Journal of Clinical Psychology in Medical Settings
https://doi.org/10.1007/s10880-024-10047-z

Combining Hypnosis and Virtual Reality: A Qualitative Investigation of User Experience During an Experimental Pain Study

Éloïse Cardinal[1,2] · Pierre Augier[1,2] · Émilie Giguère[1,3] · Mathieu Landry[4,5] · Sylvie Lemay[6,7] · Jade Véronneau[1,2] · Anne-Sophie Nyssen[8,9] · Marie-Elisabeth Faymonville[9,10] · Audrey Vanhaudenhuyse[9,10] · Pierre Rainville[2,3,12] · Floriane Rousseaux[2,3,8,9] · David Ogez[2,11]

Accepted: 28 August 2024

Abstract

Virtual reality (VR) and hypnosis (H) are useful pain management tools, but the potential benefit of their combination (VRH) has yet to be studied. This study examines the user experience of VRH, compared to H and VR alone, using interviews following an experimental study examining the effect of the three interventions on pain perception. Following a within-subjects repeated measures experimental design, 16 participants received the three interventions during which they received painful electrical stimuli. Following each intervention, explanatory interviews were conducted to allow participants to elaborate on their user experience. A thematic analysis was conducted on the data collected. Three themes emerged from the interviews: (1) satisfaction: participants mostly had positive feelings toward the three modalities, with the most beneficial effects on relaxation expressed for H. (2) Body perception and attention focus: immersion in the VR and VRH conditions was appreciated. Participants described their perceptions of pain perception during the 3 conditions. (3) Device acceptability: H was the most liked, followed by VRH, and then VR alone. Intention of use was reported following the same order. The data collected highlighted participants' opinions of these different interventions and suggested adjustments for future development of the VRH intervention in pain management.

Keywords Virtual reality · Hypnosis · Experimental pain · User experience · Qualitative analysis

Introduction

In recent years, virtual reality with hypnosis (VRH) has been gaining attention in some hospital wards. This intervention is presented as an alliance of complementary

Éloïse Cardinal and Pierre Augier—First co-authors.

Floriane Rousseaux and David Ogez—Senior co-authors.

✉ David Ogez
David.ogez@umontreal.ca

[1] Department of Psychology, University of Montreal, Montreal, Canada

[2] Medical Hypnosis Laboratory, Research Center of Maisonneuve-Rosemont Hospital, 5415, Boulevard de L'Assomption, Montreal, QC H1T 2M4, Canada

[3] Research Centre, Institut Universitaire de Gériatrie, Montreal, Canada

[4] McGill University, Montreal, Canada

[5] CocoLab, Faculty of Psychology, University of Montreal, Montreal, Canada

[6] Faculty of Nursing, University of Montreal, Montreal, Canada

[7] Research Center, CHU Ste-Justine, Montreal, Canada

[8] Laboratory of Cognitive Ergonomics and Work Intervention, University of Liege, Liege, Belgium

[9] Sensation and Perception Research Group, GIGA-Consciousness, University of Liege, Liege, Belgium

[10] Algology Interdisciplinary Center, University Hospital of Liege, Liege, Belgium

[11] Department of Anesthesiology and Pain Medicine, University of Montreal, Montreal, Canada

[12] Department of Stomatology, University of Montreal, Montreal, Canada

Published online: 13 October 2024

techniques (virtual reality and hypnosis) that have both been shown to be effective in relieving acute and chronic pain, although the results are less consistent for the second category of pain (Grassini, 2022; Mallari et al., 2019; Thompson et al., 2019). VRH is a procedure that first appeared in a clinical research context in 2004 (Patterson et al., 2004) and has been shown to be effective in reducing clinical and experimental pain in randomized controlled trials (Rousseaux et al., 2022). Various User Experience (UX) models have been devised to comprehend and articulate the holistic aspect of user interactions with interactive products (Hornbæk & Hertzum et al., 2017).

Previous reports on the UX of virtual reality and hypnosis identify several variables that are more relevant to each (Bonshtein, 2018; Phelan et al., 2019; Trost et al., 2021) but mainly focus on measuring satisfaction (Jensen et al., 2006). Satisfaction is only one part of acceptability taken from the field of new technology ergonomics and UX considerations. This does not take into account other dimensions, such as preferences or intention to use (Sagnier et al., 2019).

Objectives

We aimed to describe and compare the users' experiences when using hypnosis (H), virtual reality (VR), and their combination (VRH) in the context of an experimental study on the perception of acute pain. Data on user experiences were collected using individual semi-structured interviews, with the goal of further documenting the relevant properties of H and VR as well as the articulation of these two procedures to improve their applicability and effectiveness.

Methods

Recruitment and ethics

We recruited a convenience sample of adults between 18 and 65 years old using posters placed in the university, ads on social networks, and word of mouth. The exclusion criteria were the following: uncorrected vision or hearing problems, neurological (e.g., epilepsy) or psychiatric pathology, chronic pain, skin irritation, use of psychotropic or analgesic drugs, phobia of water, seabed, or fish displayed in the VR environment. The study was approved by the Aging-Neuroimaging Research Ethics Committee of our institution (project CR VN 21-22-27). All participants provided written informed consent and received financial compensation (15 CAD per hour) for their participation (Fig. 1).

