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Virtual Reality Helps Rheumatoid Arthritis Patients

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ABSTRACT

This paper concerns computer applications in medicine that exploit the potentially powerful interconnection between psychology (the mind) and physiology (the body). An important class of applications involve patients who suffer chronic pain caused by rheumatoid arthritis (RA); these patients look for any kind of therapeutic technique to use in addition to traditional medicine in order to alleviate pain, reduce physical disabilities caused by the disease or delay disease progress and improve their lifestyle. This paper focuses on a particular class of therapeutic techniques that provide imagery therapy using virtual reality in the treatment of rheumatoid arthritis. The paper presents a short review of virtual reality (VR) equipment and their use to provide immersive experiences. Furthermore, we describe imagery therapy (IT) involving guided imagery and illustrate its effects. We particularly describe the application of VR and IT in the treatment of rheumatoid arthritis. A brief introduction to our system and the research we have done in this field is presented, showing some preliminary results that support our hypothesis.

Keywords: Virtual reality, guided imagery, imagery therapy, rheumatoid arthritis.

INTRODUCTION

Arthritis is a term defining more than 100 different diseases. Rheumatoid arthritis is considered as one of the most common types of arthritis. According to a study published by the Arthritis Foundation in 2004 (CDC 2009), about 1.2 million Americans have been diagnosed with the disease. Since there is no effective treatment for rheumatoid arthritis (RA), managing this disease is crucial. RA is a chronic disease that cannot be cured and might in 0time lead to joint deformation. These distortions could cause disabilities. Many interventions, such as reduction of pain and stress, may control this persistent disease. In this stage, imagery therapy can be used to alleviate pain. Imagery therapy (IT) is one of the most effective complementary therapies in the United States and it has become one of the most successful and harmless treatments, as explained in a study published by a medical research team led by Wolsko (Wolsko et al., 2004). Imagery therapy uses the imagination to control the body using positive influences. It is considered as a language that is used to create a discussion and to build a rapport between the brain and the body. In this manner, the brain can communicate with the body and sends signals to modify and change the body or part of the body. This technique could be implemented using one or more of the human sensory systems such as the visual system, the somatosensory system, the auditory system, the olfactory system or the reproductive system. Scientists, researchers and health specialists have conducted number of studies

investigating the effectiveness of this technique. Studies show promising results in several diseases. Imagery techniques depend heavily on stimulating positive images for patients as presented by (Rossmann, 2000). Computers enhance these images by creating an appropriate virtual world that enables patients to interact with a three-dimensional environment using virtual reality technology. Therefore, imagery therapy using virtual reality is much better than regular images for many reasons, including patient interaction and the influence of other sensations.

Virtual reality (VR) is a computer technique full of excitement, challenges and effects. This field is growing so rapidly. Virtual reality has the advantage of being an efficient tool to interact with the body and has an influence on the mind. VR is mostly about building virtual environments to simulate reality. Imagery therapy depends heavily on advanced computer systems and computer graphics to present the environment using science fiction and images. Using VR, a user can live, act or interact in a virtual world which absolutely simulates reality. Interaction with the environment and presentation of the world is achieved using assistive devices such as a head mounted display (HMD), data gloves, joystick, mouse, and other devices. VR helps in a large number of applications such as medicine, education, training and others. In this paper, we will look at the impact of VR in medicine focusing on rheumatoid arthritis.

Virtual reality has the following properties

Immersion: where a person feels that he or she is in a particular environment, connected to it and totally immersed in the environment.

Interactivity: the ability of a user to control and respond to the environment. All of what we see in virtual reality is a computer graphics re-draw. Therefore, if we have too many details, the system has to process all of them, which results in prolonged processing time. So, this has to be taken into consideration.

The system requirements of virtual reality

The virtual reality system needs a high performance computer system to process the sophisticated graphics. However, for the hardware requirements and according to the required environment, we may need a head mounted display (HMD), virtual environment cave, manipulation and control devices such as a mouse, a joystick, and 5DT data gloves. We may also need a head and hand tracking device, an ultrasonic sensor, magnetic trackers and an optical position tracker. For the software requirements, Robinette and Manseur (Robinette & Manseur, 2001) showed that the virtual environment needs a high degree of interaction with the user. This could be achieved using advanced state-of-the-art software with high performance rendering. The authors concluded that decent software at a low price is currently available.

