REVIEW ARTICLE

# Virtual Reality in Psychiatry

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**Abstract**

Background:

Virtual Reality in the field of medicine is making a considerable progress in psychiatry. Virtual reality exposure therapy (VRET) in particular can serve as a preferable solution for PTSD (Post-Traumatic Stress disorder) patients who avoids or finds retrieving image difficult. Relevant studies were reviewed to identify the pros and cons of virtual reality technology applied to psychiatry and to determine its medical effect.

Methods:

The application of virtual reality therapy to the field of psychiatry e.g., Panic Disorder (PD), Post-Traumatic Stress disorder(PTSD), Mild Cognitive Impairment(MCI), and Attention Deficit Hyperactivity Disorder(ADHD) and the strengths and weaknesses of VR therapy were investigated.

Results:

VRET can serve as a preferable alternative to PTSD patients and can be more economical than actual exposure therapy as it is accessible, convenient and reproducible. However, the VRET can cause vertigo, nausea, vomiting, and reduced awareness, and there is a concern of abuse by uncertified practitioners.

For PTSD, according to the systematic review of VRET, the dropout rates of VRET is not higher than conventional exposure therapy, also 7 of 10 studies, the VRET is effective to PTSD patients, their effects were not different with conventional therapy as well. The important thing of VRET is that design contents scenario and establishing each hierarchy.For panic disorder, in respect with effectiveness, VR therapy compares favorably with conventional therapy. Conventional therapy versus VR therapy, it is revealed that similar therapy efficacy in exposure therapy, Interceptive exposure therapy, cognitive behavioral therapy. VR therapy is comparable to the conventional therapy in terms of efficacy. Treatments that had comparable clinical effect with the conventional VR therapy were exposure therapy, interoceptive exposure therapy, and cognitive behavior therapy.

For MCI, studies using VR to cognitive training treats general cognitive function, such as frontal function, memory, spatial navigation and so on. For ADHD, researchers and clinicians may expect lower dropout rates in treatment and positive results in cognitive training.

Conclusion:

VR therapy was not inferior to conventional therapy in its application to psychiatry regarding PTSD, ADHD etc., and holds high potential as it enables convenient use of situations that cannot be easily reproduced in real life. However, technical support and effort are necessary to prevent its side effects including vertigo, reduced awareness and nausea.

## Introduction

Virtual reality (VR) is characterized by immersion of user senses into a synthetic computer-generated environment. Virtual reality is an environment which is produced by a computer and seems very like reality to the person experiencing it.

An overview of the current VR research activities in the field of medicine includes: education, surgical planning and simulation, visualization, teleradiology, computer-aided surgery, radiotherapy planning, dentistry, tele-medicine, human-machine interfaces, and rehabilitation and therapy[1].

Virtual reality is just emerging as an accepted scientific discipline for medicine. The majority of near-term applications are in the area of surgical planning, interoperative navigation, and surgical simulations. Its use in rehabilitative medicine and psychiatry has made significant progress[2].

There are an increasing number of studies that support the use of VR as an effective tool in the treatment of several specific phobias[3-7]. VR has also been used in the treatment of other anxiety disorders, including post-traumatic stress disorder in Vietnam veterans or September 11 victims [8-9] and social phobia [10-13]. The number of panic disorder patients has increased by 15.8%, from 50,945 in 2010 to 106,140 in 2015, and the number of PTSD patients has increased by 3.6% yearly on average due to the increase in the mental health issues that have arisen in South Korea.

With the emergence of the mental health issue as a national social issue, there is a growing need for its solution using the growing VR market and technology. Therefore, the authors aimed to conduct a research on the precedent studies with regard to the effects of VR in the psychiatric field, and to introduce a development project on VR contents that could manage PTSD, panic disorder, MCI, and ADHD that mainly make up the psychiatric field.

