Relationship Between Human-Computer Interaction Features and Players' Decision-Making in Music Games

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Abstract. Music games provide a series of frequent, accurate, powerful, and rhythmic interactions for players via unique game mechanics and rule settings, guiding them to use auditory and visual cues in the scene. The development of entertainment industry promotes the research on Human-Computer interaction of music games. This paper will focus on the relationship between the Human-Computer interaction mechanism of music games and players' game behavior decisions, and analyze the causes. Firstly, this paper reviews the theoretical and experimental researches on HCI in music games, references and analyzes the existing representative cases of music games, and constructs a relational model consisting of music game mechanics and players' decision making. Then, we introduce the music game *Don't Be Popcorn* designed by the authors. It describes the design and implementation of game mechanics and rules, interaction, and art effects. Finally, the experimental analysis is carried out to verify the relational model by inviting some participants to experience our game, analyzing the data of the test results. The results show that the behavioral decisions made by professional players are more radical than amateurs. Moreover, there is a Non-linear correlation between changes in the extent of player level performance and adjustments in behavioral decisions. Therefore, the proposed relational model can further provide references for game designers and researchers to analyze the interaction between players and music games.

Keywords: Music game · Video game · Human-computer interaction design · Players' Decision-Making

1 Introduction

Music games is a significant genre in video games. Since the release of *BeatMania DX* by Japanese video game designers in the 1990s, music games have completed the iteration through various interactive devices such as arcade devices, home consoles, computers, mobile devices, physical devices, and virtual reality [1]. In the process of forming mutual interaction between players and music game scenes, the visual, auditory

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and interactive actions achieve interoperability and mutual sensation, mobilizing players' sensory stimulation, thus enhancing the fun of music game experience. Nowadays, music games have gradually come out from the niche. With various forms of interaction and unique themes, music games such as *Beat Saber*, *Taiko Drummer*, *Just Shapes and Beats*, *Geometry Dash*, *Sayonara Wild Hearts* and *Just Dance* are popular with numerous players.

Analyzed from the perspective of creation, music games can be defined as "a class of video games in which players use interactive input devices to follow the rhythm and melody of the background music while interacting with the game scene, and follow the sound and screen tips to complete frequent, accurate, powerful and rhythmic interactive operation simultaneously to achieve the game goal".[2] Compared with other types of electronic games, music is the core of the design and experience in this genre. Therefore, the interaction mechanism, interaction rules, operation performance evaluation and other modules are closely related to music elements and also play an essential role in advancing the game process, regulating the rhythm of interaction, creating an atmosphere of experience, highlighting the use of skills, and stimulating emotional resonance, etc. [3].

Music game has gradually improved with the innovation of software and Hardware-Related technologies such as interactive devices. At the same time, HCI theories are combined and explored in the field of video games, which also promotes more attention to the research of HCI design concepts and features for music games. There are many disciplines involved in the study of music games, most of them are Cross-Fertilized. At present, the research related to HCI design in music games mainly combines and applies theories of game psychology, computer graphics, ergonomics, and musicology [4, 5]. Among the academic results focusing on the HCI design of music games, scholars have studied the factors related to the interaction design of music games and the factors that affect the players' performance, the form of music interaction atmosphere shaping, the regularity of interaction spectrum generation, and other related aspects [6, 7].

In the actual experience of any video games, players follow the game mechanics and rules, receive feedback and evaluation, master and apply operational skills, and develop and adjust their strategies according to the change of perception process. This process can be described as the correlation between the interaction characteristics shaped by the game and players' behavioral decisions. Based on this, this paper aims to analyze the association between the HCI features of music games and players' Decision-Making and summarize the relationship model accordingly. We hoped this theoretical model could be used as a reference for music game developers and related researchers to conduct subsequent research on the Human-Computer interaction between players and music games.

This paper adopts case study and game experiment research as the research methods. The subsequent chapters are organized as follows: Sect. 2 is a review of the current research status, which will sort out and analyze the current academic research results and case studies from the aspects of game mechanics and rules design, operation behavior design, and players' Decision-Making of music games. Sect. 3 introduces the relationship model between Human-Computer interaction features and user behavior decisions in music games and initially analyzes the association of each module in this model. In Sect. 4 we introduce *Don't Be Popcorn*, a music game designed by our team. The design of this game will be guided by the view of interaction design features presented in the previous chapters and will be related to the preparation for the subsequent experimental study. In Sect. 5, we conduct an experimental study and verify in more detail the relevant ideas in the relational theoretical model with the results of the playtest and data analysis, and provide a more profound explanation of the model. Finally, Sect. 6 summarizes our research and make suggestions.

2 Relative Works

2.1 Game Mechanism Design

In the book Game Mechanics: Advanced Game Design, Ernest Adams and other authors suggest that "game mechanics are the rules, processes, and data at the heart of the game". Therefore, music game mechanics is the first framework that needs to be built for a music game design. The rules and gameplay in music game mechanics distinguish it from other video games and make a unique connection between player interaction and the feedback effect of the game scene [8].

