Let's Play Together:

Adaptation Guidelines of Board Games for Players with Visual Impairment

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ABSTRACT

Board games present accessibility barriers for players with visual impairment since they often employ visuals alone to communicate gameplay information. Our research focuses on board game accessibility for those with visual impairment. This paper describes a three-phase study conducted to develop board game accessibility adaptation guidelines. These guidelines were developed through a user-centered design approach that included in-depth interviews and a series of user studies using two adapted board games. Our findings indicate that participants with and without visual impairment were able to play the adapted games, exhibiting a balanced experience whereby participants had complete autonomy and were provided with equal chances of victory. Our paper also contributes to the game and accessibility communities through the development of adaptation guidelines that allow board games to become inclusive irrespective of a player's visual impairment.

CCS CONCEPTS

• **Human-centered computing** → **Accessibility;** Empirical studies in accessibility*; Accessibility design and evaluation methods.*

KEYWORDS

Accessibility; Board games; guidelines; Visual impairment;

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1 INTRODUCTION

Games have been part of our society for thousands of years. One of the first documented games, Senet, is a two-player game of luck and strategy and dates back to before 3100 BC in Ancient Egypt [7]. Games were initially non-digital and comprised of tangible components such as wood, stone, and later plastic, and often required the presence of multiple players in the same physical environment. The advent of digital technologies has led to a massive transformation (paradigm shift) of games whereby beginning in the 1950s, games have shifted to the digital domain, and currently, the majority of new games are being developed for computers, game consoles, and mobile devices [13]. Despite the paradigm shift to the digital domain, traditional board games (which we define as all non-digital games), have managed to survive and continue to have positive impacts on society. Board games are efficient tools to promote integration, interactive socialization of participants, and to improve problem-solving and communication skills [52]. The act of playing board games is also important for the psychological, cognitive and social development of children [47]. The presence of a physical space and the components shared by players has a big influence on the social nature of board games [47]. Zagal et al. noted the social interaction becomes independent of the mechanics of the game, being a byproduct of player composition: "It is hard to imagine playing a board game of any sort without engaging in idle talk with other players" [51]. Surveys conducted with players to identify the most important factors of board games have also indicated the importance of social interaction [47]. There is greater concentration, and verbal communication among the players, which helps create a sense of security, and enhance relationships [18].

Despite the benefits of traditional board games, there is several major accessibility issues associated with them that make them non-inclusive, particularly to those who have some form of visual impairment. According to the World Health Organization (WHO), the number of people with visual impairments is approximately 253 million people globally [48]. Visual impairment is defined as the functional limitation of the visual stimulus that cannot be corrected even with the use of corrective glasses or lenses [44]. There are varying degrees of visual impairment, ranging from blindness (visual acuity of less than 3/60) to low vision (visual acuity of less than 6/18), and conditions related to difficulty in perceiving specific colors or spectrums of colors, such as color blindness [46].

Board games commonly suffer from the same accessibility problems found in digital games, as most of the information in these games is presented through visual elements and thus assume that players are free of any visual impairment [50]. Digital games may provide more flexibility through the use of sound, and haptics (the sense of touch), as an alternative to visuals. In board games, not only may the use of visuals present accessibility barriers, but the interaction with tangible elements and spatial manipulation of these elements can add additional layers of difficulty for players with visual impairment to achieve full playing autonomy.

It is important to highlight the significance of autonomy for players with visual impairment. Although they may be capable of playing some games through the help of others, the ability to conduct an activity with complete independence is highly important. The increase of autonomy greatly promotes their social interaction, improves their quality of life, and personal fulfillment [1]. Playing board games may have positive impacts on players, and many of these impacts can be particularly significant for those with some form of visual impairment. For example, the social interaction between players during gameplay is relevant for those with visual impairments since this group usually presents a higher social isolation and difficulties in interpersonal relationships [32]. In order to promote effective inclusion, it is important that those with visual impairment are able to play with others regardless of whether they have a visual impairment or not.

Given the importance of board games and the non-inclusivity associated with them, our work aims to improve their accessibility by devising a set of adaptation guidelines that has shown potential to make commercial board games accessible and thus playable for those with visual impairment. Our goal is to provide game designers, publishers, and any interested groups the appropriate knowledge necessary to make board games accessible, ensuring the autonomy of players with visual impairment and inclusive play of all players. This work contributes to the wider CHI community, employing user-centric approaches to understand the needs and desires of our target audience, in order to provide solutions that increase the accessibility of a product to the largest number of people without compromising its intended experience. We also discuss the transferability of our findings to other related topics pertinent to HCI.

In order to develop our adaptation guidelines, we researched and analyzed related accessibility guidelines and employed a user-centered design approach through in-depth interviews (see Phase I: Interview Study). We then adapted two commercial board games (see Phase II: Adaptation of Board Games), and evaluated their accessibility through four rounds of playtest sessions (see Phase III: Playtests).

