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# *Quartet: Designing for an Experimental Audio Game in Mixed Reality Environments*

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***Abstract:*** Applying sonic interaction to game design has gained momentum in recent year. This paper proposes a novel approach to design an experimental audio game Quartet that is immersive and highly interactive in the mixed reality environment. The chief aims of designing this game are to explore the music improvisation techniques by using the software Touchdesigner and to create a new spectatorship of sonic interaction in immersive experiences. To achieve the goals, several methods were presented: interactive storytelling, audio visualization, ceding control, sonic interaction, etc. The research has also recorded valuable data about players' experiences of the game including their overall level of immersion, perception of the story, and overall feeling of the sound design. The results suggested that an interactive sonic design can boost players' engagement and convey emotions and information more efficiently and accurately. For further research, this audio based experiment can be contributed to the field of inclusive design especially for visually-impaired people and children with multiple disabilities.

***Keywords:*** Audio game, mixed reality, sonic interaction design, audio visualization, digital narrative

## 1. Introduction

Mixed reality (MR), referring to Milligram's Reality-Virtuality Continuum, is an application technology that sits on a scale between the completely virtual digital world and the completely real physical world, which presents the fusion of human, real environment, and digital world in the same perceptual field and builds an interactive feedback loop to enhance the immersion of user experience [1-3]. Therefore, MR, retaining the interaction with the physical world, has more potential for development and innovation compared to virtual reality (VR) and has become one of the research focuses of major technology companies such as Google and Microsoft [4].

Different from the mainstream visual-driven games, the audio game, using audio interaction to engage with players, is a field that warrants further investigation. Moreover, from an inclusive design perspective, many researchers have found that audio games can help visually-impaired people and children with multiple disabilities have a better gaming experience and have some rehabilitative effects [5]. Immersion is very subjective and dynamic, so it is difficult to build and maintain in an audio game through technical means alone, and there is a lack of unified explanation and detailed implementation cases specific to audio games in the field of MR [6].

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The quartet is an audio-based XR game that paid tribute to writer Yuji Sakamoto. The game's story background is a reference to the TV show Quartet, written by Yuji. The design purpose of Quartet is twofold: firstly, exploring the music improvisation techniques by using the software Touchdesigner, and secondly, creating new spectatorship of sonic interaction in immersive experiences. This game has found that several mechanics could help to enhance its immersive experience: audio visualization, sonic interaction, ceding control, etc.

The quartet has many breakthroughs, first of all, it uses the designer-friendly software Touchdesigner instead of Unity or Houdini. Touchdesigner, as a "visual programming language for real-time interactive multimedia content", is very suitable for game prototyping and MR interaction designing, especially sonic interaction. Compared with Unity, TouchDesigner has a node-based interface, which helps artists or designers without much programming background to complete game prototyping more efficiently. Secondly, the story setting and script of the game adopt an open-ended narrative. Let the player have the feeling of being a spectator in the theater, but also have enough freedom to change the plot and development of the story. This kind of ceding control and dynamic storytelling provides a solid emotional foundation for an immersive experience for players. Lastly, this game has a certain degree of experimental quality and has research significance not only to the field of games but also to sound art, experimental video, audio-visual interaction, and other fields.

## 2. Design Methods

The game's story background is a reference to the TV show Quartet, written by Yuji. In the game, the player becomes the writer, the actor, and the audience. There is no punishment or competition, but players will experience puzzle-solving, collaboration, embodiment, and emotional immersion in the game by finding secret objects, connecting clues, playing music, etc. This section will dwell on the game's synopsis, mechanics, visual design, audio visualization, and sonic interaction design, to illustrate how this game could enhance players' immersive experience.

### 2.1. Synopsis

The players will receive different scripts for the character they choose to act. The scripts will guide them through the whole game, and all players improvise at the end of each game level. The background story is: four strangers accidentally meet in a KTV room and form a quartet. Later on, they started to live together in the same apartment during the winter, but there are many big hidden secrets for each character. There are four characters in Quartet: Maki, Suzume, Tsukasa, and Yutaka. Through the reenactment of classic lines from the TV series and the display of special objects, the audiences and fans can become their favorite characters in the game, and develop empathy for the characters' stories. There are two modes -exploration mode (Figure 1) and music improvisation mode (Figure 2). Players will follow the script to find their secret objects and interact with them.

### 2.2. Exploration Mode

In the exploration mode (see Figure.1), each player can role-play one of the characters, and each character has his or her room where hides several special secrets. Discovering and interacting with objects in the room enable players to discover their own character's personality and secrets. When the player follows the script and finds the secret, they can choose to tell the secret to other players or not. The script is not only a re-enactment of the original TV series but also a slightly altered, open-ended script, to give players more choices and agency to change the ending and the direction of how the story develops.

