

3D Music Impact on Autonomic Nervous System Response and Its Potential Mechanism

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ABSTRACT

This paper is made to observe the impact of 3D (three-dimensional) and 2D (two-dimensional) music on autonomic nervous system and to explore the mechanism of the music. This study changes and retains some musical elements of the four music, and 73 healthy participants listened to four music tracks with headphones: 3D slow music, 2D slow music, 3D fast music, and 2D fast music. The results show that galvanic skin response (GSR) data decreased in all participants after listening to 3D music. Among them, the first and third 3D music, which bears obvious characteristics of sound spatial movements, high melody definition, stable rhythm structure, and high timbre identification of the main melody significantly changed participants' GSR compared to the benchmark obtained before the experiment ($P < 0.05$). It can be reasonably argued that 3D music may improve the regulation of autonomic nervous system responses, which contributes to the health of mind and body.

KEYWORDS

3D Music, Autonomic Nervous Response Regulation, Binaural Audio, Music Therapy, Virtual Reality

INTRODUCTION

The constant pursuit of sound quality and effect is boosted by the development of virtual reality and computer technology, which makes mono and stereo audio obsolete. 3D (three-dimensional) audio has pointed to a new development direction for high-quality music. A variety of 3D audio technologies have emerged, immersing the audience in music and enriching the hearing experiences. This immersion opens doors to both psychotherapy and physiotherapy.

3D audio refers to a three-dimensional sound effect. It is also referred to as Virtual Acoustics, Binaural Audio or Spatialized Sound (Yin 2011). The sound effect is played back through speaker sets or headphones, creating an "illusion" of the sound. The virtual image is usually omnipresent in the three-dimensional virtual sound field, including the front and back, left and right, above and below. Compared to a sphere, the sound position of 3D audio contains two degrees of freedom: horizontal angle (front, back, left and right) and elevation angle (up and down). The core of 3D audio is altitude (up and down) information, unavailable in traditional stereo audio. Stereo audio refers to a two-dimensional sound effect, which only contains sound position from front to back, left and right.

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Music sometimes triggers people's emotions and physical reactions. Different types of music evoke different emotional reactions and reflect the regulation of the autonomic nervous system through physiological indicators, such as heart rate, galvanic skin response (GSR) and respiratory rate. In the field of music therapy, the healing function of music has been repeatedly proven in improving a patient's physical condition, training a particular skill or treating illness. Stimulative music and sedative music (Hodges, 2006) are considered to be the two most important relative factors that induce autonomic nervous responses. Since 1960, a large number of studies have begun to focus on the autonomic response of different types of music, for example, Krumhansl observed emotional and physiological changes caused by six classical music clips in 1996; in China, Sihua Li and Jingcheng Li selected active (heated, happy, nervous) and calming (quiet, sad, relaxed) music as materials, and found that active music can cause changes in the temperature, respiratory frequency and heart rate.

The application of stimulative 2D music and sedative 2D music mentioned above has been the mainstream of music therapy as a sound stimulating tool. 3D audio is only used in the auditory part of virtual reality therapy and the virtual environment perception of the blind (Ghali & Soliman, 2012).

Moreover, there are limited studies on the mechanism of music on the regulation of human autonomic nervous response, that is, how various elements of music affect human autonomic nervous response and regulation, such as the movement of sound in space (3D or 2D), melody, rhythm, and speed.

Therefore, in this study, some parameters of music stimulation on human body were established in a pioneering way, and on the basis of traditional music elements, sound space elements were added (for specific methods, please see below), and the regulation mechanism of music on human autonomic nervous system is speculated.

The human body's response to music is not only reflected in emotional and psychological aspects, but also in physiological indicators through the adjustment of the autonomic nervous system, such as changes in heart rate, skin electrical response, respiratory frequency and respiratory rate (Xie & Wang, 2011). This paper selected the physiological index of GSR to measure the differences in the physiological responses to different music.

MUSIC THERAPY AND VIRTUAL REALITY TECHNOLOGY

Music Therapy

Music therapy is a systematic intervention process in which the therapist uses various forms of musical experience, as well as the therapeutic relationship developed during the treatment process, to help the participant achieve a healthy goal. The music therapy process must include three factors: music, the participant being treated, and a specially trained music therapist (Gao, 2008). Music has long been used as an alternative method of treatment to relieve patients from anxiety symptoms (Bringman & Giesecke, 2009; Trappe, 2010). The positive role of music as a therapeutic modality for the treatment of preoperative anxiety has been well documented (Maureen & Bonnie, 1997; Karen & Lawrence, 2010). Moreover, meditation music as well as classical music may decrease stress levels and improve quality of life (Hall & Schmidt, 1999; Janet & Burke, 2007).

Application of Virtual Reality Technology in Clinical and Rehabilitation

Virtual reality technology is a computer simulation system that can create and experience virtual world. It uses computer to generate a simulation environment, which is a multi-source information fusion of interactive 3D dynamic visual and physical behavior of the system simulation, so that users are immersed in the environment. Virtual reality technology (VR) mainly includes simulation environment, perception, natural skills and sensing equipment. In medical science, the purpose of virtual reality is to reduce the harm caused by traditional medical treatments. Using new techniques and advanced treatment methods in a virtual way provides new possibilities to direct human body (Graur,

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