Examination of the Use of VR Combined with Internet Technology to Enhance the Experience of Sound Art in the Treatment of Anxiety Disorders

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Abstract

Due to the rapid development of interactive technology, sound interaction, as one of the core forms of interactive art, plays an important role in sound art. Its interactivity is one of the main factors affecting audiences' perception. As far as the interaction of sound art is concerned, it can neither be extended as sound art nor give full play to its function, which is the key difficulty in the current development. Therefore, only by making full use of the existing advantages of virtual reality and the innovation of digital processing technology that the value of art therapy can be better reflected. However, in sound art therapy, the most critical thing is to establish the correct understanding of it and followed by the selection of the most appropriate treatment method to achieve the best outcomes. On this basis, this study reviews the progress and trend of virtual reality and related technologies. The results show that virtual reality can be used as an effective means to assist sound art therapy. Also, this paper explores how to use existing Internet technology to enhance the experience of virtual reality combined with sound art to improve the feasibility and effectiveness of treating anxiety disorders. After a systematic discussion through MFSC extraction algorithm, the results indicated that the extraction rate of MFSC changed several times and the index decreased significantly before and after the LF/HF experiment, which proved that this approach is more effective than the traditional one. In addition, VR can combine existing Internet technologies, such as high-speed Internet, cloud computing, Internet of Things technology, artificial intelligence, real-time performance, etc. Through these combined methods, the practice of the use of sound art in treating anxiety disorders will be enhanced by the interaction of virtual reality and high-speed Internet technology, which will deepen patients' experience and improve the treatment effect.

Keywords: Sound art therapy, Virtual reality technology, Anxiety disorder, Internet technology

1 Introduction

Virtual reality (VR) has been widely used in various fields, including the application of sound art therapy. Especially in recent years, art therapy combined with virt VR technology has been constantly explored and developed. It is very effective in relieving some mental illnesses. To discuss the application of VR in the field of art therapy, it is better to first understand the basic framework of sound art therapy and the development of VR technology. In general, sound art therapy is a kind of therapy based on the expression form of sound art. It was developed in response to trauma, with the aim of improving mood, alleviating pain, and restoring calm through music, sound production, and acoustic environment design. Being one of the useful approaches in art therapy, sound art therapy is reckoned as an effective psychotherapy method that can be used to treat a variety of mental disorders and diseases, such as anxiety disorders, depression post-traumatic stress disorder, and so on [1].

As VR is an increasingly popular technology, it simulates immersive experiences. In terms of sound art therapy, virtual reality actually offers a new way to experience sound art therapy. For example, using VR technology to create and control ambient sound effects can help patients relax and reduce anxiety and stress levels. VR can stimulate patients' rationality and emotions through speech recognition technology and emotional computing and provide feedback and guidance during treatment. It can be seen that VR technology has been widely studied and used to treat anxiety disorders. Also, the new immersive experience provided by VR placing the patient in a different sound environment, which can effectively reduce the anxiety symptoms of patients. At present, VR has been applied to many sound art therapy projects, such as music therapy, sound therapy etc. By experiencing different soundscapes and sound therapy options in a VR environment, people with anxiety disorders can be helped to better understand and manage their symptoms.

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Because of the rapid and diversified development of the economy, the high incidence of nervous system diseases such as anxiety disorders has aroused great concern, and more and more research has been done on anxiety disorders. Some studies have shown that VR can be just as effective as traditional face-to-face therapy. In addition, VR technology can also provide more personalized treatment plans to adapt to the needs and characteristics of different patients. Schmid et al. [2] proposed that simple anxiety sensitivity reduction protocols were effective for suicide risk and symptoms in patients diagnosed with anxiety disorders. In addition, a study by Bhattarai et al. [3] found a higher prevalence of anxiety disorders in patients receiving dental treatment compared to other studies conducted in similar Settings. Lee et al. [4] used patient-reported outcomes and physiological measures to test the effects of music interventions and aromatherapy on reducing anxiety in patients. However, all of the above studies are theoretical. At present, there is still a lack of relevant experiments and studies for reference.

Based on the above discussion, the application of VR will be one of the effective ways to reduce anxiety symptoms. Kim et al. [5] used a mobile device-based virtual reality program for self-training. Experiments have shown that the procedure is cost-effective in treating social anxiety disorder. Wiederhold et al. [6] have found that VR can be used to overcome specific phobias and anxiety disorders, rehabilitating patients suffering from chronic pain or other debilitating events. Glennon et al. [7] determined the effectiveness of VR intervention on pain and anxiety in patients undergoing bone marrow puncture and biopsy surgery. These studies illustrate the applicability of VR in the treatment of anxiety disorders, but there is a lack of exploration of the effectiveness of aiding the treatment of anxiety disorders with the combination of virtual reality technology and art therapy with the help of internet technology. Therefore this section also becomes necessary for the article to go into.

2 Virtual Reality Technologies

With the progress of digital technology, a new practice mode - virtual reality (VR) - has emerged in real life. From the use of computer and digital information technology to display, to the interpretation of traditional cognitive concepts, both have shown their symbolic significance [8-11]. It has shown its unique value in many social fields. However, any technology can be a double-edged sword, not only for people, but also for a range of related issues [12-13]. Virtual reality is an innovative concept and technology after PC and mobile phone, which provides users with a new interactive experience. The interactive art that uses sound as the carrier in the VR environment and uses sound to convey the emotional experience in the virtual space is a popular and innovative way. Through various forms of experience, users can freely explore and create their own personalized space in the virtual space. For example, individuals in virtual worlds can create a sense of "immersion" and "intimacy" with others through this process.