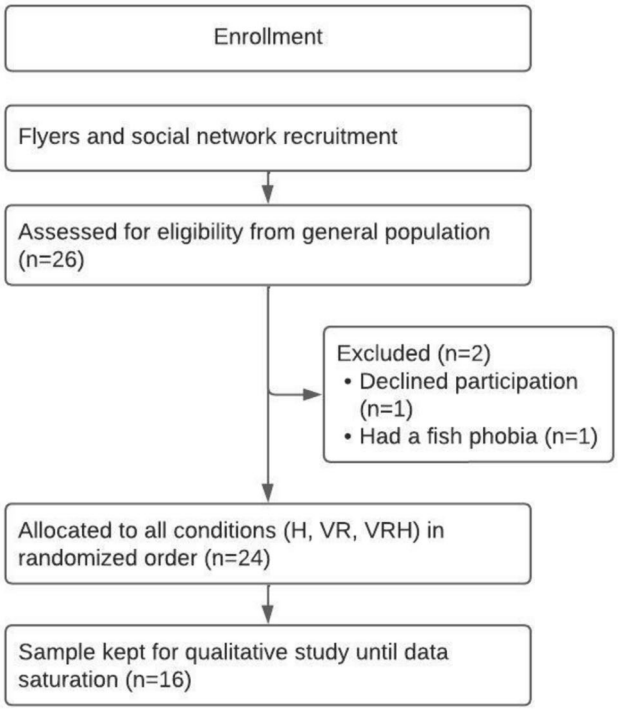

Fig. 1 Study flowchart

Material

This study was part of a larger experiment aiming to evaluate quantitatively the effects of a VRH procedure on pain perception. VRH was provided using a head-mounted display (Sedakit™, Oncomfort SA). This VRH device was described in a previous study (Rousseaux et al., 2022). This VRH is composed of a smartphone plugged in a VR headset, an audio headset and integrated software (Medical device Class IA). This device is non-invasive, with only skin contact. The VRH session used was "Aqua®", an immersive contemplative virtual experience that combines a 3D video with voice recording based on a hypnotic scenario recorded in French by a trained hypnotherapist. Visual experience is carefully synchronized with the hypnotic script and allows subject to induce and maintain a relaxed state with a disconnection from their external surrounding (Fig. 2).

Procedure

First, we individually calibrated the electrical stimuli to produce moderate pain for each participant. Participants' suggestibility was assessed in this first session using the Stanford Hypnotic Susceptibility Scale (Hilgard, 1978). Then, all volunteers went through the different conditions

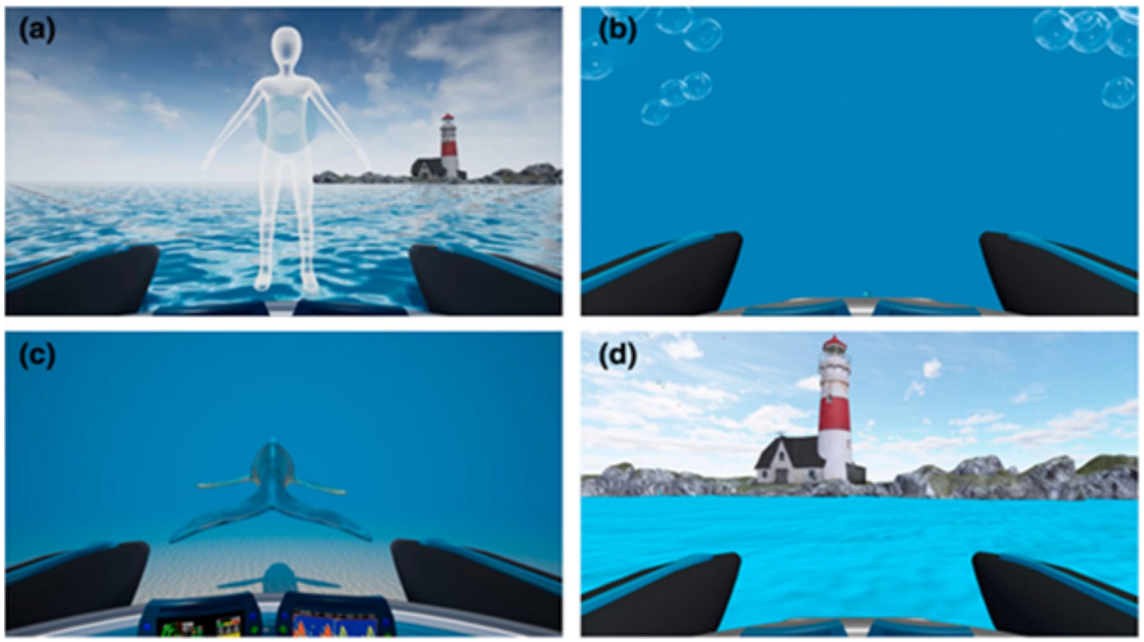

Fig. 2 Aqua device designed by Oncomfort®

in a counterbalanced order following a repeated measures within-subjects experimental design. Electrical stimuli were given during each intervention (10 stimuli in 20 min). Interviews were conducted after each session.

Device

The Aqua® VRH session follows the standard phases of hypnosis: (1) induction phase: subjects are over the surface of the sea, they are invited to focus their attention on their breath, and to induce progressive relaxation in their body; (2) guidance phase: the subjects slowly goes under the water; (3) deepening phase: subjects follow a soothing underwater experience with specific suggestions regarding their comfort and relaxation; and (4) realtering phase: the subjects are progressively back into reality, concomitant with return to normal body sensations. When the VRH device is removed, the subjects naturally return to normal perceptions. The VR procedure used the same virtual 3D video from Aqua® without the audio headset. For the H procedure, we used only the audio headset to administer only the audio session from Aqua®. Each intervention lasted for 10 minutes and was conducted sequentially on the same day, in a randomized order for each participant.

Interviews

Semi-structured interviews were conducted at the end of each session. Participants were invited to describe their experiences in each condition and to elaborate on their feelings, emotions, images, and memories. At the end of the last testing session, they were further asked additional questions about all three interventions. These questions aimed to gather information on their global experience of the three conditions, compare experiences between conditions, elicit a preference for one of the interventions, and elicit their intention to use one of the interventions in future. The individual semi-structured interviews were audio recorded and transcribed verbatim. The interview questions were open-ended, leaving flexibility for participants to clarify or elaborate on elements that they deemed relevant to their experience. The list of criteria for reporting qualitative research (COREQ) was followed to consolidate the different stages of the study (Tong et al., 2007).

