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Exploring Asymmetric Competitive Gaming for Mixed Visual Ability

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Resumo

Os jogos têm adquirido uma influência significativa como artefactos culturais, moldando a sociedade atual. Com o rápido avanço da tecnologia digital e plataformas de jogos acessíveis, tornaram-se fonte de entretenimento, satisfação pessoal e interação social para indivíduos de diversas vivências. Os jogos competitivos desempenham um papel importante no aumento da socialização e conexão entre indivíduos de diferentes faixas etárias [59, 63, 46]. Estes jogos oferecem uma plataforma para crianças, jovens e adultos se unirem, estabelecerem laços e construir comunidades. Ao participarem ativamente em jogos competitivos, os jogadores têm a oportunidade de interagir, colaborar e competir entre si, levando à criação de experiências compartilhadas e ao cultivo de interesses comuns. À medida que os jogadores envelhecem, a sua habilidade atual em jogos tende a diminuir; à medida que a qualidade auditiva e visual diminui, a coordenação diminui e o tempo de reação aumenta, tornando-se necessária a implementação de recursos de acessibilidade para a maioria das pessoas. Além disso, as barreiras criadas por ambientes inacessíveis frequentemente impedem a participação plena e efetiva das pessoas com deficiências na sociedade em igualdade de condições com os outros. Nos últimos anos, a indústria de jogos tem feito esforços significativos para melhorar a acessibilidade. No entanto, ainda há inconsistência na adoção de diretrizes de acessibilidade nos jogos *mainstream* [51]. É importante destacar que a maioria dos jogos ainda é inacessível para indivíduos com deficiências visuais graves, uma vez que não beneficiam de melhorias visuais (ou seja, opções de cores e contraste) e dependem exclusivamente do feedback auditivo. As pessoas com deficiências visuais dependem de jogos desenhados especificamente para deficientes visuais (jogos auditivos) ou compatíveis com tecnologias assistivas. Apesar desses obstáculos, elas participam ativamente na comunidade de jogos. Mais exploração é necessária no desenho e desenvolvimento de jogos para garantir experiências inclusivas e envolventes para todos os jogadores, independentemente das suas habilidades [2, 60]. A conexão social entre jogadores de jogos competitivos multijogador tem sido comprovadamente importante na criação e ampliação das comunidades de jogos [30, 9]. Assim, os jogos competitivos podem oferecer uma forma de combater os preconceitos associados a pessoas com deficiências visuais e integrá-las na comunidade de jogos em geral [37].

Os jogos de computador geralmente exigem habilidades motoras, sensoriais e cognitivas muito específicas, sendo desenhados para jogadores com um conjunto padrão de habilidades, o que resulta em oportunidades limitadas para pessoas com deficiências participarem em jogos. Apesar de diretrizes de acessibilidade de jogos têm sido publicadas e disseminadas em diversas ocasiões,

tendo algumas se tornado padrões na indústria de jogos (como por exemplo, a acessibilidade cromática para daltônicos), ainda há espaço para melhorias. Desenvolver jogos acessíveis para o público geral sem sacrificar a jogabilidade e o envolvimento do jogador é um desafio. Os jogos tendem a ser desenhados para considerar um único conjunto de habilidades de cada vez e, assim, podem ser inacessíveis ou desinteressantes para jogadores com um conjunto diferente de habilidades. Além disso, tentativas posteriores de adaptar jogos para um outro conjunto de habilidades pode ter um impacto negativo na experiência do jogador. Como os jogos *mainstream* dependem fortemente de informações e de feedback visuais, as pessoas com deficiências visuais são frequentemente excluídas dos jogos de grupo, o que as leva a serem excluídas da comunidade principal de jogadores. Embora já tenham sido feitos esforços de pesquisa para o desenvolvimento de jogos que suportem uma ampla gama de habilidades (ou seja, jogos universalmente acessíveis), estes continuam sendo a exceção. Além disso, como mencionado por Archambault et al. [4], a acessibilidade universal não garante necessariamente uma experiência igualmente envolvente para todos os jogadores. Os jogos para grupos com habilidades mistas frequentemente dependem de jogabilidade simétrica, o que acaba impondo limitações no processo de design e nas possibilidades de jogabilidade. A assimetria permite que os jogos considerem jogadores com diferentes interesses e estilos de jogo. Consequentemente, a assimetria pode permitir o desenvolvimento de jogos que sejam acessíveis e envolventes para grupos com habilidades mistas. Esforços de pesquisa foram feitos nessa direção, mas a exploração foi realizada apenas em jogos cooperativos e, portanto, há falta de conhecimento sobre como aplicar a assimetria e quais os seus efeitos em jogos competitivos em contextos de habilidades mistas.

O objetivo deste trabalho foi explorar a criação de jogos competitivos que acomode jogadores com habilidades mistas, utilizando princípios de design assimétricos. Embora o potencial da assimetria tenha sido reconhecido em jogos cooperativos, a sua aplicação em jogos competitivos apresenta desafios e oportunidades únicas. Neste trabalho, explorámos diversas abordagens para fomentar a competição, utilizando diferentes formas de assimetria e decisões de design para equilibrar a experiência e compreender como as mesmas afetam as experiências dos jogadores. Especificamente, focámo-nos na competição entre jogadores normovisuais e jogadores cegos, procurando explorar as suas percepções sobre a justiça e o equilíbrio em diferentes níveis de assimetria, abrangendo várias combinações de desafios e tipos de feedback. Estes níveis são:

- Simetria Total: Condição base equivalente a um jogo de áudio sem elementos visuais. Os jogadores enfrentam o mesmo desafio auditivo, com os mesmos controlos.
- Assimetria Parcial
 - Exclusiva - Os jogadores enfrentam o mesmo desafio com feedback diferente (ou seja, apenas visual ou apenas auditivo).
 - Combinada - Os jogadores enfrentam o mesmo desafio e têm a mesma interface. No entanto, apenas o jogador com visão é capaz de aproveitar tanto os elementos visuais quanto os auditivos, criando assim uma assimetria no feedback realizável devido a

habilidades diferentes.

- Assimetria Total: Os jogadores enfrentam desafios distintos.

Para explorar estes vários níveis de assimetria e obter uma compreensão das percepções dos jogadores sobre a experiência geral, bem como os seus componentes individuais, buscámos abranger todos os aspetos mencionados em uma única e coesa experiência de jogo. Para tal, desenvolvemos um jogo que integrou diversos componentes assimétricos, concebidos do zero para proporcionar uma experiência inclusiva para jogadores com diferentes habilidades visuais. Neste trabalho, explorámos a competição um contra um. O jogo desenvolvido é uma competição entre dois cozinheiros mágicos que estão a “cozinhar” poções e bastões mágicos. O jogo tem um ambiente bidimensional visto de cima, onde os jogadores navegam pela cozinha para recolher ingredientes, utilizar estações de cozinha e, por fim, entregar pedidos antes que o seu oponente o faça.

Ao analisar e avaliar os efeitos da assimetria, pretendemos aprimorar a compreensão de como a mesma influencia a experiência de jogo de indivíduos com diferentes habilidades visuais, contribuindo para o desenvolvimento de jogos competitivos inclusivos. Com esse efeito, realizámos um estudo presencial com 6 participantes normovisuais e 4 participantes cegos, avaliando a eficácia dos diferentes níveis de assimetria em relação à percepção dos jogadores sobre a justiça, a competência e o envolvimento. O objetivo foi explorar como a integração do design assimétrico pode contribuir para a criação de experiências de jogo competitivas envolventes e justas para grupos com habilidades visuais mistas. Além disso, buscámos identificar e analisar as vantagens e desvantagens dos diferentes níveis de assimetria em jogos competitivos com habilidades visuais mistas. Ao explorar diversos aspetos, como mecânicas de jogabilidade, comparações de desempenho e o feedback dos participantes, obtivemos *insights* sobre os desafios e oportunidades inerentes à criação de experiências de jogos competitivos justas e envolventes para jogadores com habilidades visuais mistas. Integrando as qualidades e habilidades únicas de cada jogador, desenhamos um jogo que satisfazia tanto a indivíduos normovisuais como a indivíduos cegos. Os resultados deste trabalho realçam que o jogo foi universalmente divertido e envolvente, independentemente das habilidades visuais dos participantes.

Palavras-chave: Jogos Competitivos, Acessibilidade, Assimetria, Mixed-ability, Deficiência Visual

Abstract

Limited opportunities for people with disabilities to participate in gaming stem from the demanding nature of computer games in terms of motor, sensor, and cognitive skills, despite their potential for immersive and challenging interactions. This results in limited opportunities for people with disabilities to take part in gaming.

Visually impaired people often face challenges to enjoy most games, despite the amount of research on game accessibility, since most games rely heavily on visual information and game mechanics that are at their core made for visual interaction [70, 51, 43]. This leads to a lack of intersection in both opportunities and gaming habits of people with different visual abilities, which gives rise to social exclusion and community segregation [21].

Previous work has explored the approach of using asymmetry in the context of cooperative mixed-ability games [22], however, the application of asymmetry in mixed-ability competitive games, raises concerns surrounding the principles of fairness and balance.

To address these concerns and gain insights into the players' perceptions of fairness and balance, we developed several asymmetric components and integrated them into a single game, conceived from the ground up to provide an inclusive experience for players with different visual abilities. We conducted an in-person study with 6 sighted and 4 blind participants where we evaluated the effectiveness of different levels of asymmetry in regard to the player's perception of fairness, competence, and engagement.

Our findings demonstrate how asymmetric design and ability-based roles can facilitate fair and engaging competitive gaming experiences, bridging the gaps between mixed-ability groups.

Keywords: Competitive Gaming, Accessibility, Asymmetry, Mixed-ability, Visual Impairments

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Chapter 1

Introduction

Games have transformed into influential cultural artifacts that shape modern society. With the rapid advancement of digital technology and accessible gaming platforms, they have become a source of entertainment, personal enjoyment, and social interaction for individuals across diverse backgrounds. According to ESA (Entertainment Software Association)¹, 89% of players agree that video games can bring together different types of people (individuals of different cultures, races, ages, political affiliations, etc.) and can create accessible experiences for people with different abilities and 54% have met people through video games they otherwise would not have met.

Global esports organizations, such as the International e-Sports Federation (IeSF)², advocate for the recognition of esports as professional sports, though consensus on its classification remains an ongoing discussion [61, 35, 66, 65]. Research reveals parallels between esports and traditional sports in terms of consumption motives [38, 6]. Moreover, esports is gaining acceptance within the sports community, evidenced by sport organizations investing in esports teams³⁴⁵. With attributes akin to traditional sports, such as intense competition, participation, sponsorship, and rigorous training [38, 50], esports has evolved into a significant leisure and professional activity, shaping contemporary consumer culture [53, 17, 55]. This recognition underscores the need to explore the impact and potential of games in diverse contexts.

Competitive games play a significant role in fostering socialization and connection among individuals across different age groups [59, 63, 46]. These games provide a platform for children, young people, and adults to come together, bond, and build communities. By actively engaging in competitive gaming, players have the opportunity to interact, collaborate, and compete with

¹Essential Facts About the Video Game Industry URL: <https://www.theesa.com/wp-content/uploads/2021/08/2021-Essential-Facts-About-the-Video-Game-Industry-1.pdf> (visited on 01/03/22)

²International e-Sports Federation URL: <https://iesf.org/esports> (visited on 05/07/23)

³Brian Baker (June 05, 2023). Investing in esports in 2023. Bankrate URL: <https://www.bankrate.com/investing/investing-in-esports/> (visited on 05/07/23)

⁴Matt Gardner (Jan 28, 2022). Brands Investing In Top Esports Teams Have ‘Doubled Returns Since 2019’. Forbes URL: <https://www.forbes.com/sites/mattgardner1/2022/01/28/brands-investing-in-top-esports-teams-have-doubled-roi-since-2019/> (visited on 05/07/23)

⁵Alec Nathan (February 9, 2017). NBA Announces 2K eLeague. Bleacher Report URL: <https://bleacherreport.com/articles/2692098-nba-announces-2k-eleague> (visited on 05/07/23)

one another, leading to the creation of shared experiences and the cultivation of common interests. Nevertheless, engaging in competitive scenarios carries the risk of losing, which can diminish overall enjoyment [62, 56].

1.1 Motivation

It's estimated that 15% of the world's population experiences some form of disability⁶. Age is strongly correlated to the likelihood of disability [70]. As gamers age their current level of gaming ability decreases; as the hearing and vision quality decline, the coordination decreases and the reaction time increases, accessibility features will in time become a necessity for most people. Additionally, the barriers created by inaccessible environments often prevent the full and effective participation of people with disabilities in society on equal terms with others. People with disabilities have limited opportunities to take part in gaming mainly because computer games are often very demanding in terms of motor, sensor, and cognitive skills. People with sensory impairment are unable to receive certain gameplay feedback, such as the decreased ability to differentiate visual feedback due to colorblindness or the partial or total inability to hear audio cues or dialogue between game characters.

The gaming industry has made significant efforts to improve accessibility in recent years⁷⁸⁹¹⁰. However, there is still inconsistency in the adoption of accessibility guidelines in mainstream gaming [51]. Importantly, the majority of games remain inaccessible to individuals with severe visual impairments, as they do not benefit from visual enhancements (i.e., color and contrast options) and rely on audio feedback.

Research has explored adapting visually-oriented games to audio-based gameplay, but significant redesign is often required [5, 41, 45, 58, 64, 69]. While some games have successfully undergone such adaptations¹¹, inclusive multiplayer experiences and core gameplay preservation remain challenges.

People with visual impairments rely on games designed specifically for blind people (audio games) or compatible with assistive technologies. Despite these obstacles, they actively engage with the

⁶World Bank - Disability Inclusion URL: <https://www.worldbank.org/en/topic/disability> (visited on 01/03/22)

⁷Mikel Reparaz (May 21, 2020). Ubisoft. Learning to Design Games for Blind Players URL: <https://news.ubisoft.com/en-us/article/4hE1D1MBWWssYuY7LaMmaS/learning-to-design-games-for-blind-players> (visited on 05/07/23)

⁸Hideaki Nishino (January 4, 2023). PlayStation Blog. Introducing Project Leonardo for PlayStation 5, a highly customizable accessibility controller kit URL: <https://blog.playstation.com/2023/01/04/introducing-project-leonardo-for-playstation-5-a-highly-customizable-accessibility-controller-kit/> (visited on 05/07/23)

⁹Xbox. How to use Copilot URL: <https://support.xbox.com/en-US/help/account-profile/accessibility/copilot> (visited on 05/07/23)

¹⁰Devin Coldewey (May 6, 2019). TechCrunch. An Xbox controller with a built-in Braille display is Microsoft's latest gaming accessibility play URL: <https://techcrunch.com/2019/05/06/an-xbox-controller-with-a-built-in-braille-display-is-microsofts-latest-gaming-accessibility-play/?guccounter=1> (visited on 05/07/23)

¹¹Blackbox URL: <https://www.blackboxpuzzles.com/> (visited on 05/07/23)

gaming community. Further advancements are needed to ensure inclusive and engaging experiences for all players, regardless of their abilities [2, 60].

Social connectedness between players of competitive multiplayer games has been proven to be important in the creation and broadening of gaming communities [30, 9]. Thus, competitive gaming could provide a way to fight the biases related to visually impaired people and integrate them in the general gaming community [37].

1.2 Goals

The primary goal of this study is to investigate the creation of a competitive game that accommodates players with mixed abilities. While the potential of asymmetry has been recognized in cooperative games [22], its application in competitive gaming introduces unique challenges and opportunities. In this work, we explored various ways to develop competition with different types of asymmetry and design decisions to balance the experience and understand how it affected the player experience of blind players and sighted players. Asymmetry is yet to be explored in a competitive mixed visual-ability context. In this work, we aim to explore diverse approaches to foster competition by employing different forms of asymmetry that promote a balanced and engaging gameplay experience. Moreover, we seek to comprehend the impact of these asymmetrical elements on player experience. By analyzing and evaluating the effects of asymmetry, we aim to enhance the understanding of how it influences the gameplay experience of individuals with varying visual abilities, ultimately contributing to the development of inclusive competitive games.

