Reducing Discomfort by Changing the Interpretation of the Cause of Pain

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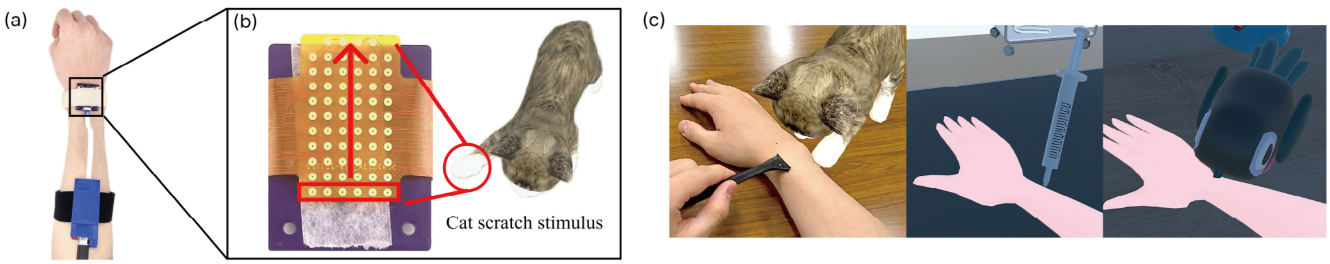

Figure 1: (a) An electrotactile device was attached to the right wrist to provide pain stimulation. (b) Pain Presentation by Electrical Stimulation. (c) Scenes of AR application experience.

Abstract

Extended reality (XR) technologies have been widely recognized for their effectiveness in pain management. Conventional XR-based pain reduction methods primarily function by diverting the user's attention away from the nociceptive stimulus, thereby reducing cognitive load. However, these methods demonstrate limited efficacy in individuals who experience anxiety or heightened pain sensitivity and who have difficulty engaging in distraction-based techniques. To address this limitation, a novel approach termed "pain masking by contextual modification" is introduced. This method modifies the visual representation of the pain-inducing stimulus by synchronizing a visual stimulus with the application of pain, creating the illusion that the pain originates from a different source. By designing the visual stimulus to be less aversive, this approach reduces the subjective perception of pain. Unlike traditional distraction-based methods, this technique does not require attentional distraction, making it particularly beneficial for individuals who find distraction ineffective, as well as for those performing self-administered procedures, such as hair removal. This study presents applications of this method within an augmented reality (AR) environment and a virtual reality (VR) environment, highlighting its potential integration into everyday contexts.

CCS Concepts

• **Human-centered computing** → **Haptic devices**; **Virtual reality**; **Mixed / augmented reality**.

Keywords

Cats, Content, Masking, Pain, Virtual Reality

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1 Introduction

The HMD XR experience is a widely used pain reduction method that does not require drug administration [Won et al. 2017]. In this approach, a distracting visual stimulus is presented simultaneously with a pain stimulus. This method reduces pain perception by reallocating cognitive resources away from processing pain [Mouraux et al. 2011]. While this approach has shown efficacy, it remains less effective for individuals with heightened fear responses to pain who struggle to divert their attention from the nociceptive stimulus [Johnson 2005]. Therefore, new approaches to pain management are required that maintain attention on the stimulus without causing distraction.

We have proposed a new method, called pain masking by contextual modification, that does not divert attention from pain stimuli but alters the appearance of the stimulus source[Onoda et al. 2025]. This method modifies the perceived cause of the sensation by presenting visual stimuli that seem to originate from a different source while the user experiences the pain stimulus. For example, when a kitten is displayed in front of the user's eyes using a head-mounted display (HMD), and the kitten "scratches" the user simultaneously with the presentation of the pain stimulus, the pain is no longer experienced as pain and is instead perceived as a pleasant interaction element. Unlike traditional methods that aim to distract attention from the pain stimulus, this method is effective only when the user directs attention toward the pain sensation itself, rather than its source. This approach can be used in situations where it is difficult to redirect attention from the pain. Prior studies indicate that perceived pain can be reduced by visually modifying the area of stimulation[Mancini et al. 2011]. In contrast, the method reported here alters the source of the stimulus rather than the site itself. In contrast, the method reported here alters the source of the stimulus rather than the site itself. A survey conducted during the proposal of this method indicated that presenting a new context for cat scratching stimuli altered the interpretation of the stimulus cause, increasing the discomfort threshold and reducing discomfort. The method's validity was also established in virtual and augmented reality (VR/AR) settings. An experiment assessed stimulus interpretation, intensity, and discomfort under three conditions: 1) electrical stimulation alone; 2) electrical stimulation synchronized with a cat-scratching animation; and 3) electrical stimulation with a delayed animation. Compared to the stimulation-only condition, the synchronized presentation of the animation significantly reduced perceived stimulus intensity and discomfort and altered its qualitative interpretation (WHC citation). Future work should directly compare this technique with established distraction-based interventions[Onoda et al. 2025].