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This player-centered storytelling approach in exploration mode allows the audience to actively engage with the story through role-playing, arousing empathy and bringing the story closer to the player. This method is similar to Chris Crawford's Interactive Storytelling, which also abandons the notion of single storyline to create a storyworld with various possibilities. By applying this method, the game becomes more unique and different from original cinematic story, which also deals largely with the study of Janet H. Murray's digital narrative [7]. As she argued in her book Hamlet on the Holodeck, computer is good at telling procedural and participatory stories.

As figure 1 shows, there may be a secret object hidden behind a piece of furniture, such as an MP3 player under a desk. When the player discovers the MP3, the story behind the object will be shown in form of animation with an authentic voice-over that token from the original TV show.




Figure1： A storyboard to illustrate the exploration mode

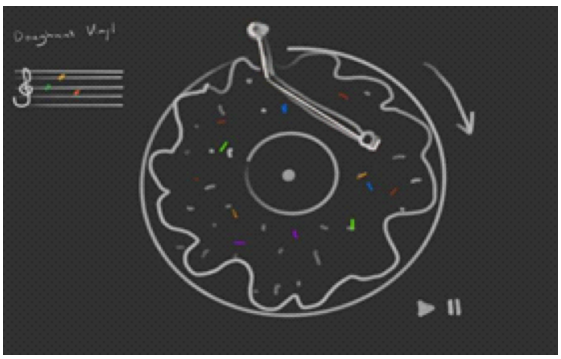

Figure2： A storyboard to illustrate music improvisation mode

## 2.3. Music Improvisation Mode

Music improvisation mode enables players to be immersed in a multi-sensory interactive world. For individual, music improvisation evokes creativity and connects many emotions, and it can enhance player's empathy about the story. For a group of players, the audio interaction can help to build a community connection among them.

In the music improvisation mode, the doughnut becomes the record, sugars with different shapes represent different musical instruments for the characters, and the color of the sugars represents different tones of the music. The songs' moods are closely related to their corresponding secrets and stories from exploration mode. Finding enough clues in the room leads to musical interaction mode, where the player can make contact with objects around them, producing the sounds of different notes.

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## 2.4. Visual Design: 3D Modelling and Rendering

This game hopes to be different from the original TV series, so the overall style is a pixel cartoon style that tries to avoid overly realistic styles. The soft light and shadow, and the blur and focus of the lens on the distant and close shots refer to traditional Impressionism. The contrasting colors and comic strip style are references to Pop Art, such as artists Wayne Thiebaud's paintings.

### 2.4.1. Characters Design

The 3D modeling for the characters was created by using the 3D sculpting application Nomad Sculpt. The character design follows the image from the original TV series but avoids the photographic realism style. Most of the sculpting was done with the help of the tools: drag, move, split, tube, and mask. Sometimes, some tools like flatten, inflate, and nudge are also used. The facial design of the characters is kept as simple and cartoonish as possible. For example, the eyes are directly represented by symmetrical spheres.



Figure3： Screen-shoot from TV show.



Figure4： The 3D characters based on the TV show.

### 2.4.2. Interior Design

Interior elements, such as furniture, cups, appliances, or carpets, are designed using another modeling software: MagicaVoxel. MagicaVoxel is a GPU-based voxel art editor that good at making cubic-grid-style elements. Referencing Nintendo Animal Crossing, the interior scenes were designed differently from those in the original TV show (see Figure 5). The furniture, looking like Lego, has become more colorful and cartoonish. The decorative posters on the wall are also made by clicking the mouse to assign different colors to different pixel frames (see Figure 6).

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Figure5： 3D modeling of the rooms.



Figure6： 3D modeling of the rooms (detailed).

## 2.5. Audio Visualization

Although it is an audio game, the visual design plays a crucial role in building emotional immersion that boosts players' engagement [8]. Visual and audio are closely connected, as the human body has a special sensation called Synaesthesia: when you use one sense to feel something, another sense is triggered. Multi-sensory interaction can not only enhance the musical experience itself but also give music a new meaning.

In the visual presentation of the game, the concept of "Cymatics" in audio visualization is applied, and the mapping patterns of sound data of various frequencies are tested. The volume, MIDI value, spectrum, and other changes in the sound will trigger visual elements in real-time [9-10]. Most of the audio-visualized elements are generated in music improvisation mode by using Touchdesigner.