Research Questions

- Can asymmetric games provide an engaging competitive experience for mixed visual ability pairs?
- How do players perceive fairness in asymmetric mixed-ability competitive gaming? How do different asymmetries affect these perceptions?

1.3 Structure

This document is organized as follows:

- **Chapter 1 Introduction** – Here we present the context, motivation, problem definition, and goals.
- **Chapter 2 Related Work** - We provide an overview of the current state of game accessibility and its impact on people with disabilities, with a focus on visually impaired individuals. We also investigate asymmetry in games and review research that studied asymmetric roles in both cooperative and competitive games. Lastly, we highlighted some research efforts on mixed-ability play.

- **Chapter 3 Designing An Asymmetric Competitive Game For Mixed Visual Abilities** – In this chapter, we provide an overview of the game and its design and development process and discuss the decisions that were made during the implementation of the game's systems.
- **Chapter 4 User Study** – A study with 6 sighted and 4 blind participants was conducted, where they competed against a simulated player of opposing visual abilities. This chapter presents the perceptions and data collected from the participants in our study, with a focus on the potential of the approach for the given context.
- **Chapter 5 Conclusion** – We provide some final reflections on the findings and discuss potential opportunities for future research.

Chapter 2

Related Work

Although game accessibility guidelines¹ have been published and disseminated [70, 43, 25], the fact remains that people with severe impairments are more often than not unable to play main-stream games as they are often designed for a stereotypical user, which excluded these individuals from the gaming community [21]. The challenge comes from developing games that are capable of supporting a variety of different player abilities without sacrificing gameplay and player engagement, “*accessible games must still be games*” [4].

In the next subsections, we present some of the research efforts that have been done in regard to gaming accessibility, gaming for people with disabilities (with a focus on visual impairments), asymmetry in games, and mixed-ability play.

2.1 Accessibility

Computer games are generally very demanding in terms of motor, sensor, and cognitive skills needed for interaction control, due to inflexible input devices and complex interaction techniques. This often renders games inaccessible to a sizable percentage of people with disabilities [28, 5, 70, 25, 7]. For this reason, options and design decisions that can help remove those barriers should be employed.

The International Game Developer Association (IGDA), with its Game Accessibility Special Interest Group, gives the following definition of game accessibility²: “*Game Accessibility can be defined as the ability to play a game even when functioning under limiting conditions. Limiting conditions can be functional limitations, or disabilities — such as blindness, deafness, or mobility limitations.*”. Yuan et al. [70] defines a generalized three-step Game Interaction Model that can be used to identify what kind of barrier a player with a given impairment faces when playing games: 1) Receive stimuli, 2) Determine response, 3) Provide input.

Visual impairments affect the first step of the model, as players are unable to perceive visual

¹Game Accessibility Guidelines URL: <https://gameaccessibilityguidelines.com/> (visited on 05/07/23)

²International Game Developers Association, Accessibility in Games: Motivations and Approaches URL: https://igda-gasig.org/wp-content/uploads/2011/10/igda_accessibility_whitepaper.pdf (visited on 01/03/22)

stimuli, commonly a primary stimulus, and therefore cannot perform steps 2 or 3 unless non-visual stimuli are provided. Since visuals are typically used as a primary stimulus, accessibility guidelines such as colorblind settings (either from presets or by letting players set their own color palette for the game elements); high-contrast color schemes, and zoom options for any interface elements are recommended. For blind people, visuals need to be replaced with audio feedback through the use of screen readers/self-voicing for text and menu narration, audio cues (e.g., footsteps), audio descriptions (that can provide context to the player) and/or sonification (unique sounds for different objects or actions; sonar-like mechanism) [16, 22] or haptic feedback [11, 3, 23]. However, this often leads to loss of information and players have less information with which to formulate their in-game response. We highlight NavStick [47], an audio-based navigation tool designed to make 3D games more blind-accessible. This tool gives players the ability to tilt a game controller's thumbstick to hear in the game environment what is in their line of sight. In this study, players felt a greater sense of agency and were able to draw a more precise mental map of their surroundings with NavStick. In addition, players would prefer to have NavStick and menu-based surveying (i.e., guided navigation) co-exist.

Hearing impairments affect the first step, as players may be unable to perceive audio stimuli. For games that do not rely on audio feedback, hearing-impaired individuals may still be able to play but suffer from reduced gaming experience. In the case of rhythm games, hearing-impaired players may be unable to perform steps 2 and 3. For the deaf or hard of hearing closed captions provide an on-screen transcription of voices and relevant audio cues [70, 7].

Cognitive impairments affect predominantly the second step, these impairments include greater difficulty learning, understanding the game and/or the feedback provided to them, memory loss, and dyslexia. Games should reduce or remove time constraints by giving players the ability to adjust the game's speed, reduce the amount and complexity of information needed to play the game, as well as reduce the number of possible inputs and display the available input options [70].

Motor impairments affect the third step, as players are restricted in their ability to provide input physically, both in terms of precision and timing. The ability to do full keybind remapping, a toggle option so that the action of holding the button down becomes a single press, the ability to adjust the game's speed (Ratchet & Clank: Rift Apart³, provides a slow-motion mode that can be turned on and off in real-time) and the ability to turn off or simplify quick time events and button mashing sequences. In addition, games should remove any forced motion controls and instead provide alternative controls (e.g., Zelda: Skyward Sword⁴ has a button-only control option). Although the standard game controller is meant to be used by everyone, that comes at the cost of being designed with certain biases (e.g. holding the controller, two hands, etc.). Microsoft developed the Xbox Adaptive Controller⁵, a highly customizable controller designed to fit the

³Ratchet & Clank: Rift Apart URL: <https://insomniac.games/game/ratchet-clank-rift-apart/> (visited on 01/03/22)

⁴The Legend of Zelda: Skyward Sword HD URL: <https://www.zelda.com/skyward-sword-hd/> (visited on 01/03/22)

⁵Xbox Adaptive Controller URL: <https://www.xbox.com/accessories/controllers/xbox-adaptive-controller> (visited on 01/03/22)

needs of their user and make games more easily accessible to people with disabilities. Hardware-based solutions require the user to purchase secondary controllers in order to obtain accessibility features and also require users to accept they need extra help. This is not the case for software / in-game settings where the player feels more comfortable accepting them, since they are offered to them.

In addition, the difficulty of a game can also prove to be an accessibility barrier [52]. Therefore, games should allow the player to adjust various difficulty settings or, at the very least offer difficulty presets. Instead of locking the difficulty of the game, *Darkest Dungeon*⁶ took the approach of informing the players, that by changing some of the difficulty settings, players wouldn't be playing the "intended experience" with which the game was designed. We highlight *Hades*⁷, a roguelike game that has no difficulty settings but offers a unique approach to God Mode. In this game, God Mode is an optional aid that can be toggled even in the middle of an encounter and provides the player with a damage resistance percentage that increases with the number of player deaths, opening the experience of roguelike games to a broader audience.

With the goal of disseminating and raising game developers' awareness of game accessibility and accessibility guidelines, *Game Over* [25] was developed as the world's first universally inaccessible game. In this game, the player faces unwinnable situations that will break each of the proposed guidelines.

Although accessibility features are becoming increasingly more prevalent in games, there are still cases where these features remain hidden behind random side quests or interactions with an arbitrary NPC. For example, the setting to balance audio levels in *Pokemon SwSh*⁸ is not available from the start of the game and requires the player to interact with a specific NPC to make that option available. Furthermore, the fact still remains that most games rely heavily on visual information and visual embellishments [34, 33], as well as precise and timely inputs [70]. Although games can be adapted, the game's core gameplay is susceptible to significant changes since some genres and game mechanics are at its core made for visual interaction. Therefore, visually impaired people often struggle to enjoy most games, despite the great amount of research on game accessibility [70, 51, 43].

2.1.1 Audio Games

Game interfaces are, in general, partially, or totally inaccessible to visually impaired people since most of the information is conveyed through visuals [34, 70]. Auditory interfaces provide an alternative way of conveying information as they allow the representation of game elements and gameplay through sound and are, therefore, accessible to visually impaired users [3].

Audio games are games with audio-based gameplay. They provide information to the player through the use of TTS (Text-To-Speech) and unique sounds for each game element, which allows players to differentiate between various sound patterns. This allows a blind player to understand

⁶Darkest Dungeon URL: <https://www.darkestdungeon.com/> (visited on 01/03/22)

⁷Hades URL: <https://www.supergiantgames.com/games/hades/> (visited on 01/03/22)

⁸Pokemon Sword & Shield URL: <https://swordshield.pokemon.com> (visited on 01/03/22)

the game context and play a game [3, 70]. Additionally, audio games can also include haptic feedback which provides an extra level of interaction to the user [11, 3].

Friberg and Gärdenfors [16], from a development point of view, categorized sounds as: avatar sounds (produced by the actions of the player), object sounds (indicating the presence of objects), character sounds (generated by NPCs), ornamental sounds (non-essential sounds that enrich the experience) and instructions (speech recordings). This categorization is an extension of Michel Chion's three listening types (casual listening, semantic listening, and reduced listening) framework [10]. The games developed within the context of this work aimed to explore how games could be designed primarily around an auditory experience. For example, the game *Tim's Journey* [16], is an open-ended exploration audio game in which the player moves through a complex surround sound environment and solves puzzles, aiming to incorporate all three listening types. To help the player navigate, they are given access to several aids: the ability to temporarily reduce the volume of all sound that they cannot directly interact with; hear footsteps and, consequently, identify the surface where they are currently walking; get help from various NPCs that the player encounters; the existence of foghorns in every quarter point of the compass that can be heard at any distance.

Archambault et al. [4] subdivides audio games in: rhythm games, artistic musical experimentations, and audio only games. At [AudioGames.net](http://www.audiogames.net/)⁹, a repository of sound-based games, a great variety of audio games genres and themes can be found, such as *Manamon*¹⁰ (a Pokémon-like adventure game), *Survive the Wild*¹¹ (a crafting survival game), *Crazy Party*¹² (which has an arcade-style mini-games mode and an online card battler mode) and *Eurofly*¹³ (a realistic flight sim), among many others, of which some are competitive audio-only games.

Another example is the RAD (racing auditory display) [58], which is a user interface that makes racing games accessible to blind players. The technique was compared with a popular audio racing game, and preferred by participants. Furthermore, it provided a blind gamer with the ability to race on complex tracks on par with sighted players. This interface gives a blind player information for them to be able to prepare for an upcoming curve in the track and gauge the speed of the car and even cut corners, which leads to the ability to compete without significantly different lap times or driving paths against sighted players. Since then technique has been announced by the authors to be leveraged in the upcoming commercial game *Forza Motorsport*, giving for the first time blind players the tools to compete with sighted peers in a mainstream commercial racing game. It is important to note that collisions between cars were not tested in this study.

Rhythm games have been found to be challenging and fun for both sighted and visually impaired players [20, 40, 69]. We highlight *Blind Drive*¹⁴, a dark comedic driving rhythm-like game

⁹AudioGames URL: <https://www.audiogames.net/> (visited on 01/03/22)

¹⁰Manamon URL: <https://www.vgstorm.com/manamon.php> (visited on 01/03/22)

¹¹Survive the Wild URL: <http://www.samtupy.com/games/stw/> (visited on 01/03/22)

¹²Crazy Party URL: <http://pragmapragma.free.fr/crazy-party/en/index.php> (visited on 01/03/22)

¹³Eurofly URL: <http://eurofly.stefankiss.sk> (visited on 01/03/22)

¹⁴Blind Drive URL: <https://blinddrivegame.com/> (visited on 01/03/22)

with hyper-immersive first-person audio-based game that is engaging to both sighted and blind players, that constantly plays with the audio cues given to the player.

Audio games struggle to reach popularity among the mainstream gaming community because they are difficult for sighted people to play due to the lack of visual information [21, 4]. Only catering to a particular set of abilities hinders the inclusion of players in communities regardless of ability.

2.1.2 Universally Accessible Games

Efforts on making accessible games often involve adapting existing games that in their design did not consider players with disabilities, like AudioQuake [5] (Quake) and Blind Hero [69] (Guitar Hero). However, *a posteriori* attempts to adapt games whose core gameplay is based on visual engagement may have a negative impact on the player's experience [70, 21].

Universally accessible games [28] are games designed for everyone, regardless of individual differences. The aim of this concept is to design games able to adapt to individual characteristics of each player, allowing gamers with a diverse range of abilities to play together, without the need for individual adaptations or modifications, and prevent the inability to play due to design flaws. For these reasons, the Universal Design¹⁵ approach in games allows for the fostering of social inclusion and equality in gaming and may eventually lead to the reconsideration of the currently stereotyped target group of “average gamers” of the worldwide game industry — in universal design multiple types of impairments are supported, but not necessarily all. An adapted Unified Design method approach was proposed by Grammenos et al. to be used in the development of universally accessible games [28, 27]. We highlight Access Invaders [26] a universally accessible remake of the classic game Space Invaders, and board games UA-Chess [24] and Universal Tic-Tac-Toe [48]. These games support players with a diverse range of impairments through the use of techniques such as switch-based scanning, speech input and output, audio cues, and zoom or resizable game objects.

A solution, proposed by Grammenos et al., for multiplayer games where people have a diverse set of abilities is Parallel Game Universes [26]. This approach allows each player to play an instance of the game that has been adapted to their requirements and needs. This concept can, however, have negative effects if it is simply used as a means to reduce the difficulty of the game since it can depict the players with disabilities as less capable, and often create simplified experiences that are not equally engaging for all players. When designing a game for people with diverse abilities it is necessary to consider their unique perspective, so that the game is both accessible and fun for everyone [21].

¹⁵What is Universal Design? URL: <https://universaldesign.ie/what-is-universal-design/> (visited on 01/03/22)

2.2 Asymmetric Play

Asymmetric play is gameplay where different players have access to different sets of mechanics; in contrast to symmetric gameplay, where all players adhere to the same set of rules to achieve their objectives. Asymmetric games allow for a wide range of players with different game preferences, playstyles, skill, abilities, and time investment to play together.

2.2.1 Asymmetry in Games

Harris and Hancock [32, 31] explored different levels of interdependence and types of asymmetry in a cooperative two-player game, “Beam me ‘Round Scotty”. They found players felt more immersed and more socially engaged with their play partner during asymmetric gameplay than in symmetric play. They also found that a high degree of interdependence (i.e., tight coupling) results in a greater sense of connectedness and engagement. However, the role a player takes on can have a significant impact on these feelings; and the combined skill of the players had a slight correlation with their preferences, with highly skilled pairs preferring tight coupling and low-skilled pairs preferring loose coupling. Concluding, information and perspective asymmetries can be used to promote communication and coordination between the players, although too much interdependence can lead to a frustrating back-and-forth where players are forced to wait for each other. As such, it is necessary to consider both emergent cooperation vs. designed interdependence and its flexibility, as well as analyze the effects of different rhythms of interdependence during gameplay.

Furthermore, asymmetry can bring VR and non-VR players together into a shared experience, in both cooperative and competitive games [39]. VR Giants¹⁶ is a cooperative 2-player game in which the VR plays the role of a giant who protects and helps the non-VR player, playing as a dwarf; the dwarf can use the giant’s body as platforms to cross abysses and reach higher platforms. Late For Work¹⁷ is a competitive game in which the VR player takes control of a giant gorilla and faces off against up to 4 non-VR players in a variety of minigames.

