

Evaluation of Passive Interaction in XR Chakra Meditation Application Based on Behavioral Biometrics

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Abstract

This study explores the effectiveness of an XR chakra meditation application developed using behavioral biometrics. A direct comparison with a similar application was impossible since no commercial XR-based chakra meditation apps exist. Instead, the study compared the XR application with popular YouTube chakra meditation video, which are widely used for meditation, as indicated by their high viewership and subscriber counts. Participants provided feedback through questionnaires and brainwave data to evaluate its strengths and weaknesses of use. The experiment focused on several aspects, including the level of interference with meditation, ease of learning and use, physical and emotional effects on users, user preferences, and the perception of vibrational realism between the two methods.

Keywords: Evaluation, Passive Interaction, XR Chakra Meditation, Behavioral Biometrics, EEG

1. Introduction

Extended reality (XR) includes a spectrum of immersive technologies that mix physical and virtual environments, including virtual reality (VR), augmented reality (AR) and mixed reality (MR). This vast area creates a transformative platform for various applications, including mental health, education, and well-being practices [1]. In the discipline of meditation, these technologies provide users with a novel method to commence mindfulness practices with immersive experiences [2], [3], [4]. The meditation of the chakra, originating from ancient Indian spiritual traditions, emphasizes the proper balance and alignment of the body's energy places of learning, known as chakras [5]. These seven energy centers are associated with the different mental, physical, and spiritual levels of an individual's wellness. Each chakra regulates particular psychological functions, encompassing creativity, intuition, self-expression, and spiritual connection. The cultural importance of chakra meditation is significant, interwoven with disciplines such as Yoga, Ayurveda, and traditional healing techniques [6]. As such, the chakra meditation serves as a therapeutic exercise and a holistic commitment to the physical and spiritual self. More specifically, a meditation application of XR Chakra can improve traditional practices by creating a passive interaction environment that promotes a deeper concentration and self-awareness, thus potentially increasing the global meditation experience [7]. The integration of behavioral biometrics into XR meditation applications is particularly relevant.



Fig. 1. XR Chakra meditation application of virtual and vibrational realities based on behavioral biometrics [7].

Traditional meditation practices are often firmly based on the practitioner's internal feedback mechanisms, generally derived from sensory experiences and cognitive states. However, improving these processes by behavioral biometrics allows immediate feedback and, based on data, can adjust the meditation experience according to the user's emotional and cognitive responses. As described in our previous development, monitoring psychological and physiological states, such as brainwave signals and heart rate variability, associated with behavioral analysis concerning passive interaction models in the XR environment, can provide real-time information on the user's state of mind [7]. This multidimensional feedback mechanism supports a more personalized meditation regime, allowing tailor-made interventions and extending the user's commitment to practice (Fig. 1). In addition, the interactive elements of the system enable users to view the energy flows

associated with the chakras, increasing their meditative experience by providing educational information on energy centers visually engagingly.

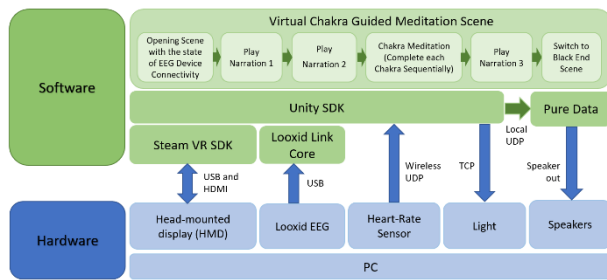


Fig. 2. System overview [7].

Fig. 2 illustrates how the XR Chakra meditation program functions within a complex system architecture that comprehensively integrates virtual and vibrational realities while incorporating behavioral biometrics to improve user experience. By combining visual and auditory components with the neurofeedback that EEG provides, the program could enhance the benefits of meditation, promoting emotional and spiritual well-being as well as relaxation.

