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Audio-Based Gamified UI/UX Design for Blind Players

Zhanhe Wang

Nanjing Foreign Language School, Nanjing, China
15951920472@163.com

Abstract. Electronic games still rely heavily on visual interfaces, and information about game status, actions, and rewards is commonly conveyed through buttons, icons, colors, text, and animations, which creates accessibility barriers for blind and low-vision (BLV) players. Although feasible approaches such as audio cues, spatial audio, voice feedback, and haptic assistance already exist, related practices are often implemented separately and lack a systematic framework for integrated accessible game UI/UX design. This paper examines how audio-based gamified UI/UX design can support accessible, easy-to-operate, and immersive gaming experiences for BLV players. Combining literature review and case analysis, the paper analyzes accessible games, audio interaction, existing difficulties in game UI/UX, and psychological factors such as flow, motivation, and immersion. The study identifies key obstacles created by visual-by-default interfaces and reviews existing auditory and tactile approaches and provides suggestions for audio-based game UI/UX design, including information, interaction, positioning, motivation, and flow. The analysis suggests that audio-led and multimodal design can improve accessibility and support richer interaction but cannot fully eliminate limitations related to information bandwidth, cognitive load, individual differences, and hardware requirements. The paper concludes that accessible game design should consider audio-led or multimodal UI/UX design and incorporate psychological factors into accessibility research, while future research could explore empirical evaluation, AI-assisted audio, cross-platform consistency, and collaborative design with visually impaired players.

Keywords: Accessible Game Design, Audio-Based UI/UX, Blind and Low-Vision Players

1. Introduction

Video games have traditionally relied heavily on visual interfaces. Menus, status prompts, operation feedback, and reward systems are mostly explained by buttons, icons, colors, words, or animations. The "visual-by-default" design creates significant accessibility barriers for blind or low-vision (BLV) players in information access, interaction, navigation, and immersion. In recent years, alternative solutions such as audio cues, spatial audio, voice feedback, and haptic feedback have emerged. Studies such as BlindFun, BlindPlayVR, and PunchPulse have demonstrated the feasibility of non-visual interaction in specific gaming contexts [1-3]. However, current attempts are largely fragmentary, and existing approaches often focus on individual interaction rather than integrating information, behavior, and user experience.

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The research question is how can audio-based UI/UX design support usable, controllable, and immersive gaming experiences for BLV players? Starting from previous research, cases, psychological perspectives, and design principles, the article analyzes accessible games and obstacles in traditional visual UI; discusses the sense of control, flow, motivation, and immersion facilitated by audio feedback; and then synthesizes design considerations for audio-based game UI/UX. This study has threefold significance: bringing the idea of audio-first UI/UX to the game development community; introducing psychology and interaction design into the field of accessibility for consideration; and pointing out directions for follow-up research.

2. Literature review and theoretical basis

2.1. Accessible game design

A study by BlindFun indicates that most commercial video games are inaccessible to blind people because they rely heavily on visual cues to convey core game mechanics [4]. Traditional game UI often communicates information through buttons, icons, colors, text prompts, and visual animations, forming a "visual-by-default" interaction pattern. For BLV players, they cannot obtain basic information about the game. Too little information also hinders actual operation. In addition, more subtly, poor accessibility conditions force them to devote a larger amount of cognitive efforts to compensate, causing an imbalance in cognitive load.

2.2. Audio-based game interaction

The existing audio cues used rely on sound effects to explain events or states. BlindFun uses contextual sound effects and spatial audio combined with text-to-speech methods [1]. As far as current experimental results are concerned, the certainty of the relevant prompts increases, and navigation is also easier to complete [1]. The GrandEscape study points out that speech voice is suitable for reporting position, while non-speech audio is more suitable for expressing direction and distance; if rhythm and tapping are also included as interaction methods, the sense of presence will be greatly improved [5].

Spatial audio constructs three-dimensional sound sources using head-related transfer functions (HRTF), enabling players to know direction and distance. Experiments based on the BlindPlayVR design show that the average accuracy of blindfolded people using touch and hearing to find enemies is 78.6%, and the reaction time to events is generally reduced from 50 seconds to 30 seconds [2].

