

# The use of virtual reality for coping with pain with healthy participants

José Gutiérrez-Maldonado<sup>1</sup>, Olga Gutiérrez-Martínez<sup>1</sup>, Desirée Loreto-Quijada<sup>1</sup> and Rubén Nieto-Luna<sup>2</sup>

<sup>1</sup> University of Barcelona and <sup>2</sup> Open University of Catalonia

The present study investigates whether a virtual reality (VR) intervention can influence pain catastrophizing, pain self-efficacy and other pain-related measures reported during a cold-pressor experience. Forty-five healthy participants underwent two consecutive cold-pressor trials, one using VR and one without VR exposure, in counterbalanced order. The VR intervention encouraged participants to search actively for the correspondence between the pain experienced and a VR stereoscopic figure, which could be interactively manipulated. The VR intervention led to significant increases in pain threshold, pain tolerance and pain self-efficacy, as well as a significant reduction of in vivo pain catastrophizing. The possibilities of using VR as a tool for enhancing perceived pain control are discussed.

*El uso de la realidad virtual para el afrontamiento del dolor con participantes sanos.* El presente estudio investiga si una intervención con Realidad Virtual (RV) puede influir en el catastrofismo, la autoeficacia y otras medidas relacionadas con el dolor. Cuarenta y cinco participantes sanos se sometieron a dos ensayos consecutivos de cold-pressor, uno utilizando RV y otro sin exposición a RV, en orden contrabalanceado. La intervención con RV estaba basada en la manipulación de una figura estereoscópica que representaba la sensación dolorosa. La intervención con RV condujo a incrementos significativos en el umbral de dolor, la tolerancia y la percepción de autoeficacia, así como a reducciones significativas en las puntuaciones de catastrofismo. A partir de los resultados obtenidos, se discuten las posibilidades de usar la RV como técnica para aumentar el control percibido sobre el dolor.

Almost 40% of adults worldwide report common chronic pain conditions, including back pain, headache, and arthritis; 25% of all adults experience chronic pain that interferes substantially with life activities, and 10% have a pronounced disability in their social life associated with chronic pain (Von Korff, 2011). Severe chronic pain is associated with increased risk of mortality, independent of socio-demographic factors (Torrance, Elliot, Lee, & Smith, 2010).

Psychological interventions are known to be effective in treating pain disorders (Eccleston, Williams, & Morley, 2009). Glombiewski, Sawyer, Gutermann, Koenig, Rief, & Hofmann (2010) conducted a meta-analysis to quantify the size of controlled and uncontrolled short-term and long-term treatment effects of psychological treatments on fibromyalgia symptoms and to identify treatment moderators. They examined 23 studies that included 30 psychological treatment conditions and 1,396 patients. The results suggested that the effects of psychological treatments for fibromyalgia are relatively small but robust and comparable to those reported for other pain and drug treatments used for this disorder. Cognitive-behavioral therapy (CBT) was associated with the greatest effect sizes. Moderator analyses revealed cognitive-behavioral treatment to be significantly better than other psychological treatments in short-term pain reduction,

higher treatment dose was associated with better outcome, and publication-bias analyses demonstrated that the effect sizes were robust. Other studies suggest that the most effective therapeutic strategies to control pain may be different for men and women (Miró, Diener, Martínez, Sánchez, & Valenza, 2012).

Distraction is a psychological pain intervention that has been shown to possess considerable efficacy (Blount, Piira, & Cohen, 2003). Of late, there has been growing interest in the use of virtual reality (VR) technology as a method of pain reduction by means of distraction. Until recently, evidence of the effectiveness of VR distraction for pain reduction came primarily from case materials and studies using a one-group pre-post design (Mahrer & Gold, 2009). However, during the last few years, there have been a growing number of controlled investigations of the effectiveness of VR distraction for reducing pain, and Malloy & Milling (2010) provide a comprehensive review. This review indicates that VR distraction is an effective intervention for acute pain; reducing experimental pain, as well as the pain associated with burn injury care.

When a patient undergoes an invasive medical procedure, it is often possible to arrange for a clinician to be available to deliver psychological interventions of established efficacy, such as distraction. It is unlikely that a clinician could always be present when a chronic pain patient is experiencing discomfort. In such situations, patients are left to manage the pain on their own. As the cost of VR technology continues to fall, VR distraction may become an increasingly affordable and potentially efficacious self-management tool for chronic pain patients (Malloy & Milling, 2010). Only one study evaluated the effectiveness of

---

Fecha recepción: 24-1-11 • Fecha aceptación: 28-3-12

Correspondencia: José Gutiérrez-Maldonado

Facultad de Psicología

Universidad de Barcelona

08035 Barcelona (Spain)

e-mail: jgutierrezm@ub.edu

VR distraction for relieving a chronic pain condition. Leibovici et al., (2009) reported that there was no difference in itching between VR distraction and non-VR distraction in dermatology patients experiencing chronic pruritus. However, there appeared to be a difference in observer ratings of scratching, although this difference was not tested statistically. Consequently, the results of this lone study on the effectiveness of VR distraction for reducing chronic pain can best be described as inconclusive.