This paper aims to assess the effectiveness of a Chakra XR meditation application compared to popular YouTube videos focused on meditation of the chakra. While YouTube serves as a widespread platform to access guided meditations, the nature of its passive visualization could be critical in contrast with the requirements of XR technology for the active engagement of its users. This change in perspective could offer new insights into how technology might enhance meditation practices, fostering situations that motivate users to engage and apply their consciousness in real time. The current investigation employed a mixed-method approach, integrating qualitative feedback with quantitative behavioral biometric measures to evaluate the entire meditation experience. Understanding these processes clarifies the frameworks of engagement, attention, and emotional states, encouraging a more sophisticated knowledge of meditation in digital contexts. The growing demand for novel well-being solutions compels the evaluation of the effectiveness of XR applications in enhancing traditional methods like chakra meditation, highlighting the significant convergence of culture and technology.

2. Methodology

The following section explains the design of the research experiment, the experimental subjects, and the procedure in sequence.

2.1. Experimental Design

The following are the questions to be studied in this experiment:

- Compare the effects of the XR Chakra meditation application and YouTube Chakra meditation video for beginners.
- Whether the sound frequency and color light related to Chakra can increase the effect of Chakra meditation.

The experimental design of the questionnaire is to let the subjects watch the YouTube Chakra guided video [8] first, fill in the questionnaire, and then use this XR Chakra meditation application to fill in the questionnaire again so that the differences between the two can be compared. Brain waves can be recorded throughout the process when using these two meditation methods.

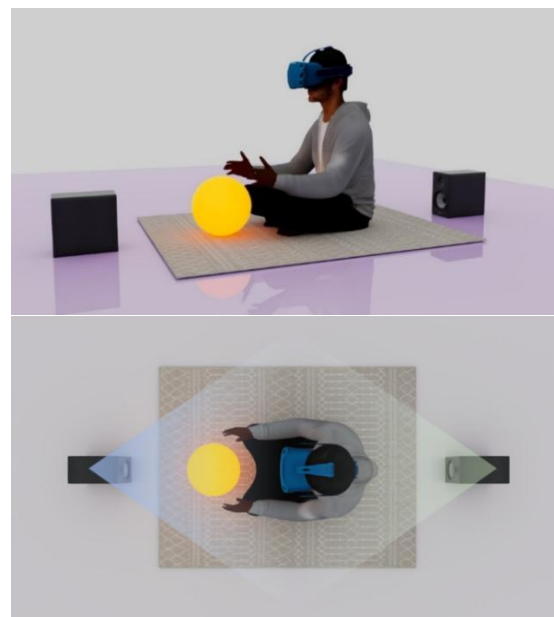


Fig. 3. Experimental environment and experimental conditions.

2.1.1 Experimental Environment

The experiment was held in a classroom with adequate space because it had ample space and less unnecessary interference. Based on its popularity, the Meditative Mind channel’s “Quick 7 Chakra Cleansing | 3 Minutes Per Chakra | Seed Mantra Chanting Meditation | Root to Crown” was selected as the experimental stimulus that compared with XR Chakra meditation application in this experiment [8]. As of November 2024, the channel has over 6 million subscribers, and this chakra-guided video has been viewed more than 15 million times. Experimental subjects can watch this YouTube Chakra guided video on the Head Mounted Display (HMD) and use the XR Chakra meditation application as stimuli with the same experimental conditions. The venue layout and experimental conditions are shown in Fig. 3. Since the HTC-VIVE Pro VR system uses at least two base stations at diagonal height for positioning, the venue size is about 2 m x 3m. Two speakers are positioned in front of and

behind the user, respectively. As shown in Fig. 3, when the user places their palm on the spherical lamp, the sound frequency emitted from the speakers causes the lamp to vibrate slightly, transmitting the sensation to the body.

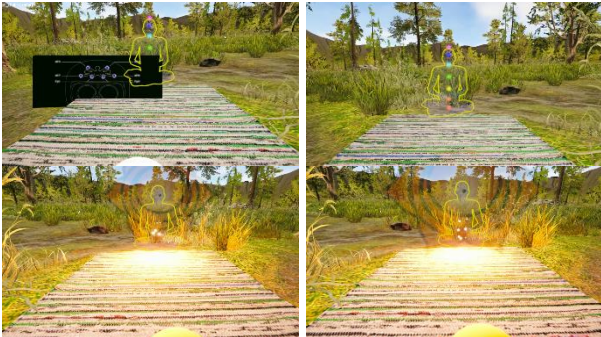


Fig. 4. The scenarios of the XR Chakra experience.