2 LITERATURE REVIEW

Accessibility solutions often consist of the substitution of the absent sense, in this case vision, for another. Although there has been significant research related to accessibility for digital games, there are very few documented efforts associated with accessibility for non-digital games. Among the initial efforts, Glinert and Wyse [17] developed an accessible digital game (called AudiOdissey), which made use of the Nintendo Wii remote control, and provided feedback through auditory cues. The game was developed with the goal of allowing players with and without visual impairment to play together. Using a tangible user interface, Gutschmidt et al. [19] adapted the classic game Sudoku for players with visual impairment through the use of touch and gestures as the main mechanism of interaction. The developed prototype sought to alleviate the difficulties of perceiving the game state through tactile perception by offering different possibilities of customization by the player, (e.g., allowing for specific areas of the interface to vibrate for ease of recognition). Magnusson et al. [31] explored the creation of inclusive games using pervasive environments where the player could navigate through different real-world rooms being guided by sound. Morelli and Folmer [34] developed a real-time assistive tool for visual objects, capable of identifying and converting visual feedback of digital games into vibrations communicated through a game controller, while gestures served as the main interaction controls for the game.

Several researchers also sought to reorganize, restructure, and bring together existing accessibility guidelines for digital games to achieve a more cohesive list. Cheiran and Pimenta [9] evaluated and unified accessibility guidelines for digital games using content analysis, and Araujo et al. [5] organized a set of guidelines focused on the development of audio games.

Efforts to ensure digital game accessibility have also been made by the gaming industry. For example, the International Game Developers Association (IGDA) prepared an accessibility report on digital games, which explored and analyzed the results of various surveys on discovering the current degree of accessibility in the industry, and discussed potential strategies to aid with the inclusion process [24]. The "Includification" guideline also discusses the presence of players with impairments and lists different approaches for a better inclusion of those in digital games [6].

However, academic research related to game accessibility is still insufficient, as most studies do not address board games and their particularities. Woods [47] highlighted that despite the existence of some studies in the area of board games, the majority of those are limited to drawing connections with digital games, and there are scarce contributions focused exclusively on board games. Moreover, most solutions that involve expensive resources or accessories that are highly complex to manufacture are unable to reach a large part of its target population [9].

While some publishers have started making their games more accessible, the majority of these efforts have primarily focused on color blindness. For example, Splendor [4] in its first edition used color as the only element to represent the needed resources for card acquisition, making the game unplayable by players who could not differentiate the colors. The addition of iconography in newer versions of the game made it accessible for this audience. Similarly, Mattel redesigned a version of the card game Uno, adding small ColorADD [36] icons to represent the card's colors [37].

Beyond academic and industry research, most of the board game accessibility efforts have come from the community. Handmade solutions are discussed and shared in forums, primarily via the Boardgamegeek website [42] and the board games sub-Reddit [38]. Users share a plethora of information, including the level of accessibility found in commercial board games, organizing lists with detailed descriptions of barriers found in different games; approaches on how to play with players that have some form of visual impairment with the least amount of changes on rules and game components; players personal experiences in playing with those with visual impairment; and how to adapt components and/or rules to make a game more accessible [12,22,28,45]. Additionally, contributors of the website Meeple Like Us [26] conduct "accessibility teardowns": reviews of board games to identify overall issues that could prevent or hinder gameplay. Moreover, they have published and discussed the toolkit (heuristics) used to carry these evaluations [20].

As the literature related to game accessibility has focused primarily on digital games, there is a lack of resources regarding accessibility solutions for board games. Our work explores this topic with the goal of developing a set of adaptation guidelines that, when applied, will make board games accessible for players with visual impairment.

3 STUDY DESIGN

In order to create our comprehensive set of adaptation guidelines, first we researched and consolidated existing lists of accessibility guidelines from related fields such as digital games [5,6,9,14,24]. These guidelines were organized, and the ones applicable to board games (e.g., proper use of color, contrast, font size) became the foundation for our list.

In *Phase I*, we involved nine participants with visual impairment through in-depth interviews, to provide us with insight regarding the accessibility barriers they face in their daily lives and approaches to solving these barriers. In *Phase II*, two commercial board games were adapted into inclusive prototypes using the guidelines resulting from Phase I. In *Phase III*, four playtest sessions were conducted on the prototypes resulting from Phase II, followed by a group discussion to collect qualitative data, which helped enhance and finalize our list of guidelines (presented in Section 4).

3.1 Phase I: Interview Study

In the first phase of our study, we conducted individual interviews with participants with visual impairment to iterate guidelines based on their feedback and insights.

3.1.1 Participants. A group of nine participants (seven male) with visual impairments were interviewed. Two of the participants were blind, (P1 legally, and P2 totally blind), four participants had low vision (P3-P6) and three were color blind (P7-P9). Participants were aged from 19 to 38 years old, held varied occupations, and all had previous experience with games (digital or board games). Individual in-depth interviews [29] were conducted allowing for freedom of time for the participants to discuss topics,

resulting in an increased level of comfort and shared personal details. All participants signed an informed consent form, which was also read out loud by the interviewer, providing consent for the interviews and recordings.

3.1.2 Procedure. The interviews included a set of guide questions focused on identifying participants' experiences related to games, social interaction, autonomy, and accessibility barriers. At the end of each interview, game components from board games were also presented to the participants so that they could point out specific accessibility issues and suggest improvements for them.

3.1.3 Interview Results. The interview recordings were reviewed in order to collate pertinent information that was discussed by the participants regarding to autonomy, games, and barriers to gameplay.

