MoodCaster: Externalizing Leader Emotions to Engage Bystanders in Virtual Reality Meetings

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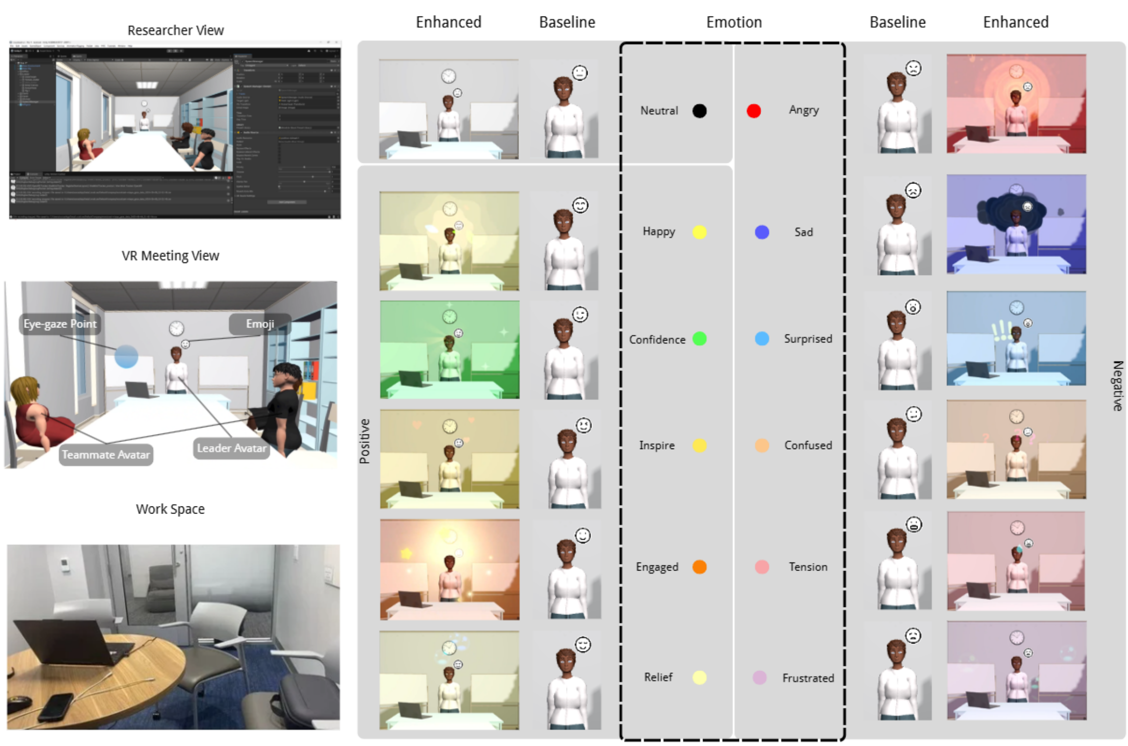

Fig. 1. Illustration of the MoodCaster system and study conditions. The figure shows examples of baseline scenarios (emoji-only overlays) and enhanced scenarios (emoji plus lighting and visual effects) across different emotions. Additional panels on the left display the researcher's view (monitoring study progress), the VR headset view (participant perspective inside the virtual meeting room), and the workspace setup (VR equipment and participant arrangement).

In leader-centered virtual reality (VR) meetings, many participants remain passive bystanders whose engagement is fragile and easily lost, even though the leader's affect strongly shapes the group atmosphere, yet often remains subtle or ambiguous in VR. We present MoodCaster, a VR system that externalizes leader emotions through environmental cues (lighting and effects) embedded in the shared space to increase bystanders' engagement. We conducted a within-subject study (N=12) to evaluate a 2×2 design crossing cue presence (emoji-only vs. emoji plus lighting/effects) with emotional valence (positive vs. negative meeting climates). Results showed that environmental cues enhanced bystander engagement and presence compared to emoji-only baselines. In positive conditions,

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environmental cues amplified the meeting's emotional tone and fostered immersion and comfort, supporting collaboration, whereas in negative conditions, they conveyed emotions more vividly and forcefully but also introduced pressure, heightening tension and distraction.

CCS Concepts: • **Human-centered computing** → **Virtual reality**; **Collaborative interaction**.

Additional Key Words and Phrases: *Collaboration, Emotion / Affective Computing, Virtual/Augmented Reality, Artifact or System*

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1 Introduction

Virtual meetings have become central to collaboration across professional, educational, and social domains. In the wake of COVID-19, they shifted from occasional alternatives to primary modes of communication for distributed teams [16, 18]. As demand for seamless remote interaction grows, immersive technologies such as Virtual Reality (VR) and Mixed Reality (MR) are explored alongside traditional videoconferencing, offering richer social interaction and stronger social presence [21, 22, 26]. These affordances make VR meetings particularly appealing for remote education, healthcare training, and globally distributed teamwork, where communication quality directly impacts collective outcomes. In virtual meetings, silent participants often show reduced attention, weaker emotional involvement, and higher risks of disengagement. This digital onlooker effect, where the presence of multiple silent attendees alters social dynamics, makes active engagement more difficult and undermines individual and group outcomes [5]. While most VR meeting systems emphasize active speakers through avatar expressivity or turn-taking tools, bystanders who primarily observe remain under-supported.