The virtual environment should minimize visual effects and create a sense of relaxation and safety. The virtual scene of XR Chakra was composed of daytime forest scenery, choosing a bright forest in the plains rather than a dense, damp black forest, and placed a meditation mat and light ball, as shown in the bottom images in Fig. 4. The actual meditation mat and light ball were identically mapped in the virtual environment.

As shown in Fig. 4 (Top left), at the beginning of the XR Chakra program, subjects can see the EEG device icon and the status of its contact points. When the contact points are correctly connected, they will be highlighted in purple, allowing subjects to see the wearing status in HMD. Once the device is worn correctly, the EEG device icon will automatically disappear. If there is poor contact with the EEG device or signal issues during meditation, the EEG device icon will also be displayed, and it will automatically disappear once the issue is resolved.

As shown in the top right of Fig. 4, a humanoid figure is designed in front of the user to help them understand the positions of the chakras. The current chakra position is displayed within the figure during the meditation process. By bringing the body into the scene and achieving a meditative presence, one becomes aware of being in the present moment—whether in a virtual environment or in reality. The spherical lights emit corresponding colors based on the current meditation chakra, illuminating the body with colored light as depicted in the images at the bottom of Fig. 4.

As shown in Fig. 5, the first narration is played when the user properly wears the devices. After the playback, the heart rate and brain waves determine that the user has entered a relaxed state. The subject then enters Muladhara Chakra (the first Chakra) meditation, and the second narration is played. The subject starts meditating at this

time, and the system detects the subject's meditation state in real-time through brainwaves. The application can assess the level of attention and accumulate time as the subject maintains the level of attention at 60% to 80%. After the accumulated time reaches one minute, the subject can proceed to the next Chakra.

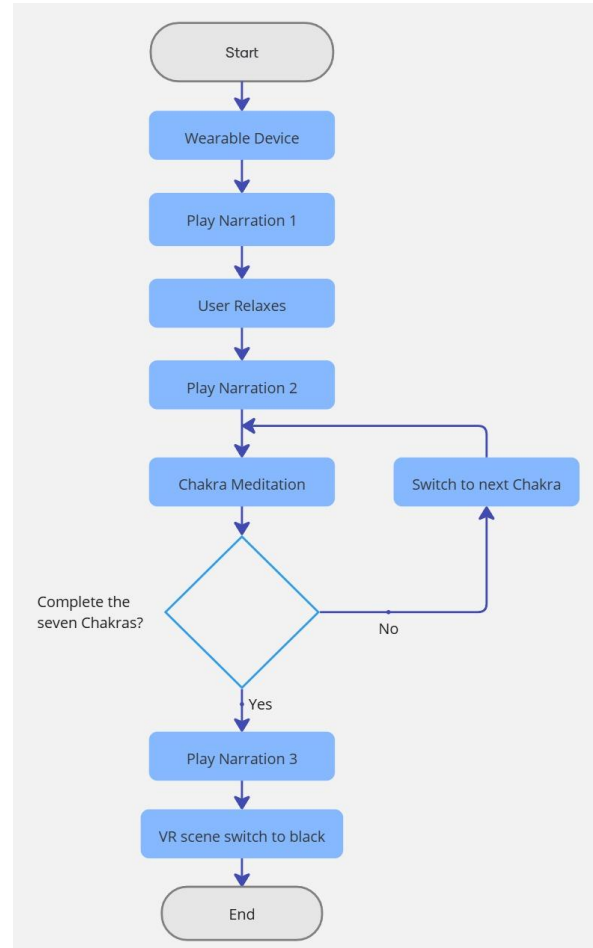


Fig. 5. Scene flow chart of the XR Chakra meditation application; [11] shows a sample screencast of one of the subjects who completed the XR Chakra meditation experience virtual scenario.

As the meditation continues, a totem representing the chakra appears on the screen. When the subject's attention level is at the right level, the totem gradually grows in size. The subject moves to the next chakra when it reaches its maximum dimension (bottom right of Fig. 4). When distracted or not relaxed enough, the totem stops amplifying. This is an essential guide and encouragement for beginners. The third narration is played after the end of the seven-chakra meditation and switches to a black scene so the subject can close their eyes and meditate. At this time, the chakras are more unblocked and balanced, and the mood is stable. It is easy to enter a more profound meditation. In this state, it is easy to get inspiration and enlightenment, and even your wishes can come true, increasing creativity.