According to traditional music games' primary mechanism and rules, many note indicators are generated in the level scene orderly and move from top to bottom according to the specified trajectory. When the note indicators move to the interactive judgment area at the bottom of the interface, the player needs to interact with the note indicators instantly to complete an effective operation. Repeat the above actions in the level and keep accumulating the score until the score reaches the requirement of passing the level. The above descriptions of the core gameplay and rules of music games form a music game interaction mechanism with the core elements of "Note Indicator", "Moving Track" and "Judgment Area", called "Dropping Interaction" (see Fig. 1).

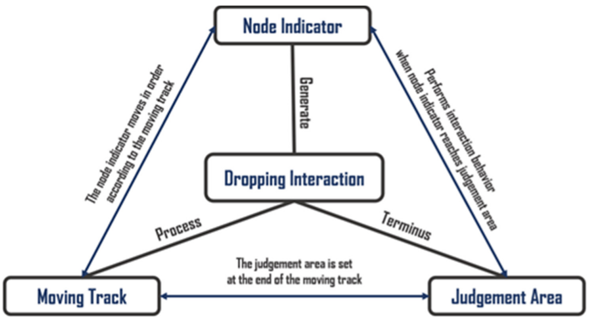

Fig. 1. Diagram of the "Dropping Interaction" mechanism.

Early music games such as *Rhythm Master* and *o2jam* are based on "drop interaction" as the core gameplay, which is used in setting the interaction mechanism and rules of the game. The current iteration and innovation of the traditional music game "falling interaction" mechanism usually involves changes in the visualization of note indicators, judgment areas, moving tracks, and movement rules. For example, the level of difficulty of the arcade music game *Maimai DX* is related to the layout of the interaction sequence composed of many note indicators. The interactive symbols such as slide, tap, Re-tap, long press is generated in an orderly manner along with the Fast-Paced music, guiding the player to tap on the touch screen inside the physical arcade or on the buttons along the outer edge. *Cytus II* levels will no longer move visually in terms of note indicators. However, they will instead scan up and down the previously fixed lines of the judgment area, with the rate and period of scanning adjusted to the soundtrack's mood (see Fig. 2).

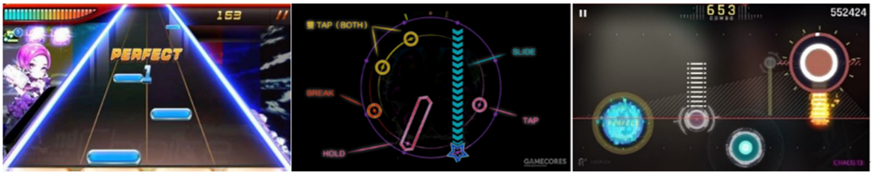

Fig. 2. Reference to the use of "Dropping Interaction" mechanism in music games (Left: *Rhythm Master*. Mid: *Maimai DX*. Right: *Cytus II*).

In the generation of note indicators in the "Dropping interaction" mechanism, Kagawa Toshimune et al. [9] focus on the technical principles of game interaction and propose the use of the "suffix tree" data parsing technique (Suffix Tree) to effectively extract the features of the background music of the level in music games, and use an adapted extraction and analysis algorithm to control the timing of game interaction and the critical sound timing, to achieve reasonable adjustment of the complexity of player interaction and the challenge of the game in music games, and provide effective guarantee for the procedural generation of the score composed of a large number of interactive notes in music games. As one of the elements of Drop-Based interaction, Jeong-up Lim and other authors [10] propose that "note indicators" are essentially a series of musical visualization symbols that can be realized through manipulation of devices by game designers by combining music theory, the thematic style and mechanics rules of music games, the data representation of sound, the use of MIDI standards, etc. The game designer combines music theory, music game thematic style and mechanics rules, sound data presentation, and MIDI standard application to create a series of music visualization symbols that manipulation devices can interact with them.

The design and application of music visualization elements are also critical to realize mutual interaction between players and music games under mechanism and rules. The use of sound visualization technology module for service video game development can effectively help to improve the quality and efficiency of music game development [11]. Timing synchronization among game music tracks, game scenes and players' interactive behaviors enables players to fully experience the rhythmic atmosphere of the "Dropping Interaction". With audio visualization technology, the information of game music tracks such as beat and pitch is transformed into a large amount of data. Then the designer constructs association rules between visual content and valuable data features to generate regular and distinctive visual elements [12]. Tzu-Chun Yeh [13] and other authors designed a music game *AutoRhythm* in such research, and by introducing the music data analysis in it and the structured generation method of the interaction spectrum in the game, and carrying out relevant experimental tests, they proposed a quality improvement scheme for the spectrum generation of music rhythm games. This scheme can effectively improve the quality of the player, background music, and game. This scheme can effectively improve the synchronization and harmony among the player, background music, and game interaction operations and provide positive effects for improving the quality of music game development.