Problem definition

This paper presents a number of studies focused on the impact of imagery therapy and VR on some diseases with an extended research on rheumatoid arthritis. This research focuses on the impact of imagery therapy and virtual reality for rheumatoid arthritis patient to find out if VR and imagery therapy would help in any way to reduce pain and symptoms.

Motivation

The studies presented in this paper show the importance of imagery therapy and VR. Applying this type of technology may significantly improve a patient's lifestyle. Many people have been diagnosed with rheumatoid arthritis. This is an interesting motivation to investigate the possibilities of pain reduction and lifestyle improvement. Lack of awareness in society regarding imagery therapy motivates us as researchers to provide scientific evidence and knowledge to patients and families to help them employ modern technologies to end their suffering and pain. Previous research and experiments on many diseases have established a sound relationship between pain sensation and mental concentration. We claim that if we implement imagery therapy using virtual reality, the pain level of rheumatoid arthritis patients will decrease dramatically. This claim can be measured using some pain estimation scales. Pain is the main symptom of this disease. Consequently, it is necessary to find different methods either to remove the pain entirely or to alleviate it to some degree. One of the methods used to achieve this goal is the use of local anesthesia. Because rheumatoid arthritis is a chronic disease, the drug dosage should

be carefully reduced, so that it does not lead to addiction. In most cases, local anesthesia does not minimize pain sufficiently and causes some side effects. For this reason, safe and effective complementary methods are adopted and used with medication to obtain satisfactory pain level reduction. One of these newly-adopted methods is virtual reality technology. When imagery therapy is engaged, the patient's attention and concentration move from the present painful situation to an exciting and attractive virtual world. Scientists have provided experimental scientific proof which supports the effectiveness of VR in minimizing pain by distracting the activities of pain sensation in the brain to the exciting virtual world. Our study shows the great influence of VR and imagery therapy in RA. These studies have demonstrated considerable reduction in pain and anxiety and improve lifestyle with a high degree of effectiveness. The studies which are presented in this paper shows that there are a quite large number of patients who suffer from rheumatoid arthritis. These patients can use the system presented in this paper to reduce pain and improve lifestyle.

Our hypothesis is built on the belief that any disease, unease or physical discomfort which has strong ties with the spirit and mind and can be controlled using VR and imagery therapy.

Objectives Of The Research:

Does imagery therapy using virtual reality techniques have measurable impacts on pain in rheumatoid arthritis patients as it does for other diseases?

Research Methodology:

In many cases, only psychological means, such as relaxation, imagery therapy and cognitive behavioral therapy are used to alleviate pain. The assumption and fundamental goal of the studies presented in this paper are to determine whether the emotional, physical, visual, and functional status changes in patients with rheumatoid arthritis after treatment with imagery therapy. To initiate this research, we obtained some high-tech virtual reality systems. We used questionnaires throughout the course of the treatment and conducted some qualitative analyses to reflect a deeper understanding of the patients and their feelings.

Background

Imagery therapy is a method categorized as psychological therapy or cognitive behavioral therapy. Iimagery therapy is a class of therapies based on strong ties between the mind and the body. The psychological effect of the body appears to be reflected accordingly on the immune system and its reactions. In practice, imagery therapy exposes the body to a virtual environment that may combine one or more sensations such as visual, auditory, somatosensory, gustatory, and/or olfactory. Imagery therapy provides a mechanism for communication to the body through the mind resulting in relaxation and the release of tension, which in turn reduces pain or distracts attention and enhances pleasure or entertainment.

Imagery therapy generally involves the use of guided imagery, which is methodology that involves directing the thoughts of a subject through a particular sequence of states of the mind. Guided imagery appears to be most effective when it provides the subject with stimulation involving multiple senses that in combination provide a realistic imagery.