In many asymmetric competitive games, teams are often imbalanced due to the fact that one of the teams is given strong abilities that require the more numerous team to stay together and communicate if they want a chance at winning; in Dead by Daylight¹⁸ and Evolve¹⁹, 4 players must work together versus 1 player whose powers far exceed any single one of them individually. Another often-used option in asymmetric competitive games is the use of round-based gameplay, where players swap roles after each round is concluded. In SpyParty²⁰ players take turns playing the spy role and the sniper role. When ranking the player’s skill, asymmetric games often take the approach of measuring the player’s performance for each role separately and may also allow players to queue for a specific role. Not all games have a fixed team or players use the same

¹⁶VR Giants URL: <https://vrgiantsgame.com/> (visited on 01/03/22)

¹⁷Late For Work URL: <https://lateforworkgame.com/> (visited on 01/03/22)

¹⁸Dead by Daylight URL: <https://deadbydaylight.com/> (visited on 01/03/22)

¹⁹Evolve URL: <https://2k.com/en-US/game/evolve/> (visited on 01/03/22)

²⁰SpyParty URL: <http://www.spyparty.com/> (visited on 01/03/22)

mechanics throughout the whole game session. In *Crawl*²¹, 1 hero attempts to escape by reaching level 10 and beating the dungeon's boss while 3 ghosts try to kill the Hero; to achieve this Ghosts possess monsters and traps. However, when the hero dies, they become a ghost and the ghost that delivered the killing blow regains their humanity and becomes a hero.

Dependent relationship between asymmetric players was explored in *Torchless* [12], a competitive two-player shared screen game, where one player's goal is to escape the dungeon while the opposing player tries to stop them. In this game, a player's actions may give the opposing player an opportunity to use a more powerful set of skills that can tip the balance of the game against them.

Asymmetry has been used for mixed-ability gaming with individuals with disabilities. *Last Tank Rolling* [19] is a cooperative two-player motion-based game, in which one wheelchair-user is able to control a tank through the use of the Kinect and play together with one able-bodied player who plays as a foot soldier, avoiding the obstacles and fighting enemies to reach their goal. The tank is the metaphoric in-game representation of the wheelchairs; a strong but slow ally for the able-bodied player and capable of providing cover, but also requiring help for repairs. This game seeks to empower people with disabilities and connect people of all abilities, fostering inclusion. Similarly, Gonçalves et al. [21] explored the use of asymmetric roles in two cooperative mixed-visual-ability games. Each game has a role designed for auditory challenges and another role designed for visual challenges; a pilot role, which has direct control over the character, and an engineer role, which has world awareness. In "Rescue: Under Pressure", the sighted player plays as the pilot while the blind player plays as the engineer; in "Rescue: Mayday", the roles are reversed. Due to the information asymmetry present in both games, players must communicate effectively to be successful. In a study with mixed-visual-ability pairs, most participants described the game as an engaging and fun inclusive experience for both sighted and blind. This work found that the asymmetrical gameplay provided people with different abilities with an equitable play space.

Asymmetry in games can manifest in several forms [32], such as asymmetry of ability (players have unique traits, unavailable to other players), challenge (differences in challenges/obstacles the player faces), interface (how players engage with the game, i.e., input and output), information (differences in player's knowledge), investment (differences in time investment), goal/responsibility (players seek different outcomes). Additionally, asymmetry can also be described in relation to the level and direction of the interdependence between players, as well as the synchronicity and timing of the players' actions at a mechanical level.

Grammenos et al. [28] proposed a solution for multiplayer games where people with diverse abilities can play together (cooperating or competing), *Parallel Game Universes*. In this approach, the player plays an instance (their own "universe") of the game in which the interface and the content has been adapted to best fit their needs and requirements and while still being able to interact and communicate with the other players.

²¹Crawl URL: <https://www.powerhoof.com/crawl/> (visited on 01/03/22)

2.3 Mixed-Ability

Games are often designed with a particular user in mind and are, therefore, framed for a set of abilities. This can lead to a lack of intersection in both opportunities and gaming habits of people with different abilities, which gives rise to social exclusion and community segregation [21]. We highlight some research efforts on mixed-ability gaming.

Several games have made use of the Kinect camera in mixed motor abilities cooperative [19, 13] and competitive games [23]. In Kinaptic [23], a sighted player who has access to visual feedback through a television and can interact via a Kinect camera and a blind player that experiences their surroundings through the use of a haptic device, wind simulation, and 3D sound play a tag-like game. The study focused on multimodality and fairness in relation to the information available to players with asymmetric input and output modalities. Therefore, factors such as the enjoyment and engagement of the players were not explored nor evaluated.

Games can also be used as a tool that helps incentivize social interactions between players. powerBall [8] is a tabletop projector-based augmented reality game designed by Brederode et al. with the goal of bringing children aged 8-14, with and without learning or motor disabilities, together and encourage social interactions between them. The visuals are projected on a table surface and players can interact with physical game pieces (that act as trampolines, accelerators, and reflectors) capable of altering the trajectory of a virtual ball. The competitive and cooperative dynamics promoted dialogue between children, which was considered a significant component of the fun.

Imbriani et al. [37] highlighted the lack of competitive games for mixed ability context and sought to create a simple party competitive game for mixed visual ability groups. In WaTa Fight, a two-player game, is a competitive fighting game designed for both sighted and blind people. In this two-player game, each player has 3 honor points (lives), and they can press two large buttons on a smartphone screen, Wa, Ta or WaTa (both simultaneously), in order to perform an attack or parry the opponent's attack. It was noted that blind players would want to play the game again, particularly against sighted opponents.

2.4 Summary

Computer games are often very demanding in terms of motor, sensor, and cognitive skills and are designed for players with a standard set of abilities in mind, which results in limited opportunities for people with disabilities to take part in gaming. Game accessibility guidelines have been published and disseminated and, although some have become standards in the gaming industry (e.g., colorblind-friendly options), there is still room for improvement.

Developing accessible mainstream games without sacrificing gameplay and player engagement is challenging. Games tend to cater to a single set of abilities at a time and are either inaccessible or uninteresting to players with a different set of abilities. In addition, *a posteriori* attempts to adapt games may induce a negative impact on the player's experience. As games heavily rely on

visual information and feedback, people with visual impairments are often excluded from group play which leads to their exclusion from the core gaming community. Even though there have been research efforts in the development of games that support a diverse range of abilities (i.e., universally accessible) they remain an exception. Additionally, as mentioned by Archambault et al. [4], universal accessibility does not necessarily equate to an equally engaging experience for all players.

Mixed-ability group play often relies on symmetric gameplay, which in turn ends up imposing limitations on the design process and gameplay possibilities. Asymmetry allows for games to cater to players with different interests and playstyles. Consequently, asymmetry can allow the development of games that are accessible and engaging to play for mixed-ability groups. There have been research efforts in that direction, but this exploration has only been made in cooperative games and, therefore, there is a lack of knowledge on how to apply asymmetry and its effects in competitive games. Embracing asymmetric game design for competitive mixed-ability games introduces unique challenges and opportunities.

Chapter 3

Designing An Asymmetric Competitive Game For Mixed Visual Abilities

The goal of this work was to explore competitive games in mixed-ability groups by leveraging asymmetric design principles. Specifically, we focused on competition between sighted and blind players, aiming to explore perceptions of fairness and balance between different types of a/symmetry: 1) Total Symmetry, 2) Partial Asymmetry (Combined and Exclusive), 3) Total Asymmetry.

To explore the aforementioned conditions and gain an understanding of the players' perceptions of fairness, we developed a game that integrated these asymmetric types, each has its own individual challenge (i.e. minigame). These were integrated into a larger cohesive game experience enabling players to reflect on the individual challenges as well as them as part of a whole experience. We aimed to have a game closer to a commercially available game promoting ecological validity, rather than test one-off minigames against one another.

3.1 Design Motivation

For this thesis, it's essential to understand: the barriers and opportunities that people with visual impairments face when playing games; the concept of asymmetric roles in games; and the current research state of mixed-ability play. To accomplish these objectives, a thorough literature review of relevant studies was conducted. Additionally, to inform the following design requirements, and enable us to reflect on the accessibility of asymmetric games, we conducted two accessibility reviews of two commercial asymmetric games (according to the template in Taming Gaming database¹, a platform designed to help parents/guardians understand video games) of two games, Tales of Arise² and Moonlighter³.

3.2 Design Requirements

To create an immersive and competitive gaming experience, we established design requirements to ensure equal participation and awareness for both sighted and blind players in the same game environment. These requirements include:

1. **Unified Gameplay:** It was crucial to enable both sighted and blind players to interact and compete within the same game map. This inclusivity allowed players with different visual abilities to engage with each other and be part of a shared gaming experience.
2. **Awareness of Other Players' Actions:** To promote fairness and strategic decision-making, all players need to have access to information about the actions and movements of other players in real time. This ensured that no player had an unfair advantage due to delays in perceiving or responding to the actions of others.
3. **Elimination of Performance Advantages:** It was essential to prevent any performance advantages that could arise from differences in sensory modalities.
4. **Elimination of Awareness Benefits:** Similarly, it was important to ensure that there were no inherent benefits or disadvantages associated with delays in perceiving information across different sensory modalities. For instance, players should not gain an advantage by being able to hear or see certain events before others.

¹Taming Gaming URL: <https://www.taminggaming.com/> (visited on 01/03/22)

²Tales of Arise URL: <https://en.bandainamcoent.eu/tales-of/tales-of-arise> (visited on 01/03/22)

³Moonlighter URL: <https://moonlighterthegame.com> (visited on 01/03/22)

3.3 Design Process

To reach a design for the game, we created a Game Design Document, which underwent iterative revisions over the course of a month. Our team held regular remote meetings at least once a week to discuss the mechanics of the two roles and how to ensure that information was conveyed in a fair and comprehensible manner to both sighted and blind players. During this stage, our primary focus was to establish a fundamental design structure for the game.

During the early design iterations, the game structure was prepared to explore competitive mixed-ability gaming between two players, or between two teams. While this thesis focuses on the exploration of one versus one in mixed-ability competition, in the following section we describe the core gameplay including the design work that will support future user studies exploring team competition.

3.3.1 Core Gameplay

The core game consists of two cooks competing to complete orders. To support team competition with a wide variety of mixed-ability group compositions, we conceptualized two roles, the cook and the adventurer, which was responsible for fetching the resources to complete orders. The game would require communication and teamwork when played in teams. This game setup would provide us with the opportunity to delve into both symmetric and asymmetric team-based competitions.

The cook role required resource and time management skills, and their gameplay focused on managing multiple cooking stations. When in a team, it additionally assisted the adventurer through various actions, such as pulling levers or standing on pressure pads triggering map changes that had an impact on the dungeon, or dropping off items to the adventurer. Drawing inspiration from the game *Overcooked*, the cook competed against another cook to fulfill a predetermined set of orders, which were presented in a different order for each player. The objective was to complete these orders before the opponent cook.

The adventurer role in our game was inspired by the gameplay mechanics of *Bomberman* (i.e., strategically placing bombs in a maze-like grid to clear obstacles and defeat opponents, and collect power-ups), focusing on strategic puzzle-solving skills. The primary objective of the adventurer would be to collect special ingredients exclusive to the dungeon, which were requested by the cook. Simultaneously, they aimed to disrupt the opposing adventurer's efforts to gather these ingredients for their own team. In certain instances, the adventurer would encounter obstacles that required assistance from the cook to overcome, such as locked doors and changing the direction of moving walkways.

In the next sections, we will focus on detailing the design and implementation work regarding the cook role that enabled the exploration of **mixed-ability one versus one competition**.

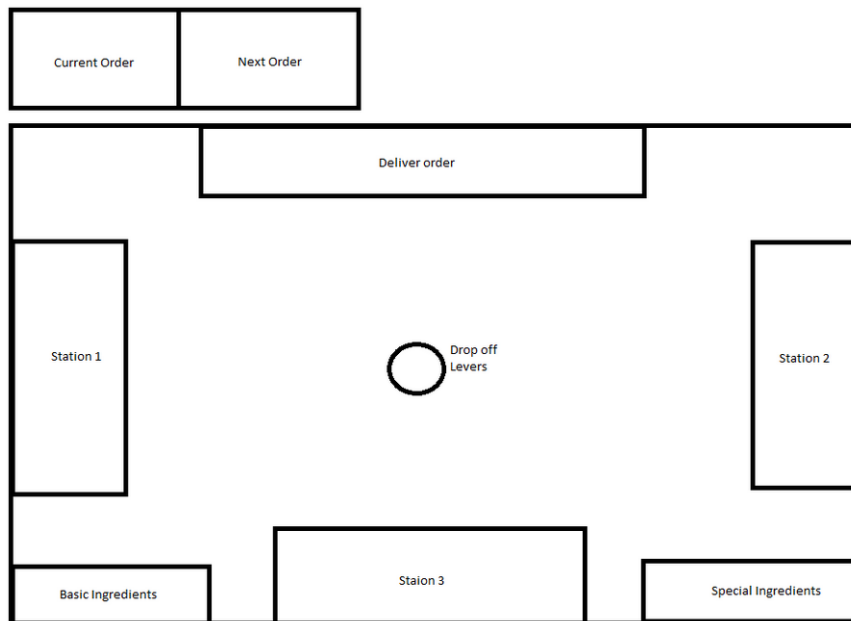


Figure 3.1: First draft of kitchen map

3.3.2 Types Of Asymmetry

In this study, we aimed to explore competitive games in mixed-ability groups by leveraging asymmetric design principles. We identified distinct types of asymmetry to be explored, encompassing various (a)symmetric combinations of challenges and feedback types. Below we detail the ones explored:

- Total Symmetry: Baseline condition equivalent to an audio game with no visuals. Players face the same auditory challenge, with the same controls.
- Partial Asymmetry
 - Exclusive - Players face the same challenge with different feedback (i.e. visual only or audio only).
 - Combined - Players face the same challenge and have the same interface. However, only the sighted player is able to leverage both visuals and audio, thus there is asymmetry of actionable feedback due to different abilities.
- Total Asymmetry: Players face distinct challenges

We included these types of asymmetry in several components of the game and designed game modules that would allow us to explore participants' perceptions of fairness. Each of these types was implemented into a different cooking station. We designed each of the challenges to be short interactions (i.e. less than 3 minutes overall) to represent the cook working on a station to complete part of the recipe. Below we describe the design process and considerations for each of the types.

Total Symmetry (TS)

In this cooking station, we decided to develop an audio-based memory card matching game. In this game, the goal is for players to uncover pairs of cards that produce identical sounds.

Exclusive Partial Asymmetry (EPA)

One of the early game design concepts for this cooking station involved a catcher game, where objects would fall from the top of the screen at random locations and the goal of the game was to catch these falling items. For the audio version of this module, falling sounds were added to each object to provide an audio cue to the player. However, during playtesting, several issues were identified with this concept.

