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Exploring Asymmetry of Information in Cooperative Games

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Resumo

O domínio dos jogos sofreu uma evolução notável ao longo das décadas, transformando-se de simples ecrãs pixelizados em mundos virtuais imersivos que cativam milhões de pessoas em todo o mundo. Desde os primórdios das máquinas de arcade até à ascensão das consolas domésticas e ao advento dos jogos multijogadores online, o panorama do entretenimento digital expandiu-se exponencialmente, oferecendo uma vasta gama de experiências a jogadores de todas as idades e origens.

Os jogos têm o potencial de suscitar sentimentos de união via uma atividade partilhada, desafiante e imersiva. Os jogos concebidos especificamente para induzir a interação social são vistos como tendo efeitos positivos nos jogadores. Investigações relacionadas com esta temática sugerem que estes efeitos positivos incluem a melhoria das competências sociais, a criação e manutenção de relações e o impacto positivo no bem-estar psicológico e nos sentimentos de confiança. Os jogos digitais contribuem para estes benefícios, uma vez que se tratam de uma forma de jogo que é frequentemente mais fácil de iniciar e de participar. A natureza dinâmica e muitas vezes fluida dos jogos digitais permite-lhes ser apelativos para um público mais vasto, sendo assim uma ferramenta que pode ser facilmente acedida por todos.

A investigação neste domínio tem feito progressos consideráveis na formalização e concetualização de vários aspetos da conceção e desenho de jogos e das experiências dos jogadores. No entanto, o panorama dos jogos está em constante evolução, com o aparecimento de novos géneros, tecnologias e demografias de jogadores. Por conseguinte, existe uma necessidade de desenvolver modelos e estruturas mais sofisticados que possam captar as complexidades das experiências de jogo modernas. Estes modelos devem ter em conta fatores como a diversidade dos jogadores, a acessibilidade e a natureza dinâmica dos ambientes de jogo digital. Ao melhorar a nossa compreensão dos jogos por meio de quadros teóricos e modelos conceptuais sólidos, os investigadores e os designers podem responder mais eficazmente às diversas necessidades e preferências dos jogadores, melhorando, em última análise, a qualidade geral e a inclusão das experiências de jogo.

Desta forma, argumentamos que a conceção de jogos assimétricos surge como uma via promissora para a geração de sentimentos de confiança e cooperação através de interações sociais mais frequentes e ampliadas. Embora a assimetria se possa manifestar em várias facetas de um jogo, centramo-nos especificamente na assimetria na distribuição de informação. O nosso propósito é refletir sobre as diversas implementações da assimetria de informação, que permanecem largamente inexploradas. Assim, o nosso objetivo é investigar o impacto dos diferentes tipos de assimetria de informação na experiência do jogador.

Primeiramente, propomos um enquadramento da assimetria de informação como uma extensão de investigação anterior neste domínio e com base em exemplos da indústria, com potencial para servir como ferramenta de análise, ideação, conceção de estudos e discurso mais claro. Este modelo pretende

encapsular as possibilidades de manipulação da assimetria de informação, desconstruindo-a nas suas componentes percecionadas, servindo assim como um primeiro passo para a compreensão e formalização deste tipo de assimetria.

Este quadro segmenta a assimetria de informação nos conceitos de Implementação e Perceção. O primeiro refere-se a quem tem a informação e a quem terá de a utilizar. Esta dimensão compreende as seguintes subcategorias: Implementação de Posse (i.e., quem tem a informação ou quem tem acesso a ela) e Implementação de Utilidade (i.e., quem usa ou precisa da informação). O segundo, Perceção, refere-se a quem tem consciência dos diferentes aspetos relacionados com a informação. Esta dimensão inclui as seguintes subcategorias: Perceção de Posse (i.e., quem sabe quem tem a informação), Perceção de Utilidade (i.e., quem sabe quem precisa da informação), Perceção de Localização (i.e., quem sabe onde a informação é utilizada), e Perceção de Consequência (i.e., quem sabe a consequência da utilização da informação).