On the other hand, it is also possible to create an "immersive" environment through the form of voice, so that users can be placed in the virtual space and constantly improve the richness of the perceptual content. According to the current development trend, VR has become an indispensable part of daily life, which not only drives the rapid development of related industries, but also allows more users to easily enter the virtual space. With the computer-centered virtual reality technology, simulation, interaction, pattern recognition and other means have become familiar and mature technologies in the application of VR. The essence of VR is the interaction of a digital virtual entity with various activities in it, for example in games, the form of sound art has long taken place in daily life already. Therefore, through computer simulation, it is able to build an interactive process that can communicate with the virtual world without taking any physical actions, so that various activities in the virtual space can become diverse emotional experiences. In the movie - Frozen, for example, deep, clear vocal echoes are used to provide audiences with a sense of security. Evidently, such a method is suitable for personal experience and has voice and image characteristics.

2.1 Practical Possibilities of VR Technology

Since the emergence of Internet, it has attracted extensive attention in society. Through virtual practice, people have made breakthroughs in three aspects - material production, society, and science. The field of practice has been expanded and the object of knowledge has been broadened. The ability to experience virtual reality has been improved [14]. As VR continues to develop, the emergence of virtual practice has a vitality. If virtual practice is a practice of creating possibility, then it may be capable to turn all possibilities into reality [15-17]. In this virtual world, everything appears to be controllable. People are no longer restricted by physical, natural, social and other aspects, nor by any kind of material conditions. The digit symbol in the unit of bit abstracts the original specific object into the entity and separates the real thing from the material carrier of the entity. At anytime and anywhere, it can function independently without being restricted by the carrier [18-19]. It is also true that VR can separate human perception and perception from the body, as to achieve the ability to transcend the limits of time and space [20-21]. This composition is shown in Figure 1.

2.2 Feature Extraction Algorithm Based on VR Technology

According to the requirements of sound art therapy combined with VR technology, the sound features can be extracted by scientific calculation and presented in the way of it. Users can interact with different levels of sound, such as the difference in timbre, resulting in differences in psychological intensity on feelings and experience, and then affect the individual's psychological state. This section introduces the causes and algorithms of feature extraction in VR technology and explains the corresponding ways and steps of the algorithms.

2.2.1 Mel Frequency Spectral Coefficients (MFSC) Extraction Algorithm

The Mel spectral coefficient is an index obtained according to the laws of statistical physics and Melhe science, which is used to describe the characteristics of an object. For example, “timbre” is often recognized and characterized by the difference between the brightest timbre and the maximum volume. Thus, is timbre really useful in life? In fact, timbre is not real because sound comes from the heart, and it is not colorless and tasteless. It has the most primitive timbre in nature. Using the Mel spectrum coefficient, sound can be introduced into the sound environment from the outside, so as to produce more sound sensory effects in the virtual system to attempt to better improve the interaction effect of sound art, which is conducive to the treatment of anxiety symptoms.

The extraction process of MFSC includes framing, windowing, Fast Fourier Transform (FFT), modulo, Mel filtering, and logarithm (Figure 2).