Data Analysis

Qualitative data from the verbatims were processed and analyzed following Braun and Clarke's thematic analysis method (Braun & Clarke, 2021a, 2021b, 2022) consisting of the following:

(1) Familiarization with the data
(2) Systematic coding of the data
(3) Development of themes
(4) Development, review of themes, and aim for an inter-judge agreement
(5) Refinement, definition, and naming of themes
(6) Report writing

Data were coded using QDA Miner V6.0.13.7 software (Provalis Research, Montreal, Canada). The thematic analyses were discussed to reach inter-judge agreement between the two coders (PA and EC). A minimum of 12 participants has to be included in the analysis to be consistent with the expected data saturation effect (Constantinou et al., 2017) and all verbatims were considered.

Results

Characteristics of the participants are in Table 1.

Table 1 Sample description

Participants' characteristics	Number of participants (N = 16)	%
Sex		
Women	7	43.75
Men	9	56.25
Level of education		
> 5 post-secondary years	9	56.25
> 3 post-secondary years	3	18.75
< 3 post-secondary years	4	25
Employment status		
Technology sector: engineering, computer science	7	43.75
Healthcare	5	31.25
Teachers	2	12.50
Students	2	12.50

The analysis allowed us to identify three main themes: (1) Satisfaction; (2) Body Perception and Attention Focus; and 3) Social Acceptability (see Fig. 3 for the Thematic Tree and Table 2 for the definitions of themes and sub-themes).

Theme 1. Satisfaction

While sharing their experiences, participants commented on their level of satisfaction with the different conditions, i.e., VR, H, or VRH. This satisfaction was related to the feelings and the relaxation resulting from the technique used. Both positive and negative points emerged from the interviews.

Feelings

Positives The positive feelings expressed were prevalent in the three conditions: "*It was a very pleasant experience*" (participant 7: P7), "*Interesting*" (P6). Specifically, VR alone was positively described as entertaining, friendly, having the quality of not asking its user to imagine by himself, "*I don't need to imagine anything*" (P09), and visually stimulating, "*There were a lot of colors, there were a lot of things moving*" (P21). Hypnosis was described as positive for clearly different reasons: "*It was reassuring*" (P27). Several mentioned enjoying being able to close their eyes. All participants did so for this condition although at no point during the experience was this asked nor suggested "*I clearly prefer to have my eyes closed and then listen to a voice…*" (P27). Others mentioned that it was easier for them to listen than to have to look at something. Finally, the VRH condition was described as complete, able to channel attention, using several senses including sight and requiring less

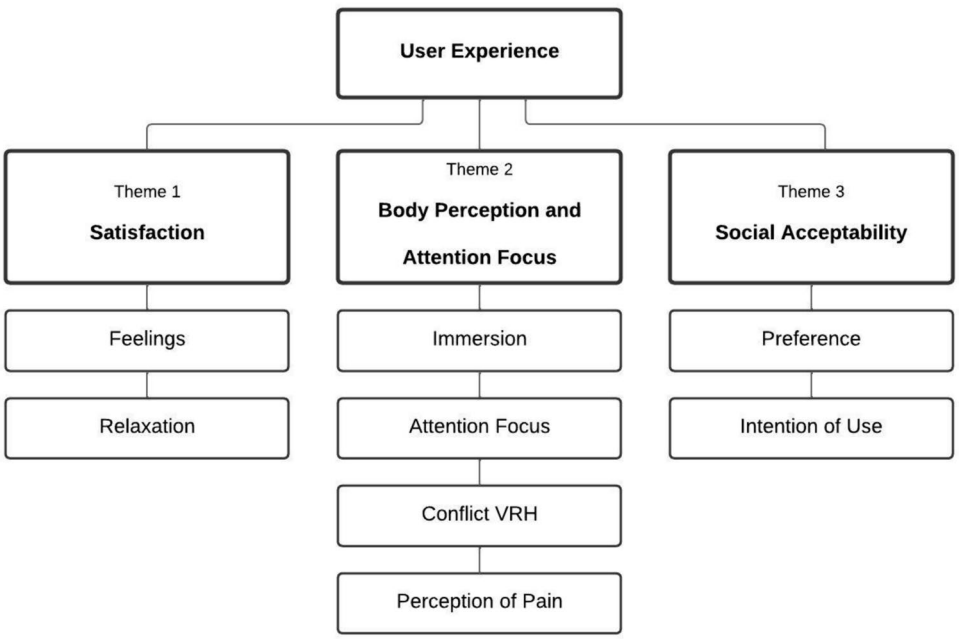

Fig. 3 Thematic Tree

Table 2 Definitions of themes

Themes	Definitions
User experience (UX)	"While creating the application, it should be attempted to provide a solution that is highly responding to the user's needs. Depending on how successfully this methodology is implemented in the application, the user experience will be better" (Kojić et al., 2023)
Satisfaction	In our study, we consider the expression of participants' satisfaction as their positive feeling toward the techniques and their improvement in terms of level of relaxation
Feelings	Positive and negatives feelings expressed spontaneously by participants in the three conditions
Relaxation	Expression of participants' level of relaxation following their exposure to the different conditions
Body perception	In literature, it is defined as a self-representation that is developed as a structure that interacts with its environment and "the conscious aspect of being a self through the subjective experience of having a body" (Neyret et al., 2020). In our study, we use this term when referring to the capacity to be aware of bodily and physical manifestations that occur during the use of hypnosis or virtual reality
Attention focus	Attention focus is considered as absorption in the H and VRH conditions as "the tendency to be completely involved in a perceptual or imaginary experience" (Spiegel, 1991), as well as presence for VR and VRH as "the sensation of being in the proposed environment without physically being there. The literature distinguishes those two terms: absorption being used in the field of hypnosis and presence in the field of VR. The particularity of presence is that it causes one to produce behaviors that are congruent with one's situation in the proposed environment" (Slater, 2003) as well as a sense of having control over the experience. Because these two terms are difficult to differentiate in the VRH condition and in order to avoid misinterpreting participants' reports, they have been subsumed under the term "Attention Focus"
Immersion	Immersion is understood here as "the extent to which computer screens are able to provide an inclusive, expansive, surrounding, and living environment, an illusion of reality to the senses of a human participant" (Slater & Wilbur, 1997) and therefore excludes condition H
Conflict VRH	Negative experience in the VRH condition and coded as a possible conflict between the VR and H features
Perception of pain	An unpleasant sensation that occurs when the stimulation of nociceptive receptors in the nervous system is strong enough, resulting in a subjective experience of a sharp, tingling pain (Garland, 2012)
Social acceptability	Social acceptability concerns the attitudes expressed toward a technology or technological device in a prospective way, upstream of the practical experience of the technology or its introduction (Schade & Schlag, 2003)
Preferences	Participants' inclination or choice of their favorite conditions, based on their taste, values, needs, and other criteria, following their first use of the three techniques
Intention of use	The intention to use a technology, without this necessarily leading to actual use (Sagnier et al., 2019)