The participants unanimously commented about the importance of autonomy in their daily lives, as they are unable to conduct some activities due to their impairment, often requiring the assistance of others. They expressed frustration regarding such dependence, commenting that activities that can be performed independently are more enjoyable and prioritized. This is fittingly captured in P7's comment: "*I want to have the freedom to do what I want anytime, and depending only on me. I rather use [an assistive] technology than have someone help me.*"

The participants with a higher degree of visual impairment commented on constantly facing problems regarding social interaction, including the prejudice from strangers, difficulty in perceiving their surroundings, the misconception that people with an impairment are inferior to those without an impairment, amongst others. P3 stated: *"at the same time that I'm extremely independent, I'm also extremely dependent, as people around me, even family, think that I'm unable to do things."*

The participants also expressed interest in the topic of accessible games in general, primarily given that five of the participants (P1, P3-P6) considered themselves gamers prior to becoming visually impaired and were not able to play as often anymore due to the lack of accessible games. P2 commented on their disbelief regarding the possibility of developing a game that could be universally accessible for persons with and without visual impairment, given the large variance of visual impairment that must be accommodated. Having an advanced knowledge of Braille, this participant also indicated a bigger interest in solutions that employ Braille, instead of other tactile approaches.

At the end of the interview session, the original game components of the board game Splendor were presented to the participants in order to verify the levels of accessibility of the game. The game proved to be completely inaccessible by all of the blind participants, as they were not able to obtain any information related to gameplay. Participants with low vision and color blindness indicated difficulties identifying the graphical elements due to the secondary art in the background, small iconography, colors, amongst others.

3.2 Phase II: Adaptation of board games

Motivated by the importance of providing players with visual impairment the opportunity to play popular games, we chose to adapt two commercial board games. The two games were Splendor, and Coup [43]. Splendor is a strategy game with estimated gameplay length of one hour. Coup is a card game that incorporates bluff and social deduction, and has a gameplay length of approximately twenty minutes. Both games were chosen because they are recent, popular, and offer different gameplay complexity. Splendor was nominated for "Game of the Year" by the award Spiel Des Jahres in 2014 and was ranked as the 101th best board game by Boardgamegeek. Coup was nominated for best card game and best party game for the Golden Geek award in 2013, and was ranked as the 30th best party game by Boardgamegeek. Furthermore, both games had different gameplay complexity levels. Splendor is categorized as a medium complexity game, as it involves resource management and planning, the interaction with the game board, and six different resources. In contrast, Coup is considered a low complexity game, with gameplay focused on the social interaction between players, and only employs cards and coins.

3.2.1 Coup's Adapted Prototype. Coup contains 50 coins and a deck of fifteen cards, with three copies each of the five different card types: i) Countess, ii) Captain, iii) Duke, iv) Assassin, and v) Ambassador. To improve their readability, the cards were enlarged and the contrast was increased whereby black strips were used as background for text and icons, and the colors of these elements were changed to a high contrast yellow. The stylized cursive font of card types was also replaced by the sans-serif monospaced font Verdana, now displayed horizontally in the top of the card (see Figure 1).

To include blind players, textures were incorporated on the center of each card to allow for identification through touch. Each card type had a different texture, and due to the available free space on each card, it was possible to shape

Figure 1. The game Coup. Comparison of the adapted card with the original card (left) and all five adapted cards (right).

the textures to provide an extra layer of recognition using shapes that made analogies to each type of card or their abilities.

The textures used on each card were: velvet fabric, EVA (rubber), sandpaper (rough), plastic tape (smooth), and light wood. A tuck box was made to hold the deck of cards. Aside from making it easier to draw cards, the tuck box also prevented the deck from being knocked off of the table, or being accidentally revealed. Considering the relevance of knowing how many coins each player possesses, an extra game rule was added requiring players to verbally communicate their coin total at the end of their turn, so that tracking changes of game state be easier for those with visual impairment.

3.2.2 Splendor Adapted Prototype. Splendor contains four different decks of cards, with 10, 20, 30, and 40 unique cards on each, (a total of 100 unique cards), and 40 rounded chips representing six different types of jewels: i) diamond, ii) sapphire, iii) emerald, iv) ruby, v) onyx, and vi) gold, each with a specific color and illustration.

Cards had their physical sizes and graphical elements enlarged to make them easier to read for players with low vision. The background illustration, an irrelevant element for gameplay, was removed and replaced with a flat black color. This replacement aimed to avoid any potential confusion that may arise by the blending of any other graphical elements present in the background area.

Cards had their top corners rounded in order to guide players on the correct way of reading them, as cards follow a logical structure that must be read from top to bottom. The top region of each card was filled with a white background to divide the card in two main regions: i) the top region contained information regarding the card type, and the amount of points it provides, and ii) the bottom region contained the required resources to acquire it.

Each card requires specific quantities of resources to be acquired, and this requirement is represented through colored circular fields with numbers, showing the required types and quantities of jewels. To improve visualization of these fields, the numbers present on cards employed the color that was complementary to its field's color, in order to achieve the greatest contrast possible.

A tactile numerical system was developed to allow numbers present in the cards to be communicated through touch, ensuring those players with severe degrees of low vision or blindness to understand them. The numerical system intended to be intuitive and easy to learn, being an alternative to Braille for those with visual impairment who are not familiar with the alphabet. This includes: bumped dots, made using white glue, where the number of dots in a region represents a number, ranging from one to seven. The position of the dots followed a pattern thus allowing players to read the number by perceiving its shape, instead of counting the number of dots. Due to the material used (i.e., transparent white glue), there was enough freedom to display these dots without blocking other visual elements.