This method can be applied not only in situations where another person inflicts pain on the user, such as during injections, but also in daily activities like hair removal and shaving, as the user does not need to be distracted from the painful stimulus. In this demonstration, experiences will be created in an augmented reality (AR) environment and a virtual reality (VR) environment to facilitate the application of this technology in everyday life.

2 System

As shown in Figure 2, the system consists of a head-mounted display (Quest3, Meta), Vive Tracker, and an electricaltactile device. The electrotactile device is affixed to the right wrist, as depicted in Figure 1(a), and the head-mounted display (HMD) presents AR and VR environments. A 3D model of a cat was introduced as a contextual element, perceived as a new source of the pain stimulus during this experience. The Vive Tracker was employed to record hand movements during VR space experiences. The electrotactile device incorporates 64 electrodes that deliver an electrical stimulus that elicits pain. Stimulation parameters were a 50 µs pulse width and an intensity adjustable in 0.1 mA increments up to a 10 mA maximum. The experimental protocol was approved by the Institutional Review Board of the University of Electro-Communications (approval number: H24013). In this configuration, the pain stimuli originally generated by the electrotactile device are recontextualized as scratching stimuli by the cat, thereby reducing the subjective perception of pain.

Figure 1(b) illustrates the stimulation pattern of the electrotactile device. A horizontal row of stimuli is presented within a flow field, moving from the bottom to the top. This pattern mimics the stimuli experienced during shaving, and the cat's scratching follows a similar trajectory.

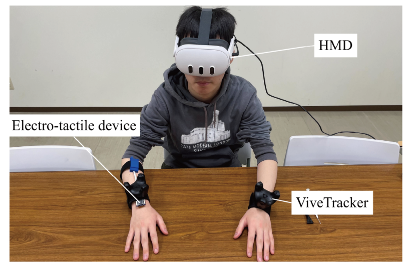

Figure 2: Overview of the experience.

3 Demo Experience

This demonstration illustrates how users can experience reduced discomfort from pain through contextual modification. The experimental setup was used to manipulate the interpretation of stimulus causality in various AR/VR scenarios, such as shaving and injections (Figure 1(c)). New contexts, including animals like cats and birds, were introduced to ensure cultural diversity. In self-application scenarios (e.g., shaving), the visual overlay was scaled to the physical object's size to maintain visibility of the surrounding skin, thereby ensuring user safety.

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References

Andrea Stevenson Won, Jakki Bailey, Jeremy Bailenson, Christine Tataru, Isabel A. Yoon, and Brenda Golianu. 2017. Immersive Virtual Reality for Pediatric Pain. 4, 7 (2017), 52. doi:10.3390/children4070052 Number: 7 Publisher: Multidisciplinary Digital Publishing Institute.

André Mouraux, Ana Diukova, Michael C. Lee, Richard G. Wise, and Gian Domenico Iannetti. 2011. A multisensory investigation of the functional significance of the "pain matrix". 54, 3 (2011), 2237–2249. doi:10.1016/j.neuroimage.2010.09.084

Malcolm H. Johnson. 2005. How Does Distraction Work in the Management of Pain? 9, 2 (2005), 90–95. doi:10.1007/s11916-005-0044-1

Hibiki Onoda, Shoha Kon, Taiki Takami, Keigo Ushiyama, Izumi Mizoguchi, and Hiroyuki Kajimoto. 2025. Investigating the Effectiveness of Pain Masking Through Contextual Modification. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, 2025-04) *(CHI EA '25)*. Association for Computing Machinery, 1–6. doi:10.1145/3706599.3719794

Flavia Mancini, Matthew R. Longo, Marjolein P.M. Kammers, and Patrick Haggard. 2011. Visual Distortion of Body Size Modulates Pain Perception. 22, 3 (2011), 325–330. doi:10.1177/0956797611398496 Publisher: SAGE Publications Inc.

Hibiki Onoda, Shoha Kon, Keigo Ushiyama, Izumi Mizoguchi, and Hiroyuki Kajimoto. 2025. Pain Masking by Contextual Modification in VR/AR Environment. In *2025 IEEE World Haptics Conference (WHC)*. 464–470. doi:10.1109/WHC64065.2025.11123221