PainMouse: Exploring Pain as an Embodied Output Modality for Real-Time Violence Awareness in Video Games

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Prolonged exposure to violent video games can increase adolescent aggression and desensitization, endangering mental health. Drawing on associative learning theories, we explore whether repeated pairing of violent actions with physical discomfort can reshape player sensitivity and perception of in-game violence. We present PainMouse, a multimodal monitoring and feedback system that leverages pain-based haptic responses to enhance players' awareness of in-game violence. It fuses game visual/audio data with the player's behavioral and emotional cues to detect violent intents and desensitization, and delivers slight pain sensations via a custom mouse. Preliminary experiments have found that pain feedback can influence players' in-game decision-making. However, there are also issues, such as players becoming habituated to mechanical pain feedback over time. This work provides empirical insights into pain as an embodied HCI modality for adaptive digital well-being interventions and sheds light on the potential and limitations of haptic feedback for modulating violent gameplay behavior.

CCS Concepts: • **Human-centered computing** → **Human computer interaction (HCI)**; *Haptic interaction*; • **Computing methodologies** → Multimodal interaction.

Additional Key Words and Phrases: Embodied HCI, Haptic feedback, Digital well-being, Violent video games, Behavioral conditioning, Multimodal detection

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1 Introduction

Long-term exposure to violent video games is increasingly linked to heightened aggression and desensitization to real-world violence, posing significant risks to adolescent mental health development. Existing interventions often rely on surface-level metrics (e.g., usage duration, demographic data) rather than multimodal assessments of in-game violence and players' real-time emotional-behavioral responses; their feedback mechanisms (e.g., text alerts, sound warnings) are usually passive and easily ignored, lacking the sensory immediacy needed to disrupt the pleasure-reward cycle of violent gameplay. Pain, as an embodied, universal sensory modality, offers a unique solution: unlike symbolic

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feedback, physical discomfort creates direct, memorable associations between actions and consequences, leveraging neuro-associative conditioning to reshape behavior. This embodied nature makes haptic pain far more effective at fostering immediate self-awareness and long-term sensitivity than detached digital prompts.

To address these gaps, we introduce **PainMouse**, a multimodal embodied AI system that targets desensitization through pain-based haptic feedback. Grounded in Neuro-Associative Conditioning (NAC) theory where behavior is shaped by pleasure-pain associations, our approach establishes a negative link between violent in-game actions and physical discomfort, fostering long-term awareness of digital violence. Unlike passive monitoring tools, PainMouse integrates real-time analysis of game content and player reactions with tangible sensory feedback, creating an interactive intervention that complements existing digital well-being frameworks.

This work makes two core contributions to HCI research: (1) a dual-path multimodal detection architecture that dynamically fuses game visuals, audio, and player behaviors to accurately identify desensitization; and (2) an embodied haptic interface that delivers contextually proportional pain feedback to reshape behavioral sensitivity. By framing pain as an active, communicative modality for human-AI interaction, we explore a new paradigm for real-time, behavior-sensitive interventions in digital media consumption.

2 Related Work

Violent video games, particularly first-person shooters (FPS), motivate aggressive behaviors by rewarding violent skills and destruction [4, 5], with links to increased bullying, reduced prosociality, and adolescent desensitization [3, 6, 9]. While behavioral conditioning theories confirm negative reinforcement can reshape such habits [1, 7], existing anti-addiction tools focus on surface-level usage patterns (e.g., duration) [13, 14] and rely on passive symbolic warnings—lacking tangible, real-time interventions tailored to violent content engagement.

Pain is a multifaceted sensory-emotional experience [10], with recent research adopting multimodal detection (e.g., EEG, facial cues, physiological signals) for pain assessment in clinical contexts [2, 8]. However, most research treats pain as a passive signal to infer rather than an active, communicative modality—few studies leverage pain as an interactive tool for real-world behavioral guidance. AI-driven haptic research enhances VR/AR immersion and human-AI alignment through dynamic feedback [11, 15]. Yet existing systems focus on haptic output for realism, not closed-loop interpretation of user states or behavioral conditioning. Multimodal haptic-visual fusion improves collaborative performance [12], but pain-based haptics as a tool for reshaping sensitivity to digital violence remains underexplored.