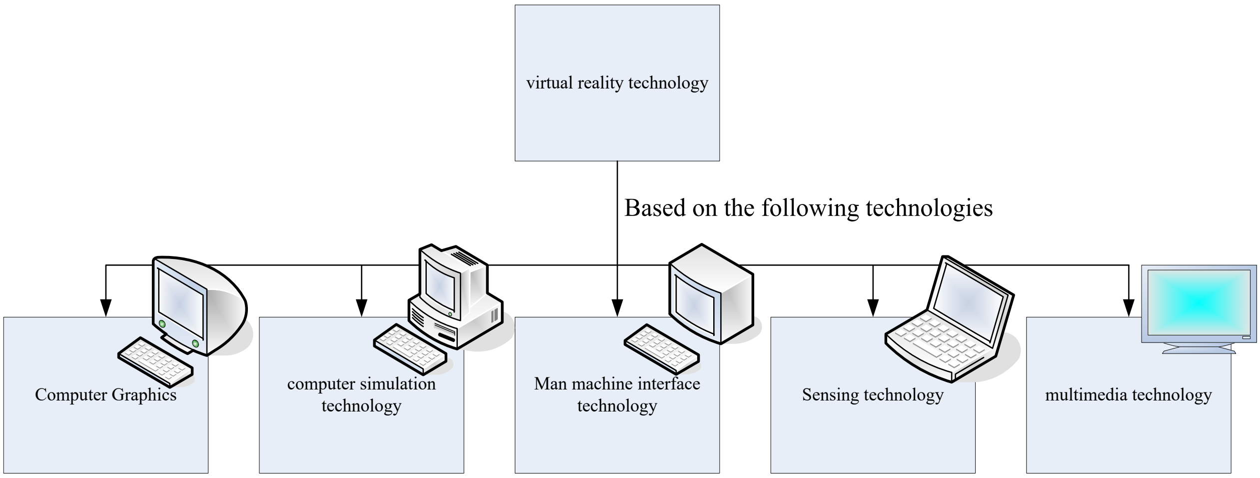


Figure 1. The composition of virtual reality technology

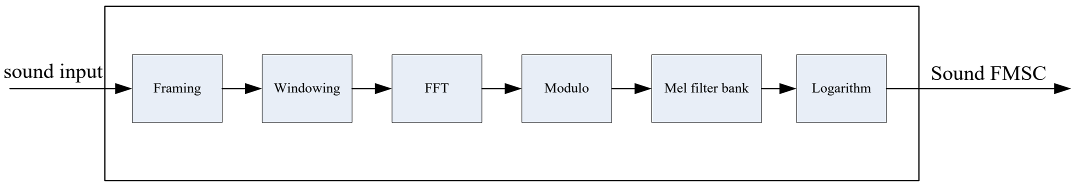


Figure 2. MFSC extraction algorithm steps

1) Framing

Framing technology divides the audio signal into several parts according to a certain length. Each part is an audio data. During data processing, FFT is generally used to treat N points as one frame for processing. The commonly used values are 128, and 512 [22]. The concatenation of frames causes data to be lost in subsequent computations, so an overlapping region appears. In this way, the excess of data does not cause sudden changes or unintended consequences. The frame length of the part that does not overlap is called frame shift, and the general frame shift is $M/2$ or $(M+1)/2$.

2) Windowing

The windowing method requires multiplying the input speech data with the known window coefficients. The regularly used window functions are Gaussian and Hanning window. In this paper, the method based on the Hanning window function was used. By reducing the values at both ends of the audio frame, the method makes the two ends of the audio frame decrease in gradient. Then the FFT can focus on the middle part of the audio frame, thereby reducing the truncation effect of the audio frame and reducing the negative impact of spectral leakage. The window length is the same as the audio frame length.

Assuming that the signal is $a(m)$ and the window function is $\xi(m)$, the windowed signal $b(m)$ can be expressed as:

$$b(m) = a(m)\xi(m),\ 0 \le m \le M-1. \tag{1}$$

Among them, $\xi(m)$ forms can be expressed as:

$$\xi(m) = \begin{cases} 0.5\left[1-\cos\left(\dfrac{2\pi m}{M-1}\right)\right], 0 \le m \le M-1 \\ 0, \text{otherwise} \end{cases}. \tag{2}$$

3) FFT

Because the sound is random and time-varying, it is difficult to transform the speech in the time domain. Generally, the windowed sound data is used for FFT processing. The sound data is converted to the frequency domain. In the frequency domain, different frequency band information can reflect different sound characteristics.

Let the sound signal be $b(m)$, and where M represents the number of Fourier transform points. $B_x(l)$ is the frequency domain information. The sound signal DFT (Discrete Fourier

Transform) formula can be expressed as:

$$B_x(l)=\sum_{M=0}^{M-1} b(m) r^{-k2\pi l/M}, 0 \le l \le M. \quad (3)$$

4) Amplitude spectrum or power spectrum

The frequency domain amplitude spectrum or power spectrum of the FFT signal is obtained by performing amplitude and square operations on the complex numbers output by the FFT. Its goal is to convert the complex frequency domain signal of the FFT signal into an actual signal, which facilitates subsequent processing and reduces the computational workload. Because of the symmetry of the output of the FFT in the frequency domain, only the first $M/2+1$ are usually studied.

Among them, the expression for finding the magnitude spectrum $Q(l)$ is:

$$Q(l)=|B_x(l)|^2, 0 \le l \le M. \quad (4)$$

The expression for finding the power spectrum $G(l)$ is:

$$G(l)=\sqrt{|B_x(l)|^2}, 0 \le l \le M. \quad (5)$$

5) Mel filtering

A mel filter bank consists of a set of mel-scaled bandpass triangular filters. Triangular filters are not of equal bandwidth but start at low frequencies. The bandwidth increases and the resolution to frequency decreases. The input audio domain signal is multiplied and added. Each individual filter outputs the signal as the basic characteristic of the sound signal. This feature is in the Mel spectral domain, and the perception of sound is linear.

A mel filter bank with N filters is defined with a center frequency of $g(n)$, n = 1, 2, ..., N . The frequency response $J_n(l)$ of a triangular filter is expressed as:

$$J_{.}(l)=\begin{cases} 0, l < g(n-1) \\ \dfrac{2(l-g(n-1))}{(g(n+1)-g(n-1))(g(n)-g(n-1))}, g(n-1) \le l \le g(n) \\ \dfrac{2(g(n-1)-l)}{(g(n+1)-g(n-1))(g(n)-g(n-1))}, g(n) \le l \le g(n+1) \\ 0, l \ge g(n+1) \end{cases}. \quad (6)$$

In Formula (6), $\sum_{N=0}^{N-1} J_n(l)=1$.

Mel filter bank can effectively reduce the dimension of spectral data, smooth processing, and extract higher-level information. It eliminates the influence caused by the signal source's own characteristics and reduces the calculation amount of the subsequent algorithm.

6) Logarithmic calculation

The mel spectrum signal of the mel filter bank is the original acoustic characteristic. Using logarithmic operations, logarithmic energy can be obtained. Through logarithmic operation, the signal amplitude is more concentrated and the spacing is reduced. This operation can make the volume of the MFSC more consistent with the hearing of the human ear.

