# Extended Reality for Chronic Pain Relief

Jiaheng Wang
Victoria University of Wellington
Wellington, New Zealand
jiaheng.wang@ecs.vuw.ac.nz

Craig Anslow
Victoria University of Wellington
Wellington, New Zealand
craig.anslow@ecs.vuw.ac.nz

Brian Robinson
Victoria University of Wellington
Wellington, New Zealand
brian.robinson@vuw.ac.nz

Simon McCallum
Victoria University of Wellington
Wellington, New Zealand
simon.mccallum@ecs.vuw.ac.nz

(a) Throwing a fireball to light campfires

(b) Pulling a block out of a tower

**Figure 1: Screenshots of the prototype in action.**

## ABSTRACT

Chronic pain is ongoing pain lasting for long periods of time after the initial injury or disease has healed. Chronic pain is difficult to treat and can affect the daily lives of patients. Distraction therapy is a proven way of relieving pain by redirecting the focus of patients' attention. Virtual reality is an effective platform for distraction therapy as it immerses the user visually, aurally, and even somewhat physically in a virtual world detached from reality. There is little research done on the effects that physical interactions have on pain management. This project aims to evaluate different types of extended reality (XR) interactions, including full body movement, for chronic pain patients to determine which is the best for pain relief. We are building a prototype for participants to interact both mentally and physically and measuring the reduction in subjective pain ratings at various points of the XR experience.

## CCS CONCEPTS

• **Human-centered computing** → **Mixed / augmented reality**; **Virtual reality**; *Interaction techniques*; *Empirical studies in HCI*; Activity centered design; • **Applied computing** → *Consumer health.*

## KEYWORDS

virtual reality, augmented reality, mixed reality, chronic pain, pain relief, pain management, user study

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## 1 INTRODUCTION

Pain is commonly divided into two categories: acute and chronic [Taub et al. 1998]. Acute pain is caused by disease, injury, or some other form of stimulation [Taub et al. 1998], and serves as a biological alert to prevent further damage [Moriarty and Finn 2014]. Chronic pain is an ongoing pain often defined by the length of time [Grichnik and Ferrante 1991]. Chronic pain is more difficult to treat as, by definition, it does not respond to the treatment which resolved the initial source of acute pain. The persistence of chronic pain also has an effect on patients' everyday life such as loss of sleep or unable to perform basic self-care tasks.

Current treatment procedures combine medication with rehabilitation and education. Various forms of analgesia each have their own side-effects. Distraction therapy is a non-pharmacological treatment for pain by directing the attention of the patient to a pleasant event or stimulation to distract the patient from the pain [Fernandez 1986].

As VR headsets become more widespread, what was once obscure uses for such devices gradually becomes mainstream. By engaging

multiple sensory systems, it is capable of taking users out of their real-world environment and placing them in any virtual world of their choosing, fully immersing them in that environment and filling the user's cognition with the pleasant stimulants for distraction therapy.

While there have been many studies on the effects of VR on subjective pain in a range of settings including burn patients [Hoffman et al. 2000], labour [Frey et al. 2018], surgery [Chan and Scharf 2017], cancer [Mohammad and Ahmad 2018], and dentistry [Wiederhold et al. 2014], most of these studies were unable to engage the full body movement aspects of XR as they were used for acute pain during medical procedures. It would be extremely dangerous for patients to be walking around the room waving their arms around while medical staff are trying to work on them. So far there have been very little research into the differences between physical and mental demand for pain management. This project proposes to develop a variety of interactive content to be delivered through VR and AR and evaluate the effect on chronic pain sufferers to determine which elements of the experience provides the most effective relief to patients.

[Bianchi-Berthouze et al. 2007] previously conducted user studies on full-body interactions and its contributions to the experience. They found that full-body movements not only increased players' engagement but also presence. [Hoffman et al. 2004] conducted many studies into how a sense of presence affected the analgesic effects of the experience and found that stronger presence, from both software and hardware, led to a decrease in pain ratings. Based on this, we hypothesize that by physically engaging the patients, the effects on pain ratings will be better than with mental engagement.

## 2 CHRONIC XR

We are designing and developing a prototype to be used as a platform to conduct user studies. The prototype is designed to have distinctly physical activities and distinctly mental activities, in order to better understand the analgesic effects of each. A passive observation component is also included to act as a control group for the user study. The content is kept the same between VR and AR, with the only difference being the surrounding environment. VR has a virtual, made-up environment whereas AR's environment is the real world.

Physical activities engage users by requiring either fine motor skills or hand-eye coordination. Although full body interactions are implemented, they are not required to fully engage with the experience. Full body interaction includes walking around the play area and interacting with the world by moving arms and hands, utilizing both upper and lower limbs. But with the target demographics being chronic pain patients, accessibility features are provided to reduce strain or excessive movement on pain regions. This includes functions like teleporting (Figure 2) instead of walking and minimizing the angles users have to move their arms. For the same reason, activities requiring vigorous movement or fast reflexes will not be included.

Mental activities engage users by requiring memorization, simple arithmetic, or logical thinking. Although these activities still require physical movement to interact, the challenge and cognitive demand will not be on the physical side.

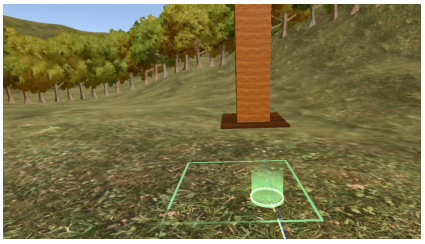

**Figure 2: Teleport system**

The virtual activities have a magical theme. Users can use various spells such as telekinesis, teleportation, and controlling elements (fire, water, lightning, etc.) Users interact with the world via controllers, using the touchpad to select the spell they want, and pulling the trigger to activate the spell. There is also a no-spell mode where users can pick up and throw objects around without magic.

The game is comprised of a series of "rooms" or levels. The player completes each level by getting a key and placing the key into the keyhole. The challenges lie in obtaining the key.

We presented a prototype of an XR game which forms the beginning of a research project to better examine using XR for chronic pain relief. A user study with chronic pain patients will be conducted to evaluate the analgesic effects. We hope the results of this study can influence the design of future pain management games to be more effective and help pain patients have a better quality of life.

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