effort: "*I find that… Well, audio, and visual together works better than just audio alone. Because on the one hand, it makes more sense to use*" (P20). One person expressed a desire to extend the experience.

Negatives Several people expressed a negative feeling tending toward boredom in VR: "*Without the sound on I was waiting to see what would happen*" (P12). Only two comments on negative feelings were reported in condition H and concerned the refusal of injunctions, "*I didn't listen because it [the voice] was going to tell me how to breathe*" (P7), the fact that the sound alone was not enough to concentrate, "*I had a really hard time concentrating on someone talking, without an image…*" and well as the pace of the voice judged too fast (P8). The negative feelings expressed about the VRH condition concerned the voice, describing it as unpleasant (P8), anxiety-provoking, and overly stimulating "*It was really frustrating*" (P7).

Relaxation

Positives The lexical field of relaxation appeared in all three conditions: "*Very relaxed*" (P14), "*Peaceful… Calm*" (P22), and "*A moment of relaxation*" (P12). In H, the use of breathing to induce hypnosis was highlighted as facilitating relaxation. Hypnosis was described as less visually stimulating, "[…] *it was much easier to calm myself*" (P21), and the voice was considered as relaxing, "*The woman's voice […] it helped me relax…*" (P19). Finally, the VRH was mentioned as allowing one to let go "*a heaviness of the body*" (P14), bringing a sense of lightness.

Negatives The VR condition was mentioned as detrimental to relaxation by some participants, "*I didn't think about the relaxation aspect at all*" (P13). A negative aspect of the deep relaxation state in the H condition was the difficulty in returning to this state following electrical stimulation. Finally, the VRH condition was also described as detrimen-

tal to relaxation. Among the negative aspects were the voice instructions to reach the relaxed state and the fact that VRH required more energy than H alone: "*It takes less effort [to listen] than to keep your eyes open*" (P14).

Theme 2. Body Perception and Attention Focus

While describing their experience, participants discussed the immersive qualities of the material, the redirection of perceived attention, and the perception of pain during the conditions.

Immersion

Positives Immersion was positively evoked in the VR condition. The quotes concerned the realism of the graphics, the closeness of the sensations between the proposed situation and the real situation, "*I felt like I was in apnea with the helmet*" (P21) and the capacity of the procedure to capture attention and arouse curiosity, "*it makes me want to continue exploring the world*" (P28). In VRH, comments related to immersion were also noted. Again, some talked about the feeling of realism fostered by the sound and image coupling, of the fact that the procedure brings you elsewhere than your direct environment. The interactivity of the procedure was sometimes mentioned: "*being able to move in the set*" (P24), "*to walk around in it*" (P13), even though it is a contemplative VR (Buche et al., 2021).

Negatives Immersion was also described negatively in the VR condition. Testimonies criticized the lack of realism and the limitations of the graphics: "*It lacked realism from a visual point of view, so I didn't focus on it and did anything*" (P23). The lack of interactivity was verbalized, "*It feels more like a movie theater than a VR experience where you can interact*" (P8). Negative critiques of immersion in the VRH condition focused primarily on the lack of realism and appeal of the proposed environment.

Attention Focus

Positives Participants in all three conditions mentioned attention focus and the feeling of being in the proposed location. In the VR condition, this may have taken the form of a sense of control in the movement of the camera: "*when we were diving underwater*" (P7) and "*I direct myself where I want to look*" (P9). It was also verbalized that the image alone allowed to leave more room for one's imagination. In the H condition, the testimonies mentioned the sensation of having felt being elsewhere: "*the journey was deeper*" (P23). In the VRH condition, some said they felt like they were in another world, or even that they had forgotten they were in the room and/or the sensation of their body.

Negatives Negative experiences of attention focus were evoked in all three conditions. In the VR condition, the sensation of being like in a movie theater, "*like a movie*" (P13), led to a difficulty in feeling involved in the environment. In the H condition, people reported a tendency to anticipate the pain stimuli. It was also mentioned that with one less stimulated sense (compared to VRH), it decreased the sense of presence: "*As soon as one of the two [image or sound] is removed, I feel less in it*" (P11). Finally, in the VRH condition, participants also emphasized a difficulty in feeling part of the environment, "*we are not in graphics that allow us to say to ourselves 'I am here'*" (P24) and a feeling of not being fully in the experience: "*I feel that I am not really gone*" (P14).

Conflict VR/H

Participants reported a difficulty in making room for their imaginations due to too many surrounding stimuli. Some felt a sense of back and forth between the voice and the visual medium: "*Since there was something audio that was drawing my attention a lot, I felt much less connected to the virtual environment*" (P21). Others commented on this difficulty in choosing between visual and auditory stimuli that made the experience difficult: "*I was inclined to want to close my eyes and then at the same time I would say to myself no, I have to look*" (P9).

Perception of Pain

A final theme related to the perception of the body that emerged from the interviews is the perception of pain. All three conditions had benefic and negative effects on the perception of pain during the shocks, due to relaxation (H, VRH), distraction (H, VR, VRH), and immersion (VR, VRH).