To control the output data, a bias of 0.01 is added to the input data. Assuming the output is $D(n)$, the calculation formula can be expressed as:

$$D(n)=\ln\left(\sum_{l=0}^{M-1}\sqrt{|B_x(l)|^2}\cdot J_n(l)\right), 0 \le n \le N. \quad (7)$$

According to the calculation of the above seven steps, the form of sound features can be obtained by calculation. These features can be applied in VR, and presented to users in VR models, giving users different sound levels due to perception and experience, and achieving the effect of affecting user's corresponding psychological state.

3 Feasibility of Applying Virtual Reality through Internet Technology to Assisted Art Therapy for Patients with Anxiety Disorders

Today, many mental health interventions are combined with various new technologies such as artificial intelligence, big data, blockchain, VR, including the use of artistic interaction, sound art, and related Internet technologies to promote an individual's physical and mental health. In addition, Internet technology can also support VR technology for collaborative sound art therapy through remote access, collaborative experience and resource sharing. First, in teletherapy, the Internet allows the operation of remote sound art therapy, enabling individuals in remote areas or with reduced mobility to access therapy [23]. Through online sessions built with VR, therapists can interact with patients, facilitating remote therapy interactions and coaching. Therapists and patients can deepen their experience of sound art therapy through online counseling and information resources. Second, in addition to developing sound art therapy applications and tools, those designed specifically based on Internet technology can incorporate interactive and customizable content from VR to enhance the experience. And scalable features such as virtual instrumentation, loop creation, effects processing, and recording capabilities will allow patients to explore and express themselves during treatment. By harnessing the power of Internet technology, VR combined with sound art therapy can extend its scope, provide a collaborative experience of resource access and treatment data analysis, and improve the effectiveness and accessibility of the entire treatment process.

Anxiety disorder patients are the focus of this study. The general condition of patients is that in the early stages, patients tend to start feeling emotional anxiety, which is followed by excessive and prolonged fear. The sound therapy through the VR environment can be very effective in enhancing and changing the psychological state of these patients. Sound is a kind of information with strong recognition ability, while auditory information has strong thinking and memory ability. For example, with the help of VR technology, patients can use their voices to intervene with anxiety. The use of sound art to express personal emotions can improve patients' cognitive quality and quality of life, and further promote the formation of patients' positive emotions. However, when it comes to VR technology, the visualization and imitation nature of virtual world immersion and interaction can be used to enhance the experience. Therefore, with the influence of VR technology and the help of artificial intelligence, the visualization and interaction of sound can reduce emotional stress. Compared with artificial simulation environment, exposure treatment using virtual reality intervention has the advantages of fast, economical, safe, flexible, and remote implementation at any time. These advantages enable patients to experience senses such as sight, hearing, and touch in a virtual environment. With the help of a therapist, the patient wears a head-mounted stereoscopic display and looks around to get a perceptual experience of the virtual environment. During therapy, a therapist can place a patient in a safe, controlled simulated environment to trigger their anxiety. Patients are gradually and repeatedly exposed to these stimuli, but eventually they learn that the threats are not dangerous. Such virtual reality environments enable patients to engage in therapeutic techniques that are not possible outside of VR, reducing their anxiety and avoidance behaviors. Figure 3 shows the current application of VR technology in various fields.

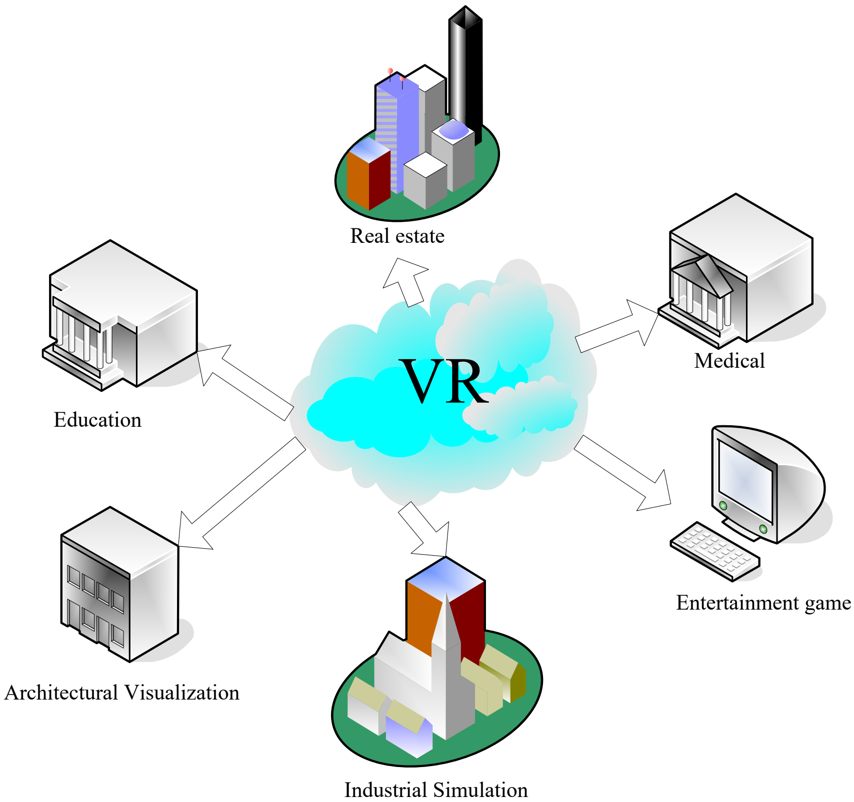


Figure 3. The field of virtual reality development

4 Experiment of Assisting Sound Art Therapy for Anxiety Disorder Patients Based on VR Technology

4.1 Experiment Preparation

4.1.1 Detection Technology of Anxiety Disorder

In this paper, a symptom self-rating scale, anxiety self-rating scale, and heart rate variability (HRV) index were selected as follows:

