LEVI: Exploring Possibilities for an Adaptive Board Game System

Joseph Tu*
joseph.tu@uwaterloo.ca
Stratford School of Interaction Design and Business,
University of Waterloo
Canada

Derrick M. Wang*
dwmaru@uwaterloo.ca
Stratford School of Interaction Design and Business,
University of Waterloo
Canada

Ekaterina Durmanova*
edurmano@uwaterloo.ca
Stratford School of Interaction Design and Business,
University of Waterloo
Canada

Lennart E. Nacke
lennart.nacke@acm.org
Stratford School of Interaction Design and Business,
University of Waterloo
Canada

ABSTRACT

Visual impairment can create accessibility barriers for players in board games because information about the gameplay is often communicated through visuals. We present *LEVI*, a standalone adaptive board game system (ABGs) using RFID technology to adapt the gameplay experience for board games for players with or without visual impairment. As many hybrid board game systems often require costly resources (digital elements) which may not be accessible to the user, we considered low-cost alternatives to our solution. Given the various gameplay styles in board games, we mainly focus on audio adaptation for this game system. We present an evaluation of our current proof-of-concept game system and future possibilities of using our adaptive board game system.

CCS CONCEPTS

• **Human-centered computing → Empirical studies in accessibility**.

KEYWORDS

game design, player experience, RFID technology, adaptive board game system (ABGs)

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1 INTRODUCTION

Recently, there has been growing interest within the Human Computer Interaction (HCI) community and board games because they can help foster creativity, self-efficacy, and social skills of their players [20]. For example, playing tabletop games can reinforce family bonding [7, 24], enhance reciprocal learning [28], bridge the gap between generational forms of play [1, 30] and reduce social anxiousness [34], all of which are beneficial in HCI research [10]. With the paradigm shift to hybrid tabletop games (also known as hybrid digital board games), research is exploring new ways to enhance the gameplay experience by combining analog and digital elements [19]. For instance, new interaction methods can enhance natural and enjoyable recreational interactions between users [17, 22]; these could include augmented reality (AR) playing pieces [21], or using a custom sensor interface to promote physical interaction on a shared public display [22]. However, despite the technological advances of hybrid board games, there still exist several major accessibility issues for individuals who have a form of visual impairment. This is an accessibility barrier to entry for players engaging in board games.

To address this issue, we propose LEVI, which is a standalone adaptive board game system (ABGs) that uses Radio Frequency Identification (RFID) technology to adapt the gameplay experience for those with or without visual impairment (see Figure 1). We used and followed the "Adaptation Guidelines of Board Games for Players with Visual Impairment" [9] to create this game system. As there are a plethora of tabletop games to adapt for the visually impaired, we chose *The Resistance: Avalon* [1] as our board game for the ABGs based on the survey data we collected (see section 4). We conducted a usability test and evaluated the prototype with regard to future design implications of the ABGs for games planning to use general-purpose input/output (GPIO) sensors. Through testing our game concept and prototype, we provide insights into the possibilities and difficulties of board game adaptation for the user, mainly those who are visually impaired and those who play games with the visually impaired.

2 RELATED WORKS

2.1 Accessibility and Board Games

There has been a growing body of research on accessibility in board games in recent years. As we enter the digital era, tabletop games have taken advantage of powerful modern technologies, including

*Authors are also affiliated with the Department of Systems Design Engineering, University of Waterloo

[1]The Resistance: Avalon: https://boardgamegeek.com/boardgame/128882/resistance-avalon

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Figure 1: Players interacting with our very first prototype of the game system. The game adapted was *The Resistance: Avalon.*

mixed reality and interactive surfaces, to enhance the player experience [3, 8, 16, 18]. For instance, researchers have found that making simple adjustments, such as larger print (e.g. fonts) on game cards and using contrasting colours, can greatly improve the game experience for individuals with visual impairment [18, 26, 29]. Delić and Vujnović Sedlar [11] highlights that even though sighted people could play a non-visual game, they mainly prefer visual feedback. However, it is important to consider players' experiences, whether they are sighted or visually impaired users. Incorporating tactile components, Braille, and audio cues within board game systems empowers visually impaired individuals to partake in the gameplay actively. By providing equal opportunities for contribution, strategy development, and enjoyment, these adaptations promote fairness and inclusive participation among all players [14]. Therefore the consideration of game experience for both visually impaired and sighted individuals should accommodate the needs of both user groups.