With the continuous innovation of the concept of music game mechanism design and the use of new game interaction devices, the "Dropping Interaction" mechanism of music games has gradually evolved into more complex and creative ways of playing. For the convenience of description, this paper refers to games that combine traditional music games with other types of game mechanics as "hybrid music games", which adjust some of the interaction mechanisms of traditional music games and incorporate other video game mechanics, and change the figurative forms of the original note indicators, movement trajectories, and judgment areas to a greater extent. The game also incorporates the mechanics of other video games. For example, *Geometry Dash* combines parkour elements with flat scrolling interaction mechanism, in which the note indicators change into obstacles to be avoided or springboards to be touched, etc. The player has to complete the effective interaction operation of avoiding obstacles according to the movement speed of the character and the current movement form of the character when the music beat is synchronized with the location where the interaction should be made. *Mush Dash* incorporates the Non-Turn-Based boss battle mechanism of Role-Playing games, in which players follow the rhythm of the music and quickly and accurately hit the monsters sent by the boss to survive and try to fight against the boss (see Fig. 3).

Fig. 3. *Geometry Dash* level scene (left) and *Mush Dash* boss battle level scene (right).

The interaction mechanism and rules of many music games make the players' action not only rhythmic but also generally reflect the features of "high interaction frequency and quick response", "appropriate timing and standard action", and "high strength and intensity of interaction". The Above-Mentioned common points and differences between traditional music game "falling interaction" and "hybrid music game" in terms of core gameplay, game rules and interaction mechanism can be summarized as follows: the main feature of music games is that "players can quickly perceive and adapt to the relationship between the rhythm of interaction and the rhythm of music within a period of time, and complete a series of specific action sequences with frequent, accurate, powerful and rhythmic feeling," which is the main feature that distinguishes music games from other electronic games in terms of game mechanics.

Another book by Ernest Adams, Fundamentals of Game Design, mentions that game mechanics will present players with "Active Challenges" and "Passive Challenges." Active Challenges are formed according to the game mechanics, while Passive Challenges do not require game mechanics and are avoided by the player character [14]. In the context of the analysis of the interaction mechanism of music games, "Active Challenges" refers to the players' ability to follow the rhythm of the music and the synchronized visual cues to perform the interaction to ensure that the game passes and achieves a high rating. "Passive Challenge" means that the user needs to avoid the rhythm of the music and the synchronized visual cues, overcome the distracting factors that lead the player to fail the game, and perform the interaction according to the actual situation to avoid reaching the failure condition. The combination of "Active Challenges" and "Passive Challenges" in music games affects the deployment of the players' interactive behavior decisions. Combining the two types of challenges in the music game requires players to fully consider and use their decisions in the deployment of the "Active Challenge" and "Passive Challenge" corresponding to the corresponding play style.

Take the VR music game *Beat Saber* as an example. The game's different level objectives, pass restrictions and game mode diversity with the player needs to use the "Active Challenge" or "Passive Challenge". Players with the VR handle to cut the operation of the music cubes has different color distinctions. The arrow on the block indicates the direction of cutting. Their generation and movement patterns will be synchronized with the background music beat to achieve the timing. If there is no arrow, it means that the player can cut them from any direction, with the corresponding color of the "Lightsaber" cutting cubes can score points. Players need to face many music blocks in the level and "Grid Barriers", "Bombs", and other objects that players need to avoid. These objects, which pose a threat to the player, will appear along with the music cubes and be interspersed (Avoiding the grid and avoiding cutting into bombs). In addition, some of the levels in *Beat Saber* Campaign mode have conditions that limit the intensity and frequency of positive interactions, such as limiting the maximum number of consecutive hits and limiting the cumulative distance that players can move with their hands (see Fig. 4).

Fig. 4. *Beat Saber* music cube with bombs (left) and electrified grid barriers (right).

2.2 Gamer Behavioral Decision

The Fast-Paced, interactive type of music games need to be designed in such a way that they can keep the player focused for a long time while continuously gaining a sense of excitement and satisfaction, providing the conditions to stimulate the player to shape a positive mind flow experience in the game interaction [15]. Along with the increase of difficulty in the levels of music games, the number of note indicators increases and the frequency of appearance accelerates, and the complexity of note indicators of different interaction types increases, which requires players to have faster Pre-judgment reaction, more accurate operation timing, and more ruthless action intensity to improve the quality of interaction operations. In the face of this change, players need to combine their assessment of operational proficiency and level performance to develop and always adjust their strategies for passing the levels and the quality of their pursuit of completing the level objectives. In this paper, we refer to this part as players' behavioral decisions in music games.

Players make behavioral decisions in games based on a variety of factors. Sam von Gillern [16] from Iowa State University of Science and Technology has proposed a behavioral framework for interpreting players' experiences in video games, The Gamer Response and Decision Framework, GRAD framework for short (see Fig. 5).

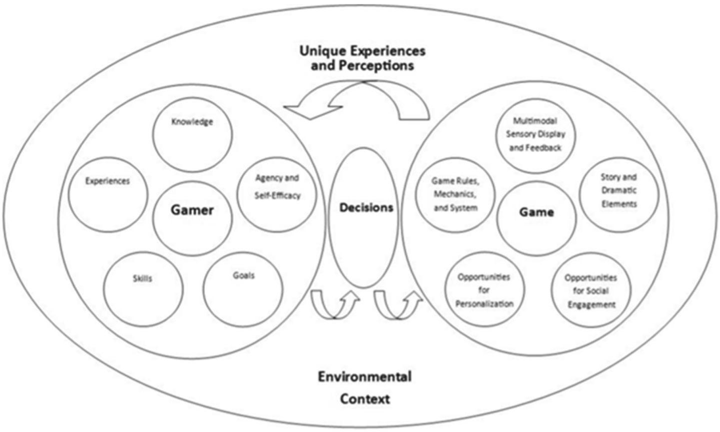

Fig. 5. GRAD framework by Sam von Gillern (image captured from [16]).