2.1.2 Electroencephalography(EEG)

Brain waves are recorded using the noninvasive EEG system Looxid Link device [9], which is installed together with the VIVE Pro HMD using a unique face gasket with the EEG sensors shown in Fig. 6. Looxid Link EEG electrodes were attached to the forehead. The contact area includes a frontal six-channel EEG system (F3, F4, F7, F8, Fp1, and Fp2) conforming to International System 10-10, based on [10].



Fig. 6. HTC VIVE Pro HMD, a face gasket with the EEG sensors (top) and Looxid Link EEG electrode placements(bottom).

Table 1. 19 Opinion survey questions in the second and third sections of the questionnaire.

#	Question
Q1	I got distracted by my surroundings.
Q2	I noticed loud noises around me.
Q3	I understood how to perform chakra meditation.
Q4	I was able to calm my mind.
Q5	I could focus better on chakra meditation.
Q6	The sounds made me feel calm.
Q7	The sounds helped me concentrate on meditation.
Q8	My mind tended to wander.
Q9	The visuals distracted me.
Q10	I enjoyed meditating using this method.
Q11	I would recommend that others use this method for meditation.
Q12	I felt physical discomfort (dizziness, nausea).
Q13	I felt eye discomfort (soreness, dryness, fatigue).
Q14	I felt sleepy.
Q15	It made me feel bored.
Q16	My mood has improved.
Q17	I gained new inspiration.
Q18	I wanted to close my eyes.
Q19	After meditating, I felt very comfortable.

2.1.3. Evaluation Questionnaire

The questionnaires in the study have five sections. The first section consisted of primary data about the user (age, biological gender, educational background, and eyesight, whether it is normal or corrected-to-normal) and several questions about their previous experience in meditation and using immersive media. The second and third sections aimed to evaluate the effects of the YouTube Chakra meditation video and XR Chakra meditation application, respectively. The second and third sections contained the same opinion survey questions shown in

Table 1. The users evaluated these 19 opinion questions separately using a 5-level rating scale. Additionally, the fourth section assessed the impact of lights and sound on the XR Chakra meditation application using a 5-level rating scale. (Table 2). The questions in the final section focused on collecting overall experimental feedback and suggestions for further improvements, as shown in Table 3.

Table 2. The questions for evaluating the impact of lights and sound on the XR Chakra meditation.

#	Question
Q20	It feels better to have sound.
Q21	It feels better with lights.
Q22	Which method do you prefer? Sound and light are available; both are needed, or neither is required.

Table 3. The questions for overall experimental feedback and suggestions.

#	Question
Q23	Which method do you prefer?
Q24	Why do you prefer that method?
Q25	Do you have any unique feelings or experiences?
Q26	Do you think any aspects of this experiment need improvement or any other suggestions?
Q27	Are there any other comments you would like to share?

2.1.4. Compliance with Ethical Standards

The collection of EEG data requires careful examination of the ethical implications and the rights of the participants involved in the research process. Therefore, the review was asked for in advance from the Human Research Ethics Review Committee of National Cheng Kung University, and the experiment was conducted only after approval (NCKU HREC-E-112-541-2). Participants were informed (1) about the purpose of the study, (2) that they had the right to stop the experiment at any time without providing any reason, and (3) that they could stop the experiment if they felt sick or had any discomfort. All the training sessions were performed under a researcher's supervision in case of an emergency.

2.2. Experimental Subjects

The experimental subjects were adults aged 18 and above who did not have eye infectious diseases. Although this experiment uses the HTC VIVE Pro system in sitting posture, it is less likely to cause dizziness. However, subjects who often have dizziness symptoms are not recommended to participate. The subjects are mainly used for questionnaire statistics and recording the brainwave state of the subjects when meditating using both methods. There are 21 subjects in total, six males and 15 females. Most of them are college students (57.1%), mainly engaged in art and music creation, and most have experience using immersive media in VR HMD (76.2%). As many as 81% have meditation experience, and most of them do not meditate often. Only 17.6% of subjects have done chakra meditation, which meets the goal of this study: to create an XR chakra meditation program for beginners.

