Research on the Design of Integrating Audio Resonance Into Immersive Stress-Relief Healing

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Abstract

This study explores the effectiveness and feasibility of audio resonance technology combined with immersive stress-relief therapeutic design in promoting mental health and managing emotions. As modern society faces mounting psychological pressure, traditional methods often fail to provide deep relaxation. In response, we integrate audio resonance technology and multi-sensory stimuli to develop an immersive therapeutic environment. An audio resonance chair delivers low-frequency sound waves and surround sound to create a three-dimensional soundscape, further enriched by generative music based on natural elements for guiding users into deep relaxation. This study aims to integrate audio resonance technology with an immersive therapeutic experience to thoroughly investigate its practical effectiveness and application potential in stress relief and emotional regulation. Ultimately, the research objectives focus on finalizing and evaluating a prototype design, successfully constructing an immersive stress-relief therapeutic environment through an audio resonance chair combined with multi-sensory experiences. On the hardware side, emphasis is placed on the integration of the chair's structure and vibration modules to ensure stable transmission of low-frequency sound waves, thereby providing a deep relaxation effect. On the software side, generative music tools and spatial audio processing are employed to create a highly natural sonic environment. Following testing and adjustments based on user feedback, the final prototype demonstrates excellent comfort and immersion, producing preliminary results in emotional release and stress relief. These outcomes offer a feasible reference for applying audio resonance in mind-body therapy and establish a foundation for future research on immersive experiences and practical stress-relief therapeutic applications.

Keywords: audio resonance, immersive experience, stress-relief therapy, emotional granularity, flow experience

Introduction

As modern life becomes faster-paced and stressors more diverse, an increasing number of people are experiencing mental health issues such as anxiety and chronic stress. University students are particularly affected, facing academic pressure, career uncertainty, and identity shifts. Surveys in Taiwan show rising rates of depressive tendencies among students, with some already exhibiting early symptoms like emotional fatigue, yet many do not seek formal counseling (Ministry of Education, 2020; Wu, 2021).

In this context, accessible, non-invasive, and drug-free stress-relief solutions are increasingly important. Traditional methods like meditation, aromatherapy, and music therapy can be helpful, but may not work for everyone—especially those with high neural sensitivity, for whom overly quiet or unguided settings may heighten anxiety.

Neuroscience research highlights that our bodies react differently to sensory input: sound can quickly trigger emotional responses via the limbic system, touch can promote relaxation through sensory feedback, and vision engages attention and cognition (Patel, 2014). Thus, multisensory integration may better support emotional and physiological regulation.

This study explores the integration of audio resonance and immersive experience design to develop a stress-relief system combining tactile (resonance), auditory (music), and visual (interactive environment) stimuli. The goal is to guide users into a flow state, enhancing emotional regulation and immersion. This approach offers a preventive and supportive therapeutic option for students and stress-sensitive individuals.

Research Motivation

As the pace of modern life continues to accelerate, psychological and physiological stress has become increasingly common, leading to widespread issues such as anxiety, depression, and chronic fatigue. Consequently, the demand for stress-relief and healing methods has grown, with particular attention given to multisensory therapeutic environments. In recent years, both audio resonance technology and immersive experiences have shown great potential in the field of therapeutic design. Audio resonance utilizes low-frequency vibrations to induce relaxation and reduce stress, while immersive experiences enhance emotional well-being through synchronized multisensory environments that foster engagement and comfort.

However, current research and practical applications face two key limitations. First, while audio resonance effectively influences the body through vibrational stimuli, it often lacks contextual and emotional guidance, limiting its impact to the physiological level without reaching deeper psychological effects. Second, although immersive experiences offer high levels of sensory engagement, they frequently lack therapeutic focus and intentionality in addressing specific needs like stress regulation and emotional balance. Therefore, integrating these two complementary approaches—each with its strengths and limitations—has become a pressing research challenge for achieving more comprehensive and effective healing outcomes.

This study is motivated by the need to address these gaps by proposing an innovative integration of visual, auditory, and vibratory stimuli within an emotionally guided, context-aware healing system. Rather than focusing on a single sensory channel or therapeutic method, the proposed design emphasizes multimodal sensory integration and emotional resonance. Grounded in flow theory, the system aims to lead participants into a state of deep focus and internal alignment, enabling profound relaxation and emotional transformation.

