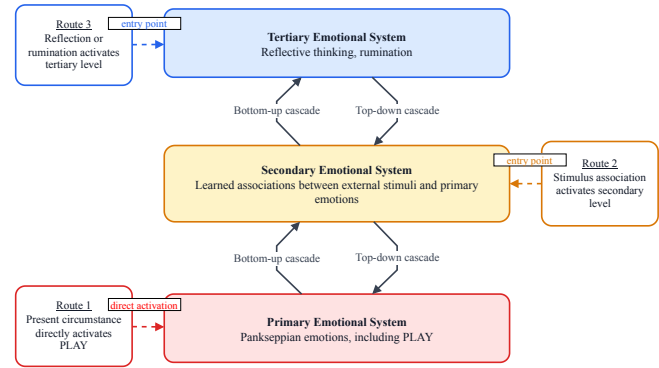


Figure 2: Emotion system hierarchy, adapted from Panksepp [39]

to Panksepp's hierarchy, these models exist at the tertiary level and according to the bidirectional nature of his hierarchy, upon PLAY being triggered it will eventually cascade up to the tertiary level. Therefore, the Dimensional Models can capture elicitations of PLAY, just indirectly. Therefore, we can use the framework outlined by Dozio et al. [16] in our PLAY-specific VEs.

To use said framework, we must map PLAY into its corresponding VAD levels. PLAY is defined as a fast-paced, highly pleasurable series of back-and-forth interactions. From this, we can see that PLAY is high valence and high arousal. For dominance, in a social setting, it refers to control over the environment. In the back-and-forth sequence of PLAY, each player's action alters how others can respond and their responses in turn reshape the action space. Every player therefore continuously influences the environment, hence we classify PLAY as high dominance. To provide quantitative figures to what "high" means, we will use the discretised interval of -1 to 1 into three equal sub-intervals to represent low, medium and high, as done in prior research [25] which is shown in Figure 3. This provides us with a target valence, arousal and dominance intervals of  $[0.33, 1]$  each.

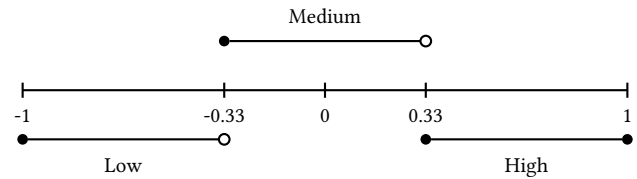


Figure 3: Categorisation of low, medium, and high values across the standardised scale [25]

However, the VAD model this framework relies on is not capable of capturing PLAY entirely. All Pankseppian emotions relate to concrete circumstances, such as engaging in social-physical touch [39], whereas the VAD model relies on cumulative VAD scores based on a semantic, overall mood. To adjust for this discrepancy, we extend Dozio et al.'s [16] framework with an affective framing component which encapsulates this concrete circumstance. The basis on which the affective framing is developed must relate to

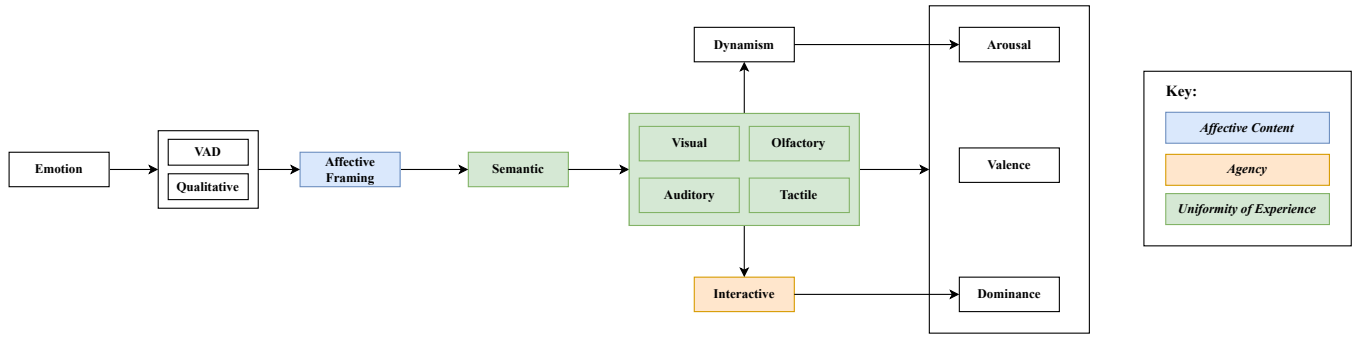


Figure 4: Pankseppian affective VE design framework

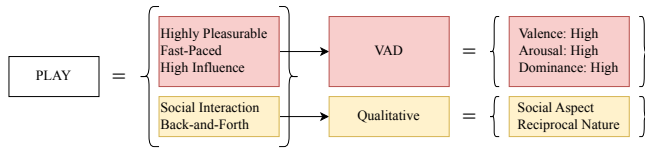


Figure 5: The decomposition of PLAY into its qualitative and VAD components

the qualitative aspect of the Pankseppian emotion which makes it unique. Therefore, we will include a qualitative aspect in our decomposition of the emotion’s definition. The full decomposition is shown in Figure 5.

Moreover, we must optimise our design for triggering PLAY at the secondary level. To activate this level, participants must be presented with the associated stimulus in a form that is very similar to that of the original conditioning stimulus [39]. This necessity for something to “feel real” speaks to the need to optimise presence. Presence can be decomposed into immersion, agency, affective content quality and uniformity of experience [1, 13, 19, 47]. At distinct sections in our VE design, we can optimise certain subcomponents. The affective content quality must be optimised with the affective framing [47]. The visual elements from the semantic and sensory sections must be uniform such that uniformity of experience is maximised [13, 19]. The interactive component must ensure strong agency [1]. Lastly, the VE setup equipment must be high quality to optimise immersion [1]. With these additions to Dozio et al.’s [16] framework, we have developed a Pankseppian affective VE design framework, which is shown in Figure 4.

## 4.2 VE Design for the PLAY Emotion

All three independent, affective VEs will be designed using the framework described in Figure 4, where each component, except olfactory, must be included. This exclusion is because olfactory stimulation has inconclusive findings regarding being able to modulate VAD levels [34, 51]. Each VE will follow the same definition decomposition of PLAY, being VAD scores in the interval [0.33,1] and the qualitative aspect being a social and reciprocal nature. The affective framing must account for this qualitative aspect, and the remainder of the design process must account for the target VAD levels across all three VEs. However, the specific design choices are

up to that specific author’s discretion. Additionally, all VEs must maximise presence, by maximising the presence-subcomponents at the stages shown in Figure 4.

Further, all authors must use the same source for the VAD ratings of the design elements. We will use the International Affective Picture System [6] for the semantic and visual elements, and the International Affective Digitised Sound System [4] for the auditory elements which contain specific VAD ratings for images and sounds.