Collectively, current research lacks embodied interventions that integrate multimodal state detection with impactful pain-based feedback. Our work addresses this gap by framing pain as an active HCI modality to bridge behavior and cognition in digital well-being.

3 System Design

PainMouse is a multimodal embodied AI system designed to evaluate and intervene in players' cognitive responses to violent gameplay. As shown in Figure 1, the system consists of two core, interconnected components: a real-time multimodal detection software and a pain-based haptic feedback hardware. Together, they form a closed-loop aversive conditioning mechanism to reinforce sensitivity to violent content.

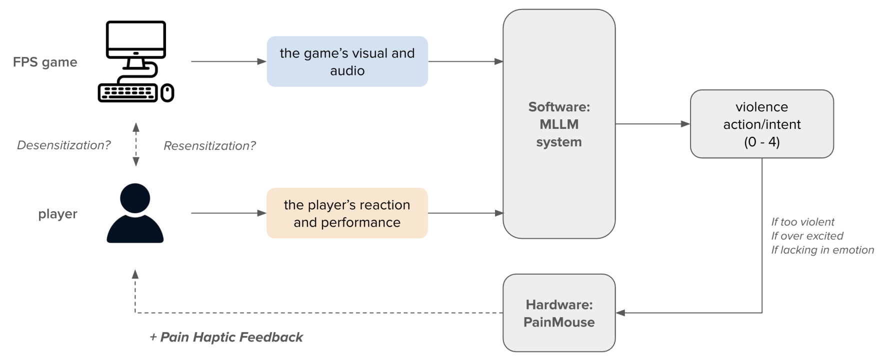

Fig. 1. System overview. The PainMouse system consists of two main components: a multimodal violence detection software and a pain-based haptic feedback device.

3.1 Software: Dual-Path Multimodal Detection

The software module dynamically integrates game content and player responses to identify desensitization, leveraging two complementary detection paths for low-latency reactivity and contextual depth (see Figure 2).

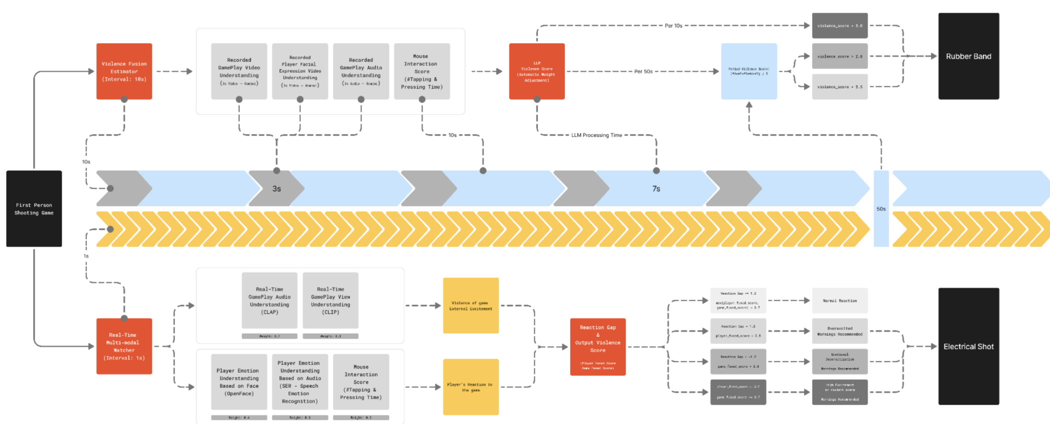

Fig. 2. Dual-path detection architecture. The system includes two parallel detection paths: a real-time monitoring module and a delayed agent module. These two paths respectively trigger fast-response (e.g., electrical) and delayed (e.g., mechanical) pain feedback via the PainMouse device.