VR was introduced first in 1960 in several papers. At that time, HMDs were introduced as a VR tool. Hall and Miller (Hall & Miller, 1963) presented their paper which introduced the HMD as an essential tool for VR. Sutherland (Sutherland, 1968) used the HMD as a 3D display object. Vickers (Vickers, 1979) presented his work in 1970 introducing a stereo system in the VR system. However, a study presented by Chung and his team (Chung et al., 1990) showed that VR may immerse the user in a virtual reality, causing him or her to produce the same reaction as if the user was in a real environment, which resulted in the establishment of VR systems as a pioneering technology which might be used in many applications such as medicine, education, training, and others. VR systems can detect the head and the body movements using sensors and trackers. These devices are connected directly to the HMD, data gloves, and other input/output devices. So, when the user moves the HMD, the sensors send signals to the computer to modify the scene accordingly. VR systems give the users a new experience which he or she might be unable to

achieve in the real world due to cost, possible hazards, distance, or other factors. Therefore, the user might get to experience and know how to deal with new scenarios. Warren and his team (Warren et al., 1981) supported previous research by providing new results showing that VR can have a great influence on human sensory systems. On top of that, the contribution of Zimmerman and his team (Zimmerman et al., 1987) was of great impact when they added an electronic device to convert arm movements into an electric signal in 1987. Similarly, Minsky and his group (Minsky et al., 1990) had an important contribution by introducing the principles of interaction in VR in 1990. Watters and his team (Watters et al., 2006) presented their research that shows the use of digital games and interactions with people and particularly among children. The spread of computer games made this technology easily accessible to use in education or to some extent in the diagnosis and treatment of some diseases such as diabetes where children might learn how to schedule their medication and acquire some positive eating habits.

In Japan, Ohsuga and Oyama (Ohsuga & Oyama, 1998) developed a virtual reality system called the "bedside wellness system". The system allows patients to walk around a virtual forest while they are in bed. A number of screens with corresponding sensors are distributed around the bedside in order to present images and sensations (i.e. bird sounds, cool breezes) to patients. In addition, there was a foot device to enhance and control the movement of the image. Twenty healthy subjects participated in a preliminary study with this system. The authors reported that the system helped patients to relax.

Rheumatoid arthritis is a chronic disease that cannot yet be cured clinically. The intensity of pain could, however, be alleviated, which may result in more controllable and stable disease. For this disease, many physicians prescribe painkillers as an essential part of the treatment plan. Pain occurs when pain signals are transmitted to the brain through networks of nerves. The body intercepts these signals by generating endorphins, a chemical that kills the feeling of pain. There are several factors that motivate the body to generate endorphins; the most important one is motivating the mind to think of and immerse itself in positive images (Machelska et al., 1998). Using imagery techniques in the treatment plan has a great advantage in enhancing endorphin production and in alleviating the sensation of pain, so the need for painkillers is reduced.

Sridhar and his team (Sridhar, 2003) reported that cognitive behavioral therapy attention and mental imagery helped patients with rheumatoid arthritis in alleviating pain and improving self-esteem (American Pain Society, 2002). Astin and his team (Astin et al., 2003) found strong evidence of the effectiveness of imagery therapy techniques for rheumatoid arthritis patients in alleviating pain and disabilities. Varni and Gilbert (Varni & Gilbert, 1982) have proven that imagery techniques can lead to reduced intensity of rheumatoid arthritis pain through a remarkable treatment plan that consists of relaxation exercises, breathing techniques and imagery techniques.

Another study analyzed 501 patients (68% with osteoporosis, 15% with rheumatoid arthritis and 17% with other forms of arthritis), using a program called "self-control of arthritis", an educational and health program in which patients undergo a number of treatments such as imagery techniques and other treatments. Lorig and his team (Lorig, 1993) found that when patients followed this program for four years, it led to a 20% decline in pain and reduced clinic visits by 40%. In addition, patients who followed this program saved approximately $648 a year per person for those with rheumatoid arthritis and $189 a year per person for those with osteoporosis. Kim and Sohng (Kim & Sohng, 1991) proved that imagery techniques can significantly improve the quality of life of patients with rheumatoid arthritis.

Previous studies which focused on the impact of imagery techniques in rheumatoid arthritis treatment have provided clear scientific support for our hypothesis with regard to the design of a computer environment to control pain for people who suffer from rheumatoid arthritis. Consequently, the impact of imagery techniques when using virtual reality as we hypothesize should provide the same results as those reported in studies investigating other diseases. This paper presents a research review on the impact of imagery techniques on rheumatoid arthritis treatments. As shown, the

impact of imagery techniques using virtual reality in rheumatoid arthritis treatment requires further investigation. Campbell and his team (Campbell, 2001) presented a paper in 2001 introducing a learning environment for a virtual anatomy lab. The authors showed that their system introduced the 3D space and online features for the learning environment. Their system has various levels of complexity. Rajaram and Marsic (Subramanian & Marsic, 2001) presented their virtual biology lab in 2001, claiming the cost effectiveness of using this kind of environment; moreover, the system did not negatively impact learning quality. Safigianni and Pournaras (Safigianni & Pournaras, 2007) introduced their high performance and low cost software laboratory tool for a virtual lab to enhance learning for students in electrical engineering. Riva and his team (Riva et al., 2000) presented an extremely extended review on a virtual reality-based experimental cognitive treatment of obesity. Their work presented a large number of studies provided by experts in the field of obesity, binge-eating disorders and virtual reality. For more details on the studies carried out in this field, it is recommended to refer to this review (Riva et al., 2000).