The use of virtual reality (VR) as a non-pharmacological technique to treat pain has focused mainly on distracting subjects' limited attention resources away from the source of discomfort. This strategy has been effective in acute pain; however, in order to increase its effectiveness in chronic pain, this technology may also be able to encourage other coping strategies. An alternative use of VR with chronic pain patients would involve exploring its ability to change cognitions related with pain adjustment. This is because cognitions are widely related to pain adjustment, and treatments aimed at changing pain cognitions have been shown to be effective (Jensen, Turner, & Romano, 2001; Jensen, Turner, Romano, & Karoly, 1991; Turner, Whitney, Dworkin, Massoth, & Wilson, 1995). Both clinical studies conducted with patients undergoing painful medical procedures (e.g. Hoffman et al., 2008; Konstantatos, Angliss, Costello, Cleland, & Stafrace, 2009) and laboratory-induced pain studies with healthy populations (e.g. Hoffman et al., 2006; Rutter, Dahlquist, & Weiss, 2009) have explored the changes produced by VR on pain-related measures such as the perceived pain intensity, pain threshold and pain tolerance, although relatively little is known about its effects on cognitive variables.

Two important cognitions for which research has provided evidence about the relationship between pain and adjustment are catastrophizing and self-efficacy (Brekke, Hjortdahl, & Kvien, 2003; Jensen et al., 1991; Keefe, Rumble, Scipio, Giordano, & Perri, 2004; Sullivan et al., 2001; Turner, Holtzman, & Mancl, 2007). Catastrophizing about pain involves the tendency to exaggerate the threat value of pain and negatively evaluate one's ability to deal with it. Perceived self-efficacy refers to people's judgments of their ability to execute given levels of performance and to exercise control over specific events (Bandura, O'Leary, Taylor, Gauthier, & Gossard, 1987). The importance of self-efficacy in understanding how patients adjust to a variety of pain conditions has also been well documented (e.g. Brekke et al., 2003). The perceived uncontrollability of pain, among other factors, appears to worsen the symptoms and perception of pain (Turk, Meichenbaum, & Genest, 1983). In addition to the evidence about the importance of these cognitions for pain adjustment, emergent clinical research suggests that cognitive-behavioural and other treatments for patients with chronic pain may be strengthened by components designed to decatastrophizing pain and to increase patients' confidence in their ability to control and self-manage their pain and related problems (e.g. Jensen et al., 2001; Spinhoven et al., 2004; Turner, Mancl, & Aaron, 2006).

The aim of the current study was to test if a VR experience, specifically designed to modify catastrophizing and pain self-efficacy in a controlled laboratory environment, could be developed. In particular, we wished to test the hypothesis that the experience of control over the parameters that define a virtual geometric figure which represents the pain will be transferred to the expectation of control that the subject has over a painful experience, indicated by decreased catastrophism and increased self-efficacy. Given

the importance of these two constructs it is interesting to explore whether VR (due to its highly interactive properties) can have an effect by changing these two kinds of cognitions. If this is the case, then this could be a strategy for using VR with chronic pain patients.

In addition to the cognitive measures of catastrophizing and self-efficacy, several widely used pain-related measures were computed: threshold, tolerance and strongest pain intensity.

## Method

### *Participants*

Participants were undergraduate psychology students. Exclusion criteria were cardiovascular disease, hypertension, metabolic dysfunctions, pregnancy, Raynaud's disease, epilepsy, mental disorders, chronic pain conditions, diseases producing neuropathic pain, and the use of pain/anti-inflammatory medications in the 4 h prior to the study. Participants were also instructed to refrain from alcohol or other drugs on the day prior to the study. Forty-six participants were invited to take part. One student refused to participate once the experimental conditions were explained. The final sample therefore consisted of 45 participants (36 women, 9 men) aged between 21 and 45 years (mean age 23.96 years, SD= 5.07).

### *Instruments and variables*

*Cold-pressor apparatus.* This consisted of a plastic tank (34 × 34 × 16 cm) filled with cold-water. The water temperature was maintained at 6 °C (±1). This level was selected to ensure a range of tolerance between 1 and 3 min (Mitchell, MacDonald, & Brodie, 2004; Piira, Hayes, Goodenough, & von Baeyer, 2006), time enough to ensure that participants interacted with the virtual environment. A waterproof thermometer was attached to the inside of the tank and used to ensure that the water temperature remained constant before and after each trial. Another tank with warm water (32 °C) was used for stabilisation of hand temperature at the start of each cold-water immersion. The room temperature was maintained at 22 °C.

*Hardware:* The stereoscopic environment was displayed with two BARCO ID R600 projectors controlled by a computer. StereoGraphics Corp polarised 3-D glasses were also used. The stereoscopic colour image was projected on a 2.43 × 1.82 m screen with a resolution of 1024 × 768 pixels. The distance between the subject and the screen was 2 m. Auditory effects were delivered through a multi-channel system of five speakers.