The meaning of speaking voice feedback is clear. According to the PunchPulse design, the joystick is used to move through menus, voice is used to confirm the selected content, and all hardware operations are explained by audio, so players can configure and start the game themselves [3]. BlindFun also uses text-to-speech to announce status [1]. Voice is more suitable for expressing individual pieces of information or commands, and is not suitable for describing continuous states.

Haptic feedback is a confirmatory channel like audio. BlindPlayVR uses touch together with spatial audio for non-visual interaction [2]. PunchPulse gives vibration, sound, and score prompts for what is struck and what is suffered, forming multiple feedback [3].

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3. Challenges in game UI/UX for blind players

3.1. Information accessibility

Traditional game interfaces are often designed around visual elements: buttons, icons, text, colors, and animations, which serve as prompts or feedback. This arrangement assumes that players can see the screen and therefore constitutes a barrier for visually impaired people. First, the reliance on visuals means much of the information is dependent on visual access. Buttons may not have semantically usable labels (for screen readers), icons have no alternative text, and information indicated by color cannot be read aloud [6]. Therefore, menus, controls, and even game choices are not easily accessible. Second, feedback-type information is not complete enough. Content related to position, resources, health, and tasks is frequently presented visually, with limited auditory or haptic alternatives. Lack of information means losing the starting point for understanding the game.

3.2. Interaction and navigation

Interaction and navigation problems themselves are caused by visual dependence. First, menu navigation is difficult. The structure of the menu, the focus order, and the current state are explained by visual highlighting and spatial form. For BLV players, menu structures can therefore become difficult to navigate without clear information about focus and current state, increasing the cognitive cost of switching between menus. Second, operation feedback is sometimes absent or too slow. Generally, animation or visual state is used to indicate that input has been accepted, while auditory confirmation is rare and slow. Without a clear indication of the result of an operation, the basic action-feedback loop becomes difficult to establish or maintain. Third, the visual interface limits the discoverability of interaction entry points. Buttons and icons have no additional verbal explanation, and BLV players may not know that they are available or operable elements. They may therefore need to rely more heavily on trial and error to identify operable objects, making exploration less efficient. As a result, completing the same game tasks may require greater interaction effort from BLV players.

3.3. Engagement and experience

The combination of these obstacles directly damages investment and game experience. First, if visual rewards cannot be reliably utilized, their motivation value may be reduced. Even when BLV players complete a task, they cannot clearly know what reward they received, which may negatively affect motivation and continued engagement. Second, if operation feedback is absent or delayed, the sense of control and flow are destroyed. According to flow theory, feedback should be immediate and stable; without feedback, there is no way to know whether an operation succeeded, and the flow state is difficult to initiate or maintain for long [7]. Third, insufficient game feedback itself coexists with cognitive load, dealing a double blow to immersion. To maintain the game rhythm, BLV players must use more cognitive resources, and the resources used for actual enjoyment, thinking, or strategic planning are correspondingly reduced. In this way, long-term overload with absence of immersion will create frustration, and the game is no longer a pleasure.

In short, limited information access can make navigation more difficult, while navigation difficulties can further increase the importance of clear and timely feedback; the combination of the two is not merely inconvenience but fundamental inequality. The challenges suggest that a unified audio design approach is needed, and local remedies alone are not enough.

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4. Psychological principles of audio-based gamified design

4.1. Flow and challenge-skill balance

According to flow theory, if a game presents players with an appropriate challenge that matches their abilities, it will help create an optimal state, neither making people bored nor making the game too hard to complete.

Immediate audio feedback can support the emergence of flow. So, it is important to design appropriate sound effects after every operation. For flow to exist, continuous and clear feedback should be given to players. For audio games, the confirmation sounds, environmental sounds, or dynamic soundscapes used can provide real-time ways for visually impaired people to obtain "operation-result" information.

Audio can be a real-time cue for changes in game difficulty and challenge. The so-called balance is not fixed once and for all but changes as players improve. Audio parameters can dynamically change. For example, if game difficulty increases, auditory design can communicate this through fast rhythms or dense prompt tones; if operation goes smoothly and difficulty decreases, the soundscape can then become a simple and harmonious type. With dynamic audio hints indicating challenges, players can better prepare for and adjust to particular levels of difficulties. A preparation before sudden changes can create confidence and a sense of control for players. Mastery together with a balanced challenge thus supports playability.

4.2. Rewards and positive feedback

Rewards and positive feedback themselves are mechanisms that psychologically motivate and maintain behavior.