Emotions are especially salient in immersive environments, as they influence not only interpersonal communication but also the overall quality of shared presence. Leaders' affect shapes morale, trust, and decision-making, and members' emotions influence coordination and cohesion [30]. In immersive contexts, emotions has been shown to significantly increase presence [12]. Presence (the feeling of 'being there') is therefore a lever to address bystander disengagement: Evoking emotion can increase presence and, in turn, sustain attention and participation [12]. Research on multimodal emotion cues shows that VR can transform subtle affect into salient, even "supernatural," signals that enable empathic collaboration [15].

Based on the foregoing, We present **MoodCaster**, a VR meeting system that externalizes a leader's emotions as environmental cues. By rendering affect through lighting changes and subtle effects, MoodCaster reduces reliance on potentially ambiguous facial or vocal signals and makes emotions perceptible in the shared environment. MoodCaster builds on prior work in affective displays [27], adapting these approaches to immersive meetings to maintain bystander engagement. We conducted a controlled study using a 2×2 design crossing cue presence (emoji-only vs. emoji + lighting/effects) with emotional valence (positive vs. negative), allowing us to assess the added value of environmental cues beyond emoji overlays.

To guide our investigation, we asked: **RQ1.** Whether environmental cues in virtual meetings can effectively support bystanders' sustained attention and engagement. **RQ2.** How different forms of emotional externalization (e.g., positive vs. negative) differentially influence bystanders' psychological involvement, including immersion, empathy, and attentional focus. **RQ3.** Whether individuals' affective states, as measured by PANAS [36], influence their subjective evaluations of virtual meetings.

In summary, the main contributions of this paper are: (1) We design and implement MoodCaster, a system that enhances bystander immersion and engagement in VR meetings by externalizing leader affect through environmental cues. (2)We conducted a user study to examine whether environmental cues produce different outcomes under varying baseline emotional conditions in meetings. (3)By incorporating the PANAS [36], we further explored how participants' affective states influenced their subjective evaluations.

2 Related Work

2.1 Emotions in Collaboration and Leadership

Emotions function as the *"interpersonal glue"* of collaboration, also shaping trust, creativity, and decision-making [2]. Affect is contagious: moods spread across groups and influence collective performance [1]. The research framework of Barsade and Gibson indicates that emotions can influence decision-making, leadership, team processes and outcomes, cooperation, etc. [2]. Research in leadership highlights emotional intelligence as a predictor of effectiveness [7].Leaders can influence the emotions of their subordinates through emotional contagion, ultimately affecting their job performance [7]. High pleasantness and arousal led to elevated positive emotions, positively affecting team dynamics [4]. These mechanisms are equally important in mediated collaboration, where nonverbal cues are filtered or transformed.

MoodCaster builds on this tradition by externalizing leaders' emotions both symbolically and environmentally, making affect perceptible to all participants, including silent bystanders.

2.2 Bystanders in VR

Most prior work has focused on reducing the disruptive impact of bystanders on VR experiences. While headsets foster strong presence, they often disconnect users from near people [6]. To address this, systems visualize bystanders in real time. Such methods are effective, yet when overlaps occur outside the main interface, immersion can be disrupted. Compared to photo-realistic visuals, avatar-based approaches support faster and more comfortable awareness [17], but remain limited when bystanders approach unexpectedly. Proximity-based alerts—arrows for distant figures and avatars for nearby ones [23]—expand coverage but introduce cognitive shifts that disrupt gameplay, while full-body avatars further raise workload [31].In these studies, bystanders are regarded as a factor that requires optimization, which constitutes the initial impression conveyed by VR-related literature that mentions them. However, bystanders can also be defined as individuals who do not exhibit explicit interactive behaviors, they play an important role in collaborative environments.

In online communities, bystanders are not marginal but the majority [24]. Even silence can have powerful effects in real world [25]. This highlights a critical gap: VR research rarely considers how to actively engage bystanders. MoodCaster addresses this by embedding leader-driven emotional cues into the shared environment, transforming bystanders from passive observers into emotionally engaged participants.

2.3 Emotional Visualization in Immersive Environments

A growing body of research explores how emotions are visualized in immersive systems. Avatar-based approaches reconstruct real-time expressions to represent affective states [3, 8, 14]. These *subjectifying* methods are effective for signaling discrete states and increasing presence but are vulnerable to omission when tracking fidelity is limited [20]. In contrast, *objectifying* strategies embed affect into environmental features such as lighting, color, or motion [13, 19, 33]. Ambient affective displays project moods into shared spaces [32], aligning with the concept of *collective emotion*, where affect is experienced at a group level [35].

More recently, multimodal systems have combined symbolic, auditory, and physiological cues for richer representations. FeelMoji supported trust in VR meetings through emoji sharing [14]; Superpowering Emotion amplified clarity through spatiotemporal multimodal augmentation [15]; and HeartBees visualized biofeedback to foster awareness of shared affect [29]. Collectively, these studies suggest that visually oriented approaches to emotion design have already become mainstream.