The author indicates that the framework is based on Rosenblatt's Reader Response Theory (1995), game research and psychology, and other related theories to understand and explain the learning process and players' Decision-Making process in the game. The GRAD framework is structured as a circular structure in which the gamer and the video game use the game scenario as the environmental context to drive the game process through the players' Decision-Making, and the Unique Experiences and Perceptions of the game feedback to influence the players' adjustment to the decision, thus forming a circular structure. In this way, the players' experiences, knowledge, skills, agency and Self-Efficacy, and goals are linked to the multimodal sensory display and feedback, game rules, mechanics and systems, Story and dramatic elements, Opportunities for personalization. The author has mentioned in the concluding statement of the GRAD model study that applying the concept of the GRAD model to the context of a specific game classification helps to highlight the exploration of connections related to the gameplay mechanics, player interaction behaviors for such games.

For the influence and causes of players' behavioral decisions in music games, Luisa Jedwillat et al. proposed the influence of background music in games on players' manipulative behaviors, arguing that the emotions brought by the soundtrack style in players' game experience can influence the way players to manipulate the game and make the interaction behavior harmonious with the music style theme [17]. Through an experimental study, Amanda C. Pasinski et al. [18] compared three groups of players, including formally trained musicians, Long-Term music game players, and general players, and analyzed and showed that the difference in the presentation of level scores of the music game *Rock Band 2* by different player groups influenced players' perception of music in music games to the operation degree of precision judgment, which in turn affects players' interactive performance ability. Joseph D. Chisholm et al. [19] compared two groups of Action Video Game Players (AVGPs) with Non-Video-Game Players (NVGPs) by conducting experiments related to eye movements and interaction responses. AVGPs are more focused, have faster response times, and have more skills and experience with these games.

3 Construction of HCI Features and Players' Decision-Making Framework in Music Games

The interaction and feedback results between different players and the game program often differ significantly in music games. The game designer takes the expected experience goal and feasible pass method as the main idea to guide and shape the game mechanism, play method, rules and other modules. However, because players have different operating abilities, interaction habits, and fitting degree, some players' interaction decisions do not faithfully reflect the game's original experience goals and design intentions, thus reducing the fun of the game.

Among the existing studies focusing on music games, few results correlate and combine the mechanisms and rules of music games and players' behavioral decisions, so this paper proposes the following hypothesis: players' behavioral decisions for music games are related to the unique game mechanisms and rules of music games, and accordingly proposes the relationship model between Human-Computer interaction features and players' decisions in music games. The proposed model can effectively clarify the factors related to the formulation and adjustment of players' behavioral decisions in music games (see Fig. 6).

The relationship model consists of three main elements: "Gamer" (same meaning as "Player"), "Gamer Behavior Decision" and "Music Game". Each of these elements contains several Sub-elements. Arrows indicate the interconnection between them (solid arrows show those directly or primarily related, indirectly or partially related are shown by dashed arrows). The specific form of their interconnection is described.

The unique game mechanics of music games determines how the player performs the "Active Challenge" or "Passive Challenge" mode of play. The various settings and rules of different music game levels will also guide players to focus more on one of the two modes of interactive play, making it more conducive for players to make reasonable

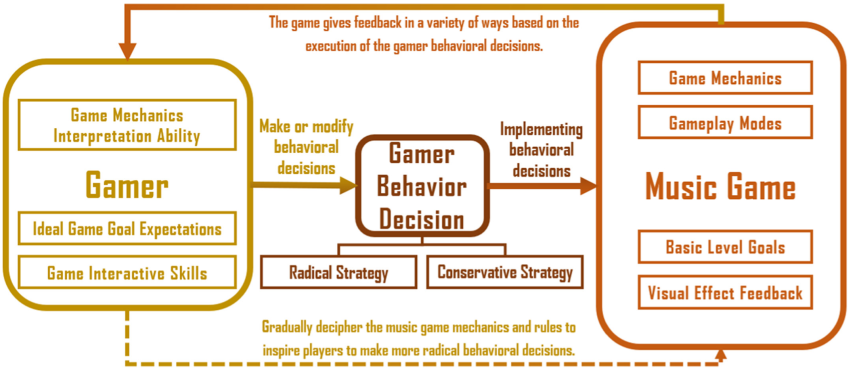

Fig. 6. HCI feature and gamer behavior decision relation model in music games.

behavioral decisions to achieve the pass conditions. Before players start to play a new music game, they will make initial behavioral decisions based on their previous proficiency in similar music games, their interpretation of the rules and mechanics of the new music game, their ideal performance and evaluation expectations. The game gives feedback in Real-Time game screen effects, score situation, scene element changes, etc., based on the operation situation established by the player's specified decision. Combined with the game pass target, these feedbacks will influence the player to adjust or decide details in the next part of the game process. After further understanding of the game objectives, gameplay mode, and their operational performance, players will decide to make more conservative strategies to reduce the risk of operational errors by tending to achieve the primary conditions of the game objectives in the following game decisions or to make more aggressive strategies to face more complicated and more likely to lead to the risk of failure by attempting more challenging game objectives by challenging higher pass conditions.