1) The symptom self-rating scale, also known as the 90 Symptom List (SCL-90), is the most widely used mental health measurement scale globally. It is most commonly used clinically.
2) The anxiety self-rating scale identifies the severity of anxiety and reflects the patient's emotional state during treatment. This scale is the most widely used measure by psychologists. Its role is to evaluate symptom severity. It is not diagnostic.
3) HRV involves neurohumoral factors that regulate the human circulatory system. It is the result of co-regulation by the sympathetic and vagus nerves in the autonomic nervous system. In patients with anxiety disorders, HRV changes are due to increased vagal activity or decreased sympathetic activity.

There is no specific quantitative standard for the mild, moderate, and severe classifications for the self-assessment scale. Raters are required to make subjective judgements. Given that there are no classifications for the two abovementioned scales, HRV was used as an objective measurement of anxiety disorders.

4.1.2 The Introduction of the Symptom Self-rating Scale, Anxiety Self-rating Scale, and HRV

1) Self-rating symptom scale

There are 90 items on the questionnaire, covering various factors such as sensory factors, consciousness, thinking, emotion, behavior, diet, sleep, living habits, and interpersonal relationships. Ten factors are selected from the questionnaire, reflecting 10 different psychological conditions. There are several test questions covering many topics. Each area may accurately reflect the subject's current state. Each question on this quiz uses a scale of 1 to 5. This scale can be used to assess mental state and explore the theory and mechanism of mental illness. The scale can be used to check which people in the population being tested have mental illnesses, as well as the severity of their illness. However, it does assess symptoms of schizophrenia. In addition, it can distinguish borderline mental disorders too. If the score is outside the normal range, then, further testing is required. This scale can be used as an early assessment tool for intervention. General hospitals often use this scale to understand the psychological state of physical disorders. Questionnaires are conducted with different professional groups using the "Symptom Self-Rating Scale" to reflect the differences in the psychological state of each professional group.

2) Self-rating anxiety scale (SAS)

The anxiety self-rating scale is suitable for adults with anxiety symptoms. It is similar to the depression self-rating scale and has a wide range of applications. Items are totaled to reflect a standard score. Higher scores suggest more severe symptoms of anxiety. Typically, those without anxiety disorders have a score less than 50, while those with mild anxiety disorders score between 51-60. Those with moderate anxiety disorders score between 61-70. Those with severe anxiety disorders score higher than 70.

3) Application of HRV

HRV reflects the regulation of neurohumoral factors on the circulatory system and varies with the heartbeat cycle. Neurohumoral factors modulate the sinoatrial node. Heart rhythm variability is the manifestation of the hearts regulatory effect. This refers to the relationship between the sympathetic and vagal nerves and their mutual balance within the autonomic nervous system. When vagal or sympathetic nerve activity decreases, HRV increases, whereas HRV decreases. Studies have shown that patients with anxiety disorders have abnormal activity of the autonomic nervous system, with an imbalance between their sympathetic and parasympathetic activity, with sympathetic hyperexcitability and a significant decrease in parasympathetic excitability. This phenomenon is presented in the form of a significant reduction in some of the heart rate variability characteristics. Therefore, many scholars have studied the autonomic function of depressed patients based on heart rate variability, aiming to understand the formation mechanism of depression and to explore potential heart rate variability indicators that can mark depression.

Because time domain and frequency domain analysis are important for HRV analysis, the time domain analysis indicators used in this test were the standard deviation of the R-R interval (SDNN) for all sinus beats within 24 hours, the mean R-R interval every 5 minutes in 24 hours (SDAN), and root mean square of the difference between adjacent R-R intervals in 24 hours. (rMSSD). The analysis of the spectrum can quantify the cycle of the electrocardiogram. The frequency domain analysis index mainly detects low frequency (LF) at 0.05 - 0.15 Hz and high frequency (HF) frequency at 0.15 - 0.45 Hz. LH/HF value.

4.2 Experimental Methods and Results

4.2.1 Experimental Method

The subjects included patients diagnosed with an anxiety disorder. Patients were recruited from the psychiatric department of a hospital. A total of 45 patients (19 males, 26 females, aged 26 - 48 years) were included. Finally, 40 subjects completed the valid trial and were randomly divided into 2 groups.

Group A completed conventional sound art therapy, while group B completed sound art therapy administered using VR. Conventional sound art therapy used traditional healing sounds, while virtual reality-based sound art therapy used the internet as a platform and VR as a tool to administer traditional healing sounds. Group B also used VR for audio-visual interaction, combining sound or music with image output. Data analyses compared symptoms from each group. Each group received treatment for one hour, 3 times per week. The duration of a course of treatment was 2 months. The SCL-90 and SAS were measured before and after treatment, SDNN, SDANN, rMSSD of HRV and the values of each parameter of frequency domain analysis, HF, LF, LF/HF, were recorded.