*Software:* 3D Studio Max 8, Adobe Photoshop 7 and Virtools 3.5 (ed. version) were used to develop the VR environment.

*In vivo pain catastrophizing reports.* In vivo reports of pain catastrophizing thoughts were obtained from the *Pain Catastrophizing Scale* (PCS) (Sullivan, Bishop, & Pivik, 1995). This scale is a 13-item, 5-point rating scale that requires individuals to recall the frequency of catastrophizing cognitions during past episodes of pain. Three subscales (Helplessness, Rumination and Magnification) represent the dimensions of the catastrophizing construct that is measured by the PCS. The PCS total score (range of 0 to 52) offers a good index of the catastrophizing construct, because the three subscales are highly correlated. Although the PCS has been validated for clinical and non-clinical populations (Osman et al., 2000; Sullivan et al., 1995), recent laboratory-based

studies (Dixon, Thorn, & Ward, 2004; Edwards, Campbell, & Fillingim, 2005; Edwards, Smith, Stonerock, & Haythornthwaite, 2006) argue for the use of in vivo measures of catastrophizing (i.e. occurring immediately after a pain task with instructions to complete the instrument based on the preceding pain experience, instead of previous occurrences of pain as is asked in the standard instructions of the PCS). Therefore, in order to assess in vivo catastrophizing the standard instructions and items of the PCS were modified in order to assess catastrophizing cognitions during cold-water immersions (i.e. “There was nothing I could do to reduce the intensity of the pain” or “I worried all the time about whether the pain would end”). Although Edwards et al., (2006) have developed an in vivo pain catastrophizing scale comprising 6 items we preferred to conserve the 13-item scale in order to maximise the reliability of the scale. The results in our sample showed that internal consistency reliabilities were high for the in vivo PCS total score after the VR cold-pressor trial ( $\alpha = 0.90$ ), as well as after the control cold-pressor trial ( $\alpha = 0.95$ ). These results are similar to those reported by Goodin et al., (2009), who also used the PCS as a measure of in vivo catastrophizing.

*Pain self-efficacy.* Pain self-efficacy was assessed using two scales derived from (Bandura et al., 1987): 1) perceived self-efficacy for tolerating pain; and 2) perceived self-efficacy for reducing the pain’s intensity. In judging their perceived efficacy in tolerating pain, subjects were presented with 20 items representing increasing lengths of cold-pressor duration, ranging from 0 s to 8 min. The participant was asked to judge his/her capability to keep his/her hand submerged in the cold water. The score was the chosen length of time among the 20 items, or the length reported by the participant if this was longer than 8 min. The items in the scale measuring pain reduction efficacy described four severities of pain ranging from dull to excruciating and, for each severity, participants rated the strength of their perceived self-efficacy for reducing pain on a 3-point scale, ranging from 0 (limited) to 2 (good). The total scale has a range from 0 to 8, with higher scores indicating greater self-efficacy in reducing pain. It displayed acceptable internal consistency in both the VR cold-pressor trial ( $\alpha = 0.78$ ) and the control cold-pressor trial ( $\alpha = 0.79$ ).

*Pain threshold.* Pain threshold was defined as the number of seconds of immersion in the cold-pressor tank until the participant reported that the cold sensation first began to feel painful.

*Pain tolerance.* Pain tolerance was defined as the total number of seconds the participants kept their hand immersed in the cold water.

*Strongest pain intensity.* The strongest pain intensity was assessed with a visual analogue scale (VAS) on which participants had to rate their most painful experience during the hand immersion in cold water. The VAS consisted of a 10-cm line with two anchors, “no pain” and “the most intense pain”. Immediately after withdrawal, participants were asked to rate their most intense pain by making a vertical mark on the point of the line which they considered representative of their pain. The distance from the left anchor to the vertical mark served as the pain rating.

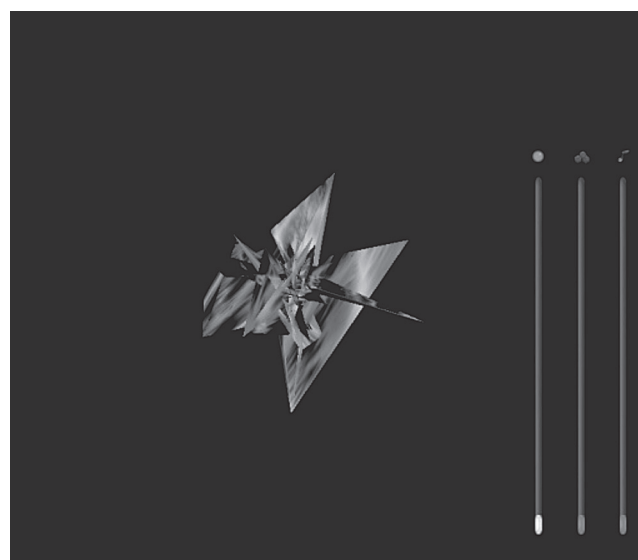
### Procedure

A within-subjects experimental design was used. Subjects participated in two consecutive cold-pressor trials, one using VR and one without. During the VR condition the participants interacted with the VR environment by using the mouse with