Lastly, in this study we will employ a user-centred VE design process. The basic user needs are navigability, no cyber-sickness and emotion induction. Each VE will be designed to ensure these are met. The VEs will undergo a heuristic evaluation using heuristics developed by Sutcliffe and Gault [59]. Following necessary revisions, pilot studies of 5 participants per VE will take place ( $n = 15$ ). Using this feedback, final revisions to the VEs will be made before main data collection occurs.

**4.2.1 Snowball Rally VE.** This VE design places the participant in a snowball rally scene whereby they throw snowballs at a non-playable character (NPC) and the NPC throws snowballs back at them. The scene is depicted in a backyard on a sunny, Winter’s day. The NPC throws snowballs with varying speeds and frequencies during the experience. This triggers route two as snowball fights are associated with PLAY. The specifics are shown in Figures 6 and 7.

**4.2.2 Tug of war VE.** In this VE the participant will be in a park on a sunny day taking part in a tug of war game. They will be interacting with the opposing team by tugging on a rope with varying force. This will trigger the secondary level as tug of war is a familiar playful childhood game with some friendly competition. The specifics are shown in Figures 9 and 8.

**4.2.3 Apple Interaction VE.** This VE design places the participant in a stylised, natural environment centred around a single climbable tree, where they interact with a squirrel-like NPC using apple-like objects or baskets. The participant and NPC can freely pick up and throw these objects, with no predefined goals or scoring system. The NPC shows responsive and initiating behaviours, enabling reciprocal interaction. The design avoids task-oriented structures, instead encouraging emergent PLAY through more open-ended, shared interaction within the environment. The specifics are shown in Figures 10 and 11.

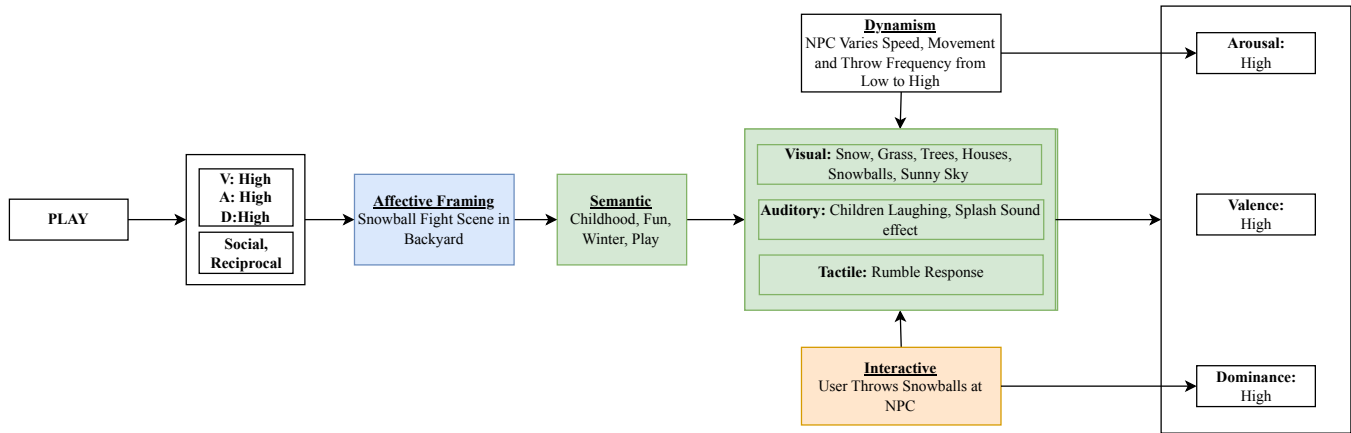


Figure 6: Snowball rally VE design



(a) Image 1



(b) Image 2



(c) Image 3

Figure 7: Snowball rally VE

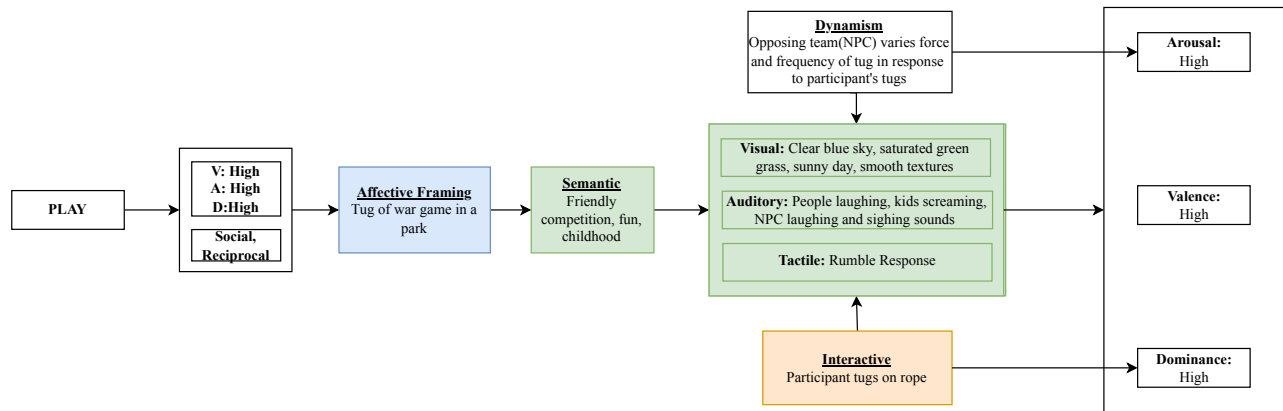


Figure 8: Tug of War VE Design

**4.2.4 Baseline VE.** The baseline virtual environment serves as a neutral tutorial space shared across all conditions. It consists of a simple environment with minimal visual complexity, allowing participants to become familiar with basic controls and interactions such as navigation and object manipulation.