## Methods

The precedent studies that applied VR in the psychiatric field that were conducted between 2005 and 2018 were retrieved and examined. The literature search about VR for each disorder is conducted in Google Scholar, keywords are : ' Panic Disorder Virtual Reality', 'PTSD Virtual Reality', 'MCI Virtual Reality', 'ADHD Virtual Reality', 'Virtual Reality Exposure Therapy for Panic Disorder', 'Virtual Reality Exposure Therapy for PTSD', ''Virtual Reality training for MCI', 'Virtual Reality training for ADHD'. Then the development status of the VR contents applied to PTSD, panic disorder, ADHD, and MCI was summarized.

## Results

In this study, we conducted exposure therapy and cognitive intervention using virtual reality(VR) on 4 psychiatric disorder: panic disorder(PD), posttraumatic stress disorder(PTSD), mild cognitive impairment(MCI), attention deficit hyperactivity disorder(ADHD). For PD and PTSD, we used Systematic Desensitization(SD) with VR contents, was set up the situation related with each

disorder. As cognitive training, MCI VR contents are focused on enhancing working memory, and for ADHD, inhibitory control and working memory training are presented.

## 1. Virtual Reality Exposure Therapy

Systematic Desensitization(SD), one of the evidence-based therapy on anxiety disorder and PTSD is conducted. Before exposure, therapist educates to patients breathing-training and relaxation. The exposure process takes 20 minutes in VR setting, following by Wiederhold & Wiederhold's suggestion[14]. The content scenarios used in this study were written by psychiatrists and licensed clinical psychologist focused on each disorder's clinical significance and set a hierarchy in each situation. For example, PD with agoraphobia(PDA) patient who complains of fear of flight, we gradually conduct the procedures of boarding flight by hierarchy: 1) arrive at the airport, 2) check-in procedures 3) take plane 4) a flight's taking off run 5) go to restroom during flight is swaying & flight landing. As the instruction of SD, during exposure procedures, patients were suggested to keep trying to be in a relaxed state. The evidence of efficacy of VR therapy are below:

### 1.1 Panic Disorder

Panic disorder is a type of anxiety disorder. It causes panic attacks, which are sudden feelings of terror when there is no real danger. You may feel as if you are losing control. You may also have physical symptoms, such as fast heartbeat,chest or stomach pain,breathing difficulty, weakness or dizziness, sweating, feeling hot or a cold chill,tingly or numb hands.( https://medlineplus.gov/panicdisorder.html)

The effectiveness of Virtual Reality Therapy has been revealed by researches using controlled experiments. Botella et al.[15] have shown the effectiveness of VR therapy for PD patients. There were two version of virtual reality therapy(Virtual Reality Environment and Immersive Virtual Environment) and waiting list group. After sessions, the anxiety index of PD patients with VRE and IVE treatment decreased significantly. In respect with effectiveness, VR therapy compares favorably with traditional therapy. Traditional therapy versus VR therapy, it is revealed that similar therapy efficacy in exposure therapy[16][19][20], Interceptive exposure therapy[17], cognitive behavioral therapy[18]. However, only a few works of literature are stacked up, further research should be conducted on VRET of PDA to validate its efficacy.

### 1.2 Post-Traumatic Stress Disorder

Post-traumatic stress disorder (PTSD) is a mental health condition that's triggered by a terrifying event — either experiencing it or witnessing it. Symptoms may include flashbacks, nightmares and severe anxiety, as well as uncontrollable thoughts about the event.

