

Virtual Reality and *Mobius Floe*: Cognitive Distraction as Non-Pharmacological Analgesic for Pain Management

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Abstract. This paper outlines the intentions and current design behind the production of *Mobius Floe*, an immersive virtual reality game catered to acute and chronic pain patients. Researchers have shown that immersive virtual reality (VR) can serve as a non-pharmacological analgesic by inducing cognitive distraction in acute pain patients [Hoffman 2000]. *Mobius Floe* experiments with virtual reality as well as auditory immersion, a more experimental approach to cognitive distraction for pain relief; the results will be tested by acute as well as chronic pain patients to determine if chronic sufferers can benefit from similar VR practices as their acute counterparts. *Mobius Floe*'s game design is informed by contemporary game design theory and cognitive psychology in order to improve its distractive properties.

Keywords. Chronic pain, acute pain, pain management, serious game design, health games, analgesia, virtual reality, cognitive load

1 Introduction

Virtual reality (VR) applications have yet to become a widely accepted complementary method to analgesics to reduce the perception of pain despite documented instances of its success. *SnowWorld*, a VR game with accompanying head mounted display (HMD) has demonstrated that VR treatments can work in tandem with pain medications to further reduce perceived instances of pain in patients with combat-related burn injuries [8]. Virtual reality has also been used to help combat other types of discomfort such as acute pain from dental procedures [6]. There is already evidence to suggest that chronic pain patients can benefit from immersive virtual reality applications [10]. Chronic pain patients, although requiring long-term pain reduction strategies, also suffer from shorter-term spikes in pain intensity [1] of which they may also benefit from non-pharmacological treatment practices suiting acute pain patients. *Mobius Floe*, the immersive VR discussed in this paper aims to expand upon non-pharmacological analgesic research for acute and chronic pain patients by improving the quality and variability of the distractive gameplay of its predecessors while introducing new forms of gameplay to examine, evaluate and compare to the field. Tasks involving cognitive

distraction and heightened cognitive load are discussed for usage in *Mobius Floe* in order to attract and maintain the attention of pain patients.

2 Related Work

Virtual reality treatments for the reduction of acute pain have seen promising results in multiple studies. A VR titled *SnowWorld*, which draws patient's attention away from their embodied experience of pain and toward the virtual 3D environment was used to curb the wound care pain of U.S. soldiers injured with significant burns at the U.S. Army Institute of Surgical Research (USAISR). *SnowWorld* featured a snowy landscape where the patient could throw snowballs and be hit by snowballs in the virtual space. This experience combined with analgesic medications served to improve the soldier's pain experiences in regards to "time spent thinking about pain" and experienced "pain unpleasantness", both of which declined significantly with the introduction of VR to their standard wound care routine [8].

Hoffman et al. reported significantly reduced levels of pain in dental patients undergoing scaling and root planing in those who were immersed in cognitive distraction via a virtual reality simulation over patients who were asked to watch a movie and those who had no distraction present during their procedures [6]. Their results imply that immersive virtual reality applications may serve as an effective non-pharmacologic analgesic which could be used in tandem with existing prescribed pain medications for dental pain; this conclusion by extension may also be applicable to other pain demographics, especially considering the surrounding literature. For example, in a randomized control trial study by Das et al., a virtual reality game was added to the procedural care schedule of children with acute burn injuries. The introduction of VR to their normally prescribed pharmacological analgesics decreased the average of the children's self-reported Faces Scale pain ratings from 4.1 (SD 2.9) to 1.3 (SD 1.8) [3].

The introduction of meaningful game design strategies can improve the gameplay of *Mobius Floe* to become more engaging than its previous counterparts, improving the quality of patient immersion. The examination of the potency of effects such as Csikszentmihalyi's 'flow' are important to maintaining virtual immersion, for flow "can be positively associated with degrees of the cognitive phenomenon of immersion and telepresence" [4]. *SnowWorld* has some degree of flow and is discussed widely in virtual reality literature. However, there is no perceivable consequence to inaction in *SnowWorld* when clear reactions from the game world in response to the player are necessary to create a more engaging design [2]. The *SnowWorld* patients also had minimal player agency in regards to their potential actions in the space, which is unusual considering player agency is an extremely useful tool for user engagement [9]. *Mobius Floe* aims to learn from and improve upon previous attempts such as *SnowWorld* by extending the software's ability to become immersive and cognitively distract in a more reliable fashion.