### 4.3 Evaluation

Our evaluation of each VE involves determining the extent to which it elicited PLAY. To capture this, we will refer to our decomposition of PLAY into its VAD levels and qualitative components. For the VAD levels, we will need to measure the actual felt VAD levels in the participants and compare it to the interval of  $[0.33, 1]$  which we assigned to PLAY in Section 4.1. To measure this, we will use the

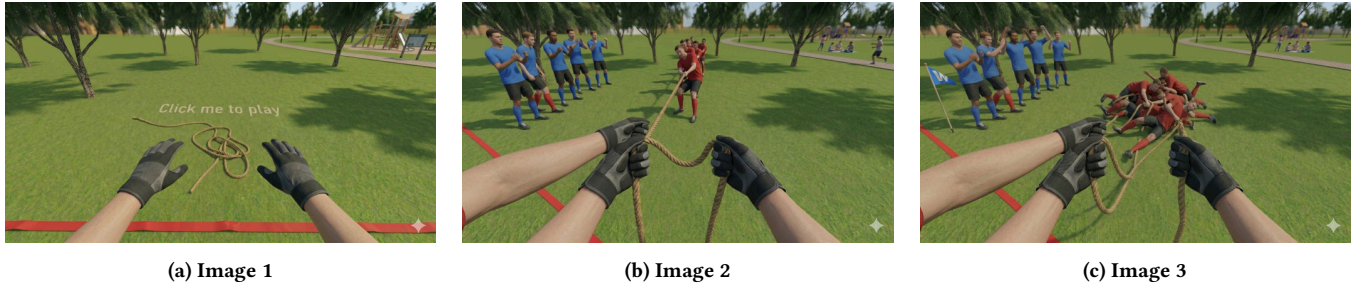


Figure 9: Tug of War VE

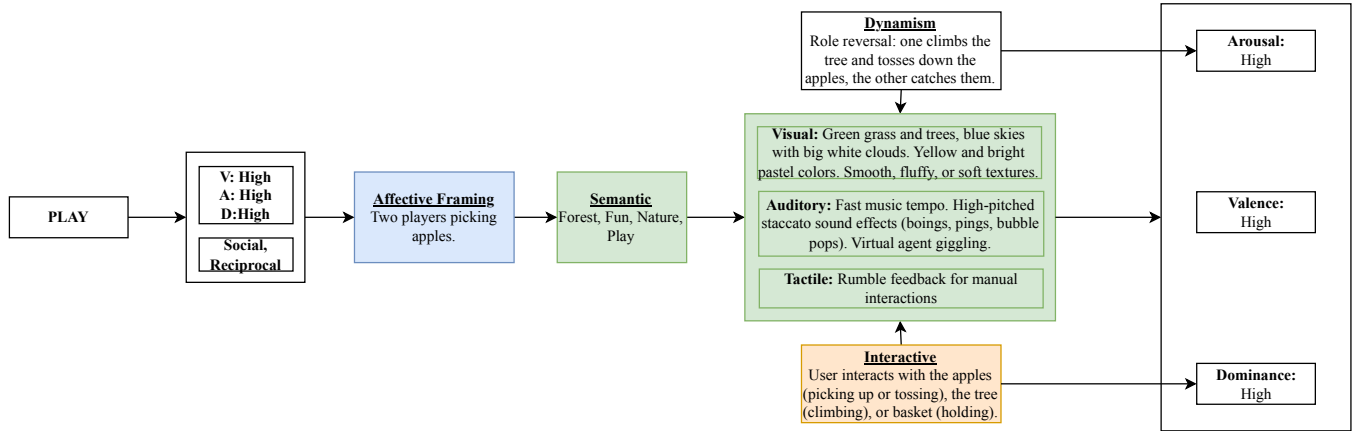


Figure 10: Apple interaction VE design



Figure 11: Apple interaction VE

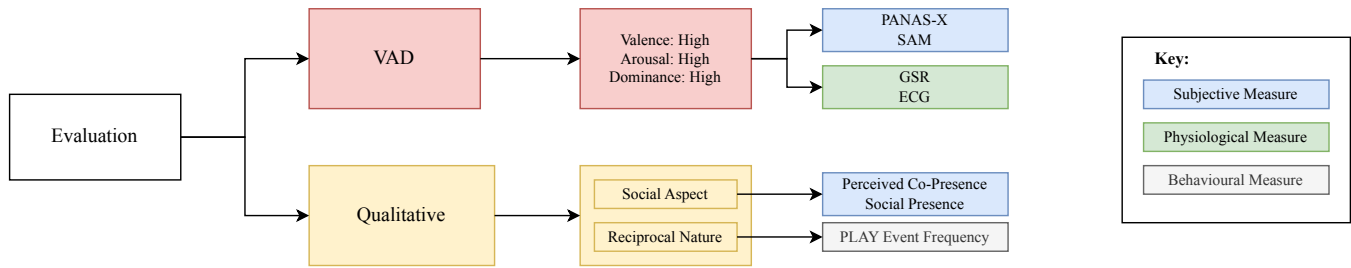
Self-Assessment Manikin (SAM) questionnaire [5] which is able to quantify the experienced VAD levels. Additionally, we will use both Galvanic Skin Response (GSR) and Electrocardiogram (ECG) measures to capture experienced arousal levels. To capture the joyous, high valence aspect, we will use the Positive and Negative Affect Scale (PANAS-X) questionnaire Joviality subscale [61] which will allow us to determine if the participant experienced joyful, high valence, affective states.

Regarding the social aspect, we will employ a combination of the perceived co-presence and social presence subscales developed by Nowak and Biocca [38]. These questionnaires capture the extent to which participants felt they were in a true social interaction with

the NPC. Additionally, since presence is linked to the intensity of an emotion's elicitation in an affective VE [47], we will measure the presence felt using the iGroup Presence Questionnaire (IPQ) [50]. Lastly, we will consider reciprocity by counting the number of events which indicate PLAY, over time. In the last 2 minutes of each VE, the NPC will gradually reduce interaction and if the participant's PLAY events decrease as well we can say the reciprocal nature of PLAY was captured. A summary of these measures is shown in Table 1 and in Figure 12.

**Table 1: Affective VE measurements**

| Measure                                                  | Type          | Captures                                 |
|----------------------------------------------------------|---------------|------------------------------------------|
| Self-Assessment Manikin                                  | Subjective    | Valence, Arousal, Dominance              |
| Positive and Negative Affect Schedule Joviality Subscale | Subjective    | Levels of joy                            |
| iGroup Presence Questionnaire                            | Subjective    | Presence                                 |
| Perceived Co-Presence and Social Presence Subscales      | Subjective    | Social presence                          |
| Galvanic Skin Response                                   | Physiological | Arousal levels                           |
| Electrocardiogram                                        | Physiological | Arousal levels                           |
| PLAY Event: Snowball Rally VE                            | Behavioural   | Number of snowballs thrown per minute    |
| PLAY Event: Tug of War VE                                | Behavioural   | Number of tugs per minute                |
| PLAY Event: Apple Interaction VE                         | Behavioural   | Number of object interactions per minute |

**Figure 12: Evaluation process for PLAY VEs****Table 2: Experimental procedure overview**

| Activity                             | Duration | Notes                                                                |
|--------------------------------------|----------|----------------------------------------------------------------------|
| Participant Recruitment              | N/A      | Done prior to experiment, detailed in Section 4.4                    |
| Participant Arrival and Consent Form | 10 min   | Participants may ask any questions                                   |
| VE Setup and Sensor Stabilisation    | 10 min   | HMD fitted, sensors attached                                         |
| Baseline VE                          | 5 min    | GSR and ECG measures recorded throughout                             |
| Subjective Questionnaires            | 15 min   | IPQ, SAM, PANAS-X questionnaires taken                               |
| Affective VE                         | 7 min    | GSR and ECG measures recorded throughout                             |
| Subjective Questionnaires            | 20 min   | IPQ, Social Presence, Co-presence, SAM, PANAS-X questionnaires taken |
| Debrief                              | 5 min    | Participant may leave if deemed well enough                          |