(https://www.mayoclinic.org/diseases-conditions/post-traumatic-stress-disorder/symptoms-causes/syc-20355967)

As seen above, one of the symptoms of PTSD, avoidance of reminders of trauma is an obstacle in treatment. It is distressing work be exposed to a traumatic stimulus, also patients complain discomfort during the therapy including this process, i.e. imaginal therapy, exposure therapy, prolonged exposure therapy(imaginal + exposure therapy)[21]. According to Schottenbauer et al. [22], the dropout rate of SD in PTSD is 25% to 100 %, and the other therapies are over 30% as well. They suggested 9 reasons for this high dropout rates of PTSD treatment: 1) patient's environments, 2) the alliance of therapist, 3) failure to forming a rapport, 4) the treatment protocol.. etc. However, these shortcomings of PTSD treatment is complement partially by using VR. In VRET, validity and suitability of VR content matter more than therapist factor. According to the systematic review of VRET[23], the dropout rates of VRET is not higher than traditional exposure therapy, also 7 of 10 studies, the VRET is effective to PTSD patients, their effects were not different with traditional therapy as well. The important thing of VRET is that design contents scenario and establishing each hierarchy.

## 2. Cognitive Intervention

Cognitive training is one type of cognitive intervention. The advantage of cognitive training using VR is that suitable tasks are available for each function[24]. It is possible to implement three-dimensional first-person perspective, which is unable in paper-based training. For example, to train spatial navigation function with VR training, we can set circumstances close to the real worlds, such as driving a specific place, set up trivial obstacles during driving and so on. However, in paper-based to train spatial function, only matching point to point or solving a maze in third-person perspective limited tasks are feasible. by VR, it is much easier to adjust the level of difficulties and speculate/train by a more suitable task.

### 2.1 Mild Cognitive Impairment

Mild Cognitive Impairment(MCI), suggested by Petersen(1999)[25], people diagnosed as MCI when they experienced loss of memory but another function is preserved with no disability in the activity of daily living. MCI is classified two type as amnestic MCI and non-amnestic MCI, these types subdivided into two type, single or multiple domains by the number of declined function[26](Fisher et al., 2007). According to studies, it is clear that cognitive training is significantly effective on the performance of cognitive function[27]. Studies using VR to cognitive training treats general cognitive function, such as frontal function[28], memory[29], spatial navigation[30] and so on. Kizony et al.[28] speculated the executive function using VR supermarket. The result is that the performance significantly improved in assessments and task. In this study, we focused on memory training, especially working memory. Before the training, we give several memory strategies to participants, such as 'method of loci', rehearsal.. etc. participants supposed to feel they are really at the supermarket in virtual reality environment, remember the list what they should buy given at the beginning of each session.

### 2.2 Attention Deficit Hyperactivity Disorder

Attention Deficit Hyperactivity Disorder(ADHD), is represented as hyper-activation, and disability to control inhibition. Most of ADHD VR training is focused on inhibitory control31], attention enhancement[32][33][34], tasks with neurofeedback[35]. Prefrontal alpha oscillation reflects that the neurocognitive processing and efficiency, the alpha oscillation significantly regressed with the development of attentional control. Also, the questionnaire and assessment of attention deficit and working memory index increased as the following with performance of the VR tasks. Patient's incentives may increase because this tool is appealing to children[22], researchers and clinicians may expect lower dropout rates in treatment and positive results in cognitive training. According to Thomas D. Parsons & Michael Barnett `s researchVirtual Classroom had good potential for controlled performance assessment within an ecologically valid environment and appeared to parse out significant effects due to the presence of distraction stimuli[36].

## 3. VR Application Cases in South Korea

### 3.1 Introduction

A considerable number of Koreans were reported to experience mental issues due to the rapid social changes and the intensifying competition. The estimated number of adults who have experienced one or more mental illness issues was 5.77M (16% of the entire population), according to the 2011 Epidemiology of Mental Disorder.

The world’s major developed countries have defined mental illness and disorder as a social issue, and have made substantial investments on the national level to address the causes of mental illnesses and disorders and to treat and prevent these.

For the national/social issue on mental health caused by the shift towards an aging society and the high stress level prevailing in the modern society, government support by means of providing public treatment and prevention facilities is necessary for the solution using VR technology. As such, the authors aimed to develop the VR contents that are necessary in the four fields of psychiatry, and sought to determine whether the VR contents are efficient using the changes in the biosignals (electroencephalogram [EEG], photoplethysmography [PPG]) and questionnaires.