One should emphasize that for any music game, the "Active Challenge" and the "Passive Challenge" of the gameplay model do not necessarily have to coexist in the Above-Mentioned relational model, and the player may use both at some point in the process of the game. Players may use both active and passive challenges at certain times during the game level, so the two are not necessarily independent of each other. In addition, the "Conservative" or "Aggressive" strategy in the player's behavioral decisions is evaluated regarding the player's proficiency, experience, and expectations of the game's goals (Including the fixed goals set by the game and the player's own desired goals).

4 Application

Don't Be Popcorn is a game based on the Unity3D engine, combining the core mechanics, rules and play methods of Pop-Up shooting and music rhythm. In terms of theme creativity, the author's creative team planned and set the game style of 8 Bit and pixel, with anthropomorphic corn kernel characters resisting turning into popcorn in the pot as the story's background. The game mechanics, game rules, score calculation and accumulation logic, music score generation, and other game design aspects follow the "Game

Mechanics and Rules" point of view in the previous relationship model and guide. The production of this game provides a vehicle for subsequent player testing experiments. It provides an effective guarantee for subsequent data analysis and experimental verification of the relationship model between Human-Computer interaction characteristics and user behavior and Players' Decision-Making in music games.

4.1 Behavior Decision and Game Mechanics Design

The game mechanics and rules design module of this game contain four main parts: the player's interactive movement control of the corn kernel character, the information collection and data transformation of the music, the synchronization setting of the fireball launch and the music track, and the dynamic adjustment and encouragement mechanism of the level difficulty.

Interactive movement control is an essential part of the game behavior decision in the execution process, determining the external representation of the Players' Decision-Making behavior and decision mode. The game program sets up the interactive input interface of the Body-Sensing device, and gets the player's hand movement information by using external Body-Sensing devices such as Kinect, and binds the position of the corn kernel in the scene with the player's hand movement position information by using the camera ray collision function so that the corn kernel can move flexibly in the game scene. The game also sets up interaction mechanisms that support mouse operation so that the game can be played using the PC client without the hardware of a somatosensory device. The somatosensory device requires players to pay extra learning costs to cooperate with the physical and dynamic elements, which makes behavioral decisions more challenging and playable but difficult. The mouse interface is the usual control mode for players, which is relatively easy to operate, and players will spend more learning costs on strategic thinking and more rational behavioral decisions.

Music data processing and information collection provide necessary guarantees for the regular operation of music game mechanics and provide accurate guidance for players to interpret the music game mechanics and make behavioral decisions following the game mechanics and rules. The music played in the level scenes will be analyzed by the program in Real-Time. The data will be processed to form a synchronization between launch and movement patterns of fireballs in the game and changes in the pitch of the music and other information. Fireball movement and pitch show a close positive correlation, so the player can predict the changes of other elements by any fireball, thus choose the corresponding Decision-Making behavior to contribute to the challenge of the level and the realization of the music style. The data results obtained from the program's analysis of pitch properties are highly compatible with the changing pattern of pitch felt by people, which helps to improve the quality of automatically generated spectral effects in music games synchronized with background music, increase the emotional impact of music, and indirectly influence the style of players' behavioral decisions. In addition, using the sound spectrum sampling function in Unity, we mainly sample the pitch information of the game sound source in Real-Time and generate the sample data required by the program. These data are grouped and integrated, processed according to specific setting requirements of the game rules to provide support for some mechanisms such as the firing of fireballs in the game scenes.

The synchronization of the fireball obstacle generation with the music will influence the Players' Decision-Making behavior during the game. Fireball will generate from 20 launch pads at the edge of the scene and move towards the center of the screen. The launch pads' launch commands are programmatically controlled. Each launchpad is numbered from 1 to 20, and the number corresponds to the range of pitch data sampled in the soundtrack, with the numbered numbers ranging from small to large, indicating the sampling of different ranges of pitch attribute parameter values for the music from small to large. The lower pitch values correspond to the melodies that make the player feel low and rough in the music, corresponding to the low part of the music. In this stage, the number of fireballs launched is low and the threat of damage to the character is low, so players can adjust their behavioral decisions during this period to score as many points as possible in the scene, while preparing for the greater threat brought by the increase in pitch. The player has to decide whether to adjust to a conservative decision to avoid the threat, or to maintain an aggressive decision to meet the challenge according to his own operational ability. These samples are collected by the program, and the fluctuation of the data value will be close to synchronization with the music beat cycle. The game uses this relationship to achieve the synchronization of the control of fireball launcher with the music beat change and climax change, allowing players to switch between different psychological states and behavioral decisions, guiding players' emotions to rise and fall, dramatically shaping the narrative and rhythm of the game.