MoodCaster contributes to this line of work by directly comparing symbolic overlays (emoji) with environmental cues (lighting and effects). By focusing specifically on bystanders, it extends emotion visualization to an overlooked role and demonstrates that ambient cues can sustain affective engagement in immersive meetings.

3 System Design

MoodCaster (see Figure 1) delivers audiovisual stimuli through three forms of emotional representation: emoji overlays, lighting changes, and visual effects.

3.1 Design Goals

DG1: Enhance Bystander Engagement

A central design goal of MoodCaster is to enhance the engagement of bystanders, who frequently remain overlooked in the context of virtual meetings. Unlike active speakers, bystanders do not contribute verbally, yet their attentiveness and emotional involvement are critical for overall meeting effectiveness.

DG2: Minimize Distraction

Another key design goal is to minimize the potential for distraction that may arise from visual or auditory augmentations. While emotional cues are valuable for clarifying the affective tone of the meeting, they must be carefully calibrated to avoid overwhelming participants or diverting attention away from the discussion itself.

DG3: Simulate Realistic Meeting Atmosphere

Finally, MoodCaster is designed to simulate a meeting atmosphere that closely resembles real-world interactions, thereby fostering authenticity and social presence.

3.2 Design Implementation

To realize these goals, MoodCaster incorporates a set of design strategies that translate abstract objectives into concrete system features:

Addressing DG1 (Enhance Bystander Engagement): Because bystanders lack direct interaction in virtual meetings, we sought to enhance their engagement through visual augmentation. Prior work has shown that emotions elicited by virtual environments are positively correlated with the sense of presence [12]. Another study further demonstrated that when avatars are supplemented with environmental cues providing externalized affect, emotions become easier to recognize, invest in, and connect with, thereby amplifying positive affect and encouraging greater attention to both the avatar and the surrounding environmental cues [15]. Building on these findings, we conclude that leader emotions can be externalized through environmental cues to amplify bystanders' emotional responses. In turn, the emotions induced by the virtual environment are likely to strengthen presence and, consequently, enhance bystander engagement.

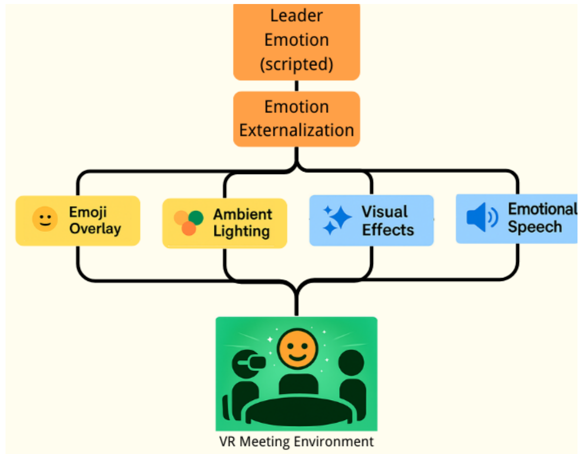

Fig. 2. Emotion Externalization Mechanism in MoodCaster. Leader emotions are externalized through four complementary channels: emoji overlays, lighting color profiles, visual effects, and emotional speech. Together, these channels provide symbolic, ambient, and auditory reinforcement, making leader affect perceptible in the shared meeting environment.

Addressing DG2 (Minimize Distraction): Prior research has indicated that variations in lighting, when used as ambient cues, exert only a negligible influence on individuals' attention and do not significantly distract them from their primary tasks [34]. Based on this insight, we initiated our design with lighting changes in order to minimize potential disruptions for users. In addition, to further reduce the impact of environmental cues (i.e., effects), we chose to externalize only the leader's emotions. This strategy not only limits the overall number of effects but also ensures that these environmental cues remain localized around the leader's avatar, thereby reducing the likelihood of diverting users' attention toward other potential distractions in the scene.

Addressing DG3 (Simulate Realistic Meeting Atmosphere): To approximate the dynamics of real-world virtual meetings, we incorporated several design elements to enhance realism. The entire environment was modeled after a typical virtual meeting setting (see Figure 1), where teammate avatars stand up when speaking, and each avatar is visually distinct in appearance. In addition, every teammate, apart from the participant, was given an opportunity to speak, thereby simulating natural turn-taking. To further differentiate roles, we used text-to-speech (TTS) with voices that matched the gender of each avatar to maximize the distinction between characters. Moreover, vocal tone was modulated according to the expressed emotion, thereby reinforcing authenticity and increasing the perceived realism of the meeting experience.

3.3 Emotion Externalization Mechanism

MoodCaster supports a predefined set of emotions that are externalized in the user study through a combination of emoji, lighting, effects, and auditory cues.(Figure 2)

Emoji overlays served as lightweight symbolic markers above the leader's avatar, ensuring immediate visibility from any seating position.

Lighting color was used to convey broad valence. Guided by Plutchik's Wheel of Emotions [28], we designed a set of distinct lighting colors to externalize the leader's emotional states (Figure 1). These adjustments established a background atmosphere that reinforced the overall affective tone of the meeting.