Relaxation

Positives By being relaxed, some participants reported feeling less intensely the electric impulses in H and VRH conditions, as if from further away. One participant reported that the first electric impulse, which was always the most intense in other conditions, was less so with condition H. Others reported that the intensity of the sensations was lower in the H condition than in the control (without any stimuli). Another participant added that this condition allowed him to relax better, accept the pain, and tense up less with each impulse than in VRH due to the absence of conflict between auditory and visual modalities. "I found it much less visually stimulating. It made it much easier to calm down and reduce the stress related to the pain" (P21). However, this opinion was nuanced between participants. Some reported

the combination of visual and auditory modalities as being helpful to relax and feel less pain from the shocks in the VRH condition.

Negatives Some comments nuanced the benefit of relaxation in the H and VRH conditions. Participants expressed that the more relaxed they were, the more anxiety the shock caused them. As one participant said: "Every time there's an electric shock, it makes me more anxious than the first time because I was in a pretty comfortable state, and all of a sudden, there's a shock, so it seems more abrupt than before" (P28). One participant also found that it was more difficult to relax in the VRH condition.

Distraction

Positives By being distracted and focusing on something else than the pain in the VR and VRH conditions (e.g., the whale), participants reported feeling less stressed and anticipating the shocks. They were able to give a meaning to the pain and to better accept it. Some reported that these setups allowed them to think about something else and to feel less pain. The shocks were less unpleasant and noticeable: "in [the VR condition], I felt that I could ignore the pain; I could even integrate a meaning to that pain since I felt a bit like I was free-diving, with the headset too. So that was okay, [the silence] was just something that was part of the experience" (P21). The distraction with the VR setup (VR, VRH) was reported to help distraction from pain better than the control condition: "[…] in terms of discomfort, I feel that it was less unpleasant when you felt the shocks with the VR headset than without" (P08). One participant explained the reduced pain in the VRH condition by the fact that he felt less present in his body: "I was really [present] in another reality. You kind of forget your real body. Even though the intensity [of the shocks] increases, I found that I felt them less because I was more in the virtual world" (P20).

Negatives Some less pleasant aspects related to distraction were mentioned. With the VR condition, one participant reported finding it difficult to focus on anything other than the shocks: "You're focused in [the] VR, but at the same time, you're aware that you're going to get shocks. I think it influences you too, because maybe you're not fully focused on the VR aspect, knowing that at any moment, a shock is coming" (P08). Also, according to some participants, purely auditory content was less distracting from the pain, making it more annoying and intense in the H condition. One participant reported that when he disagreed with what the H recording suggested, the pain felt more intense. By being less distracted once the incoherence emerged, the surprise became more significant, and the intensity of the shocks enhanced. A downside of the H recording also emerged in the VRH condition. A participant mentioned feeling the pain more intensely in this condition due to the suggestions to focus attention on breathing and the body: "I was much more focused on my physical sensations and the pain, so it was much harder to ignore. And it was more frustrating when there were shocks, maybe, than in the previous experience" (P21).

Immersion

Positives Immersion was a positive element of the VRH condition that helped participants feel less discomfort from the shocks. Some participants reported no longer feeling any pain during the electric stimulations, but rather surprised: "There were two moments where the electric shock was much more about intensity than pain. There was almost zero pain. It was more like a surprise. I kind of forgot there was that on two occasions" (P09). Thus, several participants reported that the pain felt in VRH was less than in the other two conditions: "With the image and the sound, I almost didn't feel [the electric shocks] compared to the times when there was only the image or only the sound" (P24).

Negatives A downside was the enhanced surprise caused by the shocks. In the VR condition, some found the pain and discomfort exacerbated by the surprise of being in the peaceful VR environment when the shocks came. Another participant felt that the auditory modality was missing from the experience, making it less "magical" and thus the pain felt more intense. "Because we feel the lack and it has less magic. […] We will focus on the external noises, we won't necessarily be immersed and so we are also a bit surprised when it happens, hence a much stronger feeling of pain and discomfort" (P24).

In summary, participants reported the benefits and drawbacks of each of the three conditions (H, VR, VRH) on their perception of pain during the electric shocks. The main takeaway from the interviews is the reduction of perceived pain in all three conditions, with superior benefits compared to the control condition without distractions.

Theme 3. Social Acceptability

Verbatim analysis revealed a final theme regarding the social acceptability of the different procedures, following the experimentation in all three conditions. Participants expressed their preferences and their intention to use the different procedures in real-life contexts.

Preference Regarding Condition

Half (50%) of the sample said they preferred hypnosis alone. Six (37.5%) said they preferred the VRH condition and two (12.5%), the VR condition.

Intention of Use

Overall, the VR condition was underrepresented in the responses for this third theme. In relation to the hypnosis procedure, half of the participants said they would use an audio device at other times if offered (e.g., during a visit to the dentist). Some said they already use a similar device (e.g., ASMR or meditation scripts), which led them to consider using a pre-recorded hypnosis script in future: "*If I had that available, I think it could help me, for example, for muscle pain*" (P28). However, one participant said he did not intend to use hypnosis because he found the lack of control over the voice rhythm of the condition unpleasant (P11). Regarding the VRH procedure, half of the participants said they would use the VRH again for various reasons: positive experiences of reducing pain sensations and benefits in terms of relaxation. On the contrary, some participants said they did not want to use a VRH procedure again in a context of pain perception modulation, expressing a preference for a more interactive and playful context. Three participants said they did not intend to go back to any of these three procedures, citing difficulty relaxing or cost as an obstacle: "*No, I would be surprised, already because it's expensive, and if it's for a long pain, it's not adapted*" (P20).

Discussion

In this pilot study, we collected and compared the UX of individuals using VR, H, and VRH procedures in a pain research context. We wanted to go further than just a measure of satisfaction, pursuing the idea that a single variable is not sufficient to conclude about social acceptability or provide clear recommendations for improvement. The results consist of three themes obtained by cross-thematic analysis in agreement of semi-structured interviews.