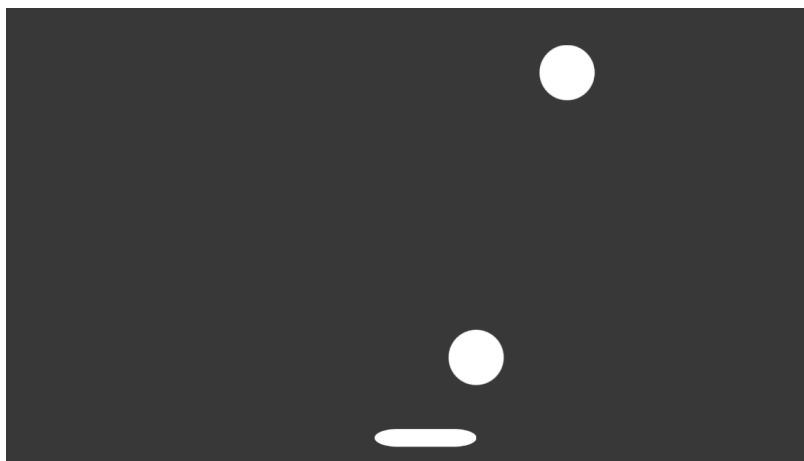


Figure 3.2: EPA - Initial prototype.
Circles falling from the top of the screen; Bar (catcher) at the bottom of the screen

Firstly, it was found that having multiple objects on the screen at the same time made it difficult for blind players to distinguish where the objects were falling from, and which object was at a lower height and had to be caught first. As a result, it was decided to limit the number of objects on the screen to one at a time. Despite this change, catching the object remained a challenging task to accomplish through audio. To address this, the Doppler effect was removed from the falling sounds to make it easier for players to perceive how far the object was and where they should position themselves to catch it. Despite the modifications made to the game, it remained a challenging experience for players due to the speed of the falling objects. Conversely, slowing down the speed of falling objects made the game tedious and unengaging.

To address the difficulties faced with the initial catcher game design for the blind version, a new concept was explored. The new design drew inspiration from the follow-the-sound game mechanic, a popular concept in audiogames. In this version of the game, the player would need to keep a sound in the middle of the screen by moving left or right to follow it, similar to catching falling objects in the original design. However, instead of scoring per object caught, players would

score continuously as long as they stayed inside a scoring zone that was constantly emitting the sound the players were meant to follow.

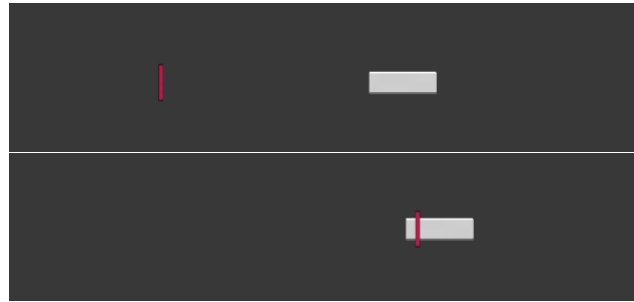


Figure 3.3: EPA - Updated prototype.
Horizontal Bar (score zone); Vertical line (catcher).

Combined Partial Asymmetry (CPA)

In this cooking station, our objective was to design a game that incorporated both visual and audio challenges, interconnected and complementing each other. We carefully selected the following concepts: for the visual challenges, players would engage in the task of revealing a target image by adjusting the transparency of multiple overlapping images. Regarding the audio challenges, players were tasked with isolating the target sound by reducing the volume of all other sounds to zero.

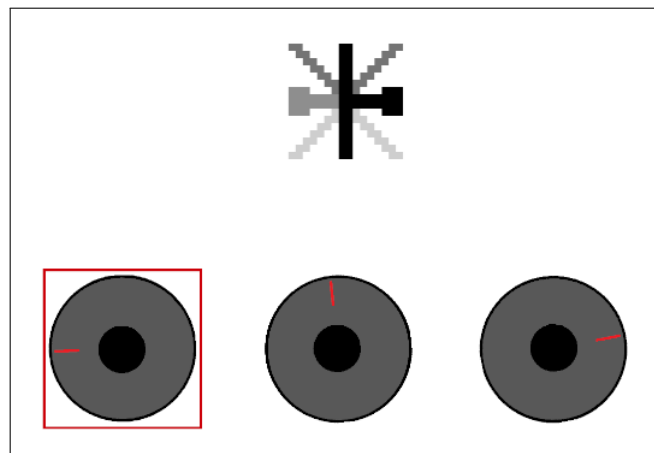


Figure 3.4: CPA - Initial prototype.
Three knobs (bottom), each able to adjust one of the overlapping images (top).

The gameplay involved a mechanism of rotating knobs, each associated with controlling both the transparency/volume of an undesired image/sound until the optimal setting was discovered for each knob. After some playtesting, we decided to make one alteration to the audio challenge. Rather than having all sounds playing simultaneously, we revised the design to include only the target sound (always playing) and the sound corresponding to the knob being rotated by the player.

This adjustment ensured that only two sounds were actively played at any given time, enhancing the clarity and focus of the audio challenge.

Total Asymmetry (TA)

In this cooking station, the objective was to create two distinct games that were equally challenging and time-consuming. Both versions aimed to provide equitable gameplay experiences in terms of complexity and difficulty.

In the sighted version of the game, the player is presented with several objects floating across the screen. Their task is to identify and keep track of the objects that possess a specific distinctive feature, known as the target objects. After a certain time, the distinctive feature is removed from the objects. The goal is to accurately select all the target objects. Through playtesting, a short delay was introduced as a penalty for incorrect guesses, preventing players from spam-clicking every object.

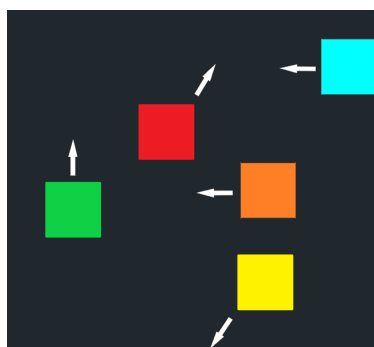


Figure 3.5: TA - Initial design, sighted version.

In the blind version, players are tasked with locating a specific sound within a grid. As they move, auditory feedback guides their direction, indicating whether they are closer to or farther from the target. In the initial design, the audio feedback employed varying pitch and directional sound cues to assist players. However, the feedback was later streamlined to provide a simplified positive or negative sound cue. This refined approach not only enhanced the engagement of blind players but also ensured a more equitable challenge compared to the sighted version.

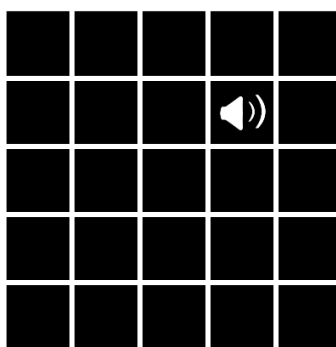


Figure 3.6: TA - Initial design, blind version.

3.4 Cryptic Kitchen

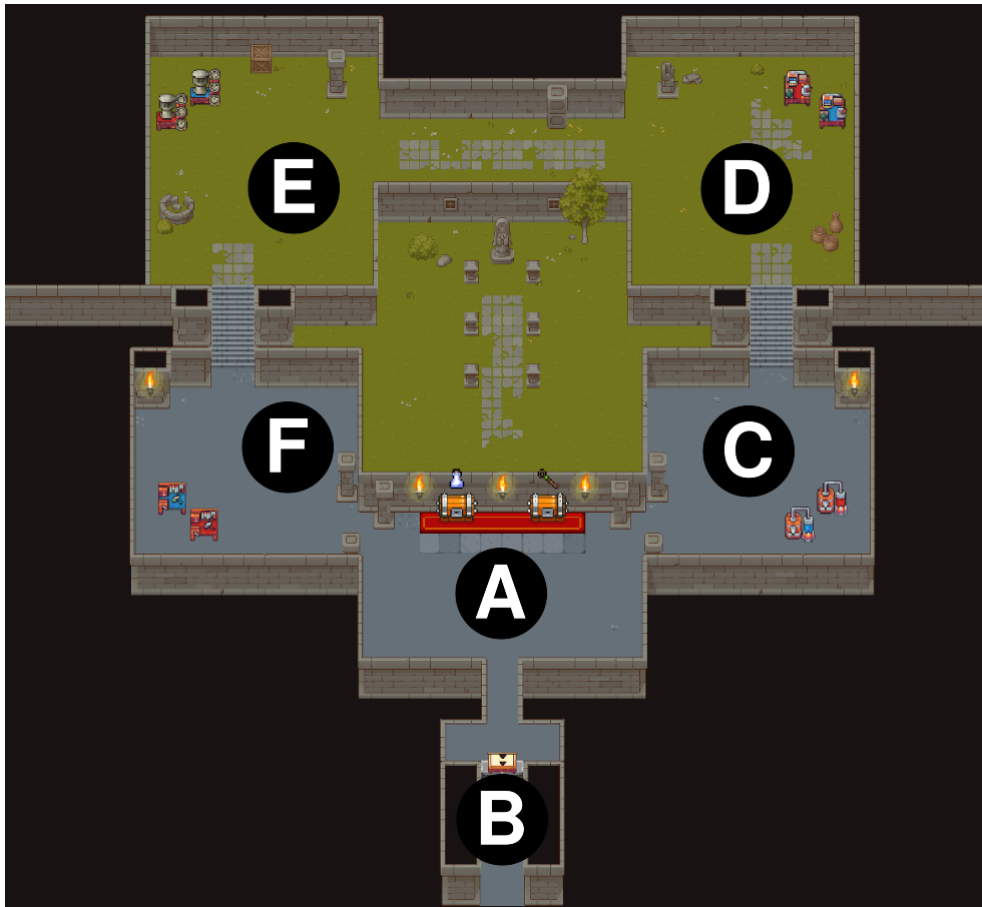


Figure 3.7: Final Version of Kitchen Map.

Central Room (A); Delivery Room (B); Potency Room (C); Effect Room (D); Element Room (E); Inscription Room (F).

The game is a competition between two magical cooks who are “cooking” magical potions and staves. Set within a 2D top-down environment, players navigate this world to gather ingredients, utilize cooking stations, and fulfill orders. In Cryptic Kitchen, players are tasked with using ingredients to complete their customers’ orders before their opponent. Orders are composed of an initial ingredient (i.e. flask or staff) and a set of additional characteristics (e.g. fire). These characteristics are incorporated into the item using one of four possible cooking stations. Each station corresponds to one of the (a)symmetric modules. The item characteristics are as follows:

- Total Symmetry - Inscription: arcane, and mystical
- Exclusive Partial Asymmetry - Potency: potion, superpotion, and hyperpotion
- Combined Partial Asymmetry - Element: fire, water, wind, and earth
- Total Asymmetry - Effect: hasty, mighty, toxic, and spooky

To complete an order, players will need to start by grabbing one of two basic ingredients: flask or staff. A flask order requires the addition of one effect, one potency, and one element characteristic. A staff order requires the addition of one inscription and one element characteristic.

As an example, let's consider the order for a Hasty Fire Potion.



Figure 3.8: Visual representation of Hasty Fire Potion.

Hasty - Boot symbol (bottom right)

Fire - Fire symbol (top right)

Potion - Star symbol (top left)

First, the player must grab a flask (Figure 3.9) from the flask chest (Figure 3.7 - A). Then, they need to visit the stations (Figure 3.11) corresponding to each desired characteristic (stations can be visited in any order): the Effect Station (Figure 3.7 - D) for adding the Hasty characteristic, the Potency Station (Figure 3.7 - C) for adding the Potion characteristic, and the Element Station (Figure 3.7 - E) for adding the Fire characteristic. Finally, to complete this order the player must take it to the Delivery Zone (Figure 3.7 - B) thus completing the order. A new order then appears.



Figure 3.9: The base ingredients.

Flask (left) and Staff (right).



Figure 3.10: Ingredients' chests.

Flask chest (left) and Staff chest (right).



Figure 3.11: Effect station, Potency station, Element station, and Inscription station.

In the following sections, we first describe the different stations and the associated challenges. Next, we examine the player's navigation systems, including movement mechanics, map awareness, and map layout. Finally, we describe several aspects of the implementation process.

3.4.1 Stations

In Cryptic Kitchen, players must utilize one of four cooking stations to add a specific characteristic (inscription, potency, element, or effect) to their ingredients. Each station is associated with a unique minigame that must be completed to process an ingredient.

To initiate a cooking station, players need to bring an ingredient/item that is compatible with that particular station. The inscription station only accepts staff-type items, while the potency and effect stations exclusively accept flask-type items. The element station, on the other hand, accepts both item types. If a player brings an incompatible item, an audio cue will notify them.

Once at the station, players are presented with a selection menu in which they can choose the desired characteristic from the available options for that station. Subsequently, they must engage in a minigame to commence the cooking process. The minigames do not have a fail state and allow players to quit at any point. Upon successful completion of a minigame, a distinct sound cue signifies their achievement, and the minigame window automatically closes.

The completion of a minigame triggers the cooking process, temporarily locking the ingredient within the station. After a certain duration, the cooking process is completed, allowing the player to retrieve the ingredient with the newly added characteristic. Players can continue progressing in other available orders during the cooking time.



Figure 3.12: Characteristic selection menus.

Effect (top left), Element (top right), Inscription (bottom left), Potency (bottom right)

The asymmetric modules were integrated in the form of minigames that the player must complete when visiting a cooking station. These minigames are:

Total Symmetry

Cards

This module is played by both sighted and blind players. This game models a traditional memory card game using sounds. The player has to find 4 card pairs in a pool of 9 cards. The player uses either the numeric keypad or the alphanumeric keypad numbers to listen to each card. When players select two cards with the same sound, they make a pair. Already paired cards have a specific sound cue indicating it. The only visuals for this game is a progress tracker for pairs found.

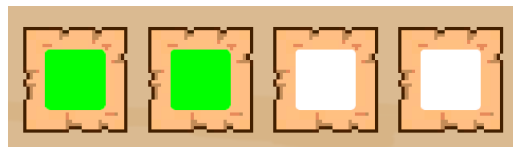


Figure 3.13: Cards minigame. Progress Tracker.

Exclusive Partial Asymmetry

Extraction

This module has two versions, one for sighted players and another for blind players. The main concept is the same: the player has to stay inside a moving score zone for a given amount of time.



Figure 3.14: Extraction minigame.
Horizontal Bar (score zone); Vertical line (catcher)

In the blind version, the player is able to perceive whether the sound is to the left or right and has an additional continuous audio feedback while inside the score zone.

In the sighted version, the player has no spatial audio feedback nor audio feedback while inside the score zone, therefore they solely rely on visual feedback.

Combined Partial Asymmetry

Knobs

This module is the same for both sighted and blind players. Both players have access to audio feedback. Sighted players also have access to visual feedback. In this module, the player is tasked with adjusting three knobs.

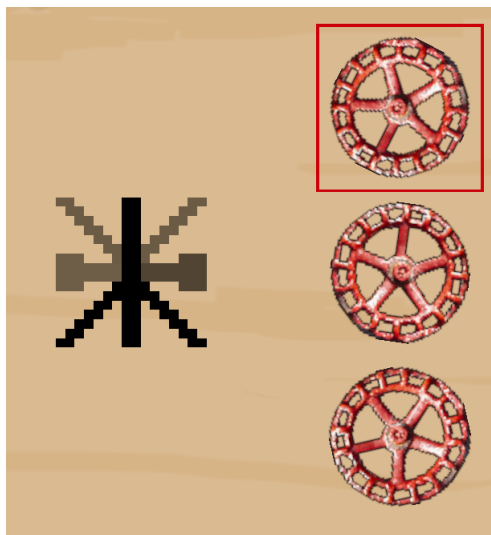


Figure 3.15: Knobs minigame.
Three knobs (right), each able to adjust one of the overlapping images (left).

Auditorily, the goal is to isolate a sound that corresponds to the chosen element. To achieve this, players need to reduce the volume of each knob sound. Each knob's sound corresponds to

one of the three elements not chosen. Only two sounds play at the same time, the sound of the chosen element and the sound of the currently selected knob.

Visually, the feedback is given via the transparency of overlapping abstract images and each knob controls the transparency of one image. The goal is to reduce the transparency of all knob-controlled images.

Total Asymmetry

In this module, blind and sighted players have a completely different challenge and interface. Blind players have the Search module, and sighted the Silhouettes. The modules were designed aiming to provide a similar challenge.

Search

The player is located in a random cell in a 5 by 5 grid and their goal is to find the goal cell (that has a unique sound). After every movement input, if the player stays in place for a short amount of time, they receive feedback regarding their movement direction (positive or negative). The player receives a “bump” feedback sound if they try to move out of the grid.