### 3.2 Introduction of VR contents

As shown in Fig. 1, VR contents were developed for four mental illnesses: panic disorder, PTSD, MCI, and ADHD. The user interface was created using the unity game engine, in which the motif is the living room of the house. The user can experience the VR content through this VR space. The space was designed to enable the user to naturally access the 360VR image content by controlling the image displayed on the TV using the remote control, while sitting on the couch.

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[Fig. 1] VR contents User interface

### *3.2.1 VR contents for panic disorder*

For application to panic disorder, a VR content was developed for the user to practice new methods of dealing with the panic symptoms and to access the circumstances that should be avoided to have a safe environment. Fig. 2 consists of five circumstances inside the elevator that can cause anxiety/phobia symptoms. Contents depicting the underground arcade, the interior of a plane, drive-in tunnels, and rain, and inside subways and trains, were also developed.


[Fig. 2] Panic disorder VR content

### *3.2.2 VR contents for PTSD*

For PTSD, the program consists of granting gradual access to the stimulation, memory, and image contents that patients usually avoid, for pain alleviation, for endurance and controllability improvement, and for learning new techniques of dealing with pain. Fig. 3 shows different scenarios, including getting used to car stimulations, approaching cars, driving a car, and using public transportation, for PTSD patients who got involved car accidents. In addition, contents depicting the scene of a fire, an industrial disaster, and subway operations were developed.

[Fig. 3] PTSD (Traffic accident) VR content

### *3.2.3 MCI responsive contents (CG-based operative contents)*

For MCI, a content depicting the purchasing of goods was developed as a cognitive training scenario for the improvement of the patient's memory, attention, and daily life functions. It consists of five difficulty levels by quantity of purchase, including a tutorial.


[Fig. 4] MCI VR content

### *3.2.4 ADHD responsive contents (CG-based operative contents)*

For ADHD, a VR content was developed based on the attention and behavioral control training scenario.

In the classroom activity section, as shown in Fig. 5, a conditional shape or word quiz was featured in five scenarios with different difficulty levels.

In the physical activity section, conditional ball catching tasks were featured with three different difficulty levels. Music room activities and scenarios involving getting into trains after listening to announcements were included.

[Fig. 5] ADHD VR content

### 3.3 Collection of questionnaires and biosignals before and after the application of VR contents

Information as in Table 1 is collected to assess the efficacy of the treatment using VR contents.

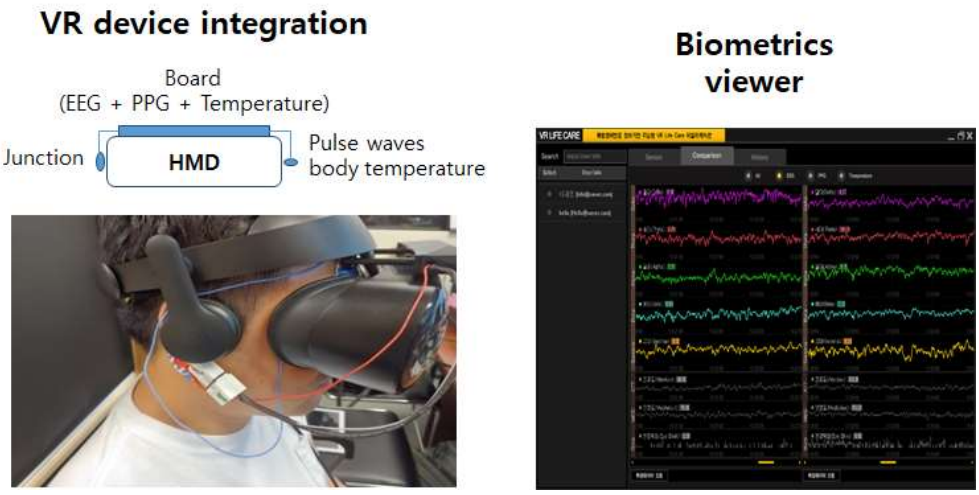
The brain wave and PPG are measured, and the measurement results are collected, before and after the exposure of VR contents, to determine the level of disease alleviation, if any. Also, applicable surveys are conducted before and after the VR content exposure. The level of engagement with the VR content and the sense of presence, sense of safety, ease of use, learnability, level of satisfaction, and improvement feedbacks are also collected after the VR content exposure. Fig. 6 shows the device used to collect brain waves, and the PPG used by connecting it to the HMD.