A simplified design process for audio visualization is shown in Figure 7: Firstly, the data input for the visualization is the audio from the digital world, including the interactive sound made by users and the background music, and from the physical world, including ambient sound and players' voices recorded in real-time. Math, envelope, filter, and other functions are used to normalize the audio sources, then the resample function will resample the sample rate and interval for the audio visualization. After sorting and optimizing the audio data, those data will become the reference for the interactive particle system, which is similar to traditional Cymatics: putting water in a circular dish above a speaker, to let them generate the visible sound wave. The color, drag, and speed of the particle system are controlled by the audio data in real time.

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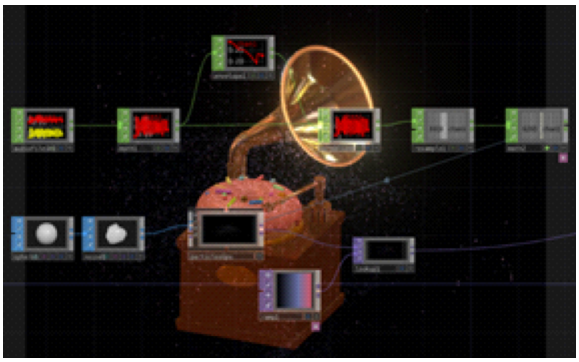

Figure7： A simplified design process for audio visualization in Touchdesigner.

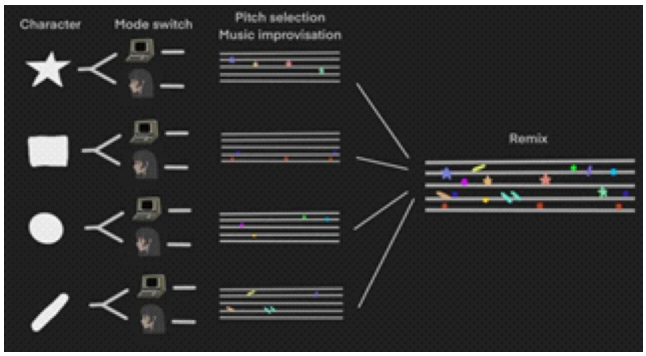


Figure8： The sonic interaction design process.

## 2.6. Sonic Interaction Design: Music Improvisation

The design of this sonic interactive system is inspired by an audio game called Genesis Noir. In Genesis Noir, the player completes their solo jazz, the system then will echo the rhythm and tone of the music created by the player. Therefore, the final music is generated by both the player and the computer system.

In order to bring players a richer audio-visual experience in the interaction of sound, the sound design abandoned the notation in professional composition and paid attention to the accidental, improvisational, and experimental sound collage. Within certain orchestration rules, the sound changes along with the players' movement. In other words, the system is giving players many agencies to interact with and customize their own music.

A simplified process for sonic interaction design is shown in Figure 8. In Touchdesigner, four audio oscillators CHOPs represent four different characters' musical instruments, by repeating common waveforms to generate sounds. To further distinguish the timbre of the different oscillators, the amplitude and base frequency of each oscillator are adjusted accordingly. All the audio oscillators have a default pitch of 0, giving a middle A at 440 Hz. The pitch of the audio oscillator can be altered by either players' input data or computers' low-frequency oscillator (LFO CHOP). Players' input data can be the X-axis and Y-axis of the hands through kinetic detection equipment, or the location of a tangible joystick. LFO can automatically synthesize curves for different pitch inputs. Finally, the system will remix all the improvisation together and send the song to the speaker.

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## 3. Results and Discussion

This game wants to create immersive content. From the content of the story and the way of narration, the use of human cognitive experience enriches the player's engagement in the game. In terms of human-computer interaction, the dual sensory fusion of vision and hearing is used to stimulate the immersive experience of players.

To verify the design effectiveness of this game and whether it has reached the original design goals, 30 players are invited to evaluate the game and discuss different performance indicators through interviews and surveys. The questionnaire and interview questions are based on the Flow Theory, which was introduced by Mihaly Csikszentmihalyi in the 1970s. Flow experience is a state that let people completely focus on something and gain enjoyment through it. Therefore, whether or not players have a flow experience or are in a flow zone is a crucial element to measure the level of players' immersive experience of this game.

### 3.1. Data Collection

The survey (see Table 1) is separated into three parts and each part consisted of three questions. The survey was conducted with 30 players who have played through this game. Players were given totally 10 minutes to answer the questions.