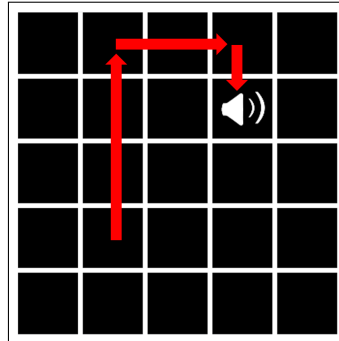


Figure 3.16: Search minigame.
Visual representation.

Silhouettes

The player is shown several items floating across the screen and has to keep track of the objects that correspond to the effect chosen (e.g., toxic = purple objects). After some time, the player is only able to see shadows of the displayed objects and after a short delay must use the mouse to click the correct ones. The player can see the object colors again if they want to but are unable to select them until they return to shadows. When the player guesses incorrectly, they are temporarily blocked from further guesses.



Figure 3.17: Silhouettes minigame.

On the left, the items can be distinguished by their color or shape. On the right, the items have no discernible feature.

3.4.2 Inventory, Orders & Scoreboard

In terms of item/order presentation, two systems were devised to cater to the abilities of each player group.

For blind players, text-to-speech technology is utilized to grant them access to their inventory, orders, and scoreboard. This allows them to listen to item descriptions containing the names of the characteristics associated with an item, and also to the state of the game.

On the other hand, sighted players rely on visual representations of their inventory, orders, and scoreboard (Figure 3.18). The inventory and orders are visually represented by the image of a basic ingredient along with the images of the additional characteristics that have been added to it. The inventory is displayed in the top right corner of the screen, while the orders are shown in the top center of the screen. The scoreboard is displayed in the top left of the screen.

A full list of the items' descriptions can be found in appendix D.



Figure 3.18: UI.

Scoreboard (A); First Order (B);
Second Order (C); Item In-Hand (D).

Regardless of visual abilities, players should have access to information at the same time to create a fair competitive experience. As blind players can only listen to one item description at a time, sighted players are also only able to view one item at a time from the three available (order one, order two, and inventory). Similarly, since blind players can only access their inventory and orders once they press a key, sighted player's inventory and orders were similarly hidden by default from the sighted player and also require the press of a key to be displayed on the screen.

During the game, players have the ability to check their inventory and orders at any time. However, they are only able to carry one item at a time while managing up to two active orders simultaneously. This limitation adds strategic depth and decision-making challenges for players.

3.4.3 Navigation

Fairness in movement mechanics was a fundamental consideration in Cryptic Kitchen. Our goal was to create an equitable gameplay experience, regardless of the player's chosen movement type, ensuring balance and eliminating any potential advantages associated with different movement styles.

Although we wanted players to play on the same map to heighten competition and engagement, we decided not to include collisions between players. This choice was motivated by the challenges of effectively communicating collision information to blind players and the potential for disruptive gameplay experiences that could lead to griefing (e.g., body-blocking paths), which we did not intend to explore.

Movement mechanics

Sighted players enjoy the freedom of unrestricted movement, allowing them to traverse the kitchen environment in any direction they choose. On the other hand, blind players' movement is guided by waypoints strategically placed at room exits, portals, stations, and chests. This waypoint system enables smoother navigation for blind players while concealing the visual abilities of the player, which is highly important for our study.

The blind player's movement system does not lock the player until the destination is reached from introducing new inputs and does not allow inputs to be queued. Instead, when new inputs are provided, the blind player's character redirects to the new destination within the same room/corridor. Playtesting was conducted to ensure that blind players would not get trapped in the map geometry or face any unfair movement obstacles.

Additionally, we included a portal in all rooms with a station. When a player, sighted or blind, interacts with the portal they are teleported to the central room (Figure 3.7). This feature not only adds an additional layer to the movement mechanics but also serves as a beacon/reset for blind players.

Map Awareness & Text-To-Speech

Sighted

For sighted players, map awareness is facilitated by visual cues such as the room's visuals, the stations, and their spatial relationships with other rooms.

Similarly, when a station starts the cooking process (i.e., the process of adding a characteristic to an ingredient), a yellow cog is displayed above it, and once the cooking is complete, a green cog is shown.



Figure 3.19: Cooking Process Tracker.
Yellow Cog - Station in progress (left);
Green cog - Station ready (right)

Blind

Text-to-speech technology plays a key role in delivering game information. Alongside auditory cues, it facilitates navigation, station identification, and cooking progress updates.

To ensure equal access to information, blind players receive room announcements through text-to-speech (TTS) when entering a room. This announcement coincides with the moment a sighted player would visually recognize the station and know which room they are in. Additionally, an alarm sound cue is played when entering a room with a station that has completed the cooking process.

These audio cues synchronize the information received by both blind and sighted players, ensuring parity in their awareness of room locations and cooking progress and preventing any undue advantage due to the possible effects of audio throughput on blind players' map awareness.

Map Layout

The design of the kitchen map in our game was carefully crafted to ensure that neither sighted nor blind players have an inherent unfair advantage. Our approach was to create a map with an equal level of traveling distance and time for both sighted and blind players. This was achieved by utilizing tight corridors and ample rooms. Moving between rooms necessitates navigation through these corridors, bringing the movement of sighted players more in line with blind players. To ensure fairness, both players' characters were given the same movement speed, contributing to a balanced and equitable gameplay experience.

A circular map layout was chosen for this study as we believed it would provide a more

intuitive layout to understand without requiring extra training by blind participants. The circular design enables continuous movement in one direction, ensuring eventual arrival at the destination, regardless of prior familiarity with the environment.

The kitchen in Cryptic Kitchen is divided into six rooms (Figure 3.7):

- Four cooking rooms (the effect, potency, inscription, and element rooms), with two identical color-coded stations each, one for each player.
- One central room, containing the two chests, where the player can obtain the initial ingredients.
- One delivery room, in which players can deliver completed orders.

3.4.4 Implementation

Tools

The game was developed from scratch in Unity⁴ along with Photon Engine⁵ for the multiplayer network. All graphics were either designed from scratch, adapted from free-licensed assets (found in opengameart.org, craftpix.net and itch.io) or Top-Down Engine⁶. Sound effects were collected from various free-licensed sound libraries (mixkit.co, pixabay.com, zapsplat.com, and opengameart.org) and post-edited.

All versions of the game are available on itch.io⁷.

Controls

We provided players with different control schemes based on their visual abilities. Sighted players utilized the standard keybind configuration, utilizing WASD for movement and mouse input for both menu navigation and playing the total asymmetry game module. Blind players utilized the arrow keys for movement, which also served as their means of navigating the menus.

Keybinds for all other in-game actions were thoughtfully selected, taking into consideration their standard/default actions (e.g., E for interacting), the corresponding English initials representing the actions (e.g., T for trashing an item), and ease of use. A full keybinds list can be found in appendix F.

Audio

In designing the audio version of the menus, we adhered to established accessibility guidelines to ensure a user-friendly experience for blind players. This entailed designing menus that seamlessly

⁴Unity URL: <https://unity.com/> (visited on 08/05/23)

⁵Photon Engine URL: <https://www.photonengine.com/> (visited on 08/05/23)

⁶Top-Down Engine URL: <https://topdown-engine.moremountains.com/> (visited on 08/05/23)

⁷Sighted version (PT) URL: <https://pedrogt.itch.io/cryptickitchen-sighted-pt>; Blind version (PT) URL: <https://pedrogt.itch.io/cryptickitchen-blind-pt>; Sighted version (EN) URL: <https://pedrogt.itch.io/cryptickitchen-sighted>; Blind version (EN) URL: <https://pedrogt.itch.io/cryptickitchen-blind>

looped, optimizing usability, and ensuring a consistent and intuitive interface to facilitate efficient navigation and interaction for individuals with visual impairments.

Given the competitive nature of the game, it is essential to ensure that information is conveyed to the players quickly and accurately through the audio design. This requires the use of sounds that can be processed rapidly and with minimal delay, as time management is critical for success. To achieve this, the sounds were edited to ensure they were optimized for audio throughput while maintaining their clarity and effectiveness in conveying information. All audio components were carefully adjusted in terms of volume and length using Audacity⁸.

Specifically, the Text-To-Speech items in the inventory system were generated using the Any Text To Voice application from the Microsoft Store, which allowed for the transformation of text into audio files. These files were subsequently refined in Audacity to ensure optimal quality and effectively contribute to a better game experience.

Logging

Every game action (e.g. movement, item pickups, minigames) is labeled and stored, along with a timestamp, for later analysis. A full log list can be found in appendix E.

Standalone & Tutorial/Walkthrough

In order to support the following user study which required participants to be able to play the cooking stations at home, we developed a standalone version with direct access to each of them.

Furthermore, a step-by-step tutorial was designed (appendix G) to help players become familiar with the game. The tutorial involves completing two predetermined orders, serving as an introduction to the necessary gameplay mechanics, controls, and the layout of the game map.

Language

The game was developed to support Portuguese and English languages. Orders' sequence and characteristics are fully randomizable.

Direct time comparisons between games played in different languages may be unreliable due to audio throughput and language structure.

Playtesting

During the final stages of the development process, we conducted playtesting with a group of selected individuals (sighted and one blind player) who were given access to earlier versions of the game. An early version of all cooking stations was also playtested by a blind participant. This allowed us to gather feedback and iterate based on their suggestions, resulting in improvements to the tutorial/walkthrough of the game, ensuring that the game mechanics were clearly explained, as well as refinements to key bindings, thereby enhancing accessibility for blind players.

⁸Audacity URL : <https://www.audacityteam.org/> (visited 19/04/23)

Chapter 4

User Study

We conducted an in-person user study that involved both sighted and blind participants. Our goal was to explore how asymmetric competitive games can be designed to create engaging and fair gaming experiences within mixed-ability groups. Additionally, we aimed to identify and analyze the advantages and disadvantages of types of asymmetry in mixed visual ability competitive games. The study was approved by the Ethics Committee of Faculdade de Ciências da Universidade de Lisboa.

4.1 Participants

We recruited 10 participants, 6 sighted and 4 blind, from Portugal. Sighted participants were aged 22-29 ($M=24.83$; $SD=2.97$). Blind participants were aged 30-43 ($M=37.5$; $SD=5.32$). To reach volunteers, we shared the study through personal connections. and contacted local institutions for education and rehabilitation for blind people. Participants applied through a form Google Forms, where they were asked about their demographic information (i.e., age, gaming frequency, and competitiveness); additionally, blind people were also asked to describe their visual acuity. Participants could not have other kinds of significant impairments (mobility, hearing, cognitive), since games were not designed considering other disabilities.

In terms of digital gaming habits, it was reported that all blind participants engaged in gaming monthly, while the frequency of sighted participants was generally higher. Among sighted participants, only one individual, S1, identified as a casual player, while the remaining participants identified as either between casual and hardcore or hardcore players. Among blind participants, one individual, B4, identified as between casual and hardcore, while the others identified as casual players. Participants S2, B3, and B4 identified as very competitive individuals.

Participant	Gender	Age	Q1	Q2	Q3	Q4
S1	F	26	Monthly	<1 Hour	Casual	4
S2	M	28	Monthly	1 to 2 Hours	Hardcore	5
S3	M	22	Daily	2 to 4 Hours	Hardcore	3
S4	M	22	Daily	2 to 4 Hours	Between Casual and Hardcore	3
S5	M	29	Weekly	1 to 2 Hours	Between Casual and Hardcore	4
S6	M	22	Weekly	1 to 2 Hours	Between Casual and Hardcore	3
B1	M	35	Monthly	<1 Hour	Casual	3
B2	M	42	Monthly	1 to 2 Hours	Casual	4
B3	F	30	Monthly	1 to 2 Hours	Casual	5
B4	M	43	Monthly	<1 Hour	Between Casual and Hardcore	5

Table 4.1: Gaming Frequency Questionnaire.

Q1 - How often do you play digital games?

Q2 - How long are on average your gaming sessions?

Q3 - As a player, how do you consider yourself?

(Casual, Between Casual and Hardcore, Hardcore)

Q4 - As a person, how competitive do you consider yourself?

(1 - Not Competitive, 5 - Competitive)

4.2 Procedure

After completing the demographic form, participants were contacted via email and provided with instructions, along with links to the standalone game versions that corresponded to their respective visual abilities. These versions did not give access to the full game, but rather to each of the modules developed directly. The full version of the game was used for the in-person session. Participants were encouraged to try each module at least once. This pre-session practice enabled participants to familiarize themselves with the modules' mechanics, reducing the information load for the in-person session. Individual in-person study play sessions were scheduled for the following week.

During the in-person study play session, participants were first asked to complete a questionnaire that assessed their frequency of playing each of the game modules and their perception of the difficulty level of each of them.

Next, participants were introduced to the main mechanics and objectives of the game. A step-by-step tutorial was then conducted, guiding participants through the controls and gameplay mechanics of the full game (i.e. navigation, orders, inventory, stations, and delivery). A researcher was present to assist and address any questions or concerns. To conclude the tutorial, participants were required to complete two orders, and they had the opportunity to seek further clarification before proceeding to the next section of the study.

Once the tutorial was completed, participants were informed that they would be engaging in an online competition with another participant located in a separate room. Importantly, participants were not yet made aware of their opponent's visual abilities.

In all sessions, the opposing player was in fact a simulated player with visual abilities different from the participant, controlled by a researcher using the version for the specific player being simulated, and performing actions according to a script based on the previous play sessions of sighted or blind playtesters. This approach ensured that the gameplay experience was similar to being able to accommodate pairs of players in the user study. We decided to always allow participants to complete two deliveries even if they exceeded the simulated player time (i.e. 10 min 32 sec, and 8 min 26 sec for blind and sighted respectively) We relied on this approach to ensure participants took as much or as little time during the step-by-step tutorial and no participant had to wait to proceed with the study, facilitating study logistics. During the gameplay session, the researcher offered minimal assistance to minimize their influence on the game's outcomes. Upon completion of the game, participants were asked to fill the Mini PXI [1] questionnaire, which aims to measure the player experience.

At this stage, participants were informed that the game was designed for mixed visual ability play. They were also made aware that their opponent possessed different visual abilities (i.e. sighted, or blind).

To further capture participants' perspectives and insights, we conducted semi-structured interviews (script in appendix A). During these interviews, we specifically sought participants' opinions regarding mixed-ability gaming, the fairness and balance of the main game mechanics, gameplay, and each of the asymmetric modules. Players were made aware of each of the challenges the opponent had to face, and when they were different than their own. Sighted players were able to experience them as they would in a real-world deployment, while for blind players the differences were described. Participants were compensated for their time with a 10€ voucher.

4.3 Data Analysis

After transcribing audio recordings from the interviews, we performed an inductive thematic analysis. The process began with annotating recurring ideas and concepts that were relevant to our approach, resulting in a preliminary coding scheme based on these ideas and concepts. We then engaged in further discussions to refine the coding scheme, adding new codes for relevant ideas that were not yet captured, merging, or removing redundant or irrelevant codes, and grouping them to account for hierarchical relationships. Once we had finalized the coding scheme (appendix C), we used it to code the data in full. We then identified relationships between codes to develop overarching themes that capture the essence of our findings (appendix B).

4.4 Limitations

The prototype game was created as a proof of concept with limited time and resources, which may have resulted in a gameplay experience that differs from what participants are accustomed to.

The amount of training time participants had was short in relation to the complexity of the game, even though we attempted to mitigate this by sending the minigames in advance.

4.5 Findings

Participant	TA	CPA	EPA	TS
S1	2 to 4 times			
S2	2 to 4 times			
S3	2 to 4 times			
S4	5 or more			2 to 4 times
S5	5 or more	2 to 4 times		
S6	2 to 4 times			
B1	1 time			
B2	5 or more			
B3	2 to 4 times			5 or more
B4	2 to 4 times	5 or more		

Table 4.2: Minigame's Training Attempts.