The first theme was Satisfaction. Regarding the first sub-theme, Feelings, participants mostly expressed positive feelings toward the three modalities and with several quite similar terms (e.g., "*cool*," "*fun*," "*nice experience*"). Negative feelings were less numerous (e.g., unpleasant, anxiety-provoking) and diversified across the different interventions. It should be noted that hypnosis stands out for having fewer negative quotes regarding feelings. This difference could partly be due to the fact that the hypnosis procedure material (an audio headset) is a much more common object than the VR headset, making it easier to use and more familiar. Negative feelings about VR revolved around boredom about video content, whereas for the H condition, we observed rather a refusal of injunctions or difficulty staying in the experience. For the VRH condition, the element that stood out was too intense stimulation and a detrimental division of attention.

Regarding the second sub-theme, Relaxation, it should be noted that compared to other conditions, H condition is most often positively mentioned with terms like calm, peaceful, relaxing. For the same theme, it is also less often negatively considered in H. The descriptions used in this theme are generally quite similar from one condition to another. Negative testimonials regarding the different conditions are as follows: VR can miss its relaxing goal by not suggesting it; in H, returning to a state of relaxation after being taken out of it can take time; in VRH, relaxation requires effort and energy.

The second theme was related to Body Perception and Attention Direction. It is divided into two sub-themes, Immersion and Attention Focus. The method of elaboration and definition of themes from the coding allowed us to link some of the properties distinguished in different studies on hypnosis and VR, such as immersion, presence, and absorption with the data collected. The first sub-theme of this theme is Immersion. Immersion was appreciated for the content of the proposed virtual environment and the possibility of exploring it. It was negatively qualified for its graphic qualities, its lack of realism, and its lack of interactivity. This is in line with literature mentioning that in a virtual environment, the possibility of interaction with the environment as well as the quality of graphics positively influence the feeling of presence and immersion (Buch et al., 2021). We used contemplative VR, but the simple fact of having control over the viewing angle (as is the case in the experiment) is sometimes qualified as a voluntary and active action on the felt experience.

For the second sub-theme, Attention Focus, we note that the term "absorption" is commonly used in the hypnosis field and "presence" for VR environments (Slater, 2003). While quotes with the VR condition tend to talk about a living experience in an environment proposed outside the body (presence), the H condition seems to rather call for an experience of "not being here" and an inner experience (absorption). The VRH condition brings together these two types of comments.

For the negative comments on the attention focus, what is more prominent regarding VR is an inability to immerse oneself in the environment or not more than in a theater. This could be linked to the use of a contemplative VR which is known to be less immersive than an interactive one (Buch et al., 2021). The VR experience could have been affected by lack of sound and the type of video used during the VR experiences. In the H condition, some felt less absorbed in the experience than if they had had additional visual content. Some of the suggestions in this condition were to focus on one's body, sensations and breathing, these could have negatively influenced the perception of pain by focusing attention on the body. In VRH, presence and absorption are mixed, and this interaction sometimes causes discomfort. We have designated this as "VR / H conflict." These testimonials

sometimes went in the direction of a saturation of the senses, a discomfort felt in the attempt to invest both the visual environment and the suggestions of the audio script. All volunteers had closed their eyes for the H condition (without this being part of the instructions or the script), while the VR procedure requires visual attention. Some noted that they had preferred to close their eyes during the VRH condition. We remain cautious in interpreting this as a preference as if it is easy to decide not to see, it is not the same for what is to hear. This would support the hypothesis that the two procedures, instead of positively influencing each other (Askay et al., 2009; Wiechman et al., 2009), could interfere with each other (Enea et al., 2014).

The last sub-theme that emerged, Perception of Pain, allowed us to understand the subjective experience of discomfort and pain relief of each device. Overall, the three conditions (H, VR, VRH) were reported to reduce perceived pain compared to the control condition without distractions. Each condition had its unique benefits: Condition H helped some participants tolerate pain better through relaxation and distraction but was less effective for others who found purely auditory content insufficiently distracting. Condition VR provided a significant distraction, though some participants felt the peaceful VR environment made the shocks more surprising and painful. Condition VRH offered the most comprehensive distraction through combined visual and auditory stimuli, reducing pain and discomfort for many, although not universally. The interviews underscore the complex interplay between distraction, relaxation, and pain perception, suggesting that a multi-sensory approach (VRH) might be the most effective in reducing perceived pain.

The third theme emerging from our analysis, Social Acceptability, concerns the preference and the intention of use for each procedure. The H procedure was the most appreciated by the participants, followed by VRH and then by VR and the intention of use for VRH and H was equal. Several times the participants talked about the use of an audio device mixing indistinctly hypnosis, relaxation, and music. This partly biases the comparison with VR and VRH, but at the same time highlights that the acceptability of a technological device must consider the public's familiarity with it (Nadal et al., 2019). Despite this, half of the studied sample said they were ready to use VRH again.

Limitations

There are some limitations to this study. Firstly, the presence of the investigator is a necessary and facilitating condition for the use of the tool; on the other hand, it may lead to a desirability bias in the interviews and may have affected the expression or omission of negative feelings toward the three interventions. Regardless of the small sample size, we still have an overall portrait of participants' satisfaction of the different conditions. Secondly, due to the absence of measurement tools made it difficult to finely distinguish presence from absorption in the use of VRH procedure, thus the creation of an umbrella theme (Attention Direction). Also, in the VRH condition, some participants decided to close their eyes due sometime to the overstimulation they felt during the procedure or in order to feel more relaxed. The purpose of the study being to evaluate the UX experience, we consider that as a behavior that is part of the VR and VRH experience and up to user choice. Our results are still very rich in that sense. All interventions were delivered in the context of experimental pain induction, and participants with chronic pain were excluded. Therefore, it is unclear whether participants' experience of each intervention would be the same in the absence of pain or in the context of daily (i.e., non-experimental) pain (e.g., chronic pain, muscle aches/discomfort). In addition, the specific characteristics of our sample (relatively young, no older adults, and well-educated) limited the representation of non-working individuals and may affect the generalizability of our findings. Future studies should take these limitations into consideration.