Strips of distinct textures were used to allow identification through touch of the jewels required to acquire the card. The limited available space on each card prevented the use of textures together with other approaches, such as the use of unique shapes (see Figure 2). The original game components used to represent jewels, rounded colored chips, were replaced with plastic objects (used for bijou) with different shapes, colors, and sizes for each different type of jewel. This allowed players to recognize jewels both through touch, and vision. A game board was created with cardboard and wood sticks to hold the cards placed at the table, allowing players to touch the

Figure 2. Comparison of an original and adapted card (left), closer view of textures and tactile numbers (middle), and comparison of original and alternative resources (right).

cards and interpret the tactile information present on them while avoiding accidental displacement of the cards. To hold the different decks of cards, cardboard boxes were created with different heights to aid differentiating each deck. Other boxes were also produced to hold the jewels, separating them by type, and using a reference texture on the side of the box as guide (see Figure 2). Game rules were also modified to include the need by players to verbally communicate their actions during a turn, making the game state easier to track by players with severe degrees of visual impairment.

3.3 Phase III: Playtests

Two playtest sessions for each prototype were conducted with participants with and without visual impairment, followed by a group discussion session after the gameplay with all of the participants.

3.3.1 Participants. We recruited 17 participants (16 male, eight with visual impairment), aged from 18-38 years, and diverse occupations. The majority of participants with severe visual impairment (5 out of 6) declared to have considerable experience with board and/or video games prior to vision loss, and limited experience after vision loss. One participant was congenitally blind and reported having very limited experience with overall games. Table 1 provides details on our participants in each session.

Table 1. Participants and length of each playtest session.

Session	Game	Participants	Length
1	Coup	P1-P4 (no vision impairment), P5 (legally blind)	1 hour; (20 mins/ match)
2	Coup	P6-P8 (no vision impairment), P9 (totally blind), P10 (low vision)	2 hours; (20 mins/ match)
3	Splendor	P11 (no vision impairment), P12 (legally blind), P13-P14 (low vision)	3 hours
4	Splendor	P15 (no vision impairment), P16-P17 (color blind)	1.5 hours

3.3.2 Procedure. At the start of each session, the overall game rules, genre, mechanics, and the different types of components (i.e., cards, chips, and coins) were presented, with the accessibility elements explained afterwards. All participants with visual impairment individually analyzed the game's components, particularly through touch, in order to learn about the different types of cards, textures, and how to spatially orient themselves around the table. During gameplay, participants with visual impairment were observed by the researchers in order to identify incidents and behaviors that could arise during play. After each gameplay session, participants joined a group session to discuss the overall gaming experience, social interaction between players, autonomy, suggestions for accessibility improvements, and interaction with game elements and components. All sessions were recorded for post-session analysis with the consent of the participants.

3.3.3 Results. The playtest recordings were transcribed in verbatim and analyzed employing an inductive coding method and thematic analysis [8,29], with codes and themes emerging directly from participants' comments made during gameplay and group discussions. The first author was the main responsible for the initial analysis, conducting open coding on a line-by-line basis of the transcriptions to identify patterns on the data and generate initial codes. Identified codes were reduced to those that addressed our research questions, relating to participants overall experience when playing accessible board games, the accessibility of our prototypes, suggested improvements, among others. Our coding process was iterative, with all authors meeting together throughout the process to discuss, refine, and agree on the codebook. The codes were compared to identify meaningful relationships in order to group them into overarching categories, with these being iteratively refined by authors into the themes presented in this section.

Autonomy. All participants commented how they experienced complete autonomy during gameplay sessions, considering they found it easy to perform any actions related to gameplay, social interactions and the identification of game elements. It was observed during gameplay that participants with visual impairment constantly engaged with the cards on the table through touch, during their turn or during the turn of other participants, in order to properly develop their strategies. Participants also reported an increase in the speed and comfort of reading and organizing cards during gameplay. P5 summarized this as follow: "*the textures [on cards] make it extremely easy to differentiate each type of card.*"

Barriers. Although all participants commented on having complete autonomy, two participants (P12, P16) considered some aspects of the prototypes less accessible. P12 considered some textures to be too similar (e.g., the sandpaper and light wood textures), requiring extra care and attention to differentiate them. P16 commented: "*the shape and color of some of the [game] icons make them hard to differentiate. Many times I would get confused on which one was which.*"

Components. 15 participants praised the approaches employed by the prototypes. The jewels used for Splendor were deemed aesthetically pleasing and easy to distinguish due to shape, size, and color contrast. The textures were considered easy to differentiate by seven of the eight participants with visual impairment, particularly when used in different shapes. P10 made the following comment: *"[I] really like that cards don't have only textures to represent the content. I've used a mix of touch and seeing to be able to play the game."* The use of textures with distinct shapes and sizes was considered an important factor to make them easier to perceive and understand. Participants were able to identify the type of cards used in Coup, (that employed cards with varied textures and shapes), faster and more comfortably than they could in Splendor (whereby all textures had the same shape). The creation of a board and boxes to store the game components was praised by all participants as being helpful in organizing the play area.