Para operacionalizar o modelo proposto, um jogo digital cooperativo para dois jogadores, Parallel Realms: Asymmetry United, foi desenhado e desenvolvido. O principal objetivo deste artefacto é investigar os efeitos de vários tipos de assimetria de informação nas perspetivas dos jogadores. No jogo, os jogadores colaboram para navegar uma masmorra, combater inimigos e enfrentar desafios na forma de puzzles. Estes seis puzzles foram concebidos com base numa seleção de tipos de assimetria de informação, construídos utilizando o modelo, e constituem o foco do nosso estudo. Através do jogo, os jogadores têm de comunicar e partilhar eficazmente informações pertinentes para ultrapassar esses desafios, proporcionando assim perspetivas valiosas sobre as dinâmicas da assimetria de informação.

O artefacto digital desenvolvido foi utilizado num estudo de laboratório com 10 pares de jogadores. O objetivo foi examinar as perceções dos jogadores sobre a assimetria de informação em jogos cooperativos e a forma como os vários tipos de assimetria influenciam a interação social. Este estudo permitiu aos participantes experienciar o jogo, preencher questionários e participar numa entrevista de grupo com os seus respetivos parceiros de jogo. A análise dos resultados utilizou uma abordagem de métodos mistos, com base em dados de jogo, respostas a questionários e gravações de entrevistas, com os quais procurámos compreender o impacto da assimetria de informação na conetividade percecionada pelos jogadores com o seu parceiro de jogo, na comunicação, na experiência, na diversão e envolvimento e no sentido de desafio.

O estudo de utilizadores revelou que os participantes, mesmo que não explicitamente conscienciali-zados, percecionaram a existência de assimetria de informação e as suas subcategorias, particularmente aqueles com experiência prévia neste tipo de jogos ou com conhecimento de conceitos de assimetria. Esta assimetria influenciou a colaboração e a progressão, tendo alguns desafios sido recebidos de forma negativa devido ao seu carácter unilateral ou à perceção de que ambos os jogadores tinham acesso à mesma informação. Além disso, a quebra das expetativas de coerência e a introdução de valores combinatórios do modelo tiveram um impacto na experiência do jogador, levando-os à confusão ou ao entusiasmo. Certas combinações de valores resultaram em puzzles desafiantes, mas bem recebidos, enquanto outros causaram frustração. Estas descobertas oferecem uma perspetiva sobre como os designers podem utilizar a assimetria e as suas subcategorias como ferramentas na conceção de jogos para criar experiências diversificadas e cativantes.

Adicionalmente, a assimetria de informação provou ser um fator significativo de interação social no

nosso contexto cooperativo, necessitando inerentemente de comunicação e colaboração para ultrapassar obstáculos. No entanto, o contraste nos padrões de comunicação observados durante as mecânicas assimétricas relativamente a outros aspetos do jogo realça o papel desta assimetria na modelação e orientação da interação social no presente contexto. Estratégias como o atraso na troca de informações ou a prioridade à exploração surgiram à medida que os jogadores navegavam no jogo, refletindo níveis variáveis de envolvimento com o seu parceiro de jogo. Isto sugere que, embora a assimetria influencie o fluxo de comunicação, os fatores individuais, por exemplo, a ligação e o desempenho do jogador, também desempenham um papel importante. Diferentes configurações de assimetria provocaram reações distintas, tais como instâncias com menos interação e outras que promoveram uma colaboração mais profunda devido à sua complexidade. A complexidade introduzida pela assimetria acabou por influenciar a quantidade e a qualidade das interações dos jogadores, moldando a perceção da eficácia da comunicação.

O trabalho desenvolvido contribui significativamente para a compreensão e aplicação da assimetria de informação. Em primeiro lugar, apresenta um modelo concetual que amplia o trabalho anterior neste domínio, fornecendo uma estrutura abrangente para analisar diferentes aspetos da assimetria de informação. Em segundo lugar, a investigação traduz este quadro numa forma tangível através do desenvolvimento de um protótipo de jogo cooperativo digital. Este protótipo apresenta seis desafios de jogo concebidos e implementados que correspondem a diferentes combinações de valores para as subcategorias da estrutura proposta. Finalmente, o estudo contribui com uma validação da abordagem, no seu contexto, através de estudos de utilizadores envolvendo 10 pares de participantes.