#### 4.4 Participants

To determine the sample size necessary, we conducted a power test using a medium effect size of 0.5 for a priori t-tests with an alpha of 0.05 and a power of 0.80 in G Power [17]. In the absence of prior PLAY-specific affective VE literature, we assume a medium effect size of 0.5 [11]. This indicated a minimum of 27 participants per VE which we have rounded up to 30, meaning 90 participants are required. We will recruit participants through the University of Cape Town's Research Recruitment Emailing List. For our study, no inclusion criteria are in place, and we will record age, prior VR experience and the fields relevant for the exclusion criteria during recruitment. Our participant exclusion criteria spans over existing psychiatric disorders, chronic stimulant use, a score of above

14 on the Beck Depression Inventory (BDI) [2] and a history of motion-sickness. Existing psychiatric disorders influence emotional reactivity [53], which may skew our findings for efficacy of emotion elicitation. Further, the use of stimulant-medications and depression, as indicated with scores of 20 or above on the BDI [2], have been shown to reduce expressions of social play which hinders our VEs ability to elicit PLAY [33, 42]. Cyber-sickness during VR experiences impacts the reported efficacy of affective VEs, and a history of motion-sickness is indicative of a higher probability in experiencing cyber-sickness [45]. Approval from the University of Cape Town Ethics Committee will be needed in order for the study to be carried out.

#### 4.5 Procedure

In this section, we will detail the procedure to practically implement this study across the pre-session, during session and post-session phases. The full details are summarised in Table 2

From Table 2, the estimated total time per participant sums to around 72 minutes. A staggering approach will be followed, whereby the next participant arrives 10 minutes before the current participant's session ends, during which they complete the consent portion and are moved into the laboratory as the current participant transitions to debrief. Experiments will run from 09h00 to 15h30 allowing for 5 experiments to be conducted each day over a period of 18 days. This procedure assumes a single VR-equipped lab and two experimenters conducting sessions. If additional resources are available, sessions may be conducted in parallel allowing for a reduction in the main data collection time. Participants will be assigned to VEs using stratified random allocation, with stratification across days of data collection to ensure balanced VE representation across the data collection period. Further, to minimise experimenter effects, experimenters will be randomly assigned to sessions and will follow standardised scripts [10]. If the experimenter observes substantial signs of distress during the VE experience, they may intervene and end the experience early. The participant may also request for the experience to be ended early and may withdraw at any stage in the experience. If they do withdraw early, their data will be excluded from the study.

#### 4.6 Data Analysis Plan

This section describes how data will be pre-processed, analysed and used to establish what counts as a successful elicitation of the PLAY emotion. In this study, the primary analyses cover per-VE analysis focusing on validation according to Dozio et al.'s [16] affective VE, hence focusing on the VAD measures. The secondary analyses involve those validating our addition to Dozio et al.'s [16], being the qualitative aspect. The specific measures for both the VAD component and qualitative component are outlined in Figure 12.

Measuring presence via the IPQ acts as an explanatory factor in the event that the necessary conditions are not met, as low presence can significantly impact the success of eliciting an emotion [8].

In terms of data pre-processing, the IPQ, co-presence subscale and social presence subscale measures will undergo reverse-coding, followed by all subjective questionnaire data being averaged according to its respective Likert scale. The GSR and ECG data will be baseline corrected. The behavioural data will be gathered via plotting incidents of PLAY, according to each VE's PLAY signifier, over the duration of the VE experience. This will be manually counted via reviewing the screen-recordings of each VE experience.

In our subjective data analyses, average scores will need to be classified as low, medium or high. This requires us to define threshold scores. We will classify scores according to thirds, where the upper third starting point is the threshold for a "high" score. This is in line with prior dimensional model of emotions research [24, 32].

In our analyses, three tests will be employed:

- (1) One-sample t-test for if the post-exposure scores are significantly greater than the "high" threshold.

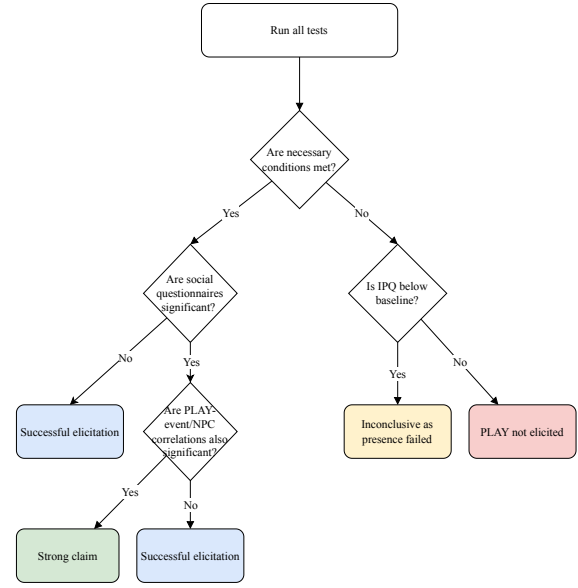


Figure 13: Findings decision tree

- (2) Paired t-test for if the post-exposure scores are significantly greater than the baseline scores. This test will be one-tailed as direction is predicted.
- (3) Linear regression test for if PLAY events declined as NPC became more subdued.

To account for family-wise error rates, the Holm-Bonferroni correction across all primary tests will be applied for each VE. Necessary conditions for claiming successful PLAY elicitation require all metrics marked as primary in Table 3 to reach significance in the predicted direction for their assigned tests.

The conditions for making a strong claim of successful PLAY elicitation include significance found for all primary analyses, as well as significant correlation in PLAY events and NPC action. However, if the necessary conditions are not met and the post-exposure mean scores for the IPQ are significantly lower than that of the baseline then the results will be classified as inconclusive. Note that we will use an alpha of 5% for all tests. The decision tree is shown in Figure 13.

#### 5 Ethical, Professional, and Legal Issues

Informed consent will be obtained prior to any involvement. Participants will receive a consent form outlining VR-related risks, the general methodology, demographic information to be collected as outlined in Section 4.4 and their right to withdraw without consequence. The specific emotion under investigation, PLAY, will not be disclosed, as prior knowledge could introduce response bias and compromise validity.

Key VR risks include cybersickness (nausea and oculomotor symptoms) and post-exposure fatigue [55]. Individual susceptibility varies, specifically correlating with prior histories of migraines or motion sickness [45]. To mitigate this, environments will be designed with cybersickness reduction as a core consideration.