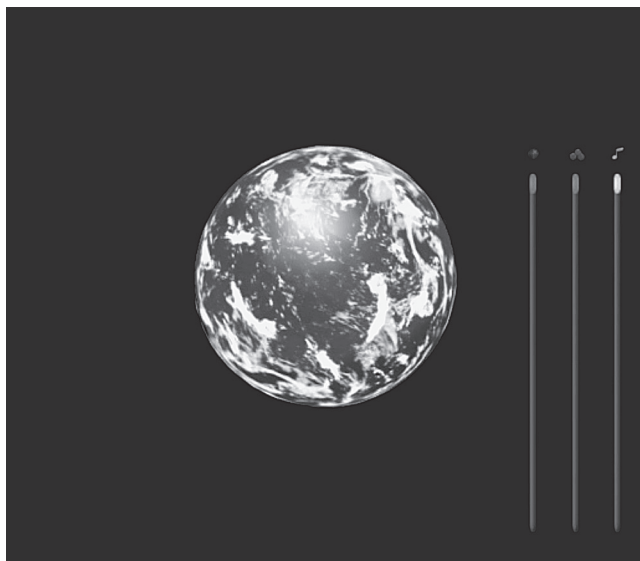
their dominant hand, while immersing their non-dominant hand in the cold-pressor tank. During the control condition, participants immersed their non-dominant hand in the cold-pressor tank while being presented with a static black screen. The order of the experimental conditions was counterbalanced; the subjects were divided into two groups and one group was treated with the VR condition followed by the control condition, and the other was tested with the control condition followed by the VR condition.

The virtual environment consisted of a stereoscopic figure that appeared in the centre of the screen with a black background. The initial appearance of the figure was modelled according to certain sensory descriptors (e.g. burning, cutting, sharp, stabbing, stinging) from the McGill Pain Questionnaire (Melzack, 1975). Following these descriptors the initial appearance of the figure was constructed as an irregular sharp-edged polygon (see figure 1). This figure was presented together with an unpleasant sound (a tone of 600 Hz at 80 dB). Therefore, and as was explained to participants, the initial figure and the sound represented an unpleasant pain sensation. This initial environment could be gradually manipulated to achieve a pleasant and quiet environment (analogous to a situation of no pain). This pleasant environment contained a spherical shape with a certain resemblance to natural scenery (see figure 2). This figure was combined with a quiet sound produced by a generative music engine. To modify the initial stereoscopic figure, subjects simply had to click the right button of the mouse, following which three slider controls appeared on the screen, allowing them to change the shape of the figure, the colour and the sound. Other interactions were also possible in the virtual environment (VE): subjects could rotate the figure and move it nearer or further away by clicking and dragging the mouse.

The study was approved by the ethics committee of the University of Barcelona and subjects had to sign an informed consent form which contained the appropriate information for participation in a pain study (Casarett, Karlawish, Sankar, Hirschman, & Asch, 2001). The participant and two experimenters were present during each trial. On arrival the participant was asked to sit down and to complete the exclusion criteria form. The participants were



**Figure 1.** Irregular Sharp-edged Polygon. A snapshot of what participants saw in the 3D virtual world when the three slider controls (shape, colour and sound) were at the bottom border



**Figure 2.** *Spherical Shaped.* A snapshot of what participants saw in the 3D virtual world when the three slider controls (shape, colour and sound) were at the top border

only told that the main purpose of the study was to investigate pain perception. Before starting the cold-pressor tasks the virtual environment was shown to the subjects and they were told how to modify the stereoscopic figure. Approximately 2 to 3 min were spent teaching them the possible interactions using the mouse. After that, their baseline hand temperature was measured. Participants were then asked to immerse their non-dominant hand in the warm water tank (32 °C) for 1 min, immediately their hand temperature was taken again. These data constituted the temperature to be reached again at the start of the second cold-water immersion.

*First cold-pressor task:* All participants completed the first cold-pressor task under one of the two conditions: VR or no-VR. Participants assigned to the VR condition followed the procedure as described below.

Before the cold-pressor trial started, the experimenter told the participants that they had to immerse their non-dominant hand in the cold water up to the wrist, palm-side down, and to leave their hand open (non-fisted). Participants were told that during the immersion they could interact with the virtual environment. The participants were instructed to say “It hurts now” when their hand began to feel uncomfortable or hurt, and “End” when they decided to remove the hand from the water. All participants were asked to repeat the instructions to make sure they understood them.