2.2 Digital Divide in HCI

Coherently, Woods [33] emphasized that despite the advances in using digital elements for board games, there is little focus on maintaining the analog system, which is the board game space itself. Additionally, many proposed solutions often require costly resources which may not be accessible to users [6, 35]. Socioeconomic status (SES) is a fundamental foundation in research and is usually overlooked in HCI research [6, 27]. Low-SES individuals may have less experience and opportunities with technology because of a lack of exposure and access to it [1, 35]. Additionally, studies have investigated how people from low-SES communities interact with technology and how technology can create new opportunities through digital design elements [31]. We, therefore, considered the cost and equipment requirements before implementing them in our adaptive board game system (ABGs). By embracing these low-cost strategies, our ABGs remain budget-friendly and welcoming to individuals from diverse socioeconomic backgrounds. For instance, having cheap customizable RFID tags can allow players to modify certain rules or actions within predefined limits within an analog board game.

2.3 RFID Technology and Board games

Radio-Frequency Identification (RFID) is a technology that uses radio waves to transmit data between a reader and a tag. The tag contains a microchip and an antenna that transmits data to the reader. For instance, RFID tags can be embedded in-game pieces or cards and used to track the movement of game pieces on the board, allowing for more sophisticated gameplay mechanics and increased player interactivity [15]. RFID technology can also provide players real-time feedback, such as scoring or status updates, during gameplay [5]. For example, Flörkemeier and Mattern [13], demonstrated that RFID technology and mobile phones can combine the benefits of both traditional card games and technology-based games. RFID technology can provide the dynamics and interactive elements of a card game, while mobile phones can provide the ease of score-keeping and computing advice. In addition, the study highlights the effectiveness of designing an RFID system that results in a portable and convenient solution. This type of design requires minimal modifications to the traditional game flow, yet it can work effectively and reliably [13]. However, using RFID technology in board games also comes with some limitations, like the need for additional equipment for players, such as a smartphone or RFID reader [12, 23]. Overall, RFID technology has the potential to enhance the gameplay experience in board games because it can be used to store information.

3 STUDY MOTIVATION

In our work, we focused on three main questions when designing an adaptive board game system (ABGs):

(1) How do we design an adaptive board game system (ABGs) for both demographics (visually impaired and sighted users)?
(2) What type of system should we choose to make it affordable for low-SES communities to interact with the technology?
(3) How do we maintain the simplicity of the adaptive board game system (ABGs) without shifting the gameplay experience to a digital platform?

In this work, we note that previous hybrid board games within the industry do not consider accessibility as their main focus, however, most are interested in automation by using digital elements [32]. We created an open-source library asset for the board game *The Resistance: Avalon* [2] in which the players to use, create, and build on. This means future board game designers can use our ABGs for their desired board game, given there is a library available for the visually impaired. We use Near Field Communication (NFC) tag stickers, a subset of the RFID technology, to embed and store digital data into the tangible elements of the board game because they are inexpensive. We mainly focus on the system's simplicity to do a proof-of-concept, thus, only one RFID sensor is used throughout our system. We do note that it is possible to use a smartphone to replace our system. We argue through our playtest sessions, our participants state they prefer a standalone system that allows them to *"disengage from the digital world"*, and it does not require any downloads or setup because most hybrid board games require a companion application whereas our ABGs is just *plug-and-play*. We heavily emphasize the fact that the system does not require

[2]The Resistance: Avalon: https://boardgamegeek.com/boardgame/128882/resistance-avalon

engagement from all users, as the audio prompts can just be an aid for the visually impaired user. However, we note there is some exclusion play if sighted users do not use the game system. Lastly, we plan to run more studies in the future to determine what sensors can enhance the gameplay experience of visually impaired users without comprising sighted users.

4 GAME DESIGN IMPLEMENTATION

Prior to designing the adaptive board game system (ABGs), we surveyed the visually impaired user to select a board game they would like us to adapt. From our survey response with visually impaired users (n=5), the selected game was *The Resistance: Avalon* because most of the participants stated there is always a need for a player to act as a game master (reading the lore to assign player roles and determining which team passes the missions). The board game could be played without a game master, however, it requires a player to memorize the lore. In some cases, players could use a companion application to play the narrative, however, this assumes the playing group has experience with the board game.

4.1 Design Approach

Braille is a system of raised dots that can be read with the fingers by people who are blind or who have low vision and is used to help assist players with visual impairment. However, it may not be feasible for the board game *The Resistance: Avalon* as character roles and missions must be hidden amongst the players. From our survey response, players noted that a Braille system embedded on the surface of tangible objects may give certain clues or advantages to certain users. For example, when the leader tallies the votes for the success and failure missions, they can employ deductive reasoning to anticipate the votes before the mission. This strategic approach might enable them to deduce the roles of individual characters through a process of elimination. On the contrary, research has shown that the use of sound works as effectively in board games than Braille [4]. With this in mind, we plan to make our ABGs intuitive as possible.