Visual games mostly use icons, score prompts, or celebration animations as reward markers. For visually impaired people, sound effects should be designed as an independent reward. Related gamification research has pointed out that expressing achievement through audio can be an effective way to communicate positive outcomes [8]. In designed learning programs for visually impaired users in the form of games, each game item has a dedicated sound effect that can be quickly identified, and the relevant achievements are explained by audio. This arrangement is feasible because hearing can firmly connect a certain sound with a positive result, therefore forming a learned association: if a specific sound effect consistently follows the target behavior over time, players may associate the sound with a positive outcome. The sound itself can function as a reward cue instead of simply representing a visual reward.

Moreover, emotional effects should also be taken into consideration when designing auditory feedback. Sound effects with positive valence (joy, satisfaction) are potentially effective forms of reward. For example, a short rising tone is suitable for ordinary success; a sequence composed of multiple notes is a marker of great achievement. The complexity of the sound effects used should correspond to the achievement and be applied in layers, incorporating player development into the sound narrative.

4.3. Immersion and audio experience

For visually impaired players, immersion can be supported through auditory designs instead of relying primarily on visual presentation. The immersion elements referred to psychologically

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(spatiality, environmental sense, and narrative involvement) can all be stimulated or facilitated by sound.

As a basic element of immersion, presence as well as realism and engagement can be promoted through haptic feedback, which provides physical responses to player actions. For visually impaired people, spatial audio has a similar function. After sound provides correct direction and distance information, the human brain can form a mental representation of virtual space, thereby gaining the feeling of being inside it.

An environment with internal logic and an accurate response to operations can strengthen immersion. In existing research on immersive 3D audio for visually impaired people, it is pointed out that spatial audio accuracy, adaptive sound design, and haptic cues are the three elements that constitute a mental map of a virtual environment [2]. Beyond mere spatial recognition, voice, contextual soundscapes, and even dynamic audio make players feel that they are inside the story, not merely operating a machine. The logic between these environmental and narrative elements should remain consistent in order to shape characters and maintain a sense of realism.

5. Design strategies for accessible audio game UI/UX

5.1. Audio-based information architecture

Firstly, textual UI should be made accessible through audio [9]. Menus, prompts, tutorials, task records, and system information can all be explained by text-to-speech or recorded voice, combined with a good focus order and semantic markup, so that screen readers can process content stably. Secondly, different types of key information should be expressed through different types of audio cues. Tasks, sudden events, and other qualitative information can be communicated through voice. By contrast, quantitative statistics like health and time can be communicated through sound effects at certain important points, such as low HP or when time is about to run out. What's more, the priority of each kind of audio should be determined according to the information hierarchy. Urgent items should use obvious auditory features that are not easily missed—short transients, rising tones, or increased volume. General items like background should use soft, low-priority sound effects. This layered arrangement protects hearing and is convenient for visually impaired players.

5.2. Spatial audio for navigation

Spatial audio is a basic non-visual navigation technology used in 3D games. Using head-related transfer functions (HRTF) game programs can provide directional, height-related, and distance information about sound sources, thereby enabling blind people to discern the direction and distance of objects, enemies, or targets [10].

A basic design point is the use of audio landmarks: using sound effects with positional characteristics emitted from certain fixed locations (such as fountains, blacksmith shops, or distinctive wind sounds) as markers for constructing a mental map. Based on these marks, players are able to explore nearby unknown areas with the help of system hints. Using multiple important sites as marks, the games allow players to construct a mental representation of the overall map simply by relating the marks.

When players have to be navigated to a certain location, the system can create a special sound effect for guiding them. Combining the guiding sound with HRTF and surrounding environmental sounds, clear direction and distance cues are exhibited. Then the sound effect can disappear as soon as the player reaches the point.