Social interaction. All participants expressed enjoyment with respect to the social interaction that occurred during gameplay, considering it strong, important, and fun. Participants interacted spontaneously with each other, engaging in conversations related or not to the game. P14 said that "*when players start to tease each other about their plays, you know things are going well, that the [social] interaction is great*". P6 considered the matches to have been completely common, not noticing any difference when playing with someone with or without a visual impairment.

Board games experience. Five of the eight participants with visual impairment had no prior experience with board games, with others having either played before the onset of their visual impairment or played accessible versions of classic abstract games, such as chess and checkers. P12 commented that they had previously played some card games with the help of non-visually impaired family members, although they never played anything similar to the games they played here. All participants expressed a positive experience with the game prototypes, with P9 commenting that *"[I've] never played a similar game before. I wonder if there are other games like this one that are already accessible".* P14 said that *"[I] keep hearing about a board game called 'Zombicide', that all my friends say how fun it is. But I never had the opportunity of playing a game like that until now."* The approaches employed with the prototypes didn't lead to any negative experiences for any group of participants. Due to the abstract nature of the game Splendor, the removal of the background illustration was not perceived as harmful by players without any visual impairment and the textures weren't seen as visually or tactile uncomfortable for the participants. P17 mentioned that they did not notice the textures during the gameplay session, even though they were presented during the rules explanation prior to beginning the gameplay session. P10 stated that their participation in the playtest of an accessible game helped raise awareness regarding what was possible with respect to developing accessible games, and stated that he would start researching the topic on his own.

Assistive Technology. During and after gameplay, participants provided suggestions regarding what they believed would further improve board games' accessibility. Ten participants (seven with visual impairments) discussed how the use of a digital assistive technology would be beneficial to assist with tasks prior to and during gameplay. They unanimously suggested the development of an application able to teach game rules and to highlight the accessibility features of the game and how to use them. P14 discussed the relevance of this, saying: "*despite the game itself being accessible, it is very important that we [persons with visual impairment] be able to learn the rules by ourselves. Otherwise, a group of only blind people won't know how to play the game.*" Six participants (five with impairment) also demonstrated interest in an application that would be capable of identifying the components present in the play area and communicating their corresponding information through sound, as it would decrease the need to constantly touch components to track changes in game state. For example, P12 discussed that ideally "*a 'high-tech' version of this game [Splendor] could automatically say [through audio] the new cards that show up and tell which gems are available*", while P13 suggested that "*it would be interesting if each card had a [computer] chip, and by the press of a button you could hear information about it*".

Balance. 16 of the participants expressed that they felt they had equal winning chances, and that none of the participants had any advantage over others. The only exception was P11, who believed that he had an advantage over the participants with visual impairment, with respect to collecting more cards of one type, commenting that *"To me, it felt like it was hard for them [players with visual impairment] to track so many different decks of cards."* However, the other participants disagreed with this. The gameplay sessions resulted in a variety of winners, and more specifically, winners included participants with total blindness, legal blindness, low vision, color blindness, and without visual impairment.

4 GUIDELINES

In this section we present and discuss a set of board game adaptability guidelines, devised based on the results of the interview and playtest sessions, and when implemented, will allow board games to become accessible to those with visual impairment. Our list of guidelines is divided into five main categories, according to their approach: i) Tactile Feedback, ii) Color and Contrast, iii) Information Design, iv) Game Rules, and v) Assistive Technology. A summary of our guidelines is provided in Table 2 at the end of this section.

4.1 Tactile Feedback

This category focuses on employing the sense of touch to convey information related to gameplay and components.

4.1.1 Use of tactile patterns to delimit, identify or describe pieces.

Simple tactile patterns, such as embossed geometric shapes and textures, can be used to communicate short information about game components. For example, in social deduction games, such as Werewolf [2] or The Resistance [15], the use of different textures on the role cards can communicate a player's team without the need to (visually) read the card. The use of analogies, such as a texture or shape, that resembles the referenced object or game action, can assist with the learning and memorizing of patterns. Emboss and textures can also assist with spatially orienting players to the position of elements, as they can delimit specific points on a board. Borders on a game board can include small mounds, created with simple materials (e.g., white glue), and locations can differ with respect to height, and/or texture.

4.1.2 Use of pieces with different physical characteristics to represent different resources or player ownership.

Board games often use sets of components (e.g., cubes, discs, chips, miniatures), to track in-game resources and/or units for each player. Color is often solely used by these components to differentiate pieces, thus making it difficult for players who are color blind to distinguish them. The use of components with different shapes, whereby a resource resembles the simulated object (e.g., a tree trunk to represent a "wood" resource), helps improve accessibility. We used plastic jewelry in our Splendor prototype to provide a range of options to customize and differentiate game resources.

4.1.3 Use of tactile patterns to differentiate pieces that must preserve their original shape.

Common in abstract strategy games such as Checkers, or Hive [49], is the use of pieces that have identical physical structures for all players, and require to maintain its structure for gameplay purposes. These pieces are often differentiated using color only, making it difficult, if not impossible, for players with visual impairment to distinguish the pieces. The use of tactile patterns to slightly change the form of such pieces by, for example, inserting a texture on a piece, allows players to recognize the pieces without compromising gameplay. For example, the classic game Othello [33], which includes rounded game pieces with different colors on each side, becomes fully accessible with the addition of a texture on one of the sides of a game piece. This allows players to easily distinguish the smooth or textured side of a piece.