Furthermore, through systematic prototype development, experimental design, and data analysis, this study evaluates the effectiveness of the immersive audio resonance system in real-world applications. It also explores adaptive strategies for different contexts and user needs. The findings aim to bridge existing gaps in stress-relief and therapeutic design practices, offering both methodological insights and empirical evidence. Ultimately, this research aspires to support future applications of healing design in clinical therapy, health promotion, and holistic care, contributing to a more mature and practically valuable direction for the field.

Research Objectives

This study aims to integrate audio resonance technology with immersive experience design to develop and validate an innovative system for stress relief and emotional healing. The specific research objectives are as follows:

1. **To examine the stress-relief effects of audio resonance**
   Investigate how low-frequency sound vibrations influence physiological relaxation (e.g., HRV) and emotional states (e.g., PANAS), validating audio resonance as an effective tool for stress regulation.
2. **To develop an immersive stress-relief prototype using audio resonance**
   Design a multisensory environment integrating visuals, sound, and body vibrations, focusing on interactivity and user comfort through iterative prototype testing.
3. **To evaluate the system’s therapeutic effectiveness**
   Use mixed methods to assess changes in physiological indicators, emotional states, and subjective experiences (e.g., flow and relaxation) before and after use.

Stress-Relief and Healing Design

Stress is a complex mind-body response triggered by perceived threats or challenges. Walter Cannon (1932) introduced the "fight or flight" response as a basic survival mechanism involving the sympathetic nervous system. Later, Richard Lazarus (1966) emphasized the role of cognitive appraisal, suggesting that stress is shaped by personal interpretation, not just external events.

In recent years, healing design has gained attention across healthcare, workplaces, urban spaces, and digital environments. By integrating environmental psychology, technology, and health promotion, it seeks to reduce psychological stress and enhance well-being.

However, three major challenges persist:

1. **Mind-body inconsistency** – Healing interventions may improve emotional states but don’t always align with physiological indicators (e.g., HRV), making comprehensive evaluation difficult (Ulrich, 2008).
2. **Individual differences** – Users respond differently to the same healing environments based on factors like sensitivity, resilience, and current state, highlighting the need for personalized approaches (Kaplan & Kaplan, 1989).
3. **Cross-cultural limitations** – Healing preferences and emotional responses vary across cultures, yet many designs lack cultural adaptability (Heine & Norenzayan, 2006).

To address these issues, this study integrates audio resonance with immersive multisensory environments, aiming to create a more holistic, context-aware, and adaptable healing design.

Audio Resonance

Audio resonance involves using sound waves at specific low frequencies to stimulate the body through vibration and tactile input. In recent years, it has shown promising results in health promotion and mind-body healing (Porges, 2011). This technique helps activate parasympathetic responses, reduce sympathetic nervous activity, and promote relaxation and emotional balance.

Studies by Reybrouck et al. (2019) and Chion (2016) highlight that combining auditory and tactile stimuli enhances both physical and psychological relaxation, while also deepening the immersive sensory experience. This multisensory integration has become a growing focus in therapeutic and healing design.

However, current applications often rely on isolated sensory stimuli and lack contextual or emotional guidance. This study aims to address that gap by developing a more integrated, emotionally aware application of audio resonance.

Immersive Experience Design

Immersive experiences originally described a user's full engagement in virtual environments, marked by a strong sense of presence and agency, creating the feeling of "being there" (Witmer & Singer, 1998). The concept has since expanded into fields such as art, healthcare, and entertainment, becoming a key strategy for enhancing user engagement and experience quality.

Csikszentmihalyi (1975) linked immersion to the flow state—an optimal experience characterized by deep focus, control, and self-efficacy (Beard, 2015). Immersive design thus aims not only to stimulate the senses, but also to promote psychological and physiological well-being.

Despite its potential, applying immersive experience design effectively for stress relief and healing still requires further research. Designing goal-oriented and emotionally responsive immersive systems remains a key challenge in therapeutic applications.