4.2 Adaptive Board Game System in The Resistance: Avalon

In this section, we will not go in-depth on how to play the board game *The Resistance: Avalon* (see Rulebook) [3]. Through various playtesting, we noted down each game state that is feasible for us to enhance the experience of visually impaired users while maintaining the physical integrity of the game. Based on our observation, there exist four main game states in which we can adapt for our game system by using embedded NFC stickers:

- **Setup Phase**: As the board game requires one player to read the lore and assign player roles, our game system can automate this process and assign roles to the designated players (see Figure 2).
- **Team-Building Phase**: A game phase where the leader proposes a team to complete a quest. All the players will need to approve of the team before continuing to the quest phase. If a player disapproves of the team designated by the leader, a new leader is chosen and repeats the process until a team is approved (up to five times). As social deception games like *The Resistance: Avalon* are very chaotic, our system keeps track and provides prompts when the team is approved by registering the user's inputs.
- **Quest Phase**: In this game phase, the team going on the quest can select pass or fail (the quest fails if one or more fail cards have been played). The cards are shuffled to prevent players from deciphering who voted pass or fail. In our system, each player will tap their "Quest Token" (either pass or fail), and the system will register all responses before giving a lore audio prompt of either: success or failure. Usually, the leader would collect the token and then shuffle it to prevent this. However, if the leader has a photographic memory, they can still determine which player has voted for, which defeats the social aspect of the game [33].
- **Game End Phase**: There are two teams in the board game: Loyal Servants of Arthur (good) and Evil Ways of Mordred (evil). The game ends when there are three successful or failed quests. The evil players win when three quests fail or if they cannot successfully go into a quest phase after five team-building phases. Vice-versa, the good team wins when their three successful quests pass. However, the player playing the Assassin Role is revealed in this situation. They can assassinate one player. If the player assassinated is Merlin, the evil team wins. If they fail to assassinate Merlin, then the good team wins. In our system, the Assassin player will place their "character card" first, followed by the player they plan to assassinate (see Figure 2).

4.3 Technical Development

The adaptive board game system runs on a Raspberry Pi 3 (2GB) configuration with an RFID RC522 module reader. Any speaker can be paired with the system (either through input or Bluetooth).

4.3.1 Hardware. The environment is developed in Python (using Thonny IDE). We used the PyGame library to read the embedded data from the NFC sticker. Each NFC sticker tag has a unique identification number, all cards are registered and documented within the system and will trigger based on the actions taken. One of the main challenges with this system is ensuring there are no double-frequency readings. Therefore, each NFC sticker must be tested to ensure data is properly embedded. A craft wood board is laser cut to create an enclosure for the system (see Figure 3). We do acknowledge that visual aesthetics could affect the gameplay experience. Thus, we plan to create unique enclosures for each specific board game.

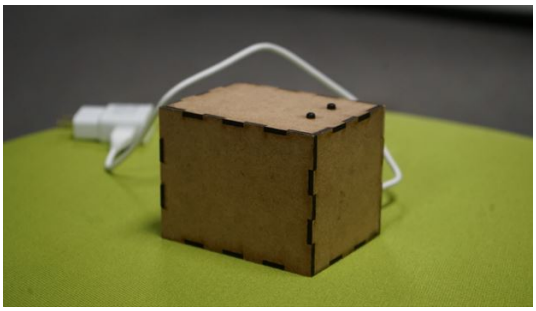
4.3.2 Audio Prompts. As there is no official audio integration from the board game developers, we designed and created an audio library for users. All audio prompts were created from scratch to fit the board game *The Resistance: Avalon*. We sampled and composed the background music for each lore that fits the narrative given by the feedback from our players. As the game lore varies on the number of special characters in the play, we only created one variability for a group of five players. Sound cues are reflected in each game state (moving from one game phase to another). Future iterations

[3]The Resistance: Avalon Rulebook: https://avalon.fun/pdfs/rules.pdf

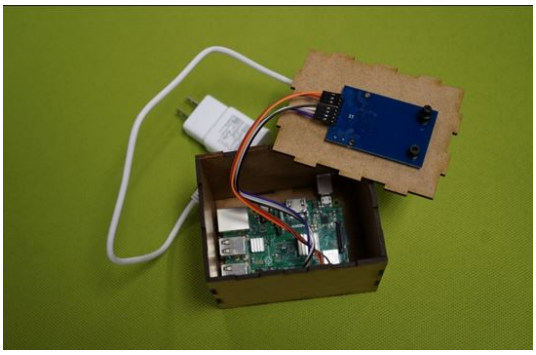
(a) Player using the Leader Token that is embedded with an NFC sticker

(b) The Assassin is revealed and selects one player to eliminate

Figure 2: A demonstration of the gameplay experience using the adaptive board game system (ABGs).