Em suma, o nosso estudo realça o impacto da assimetria de informação nos jogos cooperativos. Através da nossa estrutura e conceção do jogo, explorámos a sua influência nas interações dos jogadores. Compreender dinâmicas como estas é crucial para criar experiências de jogo envolventes e socialmente enriquecedoras no cenário em evolução que é o dos jogos.

Palavras-chave: jogos, assimetria, cooperativo, informação, modelo concetual

Abstract

Digital gaming has the potential to prompt feelings of togetherness through a shared, challenging and immersive activity. Games designed to specifically induce social interaction positively affect players. We argue that asymmetry can act as an important catalyst in generating feelings of trust and cooperation through more frequent and heightened social interactions. Asymmetry can be applied to many facets of a game. In our work, we focused on asymmetry of information, more specifically in the context of cooperative games, which presumes the distribution of information among players. Prior work categorised this dimension as a form of asymmetry, as well as the dimensions that affect it, however, the way this distribution is implemented can vary significantly, as it is unclear what these are and how different implementations of this design strategy lead to different interactions. Our aim was to understand how different types of information asymmetry affect the player experience. To achieve this, we expanded upon previous research and propose an extension to the concept of asymmetry of information through a devised framework. This framework was applied to the design and development of a collaborative prototype game based on information asymmetry. In a laboratory study with 10 player pairs, we sought to understand the impact of asymmetry of information on the players' perceived connectivity with their play partner, communication, overall experience, fun and sense of challenge, through a mixed-methods approach. Our results suggest that players could perceive the presence of asymmetry of information and its various subcategories, and that these differences shaped social interactions between players.

Keywords: gaming, asymmetry, cooperative, information, framework

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Chapter 1

Introduction

Over the course of several decades, gaming experienced a remarkable evolution, progressing from its modest beginnings of pixelated screens to immersive virtual worlds that captivate the imaginations of millions worldwide. From the era of arcade cabinets to the widespread adoption of home consoles and the advent of online multiplayer gaming, the digital entertainment landscape has expanded exponentially, offering a diverse array of experiences to players of all ages and backgrounds [1].

Games have a distinct ability to foster a sense of connection and togetherness through shared, engaging activities. Particularly, games designed to promote social interaction have been observed to yield positive effects on players, including enhancements in social skills, facilitation of relationship formation and maintenance, and contributions to psychological well-being [2, 3, 4]. The accessibility and versatility of digital games further enhance their role in social engagement, appealing to a broad audience with their dynamic and adaptable nature [5].

Despite significant progress in understanding game design and player experiences, the gaming landscape continues to evolve rapidly. New genres, technologies, and player demographics emerge regularly, challenging designers and researchers to keep pace. There is a growing need for more sophisticated models and frameworks that can effectively capture the complexities of modern gaming experiences. These models must consider factors such as player diversity, accessibility, and the dynamic nature of digital gaming environments.

By advancing our understanding of games through robust theoretical frameworks and conceptual models, researchers and designers can better cater to the diverse needs and preferences of players. This, in turn, can lead to improvements in the overall quality and inclusivity of gaming experiences, ensuring that gaming remains a vibrant and engaging form of entertainment.

1.1 Asymmetric Play and Social Interactions

Asymmetry within games can serve as a catalyst for nurturing trust and cooperation, particularly in cooperative gaming contexts. While asymmetry can manifest in various facets of gameplay, our focus lies specifically on the asymmetry of information distribution. We aim to shed light on the diverse implementations of this aspect, which remain largely unexplored. Thus, our objective is to investigate how different types of information asymmetry impact the player experience. To achieve this, the first step was to extend upon existing research on asymmetry by designing and iterating over a novel framework for

understanding asymmetry of information. This framework aims to inform the design and development of asymmetric games centred around information asymmetry. Consequently, the second step was to design and develop a digital cooperative game prototype bolstering asymmetric challenges based on the framework proposed. Finally, through a laboratory study involving player pairs, the final step was to examine the effects of asymmetry of information on players' perceived connectivity, communication, overall experience, enjoyment, and sense of challenge, by allowing them to engage with the digital game developed and applying a mixed-methods approach.