Literature Review

While audio resonance and immersive experience design differ in their technical principles and methods, they share several key features. Based on a review of existing literature, this study identifies four major commonalities that support the theoretical and practical integration of the two approaches:

1. **Multisensory Input**
   Both techniques emphasize multisensory integration. Audio resonance engages the body through tactile and auditory vibrations, promoting relaxation, while immersive experiences rely on high-fidelity visual, auditory, and interactive elements to create a fully engaging environment. These multisensory stimuli help guide users into a state of emotional and physiological alignment (Reybrouck et al., 2019; Witmer & Singer, 1998).

2. **Connection to the Sense of Reality**
   Audio resonance enhances the perception of physical reality through synchronized sound and touch, while immersive design creates a strong illusion of presence through detailed audiovisual environments. This heightened sense of reality increases user engagement and therapeutic impact (Chion, 2016).
3. **Impact on Emotional and Psychological States**
   Specific frequencies in audio resonance can induce alpha or theta brainwaves associated with relaxation and focus. Immersive experiences influence emotions by simulating contextual scenarios, enhancing affective involvement. These complementary effects support deeper emotional regulation (Beard, 2015; Porges, 2011).
4. **Emotional Synchronization and Entrainment**
   Both techniques promote emotional entrainment. Audio resonance supports rhythmic bodily alignment with external stimuli, while immersive environments foster a sense of agency and active participation. Together, they enhance emotional coherence and engagement (Csikszentmihalyi, 1975; Witmer & Singer, 1998).

In summary, audio resonance and immersive experience design share strong theoretical and practical synergies in multisensory engagement, perceived realism, emotional influence, and synchronization. Integrating these approaches offers promising potential for advancing the effectiveness and applicability of therapeutic design.

Research Structure

This study adopts a prototype development and experimental approach, carried out in three stages:

1. **Design and development** of the immersive audio resonance healing system.
2. **Pre-test implementation**, including the PANAS emotional scale and HRV physiological data collection.
3. **Execution of the immersive healing experience**, followed by post-test assessments and in-depth interviews.

Prototype Development

The immersive audio resonance healing system developed in this study consists of three main modules: an audio module, a visual module, and a vibroacoustic chair system. The prototype emphasizes multisensory integration and interactivity to enhance immersion and therapeutic experience.

1. **Audio Module: AI-Generated Sound via Stable Audio**
   The system uses Stable Audio to generate healing soundscapes through text-based prompts, allowing customization of style, rhythm, and emotional tone. Keywords like "528 Hz," "alpha waves," or "meditative beats" guide the creation of audio content that supports relaxation. These sounds serve both as spatial audio and as input to drive vibration, achieving synchronized audio-vibration coupling.
2. **Visual Module: Generative Graphics via TouchDesigner**
   TouchDesigner is used to create reactive visuals based on audio rhythm, user interaction, or biometric signals. The system produces dynamic effects such as particle flow, waveforms, and light modulation, enhancing sensory alignment and overall immersion.

3. **Vibroacoustic Chair System**
   The chair system includes a computer, low-frequency audio amplifier, and embedded vibration units. Audio signals are processed and transmitted to tactile transducers embedded in the chair, allowing users to physically feel the sound through low-frequency vibrations across multiple contact points. These vibrations correspond with the music's rhythm and tension, promoting deep physical relaxation.

The overall design supports multimodal integration of sound, light, and vibration, and features adjustable parameters for flexible testing across various experimental or therapeutic scenarios.

Pilot Experiment

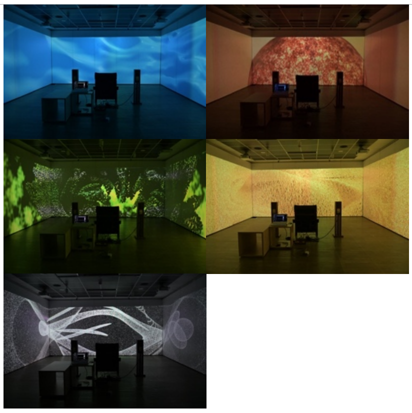
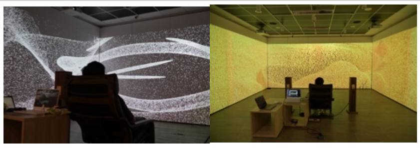
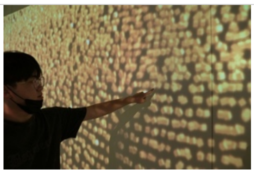
The first pilot study recruited five university students with no major health conditions. Each session lasted approximately 60 minutes. The setup included a vibroacoustic chair, a three-wall projection environment, and a surround sound system. The experiment followed this procedure: consent and pre-test → immersive experience → post-test and interview.