4.1.4 Use of storage compartments to organize components on the play area.

A common characteristic of board games is the use of diverse game elements (cards, cardboard tokens, miniatures, etc.), organized around and/or on top of a board, following a particular spatial logic. The use of accessories such as card shoes, tuck boxes, or plastic organizers, such as a plano box, helps with game setup, play, and cleanup. Such divisions provide players with quick access to components without accidentally scattering them around the game area.

4.1.5 Fixed game components to prevent accidental moving.

The constant spatial manipulation of components to specific places on a board is a difficult task for players with visual impairment, and may hinder their ability to touch pieces for identification as this may accidentally change their position and affect gameplay. Modifying components ensuring that they won't be easily moved, using, for example, Velcro, magnets, or pegs, allows for tactile perception without accidentally changing the game state.

4.1.6 Use of Braille for identification and description of components.

With board games, Braille can act either as an option to communicate printed text, or as a tactile pattern to discern different components or spaces on a board. It can be directly added to game components or accessories such as card sleeves: small protection films used by players to secure game components. Tools to include Braille in objects, such as the slate and stylus, and Braille stickers, help make this approach more flexible. For example, consider the popular card game Magic The Gathering [16]. Using a puncher machine to adapt card sleeves by inserting keywords in Braille, allowed a legally blind player to join a tournament and recognize cards during a match [21]. However, Braille presents drawbacks such as its requirement of more physical space to represent textual

information when compared to Roman characters, and thus impractical when transcribing extensive bodies of text to small, limited spaces.

4.2 Color and Contrast

This category addresses the use of color and contrast in an inclusive manner. Color and contrast can hinder a player's ability to properly visualize elements, read, or distinguish entire elements to players with visual impairment. With board games, color is often used for aesthetic purposes and to convey important gameplay information. The change of simple graphical elements can make games more accessible to all players and often involves minimum effort [6].

4.2.1 Don't use color alone to convey meaning.

The use of color alone to communicate information poses problems for players that have difficulties perceiving color. The complementary use of text, icons, geometrical shapes, contrast, texture, patterns, and figures can solve this problem.

4.2.2 Prioritize the use of color blind friendly palettes.

Color can be a useful tool to quickly communicate information provided that this information is also communicated in another manner to ensure it won't exclude players with visual impairment. Selecting color blind-friendly palettes for gameplay related elements allows for color information to be used in a meaningful manner. Knowing that the most common color blindness is related to the perception of red-green [11], avoiding the combination of these colors can also make games more accessible to visually impaired players. DeFrisco [12] suggests six colors that are considerably distinct among themselves when considering the main types of color blindness, being a good starting point for games that do not use many different colors.

4.2.3 Use of highly contrasted colors.

The use of highly contrasted colors makes it easier to identify shapes, read text, and to distinguish different colored components. One of the options to obtain a high contrast is through use of complementary colors, whereby two colors are chosen such that they have the largest possible contrast between them. However, some adjustment and testing may be necessary to ensure that the level of contrast is appropriate to all players, including those without visual impairment, as a high contrast may lead to visualization difficulties for some players. The use of a black background with text in white or yellow, or the use of a white background with black text presents enough contrast for most people with low vision.

4.3 Information Design

This category focuses on modifications to the graphic design of games to improve the communication of overall visual information. Such modifications can improve gameplay for players with moderate visual impairment. Recommendations include layout changes and resizing of elements, in order to highlight gameplay information, and increase readability.

4.3.1 Use of larger size fonts and higher readability.

Prioritizing fonts with high readability and large size can make it easier to read text present in game components. The American Foundation for the Blind (AFB) recommends a print size of 18 points, and avoiding decorative fonts and stylings such as Italic fonts [3]. Mono-spaced sans-serif fonts such as Verdana or Helvetica, provide greater readability for those with low vision [3]. However, increasing the font size may be difficult to achieve due to limited free space on components. Modifying the writing, enlarging physical components, or removing irrelevant graphical elements to prioritize text are some alternatives to alleviate this problem.

4.3.2 Enlarging game components whose size doesn't affect gameplay.

The size of components, such as cards or boards, is usually defined by industry standards based on manufacturing costs. Increasing a component's size generally ensures the component is easier to identify, read, and manipulate by those who are visually impaired thus, improving their gaming experience. However, it's important to note that in some cases, enlarging components may make them harder to handle (e.g., cards that are too big to be held/shuffled).

4.3.3 Re-write text to make it concise and/or use keywords.

Shortening text, thus making it simpler and more concise, decreases the amount of reading required during gameplay. Some card games such as Magic the Gathering use keywords to compress recurring text, avoiding extensive repetition on many cards. However, keywords require extra memorization of rules, increasing the game's learning curve. To alleviate this issue, accessible individual player guides summarizing and explaining terms and keywords should be provided.

4.3.4 Highlight important graphics related to gameplay.

Graphical elements that are present solely for aesthetic purposes must be used in ways that don't conflict with graphical elements directly related to gameplay, prioritizing the communication of the information that is required to play. The use of contrasted demarcations, such as colored outlines, or different levels of image transparency, can quickly convey the hierarchy of information present, and facilitate the identification of elements. Some redesign of components such as cards and boards, to reduce irrelevant graphical elements, may be helpful to provide some players the ability to identify important elements.

4.3.5 Use of iconography complementary to text

The use of iconography allows an element to be quickly identified and its meaning to be understood without the need to read any text. However, it is important that text is still used, as symbols may, at times, be confusing, particularly when players are still learning the rules of the game.