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5.3. Gamified feedback

Gamified feedback converts the various mechanisms used in games into auditory form to promote learning and maintain interest. Operation confirmation sounds should be immediate and concise right after players' input, for example, a clicking sound. Status notification reports changes through voice or distinctive non-speech sounds (as designed in 5.1). Achievement is treated as a reward, using sound composed of more pleasing, chord-like notes to mark milestones reached. The reward sound effects used should be determined in complexity according to the achievement level: a simple chord can mark a small mission completion, while a trail of delicate and exhilarating notes can represent a major victory, such as defeating a big boss. A single note can also be used for simple or minor achievements. Reward sounds should be positive in valence and moderate in arousal and should not harm game enjoyment by being too sharp. Arranging the sound effects used in the game and their complexity according to player growth is a way to create a sense of growth auditorily. If unified, layered, and emotionally appropriate sound effects can correspond to various events, game feedback can help visually impaired people maintain interest, grasp status, and obtain a sense of achievement that is more comparable to the experience available to sighted players.

5.4. User control and customization

For visually impaired players, the auditory methods used, hearing ability, and input means are not necessarily the same, so setting various parameters according to individual needs is a fundamental point of accessibility design. First of all, the audio used must be adjustable. Various types of sound (environmental sound, navigation prompts, voice, reward sounds, and background music) should all allow separate volume adjustment: the importance of each piece of information should be determined according to personal habits and actual hearing ability. For visually impaired players who are trying audio-based games for the first time, adaptive tutorials and sound learning are essential. Beginners who are not yet familiar with game sound effects can learn in a low-pressure way, and the audio tutorial used will point out the purpose of each sound and the corresponding strategy. What’s more, it is better to incorporate AI to help adjust or modify different aspects of audio if individuals have unique preferences towards some sound effects. Finally, the configuration files used can be saved or recalled, and preferences can be maintained across sessions. Giving players the right to decide what to hear and how to interact can thus better meet individual needs and make operations more comfortable and proactive.

6. Discussion

6.1. What can audio-based design solve

Audio-based design primarily addresses the problems caused by limited information channels for BLV players. By transforming visual information into auditory forms through sonification, spatialization, and voice feedback, it provides alternative ways for them to access important game information. Second, it helps complete the interaction loop: immediate and consistent audio feedback enables blind players to navigate, make decisions, and monitor game states with greater independence. Third, it supports spatial cognition and immersion: spatial audio and audio landmarks allow players to build mental maps and experience a sense of presence in 3D spaces. Fourth, it sustains motivation and flow. Layered audio feedback can support control, reward, and challenge-skill balance, moving design beyond accessibility towards fuller participation and continued

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engagement. In conclusion, audio-based design can support a shift in design perspective from "visual default" towards "audio-first or multimodal approaches," treating sound as a primary rather than supplementary channel.

6.2. What can it not fully solve

First, auditory bandwidth is limited. Overlapping sound sources will cause auditory overload, which design can optimize but cannot completely eliminate. Second, cognitive demands persist. Blind players must still learn sound vocabularies and maintain mental maps. Third, audio immersion differs in form from visual experience, and visual art and animation aesthetics cannot be fully translated into sound. Fourth, platform APIs, screen reader compatibility, haptic hardware, and development costs cannot be resolved at the audio layer alone. Audio-based design is therefore necessary but not sufficient.

7. Conclusion

Traditional games systematically exclude non-visual people from information input, operation, spatial understanding, and even incentive mechanisms. There are currently proven feasible alternative solutions such as audio cues, spatial audio, voice, or haptic feedback, but the methods involved are not yet unified and lack an overall design approach. Combining the three theories of flow, positive reward, and immersion, the paper proposes the overall framework: accessible information architecture, user-centric customization, dynamic feedback loops, immersive spatial design, and optimal challenge-skill balance. The proposed framework treats audio as the primary information source. Accessibility design must simultaneously satisfy the three levels of information, operation, and feeling. The discussion also explains that audio-based processing can basically dissolve structural obstacles in information, interaction, space, motivation, and flow but cannot completely avoid systemic difficulties such as auditory capacity, cognitive load, individual differences, and device support. Audio-based design is necessary but not sufficient. This paper has several limitations: it is mainly a literature review and did not conduct direct experimental observation of visually impaired players and the framework itself has not yet been tested in actual development. Future work should focus on empirical testing of the framework, long-term user use, AI-guided adaptive audio, multi-platform compatibility, and collaborative design for visually impaired people. In conclusion, it is necessary to avoid replicating visual experience and instead focus on promoting fair, controllable, and sustainable immersive experiences. Future designers should therefore prioritize inclusive co-creation, iterative evaluation, and adaptable audio systems that empower blind players across diverse gaming contexts and continuously evolving platforms worldwide.

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