Preliminary results showed a slight increase in heart rate variability (HRV) and a decrease in average heart rate, indicating relaxation. Subjective feedback included feelings of calmness and pleasure. Several participants noted the resonance effect as particularly impactful for bodily relaxation and internal grounding.

Experimental Procedure Overview

Table 1
Changes in PANAS Positive and Negative Affect Scores After the Second Immersive Session

步驟	流程	說明	畫面
1		Explanation of study and signing of consent form	
2	Pre-Test (15 min)	Completion of PANAS and emotional granularity scales	
3		Collection of baseline psychological data	

步驟	流程	說明	畫面
4		Guided to vibroacoustic chair	
5	Immersion (15 min)	Selection of visual theme	
6		Equipped with EEG headset and ASUS smartwatch	
7		Immersive audio resonance experience begins	
8		Post-experience data collection on the chair	
9	Post-Test (15 min)	Completion of PANAS, granularity, and flow experience scales	
10		Participant feedback and suggestions	

Methodology & Instruments

To evaluate the stress-relief effects of the immersive audio resonance system, this study adopted a mixed-methods approach, combining quantitative and qualitative data collection and analysis. Three primary instruments were used to assess changes in physiological and psychological states before and after the experience:

1. **HRV (Heart Rate Variability) Monitoring**
   Participants wore biometric sensors to track HRV indicators such as SDNN, LF, HF, and LF/HF ratio. These values reflect autonomic nervous system regulation and physiological relaxation.
2. **PANAS (Positive and Negative Affect Schedule)**
   This self-report questionnaire measured changes in emotional states by comparing scores on positive and negative affect scales before and after the experience.
3. **RDEES (Revised Differential Emotions Experience Scale)**
   RDEES assessed participants' emotional granularity, indicating their ability to identify and describe distinct emotional experiences.

Changes in HRV Indicators Across Two Immersive Sessions

Table 2
Changes in HRV-SDNN (ms) Across Two Immersive Sessions

Participant	Variable	First Session			Second Session		
		Pre-Experience Test (1st)	Post-Experience Test (1st)	Outcome (1st)	Pre-Experience Test (2nd)	Post-Experience Test (2nd)	Outcome (2nd)
A	HRV-SDNN(ms)	65.1	70	Increase	44.4	63.1	Increase
	LF(ms^2)	310.2	657.7	Moderate	438.8	1118.8	High
	HF(ms^2)	2093.9	2056.7	High	1933.9	198.0	Moderate
	LF/ HF	0.2	0.3	Low	0.2	0.5	Relaxed
B	HRV-SDNN(ms)	56.2	48.5	Decrease	32.9	42.6	Increase
	LF(ms^2)	461.4	897.4	Moderate	677.2	513	Moderate
	HF(ms^2)	500.4	661.9	Moderate	453	314.4	Moderate
	LF/ HF	0.5	1.4	Active	1.5	1.6	Active
C	HRV-SDNN(ms)	24.2	33.9	Increase	14.2	42.4	Increase
	LF(ms^2)	93.4	109.3	Low	19.4	287.9	Moderate
	HF(ms^2)	297.3	445	Moderate	46.5	545	Moderate
	LF/ HF	0.3	0.2	Low	0.4	0.5	Relaxed
D	HRV-SDNN(ms)	17.2	8.4	Decrease	8.2	10.5	Increase
	LF(ms^2)	23.2	4.8	Low	4.8	3.6	Low
	HF(ms^2)	9.5	0.7	Low	3.1	2.5	Low
	LF/ HF	2.5	7.3	Balanced	1.6	1.4	Active