Visual effects added dynamic environmental cues for intensity and arousal. Their specific mappings are illustrated in Figure 1. These effects were primarily designed by us, with several elements adapted from the Unity Asset Store package *Emotion Effects Pack 1*[1].

AI-generated speech further reinforced affect by modulating pitch, tempo, and intensity to align with each emotion. For instance, Angry speech adopted sharper tone and higher intensity, while Relief was characterized by slower tempo and softer cadence.

Together, these channels offered symbolic (emoji), environmental (lighting and effects), and auditory (speech) reinforcement of affect, ensuring that leader emotions were perceivable even to silent bystanders.

4 User Study

The user study was designed to evaluate how externalizing leader emotions through ambient environmental cues affects bystander engagement in VR meetings.

4.1 Participants

We recruited 14 participants (9 male, 5 female; age range 19–30) from a local university community. All were fluent in English, reported normal or corrected vision, and had no medical conditions that would make VR use unsafe. Participants varied in prior VR familiarity and all had experience with remote meetings, with academic backgrounds spanning computer science, psychology, education, and engineering. Each received a $20 Amazon gift card as compensation.

Inclusion criteria required participants to be at least 18 years old, proficient in English, and medically fit for VR use. Exclusion criteria included epilepsy, severe motion sickness susceptibility, or uncorrected vision impairments. All procedures were approved by the Institutional Review Board (IRB).

4.2 Design

We employed a 2×2 within-subjects factorial design with two independent variables:

- **Cue presence**: Emoji-only (baseline) vs. Emoji + Environmental cues (enhanced)
- **Valence**: Positive vs. Negative

This yielded four conditions: Baseline Positive (PB), Baseline Negative (NB), Enhanced Positive (PE), and Enhanced Negative (NE). A within-subjects design allowed direct comparisons across conditions while controlling for individual differences.

Each condition was presented through a distinct scripted meeting lasting ~5 minutes. Positive scripts emphasized steady progress, successful outcomes, and collaborative improvements, while negative scripts highlighted project delays, repeated bugs, and communication challenges ending with scope adjustments. Scripts within each valence type were matched in structure to ensure comparability, and the two scripts with only minor variations in content per valence were alternated across cue conditions, ensuring that participants never encountered identical content twice. Baseline conditions relied on emoji-only cues, whereas Enhanced conditions combined emojis with lighting and particle-based effects to externalize leader affect into the environment.

Guided by organizational psychology research on meeting emotions [2, 7, 10], we selected twelve emotions that are commonly reported in organizational and meeting contexts to ensure ecological validity while enabling systematic examination of valence effects. The **positive set** included *Happy, Engaged, Confidence, Inspire,* and *Relief.* The **negative**

[1]https://assetstore.unity.com/packages/vfx/particles/emotion-effects-pack-1-14751

set included *Angry, Sad, Surprised, Confused, Frustrated,* and *Tension.* A **neutral state (Natural)** appeared in both positive and negative conditions to provide consistency across scripts.

This scripting strategy ensured that participants experienced meetings with distinct affective climates. The alternation of scripts across cue conditions prevented repetition effects and allowed us to isolate the influence of cue presence and valence on bystander engagement.

4.3 Apparatus

The study was conducted in a quiet laboratory room (~4m × 4m) with controlled lighting and minimal external noise. Participants were seated around a virtual conference table, with the leader avatar at the center and teammates positioned to the sides.

Hardware. The VR system ran on a Vive Focus Pro headset (6DoF, 120Hz refresh rate) with integrated eye-tracking (120Hz). A Fitbit Luxe wristband worn on the non-dominant hand recorded continuous heart rate.

Software. MoodCaster was implemented in Unity 6 and presented a standard VR meeting room augmented with emoji overlays, environmental cues, and emotion-specific synthetic speech synchronized with the leader's avatar.

Data collection. Heart rate (HR) was recorded continuously to assess physiological arousal across conditions, focusing on average beats per minute (BPM) and variability. Eye-tracking (ET) data were analyzed for gaze dispersion and attentional focus, comparing how participants distributed attention between the leader, the environment, and neutral space.

4.4 Procedure

Each session lasted approximately 45–50 minutes. Upon arrival, participants reviewed and signed the informed consent form, being reminded that participation was voluntary and could be withdrawn at any time. They then completed a demographic questionnaire covering age, gender, background, and prior VR/meeting experience, along with the Positive and Negative Affect Schedule (PANAS). Afterward, participants were fitted with a Fitbit Luxe wristband that continuously recorded heart rate from the moment it was worn, with data logged for later export. They were then introduced to the Vive Focus Pro headset and received verbal instructions to take the role of a bystander, observing without speaking or influencing the meeting flow.

Next, participants experienced four meeting scenarios corresponding to the 2×2 factorial design, each lasting about five minutes. The scripts simulated project-team Meetings with the leader setting the agenda, teammates giving short updates, and the leader closing the meeting. Leader affect cycles incorporate both positive emotions and negative emotions. Environmental cues in the enhanced conditions were synchronized with the leader's emotions. The two scripts within each valence type were alternated across cue conditions to prevent repetition while keeping structure comparable. Throughout the study, both eye-tracking and heart rate data were continuously recorded.