Table 3: Summary of measurement metrics

| Metric                                              | Type          | Tests/s | Primary/Secondary | Necessary Condition |
|-----------------------------------------------------|---------------|---------|-------------------|---------------------|
| SAM (each dimension)                                | Subjective    | 1, 2    | Primary           | ✓                   |
| PANAS-X Joviality Subscale                          | Subjective    | 1, 2    | Primary           | ✓                   |
| GSR                                                 | Physiological | 1, 2    | Primary           | ✓                   |
| ECG                                                 | Physiological | 1, 2    | Primary           | ✓                   |
| Perceived Co-Presence and Social Presence Subscales | Subjective    | 1       | Secondary         | ✗                   |
| PLAY-events                                         | Behavioural   | 3       | Secondary         | ✗                   |
| IPQ                                                 | Subjective    | 1, 2    | Explanatory       | ✗                   |

Table 4: Risk analysis table

| Risk Description            | Probability | Mitigation Strategy                                                                                                                                                         |
|-----------------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Affective measurement noise | High        | Participants may experience multiple emotional states simultaneously. Baseline VE exposure will be used to isolate the specific affective shift caused by the target VE.    |
| Novelty effect              | Medium      | Participants will complete a tutorial to reduce excitement during exposure to VEs.                                                                                          |
| Ethics approval delay       | Low         | Submit the ethics approval application at least 8 weeks prior to data collection. Maintain a flexible recruitment schedule to account for potential administrative backlog. |
| Cybersickness               | Medium      | Adhere to design principles. Have a dedicated stop word and a safe procedure for removal of devices from the participant.                                                   |

Table 5: Project resources by phase and availability

| Phase             | Resource                                                        | Status  |
|-------------------|-----------------------------------------------------------------|---------|
| Development of VE | Game Engine (Unity)                                             | Ready   |
|                   | 3D Modelling Software                                           | Ready   |
|                   | Version Control Software (GitHub)                               | Ready   |
|                   | Affective Assets                                                | Ready   |
|                   | Controller                                                      | Ready   |
|                   | Head-Mounted Display                                            | Ready   |
| Data Collection   | 30 Participants per VE                                          | Pending |
|                   | Controller                                                      | Ready   |
|                   | Virtual Environments                                            | Pending |
|                   | Head-Mounted Display                                            | Ready   |
|                   | Ambulatory Monitoring System (VU-AMS)                           | Ready   |
|                   | Questionnaires: PANAS-X, SAM, Co-presence, Social Presence, IPQ | Ready   |
| Data Analysis     | CoreLab                                                         | Ready   |
|                   | Kubios HRV                                                      | Ready   |
|                   | R Studio                                                        | Ready   |
|                   | Taguette                                                        | Ready   |
|                   | Matplotlib                                                      | Ready   |

Controlling for display resolution (2K), latency (below 20ms), frame rate (above 70fps), and sparing use of environmental motion [56].

All participant data will be stored securely on ZivaHub (Open Data UCT) for five years, with access restricted to the supervisor, second reader, and team members. Data collection, storage, and

## My Team | Project timeline

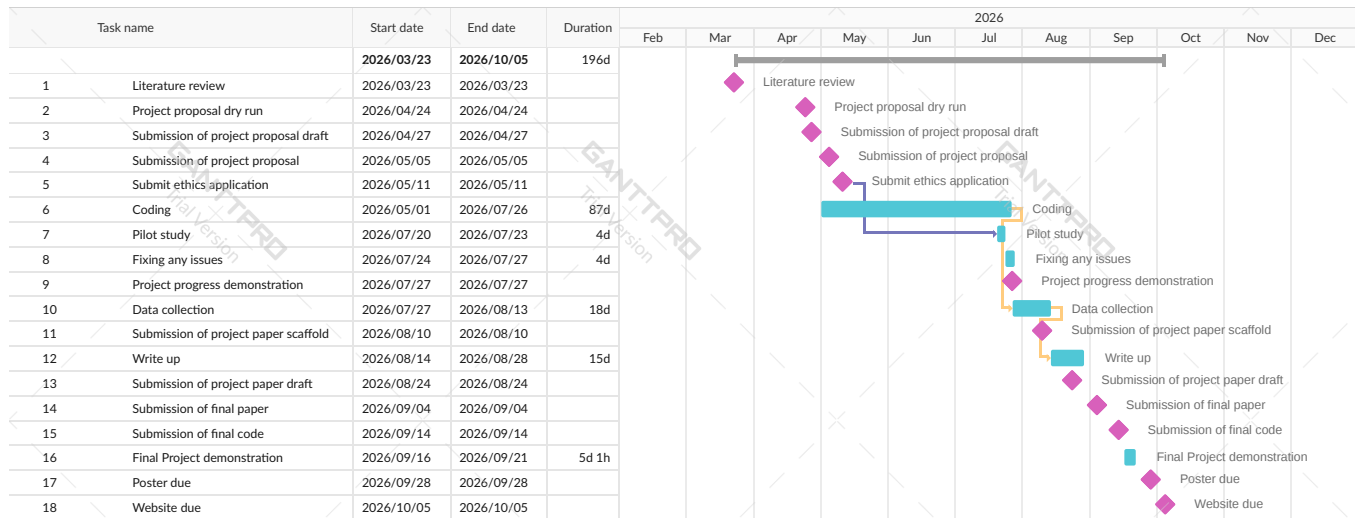


Figure 14: Gantt chart of project milestones

processing will comply with the Protection of Personal Information Act (POPIA) and ACM Code of Ethics. Intellectual property will be owned by the University of Cape Town (UCT) in accordance with its Intellectual Property Policy. Upon completion, anonymised data may be shared publicly, under a CC BY licence.

## 6 Project plan

### 6.1 Risks

Table 4 summarises the key risks associated with our project and the mitigation strategy for each risk.

### 6.2 Resources

In order to complete the project successfully, the resources required for each stage are summarised in Table 5.

### 6.3 Milestones and deliverables

The key milestones and deliverables for this project are summarised by the Gantt chart in Figure 14.

## 7 Anticipated Outcomes

We hope to make contributions to affective computing in the following ways:

- (1) Establish that Panksepp's primary-process emotions can be targeted through systematic mapping to Valence-Arousal-Dominance (VAD) levels.
- (2) Successfully elicit the PLAY emotion within a controlled virtual environment.
- (3) Apply and validate Nowak and Biocca frameworks to assess reciprocity and social co-presence within the context of the PLAY system.
- (4) Establish a triangulated measurement model that efficiently detects real-time, state-level PLAY activation.

## 8 GenAI declaration

Generative Artificial Intelligence tools (Claude, Gemini) were used in order to generate prototype storyboard images and for proof reading of the document. The images served as conceptual illustrations only and do not represent the final implemented environments.