Dynamic difficulty adjustment and interactive encouragement mechanisms ensure that players continue to have a positive experience and are motivated to change their strategies to achieve better results. [20] The game uses a dynamic difficulty adjustment mechanism, which varies significantly from level to level and dynamically adjusts the degree of difficulty in the same level according to the player's stage performance. The fireball launch control will be subject to the change of sound sampling value, at the same time, after processing the sampling value and the player's operation performance will further affect the fireball launch frequency, movement speed, the probability of aiming at the player launch, the maximum number of simultaneous presences in the scene, to achieve the dynamic adjustment of the game difficulty. At the beginning of the game, fireballs have a long interval time, slow movement speed and low accuracy in targeting players. Suppose the player insists on staying unharmed for a long time during the game. In that case, the above parameters about the fireballs will gradually change. The player will gradually face a more significant number of fireballs with higher speed and accuracy, testing the player's ability to avoid obstacles. Once hit by the fireball, these parameters will immediately reset to the initialization stage, reducing the difficulty dynamically. This mechanism ensures the timeliness of the player's decisions and gives a progressive difficulty increase. On the one hand, it ensures that the player's strategy is feasible. On the other hand, it ensures that the chosen strategy can inspire the player to appropriate challenges. The work achieves a continuous appeal of the game by grasping the dependency between achievement and challenge and motivates the player to conceive more affluent behavioral strategies continuously.

In addition, in order to guide players to develop a clearance strategy more in line with their operating skills and proficiency, the game scene area is divided into a "Scoring Zone" and a "Recovery Zone" (see Fig. 7).

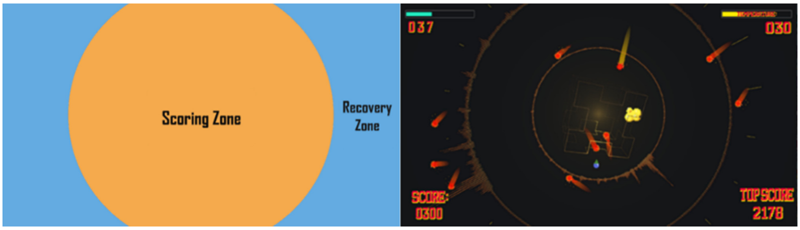

Fig. 7. The “Scoring Zone” and “Recovery Zone” (Left: Sketch. Right: Actual scene).

The “Scoring Zone” is located in the circle area in the center of the screen, insisting that the corn kernels move in the center area of the screen where fireballs easily hit them can accumulate points. As the cumulative damage received increases, the corn kernels will change shape and gradually puff up into popcorn. At this point, the collision volume of the character will become larger, more vulnerable to fireball damage, resulting in the risk of failure to enhance the pass. Players facing this situation to avoid the risk need to leave the “Scoring Zone” as soon as possible to avoid the “Recovery Zone”. The “Recovery Zone” is located in the edge area outside the screen circle. Character in this area is less threatened by fireball damage. If the corn grain character’s lifetime value is not full, move to the “Recovery Zone” will recover the health point. The lower the current life value, the faster the recovery efficiency, but the character will not accumulate points during the “Recovery Zone”. This situation leads the player to return to the “Scoring Zone” to get a score.

These areas are designed to allow players to adapt to the game’s difficulty, indirectly control the game’s difficulty, and try new Decision-Making behaviors by adjusting their behavior and patterns. This setting avoids the game to win or lose binary mode to give players the blow of losing. under the premise of ensuring players’ survival, it promotes players to adjust their behavioral decisions in the dynamic process to pursue higher scores. Then, the remaining life value will not be counted as an additional score when the game is paused bonus.

The mechanism as mentioned above of interaction incentive mechanism in this game on the dynamic change of level difficulty, the division of different functions in the interaction area, as well as the settings of score and life recovery mechanism, aim to jointly influence the player’s behavioral decision and guide to adjust the player’s interaction behavior. The change of music climax and the character’s state will also prompt the player to make timely conservative low score behavior decisions, aggressive high score behavior decisions or custom behavior decisions in line with the player’s operation level. The game is also a great way to ensure that the player is satisfied with the score and stimulates the player’s sense of strategic behavior, thus effectively adding to the game’s fun.

4.2 Behavior Decision and Art Effects Design

The game’s art and effects design also play an essential role in shaping and deploying the player’s behavioral decisions. In the GRAD framework, visual elements such as art and effects will act as “Multimodal Symbols” to the players, responding to game mechanics and rules and providing visual feedback to the players' interaction behavior. Players will repeatedly receive these static or dynamic symbols during the game and gradually understand the relationship between the symbols and the game's performance. At the same time, the storytelling relationship between different symbols and the player's role also helps players interpret the meaning of art elements and visual effects, which helps players to use a more accurate grasp of the game mechanics, and thus make behavioral decisions more clearly implemented and adjusted during the game. In this game, players will take on the role of "Corn Kernels", the character has to avoid contact with the source of damage "Fireball" to prevent excessive heat in the "Passive Challenge" part. In the "Active Challenge" part, corn kernels need to touch the bonus prop "Water drops" to get extra points while recovering from their health point. Therefore, "Fireball" and "Water Drops" will become essential art design elements in the game scene.