Our System

Virtual reality system has been used with imagery therapy to distract patients' attention away from the painful real world to a positive virtual environment which helps in alleviating pain in numerous diseases including leukemia, breast cancer, burns, phobia, and many others. From prior data and scientific evidences, we can infer that the percentage of imagery therapy methods using virtual reality techniques which have been successfully implemented in controlling pain associated with rheumatoid arthritis is very high.

The greatest help needed by rheumatoid arthritis patients is pain relief. When we design a virtual environment to stimulate relaxation and immerse patients in its quiet world, we can say that the patient is controlling the disease and can control the amount of pain. We have implemented a scenario where the patient in the virtual world wants to go after their dream and bring it to reality. The character in the virtual world embarks on a quest to tour the world and enjoy the sunset in different locations around the globe. These unforgettable scenes attract patients' attention and immerse them into a virtual world full of relaxation. Listening to different music according to the location where the patient is virtually visiting gives the patient a wonderful experience. This scenario supports patient confidence and charges him or her with a lot of energy to cope with their disease.

Stray Light was developed in 2001 to deliver detailed 3D virtual reality images for Abbott Labs Research Centers. This virtual reality presents a detailed scientific view of rheumatoid arthritis therapies, including the new fully human monoclonal antibody treatment. Earlier monoclonal antibody treatments used varying portions of the antibody from non-human sources, often from mice. Abbott Labs Research Centers have led the development of a fully human monoclonal antibody treatment for rheumatoid arthritis, and Stray Light's virtual reality has complemented this new medical treatment. This virtual reality has taken thousands of rheumatologists and other healthcare professionals virtually to the microscopic perspective inside an animated inflamed knee joint to witness the debilitating effects of rheumatoid arthritis. The attendees were then virtually shrunk down even further to become part of a cellular surface landscape entering into the molecular actions of rheumatoid arthritis and the effects of various therapies used to treat the disease. The "New Rheumatoid Arthritis Drug" virtual reality has impressed attendees at demonstrations at many universities and conferences in the US and Europe, including the American College of Rheumatology (ACR), the American Academy of Allergy Asthma & Immunology (AAAAI), the American Association of Immunologists (AAI), the American College of Physicians (ACP), the Federation of Clinical Immunology Societies (FOCIS), and the Annual European Congress of Rheumatology (EULAR) in Stockholm, Sweden (New Rheumatoid Arthritis Drug, n. d.).

Imagery Way is a virtual reality program used in the treatment of acute lymphoblastic leukemia in children by solving the following problems:

1. The pain with acute lymphoblastic leukemia resulting from chemotherapy, especially in the first year of treatment.

2. The need to improve children's quality of life and their requalification.
3. Depression resulting from long stay in hospital (about six months with complete isolation because of weak immunity). This situation generates a feeling of isolation for children and a feeling of missing out on the normal life enjoyed by other children of the same age.
4. The side effects of chemotherapy in the first year of treatment such as nausea and vomiting.

The game was divided into five main stages; all of these stages are within the human body and vary depending on the location of the body and the form of cells surrounding the player as well as the form of cancer cells which should be eliminated by the player and the type of alternative medicine (honey, grapes, special water, green tea, bees) which is collected in each of these five stages. The sites of the five stages were selected as follows: the right hand represents the first stage, the left hand represents the second stage, the left leg represents the third stage, the right leg represents the fourth stage, and the middle of the body represents the fifth stage. Finally, the player reaches the stage of the beast and beats him, thus overcoming the disease (Alhalabi et al., 2008).

Our newly designed system helps patients to relax and do not feel that much pain. It is built on top of the imagery way discussed earlier in this section, but for the rheumatoid arthritis patients.