## References

- [1] R.M. Baños, C. Botella, M. Alcañiz, V. Liaño, B. Guerrero, and B. Rey. 2004. Immersion and Emotion: Their Impact on the Sense of Presence. *CyberPsychology & Behavior* 7, 6 (Dec. 2004), 734–741. doi:10.1089/cpb.2004.7.734
- [2] Aaron T. Beck, R. A. Steer, and G. Brown. 2011. Beck Depression Inventory–II. doi:10.1037/t00742-000 Institution: American Psychological Association.
- [3] Maor Bluman, Keren L.G. Snider, Guy Baratz, Amit Cohen, Daphna Canetti, and Béatrice S. Hasler. 2023. Virtual Reality-Based Joy Induction: The Role of Interactivity and Prior Mood. *Cyberpsychology, Behavior, and Social Networking* 26, 4 (April 2023), 229–237. doi:10.1089/cyber.2022.0250
- [4] M. Bradley, P.J. Lang, University of Florida. Center for the Study of Emotion, Attention, and National Institute of Mental Health (Estats Units d'América). 1999. *The International Affective Digitized Sounds (IADS): Stimuli, Instruction Manual and Affective Ratings*. NIMH Center for the Study of Emotion and Attention. <https://books.google.co.za/books?id=NFeZMwEACAAJ>
- [5] Margaret M. Bradley and Peter J. Lang. 1994. Measuring emotion: The self-assessment manikin and the semantic differential. 25, 1 (1994), 49–59. doi:10.1016/0005-7916(94)90063-9
- [6] Margaret M. Bradley and Peter J. Lang. 2017. International Affective Picture System. *Encyclopedia of Personality and Individual Differences* (2017). doi:10.1007/978-3-319-28099-8\_42-1
- [7] Jeffrey Burgdorf and Jaak Panksepp. 2006. The neurobiology of positive emotions. *Neuroscience & Biobehavioral Reviews* 30, 2 (Jan. 2006), 173–187. doi:10.1016/j.neubiorev.2005.06.001
- [8] Alice Chirico, Francesco Ferrise, Lorenzo Cordella, and Andrea Gaggioli. 2018. Designing Awe in Virtual Reality: An Experimental Study. *Frontiers in Psychology* 8 (Jan. 2018), 2351. doi:10.3389/fpsyg.2017.02351
- [9] Alice Chirico and Andrea Gaggioli. 2019. When Virtual Feels Real: Comparing Emotional Responses and Presence in Virtual and Natural Environments. *Cyberpsychology, Behavior, and Social Networking* 22, 3 (March 2019), 220–226. doi:10.1089/cyber.2018.0393
- [10] James Coan and John Allen. 2007. *Handbook of Emotion Elicitation and Assessment*.
- [11] Jacob Cohen. 2013. *Statistical Power Analysis for the Behavioral Sciences* (0 ed.). Routledge. doi:10.4324/9780203771587
- [12] Julie Collange and Jérôme Guegan. 2020. Using virtual reality to induce gratitude through virtual social interaction. *Computers in Human Behavior* 113 (Dec. 2020),