After each scenario, participants completed self-report questionnaires assessing engagement, presence, affect, and workload. Once all four conditions were completed, they responded to open-ended questions about experience(see Figure 3). Finally, participants were thanked, debriefed about the study purpose, and compensated with a $20 Amazon gift card. An overview of the study procedure is illustrated in Figure 3.

4.5 Measures

We collected both subjective and objective measures.

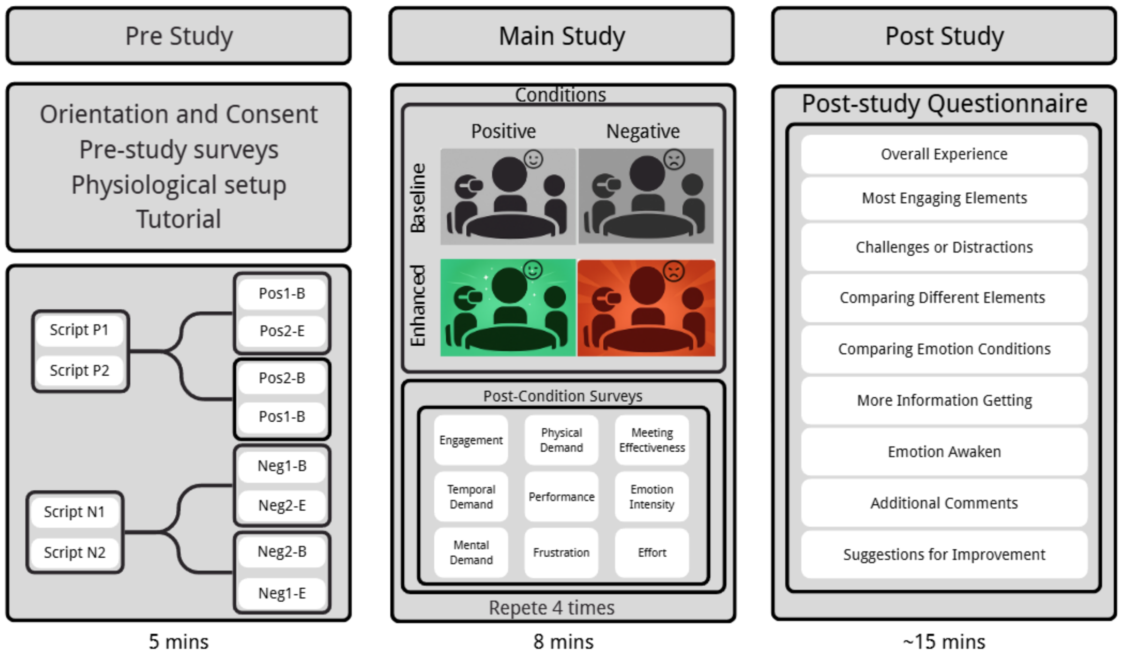

Fig. 3. Overview of the user study procedure. The study began with initial steps including Orientation and Consent, Pre-study surveys, Physiological setup and Tutorial. We will generate the meeting scenarios in different scripts. They then experienced four meeting scenarios in a 2×2 factorial design, with condition order counterbalanced by a Latin square. After each scenario, participants completed a post-condition survey. The study concluded with a post-study survey followed by debriefing and compensation.

Subjective measures. Baseline affect was assessed with the Positive and Negative Affect Schedule (PANAS) [36]. After each condition, participants completed the NASA-TLX for workload [9] and brief questionnaires on engagement, presence, and affect. At the end of the study, the open-ended questions captured overall impressions.

Objective measures. Physiological arousal was measured via heart rate (mean and variability) recorded by a Fitbit Luxe. Eye-tracking metrics included fixation duration, dwell time, and gaze dispersion across predefined areas of interest (leader, environment, neutral space).

5 Results

5.1 Subjective Measures

5.1.1 Affect–Experience Correlations. Correlation analyses revealed systematic relationships between participants' affective states and their meeting experiences (Figure 4). Positive affect (PA) was positively associated with engagement ($r = 0.43$, $p < .01$), meeting effectiveness ($r = 0.47$, $p < .001$), and perceived performance ($r = 0.31$, $p < .05$). Participants who felt more positive also reported lower workload, as reflected in negative correlations with temporal demand ($r = -0.46$, $p < .001$), effort ($r = -0.29$, $p < .05$), and frustration ($r = -0.37$, $p < .01$).