4.2.2 Experimental Results

1) SCL-90 scale results

Scores above 160, positive items above 43, or any factor above 2 reflect symptoms of anxiety. A paired samples *t*-test was used to compare SCL-90 scores within groups A and B. The results are shown in Table 1 and Table 2: ("*" $P<0.05$ significant difference, no "*" $P>0.05$ no significant difference)

Table 1. Comparison of SCL-90 results in group A before and after treatment

Symptom	Before therapy	After treatment	T
Somatization	1.99	1.01	3.51*
Force	1.14	1.01	2.77*
Interpersonal relationship	2.21	1.01	4.43*
Depressed	2.34	1.01	4.85*
Anxious	3.63	1.57	32.18*
Hostile	1.14	1.01	2.90*
Terror	1.14	1.01	3.05*
Paranoia	1.14	1.01	2.63*
Psychopathic	1.14	1.01	3.39*
Other	1.11	1.01	2.78*

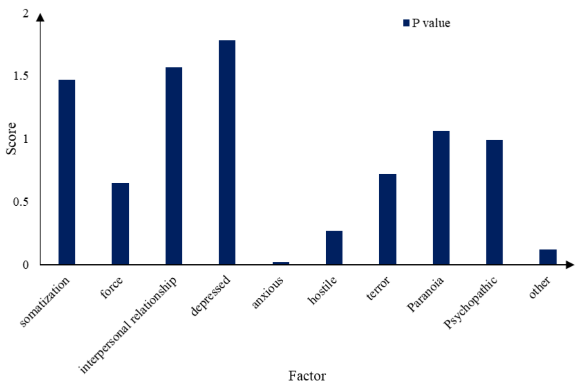
Table 2. Comparison of SCL-90 results before and after treatment in group B

Symptom	Before therapy	After treatment	T
Somatization	1.52	1.01	3.31*
Force	1.18	1.01	3.42*
Interpersonal relationship	1.70	1.01	3.86*
Depressed	1.76	1.01	4.43*
Anxious	3.02	1.17	20.59*
Hostile	1.12	1.01	2.56*
Terror	1.10	1.01	2.30*
Paranoia	1.07	1.01	1.81
Psychopathic	1.09	1.01	3.44*
Other	1.11	1.01	2.07

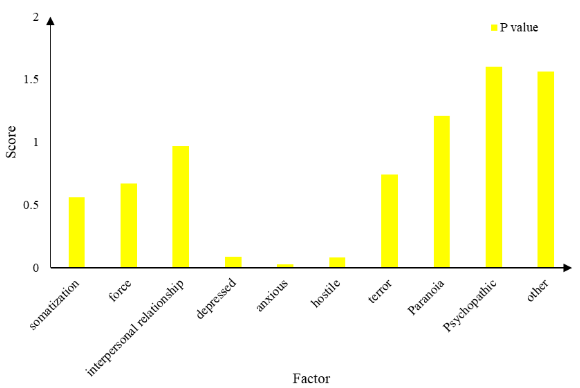
The anxiety factor score of the SCL in group A is 3.63, which is reduced to 1.57 after treatment (Table 1). Significant reductions are seen before and after treatment within each group. There are significant differences in each factor before and after treatment.

The anxiety factor score of the SCL scale of group B was 3.02 before treatment and 1.17 after treatment (Table 2). The scores before and after treatment were significantly decreased. Only paranoia and two other factors were not significantly different, and the scores of the other factors were significantly different before and after treatment.

To compare the effect of the two treatments on symptomology, total scores from each group were compared using an independent samples *t*-test (Figure 4).



(a) Before treatment



(b) After treatment

Figure 4. Comparison of SCL-90 results between the two groups before and after treatment

Among the ten factors, only the anxiety factor has a P value of 0.02, which is less than 0.05 (Figure 4(a)). The P-values for the other factors are all greater than 0.05. Among the ten factors, only the anxiety factor has a P value of 0.03, which is less than 0.05 (Figure 4(b)). The p-values of other factors are also greater than 0.05. Anxiety factors related to anxiety disorders on the SCL scale between the two groups of patients before treatment were significantly higher than the normal range. However, the results of the two groups differs significantly (Figure 4). After treatment, there are still significant differences in symptoms between the two groups. The differences between the two groups before and after treatment were compared (Table 3).

Table 3. Comparison of pre-test and post-test difference results of SCL-90 anxiety factor between two groups

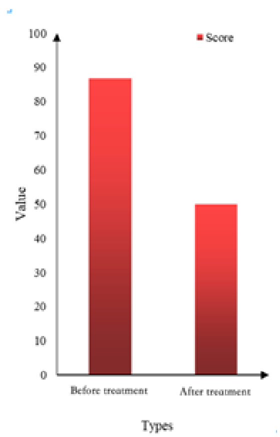
	Front and rear measurement difference of two groups	P
Group A	1.86	0.22
Group B	2.08	

Pre-test and post-test differences in anxiety factors between group A and group B are 1.86 and 2.08, respectively, with little difference in value. However, the P value of 0.22 is significantly greater than 0.05. Results suggest that there is no significant difference in the effects of the two treatments on anxiety symptoms.