4.4 Game Rules

This category presents modifications of game mechanics, improvements to rules teaching, and promotes behavior change of players. The goal is to improve a player's autonomy and game enjoyment by removing barriers that can hinder their ability to learn a game or engage in gameplay.

4.4.1 Providing accessible rulebooks.

Rules learning can be troublesome for players with visual impairment, as digital versions of rulebooks tend to be incompatible with screen readers [30]. The writing is often targeted to sighted individuals, with information pertaining to game pieces represented only through images, making them hard to identify for those with visual impairment. The re-writing of rulebooks, including descriptions of the images presented, and proper formatting allow screen readers to be used. Moreover, the use of prerecorded inclusive audio/video is another alternative.

4.4.2 Provide audible feedback about actions performed by players and changes on game state.

The recommendation for players to express their actions by talking out loud during a turn is a behavior that can assist players with keeping track of changes occurring between turns. This helps reduce the need to individually check what other actions players have performed, and how these actions have modified the game state (e.g., changes in resource availability, accessible areas).

4.5 Assistive technologies

This category explores the use of digital technologies and accessories to better accommodate players with visual impairment. Some examples include computerization of game components, or apps that are able to identify visual information and communicate it in an alternative manner (e.g., through sound).

4.5.1 Use of an assistive application to identify and read aloud game elements.

The use of digital technologies to recognize real objects, such as QR code, Radio Frequency Identification (RFID), and Near Field Communication (NFC), can be used in board games to allow game components, such as cards, to be identified and described using sound. Moreover, a system capable of identifying changes in game state (e.g., the availability of new cards), and communicating these changes to the players can improve the game experience as it constantly provides feedback to the players without the need for tactile reading. For example, the board game Alchemists [10] employs a smartphone-based digital app as part of its gameplay and makes use of the smartphone's camera whereby through using an image recognition system, the app is able to identify different cards simultaneously and secretly communicate the information to the player.

4.5.2 Computerization of analog components and/or gameplay actions.

The management of some common game components can pose difficulties for those with visual impairment. For example, regular dice can be problematic due to its small size, slight interactions can accidentally modify their value, and checking the result of multiple dice at the same time can be exhaustive. Additionally, gameplay tasks that employ visual cues (e.g., winking, gestures) may be unfeasible. Such game components and tasks can be supported through use of digital systems that enable or facilitate their gameplay. For example, tasks such as dice rolling and score tracking can be adapted to digital apps, allowing for sound-based feedback to communicate the results.

It is pertinent to highlight that the tangibility of game components is a critical aspect that positively contributes to the user experience of board game gameplay [27,40], and thus computerization of game elements must be carefully made. Preferably, such digital systems should be designed to support the original game elements, being used along the original components, or be available as an alternative, rather than a replacement. It is also important that many of

the original affordances be preserved, automatizing only aspects that are problematic to players. For example, players should be allowed to "shake" their phones to carry a dice roll, simulating the original task, while the outcome of rolls can be communicated through audio.

Publishers are starting to explore the use of companion apps to complement or provide an alternative to original tangible components. For example, the official app for the game Dead of Winter [35] provides a voice acted version of the "Crossroads Deck" of cards found in the game.

Table 2. Summary of adaptation guidelines.

Tactile Feedback
Use of tactile patterns to delimit, identify, or describe pieces
Use of pieces with different physical characteristics to represent different resources or player ownership
Use of tactile patterns to differentiate pieces that must preserve their original shape
Use of storage compartments to organize components on the play area
Fix game components to prevent accidental moving
Use of Braille for identification and description of components
Color and Contrast
Don't use color alone to convey meaning
Prioritize the use of color blind friendly palettes
Use of highly contrasted colors
Information Design
Use of larger size fonts and higher readability
Enlarging game components whose size doesn't affect gameplay
Re-write text to make it concise and/or use keywords
Highlight important graphics related to gameplay
Use of iconography complementary to text
Game Rules
Providing accessible rulebooks
Provide audible feedback about actions performed by players and changes on game state
Assistive technologies
Use of an assistive application to identify and read aloud game elements
Computerization of analog components and/or gameplay actions

5 DISCUSSION

In this section we discuss considerations regarding our proposed adaptability guidelines (summarized in Table 2), and challenges for developing inclusive board games.

5.1 Accessible Board Games for Players with Visual Impairment

One of the biggest concerns regarding the process of making board games inclusive is the potential increased gameplay complexity and cost. We accounted for the possibility that even if all game components could be represented without visuals, our explored alternatives may not be viable to achieve the intended gameplay experience for those with visual impairment. However, we observed that our participants (with and without visual impairment) enjoyed their gameplay. Our key driving force was witnessing participants with visual impairment playing with our adapted board game prototypes while presenting similar levels of autonomy, performance, and social interaction as those without a visual impairment. Our data analysis of the playtest sessions further helped us to identify pertinent aspects that contribute to the accessibility of these games, such as participants' praise of the use of tactile textures, the request for autonomy when learning rules, the desire for digital assistive technologies to facilitate their gameplay, among others. Our guideline list and recommendations were crafted taking into consideration this resulting knowledge in order to reflect the needs of those with visual impairment when considering the context of board game gameplay. We also wish to highlight that in order to provide complete inclusion for players with visual impairment, it is imperative to ensure that all players are able to compete without any advantage and with equal game winning opportunity.