In contrast, negative affect (NA) showed an overall detrimental pattern. NA was negatively correlated with engagement ($r = -0.35$, $p < .05$) and perceived performance ($r = -0.27$, $p < .05$). NA was also negatively associated with

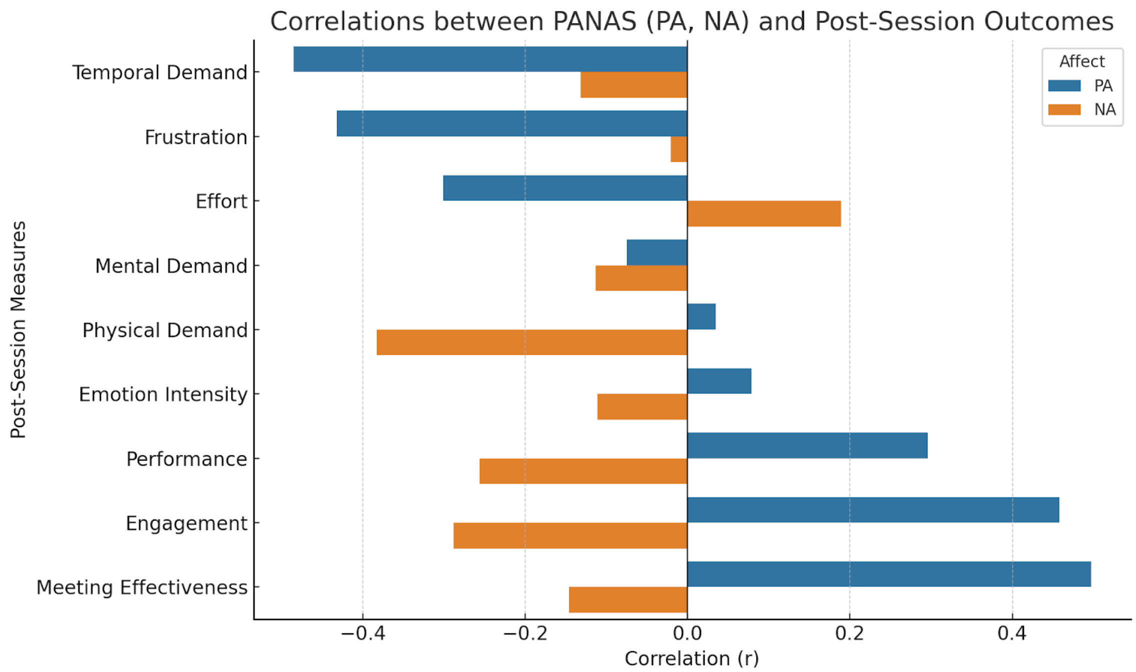

Fig. 4. Correlations between PANAS positive affect (PA), negative affect (NA), and post-session questionnaire indicators.

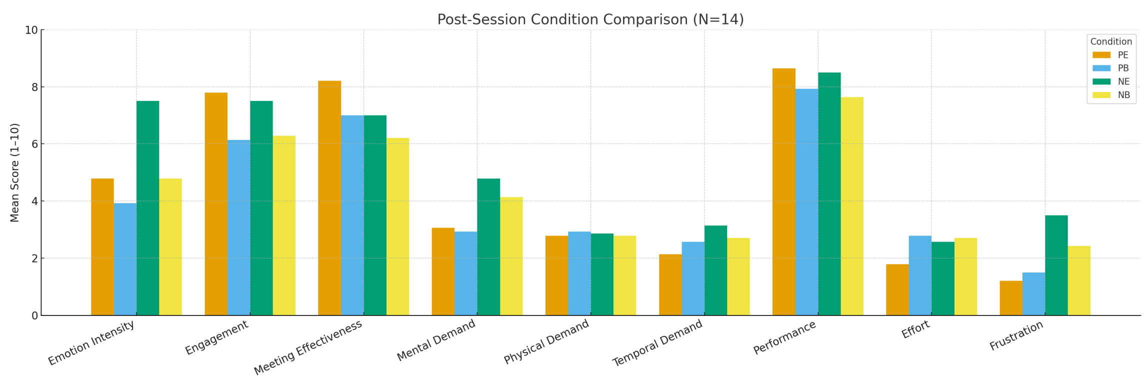

Fig. 5. Post-Session Condition Comparison

physical demand ($r = -0.34,\ p < .05$), suggesting that participants experiencing negative emotions may have felt less physically involved or more focused on their emotional state than the task.

Overall, participants' affect strongly reflected their subjective experiences: positive states enhanced attentiveness and confidence while reducing perceived workload, whereas negative states weakened engagement and performance. These findings highlight the relevance of affective factors in shaping users' experiences in virtual meetings.