Conclusion

The results of this study draw our attention to the user's experience of technological devices. They showed that participants had positive feelings and experience for all conditions, especially H and VRH, and that these techniques can be useful to reduce pain perception. More investigations would help better understand the underlying mechanisms. However, some reports highlighted important points that need to be considered when using VRH device. The data and their analysis highlight a conceptual limit between presence and absorption. Refining their definitions and means of measuring them could increase the adequacy between the procedure and the user by the possible emergence of certain measurable predictors. Some results support the idea of discomfort felt when using a procedure that simultaneously uses a recorded hypnosis script and a virtual reality environment, linked here to the way the user is invited to invest in the proposed environment. This leaves open the exploration of a non-simultaneous VRH intervention, supported by several participants who mentioned relying on the visual of the previously proposed VR when exposed to the H condition alone. Another possibility would be to deepen the elements that increase a sense of coherence between the audio and visual content of the VRH condition. This also emphasizes the importance of focusing on the user's experience when developing a technological procedure for care. Indeed, although these testimonies do not allow us to conclude on the effectiveness of the VRH intervention, they remain rich in information that can help better understand

and explain the possible effects if it were to be measured in a randomized controlled trial.

Acknowledgements We thank Carolane Desmarteaux for her help in setting up the laboratory to run the experiment, Anna Bendas and Regine Paul for the lab coordination. We thank Aminata Bicego, Nolwenn Marie, Charlotte Grégoire and all the Sensation and Perception Research Group for their support and advice. We thank Mathieu Piché for his help and discussions. We thank the CRIUGM and Udem for providing spaces and material.

Author Contributions Conceptualization and research design: FR, AV, PR, ASN, and MEF; Funding acquisition: FR, PR, AV, DO, MEF, and ASN; Experimentation and qualitative data acquisition: FR, EG, and PA; Data curation: EG, PA, EC, and FR; Qualitative data analysis: PA and EC; Visualization: PA, EC, DO, and PR; Writing of the Original draft: EC and PA; Supervision and revisions: DO, ML, PR, FR, and AV; all authors reviewed and approved the final version of the article.

Funding This study was funded by a pilot grant for Strategic and Structuring Research Projects of the Research Center of the *Institut universitaire de gériatrie de Montréal (CRIUGM)* and Mitacs Funding (Wallonie-Bruxelles International, Belgium). This research is also funded by the National Funds for Scientific Research (FRS-FNRS Télévie), the University and University Hospital of Liège, the AstraZeneca Foundation, the Belgian Foundation Against Cancer (Grants Number: 2017064 and C/2020/1357), the Benoit Foundation (Brussels), Crédits Sectoriels de la Recherche and Non-Fria Grant (University of Liege, Belgium), and Wallonia as part of a program of the BioWin Health Cluster framework.

Data Availability Data transparency.

Code Availability Software application or custom code.

Declarations

Conflict of interest Éloïse Cardinal, Pierre Augier, Émilie Giguère, Mathieu Landry, Sylvie Lemay, Jade Véronneau, Anne-Sophie Nyssen, Marie-Elisabeth Faymonville, Audrey Vanhaudenhuyse, Pierre Rainville, Floriane Rousseaux, and David Ogez declare that they have no conflict of interest. The VR device and a license to use OnComfort Digital Sedation™ were provided, free of charge, to conduct the study. AV provides expert counsel to OnComfort on research on clinical application of VRH but receives no personal advantage, financial or otherwise, for this participation.

Ethical Approval This study was performed in line with the principles of the Declaration of Helsinki. The study was approved on the 06/12/2021, by the Aging-Neuroimaging Research Ethics Committee and the Clinical Research Ethics Committee of the University of Montreal, as part of CR VN 21-22-27.

Consent to Participate Include appropriate consent statements.

Consent for Publication Consent statement regarding publishing an individual's data or image.

References

Askay, S. W., Patterson, D. R., & Sharar, S. R. (2009). Virtual reality hypnosis. *Contemporary Hypnosis: The Journal of the British Society of Experimental and Clinical Hypnosis, 26*(1), 40–47. https://doi.org/10.1002/ch.371

Bonshtein, U. (2018). Hypnosis for pain relief. *Journal of Anesthesia & Intensive Care Medicine*. https://doi.org/10.19080/JAICM.2018.05.555657

Braun, V., & Clarke, V. (2021a). One size fits all? What counts as quality practice in (reflexive) thematic analysis? *Qualitative Research in Psychology*, *18*(3), Article 3. https://doi.org/10.1080/14780887.2020.1769238

Braun, V., & Clarke, V. (2021b). *Thematic analysis: A practical guide*. SAGE.

Braun, V., & Clarke, V. (2022). Conceptual and design thinking for thematic analysis. *Qualitative Psychology*, *9*(1), Article 1. https://doi.org/10.1037/qup0000196

Buche, H., Michel, A., Piccoli, C., & Blanc, N. (2021). Contemplating or acting? Which immersive modes should be favored in virtual reality during physiotherapy for breast cancer rehabilitation. *Frontiers in Psychology*. https://doi.org/10.3389/fpsyg.2021.631186

Constantinou, C. S., Georgiou, M., & Perdikogianni, M. (2017). A comparative method for themes saturation (CoMeTS) in qualitative interviews. *Qualitative Research, 17*(5), 571–588. https://doi.org/10.1177/1468794116686650

Enea, V., Dafinoiu, I., Opriş, D., & David, D. (2014). Effects of hypnotic analgesia and virtual reality on the reduction of experimental pain among high and low hypnotizables. *International Journal of Clinical and Experimental Hypnosis, 62*(3), 360–377. https://doi.org/10.1080/00207144.2014.901087