Real-Time Detection Path operates at 1-second temporal resolution to enable immediate intervention. It processes three parallel input streams: **1) game visuals** (RGB frames) analyzed via CLIP to assess violence intensity; **2) game/audio signals** (environmental sounds, player speech) evaluated using CLAP and Speech Emotion Recognition (SER) for emotional cues; and **3) player behavioral data** (gaze fixation rate, mouse click/shooting frequency) to capture engagement patterns. These modalities are fused using a weighted decision strategy to compute two key metrics: violence intensity score (severity of in-game violence) and player response score (emotional-behavioral reactions via

OpenFace-analyzed facial expressions and behavioral cues). A "desensitization gap" is calculated as the discrepancy between these two scores; when the gap exceeds a predefined threshold, the system triggers haptic feedback.

Context-Aware Agent Path integrates a Gemini-2.0-Flash-powered fusion module to capture subtler, longer-term behavioral patterns. Every 10 seconds, it synthesizes gameplay visuals, audio segments, and facial expression sequences into textual summaries, which are combined with aggregated player interaction scores (e.g., 10-second click rate averages). Gemini dynamically adjusts the weight of each modality based on contextual relevance—for example, prioritizing game visuals/audio if a player shows minimal facial expressions—to generate a robust violence intensity score (ranging from 0.0 for peaceful to 5.0 for extreme violence). Every five timesteps, these scores are averaged to form a wave-level assessment, ensuring the system accounts for contextual nuance beyond isolated moments of gameplay.

3.2 Hardware: Painmouse Haptic Feedback Device

The PainMouse is a modified computer mouse embedded with dual pain-delivery mechanisms, designed to deliver proportional, contextually appropriate "discomfort" without compromising usability. (see Figure 3 left)

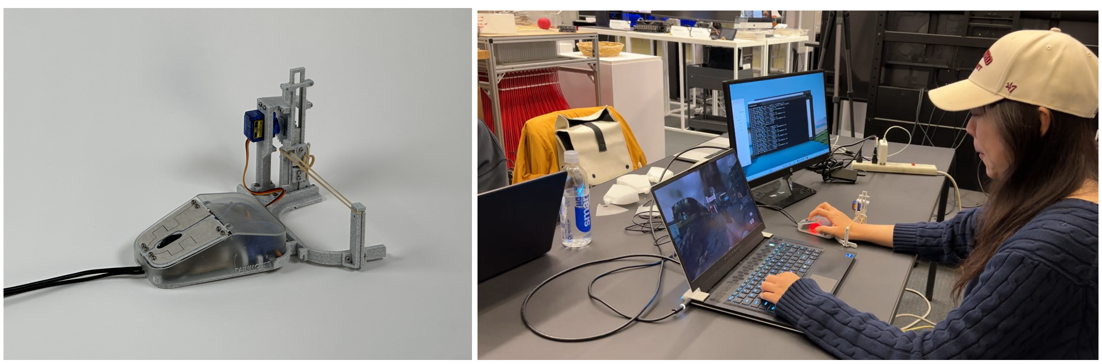

Fig. 3. Left: Painmouse device; Right: Experimental setup.

There are two distinct feedback types addressing different conditioning goals. **Electrical stimulation** is a low-Latency ($\leq 200ms$) mild electrical pulse delivered via contact points on the mouse grip. Triggered by the real-time detection path, this feedback aligns with immediate violent actions (e.g., a shooting spree) to create direct stimulus-response associations. **Mechanical impact** is a delayed, gentle rubber band lash activated by the context-aware path. Administered post-action (e.g., after a violent game segment) to reinforce reflective awareness, it is perceived as a more deliberate consequence rather than an in-game mechanic.