With the work conducted, we aim to answer the following research questions:

- **RQ1:** How do players perceive asymmetry of information in cooperative games?
- **RQ2:** How do different types of asymmetry of information shape social interaction between players?

1.2 Contributions

This work constitutes the following contributions:

- **A conceptual approach to asymmetry of information.** A framework for the concept of asymmetry of information was devised, as an extension of previous work in the field. This framework aims to capture the multiple subcategories of asymmetry of information and their possible values.
- **A proof-of-concept instance of the framework.** A digital cooperative game prototype was designed and developed based on the concept of asymmetry of information. Six game challenges were designed and implemented, which correspond to six different combinations of values for the subcategories of the framework for asymmetry of information.
- **Validation of the approach through user studies.** Laboratorial studies were conducted with 10 player pairs, where the developed digital game was used as the research artefact. A mixed-methods approach was applied to the analysis of the results.

1.3 Structure

This document comprises the following chapters:

- **Chapter 1 - Introduction:** This section presents the context, motivation, problem definition, approach, contributions, and structure of this work.
- **Chapter 2 - Related Work:** Here, we offer an overview of related work in the field, focusing on the advantages of gaming, asymmetric game design, and the various models, frameworks, and structures used to define games.
- **Chapter 3 - Defining Asymmetry of Information:** In this section, we introduce our proposed framework for asymmetry of information, outlining the process of its conception, design, and iterative refinement, along with its key components.

- **Chapter 4 - Designing for Asymmetry of Information:** This section introduces the developed digital game prototype, outlining the process of its conception, design, and iterative development. It includes a description of the game, the tools utilised, and the systems implemented. Furthermore, an overview of the asymmetric challenges designed based on the asymmetry of information framework is provided.
- **Chapter 5 - Evaluating Asymmetry of Information:** Here, we outline the evaluation protocol undertaken with 10 player pairs who engaged with the developed game. This section encompasses an explanation of the collected data, participants' perceptions, and a subsequent discussion on the implications thereof.
- **Chapter 6 - Conclusion:** In this section, we offer a summary of the conducted work, discuss its limitations, and explore potential avenues for future research.

Chapter 2

Related Work

In this section we will be reviewing the literature analysed, presenting the state of the art and giving better context to the subject at hand. We will begin by presenting related work and its findings on the potential of gaming as a catalyst for social interactions, as well as previous work regarding asymmetric games, as these are considered to be a viable option to tackle differences between players and to have the potential to generate richer interactions when compared to symmetric play experiences, thus aiding in the design of games and expanding the design space of possible game mechanics. Finally, we present past work regarding the definition of games through frameworks and models.

2.1 Gaming Promoting Social Interactions

Engaging in digital gaming offers a unique avenue for fostering social interaction and communication among individuals. Through multiplayer gameplay, participants can experience a multitude of benefits, such as the development of prosocial behaviour [6] and the reinforcement of interpersonal bonds [2, 4, 7, 8, 9, 10, 11, 12]. Gaming not only has the potential to strengthen connections between players but also has the potential to empower individuals with disabilities through inclusive gaming experiences [13, 14]. Moreover, gaming together can yield cognitive, motivational, and emotional advantages for all involved [8, 15]. Digital gaming has the potential to prompt feelings of togetherness. This is further supported by several studies which analysed the positivity elicited by gaming, as well as in-game social capital, psychological well-being and feelings of trust.