Mobius Floe also incorporates techniques from the cognitive sciences by introducing n-back tasks, attentional switching and dual-task paradigms which work in tandem to invoke strong immersion, cognitive load, continuous action and heighten arousal

[5][11]. Patients are rewarded with ‘health packs’ to increase their player’s health points (HP) when memorizing short visual patterns within the *Mobius Floe* space, recalling them later using a throwing mechanic to interact with the correct sequence of colors. Attentional switching and dual-task paradigm examples are discussed in the following section.

3 Virtual Reality Design and Development for *Mobius Floe*

Mobius Floe is currently being constructed in the Unity game engine and sports various distraction-based gameplay strategies in different areas of the virtual space. It can be played with the Oculus Rift head-mounted display (HMD) or a stereoscopic HMD provided by Firsthand Technologies, which sits in front of the eyes without touching the patient; the intent of using this hardware is to provide greater depth of cognitive immersion.

Mobius Floe appears as a sprawling snowy landscape, and the player is automatically moved forward through the space. The patient can look around the virtual space using the Oculus Rift or with a mouse as they are brought to their next destination.

The patient quickly finds themselves under threat from monsters which appear to be half neuron, half tree (see Fig. 1). These ‘neuron trees’ have menacing expressions and require sedation to escape from successfully. They chase the player and will damage their Health Points (HP) on contact. The neuron trees represent the neurological systems in the human body which are causing the pain experience; patients are able to calm them down by throwing abstracted particle systems representing analgesics with the left mouse button. The neuron trees serve as a key mode of cognitive distraction as they coerce the player into taking defensive actions against them in a strategic and time sensitive manner. Overuse of drugs against the neuron trees results in negative consequences, some of which manifest as detrimental behaviors in the neuron trees, while others affect the visual rendering of the virtual space in a negative fashion. For example,



Fig. 1. A production still of *Mobius Floe* which shows an idling neuron tree.

overuse of morphine slows the neuron trees down considerably, but they become more aggressive once the effect wears off.

Sea otters also wander the virtual space and are able to interact with the patient (Fig. 2). They are friendly entities always approaching the player on sight, serving as metaphors for the patient’s friends and family. Sea otters wag their tails and smile up at the patient when nearby. The patient can toss sea urchins at the otters in the same way they toss analgesics to the neuron trees. Otters who receive sea urchins will drop health packs for the player.

Occasionally the n-back tasks discussed in the previous section, sea otters and neuron trees will be in the proximity of the player at the same time, encouraging attentional switching and dual-task paradigms. The player must switch their attention between the neuron trees’ location, the n-back task memorization, their health points, and the otters, fully engaging their cognitive load. For example, the player may find themselves fending off neuron trees, trying to memorize the n-back task hint and trying to feed the otters simultaneously.

4 Future Work

The retention of pain experience metaphors and how they translate to new patients would help distinguish *Mobius Floe* from ordinary games. For example, do the helpful sea otters naturally correlate to feelings of comfort, friends or family? How does the health point mechanic translate to patient’s experiences? Do the depictions of drugs and how they operate in the virtual space realistically represent pain patient’s affective experiences? We will conduct several case studies with patients from Greater Vancouver to help evaluate the existing pain experience metaphors as well as the effectiveness of cognitive distraction and perceived pain reduction within *Mobius Floe*. To do so will help situate the position of *Mobius Floe* within the research field and provide further context as to where the development of *Mobius Floe* should gravitate toward.



Fig. 2. Two otters greeting the player. ‘HP’ is visually represented as a red icicle in the top left.

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