[Table 1] Assess the efficacy of the treatment using VR contents

| Mental disorder | Questionnaires | Biometric data | | | VR contents evaluation |
|---|---|---|---|---|---|
| | | Unit | Diagnosis | Treatment effect | |
| MCI (Mild Cognitive Impairment) | CEARD - K<br>SNSB<br>MOCA -K<br>WMS -IV | EEG | • Decreased alpha wave<br>• Decreased beta wave<br>• Increased beta delta(δ) wave & theta(θ) wave | • α-wave normalization<br>• β –wave normalization<br>delta(δ) wave and theta(θ) wave normalization | Subjective Units of Distress Scale: SUDS<br>❖ Immersion<br>❖ Presence<br>❖ Motion Sickness<br>❖ Usability<br>❖ Ease of learning<br>❖ satisfaction<br>❖ Improvement |
| | | Heart Rate Variability | • The more severe the cognitive degradation, the less likely the results are to be found in the various parameters of the HRV | • Normal range of HRV | |
| ADHD (Attention Deficit Hyperactivity Disorder) | K-CAARS - 26 ( Korean version of Conners Adult ADHD Rating Scale-IV | EEG | • Increased beta delta(δ) wave<br>• Increased theta(θ) wave **(frontal lobe)**<br>• Decreased alpha wave<br>• Decreased beta wave | • delta(δ) wave and theta(θ) wave normalization<br>• α-wave normalization<br>• β –wave normalization | |

| | | | | | |
|---|---|---|---|---|---|
| | Rating Scale-26) | | • Increase in low frequency activity<br>• Increase **a slow wave of the frontal lobe** | ❖ **normalize the slow wave of the frontal lobe** | |
| | | Heart Rate Variability | • Decreased LF<br>• Increased LF | • Normal range of LF | |
| Panic Disorder | Anxiety Sensitivity Inventory(ASI)<br>Panic Disorder Severity Scale (PDSS) | EEG | • Decreased alpha wave<br>• Decreased beta wave<br>• **Reduced or slow of theta(θ) wave** | • α-wave normalization<br>•<br>• β –wave normalization<br>•<br>• θ wave normalization | |
| | | Heart Rate Variability | **• Reduces flexibility of overall autonomic nerves**<br>1) SDNN (standard deviation of RRI) shown in 24-hour analysis is significantly lower in patients with panic disorder<br>2) Low total power of 5 minute analysis<br>**• The activation of the low-sensor nervous system.**<br>1) High VLF(very low frequency)& LF(low frequency)<br>2) High Normalized | • Normalize the flexibility of the autonomic nervous system<br>• normalization of the sympathetic nervous system | |

| | | | | | |
|---|---|---|---|---|---|
| | | | HF(normalized high frequency) | | |
| PTSD(Post-Traumatic Stress Disorder | (Post-traumatic Stress Disorder Checklist, PCL)<br>(Impact of Event Scale - Revised, IES-R) | EEG | • Decreased alpha wave<br>• Increased beta wave<br>• Increased delta(δ) wave and theta(θ) wave | • α-wave normalization<br>• β –wave normalization<br>delta(δ) wave and theta(θ) wave normalization | |
| | | Heart Rate Variability | • **High level of sympathetic nerve activity**<br>❖ Reduced standard deviation of RRI, low RMSSD showed faster heart rate and higher level of sympathetic nerve activity than normal group<br>• **High level of sympathetic nerve activity, reduced HF, reduced LF**<br>• **High LF/HF (**sympathetic /parasympathetic nerve **Ratio) appears to indicate the deflection of the sympathetic nerve** | • stabilization of the sympathetic nerve<br>•<br>• Normalize the deflection of the sympathetic nervous system | |