2.3. Procedure

The experiment was expected to last 60 minutes but lasted about 40 minutes. During the experiment, the subject needed to wear a wrist heart rate monitor and the HTC VIVE Pro HMD. The HMD contains the EEG device, and its EEG electrodes fit on the forehead, with the contact points shown in Fig. 5. The EEG and HMD were disinfected with alcohol after each use. Beforehand, inform the subjects that because this experiment requires concentration, they are advised to avoid activities that may interfere with physiological indicators 24 hours before the designated experimental time, such as drinking caffeinated beverages, taking medicine, or staying up late. In addition, to better measure brain waves and avoid wiping off cosmetics, washing the forehead before the experiment was recommended. The detailed experimental procedure is explained below.

- *Explain the Content of the Experiment.*
The subjects were explained the consent form for experimental research participation, which included the name of the project, the purpose of the experiment, the equipment used, the conditions of the participants, the expected experimental time, possible risks and damages, research compensation, data storage, and processing methods, and finally, the experimental process.
- *Fill out the Consent Form and Pre-questionnaire.*
The subjects completed the consent form for the experimental study, the anonymous basic information, and the pre-questionnaire.
- *Wear a Heart Rate Sensor*
This experiment used a heart rate sensor worn on the wrist, similar to a watch, to detect the subject's heartbeat. A green light was on the subject's wrist, and no electrical stimulation was to be used. The heart rate was only used as an interactive reference in the program and was not used for recording.
- *Wearing HTC VIVE Pro HMD and EEG Device*
Before the measurement, the subjects were asked to remove any metal objects, hair bands, and mobile phones and if they needed to go to the bathroom first to avoid the inconvenience of going out during the experiment. As shown in Fig. 5, the EEG device used in this study is connected to the HMD, so it was sufficient to wear the HMD. The EEG electrodes should be aligned with the forehead before wearing, and the virtual screen should show whether it was worn correctly.
- *Watch the Chakra Meditation YouTube Video*
The subjects watched the YouTube Chakra meditation video to do a Chakra meditation session for 10 minutes.
- *Fill out the Questionnaire*
The subject completed the second section of the questionnaire (Table 1), which aimed to evaluate the effects of the YouTube Chakra meditation video.

- *Use the XR Chakra Meditation Program*
The system recorded brainwave data during use. After wearing the HMD, the subjects followed the voice guidance and used the XR Chakra meditation program for 10 minutes to complete the seven-chakra meditation. The EEG device recorded the brain's electrical activity and transmitted it to the computer to save in data files. It was a noninvasive measurement and did not send any energy or substance to the human body.
- *Complete the Questionnaire*
The subject completed the 27-question questionnaire (Table 1, Table 2, and Table 3), including the fourth and last sections, about the impact of lights and sound on the XR Chakra meditation application and the overall comparison of both meditation methods.

3. Results and Discussion

3.1. Questionnaire Data Analysis

Most comparison questions have five options, from left to right: strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree. This section analyzes user opinions on both meditation methods using Likert plots.

3.1.1. Inference Level

The questionnaire survey divided interference into external interference and sound and image interference, checking whether it is possible to meditate.

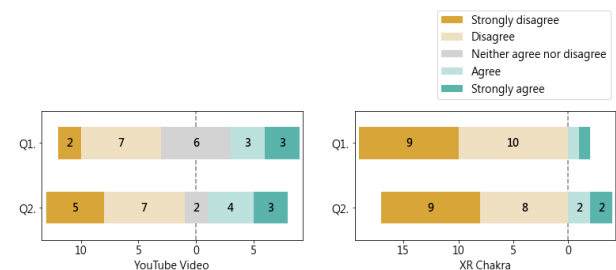


Fig. 7. Degree of external interference.

External interference: More subjects responded as they disagreed with the answers to questions Q1 (got distracted by my surroundings) and Q2 (noticed loud noises around me). As shown in Fig. 7, watching YouTube videos is more disturbing, but the impact is insignificant in a controlled environment. Even if we want to meditate at home, we will find a more isolated space. When using XR Chakra for meditation, it is less likely to be disturbed by surroundings.