Before the in-person study session, participants were provided with the chance to familiarize themselves with the minigames and practice on their own (Table 4.2). The majority of participants practiced all minigames for a range of two to four times. However, participant B1 practiced each minigame only once.

Participant	1st Order	2nd Order	3rd Order	4th Order
S1	3:36	4:03	6:37	7:50
S2	2:24	4:24	6:18	7:10
S3	3:12	5:39	7:12	8:13
S4	1:50	3:26	4:48	6:25
S5	2:28	3:51	5:20	6:19
S6	3:20	3:33	5:39	6:38
B1	5:43	7:40	-	-
B2	8:58	9:29	-	-
B3	8:51	17:32	-	-
B4	7:41	9:49	-	-
Best (Blind)	5:43	7:40	-	-
Best (Sighted)	1:50	3:26	4:48	6:19
Average (Blind)	7:49	11:08	-	-
Average (Sighted)	2:49	4:09	5:59	7:06

Table 4.3: Delivery Times (m:s)

Sighted participants were faster during the game, and all were able to beat the simulated player (Table 4.3). In contrast, all blind participants lost to the simulated player, and only one completed their second order before the simulated player finished.

Participant	TA	CPA	EPA	TS
S1	11,92	10,10	8,12	22,05
S2	12,51	5,36	8,19	14,58
S3	8,85	6,75	7,10	15,39
S4	11,70	4,16	6,69	12,38
S5	7,83	5,96	6,63	17,55
S6	8,40	5,14	6,59	16,55
B1	8,37	11,58	24,55	21,93
B2	13,96	15,97	5,42	29,91
B3	15,85	12,65	16,60	39,43
B4	22,60	15,75	28,11	34,18
Best (Sighted)	7,83	4,16	6,59	12,38
Best (Blind)	8,37	11,58	5,42	21,93
Average (Sighted)	10,20	6,25	7,22	16,42
Average (Blind)	15,20	13,99	18,67	31,36

Table 4.4: Best Minigame Times (s).

Comparing the best minigame times for each minigame we can observe that, in all minigames, sighted participants were on average faster than blind participants. Specifically, in the Total Asymmetry module (Silhouettes/Search minigame), blind participants took 1.5 times longer than sighted participants, while in other minigames they took at least twice as long as sighted participants. In the Extraction minigame, sighted participants were faster on average than blind participants. However, it is worth noting that participant B2 achieved the best time for this minigame, but considering participant's B2 other times for this minigame it is difficult to determine whether this result was due to skill or luck, given the randomness of the game.

Participants in the study seemed to have had a positive, enjoyable, and immersive experience (appendix H). Participants expressed their overall interest, stating, "*I found it interesting [...] it was simple [...] but still entertaining.*" (S5); "*it was fun*" (S6). Interacting with others during gameplay was also appreciated, as mentioned by a participant (B2), who stated, "*I really liked it, especially interacting with other people*". However, some participants experienced slight confusion during gameplay, as one mentioned, "*I really enjoyed it, but I felt it was a little confusing*" (B3).

Each subsequent section corresponds to a theme resulting from the thematic analysis, where we further explore the participants' experiences and provide a more in-depth discussion of their perceptions.

4.5.1 Discrepancy of Perspectives

Participant	TA	CPA	EPA	TS
S1	2	3	5	3
S2	2	4	5	3
S3	3	4	4	3
S4	5	5	4	3
S5	2	5	5	3
S6	3	3	4	3
B1	3	3	3	3
B2	3	2	3	3
B3	3	3	3	3
B4	2	2	3	5
Average (Sighted)	2,83	4	4,5	3
Average (Blind)	2,75	2,5	3	3,5

Table 4.5: Minigames' Fairness.

The minigame fairness questionnaire (Table 4.5), where participants rated fairness on a scale of 1 to 5, with 1 corresponding to "In Disadvantage" and 5 to "In Advantage", revealed that there was a discrepancy between the perspectives of fairness among sighted and blind participants in games featuring partial symmetry, the Knobs and Extraction minigames. Sighted participants perceived that the visual feedback offered them a significant advantage against blind participants.

In the Knobs minigame, sighted participants perceived that they were able to distinguish the images more quickly compared to blind participants' ability to distinguish the sounds. One participant (S5) highlighted the influence of visual perception, saying, *"If he could discern the fire and wind like I visually see, [...] the minigame would be exactly the same (in terms of fairness)."* Conversely, a blind participant (B2) expressed a disadvantage, noting the reliance on auditory cues, stating, *"I felt more disadvantaged. The game utilizes vision, whereas I rely solely on hearing."* Additionally, participants also commented that those who use visual stimuli may disregard the auditory stimulus.

In the Extraction minigame, sighted players identified that the visual feedback was faster to interpret. Sighted participant (S5) reflected on their experience with the blind version of the game, stating, *"Perhaps a blind person can play that game flawlessly. I couldn't, nor could I see how my progress would improve."* In contrast, blind participant (B4) expressed, *"There's neither an advantage nor a disadvantage."*

While blind participants only experienced the blind minigame versions and were given descriptions of the sighted minigames, sighted participants had the opportunity to play both versions of the cooking station's minigames, sighted and blind, and therefore had access to more information than blind participants. Participant (B1) highlighted the equivalence between the two approaches, stating:

"It's about equivalence, arriving through audio or through images. But ultimately, the goal is the

same. Instead of silhouettes, we have sounds. Instead of a bar, we have sound too. So... the images fade away, and the same happens with the sounds. I don't perceive any disadvantages or advantages on either side."

Regarding the game as a whole, some sighted participants perceived that they had an advantage throughout the game, while others considered the game to be a balanced experience. Participant S5 expressed, *"It provides the opportunity, but still not with the same capacity as I can play."* Conversely, participant S1 remarked, *"Overall, I think it was quite balanced. We were almost neck and neck. Actually, I thought the other person was ahead."* On the other hand, blind participants generally perceived the game as a balanced experience. Participant B1 shared, *"Based on the data I have, I don't feel that the game is unbalanced."* Similarly, participant B3 stated, *"I think it's very similar to the objective of both me and the person on the other side... adjusted to the needs of each individual."*

4.5.2 Asymmetric Game Design Perceived as Fair

When evaluating fairness in the different minigames (Table 4.5), both sighted and blind considered the minigame pair with total asymmetry, Silhouettes and Search, as fair. In games with partial asymmetry, sighted participants felt an advantage in using visual feedback, which most considered quicker.

"It's much faster visually." – S5, referring to the Knobs Minigame

"I see that the bar escapes faster than I can hear that it has escaped." – S1, referring to the Extraction Minigame

Blind participants also acknowledged that visual feedback provided an advantage over audio feedback in direct comparisons.

"Visual stimuli are always faster." – B2

As such the only minigame(s) with asymmetries that was considered fair by both sighted and blind participants was the one that was designed with each player's abilities in mind.

4.5.3 Equal Game Fair

When evaluating the potential for a mixed-ability scenario, both sighted and blind participants considered that the Cards minigame (Total Symmetry module) held the most promise, with Participant 5 expressing how it could be enjoyed by anyone, regardless of visual abilities.

The game was perceived as balanced and equally challenging for both sighted and blind participants.

"The stimuli are the same. They can only use hearing, just like me." – B2

Some sighted players considered a slight advantage or at least comfort having the progression bar. Participant (S5) stated “*Seeing the progression provides me with some relief that a blind player may not experience.*”

Importantly, not all sighted participants enjoyed the Cards minigame, as participant (S3) straightforwardly stated, “*I don’t like this minigame.*”

Despite participants’ inclination towards the Total Symmetry module in mixed-ability contexts, the results from the fairness questionnaire (Table 4.5) indicated that both sighted and blind participants rated the Total Asymmetry module as fairer.

4.5.4 Individual Self-Accessed Mastery

Participant (S4) highlighted the potential influence of prior gaming experience on the game’s outcome. Sighted participants, having previous experience with similar games such as Overcooked, may have had an advantage in quickly adapting to the game’s mechanics and understanding the gameplay compared to blind participants. According to participant (S4), “*blind individuals might need to invest twice the effort or more to attain comparable proficiency to mine.*”

Blind participants expressed their belief that they could enhance their gameplay through increased practice and experience.

“I lost the game, but I think it was mainly due to lack of practice. [...] I felt that as time went on, I was becoming more adept at performing the tasks. It’s all about trial and error and gaining experience.” – B1

4.5.5 Mental Load & Spatial Awareness

Blind players are required to rely heavily on their memory to keep track of crucial information such as their current location, objectives, and ongoing tasks as they are unable to obtain information visually as quickly and easily as sighted players. Moreover, minigames add to the challenge by also requiring some level of memorization and forcing blind players to switch their focus. Additionally, blind players’ movement encompasses a larger range of controls and requires a greater number of inputs compared to their sighted counterparts.

In addition, blind participants had difficulties associating the room names to the item characteristics, resulting in longer deliberation about where to go next.

“I probably needed a better context beforehand. It’s difficult for me to think about terms like ‘inscription,’ ‘element,’ ‘effect.’” – B3

In contrast, sighted players could more easily obtain this information through visual and spatial cues, without having to rely on memory as much.

“I thought about locations like ‘here and there’, but not the names.” – S3

Additionally, some blind participants also mentioned that having to work on two orders with three characteristics each at the same was challenging:

“We have to alternate, and we tend to forget. It’s a matter of training and interpretation. Initially, it’s more complicated, but eventually, we get there.” – B2

This is supported by our data on total rooms traveled and number of portals used. In the tables below, we present the data obtained during the game. In the first table (Table 4.6), we present the data for sighted participants for the full length of the game. For better comparison with blind participants, as they only completed two orders each, we present a second table (Table 4.7) with the data relevant for the first two deliveries for both sighted and blind participants.

Participant	Total Rooms	Total Portals
S1	81	6
S2	52	8
S3	34	8
S4	25	8
S5	25	6
S6	26	9
Best	25	-
Average	27,17	3,83

Table 4.6: Navigation - Full Data for Sighted Players

Participant	Total* Rooms	Total* Portals
S1	25	2
S2	28	5
S3	34	5
S4	25	4
S5	25	4
S6	26	3
B1	32	7
B2	39	8
B3	54	8
B4	87	12
Best (Sighted)	25	-
Best (Blind)	32	-
Average (Sighted)	27,17	3,83
Average (Blind)	53	8,75

Table 4.7: Navigation* - Data for the first two Deliveries.

The portal was very important for blind participants, serving as a beacon/reset when they got lost in the map’s layout, as such blind participants ended up using portals more times than sighted participants.

“It helped a lot because when I needed to return to the center, I couldn’t remember whether it was

to the left or right, but the portal would take me there quickly.” – B3

As a result of the high mental load, blind players were also more likely to stop their movement to check their inventory and/or orders, as opposed to sighted players who rarely did so.

4.5.6 Accounting for Audio Throughput

Navigating the kitchen efficiently is one of the key challenges of the game. As every station in the kitchen takes a certain amount of time to process the ingredients, players must try to complete two orders simultaneously to get a faster time. Navigation is not instantaneous, which means that players need to carefully plan their route in advance to ensure that they can complete orders as quickly and efficiently as possible.

In terms of information processing, sighted players were able to interpret information more quickly and efficiently about their inventory and orders by only looking at one symbol at a time and ignoring the others. On the other hand, blind players were always forced to listen to the full item name whenever they checked their inventory or orders, which slowed down their ability to know both what item they needed and where they needed to go, making navigation more time-consuming compared to sighted players.

Participant (S5) proposed revealing inventory and order symbols sequentially (i.e., one by one), simulating the information processing limitations faced by blind players. This adjustment could create a more balanced experience, with sighted players also experiencing a delay in accessing complete information.

Participant (B1) expressed the desire for additional keys that could provide specific information, stating, *”I would like to have a shortcut key that tells me, ‘characteristic 1 is missing this, characteristic 2 that’.*” This would allow blind players to quickly access the necessary details without having to listen to the entire item description.

While the movement system was designed to be fair and equitable for both sighted and blind players in a vacuum, we recognize that the audio throughput has a significant impact on how the players, especially blind players, are expected to play.

4.5.7 Navigation Performance

Considering the minigame completion times and the delivery times (Table 4.3) we can observe that one determining factor in who wins the game was how well players could navigate through the map. Participant S2 made an interesting observation regarding the movement mechanics of blind players. According to S2, blind players’ navigation is *”more optimized because it takes a shorter path”* and it can be more efficient than a sighted player’s navigation mechanics if mastered.

Although efforts were made to provide players with fair and equitable navigation mechanics-wise, blind players were at a significant disadvantage due to audio throughput limitations. A comparison of total minigame times and decision times reveals that blind players spent considerable time checking their orders and deciding on the appropriate characteristics to select in the minigames.

Participant	Decision	Minigame
S1	0:18	2:20
S2	0:33	2:11
S3	0:21	2:02
S4	0:11	1:53
S5	0:19	1:48
S6	0:14	1:38
Best	0:11	1:38
Average	0:19	1:59

Table 4.8: Minigame Total Times (m:s) - Full Data for Sighted Players

Participant	Decision*	Minigame*
S1	0:10	1:13
S2	0:20	1:31
S3	0:15	1:28
S4	0:05	1:11
S5	0:13	1:08
S6	0:05	0:53
B1	0:36	1:20
B2	0:20	1:40
B3	0:44	2:56
B4	1:20	6:30
Best (Sighted)	0:05	0:53
Best (Blind)	0:20	1:20
Average (Sighted)	0:11	1:14
Average (Blind)	0:45	3:07

Table 4.9: Minigame Total* Times (m:s) - Data for the first two Deliveries.

Furthermore, as mentioned previously (Table 4.7), blind players relied more on portals to orient themselves within the map, resulting in a higher number of room traversals compared to sighted participants. However, it is important to note that a lower total room count does not necessarily indicate better performance, as it may imply a tendency to wait for station completion rather than multitask available orders. This observation is also applicable to the usage of portals.

Participants also provided feedback on potential improvements to the movement mechanics. Some sighted participants suggested the inclusion of identifiable names or text for each station/room. In addition, one blind participant (B3) suggested the inclusion of clear boundaries in the map design, moving away from a circular layout. Another blind participant (B2) proposed an alternative approach to the portal system, suggesting the option to choose destinations instead of being automatically directed to the center. These suggestions could potentially improve spatial orientation and contribute to a better sense of structure for blind players. However, further testing

is necessary to assess their effectiveness and suitability within the game. Notably, both sighted and blind players made a similar number of mistakes (Table 4.10), suggesting that player distraction rather than discrepancies in feedback influenced the error rates. This supports the fact that the feedback provided by both sighted and blind navigation systems was equitable. The two types of mistakes considered were: 1) accessing a station and quitting before making a characteristic selection/completing the minigame (i.e., the player realized that they were not accessing an intended station), 2) accessing a station and completing the minigame with an incorrect characteristic (i.e., the player only realized their mistake once they collected item).

		TA	CPA	EPA	TS
Sighted	Incorrect Interaction (Access)	1	1	-	-
	Wrong Selection (Completed Minigame)	-	-	-	1
Blind	Incorrect Interaction (Access)	-	-	-	1
	Wrong Selection (Completed Minigame)	-	1	1	-

Table 4.10: Gameplay Mistakes

4.5.8 Enjoyment of Fair Mechanics

Navigation mechanics were balanced on technical terms for each player's visual abilities. However, blind participants considered the navigation system to be challenging and confusing, as mentioned previously. Blind participants expressed a preference for more streamlined navigation options, such as having the ability to teleport between rooms (i.e., the ability to choose destinations in the portal) or not having a connected room/circular layout.