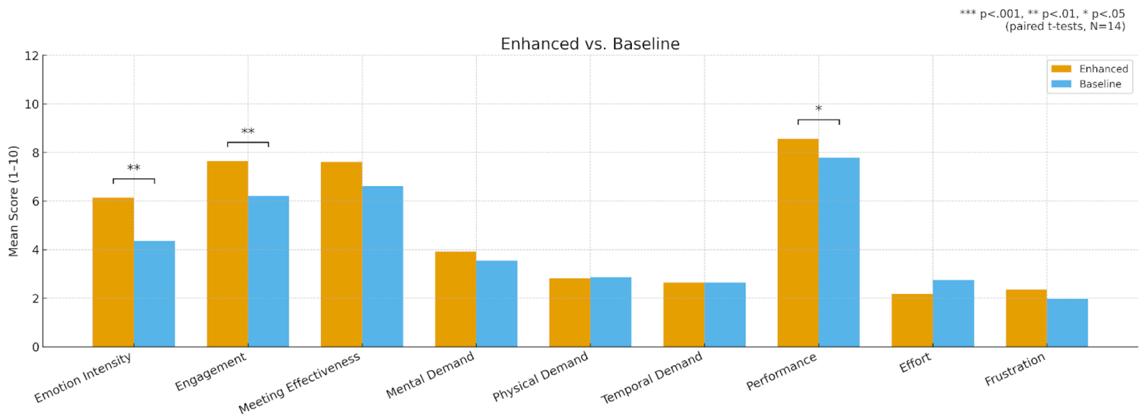

Fig. 6. Comparison of subjective indicators between Enhanced and Baseline conditions. Asterisks denote significance (*$p < .05$).

5.1.2 Condition Comparisons. Paired-sample t-tests showed that enhanced conditions (PE, NE) significantly improved several subjective measures compared to baseline conditions (PB, NB) (Figure 5). Emotional intensity was significantly higher in the enhanced condition ($t(13) = 3.22,\ p = .0067$), indicating that the augmentation mechanisms effectively increased emotional arousal. Engagement likewise increased under enhancement ($t(13) = 3.62,\ p = .0031$), suggesting deeper concentration and immersion. Participants also reported higher perceived performance in the enhanced condition ($t(13) = 2.29,\ p = .0391$).

Meeting effectiveness ($p = .062$) and effort ($p = .063$) showed marginal trends favoring the enhanced condition, although they did not reach statistical significance. No reliable differences were observed for psychological demand, physical demand, temporal demand, or frustration ($p > .10$).

These findings indicate that emotion enhancement primarily influenced emotional intensity, engagement, and self-evaluated performance, while its impact on perceived workload remained limited.

5.1.3 Qualitative Feedback. Participants' open-ended responses further contextualized these effects. Several noted that lighting changes and avatar expressions improved emotional clarity and helped maintain focus: *"The lighting makes me feel very clear, and I can better understand others' emotions"* (P6). Others reported occasional distraction in the negative-enhanced condition, especially when *"the special effects behind the characters can be distracting"* (P1). Participants also suggested improvements such as more realistic avatar motion, collaborative tools (e.g., shared whiteboards), and customizable visual intensity. These comments indicate that while augmentation increased emotional clarity and engagement, it must be balanced against potential attentional load.

5.2 Objective Measures

5.2.1 Heart Rate. Heart rate data exhibited small but consistent differences across conditions (Figure 7). Enhanced conditions showed slightly elevated arousal (PE: 82.0 bpm; NE: 81.4 bpm) relative to baseline (PB: 80.5 bpm; NB: 79.6 bpm). While differences were modest, the pattern aligns with subjective reports that enhanced cues increased emotional intensity. Substantial individual variability suggests differing sensitivity to environmental cues and VR comfort, which future work may explore.

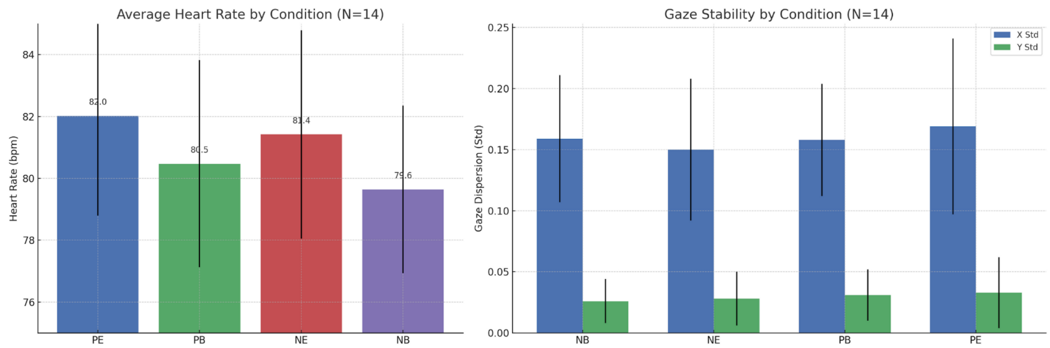

Fig. 7. Objective measures: Heart rate and gaze dispersion across conditions.

5.2.2 Eye-Tracking. Eye-tracking revealed distinct gaze behaviors across conditions (Figure 7). PE produced the broadest gaze dispersion, reflecting more exploratory visual behavior, whereas NE led to the most concentrated gaze, indicating narrowed, focused attention. Baseline conditions fell between these extremes. Participants confirmed this pattern: in PE they reported "looking around more," whereas in NE they felt "locked in" on the leader. These results demonstrate that emotional augmentation not only shaped affect but also influenced visual attention allocation.