Each participant was provided with stereoscopic glasses. The non-dominant hand was placed above the cold-pressor tank and the dominant hand above the mouse. The lights of the room were turned off and the experimenters remained out of sight behind the participant in order to minimise any influence which their presence might have on performance. The cold-pressor trial was then immediately started and the participant immersed his/her hand in the tank, as instructed. For safety reasons the maximum permitted duration of immersion was 5 min, although participants were unaware of this. At the end of the trial, participants were asked to rest their hand on a towel placed on the table. They were then immediately asked to complete the strongest pain intensity VAS, the self-efficacy scales, and the in vivo catastrophizing PCS, being

told to complete these measures based solely on their experience during the cold-pressor task with the virtual environment. After completing the measures all participants were instructed to immerse their hand in the container with warm water for approximately 5 min. The hand temperature was again measured, ensuring it was within 1 °C of the stabilised temperature at the start of the cold-water immersion.

Participants assigned to the no-VR condition during the first cold-pressor task received the same instructions and procedure described above, with the exception that they were told that, during the immersion, they had to look at a static blank screen in front of them.

*Second cold-pressor task.* The second phase of the cold-pressor task was procedurally identical to the first. According to the within-subjects design, participants assigned to receive VR during the first cold-pressor task completed the second cold-pressor task without VR. Participants who were not assigned to the VR condition in the first task now completed the second task while experiencing the VR technology.

#### Data analysis

Descriptive statistics were computed for the different pain and psychological measures. Within-subjects univariate and multivariate analyses of variance were used to test the effects of condition (VR vs. no-VR) on pain threshold, tolerance, strongest pain intensity, in vivo pain catastrophizing reports and pain self-efficacy.

#### Results

Table 1 shows the means and standard deviations of pain threshold, pain tolerance, strongest pain intensity, self-efficacy for tolerating pain, self-efficacy for reducing pain, and in vivo pain catastrophizing reports for both the VR and no-VR conditions. A series of within-subjects ANOVAs were conducted to ascertain the effects of condition (i.e. VR vs. no-VR) on the abovementioned variables. The results revealed that participants demonstrated significantly higher pain thresholds ( $F(1, 44) = 12.33, p < .01, \eta^2 = .22$ ) and pain tolerance ( $F(1, 44) = 15.82, p < .001, \eta^2 = .26$ ) while interacting with the VR environment. Inspection of the mean scores also indicates that participants in the VR condition reported slightly lower VAS intensity ratings, although the difference between conditions did not reach statistical significance ( $F(1, 44) = 1.47, p = .23, \eta^2 = .03$ ).

Measures (range)	VR		No-VR	
	M	SD	M	SD
Threshold (0-300)	57.82	50.69	33.27	19.85
Tolerance (0-300)	149.44	110.90	98.87	98.11
Strongest pain intensity (0-100)	73.04	22.99	75.65	17.61
In vivo catastrophizing (0-52)	12.82	9.45	15.84	10.77
Self-efficacy for tolerating pain (0-480)	137.44	134.60	94.23	107.09
Self-efficacy for reducing pain (0-8)	4.16	1.48	3.76	1.75

Differences in pain catastrophizing and self-efficacy scores were significant in the hypothesised directions. In comparison to the control condition, in vivo catastrophizing was significantly lower in the VR condition ( $F(1, 44) = 9.75, p < .005, \eta^2 = .18$ ). Similarly, a MANOVA indicated that there was a statistically significant difference between the two experimental conditions on the combined perceived self-efficacy scores ( $F(2, 41) = 6.61, p < .005$ ; Wilks'  $\lambda = .76; \eta^2 = .25$ ). Univariate tests indicated that both self-efficacy for tolerating pain ( $F(1, 42) = 11.66, p < .005, \eta^2 = .22$ ) and self-efficacy for reducing pain ( $F(1, 42) = 6.04, p < .05, \eta^2 = .05$ ) were significantly higher in the VR condition.

#### Discussion and conclusions

The present study explored the impact of an interactive VR environment on pain cognitions (in vivo catastrophizing and pain self-efficacy) and pain-related measures (pain threshold, pain tolerance and pain intensity) in a cold-pressor task. VR was shown not only to have a positive effect on pain cognitions (a reduction in pain catastrophizing and an increase in self-efficacy) but also to increase pain threshold and pain tolerance. There were no differences in pain intensity between the VR and the no-VR conditions. Taken together, these findings suggest that the VR experience led participants in our sample to modify their pain cognitions and to endure pain differently, despite the fact that they were experiencing the same pain intensity as in the control condition.

Our results concerning the pain threshold and pain tolerance are consistent with other laboratory studies (Dahlquist et al., 2007; Rutter et al., 2009; Tse, Ng, Chung, & Wong, 2002). However, most VR pain studies, including the ones mentioned above, have also shown that VR produces a significant reduction of pain intensity (see Mahrer & Gold, 2009). This discrepancy regarding pain intensity can be explained by the different nature of our intervention. The vast majority of VR interventions for pain management involve the presentation of a VE in order to enhance attentional distraction from pain. In fact, VR research is showing that the most attention-grabbing VR analgesia systems are more effective at reducing pain (Hoffman et al., 2006). However, the aim of our VE was to facilitate changes in pain cognitions by directing attention towards a virtual figure that represented pain and how it could be manipulated. This difference in the purpose of our VE may explain the different results with respect to pain intensity, because whereas traditional VE focuses on pain reduction by means of distraction, our focus was on directing attention toward pain in order to achieve increased cognitive control over it.