In terms of visual design, the design uses the metaphor of corn kernels and fire for the character part. The player controls the character as a corn kernel, which needs to avoid becoming an expanding popcorn and therefore avoid touching the fireball generated with the music rhythm. Corn kernels and fireballs are used as visual symbols, and through graphical representation, the player's experience of the popcorn making process is integrated into the understanding of the game rules. By extension, the fireball serves as an obstacle to be avoided in the game. The water droplet correspondingly conveys the opposite concept of the fireball, symbolizing a prop that is beneficial to the player. In the center of the screen, a Ring-Like pattern of the fire circle changes with the rhythm to divide the "Scoring Zone" and the "Recovery Zone". The circular shape of the fire ring reminds the player of the top view of a stove, using the stove metaphor to convey to the player the more dangerous hints represented by the center part of the screen as the "Heat Source".

In addition, the art design also uses rapid and intense visual changes to provide players with feedback on the interactive behavior, suggesting whether the interaction made by the player is in line with the interactive features and rules of the music game, and help the implementation and advancement of the pass decision. For example, the player manipulates the role of "Corn Kernels" in the fireball damage, the screen produces a momentary white splash screen effect. At the same time, the current life value of the character dynamically changes the puffed state of the corn kernels, adding to the expressive effect of the character's damage cue. When the player's health point is 0, the popcorn will be fully expanded and turned into ashes. Its visual representation can quickly identify the character's life state. In addition, the music in the climax of the drumbeat will drive the screen to produce a perspective shaking effect, shaping a more dynamic game scene Audio-Visual experience to help players control the law of interactive action (see Figs. 8, 9, 10 and 11).

Fig. 8. Corn kernel character in different life states.

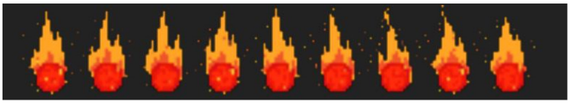

Fig. 9. Fire ball obstacle (Sequence frame animation display).

Fig. 10. Bonus item – water drop (Sequence frame animation display).

Fig. 11. Popcorn turned into ashes (Sequence frame animation display).

5 Experiment and Result Analysis

Following the relationship model proposed in the previous section and the specific implementation of each element in the model in the game design, this study will further explore the following elements in the game test, questionnaire feedback, and data analysis phases: the specific implementation of interaction decisions in *Don't Be Popcorn.* The relationship between game proficiency and willingness to challenge for higher scoring goals.

5.1 Experiment Design for Game Test

In selecting the experimental group for the game test, the participants invited to this experiment came from the college students in the author's university, and their ages ranged from 18 to 28 years old. The experimental population was divided into two groups according to whether they had played music games in the past year or not: the experimental group was the group of players who had played music games (n = 22), and the control group was ordinary players (n = 16) Participants have generally played music games such as *Taiko Drummer*, *Cytus II*, and *Rhythm Master* within the past year.

The test process will be conducted in both online and offline formats. The offline test will directly invite players to play *Don't Be Popcorn.* It will focus on observing the specific operation of the players' strategy, adjusting the strategy and performance of the level score during the game, and providing feedback on the performance and operation evaluation through a questionnaire after the game experience. In the online testing session, the researcher encapsulated the game program, uploaded it to the online network cloud and provided a sharing link. The players downloaded the game and started to play it directly through the PC client. The research questionnaire mainly asked the test players whether they had experience in playing music games and their evaluation of the difficulty of each level, as well as objective data such as the number of attempts required to pass each level for the first time and the score of each level.

38 questionnaires were collected from which 23 valid questionnaires were screened through the valid responses, including 14 for the experimental group and 9 for the

control group. After counting, we conducted a preliminary analysis of the questionnaires in a traditional nonquantitative method, and the statistical results tentatively showed that players with music game experience (experimental group) generally scored higher than the average players (control group), but there was no significant difference in the "Number of Attempts" and "Level Difficulty Rating" between the two groups of players. To demonstrate the experimental results' generalizability and significance and verify whether there is a more complex correlation between Decision-Making behavior and game mechanics, we further quantitatively analyzed and evaluated the test papers.

5.2 Questionnaire Research Analysis

The questionnaire results study will be carried out using SPSS 19.0 for data analysis. The results of the questionnaire analysis will be used to summarize the players' scores and difficulty ratings in the game experience sessions, and this will lead to further analysis of the players' characteristics in terms of their operational performance and Decision-Making strategies for interactive behaviors in music games.

The reliability test used the alpha coefficient model, and the results showed that Cronbach's alpha coefficient is 0.750. the KMO and Bartlett's sphericity tests were performed on this questionnaire (Sig. < 0.001, KMO $= 0.649$). The overall reliability of all questions involved in the data analysis was acceptable.

The relationship between the dependent variable "Score of Each Level" and the independent variable "Possess Experience of Music Games" was examined using the mean analysis method. The results showed that players with music game experience performed better than the average players in any level, and the difference between the scores of the two types of players in each level was about 209 points. In addition, comparing the score difference between the two types of players in different levels, it can be concluded that the average score of the second level is the highest, and the average score of the third level is the lowest (see Table 1). These results tentatively show that players with experience in music games can more easily use their previously acquired operational experience to decipher the game mechanics and master the skills of passing the game faster when experiencing the operational aspects of new music games. Moreover, the game's difficulty was negatively correlated with the performance of the player's pass score, and increasing the difficulty of the level reduced the performance of the player's pass score in general.