Participant	Variable	First Session			Second Session		
		Pre-Experience Test (1st)	Post-Experience Test (1st)	Outcome (1st)	Pre-Experience Test (2nd)	Post-Experience Test (2nd)	Outcome (2nd)
E	HRV-SDNN(ms)	36.6	43.4	Increase	34.9	54.5	Increase
	LF(ms^2)	218.1	610.3	Moderate	164.1	1302.1	High
	HF(ms^2)	576.8	752.1	Moderate	394.7	873.1	Moderate
	LF/ HF	0.4	0.8	Relaxed	0.8	0.8	Relaxed

Changes in PANAS Scores After Second Immersive Session

Table 3
Changes in Positive and Negative Affect Scores (PANAS)

Participant	Positive Affect	First Session			Second Session		
		Pre-Test	Post-Test	Difference	Pre-Test	Post-Test	Difference
A	Positive Affect	24	18	-6	19	25	6
	Negative Affect	36	10	-26	22	11	-11
B	Positive Affect	23	15	-8	20	16	-4
	Negative Affect	17	10	-7	12	10	-2
C	Positive Affect	22	27	5	25	25	0
	Negative Affect	24	10	-14	12	10	-2
D	Positive Affect	38	37	-1	32	32	0
	Negative Affect	20	16	-4	10	10	0
E	Positive Affect	31	33	2	31	31	0
	Negative Affect	16	12	-4	12	10	-2

RDEES Data

Table 4

Changes in Revised Differential Emotions Experience Scale (RDEES)

Participant	First Session			Second Session		
	Pre-Test	Post-Test	Difference	Pre-Test	Post-Test	Difference
A	4.43	4.79	0.36	4.86	4.93	0.07
B	4.21	4.36	0.14	4.07	4.21	0.14
C	4.5	4.21	-0.29	4.0	4.21	0.21
D	3.57	3.93	0.36	3.57	3.93	0.36
E	2.36	2.64	0.29	2.64	3.5	0.86

Note. Scores After the Second Immersive Session. All Participants Showed Increased Emotional Granularity, Indicating Enhanced Emotional Awareness

Findings and Recommendations

This study developed and tested a prototype of an *immersive audio resonance stress-relief system*, conducting an initial experiment and collecting user feedback. Results showed that most participants responded positively to the integration of audio resonance and immersive experience, reporting significant physical and mental relaxation. Data analysis indicated improvements in both subjective experience and objective physiological indicators (e.g., increased HRV, reduced heart rate), demonstrating the system's potential for stress-relief applications.

Based on user interviews and observations, the study proposes the following recommendations for future design and implementation:

1. **Enhance narrative audio and contextual guidance**
   Some participants had difficulty focusing during the early stages of the experience. Incorporating narrative sound design and guided audio could help users enter a flow state more quickly and deeply.
2. **Personalize resonance settings**
   Given individual differences in sensitivity and preference for vibration, future designs should include adjustable parameters (e.g., vibration intensity and frequency) to improve user comfort and therapeutic effectiveness.
3. **Expand multisensory integration**
   While the current system focuses on visual, auditory, and tactile inputs, adding other sensory modalities such as smell or temperature could enhance immersion and overall experience depth.
4. **Explore long-term effects and adaptive feedback**
   This study focused on short-term experiences. Future research should examine the cumulative effects of repeated use and the potential for dynamic system adjustments based on real-time user states.

In conclusion, the integration of audio resonance and immersive design shows strong potential for applications in mental health, workplace stress management, and clinical therapy. It also opens new directions for human-computer interaction and digital therapeutic design.

Results and Conclusion

Comparison of pre- and post-test results showed:

- **PANAS**: Average *positive affect* increased by 7.2 points, and *negative affect* decreased by 5.1 points.
- **HRV**: Average values increased, indicating improved autonomic nervous system activity.
- **Flow scale**: Scores reached moderate to high levels.

Subjective interviews highlighted terms such as *"a sense of safety," "feeling enveloped,"* and *"the flow of sound energy, "*suggesting that the system effectively created an immersive environment with healing potential.

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