When asked about the fairness of the ability to freely teleport between rooms, blind participants considered it an advantage and suggested it should also be available to sighted players.

4.5.9 Audio Feedback Optimization

Sighted participants identified that it was difficult for them to distinguish between certain sounds, which had intermittent moments of audibility, in the Knobs minigame. Both blind and some sighted participants expressed a desire for continuous sounds to enhance gameplay.

“The fire, as it crackles, has moments when you can hear it and others when you can’t” – S5

Participant (B1) also mentioned the need for overall improvement in sound design, stating, *“The sound effects, in general, could be enhanced a bit.”*

4.5.10 Misplaced Sympathy/Empathy

“I enjoyed it, except for the fact that you didn’t tell me the other person was blind until after I won.” – S3

Some sighted participants disclosed that they would have approached the game differently if they had been aware of their opponent's visual impairments beforehand. Specifically, they mentioned that it would have been less competitive and put forth less effort to win. This contrasts with

how blind participants see themselves regarding competition (Table 4.1). Furthermore, sighted participants expressed a sense of guilt regarding their previous attitude during gameplay.

Chapter 5

Discussion

Asymmetric competitive mixed-ability gaming can and did create an engaging experience for pairs (RQ1). Players had a positive experience and expressed their appreciation for the opportunity to engage and interact with individuals with different visual abilities.

Participants highlighted the lack of games that can be enjoyed by both people with and without visual impairments. We obtained valuable feedback from participants' perceptions, which we believe can be informative for future research in gaming and accessibility. Specifically, our observations are particularly relevant for mixed-ability gaming contexts, and we believe that the feedback we collected can contribute to the development of more inclusive and accessible games in the future.

Below we discuss the *Asymmetric Perspectives of Fairness* (RQ2), and reflect on *Asymmetry in Competitive Mixed-Ability Play*.

5.1 Asymmetric Perspectives of Fairness

In the context of our user study on mixed-ability competitive gaming, one interesting finding was the distinct perceptions of fairness among sighted and blind participants in the Partial Asymmetry modules. Notably, the sighted players considered themselves to possess an inherent advantage over blind players. This observation can be attributed to the opportunity given to sighted participants to test both versions of the minigames, enabling them to gain a deeper understanding of the differences between sighted and blind gameplay. which may have influenced their perception of fairness as they were more aware of the asymmetries in the gameplay. We contend that this factor may have influenced sighted participants' classification of fairness in the Partial Asymmetry modules. However, it is important to note that excluding sighted participants from playing the blind minigame would not provide a realistic representation of a real-world experience.

This discrepancy in perception raises questions about the role of knowledge in shaping players' experiences and judgments of fairness. The participants' understanding of the game mechanics and their implications on gameplay fairness deserves careful consideration when designing and evaluating mixed-ability competitive games.

It is crucial to emphasize that these findings do not diminish the validity of asymmetric game

design or its potential benefits for inclusivity. On the contrary, they illuminate the complexities associated with striking a balance between fairness and accessibility when incorporating asymmetry into game mechanics. As game designers, acknowledging these discrepancies opens the door to exploring innovative strategies that ensure both sighted and blind players can have a meaningful and enjoyable experience, without compromising on the unique challenges that asymmetry introduces.

5.2 Asymmetry in Competitive Mixed-Ability Play

Asymmetry in competitive mixed-ability games brings forth unique and dynamic gameplay experiences. However, ensuring a fair, balanced, and engaging gaming environment requires addressing the asymmetry between players with different abilities.

Some sighted participants experienced a sense of guilt and perceived the need to play less competitively when facing blind players. This highlights the need for a change in attitudes and mentalities within the gaming community to ensure an inclusive competitive gaming experience. Both game designers and players should be mindful of these dynamics to foster a truly inclusive competitive gaming environment.

In competitive mixed-ability play, incorporating asymmetry allows both players to feel included, challenged, and engaged, providing equity in the gaming experience. By recognizing the importance of asymmetry in this context and actively striving to create fair gaming experiences we can work towards a gaming landscape that promotes inclusive fun and offers engaging gameplay for players of all abilities. An important aspect for achieving this inclusivity lies in understanding the diverse limitations, perspectives, and needs of players, forming the fundamental basis for cultivating a more inclusive gaming environment.

The results of this highlight work on how it is possible to create mixed-ability competitive gaming that is engaging and perceived as fair. Notably, asymmetric game design was perceived as fair when tailored to each player's abilities (i.e., Total Asymmetry), accommodating their unique strengths and challenges. This concept proves the potential of asymmetry in competitive mixed-ability play and should serve as an inspiration for other researchers and game designers to explore alternative approaches that prioritize inclusive fun, even if they may not cater to universal accessibility.

Chapter 6

Conclusion

This thesis has explored the challenges and opportunities related to the dynamics of asymmetric mixed-ability competitive gaming, specifically focusing on the integration of blind and sighted players. Through an exploration of various aspects such as gameplay mechanics, performance comparisons, and participant feedback, insights have been gained regarding the challenges and opportunities inherent in creating fair and engaging competitive gaming experiences for players of different abilities.

Embracing the unique qualities and abilities of each player, we designed a game that catered to both sighted and blind individuals, where both players competed to be the fastest cook in the kitchen. The findings from our research emphasize that the game was universally enjoyable and engaging, regardless of the participants' visual abilities. Furthermore, the assessment of game balance and fairness was a key aspect of this research. Participants expressed positive sentiments regarding the fairness of the game, underscoring that both the Total Asymmetry and Total Symmetry modules presented equitable opportunities for blind and sighted players to compete. However, only the Total Asymmetry module provided an enjoyable and engaging experience for both sighted and blind players. It is worth highlighting a significant shift in perspective observed among some sighted participants. Upon becoming aware of their opponents' visual impairments, these individuals demonstrated a reduced level of competitiveness and a decreased effort to win, accompanied by a sense of guilt regarding their previous gameplay performance. This contrasted with the perceptions of blind participants, who embraced the spirit of competition and approached the game with a different mindset.

By carefully considering the feedback of participants, implementing accessible features, and fostering a sense of inclusivity, game designers can create competitive experiences that captivate and entertain players with diverse abilities. The insights gained from this research contribute to the ongoing pursuit of creating inclusive gaming environments that promote diversity and provide meaningful experiences for all players, regardless of their abilities.

6.1 Future Work

This thesis approached a specific topic to explore how different combinations of asymmetric and symmetric challenges affected the perceptions of fairness in mixed-ability competitive play, specifically focusing on sighted and blind players. It served as a first step in exploring mixed-ability competitive gaming. Building upon the findings of this thesis, there are several important avenues for future research in the field of mixed-ability competitive gaming.

Firstly, it would be valuable to further explore the impact of direct interaction mechanics on the perceptions of fairness in mixed-ability competitive play. This would involve ensuring players are not only aware of each other but believe they can impact each other's play directly, such as through shared order pools or station sabotage mechanics. Investigating the perceptions of fairness in these scenarios would provide insights into whether asymmetric game design is still perceived as fair when players have the means to affect each other's progress, and how we can make asymmetry unbalanced by design to accommodate the players' perceptions (e.g., based on the results of this thesis, sighted players believe they have the advantage).

Secondly, team competition also presents an intriguing area for future exploration. This would involve team-versus-team gameplay for mixed-ability groups, including roles that allow for team compositions of sighted-only, blind-only, or mixed-ability teams. In this scenario, it would be important to examine whether players with different roles perceive themselves as equally contributing to the game outcome and whether mechanics can be implemented to facilitate effective interplay among teammates, fostering a sense of shared experience and teamwork. Additionally, investigating the perceptions of fairness in these team-based scenarios would provide insights into how asymmetric game design can be leveraged to promote engaging team dynamics, collaboration, and player experiences (e.g., equal recognition of contributions from both sighted and blind players).

Overall, future research should continue to push the boundaries of mixed-ability competitive gaming, exploring new mechanics, team dynamics, and combinations of challenges to create inclusive and balanced gameplay experiences that cater to diverse player abilities and preferences. By addressing these areas, we can further advance the field and pave the way for more accessible and enjoyable competitive gaming experiences for players of all abilities, regardless of their abilities.

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Appendix A

Interview Script

1. What did you think of the experience?
 - a. Do you usually play this type of games?
 - b. What did you think of this game, considering it was designed for a mixed ability context?
2. Explain/Show the asymmetries in the mini-games [Sighted participants can try the other version (use headphones)]

Minigames

- Silhouettes: The player is shown various items floating on the screen. The player tries to memorize those that match their selection in the selection menu (e.g., toxic = purple objects). After some time, the player can only see shadows of the displayed objects and must click on the correct ones after a short delay. The player can see the objects again if they want. When the player guesses incorrectly, they are temporarily blocked from further attempts.
- Search: The player is located in a cell on a 5x5 grid, and their goal is to find the target cell (which has a unique sound). After each move, if the player stays in the location for some time, they receive feedback about their movement direction (positive or negative). The player receives a "bump" feedback sound if they try to leave the grid.
- Extraction: The sighted player sees a bar they have to follow. The blind player follows a directional sound.
- Knobs: The game is the same, i.e., visual and auditory.
- Cards: The game is the same, i.e., entirely auditory.

Navigation

- Sighted: Navigation is free, and the layout of the rooms is exactly the same for both.
- Blind: Navigation is point-based, and movement is automatic between points [show].

Station

- Sighted: There is a symbol above the station that changes color when the station is ready.
- Blind: An alarm sound is heard when the station is ready if the player is inside that room or upon entering that room.

Inventory

- Sighted: The item in hand appears visually.
- Blind: The item in hand is similar to hearing a request.

Orders

- Orders are the same and given in the same order.

3. Fairness
 - a. Could you comment on the fact that you now have knowledge of these asymmetries?
 - b. Minigames **Fairness Questionnaire** (counterbalanced) - On a scale from 1 to 5, with 1 being at a disadvantage and 5 being at an advantage, how did you feel about your opponent and why?
 - i. In the Silhouettes/Search minigame?
 - ii. In the Knobs minigame?
 - iii. In the Extraction minigame?
 - iv. In the Cards minigame?

Appendix B

Themes Outline

EXPLORING ASYMMETRIC COMPETITIVE GAMING FOR MIXED VISUAL ABILITY

Outline of Themes Discussed

THEME TITLE	DESCRIPTION	INFORMING CODES
Discrepancy of Perspectives	Players had different perspectives on the game, with some sighted players perceiving an inherent advantage throughout the game, while blind players generally found the game to be a balanced experience.	MINIGAME, NAVIGATION, FAIRNESS, PLAYER EXPERIENCE, GAME, EXPERIENCE CONTEXT
Asymmetric Game Design Perceived as Fair	Both sighted and blind considered the minigame pair with total asymmetry as fair.	MINIGAME (SILHOUETTES, GRID), FAIRNESS, EXPERIENCE CONTEXT (MIXED ABILITY)
Equal Game Fair	The minigame with total symmetry was considered by both sighted and blind participants to be fair.	MINIGAME (CARDS), FAIRNESS, EXPERIENCE CONTEXT (EQUAL ABILITY)
Individual Self Accessed Mastery	The amount of practice time and prior gaming experience with similar game mechanics may have influenced players' ability to adapt to the game's mechanics.	GAME (ONBOARDING), EXPERIENCE CONTEXT (COMPETITION), PRACTICE
Graphic vs Audio Feedback	The use of different types of feedback can lead to varying levels of mental load and information processing time for players.	FEEDBACK, MECHANICS CHANGES, PLAYER EXPERIENCE, TIME, PRACTICE
Navigation Performance	One determining factor in who wins the game was how well players could navigate through the map. Navigation was a greater challenge for blind players than for sighted players.	NAVIGATION, FAIRNESS, MECHANICS CHANGES, FEEDBACK

Appendix C

Codebook

CompetitiveMixed Codebook

1. Player Type	The visual ability of the player being referenced.
1.1 SIGHTED	
1.2 BLIND	
2. Minigame	The different minigames and their asymmetry level
2.1 SILHOUETTES	Total Asymmetry, sighted version
2.2 GRID	Total Asymmetry, blind version
2.3 KNOBS	Combined Partial Asymmetry
2.4 EXTRACTION	Exclusive Partial Asymmetry
2.5 CARDS	Full Symmetry; audio only
3. NAVIGATION	How the player experienced navigation
3.1 ROOMS	
3.2 TELEPORTATION	Teleportation of any form
3.2.1 PORTAL	Teleportation via portal
3.3 AWARENESS	Participant's spatial awareness / mental map
4. Fairness	How the player perceived a play experience or game mechanic
4.1 ADVANTAGE	
4.2 DISADVANTAGE	
4.3 EQUALITY	
4.4 EQUITY	
4.5 UNSURE	
5. Feedback	How the information is conveyed in the game
5.1 Attitude	Reaction to the feedback
5.1.1 POSITIVE	
5.1.2 NEGATIVE	
5.2 Output	The type of feedback
5.2.1 AUDIO	
5.2.2 GRAPHIC	
6. Mechanics Changes	How a certain mechanics could/should be change, according to the participant
6.1 Type of Change	
6.1.1 ADD	Add a new mechanic
6.1.2 REMOVE	Removing an existing mechanic
6.1.3 CHANGE	Alter an existing mechanic
7. Player Experience	How participants describe a play experience or game mechanic
7.1 BALANCED	
7.2 FUN	
7.3 CHALLENGING	
7.5 INTERESTING	
7.6 CONFUSING	
7.9 SIMPLE	
8. GAME	The game in general
8.1 NAMES	When referring to the names used in a game component
8.2 INVENTORY	The player's inventory
8.3 ORDERS	The orders to be completed
8.4 ALARM	When referring to the station sound alarm/visual indicator
8.5 CHARACTER	The player character in the game
8.6 ONBOARDING	The onboarding process

9. Experience Context	
9.1 COMPETITION	When referring to the game in a competitive context
9.2 MIXED ABILITY	When referring to the game in a mixed ability context
9.3 EQUAL ABILITY	When referring to the game in an equal ability context
10. TIME	When referring to the speed at which a certain action or task can be completed
11. PRACTICE	The participant's thoughts on how more or less practice would affect their performance.

Appendix D

Item Descriptions/Voice-overs

Weapon 16 in total

Inscription	Weapon Type	Element
Arcane	Wand	of Flames
		of Blizzards
		of Tempest
		of Sandstorms
	Staff	of Flames
		of Blizzards
of Sandstorms		
Mystical	Wand	of Flames
		of Blizzards
		of Tempest
		of Sandstorms
	Staff	of Flames
		of Blizzards
of Sandstorms		

Weapon Type	Inscription	Element
Varinha	Luminoso(a)	de Fogo
		de Água
		de Vento
		de Terra
	Místico(a)	de Fogo
		de Água
de Terra		
Bastão	Luminoso(a)	de Fogo
		de Água
		de Vento
		de Terra
	Místico(a)	de Fogo
		de Água
de Terra		

Table D.1: Weapon Item - Characteristics Table.

During the study session of the game, the Weapon Type "Staff/Bastão" remained unused.

Flask		48	in total			
Effect	Element	Potency	Potency	Effect	Element	
Hasty	Flaming	Potion	Poção	Energético(a)	de Fogo	
		SuperPotion			de Água	
		HyperPotion			de Vento	
	Frosting	Potion		de Terra	Vigoroso(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Tempestuous	Potion		de Terra	Tóxico(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Crystallized	Potion		de Terra	Fantasmal	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
Mighty	Flaming	Potion	Super-Poção	Energético(a)	de Fogo	
		SuperPotion			de Água	
		HyperPotion			de Vento	
	Frosting	Potion		de Terra	Vigoroso(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Tempestuous	Potion		de Terra	Tóxico(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Crystallized	Potion		de Terra	Fantasmal	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
Toxic	Flaming	Potion	Hiper-Poção	Energético(a)	de Fogo	
		SuperPotion			de Água	
		HyperPotion			de Vento	
	Frosting	Potion		de Terra	Vigoroso(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Tempestuous	Potion		de Terra	Tóxico(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Crystallized	Potion		de Terra	Fantasmal	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
Spooky	Flaming	Potion	Hiper-Poção	Energético(a)	de Fogo	
		SuperPotion			de Água	
		HyperPotion			de Vento	
	Frosting	Potion		de Terra	Vigoroso(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Tempestuous	Potion		de Terra	Tóxico(a)	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		
	Crystallized	Potion		de Terra	Fantasmal	de Fogo
		SuperPotion		de Água		
		HyperPotion		de Vento		

Table D.2: Flask Item - Characteristics Table.