Sound and visual interference: The results of the questionnaire questions Q6 (sounds made me feel calm), Q7 (sounds helped me concentrate on meditation), and Q9 (visuals distracted me) are shown in Fig. 8. Questions Q6 and Q7 examined whether the sound design of the YouTube video and XR Chakra application can make subjects feel calm, relaxed, and helpful. Meditation results show that all have such functions, but XR

meditation programs can achieve calmness and focus on meditation.

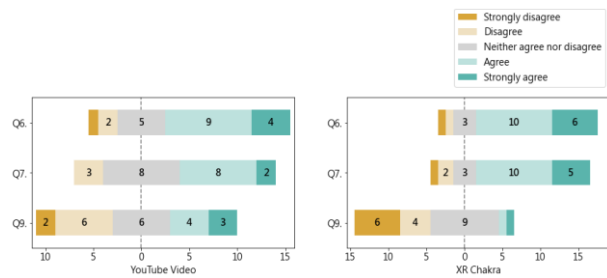


Fig. 8. Degree of interference from sound and visuals.

Question Q9 explored whether the visuals interfered with the subjects' meditation. According to the survey results of the YouTube video, 33.3% (7) of the subjects felt it would have an impact. Only 10% (2 people) thought the XR Chakra program had an effect.

Meditation difficulty level: Fig. 9 shows the results of questionnaire questions Q4 (I was able to calm my mind) and Q5 (I could focus better on chakra meditation). It indicates that the XR Chakra meditation program can help subjects calm down and concentrate on chakra meditation. Question Q8 (mind tended to wander) represents the degree of distraction. The results show that watching YouTube made subjects more likely to have their mind wander.

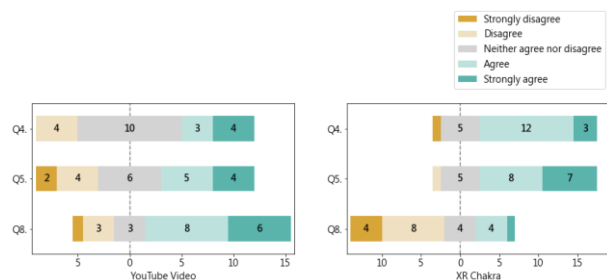


Fig. 9. The level of difficulty in meditation.

3.1.2. Ease of Learning

Question Q3 (I understood how to perform chakra meditation) attempts to determine whether the subject can use these two methods to learn how to perform chakra meditation, as shown in Fig. 10. Since YouTube videos do not have any guidelines, they only play images and chant, so the user cannot learn how to do chakra meditation.

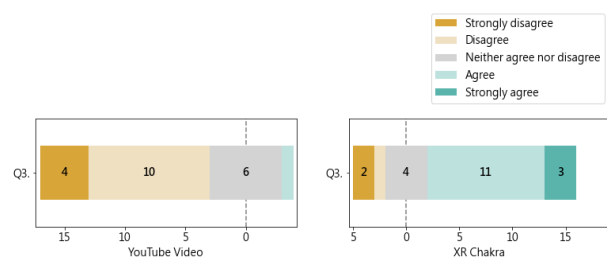


Fig. 10. The level of ease of learning chakra meditation.

However, users can learn to meditate using this XR Chakra application's simple guidance.

3.1.3. Physical Effects

Fig. 11 shows the results of questionnaire questions Q12 (I feel physical discomfort, such as dizziness or nausea) and Q13 (I feel eye discomfort, such as soreness, dryness, or fatigue). Displaying YouTube has less impact on the body, especially HMD, which can easily cause eye fatigue. Questionnaire feedback also shows that the weight of HMDs can easily cause discomfort.

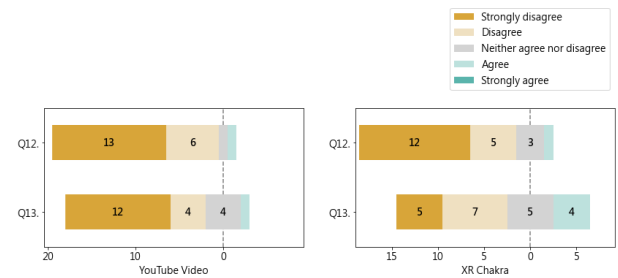


Fig. 11. The level of physical effects on the body.