[Fig. 6] Device and Viewer for acquiring EEG and PPG

### 3.5 Progress status

The developed VR contents were applied to 200 panic disorder, PTSD, MCI, and ADHD patients using HMD. The change in brain waves and PPG and the survey results by disease were reviewed to assess if the VR contents are effective. For panic disorder for instance, if the reduced alpha waves, elevated beta waves, and reduced or slow theta waves are normalized after the patient is exposed to the VR contents, the contents can be considered effective. The results of all the subjects were collected and analyzed.

## 4. Discussion

According to several studies, about 50% of PTSD patients withdraw or do not respond to treatments as they find it difficult to recollect an image under the conventional exposure therapy . VR exposure therapy, however, can serve as a preferable alternative for PTSD patients who avoid the trouble of recollecting an image as it directly provides relevant circumstances.

For PTSD, according to the systematic review of VRET, the dropout rates of VRET is not higher than conventional exposure therapy, also 7 of 10 studies, the VRET is effective to PTSD patients, their effects were not different with conventional therapy as well. The important thing of VRET is that design contents scenario and establishing each hierarchy.

For panic disorder, in respect with effectiveness, VR therapy compares favorably with conventional therapy. Conventional therapy versus VR therapy, it is revealed that similar therapy efficacy in exposure therapy, Interceptive exposure therapy, cognitive behavioral therapy. VR therapy is comparable to the conventional therapy in terms of efficacy. Treatments that had comparable clinical effect with the conventional VR therapy were exposure therapy, interoceptive exposure therapy, and cognitive behavior therapy.

For MCI, studies using VR to cognitive training treats general cognitive function, such as frontal function, memory, spatial navigation and so on. For ADHD, researchers and clinicians may expect lower dropout rates in treatment and positive results in cognitive training.

VR therapy was not inferior to conventional therapy in its application to psychiatry regarding PTSD, ADHD etc., and holds high potential as it enables convenient use of situations that cannot be easily reproduced in real life[37].

The use of VR contents as medical therapeutic contents, however, has some shortcomings. Although decreased vision, dizziness, and discomfort during use are issues that can be eventually resolved, the response can differ depending on the patients' health status, age, sense of balance, and cognitive problems, and the users can be prone to addiction as one can find telling VR from reality difficult.

It is thus recommended that VR be used for approximately 20 minutes only as the use of VR devices can cause dizziness, reduced awareness, nausea, and vomiting. It was also pointed out that the VR industry is overly focused on technical development and that the results of various clinical studies and researches on the mental effect of VR should be included in the development guideline.

In addition, the "uncanny valley" issue can be a problem when it comes to VR contents where people appear. People may feel uncomfortable if artificial individuals like computer graphics and robots resembling humans over a certain extent appear, and if such discomfort arises in the course of treatment, it may affect the efficacy of the treatment.

Another blind spot is that uncertified practitioners may abuse VR therapy, resulting in expertise and ethical issues owing to excessive commercial use.

Although VR is emerging as an alternative to the conventional therapy in the psychiatry field, it is necessary to research on and develop preventive measures that can minimize the discomfort that may be caused to the human body, and further research and discussion on the effects of VR on the brain would be necessary.

## Conclusions

Although the application of VR in medicine is efficient in certain areas, more research and development are needed to minimize the discomfort that it may bring to the human body. Also, it is necessary to determine what VR contents can be applied to the medical field by presenting clear large-scale research results that demonstrate such.

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