Garland, E. L. (2012). Pain processing in the human nervous system: A selective review of nociceptive and biobehavioral pathways. *Primary Care, 39*(3), 561–571. https://doi.org/10.1016/j.pop.2012.06.013

Grassini, S. (2022). Virtual reality assisted non-pharmacological treatments in chronic pain management : A systematic review and quantitative meta-analysis. *International Journal of Environmental Research and Public Health, 19*(7), 4071. https://doi.org/10.3390/ijerph19074071

Hilgard, E. R. (1978). The Stanford Hypnotic Susceptibility Scales as related to other measures of hypnotic responsiveness. *American Journal of Clinical Hypnosis*, *21*(2–3), Article 2–3. https://doi.org/10.1080/00029157.1978.10403965

Hornbæk, K., & Hertzum, M. (2017). Technology acceptance and user experience: A review of the experiential component in HCI. *ACM Transactions on Computer–Human Interaction*, *24*(5), Article 5. https://doi.org/10.1145/3127358

Jensen, M. P., McArthur, K. D., Barber, J., Hanley, M. A., Engel, J. M., Romano, J. M., Cardenas, D. D., Kraft, G. H., Hoffman, A. J., & Patterson 1, D. R. (2006). Satisfaction with, and the beneficial side effects of, hypnotic analgesia. *International Journal of Clinical and Experimental Hypnosis*, *54*(4), Article 4. https://doi.org/10.1080/00207140600856798

Kojić, T., Spang, R., Vergari, M., Meier, L., Möller, S., & Voigt-Antons, J.-N. (2023). Effects of user factors on user experience in virtual reality: Age, gender, and VR experience as influencing factors for VR exergames. *Quality and User Experience, 8*(1), 3. https://doi.org/10.1007/s41233-023-00056-5

Mallari, B., Spaeth, E. K., Goh, H., & Boyd, B. S. (2019). Virtual reality as an analgesic for acute and chronic pain in adults : A systematic review and meta-analysis. *Journal of Pain Research, 12*, 2053–2085. https://doi.org/10.2147/JPR.S200498

Nadal, C., Gavin, D., & Sas, C. (2019). *Technology acceptability, acceptance and adoption—Definitions and measurement*. CHI Conference on Human Factors in Computing Systems, Lancaster University.

Neyret, S., Bellido Rivas, A. I., Navarro, X., & Slater, M. (2020). Which body would you like to have the impact of embodied

perspective on body perception and body evaluation in immersive virtual reality. *Frontiers in Robotics and AI, 7*, 492886.

Patterson, D. R., Tininenko, J. R., Schmidt, A. E., & Sharar, S. R. (2004). Virtual reality hypnosis: A case report. *International Journal of Clinical and Experimental Hypnosis, 52*(1), 27–38. https://doi.org/10.1076/iceh.52.1.27.23925

Phelan, I., Furness, P. J., Fehily, O., Thompson, A. R., Babiker, N. T., Lamb, M. A., & Lindley, S. A. (2019). A mixed-methods investigation into the acceptability, usability, and perceived effectiveness of active and passive virtual reality scenarios in managing pain under experimental conditions. *Journal of Burn Care & Research, 40*(1), 85–90. https://doi.org/10.1093/jbcr/iry052

Rousseaux, F., Dardenne, N., Massion, P. B., Ledoux, D., Bicego, A., Donneau, A.-F., Faymonville, M.-E., Nyssen, A.-S., & Vanhaudenhuyse, A. (2022). Virtual reality and hypnosis for anxiety and pain management in intensive care units : A prospective randomised trial among cardiac surgery patients. *European Journal of Anaesthesiology, 39*(1), 58–66. https://doi.org/10.1097/EJA.0000000000001633

Sagnier, C., Loup-Escande, É., & Valléry, G. (2019). Acceptabilité de la réalité virtuelle : Une revue de la littérature. *Le Travail Humain, 82*(3), 183–212. https://doi.org/10.3917/th.823.0183

Schade, J., & Schlag, B. (2003). Acceptability of urban transport pricing strategies. *Transportation Research Part F: Traffic Psychology and Behaviour, 6*(1), 45–61. https://doi.org/10.1016/S1369-8478(02)00046-3

Slater, M. (2003). A note on presence terminology. *Presence Connect*, *3*.

Slater, M., & Wilbur, S. (1997). A framework for immersive virtual environments five: Speculations on the role of presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, *6*(6), 603–616. https://doi.org/10.1162/pres.1997.6.6.603

Spiegel, D. (1991). Neurophysiological correlates of hypnosis and dissociation. *The Journal of Neuropsychiatry and Clinical Neurosciences, 3*(4), 440–445. https://doi.org/10.1176/jnp.3.4.440

Thompson, T., Terhune, D. B., Oram, C., Sharangparni, J., Rouf, R., Solmi, M., Veronese, N., & Stubbs, B. (2019). The effectiveness of hypnosis for pain relief: A systematic review and meta-analysis of 85 controlled experimental trials. *Neuroscience & Biobehavioral Reviews, 99*, 298–310. https://doi.org/10.1016/j.neubiorev.2019.02.013

Tong, A., Sainsbury, P., & Craig, J. (2007). Consolidated criteria for reporting qualitative research (COREQ): A 32-item checklist for interviews and focus groups. *International Journal for Quality in Health Care: Journal of the International Society for Quality in Health Care*, *19*(6), Article 6. https://doi.org/10.1093/intqhc/mzm042

Trost, Z., France, C., Anam, M., & Shum, C. (2021). Virtual reality approaches to pain: Toward a state of the science. *Pain, 162*(2), 325–331. https://doi.org/10.1097/j.pain.0000000000002060

Wiechman, S., Patterson, D., & Sharar, S. (2009). Virtual reality hypnosis. *Contemporary Hypnosis: The Journal of the British Society of Experimental and Clinical Hypnosis, 26*, 40–47. https://doi.org/10.1002/ch.371