5.2 Board Games as Accessibility Advocator

Our accessible board game prototypes also provided valuable insight with respect to the possibility of accessible board games acting as an informative tool, presenting the different approaches and strategies on how to achieve inclusion for users with visual impairment. Participants, both with and without visual impairment, commented that they didn't expect the possibility of accessible board games, given that these games are predominantly visual. However, after participating in our playtest sessions, they all expressed interest in pursuing the topic of board game accessibility, aiming to identify other games that could be adapted.

5.3 Challenges When Designing Accessible Board Games

Although the prototypes were praised and enabled all participants to play without any major issues, the adapted games still presented barriers to some participants. For example, elements that were easily perceived by some, such as textures, imposed accessibility issues for others. The varying degree of visual impairment is one of the major challenges when designing accessible products. Low vision, for example, includes problems such as distortion of vision, spots before the eyes, extreme sensitivity to light or glare, absence of peripheral vision, and night blindness, amongst others [46], all of which require different strategies to overcome. The use of participatory design and including a

larger number of users with visual impairment in the development cycle can potentially minimize such issues.

5.4 Guideline Applicability and Reach

Our list of guidelines represents the first effort focused on enabling the accessibility of board games. In contrast with related work that only provides an evaluation tool [20] or that mainly highlight the accessibility of the field [24], these accessibility guidelines were designed with the intent to aid all interested parties (e.g., designers, publishers, persons with visual impairments), to either adapt or design accessible board games, suggesting approaches that target diverse degrees of visual impairment. The guidelines can be used during the design process, providing considerations to be accounted for when designing for those with visual impairment, or as a checklist to assess a game's current level of accessibility and which aspects need to be improved. We should also highlight that our guideline can be used when developing an accessible game for a smaller audience, such as family or friends, given that the requirements of the individuals in such a situation can easily be considered and addressed.

It is also important to highlight that our findings and guidelines also contribute with insight on the aspect of accessibility of related topics pertinent to the HCI community, such as tangible computing and the accessibility of tangible user interfaces (TUIs). The design of TUIs require considerations regarding the interaction of both digital and physical aspects of a system, and presents a similar context of use and elements also found in board game gameplay, such as the face-to-face interaction between participants, the importance of tangibility, and the tactile manipulation of physical objects [23,25,40,41]. Due to the generalizability of our guideline list and the similarities present in these two fields, our findings regarding the experience of those with visual impairment engaging with accessible board games and our proposed guideline list can be translated to support the development of more accessible TUIs for this audience.

5.5 Digital Assistive Technology for Board Game Gameplay

The discussion regarding digital assistive technologies derived from participants during the playtests revealed that this approach is seen favorably and can potentially be a significant next step to facilitate gameplay of board games. These technologies can reveal new strategies that would be otherwise manually unfeasible or too demanding, such as the automation of gameplay related tasks, auditory feedback regarding game state, and further flexibility of exploring additional user senses. We discuss some of these ideas in our guidelines section, considering specific technologies that could be employed. It is important to highlight that expensive technologies should be avoided, as the majority of those with visual impairment also live in low income settings [48]. Additionally, as discussed in our guideline section, it is important that these digital technologies preserve critical aspects to the experience of board games, such as tangibility. The utilization of NFC tags and head-mounted displays to improve visual accessibility has been investigated for similar applications and demonstrated sufficient success [39,53]. We acknowledge that such technologies could be adapted to cater to the context of board games, further improving the gameplay experience of players with visual impairment.

5.6 Limitations and Future Work

Although we were able to conduct four playtest sessions with 17 participants, we recognize that the quantity of tests performed and the data collected was limited. In order to identify greater details regarding the gameplay experience of players with visual impairment, further playtest sessions must be conducted with a larger number of participants, and other adapted games, in order to identify potential barriers that may arise from specific mechanics or components. The adaptation and playtesting of a game from each genre, mechanics, or category of board games could be valuable to identify: i) specific approaches that can be used for similar groups of games, and ii) player's difficulties and preferences. In addition, we plan to conduct further investigation on the development of a digital assistive technology that enable board game gameplay to those with visual impairment.

6 CONCLUSION

In this paper, we presented our three-phase study designed to devise a set of guidelines for the adaptation of board games in order to make them accessible to those with visual impairment. We showed the positive impact of board games, particularly for those with visual impairment, and we discussed the lack of efforts related to board game accessibility. Through this multi-phase study, we have highlighted a) our participants' experiences when playing adapted accessible board games, b) new insights that resulted from the accessible prototypes we developed and tested, and c) the challenges that arise when designing accessible board games for players with visual impairment. Our work is the first study of its kind to report the importance of board game accessibility and propose a set of guidelines to adapt commercially available board games for

players with visual impairment. We also discussed the use of digital technologies to support the accessibility of board games and the applicability of our findings and guidelines to improve the accessibility of TUIs. Immersive technologies, including virtual/augmented reality, could be used to tailor specific players' needs, or to provide alternatives on how to interact with games' components or receive gameplay information. The use of sound-based descriptions can also be a potential strategy to help improve player's immersion. The integration of technologies that can replace the visual stimuli offers countless possibilities and is a topic that has not been fully explored from the prospective of HCI, board game design, and accessibility.

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