RESULTS

Once the system was implemented and used, we ran the test using observation on two groups, the test group and the control group. The test group used the same medication prescribed by their physicians, however, they were under the influence of VR and imagery therapy systems.

According to MADRS (Perris, 1979), we obtained the following results:

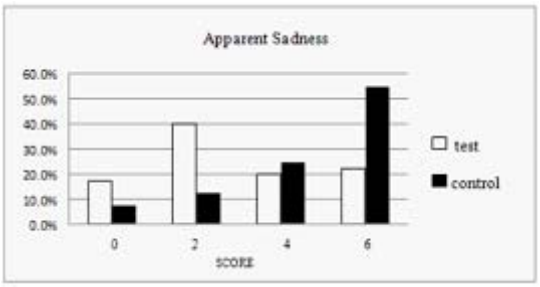

Fig. 1:

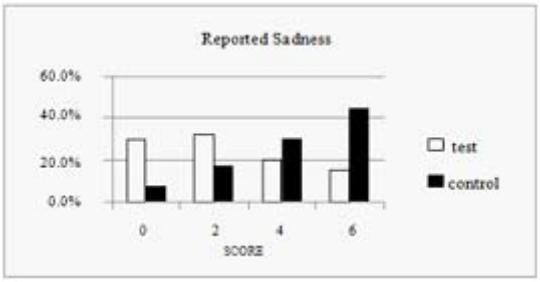

Fig. 2:

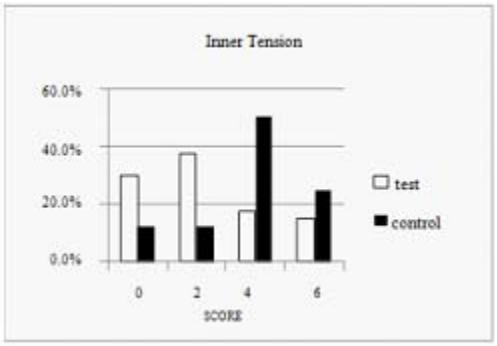

Fig. 3:

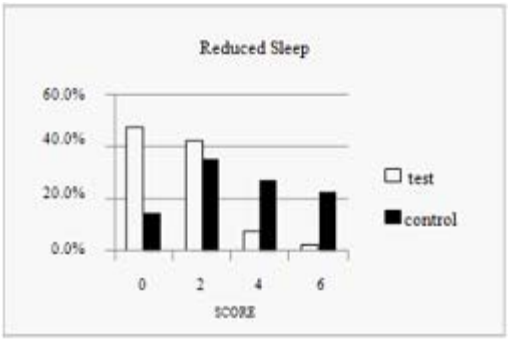

Fig. 4:

Questionnaires

Throughout the course of the treatment, data were collected for both groups for several months. Data were analyzed using the following questionnaire and scales: MADRS (Perris, 1979), CPRS (Perris, 1979) and SSP (Gustavsson et al., 2000).

Discussion

The results presented in Section 4 provide clear quantitative evidence that imagery therapy using virtual reality can aid in the reduction of various negative factors such as sadness, tension or inability. These initial results appear to us to be quite premising, and provide encouragement to motivate further work in this field seeking improvements. Our ongoing and future work will explore potential improvements that include an even more engaging VR interface, the use of further advances in guided imagery, and improved statistical analysis of the experiments.

Many complementary therapies have shown efficiency and effectiveness in treating a variety of chronic diseases. Imagery therapy is one of the most successful therapies in this field and

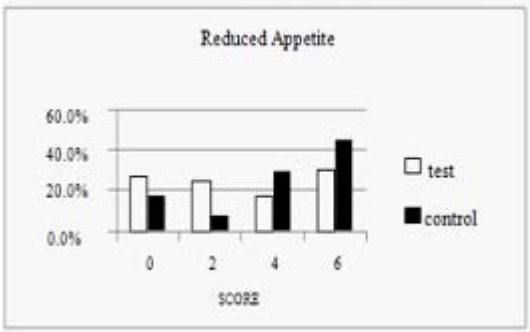

Fig. 5:

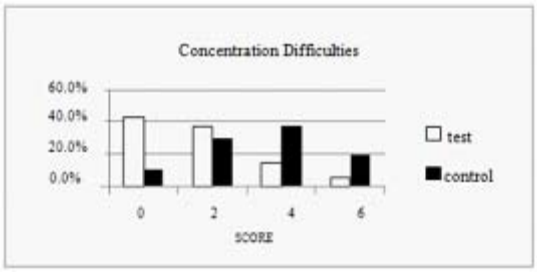

Fig. 6:

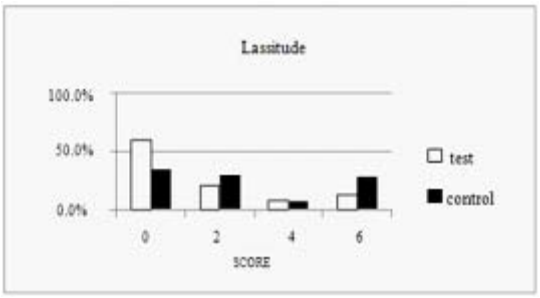

Fig. 7:

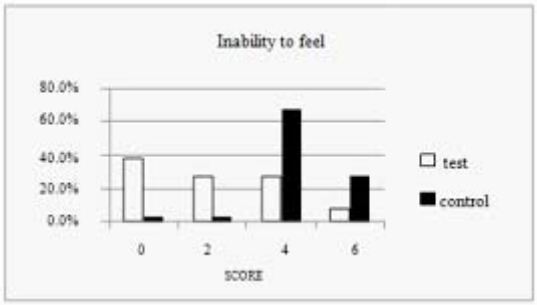

Fig. 6:

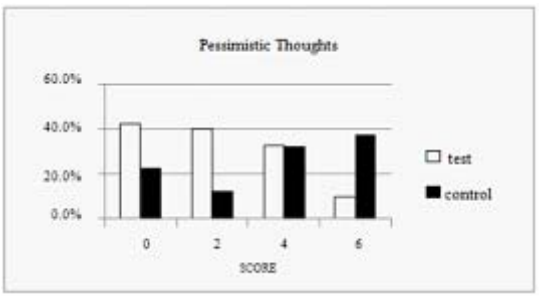

Fig. 9:

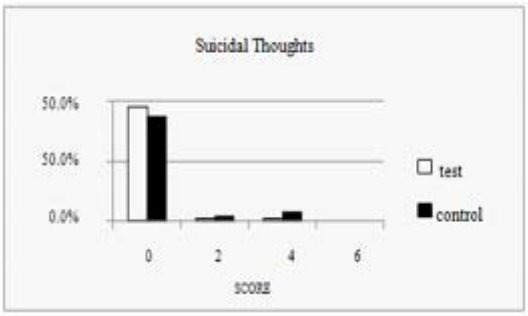

Fig. 10:

rheumatoid arthritis is representative of the chronic diseases. Using imagery therapy techniques in the treatment plan should help with alleviating pain, which is the main symptom of this disease.

Imagery techniques are a useful method for reducing pain intensity, as they have demonstrated their ability to improve the quality of life in depressed patients who feel helpless and isolated. Moreover, imagery techniques are used as a tool to reduce disability and slow down the progress of disease. This paper provided some of the results of using virtual reality in the treatment of rheumatoid arthritis and shows that the impact of imagery techniques using virtual reality in rheumatoid arthritis is noticeably high.

Earlier studies clearly indicated that the use of VR has a positive influence on patient improvement, not only in terms of disease kinetics but also extending its impact onto the psychological condition of the patient. Psychological trauma occurring after stroke, as a result of sudden disability, makes the patient dependent on others for daily activities, and results in depression. This is usually treated with anti-depression drugs. However, the use of VR is a better alternative with which to replace these drugs for the treatment of depression. The patient can live in a world filled with adventures, and forget about his or her deficiency. Simultaneously, his or her motor disability is treated. The choice of a VR environment depends on the patient's background and his or her hobbies. For example, if the patient was an amateur soccer player before the stroke, the use of such an environment within VR will have a great impact on his or her psychology and kinetic abilities. When he or she can no longer practice the hobby after a stroke, VR provides an opportunity to pursue the hobby, even with a disability. It may be a VR world, but the patient can experience this every day. With patience, despite a disability, the patient is able to play and perform other activities, such as making coffee, shopping, and so on.

This paper showed how imagery therapy along with virtual reality help in reducing pain and adding value of life for patients diagnosed with rheumatoid arthritis. The result of the experiments that were included in this paper is in consistent with other results of many diseases. This would improve the use of virtual reality and imagery therapy as an alternative medicine to support the clinical treatments of rheumatoid arthritis.

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