106473. doi:10.1016/j.chb.2020.106473
- [13] Terry C. Daniel and Michael M. Meitner. 2001. Representational Validity of Landscape Visualizations: The Effects of Graphical Realism on Perceived Scenic Beauty of Forest Vistas. 21, 1 (2001), 61–72. doi:10.1006/jevp.2000.0182
  - [14] Julia Diemer, Georg W. Alpers, Henrik M. Peperkorn, Youssef Shibani, and Andreas Mühlberger. 2015. The impact of perception and presence on emotional reactions: a review of research in virtual reality. *Frontiers in Psychology* 6 (Jan. 2015). doi:10.3389/fpsyg.2015.00026
  - [15] Amir Dirin and Teemu Laine. 2023. The Influence of Virtual Character Design on Emotional Engagement in Immersive Virtual Reality: The Case of Feelings of Being. *Electronics* 12 (May 2023), 2321. doi:10.3390/electronics12102321
  - [16] Nicolò Dozio, Federica Marcolin, Giulia Wally Scurati, Luca Ulrich, Francesca Nonis, Enrico Vezzetti, Gabriele Marsocci, Alba La Rosa, and Francesco Ferrise. 2022. A design methodology for affective Virtual Reality. *International Journal of Human-Computer Studies* 162 (June 2022), 102791. doi:10.1016/j.ijhcs.2022.102791
  - [17] Franz Faul, Edgar Erdfelder, Albert-Georg Lang, and Axel Buchner. 2007. G\*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. 39, 2 (2007), 175–191. doi:10.3758/BF03193146
  - [18] Anna Felnhöfer, Oswald D. Kothgassner, Mareike Schmidt, Anna-Katharina Heinze, Leon Beutl, Helmut Hlavacs, and Ilse Kryspin-Exner. 2015. Is virtual reality emotionally arousing? Investigating five emotion inducing virtual park scenarios. *International Journal of Human-Computer Studies* 82 (Oct. 2015), 48–56. doi:10.1016/j.ijhcs.2015.05.004
  - [19] Sylvain Fleury, Laurent Dupont, Noemie Chaniaud, Saadallah Tamazart, Benjamin Poussard, Geoffrey Gorisse, and Simon Richir. 2022. An investigation of design in virtual reality across the variation of training degree and visual realism. In *2022 IEEE 28th International Conference on Engineering, Technology and Innovation (ICE/ITMC) & 31st International Association For Management of Technology (IAMOT) Joint Conference* (Nancy, France, 2022-06-19). IEEE, 1–7. doi:10.1109/ICE/ITMC-IAMOT55089.2022.10033258
  - [20] Dominik Gall, Daniel Roth, Jan-Philipp Stauffert, Julian Zarges, and Marc Erich Latoschik. 2021. Embodiment in Virtual Reality Intensifies Emotional Responses to Virtual Stimuli. *Frontiers in Psychology* 12 (Sept. 2021), 674179. doi:10.3389/fpsyg.2021.674179
  - [21] Didier Grandjean, David Sander, and Klaus R. Scherer. 2008. Conscious emotional experience emerges as a function of multilevel, appraisal-driven response synchronization. *Consciousness and Cognition* 17, 2 (June 2008), 484–495. doi:10.1016/j.concog.2008.03.019
  - [22] A. Halbig and Marc Erich Latoschik. 2021. A Systematic Review of Physiological Measurements, Factors, Methods, and Applications in Virtual Reality. 2 (July 2021). doi:10.3389/frvir.2021.694567
  - [23] Eddie Harmon-Jones, David M. Amadio, and Leah R. Zinner. 2007. Social Psychological Methods of Emotion Elicitation. In *Handbook of Emotion Elicitation and Assessment*, James A. Coan and John B. Allen (Eds.). Oxford University Press, New York, NY, 91–105. doi:10.1093/oso/9780195169157.003.0007
  - [24] S. Koelstra, C. Muhl, M. Soleymani, Jong-Seok Lee, A. Yazdani, T. Ebrahimi, T. Pun, A. Nijholt, and I. Patras. 2012. DEAP: A Database for Emotion Analysis Using Physiological Signals. *IEEE Transactions on Affective Computing* 3, 1 (Jan. 2012), 18–31. doi:10.1109/T-AFFC.2011.15
  - [25] Yisi Liu and Olga Sourina. 2013. EEG Databases for Emotion Recognition. In *2013 International Conference on Cyberworlds* (Yokohama, Japan, 2013-10). IEEE, 302–309. doi:10.1109/CW.2013.52
  - [26] Dongbiao Luo. 2024. Design and Implementation of Virtual Reality Emotion Induction System. In *Proceedings of the 2024 International Conference on Intelligent Perception and Pattern Recognition*. ACM, Qingdao China, 1–5. doi:10.1145/3700035.3700036
  - [27] Mariana Magalhães, Miguel Melo, António Fernando Coelho, and Maximino Bessa. 2024. Affective Landscapes: Navigating the Emotional Impact of Multisensory Stimuli in Virtual Reality. *IEEE Access* 12 (2024), 169955–169976. doi:10.1109/ACCESS.2024.3499858
  - [28] Silvia Marocco, Valeria Vitale, Elena Grossi, Veronica Giffi, and Morena Santoriello. 2025. The impact of natural virtual environments on emotion elicitation: a state-of-the-art review. *Frontiers in Virtual Reality* 6 (Aug. 2025), 1638419. doi:10.3389/frvir.2025.1638419
  - [29] Alison Jane Martingano, Fernanda Hererra, and Sara Konrath. 2021. Virtual reality improves emotional but not cognitive empathy: A meta-analysis. *Technology, Mind, and Behavior* 2, 1 (2021), 7–21. doi:10.1037/tmb0000034
  - [30] J. Marin-Morales, J. Higuera-Trujillo, A. Greco, J. Guixeres, C. Llinares, E. Scilingo, M. Alcañiz, and G. Valenza. 2018. Affective computing in virtual reality: emotion recognition from brain and heartbeat dynamics using wearable sensors. *Scientific Reports* 8 (Sept. 2018). doi:10.1038/s41598-018-32063-4
  - [31] Nikhil Masters, Tim Lloyd, and Chris Starmer. 2025. Do emotional carryover effects carry over? 114 (2025), 102312. doi:10.1016/j.soccc.2024.102312
  - [32] Oana Mitruț, Gabriela Moise, Livia Petrescu, Alin Moldoveanu, Marius Leordeanu, and Florica Moldoveanu. 2019. Emotion Classification Based on Biophysical Signals and Machine Learning Techniques. *Symmetry* 12 (Dec. 2019), 21. doi:10.3390/sym12010021
  - [33] Christian Montag, Katharina Widenhorn-Müller, Jaak Panksepp, and Markus Kiefer. 2017. Individual differences in Affective Neuroscience Personality Scale (ANPS) primary emotional traits and depressive tendencies. 73 (2017), 136–142. doi:10.1016/j.comppsy.2016.11.007
  - [34] Benson G. Munyan, Sandra M. Neer, Deborah C. Beidel, and Florian Jentsch. 2016. Olfactory Stimuli Increase Presence in Virtual Environments. *PLOS ONE* 11, 6 (June 2016), e0157568. doi:10.1371/journal.pone.0157568
  - [35] Janet Horowitz Murray. 2017. *Hamlet on the holodeck: the future of narrative in cyberspace* (updated edition ed.). The MIT Press.
  - [36] Frédéric Mérenne. 2017. Virtual Reality: Principles and Applications. In *Encyclopedia of Computer Science and Technology*. Taylor and Francis, 1–11. doi:10.1081/E-ECST2-140000194
  - [37] Yunfang Niu, Danli Wang, Ziwei Wang, Fan Sun, Kang Yue, and Nan Zheng. 2019. User Experience Evaluation in Virtual Reality based on Subjective Feelings and Physiological Signals. *Journal of Imaging Science and Technology* 63, 6 (Nov. 2019), 060413–1–060413–11. doi:10.2352/J.ImagingSci.Technol.2019.63.6.060413
  - [38] Kristine L. Nowak and Frank Biocca. 2003. The Effect of the Agency and Anthropomorphism on Users' Sense of Telepresence, Copresence, and Social Presence in Virtual Environments. 12, 5 (2003), 481–494. doi:10.1162/105474603322761289
  - [39] Jaak Panksepp. 2005. Affective consciousness: Core emotional feelings in animals and humans. *Consciousness and Cognition* 14, 1 (March 2005), 30–80. doi:10.1016/j.concog.2004.10.004
  - [40] Jaak Panksepp. 2010. Affective neuroscience of the emotional BrainMind: evolutionary perspectives and implications for understanding depression. *Dialogues in Clinical Neuroscience* 12, 4 (Dec. 2010), 533–545. doi:10.31887/DCNS.2010.12.4/jpanksepp
  - [41] Jaak Panksepp and Lucy Biven. 2012. *The archaeology of mind: neuroevolutionary origins of human emotions* (1st ed ed.). W. W. Norton.
  - [42] Jaak Panksepp, Steve Siviy, and Larry Normansell. 1984. The psychobiology of play: Theoretical and methodological perspectives. *Neuroscience & Biobehavioral Reviews* 8, 4 (Dec. 1984), 465–492. doi:10.1016/0149-7634(84)90005-8
  - [43] Katarina Pavic, Laurence Chaby, Thierry Gricourt, and Dorine Vergilino-Perez. 2023. Feeling Virtually Present Makes Me Happier: The Influence of Immersion, Sense of Presence, and Video Contents on Positive Emotion Induction. *Cyberpsychology, Behavior, and Social Networking* 26, 4 (April 2023), 238–245. doi:10.1089/cyber.2022.0245
  - [44] Xiaolan Peng, Jin Huang, Alena Denisova, Hui Chen, Feng Tian, and Hongan Wang. 2020. A Palette of Deepened Emotions: Exploring Emotional Challenge in Virtual Reality Games. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu HI USA, 2020-04-21). ACM, 1–13. doi:10.1145/3313831.3376221
  - [45] Lisa Rebenitsch and Charles Owen. 2014. Individual variation in susceptibility to cybersickness. In *Proceedings of the 27th annual ACM symposium on User interface software and technology*. ACM, Honolulu Hawaii USA, 309–317. doi:10.1145/2642918.2647394
  - [46] Simon Riches, Soha Elghany, Philippa Garety, Mar Rus-Calafell, and Lucia Valmaggia. 2019. Factors Affecting Sense of Presence in a Virtual Reality Social Environment: A Qualitative Study. *Cyberpsychology, Behavior, and Social Networking* 22, 4 (April 2019), 288–292. doi:10.1089/cyber.2018.0128
  - [47] Giuseppe Riva, Fabrizia Mantovani, Claret Samantha Capideville, Alessandra Preziosa, Francesca Morganti, Daniela Villani, Andrea Gaggioli, Cristina Botella, and Mariano Alcañiz. 2007. Affective Interactions Using Virtual Reality: The Link between Presence and Emotions. *CyberPsychology & Behavior* 10, 1 (Feb. 2007), 45–56. doi:10.1089/cpb.2006.9993
  - [48] Radiah Rivu, Ruoyu Jiang, Ville Mäkelä, Mariam Hassib, and Florian Alt. 2021. Emotion Elicitation Techniques in Virtual Reality. In *Human-Computer Interaction – INTERACT 2021*, Carmelo Ardito, Rosa Lanzilotti, Alessio Malizia, Helen Petrie, Antonio Piccinno, Giuseppe Desolda, and Kori Inkpen (Eds.). Vol. 12932. Springer International Publishing, Cham, 93–114. doi:10.1007/978-3-030-85623-6\_8 Series Title: Lecture Notes in Computer Science.
  - [49] James Russell and Albert Mehrabian. 1977. Evidence for a Three-Factor Theory of Emotions. *Journal of Research in Personality* 11 (Sept. 1977), 273–294. doi:10.1016/0092-6566(77)90037-X
  - [50] Thomas Schubert, Frank Friedmann, and Holger Regenbrecht. 2001. The Experience of Presence: Factor Analytic Insights. 10, 3 (2001), 266–281. doi:10.1162/105474601300343603
  - [51] Berenice Serrano, Rosa M. Baños, and Cristina Botella. 2016. Virtual reality and stimulation of touch and smell for inducing relaxation: A randomized controlled trial. 55 (2016), 1–8. doi:10.1016/j.chb.2015.08.007
  - [52] Alexander J. Shackman and Tor D. Wager. 2019. The emotional brain: Fundamental questions and strategies for future research. *Neuroscience letters* 693 (Feb. 2019), 68–74. doi:10.1016/j.neulet.2018.10.012
  - [53] Gal Sheppes, Gaurav Suri, and James J. Gross. 2015. Emotion Regulation and Psychopathology. 11, 1 (2015), 379–405. doi:10.1146/annurev-clinpsy-032814-112739
  - [54] Mel Slater. 2003. A Note on Presence Terminology. *Presence Connect* 3 (Jan. 2003).