The relationship between "Attempts Required to Pass the Level", "Level Difficulty Rating", and "Possess Experience of Music Games" was analyzed using biased correlation. "Possess Experience of Music Games" was set as a control variable to exclude the interfering factors that affect the difficulty of this game according to the players' previous proficiency in playing music games. The two variables were tested for Two-Tailed significance using game level 1 as an example. The results showed that the partial correlation coefficient Correlation is 0.589 and the Two-Tailed significance is 0.004, indicating that there is a significant correlation between the number of first pass attempts in level 1 and the level difficulty evaluation, and this correlation coefficient is significant (see Table 2). It can be tentatively concluded that players' evaluation of the game's difficulty increases with the gradual increase in the number of passes required.

Table 1. Mean and standard deviation of the score of each level for different players.

Possess experience of music games		Score level1	Score level2	Score level3
Yes	Mean	1984.44	2116.25	1655.44
	N	16	16	16
	Std. deviation	834.357	827.630	817.357
No	Mean	1755.43	1957.14	1415.00
	N	7	7	7
	Std. deviation	934.388	900.951	839.385

Table 2. Skewed correlation analysis of the pass attempts and difficulty evaluation (level 1).

Control variables			Attempts required to pass the level	Level difficulty rating
Possess experience of music games	Attempts required to pass the level	Correlation	1.000	.589
		Sig. (Two-tailed)		.004
		df	0	20
	Level difficulty rating	Correlation	.589	1.000
		sig. (Two-tailed)	.004	
		df	20	0

Linear regression analysis was used to explore whether there was a linear relationship between the number of attempts required to pass different levels and the level score. Take level 1 as an example, set the independent variable as "Attempts Required to Pass the Level" and the dependent variable as "Level Score", and obtained the regression coefficient table of the first level score (see Table 3).

Table 3 gives the unstandardized coefficient constant value (B = 1576.336, Sig. = 0.025), and the corresponds value of passes required as the independent variable (B = 181.007, Sig. = 0.596). Based on the above data analysis results, it is assumed that as the number of first pass attempts increases while the player is playing the first level, the final score of the pass will also increase. However, since the significance of the unstandardized coefficient of the independent variable (sig > 0.05), it is denied that the linear regression results present a correlation. The above hypothesis needs rejected.

Table 3. Regression coefficients result for the score in level 1.

Model	Unstandardized coefficients		Standardized coefficients	t	Sig.	95% Confidence interval for B	
	B	Std. error	Beta			Lower bound	Upper bound
(Constant)	1576.336	654.559		2.408	0.025	215.105	2937.566
Attempts required to pass the level	181.007	336.553	0.117	0.538	0.596	518.894	880.907

6 Discussion

There is a linear relationship between the number of attempts required to pass different levels and the level score from the test results. However, this linear relationship should be denied from the significance analysis. After different players have a preliminary understanding of the difficulty of the music game levels and the focus of the play mode, players' clearance strategies will be evaluated and adjusted. In the process of repeatedly failing to pass the game, players accumulate skills and experiences that help them succeed in passing the game, and at the same time, the differences in frustration and Self-Confidence brought by repeated failures also affect the results of players' decisions to adjust their behaviors.

In addition, the scoring incentive mechanism and dynamic difficulty changes in this music game will also cause significant differences in the behavioral decisions of different players. Players are willing to adopt a higher risk of failure to pursue higher scores, trying to make aggressive game decisions and move within the "Scoring Zone" as much as possible. While other players chose to make relatively conservative decisions, giving priority to maintaining a safe life state for their characters, wandering between the "Scoring Zone" and the "Recovery Zone" more frequently, and even move directly to the "Recovery Zone" at the risky period of the game level, in which to avoid the threat of fireball obstacles and give up scoring more points.

The above experimental analysis and data research results show that players' behavioral decision making and adjustment in music games are related to the difficulty level of different interactive game modes, players' ability to master music game skills, and their ability to interpret and implement game mechanics and rules, etc. The results of players' strategies and behavioral decision making and adjustment are not only influenced by the game performance, but also include various factors such as players' tendency to pursue certain types of the gameplay experience and changes in skill mastery.

7 Conclusion

This paper combines theoretical research and case studies of works on game mechanics, rules and interaction of music games. With analyzing the context of music games, we propose a model of HCI characteristics and user decision relationship based on music games, sorting out the characteristics and interactive relationship of player experience of music games. The proposed model explores and sorts out the correlation and influencing factors between game mechanism and players' Decision-Making in the music game context. The model is proved through case studies of existing music game works and experimental tests of game projects.

Due to the technical environment of game development, our game needs further iteration and optimization in terms of the accuracy of temporal synchronization and the design of rhythmic interactive operation. Besides, fewer samples were available for experimental data analysis in this game test session. The analysis results were not entirely sufficient to verify the association between players' interaction behavior characteristics and music game design strategies in music games in general. Further research is needed to explore in more detail the Sub-Characteristics of the "Mechanics and Rules of Music Games" module of the proposed model, and to analyze how these Sub-Characteristics affect the formulation, execution, and adjustment of players' game behavior decisions at a deeper level. The model will be further explored and refined by conducting more extensive and targeted experiments on music games.

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