Table1: The Survey for players.

| Part 1: Overall Feeling | | |
|---|---|---|
| How challenging did you feel in this game? | Scale it from 0 to 100 | |
| How skilled were you in this game? Scale it from 0 to 100. | Scale it from 0 to 100 | |
| Interview: What did you feel about the overall game design? | | |
| **Part 2: Perception of the Story** | | |
| Did you have clear objectives for the tasks? | Yes | No |
| Did you get enough instant feedback during or after the interaction? | Yes | No |
| Did you interested in the role you play? | Yes | No |
| **Part 3: Sonic Interaction** | | |
| Did the music improvisation evoke your creativity? | Yes | No |
| Did you work well with other players when playing the music? | Yes | No |
| Interview: When you were listening to the sound, what did you feel? | | |

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## 3.2. Data Analysis

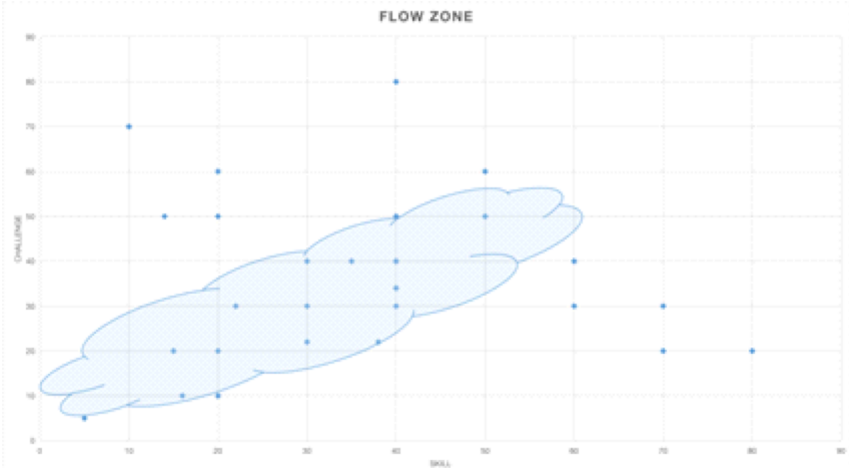


Figure9： Flow Zone in relation to skill and challenge.




Figure10： Emotion in relation to skill and challenge

The results of part 1 are shown in figures 9 and 10. In figure 9, the x-axis is the level of skill and the y-axis represents the level of challenge. as flow experience happens when there is a balance between skill and challenge, a flow zone is created and colored in blue in figure 9, indicating that 50% of the players had flow or immersive experience when playing this game.

Figure 10 elaborates on various emotions that correspond to challenges and skills at different levels based on Csikszentmihalyi's flow chart. As shown in figure 10, more than half of the players are in a state of intrinsic motivation, and some players are in a state of apathy, routine expertise, arousal, or worry. In part 2, 86% of players claimed that they had clear objectives concerning the tasks, 83% of players agreed that they were interested in the role they play, and 76% of players got enough instant feedback during or after the interaction. Since having clear goals and instant feedback are the crucial conditions of flow experience, the founding of part 2, indicates that most of the players are enjoying the game. In part 3, 66% of players agree that they worked well with other players when playing the music and that the music improvisation evoked their creativity. During the audio interaction, some players feel that they can fit well into the character and have enough freedom to complete the creation of music. Some players think it's fun to hear some sounds that are tokens from the physical world in real-time during gameplay, which makes them feel like they're not completely cut off from the real world.

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Overall, players have given many positive comments about the immersion and the sonic interaction of the game. Most players consider this to be an MR game that doesn't require too many skills or a lot of challenges, so it's perfect for entertaining and chilling during free time. Players who like music and Japanese TV dramas will be more interested in this game and it will be easier to get into the flow state. However, players who have not seen the TV series, still have a great curiosity about the plot of the story and they are more excited about the game clues than those who have watched the TV series.

## 4. Conclusion

As an experimental audio game, Quartet is designed for exploring music improvisation techniques by using the software Touchdesigner, and creating new spectatorship of sonic interaction in immersive experiences through several methodologies such as audio visualization, sonic interaction, and ceding control. A survey and interview were designed based on the flow theory to verify the immersion that the game brings to the players. The results indicate that most of the players had flow and immersive experiences when playing the game and interacting with each other.

The sonic interaction design for the Quartet created different spectatorship which can be conceptualized for further research. Traditional compositional techniques were replaced with improvisation techniques that emphasize randomness or spontaneity. In many audio games, players are passive listeners. However, in this game, they are active participants in the creation of music. In the future, this sonic interaction design can be explored in the domain of MR audio games: What kind of auditory source is more likely to evoke the listener's emotional and immersive experience? In what way that psychoacoustics could help to develop story-telling or story-making?

To recapitulate, in the field of game design, the visual aspect of the design is often considered the most important, but from the perspective of user experience, auditory, visual, tactile, and other multi-sensory interaction can effectively boost players' engagement and convey emotions and information more efficiently and accurately. In the future, more research on sound design will significantly contribute to the immersive experience of games.

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