This study is the first to find significant improvements in in vivo catastrophizing and pain self-efficacy as a result of a VR intervention. The present results contribute to a better understanding of the psychological process underlying the action of VR, and suggest that an enhanced sense of pain control may at least partly explain why some VR applications are effective. These results are relevant since the pain literature shows that self-efficacy is a variable that is widely related with the pain experience. Moreover, increased self-efficacy as a consequence of cognitive-behavioural interventions is related with improved outcomes (Gatchel, Peng, Peters, Fuchs, & Turk, 2007; Turner et al., 2007; Turner et al., 2006). Although the results need to be replicated in further studies, they are interesting because the interaction with our VE led to a significant increase in self-efficacy. If these results are indeed replicated in the future,

especially with clinical samples, the present design could prove highly useful for addressing self-efficacy in the treatment context.

The findings concerning in vivo catastrophizing are of interest not only for their theoretical and methodological relevance but also for their potential as regards the clinical management of pain. The VR intervention significantly reduced participants' in vivo catastrophizing reports. These findings are consistent with previous studies about targeted interventions for reducing catastrophizing in clinical and experimental contexts (Thorn et al., 2007; Vallis, 1984) and support a conceptualization of catastrophizing as a readily modifiable, situation-specific cognitive style, contrary to the immutable character ascribed to personality traits. However, the current study represents an advance over these previous studies that show decreases in catastrophizing with brief interventions based on asking participants not to engage in catastrophic thinking. The clear limitation of these studies is the strong demand characteristics associated with specifically instructing participants not to engage in catastrophic thinking. The present research is a step forward because participants were never instructed to reduce catastrophizing reports.

Mention should be made of certain methodological aspects regarding the assessment of catastrophizing. Recent research has emphasised that the context in which catastrophizing is assessed (both timing and instructions) may influence the relationship between catastrophizing and pain (Dixon et al., 2004; Edwards et al., 2005; Rhudy, Maynard, & Russell, 2007). The evidence available to date has shown that in vivo catastrophizing scores (i.e. the Pain Catastrophizing Scale (PCS) with instructions about a particular pain one has just experienced) are more strongly correlated with experimental pain outcomes than are standard PCS scores. Consistent with previous reports (Edwards et al., 2006; Goodin et al., 2009) our study also supports the reliability of in vivo catastrophizing measures for assessing change after a brief intervention designed to help people cope with experimental pain. Future studies are needed to corroborate whether in vivo catastrophizing measures provide greater accuracy in the report of changes in catastrophic emotions/cognitions associated with real pain coping, especially in patients with chronic pain.

Although the participants in this study were not experiencing clinical pain, some implications for VR-assisted clinical pain management can cautiously be drawn. To date, VR has mainly been used as a distraction technique in various medical settings, including cutaneous burns, postoperative physical therapy, dental pain, urological thermotherapy and cancer pain (Mahrer & Gold, 2009; Malloy & Milling, 2010). However, research suggests that VR can be more than a tool for pain distraction during medical procedures. The VR intervention designed for the present study encouraged participants to search actively for the correspondence between the pain experience and a VR stereoscopic object, which by means of its voluntary modification by subjects seemed to provide them with a high degree of perceived control over their pain. In other words, the experience of control over the virtual object, which represents the pain, gave subjects a sense of control over the actual pain.

In contrast to CBT, the acceptance and commitment therapy (ACT) model is based on the theory that attempts to change certain aversive internal experiences, such as chronic pain, are likely to be futile at best, and at worst may contribute to increased distress and interference (McCracken, 2005). The objective is to improve functioning and decrease interference of pain with value-driven action; the mechanism is presumed to be acceptance, in

contrast to control-oriented treatments such as CBT. However, in a randomized, controlled trial of ACT and CBT for chronic pain conducted by Wetherell et al., (2011) there were no significant differences in improvement between the treatment conditions on any outcome variables. With respect to mechanism, the mediation analyses suggested that an increase in perceived control over pain rather than increased acceptance of pain was driving reductions in pain interference across both conditions.

The present study is not without limitations. Although the effects of the VR intervention on the cold-pressor pain stimulus were notable, one cannot assume that the VR intervention would be equally effective in clinical situations in which patients have no control over the duration, intensity or severity of the pain they

experience, or in people who have a long history of pain. A further limitation concerns the characteristics of the sample, i.e. university students, and mostly females, which limits the generalisability of the findings.

As researchers gain a better understanding of the specific psychological mechanisms associated with VR, its applications in the field of pain management may render it more than just an immersive distraction technique and turn it into a powerful tool for training people to develop other coping responses.

#### Acknowledgments

This work was supported by *Fundació La Marató de TV3*.