Appendix E

Logs

Log File	Log Name	Description
Movement	UP, DOWN, LEFT, RIGHT, ONE, TWO, TELEPORT	Movement related key presses (Blind-only)
Rooms	MAIN, DELIVERY, ELEMENT, POTENCY, EFFECT, INSCRIPTION	Tracks player's movement between rooms
Minigames	minigameType, decisionTime, completionTime, completed	Minigame, decision time (time in selection menu), minigame duration, minigame completed/canceled
UI	Z	Player checks the first available order
	X	Player checks the second available order
	C	Player checks the held item
	V	Player cancels item narration (blind only)
	T	Player trashes (deletes) the held item
	M	Player checks the current room (blind only)
	TAB	Player checks the score
Stats	playerType	The type of player (sighted or blind)
	totalRooms	Total number of rooms travelled
	totalPortals	Total number of portals used
	totalItemsDelivered	Total number of items delivered
	totalItemsPicked	Total number of items picked from chests or stations
	totalItemsDropped	Total number of items dropped in stations
	totalItemsSwapped	Total number of item swaps (i.e., switch held item with item in station) in stations
	totalDecisionTime	Total time in the characteristic selection menu
	totalMinigameTime	Total time playing the minigame
	totalGameTime	Total game time
	stationProcessingTime	The time it takes for a station to be 'ready'
	usedNumPad	Did the player use numpad? [only relevant for the Cards minigame]
	usedAlphaNum	Did the player use alphanumeric? [only relevant for the Cards minigame]
isWin	Did the player win?	
Actions	-	All Logs in one file

Table E.1: Log List
All logs are timestamped.

Appendix F

Keybinds

Keybind	Action
WASD Keys	Sighted player's movement
Arrow Keys	Blind player's movement between rooms and menu navigation
Numbers 1 and 2	Blind player's movement inside a room
E/Spacebar	Interact with chests, stations, portals and the delivery
Z	Checks the first available order
X	Checks the second available order
C	Checks the held item
V	Cancels item narration (blind only)
T	Trashes (deletes) the held item [requires double tapping]
M	Checks the current room (blind only)
TAB	Checks the score
Spacebar/Enter	Confirmation key for menus and minigames
Numbers 1 through 9	Cards minigame - listen cards
Escape	Cancel the minigame

Appendix G

Tutorial/Walkthrough

Game

Now, we will use the minigames you've already played and include them in a game that consists of the following:

- This game is a competition between two cooks. The objective is to fulfill a given number of orders before the opponent.
- You will be walking around the kitchen and will be able to grab items and access stations.
- These orders are related to potions and staffs, to which you need to add various characteristics (for example, adding Fire to a Potion to get a Fire Potion) and take it to the delivery area.
- The process of adding these characteristics requires the completion of one of the minigames. These characteristics are chosen in the selection menu that appears before each mini-game.

I ask you to put on headphones [Start the application]

(In this tutorial, I am the opponent [Start on the second computer])

At any time, you can provide feedback about the experience.

Kitchen Sighted Walkthrough (Step-by-Step)

Explain Controls/Mechanics

a. Orders

- i. **Spooky Tempestuous Super-potion**
- ii. **Arcane Staff of Blizzards**

- At the beginning of the game, you will hear the first two orders. And, after the starting signal, you can begin to play.
- There are 2 types of orders: **Potion** and **Staff**.
- To repeat the first order: press **Z**. To repeat the second order: press **X**. To cancel: press **V**.
- The game starts in the **Main Room/Centre**, where we can fetch ingredients to fulfill the orders. To move, use the **WASD** keys.
- To create a potion, we need a flask.
- [Player approaches a chest]
- To interact, use the **Space Bar** or **E**. [Player grabs an ingredient].
- To check what we are holding, use the **C** key. [Player confirms the ingredient they have in hand]
- **T** allows dropping/disposing of the item in hand (requires confirmation: double-tap). [Player discards the object in hand]
- Let's start the first order then. [Player grabs a **Flask**]
- Now, concerning the **Flask**, we can add a power: **Potion**, **Super-Potion**, or **Hyper-Potion**; an effect (**Hasty**, **Mighty**, **Toxic**, or **Spooky**); and an element (**Water**, **Earth**, **Fire**, or **Wind**).
- Now, let's find out what each room does [Navigate through the rooms and explain what each one does]
 - Main Room/"Centre" - In this room, you can access chests to obtain a base ingredient (**Flask** or **Staff**).
 - Element Room - In this room, you can add an element (**Water**, **Earth**, **Fire**, or **Wind**) to one of the items [Knobs minigame].
 - Inscription Room - In this room, you can add an inscription (**Mystical** or **Arcane**) to a **Staff** [Cards minigame].
 - Effect Room - In this room, you can add an effect (**Hasty**, **Mighty**, **Toxic**, or **Spooky**) to a **Flask/Potion** [Silhouettes minigame].
 - Potency Room - In this room, you can add a power (**Potion**, **Super-Potion**, or **Hyper-Potion**) to a **Flask/Potion** [Extraction minigame].

- In each room, there is a station where you can transform the ingredient. You can start making the first order. [Player approaches one of the stations, reminding to use **Space Bar** or **E** to interact]
- [Player completes the minigame] The station takes some time to process. So, to be more efficient, it is advisable to fulfill multiple orders at the same time.
- You can find out if a station is ready through the indicator above it.
- Therefore, let's start the second order. [Remind to press **X** to hear the second order]
- To quickly access the **Main Room/Centre**, you can use the portal. To confirm, press the **Space Bar** or **E**. [Player uses the portal]
- [Player starts making the staff]
- For the **Staff**, we can add an inscription: **Mystical** or **Arcane**. And just like with the potion, we also have to add an element: **Water**, **Earth**, **Fire**, or **Wind**.
- While the staff is being made, we will continue with the potion.
- [Player goes to the room where the potion is] To grab the Potion, use the **Space Bar** or **E**.
- [Player continues until having a ready order]
- To deliver an order, you need to take it to the delivery area, which is located below the **Main Room/Centre**. [Player goes to the **Delivery** and interacts to complete the order].
- During the game with an opponent, you can use the **Tab** key to see the number of orders delivered by each player (player, opponent). [Player confirms the score]
- [Player completes the second order]

Kitchen Blind Walkthrough (Step-by-Step)

Explain Controls/Mechanics

a. Orders

- i. **Spooky Tempestuous Super-potion**
- ii. **Arcane Staff of Blizzards**

- At the beginning of the game, you will hear the first two orders. And, after the starting signal, you can begin to play.
- There are 2 types of orders: **Potion** and **Staff**.
- To repeat the first order: press **Z**. To repeat the second order: press **X**. To cancel: press **V**.
- The game starts in the **Main Room/Centre**, where we can fetch ingredients to fulfill the orders. Navigation within a room is done using the numbers **1** and **2**.
- To create a potion, we need a flask.
- [Player approaches a chest]
- To interact, use the **Space Bar** or **E**. [Player grabs an ingredient].
- To check what we are holding, use the **C** key. [Player confirms the ingredient they have in hand]
- **T** allows dropping/disposing of the item in hand (requires confirmation: double-tap). [Player discards the object in hand]
- Let's start the first order then. [Player grabs a **Flask**]
- Now, concerning the **Flask**, we can add a power: **Potion**, **Super-Potion**, or **Hyper-Potion**; an effect (**Hasty**, **Mighty**, **Toxic**, or **Spooky**); and an element (**Water**, **Earth**, **Fire**, or **Wind**).
- The rooms are arranged in a circle, and navigation between rooms is done using the directional arrows (left and right). When trying to leave one, you will hear a door sound. To confirm that you want to leave, press the same arrow.
- When playing with another person, you will also hear their footsteps when they are in the same room.
- Now, let's find out what each room does [Navigate through the rooms and explain what each one does]
 - Main Room/"Centre" - In this room, you can access chests to obtain a base ingredient (**Flask** or **Staff**).
 - Element Room - In this room, you can add an element (**Water**, **Earth**, **Fire**, or **Wind**) to one of the items [Knobs minigame].

- Inscription Room - In this room, you can add an inscription (**Mystical** or **Arcane**) to a **Staff** [Cards minigame].
- Effect Room - In this room, you can add an effect (**Hasty**, **Mighty**, **Toxic**, or **Spooky**) to a **Flask/Potion** [Search minigame].
- Potency Room - In this room, you can add a power (**Potion**, **Super-Potion**, or **Hyper-Potion**) to a **Flask/Potion** [Extraction minigame].
- To access the station (which transforms the ingredient) of a room, use the key **1**. You can start making the first order. [Player approaches one of the stations, reminding to use **Space Bar** or **E** to interact]
- [Player completes the minigame] The station takes some time to process. So, to be more efficient, it is advisable to fulfill multiple orders at the same time.
- When a station is ready, you will hear an alarm if you are inside that room or when you enter the room. [Wait for the station alarm]
- Therefore, let's start the second order. [Remind to press X to hear the second order]
- To quickly access the **Main Room/Centre**, you can use the portal. To access the portal, use the **up arrow**. To confirm, press the **Space Bar** or **E**. [Player uses the portal]
- [Player starts making the staff]
- For the **Staff**, we can add an inscription: **Mystical** or **Arcane**. And just like with the potion, we also have to add an element: **Water**, **Earth**, **Fire**, or **Wind**.
- While the staff is being made, we will continue with the potion.
- [Player goes to the room where the potion is] To grab the Potion, use the **Space Bar** or **E**.
- [Player continues until having a ready order]
- To deliver an order, you need to take it to the **Delivery** area, which is located below the **Main Room/Centre**. [Player goes to the **Delivery** and interacts to complete the order]
- During the game with an opponent, you can use the **Tab** key to see the number of orders delivered by each player (player, opponent). [Player confirms the score]
- [Player completes the second order]

Appendix H

Mini PXI

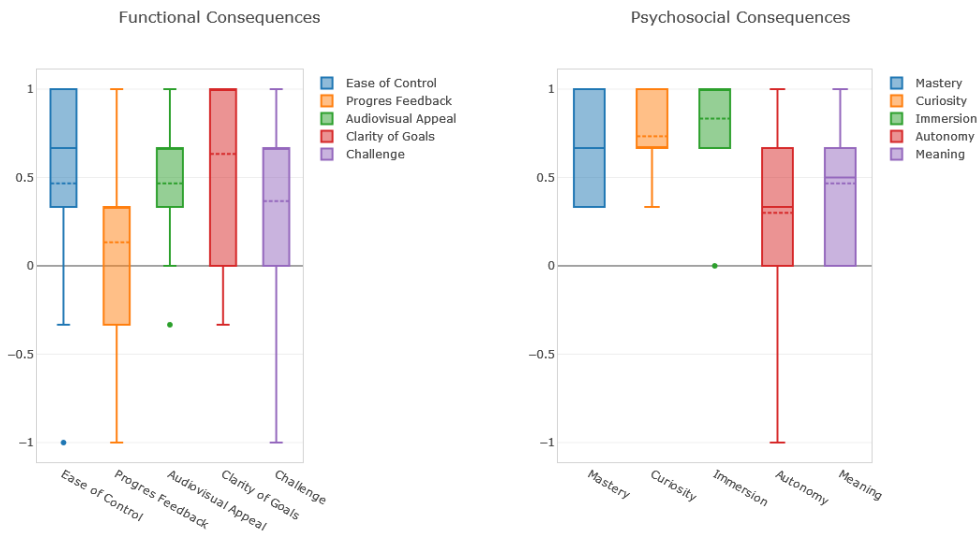


Figure H.1: Mini PXI - Overall

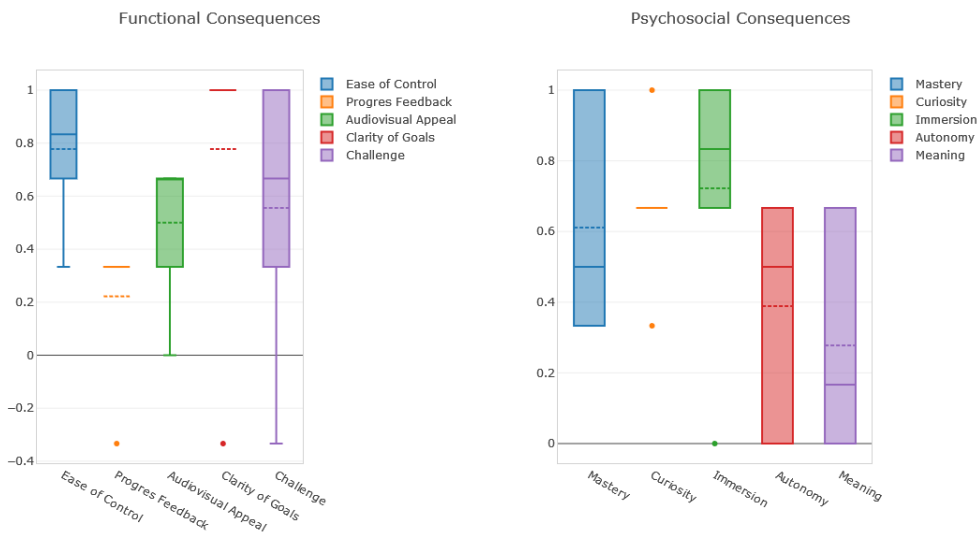


Figure H.2: Mini PXI - Sighted

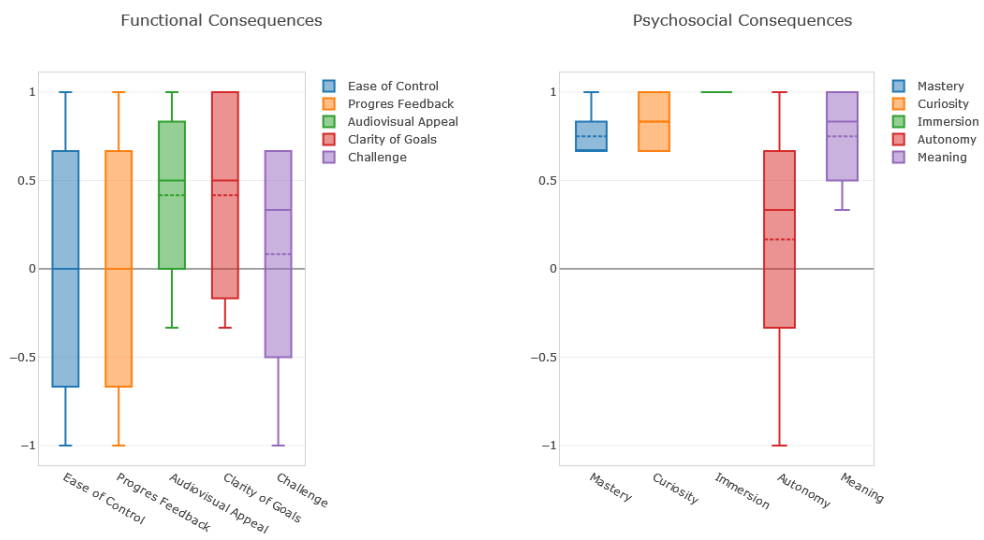


Figure H.3: Mini PXI - Blind