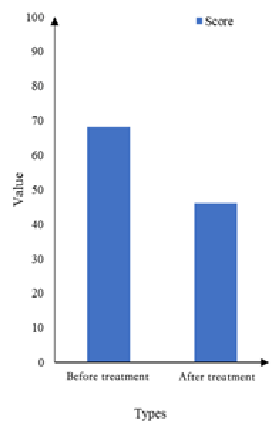
2) SAS scale results

The SAS score is a standardized score. Higher scores reflect more severe anxiety symptoms. Overall, an anxiety score below 50 is normal. Before treatment, anxiety was assessed in both groups using the SAS scale (Figure 5).

Group A scores before and after treatment were 86.68 and 50.00, respectively (Figure 5(a)). Group B scores before and after treatment were 68.07 and 46.12, respectively (Figure 5(b)). SAS scores across both groups of patients before treatment were above 50 (Figure 5). After treatment, scores in both groups decreased relative to pre-treatment scores.



(a) Conventional sound art therapy



(b) Sound art therapy based on VR technology

Figure 5. Comparison of SAS results between the two groups before and after treatment

A *t*-test was performed to determine whether there were differences in anxiety scores between treatments. Results are displayed in Figure 6.

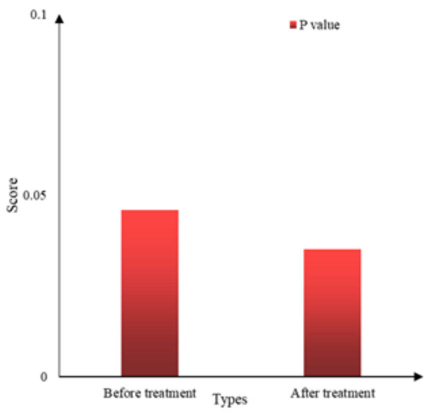


Figure 6. Comparison of P values before and after two treatments

The P value before treatment was 0.046, and the P value after treatment was 0.035 (Figure 6). These results suggest that there were significant differences between the two treatment methods before and after treatment. Finally, the differences between the two groups before and after treatment were compared, the results are shown in Table 4.

Table 4. Comparison of pre-test and post-test differences between the two groups of SAS scales

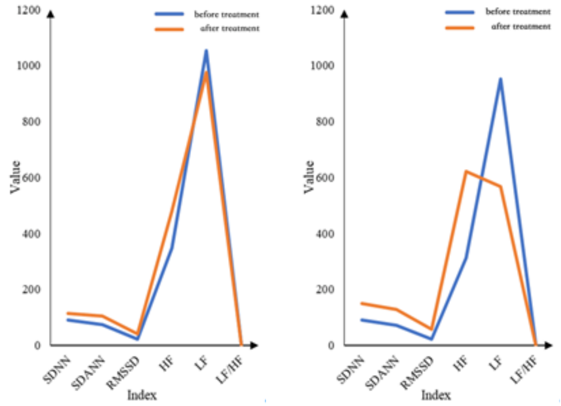
	Front and rear measurement difference of two groups	P
Sound art group based on virtual reality technology	21.91	0.03
Regular sound art group	36.61	

Sound art therapy based on VR was 21.91, while conventional sound art therapy was 36.61. Conventional sound art therapy may be more effective than virtual reality-based sound art therapy. The P value was 0.03, which is less than 0.05. There is a significant difference between the two treatments.

3) HRV results

Before treatment, the rms values of SDNN, SDANN, rMSSD were below the normal range. The LF to HF ratio was above the normal range (Figure 7).

The values of SDNN, SDANN, and rMSSD for conventional sound art therapy before treatment were 91.16, 75.3, and 22.26, respectively (Figure 7(a)). The values of HF, LF, and LF/HF were 348.06, 1053.46, and 3.096, respectively. After treatment, SDNN, SDANN, and rMSSD were 114.41, 104.61, and 41.06, respectively. The values of HF, LF, and LF/HF were 480.66, 975.51, and 2.03, respectively. The values of SDNN, SDANN, and rMSSD during sound art therapy based on virtual reality before treatment were 90.21, 72.01, and 22.21, respectively (Figure 7(b)). The values of HF, LF, and LF/HF were 312.56, 952.46, and 3.08, respectively. After treatment, SDNN, SDANN, and rMSSD were 149.91, 128.91, and 58.66, respectively. The values of HF, LF, and LF/HF were 622.01, 567.06, and 0.92, respectively. The SDNN, SDANN, and rMSSD were all lower than the normal range before treatment (Figure 7). LF/HF was significantly higher than normal. SDNN, SDANN, rMSSD and three other indicators were significantly increased after treatment, with some being close to normal. The LF/HF ratio was significantly decreased, indicating decreased activity of the sympathetic nervous system.