(a) Enclosed game system



(b) Raspberry Pi 3 (2GB) and the RFID module hidden on the top panel

Figure 3: Proof-of-concept adaptive board game system.

will consider voice actors to fit character roles. With the current proof-of-concept, we did our best to "voice act" each character as we seemed fit.

Fundamentally, the structure of the audio prompt follows "*nested if statements*" that reflect the current game state. Audio prompts can only be triggered if the user interacts with the system. The system's purpose is to help the visually impaired, so the game can still function without the need for all players to use the game system.

5 EVALUATION

Design for visual impairment is always a challenge. For the playtest sessions, a semi-structured interview was used to collect qualitative feedback to improve our game system. The purpose of the playtest was to determine how intuitive it would be to use the system and whether the gameplay experience is seamlessly enhanced into the board game. During this stage, the purpose was to evaluate the level of enjoyment for both sighted and visually impaired users using the player experience index (PXI) [2]. For example, based on the player's feedback, players preferred a more *thematic lore*; thus, the background lore was adjusted to fit the atmosphere of the game environment.

5.1 Procedure and Process

We held four playtest sessions, with 5 participants per session (n=20). Each gameplay session was roughly 20 minutes long, along with a 20-minute interview. We took each player's feedback into account in our board game and iterated on each game state until all participants rated no negative outcomes of the game (mainly for those who are visually impaired). As this paper is still in works-in-progress, we focus on the preliminary results derived from our initial summative content analysis, in which will aid in the next iteration of our adaptive board game system (ABGs).

5.2 Preliminary Results

5.2.1 Purpose of NFC Stickers. At the start of our game design, we only created basic NFC audio prompts to replace the leader *(the person in charge of the teams and quest)*. NFC stickers were used in this prototype because they are often inexpensive. In addition, **P5** states: "I'm glad y'all used NFC stickers because I actually use it for automating my smart home system. It's cheap and fits in this idea that you have".

5.2.2 Level of Enjoyment. As the system is intended to be for visually impaired and sighted users, all players report high levels of enjoyment with our adaptive board game system; we take this information with a grain of salt because there may be a strong novelty bias effect that must be considered. However, the players

indicated that using audio prompts helps them progress in the game faster and reduces the need for idling time.

5.2.3 Playing Space. Participants noted that our game system is a great alternative for small playing spaces as most of our participants note the *limited playing space* in their homes. For instance, this system can help retain the joy of tangible game pieces without forcing too much of a digital agenda.

5.2.4 Introverted Playing Style. From our playtest, we note that some participants who are "*shy*" prefer the audio prompts in our ABGs, as they feel less inclined to be vocal during the discussion stage. As **P18** notes: "I'm shy, so I prefer the system to do the narration when I'm the leader during Round 2".

5.3 Discussion and Suggestions

Through our first couple of playtest sessions, players felt a more atmospheric effect when they tapped their *Character card* onto our game system rather than just revealing their roles at the end. We noted that some players are quite disruptive and abuse the game system by aggressively tapping the physical object repeatedly. To prevent the system from going into an infinite loop, multiple "if statements" are implemented in our code. For example, the game must detect at least three failures or passes in the quest for the Assassin role to be in effect, or else nothing will happen. An audio prompt is played to remind the players. As the Raspberry Pi is capable of handling more GPIO sensors, a couple of participants suggest the use of haptics within our game system, which could be used as a replacement for Braille systems [25]. Although the participants were informed that this was a proof-of-concept prototype, as P2 suggested, the importance of the aesthetic of the ABGs: "*It would be cool if you made this system part of the game and not just a simple box. Maybe you can 3D print something to fit the game.*" This is an interesting point as future iterations can consider various enclosures to match the board game aesthetic.

5.3.1 Limitations and Future Works. One limitation of our system is the ability to replay the audio prompt. As we took measures to prevent disruptive gameplay, future iterations may include a button to repeat the last audio prompt played. Although the NFC stickers can be read on most smartphone devices, we did not develop an API system to call audio prompts; therefore, the current data is stored locally on the Raspberry Pi. We plan to continue recruiting more participants and comparing the game experience between visually impaired users and those who are not. Lastly, we plan to explore ways to make this system appealing to introverted playing styles.

6 CONCLUSION

In conclusion, we believe that *LEVI* which is an adaptive board game system could be used to enhance the board game experience for both visually impaired and sighted users. The purpose of using NFC stickers in our adaptive board game system was because we wanted to provide an inexpensive and easy-to-use alternative to traditional hybrid board games, while maintaining the analog elements of the board game. Future iterations may include additional features such as haptic feedback to replace Braille systems and various considerations of making the system aesthetically pleasing to fit the board game. Overall, the proof-of-concept showed that players are highly engaged with this system, however, further research is needed to account for the novelty bias effect.

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