Pain signals are injected into interaction flows (mouse clicks, movement) to foster embodied associations between violent behaviors and discomfort. Three delivery modes enhance conditioning flexibility: (1) immediate (within 1 second of violent acts); (2) embedded (integrated into subsequent mouse clicks); (3) patterned (distributed across action sequences to target complex behaviors). This design balances real-time reactivity and long-term contextual awareness to explore diverse behavioral conditioning modes.

4 Pilot Study

To evaluate PainMouse's feasibility and behavioral impact, we conducted a pilot study with 4 participants (2 female, 2 male; aged 19–25; 2 novice FPS players, 2 experienced players with $\geq$ 3 years of violent game exposure). The study focused on two core research questions: *(1) Can PainMouse effectively detect desensitization to in-game violence? (2) Does pain-based haptic feedback modulate players' violent behaviors and awareness?* Below we detail the study design, key findings, and implications for HCI research.

4.1 Study Design

Participants played *Call of Duty: Black Ops 2 – Zombies* (a FPS game with clear, gradable violent actions) on a desktop computer. We used the PainMouse for intervention phases and a standard mouse for baseline/post-test phases. Data collection included: (1) objective metrics (in-game aggressive action frequency, e.g., shooting rate; mouse interaction patterns); (2) physiological data (skin conductance level, SCL, via a wearable sensor to measure emotional arousal); (3) subjective feedback (post-session questionnaires, semi-structured interviews).

The study followed a within-subjects, three-phase design (each phase = 15-minute gameplay): **(1) Baseline**: Participants used a standard mouse with no feedback; we collected baseline violent behavior and SCL data. **(2) Intervention**: Participants used PainMouse, with both real-time electrical stimulation and delayed mechanical feedback active. The dual-path software dynamically detected desensitization and delivered proportional feedback. **(3) Post-test**: Participants returned to the standard mouse; we measured residual behavioral changes and administered a questionnaire on awareness and feedback perception.

4.2 Results

Across all participants, we observed a 25% reduction in aggressive in-game actions (shooting rate, grenade use) during the intervention phase compared to baseline. Post-test data showed a sustained reduction relative to baseline, indicating residual conditioning effects. Notably, novice players exhibited a larger behavioral shift (33% reduction) than experienced players (15% reduction), suggesting prior violent game exposure may moderate the impact of pain feedback.

The dual-path software successfully identified desensitization gaps: experienced players consistently showed lower SCL and facial expression arousal (measured via OpenFace) relative to novice players, even when exposed to identical violent content (see Figure 4). This aligns with our hypothesis that desensitization manifests as a mismatch between violent stimuli and emotional response—validating the system's detection capability. SCL spikes correlated with feedback delivery (r=0.72), confirming that pain feedback effectively disrupted low-arousal (desensitized) states.

Questionnaire and interview data revealed nuanced responses to different haptic feedback types. Electrical stimulation was perceived as "part of the game challenge" (3/4 participants) rather than punishment, integrating seamlessly with gameplay. Mechanical impact was viewed as "deliberate feedback" (4/4 participants), increasing reflective awareness of violent behavior (e.g., "I noticed I was shooting unnecessarily because the rubber band reminded me"). Besides, PainMouse also shows the trend to shift palyer's behavioral intent. 3 out of 4 participants reported adjusting their gameplay to "avoid discomfort," with one stating, "I stopped spamming shots because I didn't want to get shocked", which directly reflects operant conditioning effects.

4.3 Insights

Timing and Framing Shape Feedback Efficacy. The study highlights that feedback timing modulates how players interpret and respond to pain-based interventions. Real-time, action-aligned feedback (electrical stimulation) integrates with gameplay flow, while delayed, reflective feedback (mechanical impact) fosters metacognitive awareness. This duality suggests that future embodied HCI interventions should tailor feedback timing to intervention goals (immediate behavior change vs. long-term attitude shift) rather than adopting a one-size-fits-all approach.