3.1.4. Psychological and Emotional Effects

The questionnaire Questions Q14 to Q19 considered psychological and emotional states, including wanting to sleep, feeling bored, being in a good mood, getting new inspiration, wanting to close their eyes, and feeling comfortable. The results are shown in Fig. 12. Most subjects felt good and comfortable after meditation. There is not much difference between these two methods, but the XR Chakra meditation method is not dull.

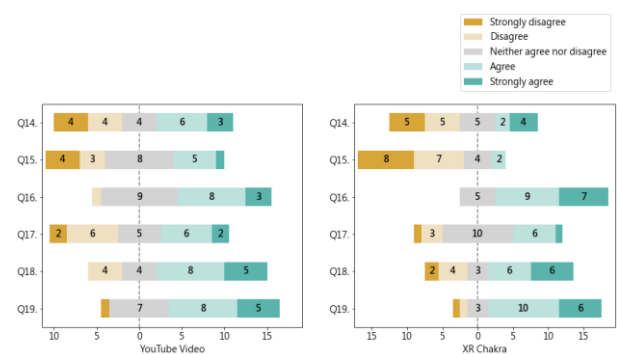


Fig. 12. The level of physical effects on the body.

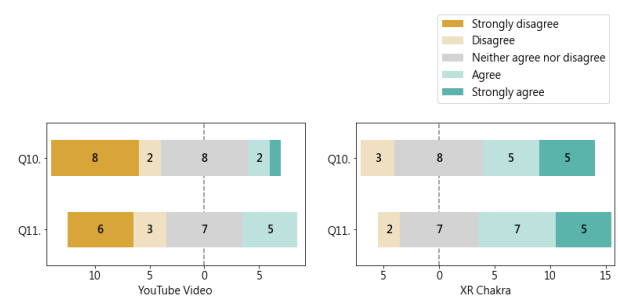


Fig. 13. Comparison of user recommendations on two methods.

3.1.5. Overall Comparison

The results of questionnaire questions Q10 (I enjoyed meditating using this method) and Q11 (I would recommend others meditate this way) are shown in Fig. 13. And Fig. 14 shows the results of Question Q23 (Which method do you prefer?), which shows that most of the subjects prefer the XR Chakra meditation program.

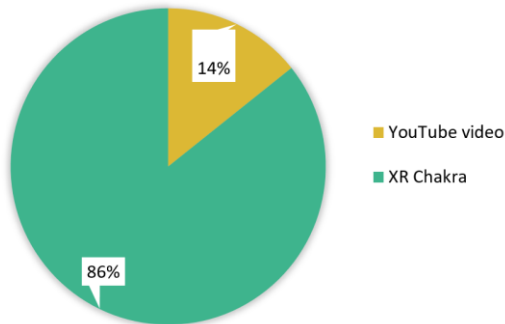


Fig. 14. Overall comparison of user preferences on both meditation methods.

3.2. Vibrational Realism

Fig. 15 shows the results of questionnaire questions Q20 (It feels better to have sound) and Q21 (It feels better with lights). Some subjects mentioned that sound makes it easier for them to meditate. Some subjects found that the color of light affects their mood. However, some subjects also felt that dimming or having no lights might be more relaxing.

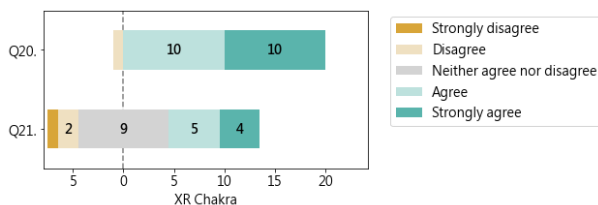


Fig. 15. The preferences for sound and lighting.