#### References

- Bandura, A., O'Leary, A., Taylor, C.B., Gauthier, J., & Gossard, D. (1987). Perceived self-efficacy and pain control: opioid and nonopioid mechanisms. *Journal of Personality and Social Psychology*, 53(3), 563-571.
- Blount, R.L., Piira, T., & Cohen, L.L. (2003). Management of pediatric pain and distress due to medical procedures. In M.C. Roberts (Ed.), *Handbook of pediatric psychology* (pp. 216-233)., 3rd ed. New York: Guilford.
- Brekke, M., Hjortdahl, P., & Kvien, T.K. (2003). Changes in self-efficacy and health status over 5 years: A longitudinal observational study of 306 patients with rheumatoid arthritis. *Arthritis and Rheumatism*, 49(3), 342-348.
- Casarett, D., Karlawish, J., Sankar, P., Hirschman, K.B., & Asch, D.A. (2001). Obtaining informed consent for clinical pain research: Patients' concerns and information needs. *Pain*, 92(1-2), 71-79.
- Dahlquist, L.M., McKenna, K.D., Jones, K.K., Dillinger, L., Weiss, K.E., & Ackerman, C.S. (2007). Active and passive distraction using a head-mounted display helmet: Effects on cold pressor pain in children. *Health Psychology*, 26(6), 794-801.
- Dixon, K.E., Thorn, B.E., & Ward, L.C. (2004). An evaluation of sex differences in psychological and physiological responses to experimentally-induced pain: A path analytic description. *Pain*, 112(1-2), 188-196.
- Eccleston C., Williams, A.C.D., & Morley, S. (2009). Psychological therapies for the management of chronic pain (excluding headache) in adults. *Cochrane Database of Systematic Reviews 2009*, 2. Art. No.: CD007407. DOI: 10.1002/14651858.CD007407.pub2.
- Edwards, R.R., Campbell, C.M., & Fillingim, R.B. (2005). Catastrophizing and experimental pain sensitivity: Only in vivo reports of catastrophic cognitions correlate with pain responses. *Journal of Pain*, 6(5), 338-339.
- Edwards, R.R., Smith, M.T., Stonerock, G., & Haythornthwaite, J.A. (2006). Pain-related catastrophizing in healthy women is associated with greater temporal summation of and reduced habituation to thermal pain. *The Clinical Journal of Pain*, 22(8), 730-737.
- Gatchel, R.J., Peng, Y.B., Peters, M.L., Fuchs, P.N., & Turk, D.C. (2007). The biopsychosocial approach to chronic pain: Scientific advances and future directions. *Psychological Bulletin*, 133(4), 581-624.
- Glombiewski, J.A., Sawyer, A.T., Gutermann, J., Koenig, K., Rief, W., & Hofmann, S.G. (2010). Psychological treatments for fibromyalgia: A meta-analysis. *Pain*, 151, 280-295.
- Goodin, B.R., McGuire, L., Allshouse, M., Stapleton, L., Haythornthwaite, J.A., Burns, N., et al. (2009). Associations between catastrophizing and endogenous pain-inhibitory processes: Sex differences. *Journal of Pain*, 10(2), 180-190.
- Hoffman, H.G., Patterson, D.R., Seibel, E., Soltani, M., Jewett-Leahy, L., & Sharar, S.R. (2008). Virtual reality pain control during burn wound debridement in the hydrotank. *The Clinical Journal of Pain*, 24(4), 299-304.
- Hoffman, H.G., Seibel, E.J., Richards, T.L., Furness, T.A., Patterson, D.R., & Sharar, S.R. (2006). Virtual reality helmet display quality influences the magnitude of virtual reality analgesia. *Journal of Pain*, 7(11), 843-850.
- Jensen, M.P., Turner, J.A., & Romano, J.M. (2001). Changes in beliefs, catastrophizing, and coping are associated with improvement in multidisciplinary pain treatment. *Journal of Consulting and Clinical Psychology*, 69(4), 655-662.
- Jensen, M.P., Turner, J.A., Romano, J.M., & Karoly, P. (1991). Coping with chronic pain: A critical review of the literature. *Pain*, 47(3), 249-283.
- Keefe, F.J., Rumble, M.E., Scipio, C.D., Giordano, L.A., & Perri, L.M. (2004). Psychological aspects of persistent pain: Current state of the science. *Journal of Pain*, 5(4), 195-211.
- Konstantatos, A.H., Angliss, M., Costello, V., Cleland, H., & Stafrace, S. (2009). Predicting the effectiveness of virtual reality relaxation on pain and anxiety when added to PCA morphine in patients having burns dressings changes. *Burns*, 35(4), 491-499.
- Leibovici, V., Magora, F., Cohen, S., & Ingber, A. (2009). Effects of virtual reality immersion and audiovisual distraction techniques for patients with pruritus. *Pain Research and Management*, 14, 283-286.
- McCracken, L.M. (2005). Contextual cognitive-behavioral therapy for chronic pain. *Progress in Pain Research and Management*, 33. IASP Press, Seattle, WA.
- Mahrer, N.E., & Gold, J.I. (2009). The use of virtual reality for pain control: A review. *Current Pain and Headache Reports*, 13(2), 100-109.
- Malloy, K.M., & Milling, L.S. (2010). The effectiveness of virtual reality distraction for pain reduction: A systematic review. *Clinical Psychology Review*, 30(8), 1011-1018.
- Melzack, R. (1975). The McGill Pain Questionnaire: Major properties and scoring methods. *Pain*, 1(3), 277-299.
- Miró, E., Diener, F.N., Martínez, M.P., Sánchez, A.I., & Valenza, M.C. (2012). La fibromialgia en hombres y mujeres: comparación de los principales síntomas clínicos. *Psicothema*, 24, 10-15.
- Mitchell, L.A., MacDonald, R.A., & Brodie, E.E. (2004). Temperature and the cold pressor test. *Journal of Pain*, 5(4), 233-237.
- Osman, A., Barrios, F.X., Gutiérrez, P.M., Kopper, B.A., Merrifield, T., & Grittmann, L. (2000). The Pain Catastrophizing Scale: Further psychometric evaluation with adult samples. *Journal of Behavioral Medicine*, 23(4), 351-365.
- Piira, T., Hayes, B., Goodenough, B., & von Baeyer, C.L. (2006). Effects of attentional direction, age, and coping style on cold-pressor pain in children. *Behaviour Research and Therapy*, 44(6), 835-848.
- Rhudy, J.L., Maynard, L.J., & Russell, J.L. (2007). Does in vivo catastrophizing engage descending modulation of spinal nociception? *Journal of Pain*, 8(4), 325-333.
- Rutter, C.E., Dahlquist, L.M., & Weiss, K.E. (2009). Sustained efficacy of virtual reality distraction. *Journal of Pain*, 10(4), 391-397.