- [55] Beata Sokółowska. 2023. Impact of Virtual Reality Cognitive and Motor Exercises on Brain Health. *International Journal of Environmental Research and Public Health* 20, 5 (Feb. 2023), 4150. doi:10.3390/ijerph20054150
  - [56] Rukshani Somarathna, Tomasz Bednarz, and Gelareh Mohammadi. 2023. Virtual Reality for Emotion Elicitation – A Review. *IEEE Transactions on Affective Computing* 14, 4 (Oct. 2023), 2626–2645. doi:10.1109/TAFFC.2022.3181053
  - [57] Sophia C. Steinhäusser, Sebastian Oberdörfer, Sebastian Von Mammen, Marc Erich Latoschik, and Birgit Lugrin. 2022. Joyful Adventures and Frightening Places—Designing Emotion-Inducing Virtual Environments. *Frontiers in Virtual Reality* 3 (July 2022), 919163. doi:10.3389/frvir.2022.919163
  - [58] Nazmi Sofian Suhaimi, Chrystalle Tan Bih Yuan, Jason Teo, and James Mountstephens. 2018. Modeling the affective space of 360 virtual reality videos based on arousal and valence for wearable EEG-based VR emotion classification. In *2018 IEEE 14th International Colloquium on Signal Processing & Its Applications (CSPA)*. IEEE, Batu Feringghi, 167–172. doi:10.1109/CSPA.2018.8368706
  - [59] Alistair Sutcliffe and Brian Gault. 2004. Heuristic evaluation of virtual reality applications. 16, 4 (2004), 831–849. doi:10.1016/j.intcom.2004.05.001
  - [60] Olga Sutskova, Atsushi Senju, and Tim J. Smith. 2023. Cognitive Impact of Social Virtual Reality: Audience and Mere Presence Effect of Virtual Companions. *Human Behavior and Emerging Technologies* 2023, 1 (2023), 6677789. doi:10.1155/2023/6677789 \_eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1155/2023/6677789>.
  - [61] David Watson and Lee Anna Clark. 1994. The PANAS-X: Manual for the Positive and Negative Affect Schedule - Expanded Form. doi:10.17077/48vt-m4t2
- Institution: University of Iowa.
  - [62] Rainer Westermann, Kordelia Spies, Günter Stahl, and Friedrich W. Hesse. 1996. Relative effectiveness and validity of mood induction procedures: a meta-analysis. *European Journal of Social Psychology* 26, 4 (1996), 557–580. doi:10.1002/(SICI)1099-0992(199607)26:4<557::AID-EJSP769>3.0.CO;2-4 \_eprint: <https://onlinelibrary.wiley.com/doi/pdf/10.1002/%28SICI%291099-0992%28199607%2926%3A4%3C557%3A%3AAID-EJSP769%3E3.0.CO%3B2-4>.
  - [63] Carolin Wienrich, K. Schindler, Nina Döllinger, S. Kock, and O. Traupe. 2018. *Social Presence and Cooperation in Large-Scale Multi-User Virtual Reality - The Relevance of Social Interdependence for Location-Based Environments*. doi:10.1109/VR.2018.8446575 Pages: 214.
  - [64] Jason W. Woodworth and Christoph W. Borst. 2024. Design and Validation of a Library of Active Affective Tasks for Emotion Elicitation in VR. In *2024 IEEE Conference Virtual Reality and 3D User Interfaces (VR)*. 398–407. doi:10.1109/VR58804.2024.00061 ISSN: 2642-5254.
  - [65] Shuran Yang and Wenxiang Zhang. 2022. Presence and Flow in the Context of Virtual Reality Storytelling: What Influences Enjoyment in Virtual Environments? *Cyberpsychology, Behavior, and Social Networking* 25, 2 (Feb. 2022), 101–109. doi:10.1089/cyber.2021.0037
  - [66] N.L. Yeo, M.P. White, I. Alcock, R. Garside, S.G. Dean, A.J. Smalley, and B. Gatersleben. 2020. What is the best way of delivering virtual nature for improving mood? An experimental comparison of high definition TV, 360° video, and computer generated virtual reality. *Journal of Environmental Psychology* 72 (Dec. 2020), 101500. doi:10.1016/j.jenvp.2020.101500