(a) Conventional sound art therapy

(b) Sound art therapy based on VR technology

Figure 7. Comparison of various indicators of heart rate variability before and after treatment

In conclusion, there was no significant difference in SCL scores between the control group and the experimental group. The results of SAS scale show that traditional sound art therapy is superior to VR sound art therapy. The results of HRV analysis indicated the sound art therapy combined with VR technology was more effective. According to the analysis of research results, patients with anxiety disorders are likely to have a psychological state of constant tension, fear and worry. Therefore, during the self-assessment process, when patients encounter problems related to their own anxiety, they will become more nervous, more anxious, and more easily afraid. In addition, patients may also experience symptoms such as headache, chest tightness and heart palpitations. As a result, when faced with similar problems, patients may self-rate higher than those who already have specific or severe symptoms. After treatment, the patient's syndromes will be relieved, and the state of emotional distress will be improved. Besides, it can be possible that the patient is too worried and suspicious about his or her condition, and thus makes a different judgment than usual. Therefore, the effect of the scale may not necessarily reflect the actual effect of treatment. In particular, the decrease in the activity of the sympathetic and parasympathetic nervous system of the human body is a physiological change and reaction which is not controlled by people. Therefore, the functional adjustment of patients' autonomic nervous system after treatment will increase HRV. Such results show that using the physiological indicators before and after treatment to measure the effect of treatment will be more accurate. All in all, sound art therapy combined with VR technology will be more effective than traditional sound art therapy in the treatment of anxiety conditions.

4.3 Specific Operations of Applying VR Technology for Sound Art Therapy

Based on previous statistical data, results, and discussions, it is evident that using VR to assist in administering sound art therapy is effective and useful. The attempt of combining VR with current Internet technology could reproduce its process and effect of sound art therapy to further strengthen outcomes for anxiety patients. Specific operations are proposed by the present study to achieve better outcomes when using VR technology. These operations include:

1) Develop a virtual environment: according to the needs of different patients, different scenes can be designed and completed first, and then corresponding sound effects may be used with music or sound wave therapy to create an appropriate treatment atmosphere.
2) Add personalized elements: adding personalized elements to the virtual environment to meet the individual needs of each patient may make the treatment more appropriate.
3) Multi-sensory experience: improving the quality of music or acoustic therapy by increasing the sensory experience. For example, tactile devices can be added to virtual environments to allow patients to feel the rhythm and force of music or sound waves enhancing the effectiveness of sound therapy.
4) Combined with artificial intelligence technology: by combining with artificial intelligence technology, the effect of sound in therapy can be automatically adjusted according to different conditions, thus making the treatment more targeted.

5 Conclusions

The purpose of this paper is to explore the effectiveness of using VR to assist in the management of sound art therapy for patients with anxiety disorders. The results show that the application of VR technology can improve the effectiveness of sound art in the treatment of anxiety patients. There were forty patients with anxiety disorders participated in the study and they were divided into two groups. One group received traditional sound art therapy and the other group received sound art therapy combined with VR. In previous studies, sound art therapy was proven to have the positive effect on reducing anxiety. Although the starting point of this paper is the study of how to use VR technology in sound art therapy, it also considers and discusses the use of Internet technology to enhance the effectiveness of current treatments on anxiety disorders. As a result, the data obtained by the research confirm the practicability of the original hypothesis and guide the direction of Internet technology application. It also provides new treatment modalities, techniques and approaches to the treatment of anxiety disorders.

Meanwhile, the enhancement of user experience can also be regarded as another core goal of treating anxiety disorders with virtual reality-assisted sound art proposed in this study. Currently, Internet technology can assist VR to enhance user experience in the following ways:

1) High-speed Internet can ensure that each element of the VR scene can be presented to users quickly and clearly.
2) Through cloud computing, users can experience smooth VR effects as long as they have a stable Internet.
3) VR requires a complete and real environment scene. Internet of Things technology enables VR to interact with the real world.
4) Artificial intelligence technology can improve the intelligence and adaptability of VR.
5) The low delay transmission technology in Internet technology can ensure the real-time performance of VR systems, so that users may have a more realistic experience when using it.

In addition, the main points discussed in this study can be divided into two parts. One is how to combine virtual reality technology to enhance the experience and effectiveness of art treatment. The second is the feasibility of promoting VR combined art therapy treatment through existing Internet technology. After the analysis and discussion, the results showed that the treatment of some anxiety disorder patients was significantly effective.

But at the same time, there are corresponding limitations in both aspects such as the limitations relating to technical and the treatment objects. Furthermore, the application of virtual reality technology in sound art therapy is a relatively new field, and there is insufficient clinical practice to prove its efficacy. Some patients may reject virtual reality technology, causing them to be unwilling to cooperate with treatment, which will affect the efficacy. As the application of VR technology cannot be separated from the support of Internet technology, the limitations between them include bandwidth limitations, Internet latency, cybersecurity, and compatibility issues. As a result, it is necessary to grasp the application scenario and scope of its application in order to better promote its application and promotion in clinical practice.

In the future, sound art therapy for anxiety patients will be further developed and improved by combining VR and Internet technology. For instance, VR technology can create a virtual environment that allows patients to complete therapy sessions at any time, remotely, and without worrying about distractions of the physical environment. In the virtual environment, patients can choose their favorite music or natural sounds, and receive auditory stimuli to relieve anxiety. Further, VR technology can continuously adjust and improve the treatment plan according to patient response and treatment progress, improving the effectiveness of treatment. Although the application of VR technology in sound art therapy has made some achievements, there are still many challenges to overcome limitations and the evaluation of therapeutic effects. However, with the continuous development of virtual reality technology, it is expected that applications in sound art therapy will be more widely promoted and further studied. In addition, Internet technology can help therapists better communicate with patients, provide therapy remotely, and communicate with other patients through online communities to share experiences and enhance mutual support. In short, combined with VR and Internet technology, sound art therapy treatment for patients with anxiety disorder will become more convenient, practical, and the therapeutic effect will be better improved.

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