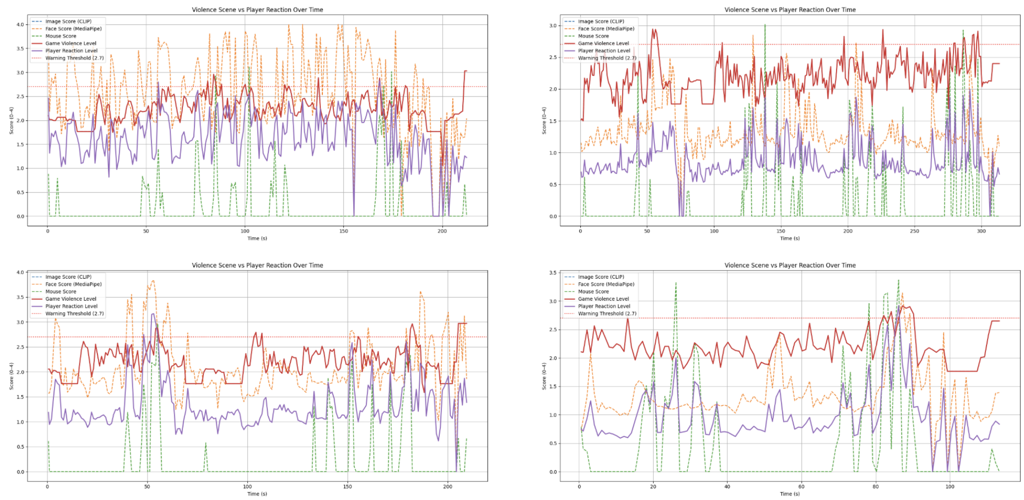

Fig. 4. Comparison of Different Game-play Experience users

Prior Experience Moderates Conditioning Effects. Experienced players' reduced responsiveness to feedback underscores the need for adaptive embodied interventions in digital well-being. Current HCI research often overlooks user heterogeneity in exposure to harmful content; our findings suggest that systems targeting desensitization must calibrate feedback intensity and modality based on prior user experience to avoid habituation (a concern raised by one participant: "The shocks felt less noticeable after repeated exposure").

Pain as a Bivalent Haptic Modality. Contrary to our initial assumption that pain is universally aversive, some participants described the feedback as "engaging" and make them "additive to gameplay", revealing pain's potential as a bivalent HCI modality (not just punitive). This challenges the intuitive framing of pain as a "negative" signal, opening new avenues for research: Could pain-based haptics enhance learning (e.g., safety training) or empathy (e.g., simulating harm consequences) beyond aversive conditioning?

4.4 Limitations

The pilot study's small sample size (N=4) and short intervention duration (15 minutes) limit the generalizability of our findings and prevent capturing long-term desensitization reversal or sustained behavioral changes. Ethically, pain-based feedback raises non-trivial concerns: imposing physical discomfort as an intervention carries inherent risks of psychological distress, and individual differences in pain tolerance (e.g., varying thresholds for electrical stimulation) introduce inequity in feedback efficacy. These limitations highlight the need for more rigorous validation and ethical refinement before broader application.

5 Conclusion and Future Work

This work introduces PainMouse, a multimodal embodied system that leverages pain-based haptic feedback to address desensitization to in-game violence, with the aim of filling a critical gap in digital well-being interventions. By combining multimodal detection with contextually tailored physical feedback, the system translates associative learning into tangible interaction, fostering self-awareness and reducing aggressive gameplay. Our pilot study validates PainMouse's feasibility in the detection of desensitization and violent behavior modulation. Future work will expand to larger and more diverse user groups and open-world games, with more adaptive and personalized feedback to mitigate habituation (e.g., calibrating feedback intensity, type, and timing to individual pain tolerance, prior game exposure, and behavioral responses). This research advances embodied HCI by illuminating the potential and limitations of pain as a feedback modality, offering a actionable framework for real-time, behavior-sensitive digital well-being tools that bridge virtual and physical experiences.

References

[1] Ben Akpan. 2020. Classical and operant conditioning—ivan pavlov; burrhus skinner. In *Science education in theory and practice: an introductory guide to learning theory*. Springer, 71–84.