6 Discussion

6.1 Environmental Cues as a Channel for Bystander Engagement

The environmental cues improved bystander experience more effectively than emoji-only signals. Emojis provided a direct and unambiguous channel for perceiving the leader's emotional state, thereby preventing confusion that might otherwise increase participants' cognitive workload. Our comparative analysis between enhanced and baseline conditions further supports this initial design rationale. Beyond engagement, the enhanced condition also yielded significant improvements in both emotional intensity and perceived performance. At the same time, the lack of significant differences in psychological demand, physical demand, time demand, and frustration suggests that the environmental cues did not lead to increased workload. Consistent with this, heart rate data showed that overall heart rates were higher in the enhanced condition compared to the baseline, although the difference was not statistically significant. This nevertheless indicates that environmental cues successfully heightened participants' arousal levels, helping them to remain more attentive and focused on the meeting.

6.2 Valence Effects: Positive vs. Negative Atmospheres

In Enhanced Condition, Positive Atmosphere enhanced clarity and immersion with low frustration, while negative Atmosphere increased intensity and tension, sustaining attention but reducing comfort. For instance, one participant remarked, "I felt more pressure in the negative condition. Especially, I felt more pressured in the negative condition with effects" (P14). These findings are consistent with the condition comparison results.

Eye-tracking data offered additional insights into attentional patterns. In the Positive Enhanced (PE) condition, participants exhibited the widest gaze distribution, whereas in the Negative Enhanced (NE) condition, gaze was more narrowly focused. This suggests that, in the absence of interactive tasks, participants dispersed some of their attention toward environmental cues under PE, whereas in the NE condition their gaze was more narrowly concentrated on the avatar. This also indicates that users will be more focused under NE condition. Social psychology literature has shown that individuals often display defensive reactions to negative feedback [11], which may explain why participants in NE conditions allocated greater attention to the leader rather than the surrounding environment. Consistent with the condition comparisons, NE supported strong engagement and performance, but at the expense of heightened stress, which may also account for the increased attentional concentration observed in this condition.

6.3 Affective States and Perceived Meeting Experience

Our analysis indicates that individuals with higher Positive Affect (PA) tend to demonstrate greater engagement, meeting effectiveness, and perceived performance, while simultaneously reporting lower temporal demand, effort, and frustration. Conversely, elevated Negative Affect (NA) was associated with reduced engagement and perceived performance, alongside a diminished sense of physical demand. Importantly, because the PANAS assessment was administered prior to the experimental sessions, the results reflect participants' baseline affective dispositions rather than emotions elicited during the meetings. This suggests that participants' everyday emotional states may have systematically influenced their subsequent subjective evaluations. Such findings raise a critical methodological consideration: when employing self-report questionnaires in affective computing and VR studies, researchers should account for the potential impact of pre-existing emotional states on participants' perception and response to different experimental conditions.

6.4 Limitations

The small sample size (N = 14) and predominantly student population constrain generalizability, particularly to professional or cross-cultural teams. Scripted meetings improved internal validity but reduced ecological realism compared to spontaneous, multi-speaker discussions. Measurement accuracy also presents constraints: eye-tracking with the Vive Focus Pro was less precise than research-grade systems, and calibration drifts may have introduced noise into fixation and gaze measures. Moreover, employing a female avatar as the meeting leader may have introduced gender-related biases. In addition, variations in personal experiences and cultural backgrounds could shape how participants interpret emotions, thereby influencing the outcomes. Finally, practical factors such as the physical weight of the headset or unexpected technical issues during the study may also have affected participants' emotional states.

6.5 Future Work

Future research can extend MoodCaster in several directions. First, field studies in organizational and professional meetings are needed to enhance ecological validity and to examine how environmental cues function within natural group dynamics. Second, integrating MoodCaster with emotion recognition (ER) technologies could enable more adaptive and responsive systems, opening new opportunities for exploring its effectiveness in real-world meeting contexts. Third, incorporating adjustable scales for environmental cues would allow participants to personalize the intensity of affective signals, thereby improving comfort and accommodating individual differences in sensitivity.

Pursuing these directions will help establish how environmental externalization scales from controlled laboratory studies to diverse, real-world VR meeting contexts, supporting the development of emotionally intelligent systems that balance engagement, clarity, and well-being.

7 Conclusion

Bystander disengagement remains a challenge in both physical and virtual meetings. While VR offers stronger presence than video conferencing, silent participants often remain unsupported. To address this, we developed **MoodCaster**, a VR meeting system that externalizes leader emotions through emoji overlays and environmental cues.

A controlled 2×2 study showed that environmental cues clearly enhanced bystander engagement compared to emoji-only baselines. In positive-valence scenarios, environmental cues fostered immersion and comfort, while in negative-valence scenarios, they amplified intensity and urgency but risked stress when overused. These results suggest that affective externalization is a design trade-off requiring careful calibration.

Looking ahead, VR meeting systems can integrate external adaptive affect externalization, dynamically calibrating cue intensity with real-time signals such as gaze or physiological arousal. Embedding such features into mainstream platforms like Zoom, Teams, or Horizon Workrooms would give leaders flexible tools to shape meeting atmosphere. By treating bystanders not as passive onlookers, but as active listeners whose engagement shapes collective outcomes, MoodCaster points toward emotionally intelligent VR collaboration that balances inclusion, empathy, and effectiveness.

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