Among 52.4% of the subjects prefer to have sound, and 42.9% of the subjects want to have both. The position of the light is on the ground in front, as shown in Fig. 16. Since the design of the HMD has light leakage, the light can shine from the bottom of the HMD to the eyes, causing eye discomfort. In the future, we can design lights at the top and one at the front so that the front and rear chakras and the crown chakra can be illuminated simultaneously without the problem of illuminating the eyes.



Fig. 16. The position of the light ball.

3.3. Feedback on Contents of the XR Chakra

Based on the responses to questions Q24 to Q27, some subjects said they were very excited when they saw the totem getting more extensive and then stopping. We also considered the dynamic state of the totem when designing its motion. On the one hand, we hope that users can quickly know their meditation status, but they do not want it to cause interference. Some test subjects said that they felt perfect when seeing the forest. Virtual content was also researched during the production of the XR Chakra program, which is a suitable virtual scenario that would make users feel safe and secure enough to meditate [7]. In addition to forests, users suggested and wanted to test the future scenes of the seaside, mountains, etc. In addition, some subjects thought that after using the XR chakra meditation program, they felt calmer and brought a sense of freshness.

3.4. Brainwave Analysis

This experiment aimed to determine whether the XR Chakra meditation program can help subjects more easily enter a state of chakra meditation. Therefore, the experiment sessions recorded the subjects' brainwaves while watching the YouTube chakra meditation video and used our XR Chakra meditation program. The attention level obtained from brainwave data was divided into one-minute intervals, three to six minutes, and the last minute for comparison and analysis. The median value was calculated and depicted in a box plot, as shown in Fig. 17.

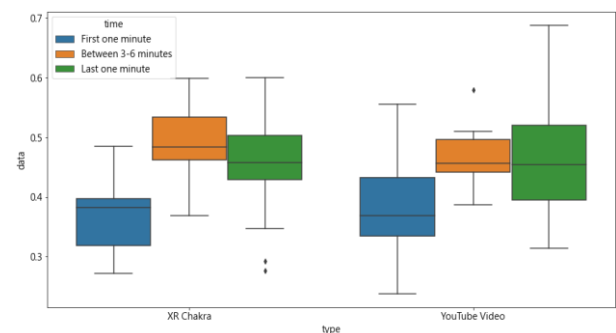


Fig. 17. Comparison of attention between two methods.

At 3-6 minutes, the subjects entered a meditative state, and the attention level was higher. This was even more obvious when using the XR Chakra meditation program. At the last minute, the subject may feel tired, you can no longer concentrate, and become more confused.

4. Conclusion

Based on Chakra meditation, a chakra meditation program was developed in an XR environment using passive interactive technology based on behavioral biometrics. Brainwaves and heart rate were used as passive interaction methods. The user does not need to use gestures or controllers, and the system executes

automatically. This research also introduces basic vibration reality into the system through sound waves and light wave vibrations to assist the human body's chakras enter a balanced state.

After comparing watching a YouTube chakra meditation video with using the XR Chakra meditation program developed by this research, it was found that the XR Chakra program is better than YouTube video in terms of interference level, ease of learning, psychological and emotional impact, and physical impact. However, the subjects generally preferred the XR Chakra meditation method. At present, the weight of the HMD is a problem that is difficult to ignore for meditation. However, with the advancement of technology, it can be solved one day. The VIVE Pro weighs about 800 grams, while the latest Bigscreen Beyond HMD is only 127 grams [12], making meditation more comfortable. Regarding the vibration reality, most respondents liked the sound design, while only 42.9% wanted the lighting design. Vibrational reality is an emerging field of study that utilizes various technologies, such as ultrasound, to be developed and integrated into future versions.

Moreover, for the design of the XR Chakra meditation program, it is necessary to complete the seven chakras and then continue to meditate to gain inspiration. Based on the current estimate that most subjects entered the 4th chakra within 10 minutes, it takes approximately 20 minutes. Further research and experiments can be done in the future. In brain wave experiments, this XR Chakra meditation program can keep subjects in a meditative state better than YouTube videos, but not significantly. Perhaps longer, long-term experiments are needed to make a significant difference. Experimental results show that meditation has a positive impact on emotions. For the general public and artistic creators, regular meditation will help stabilize emotions, increase awareness and empathy, and make people more focused. These characteristics can help individuals grow and achieve success.

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Authors Introduction

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