[2] Siqi Cao, Di Fu, Xu Yang, Stefan Wermter, Xun Liu, and Haiyan Wu. 2024. Pain recognition and pain empathy from a human-centered AI perspective. *Iscience* 27, 8 (2024).

[3] Florian Ferreri, Alexis Bourla, Stephane Mouchabac, and Laurent Karila. 2018. e-Addictology: an overview of new technologies for assessing and intervening in addictive behaviors. *Frontiers in psychiatry* 9 (2018), 51.

[4] Douglas A Gentile and J Ronald Gentile. 2008. Violent video games as exemplary teachers: A conceptual analysis. *Journal of youth and adolescence* 37 (2008), 127–141.

[5] Douglas A Gentile, Paul J Lynch, Jennifer Ruh Linder, and David A Walsh. 2004. The effects of violent video game habits on adolescent hostility, aggressive behaviors, and school performance. *Journal of adolescence* 27, 1 (2004), 5–22.

[6] Tobias Greitemeyer. 2022. The dark and bright side of video game consumption: Effects of violent and prosocial video games. *Current opinion in psychology* 46 (2022), 101326.

[7] Tal Moran, Yahel Nudler, and Yoav Bar-Anan. 2023. Evaluative conditioning: Past, present, and future. *Annual Review of Psychology* 74, 1 (2023), 245–269.

[8] Emad Kasaeyan Naeini, Mingzhe Jiang, Elise Syrjälä, Michael-David Calderon, Riitta Mieronkoski, Kai Zheng, Nikil Dutt, Pasi Liljeberg, Sanna Salanterä, Ariana M Nelson, et al. 2020. Prospective study evaluating a pain assessment tool in a postoperative environment: protocol for algorithm testing and enhancement. *JMIR Research Protocols* 9, 7 (2020), e17783.

[9] Gayathri Soman, MV Judy, and Aadhil Muhammad Abou. 2025. Human guided empathetic AI agent for mental health support leveraging reinforcement learning-enhanced retrieval-augmented generation. *Cognitive Systems Research* (2025), 101337.

[10] Mustafa Hüseyin Temel, Yakup Erden, and Fatih Bağcıer. 2025. Lumbar Radicular Pain in the Eyes of Artificial Intelligence: Can You 'Imagine'What I 'Feel'? *World Neurosurgery* 193 (2025), 309–314.

[11] Karthikeya Puttur Venkatraj, Wo Meijer, Monica Perusquía-Hernández, Gijs Huisman, and Abdallah El Ali. 2024. Shareyourreality: Investigating haptic feedback and agency in virtual avatar co-embodiment. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems*. 1–15.

[12] Jiahao Wu, Bowen Sun, Hengxu You, and Jing Du. 2025. Enhancing Human-AI perceptual alignment through visual-haptic feedback system for autonomous drones. *International Journal of Industrial Ergonomics* 109 (2025), 103780.

[13] Leon Y Xiao. 2020. People's Republic of China legal update: The notice on the prevention of online gaming addiction in juveniles (published October 25, 2019, effective November 1, 2019). *Gaming Law Review* 24, 1 (2020), 51–53.

[14] Qiongyao Yang, Han Wang, Hongye Wu, Wei Li, Yueyue Zhang, Yitan Yao, Xiaoping Yuan, Chuanchuan Chen, Yue Wang, Yongjie Zhong, et al. 2023. Effect of online game policy on smartphone game play time, addiction, and emotion in rural adolescents of China. *BMC psychiatry* 23, 1 (2023), 814.

[15] Yunxiang Zhang, Benjamin Liang, Boyuan Chen, Paul M Torrens, S Farokh Atashzar, Dahua Lin, and Qi Sun. 2022. Force-aware interface via electromyography for natural VR/AR interaction. *ACM Transactions on Graphics (TOG)* 41, 6 (2022), 1–18.