- Spinhoven, P., TerKuile, M., Kole-Snijders, A.M., Hutten Mansfeld, M., Den Ouden, D.J., & Vlaeyen, J.W. (2004). Catastrophizing and internal pain control as mediators of outcome in the multidisciplinary treatment of chronic low back pain. *European Journal of Pain*, 8(3), 211-219.
- Sullivan, M.J., Bishop, S.R., & Pivik, J. (1995). The Pain Catastrophizing Scale: Development and validation. *Psychological Assessment*, 7, 524-532.
- Sullivan, M.J., Thorn, B., Haythornthwaite, J.A., Keefe, F., Martin, M., Bradley, L.A., et al. (2001). Theoretical perspectives on the relation between catastrophizing and pain. *The Clinical Journal of Pain*, 17(1), 52-64.
- Thorn, B.E., Pence, L.B., Ward, L.C., Kilgo, G., Clements, K.L., Cross, T.H., et al. (2007). A randomized clinical trial of targeted cognitive behavioral treatment to reduce catastrophizing in chronic headache sufferers. *Journal of Pain*, 8(12), 938-949.
- Torrance, N., Elliot, A.M., Lee, A.J., & Smith, B.H. (2010). Severe chronic pain is associated with increased 10 year mortality. A cohort record linkage study. *European Journal of Pain*, 14(4), 380-386.
- Tse, M.M., Ng, J.K., Chung, J.W., & Wong, T.K. (2002). The application of eyeglass displays in changing the perception of pain. *Studies in Health Technology and Informatics*, 85, 532-535.
- Turk, D.C., Meichenbaum, D., & Genest, M. (1983). *Pain and Behavioral Medicine: A Cognitive-Behavioral Perspective*. New York: Guildford Press.
- Turner, J.A., Holtzman, S., & Mancl, L. (2007). Mediators, moderators, and predictors of therapeutic change in cognitive-behavioral therapy for chronic pain. *Pain*, 127(3), 276-286.
- Turner, J.A., Mancl, L., & Aaron, L.A. (2006). Short- and long-term efficacy of brief cognitive-behavioral therapy for patients with chronic temporomandibular disorder pain: A randomized, controlled trial. *Pain*, 121(3), 181-194.
- Turner, J.A., Whitney, C., Dworkin, S.F., Massoth, D., & Wilson, L. (1995). Do changes in patient beliefs and coping strategies predict temporomandibular disorder treatment outcomes? *The Clinical Journal of Pain*, 11(3), 177-188.
- Vallis, T.M. (1984). A complete component analysis of stress inoculation for pain tolerance. *Cognitive Therapy and Research*, 8, 313-329.
- Von Korf, M. (2011). Public health approaches to chronic pain: The role of epidemiology. *The Lancet Neurology*, 10(3), 210-211.
- Wetherell, J.L., Afari, N., Rutledge, T., Sorrell, J.T., Stoddard, J.A., Petkus, A.J., Solomon, B.C., Lehman, D.H., Liu, L., Lang, A.J., & Atkinson, J.H. (2011). A randomized, controlled trial of acceptance and commitment therapy and cognitive-behavioral therapy for chronic pain. *Pain*, 152(9), 2098-2107.