The study by Khalis et al. [3] aimed at analysing the role of social interactions on positivity generated by playing an AR game - *Pokémon GO* [16]. In the study, it was found that players who displayed higher noxious mood states or depressive symptoms, in relation to the remaining users, experienced a stronger association between more positive social interactions and positivity [3]. These findings contribute to the idea that gaming can be beneficially impactful as a venue for the establishment of bonds through social interactions, supporting contemporary views of gaming that dispel the myth of socially inadequate gamers [2, 3, 17]. As such, games like *Pokémon GO* [16], which encourage social interaction, both in the virtual world as well as in the real world, through specifically designed mechanics, namely gift giving, battling with friends and raids, can prove to be effective at making the hurdles of socialising smaller for those who might struggle in social settings [3]. These findings are further supported by other studies, such as the one carried out by Depping et al. [2].

In the study by Depping et al. [2], the authors aimed at modelling the properties of play, and in-game social capital, and analysing their impact on psychological well-being. The study found that social connections developed in-game were highly associated with the users' psychological well-being [2]. In its context, players built social capital in games, depending on how they played, which was also linked to positive effects on their psychological well-being [2]. This in-game social capital was found to be strongly linked to reduced feelings of loneliness and higher satisfaction of relatedness [2], further supporting the idea that gaming is a possible catalyst for social interactions and bonding.

This bonding effect that gaming provides can be somewhat attributed to the effect of trust between players. In prior work, the authors found that the conditions provided in the study's developed game allowed players to practise or conduct cooperation and trusting behaviours, leading to activity-based interactions which were considered to have built an interpersonal connection through experimentation, rather than through shared knowledge or similarities, which were often the main bonding aspects in a social conversation [18]. Although these results should be generalised considering the fact that they could be attributed only to the specific mechanics exclusively implemented in the game developed, the game still proved to be as effective at fostering a relational connection between two players as a social conversation [18].

As mentioned in the sections above, gaming is a large growing activity nowadays bringing together both the young and the old [1], through intergenerational gaming, which is defined as a field of study in gaming research which focuses on determining what it means to play with another generation, and what are the best practices to keep in mind or to avoid when designing games for multiple generations to play together. Hera et al. [10], which conducted a systematic literature review on the benefits and factors influencing the design of intergenerational digital games, present the ideas of Xu et al. [19] when stating that intergenerational practices, including gaming, can work to reduce social anxiety as well as increase the sociability of players, especially those who live in situations of social isolation.

In a family setting, contemporary games can be seen to facilitate conversations and interactions between parents and children, both during and after gameplay [5, 10]. In the study by Musick et al. [5], it was found that, for some participants, playing digital games together brought about a sense of friendship between parents and children, contributing to the enhancement of the relationship between the two groups. It was also found that digital games were able to promote close connections since they have the ability to remove physical and emotional barriers (e.g., separate residences and teenager disengagement) [5]. Therefore, it is safe to enunciate that modern games can facilitate quality family time by lowering the barriers of starting an activity while maintaining it through its implicit engaging nature [5]. In the same study, it was found that, for families which engage in favourable co-play experiences, digital games can be used as a communal activity which is able to support and encourage parent-child relationships through a democratised life, as interactions while playing, for example, usually require balanced and collaborative forms of communication and interaction [5].

An additional concept that contributes to the development of bonds is interdependence, as is shown in studies by Emmerich et al. [20] and Depping et al. [4]. In the first study, conducted with participants who already knew each other well, the results of playing the developed testbed game (Figure 2.1) showed that player interdependence influenced the communication between both parts, as high interdependence resulted in higher values regarding behavioural engagement where players took longer to command and

telling the other player how to proceed [20]. This led to players reporting less negative feelings towards the other player and their interdependence, as dependent players focused on their common goals and did not discuss who to blame for the mistakes that would occur [20]. In contrast, independent players revealed that the game's levels were perceived and experienced as individual challenges, possibly even conveying a competitive atmosphere [20]. As such, the authors concluded that player dependencies integration was revealed to be a suitable way to promote in-game social interaction between players, so as to enhance their social experience [20]. The second study, on the other hand, separates collaboration and interdependence, stating that they are two distinct mechanics that separately influence game enjoyment and the experienced relatedness while playing [4]. Subsequently, these aspects are also considered to separately and significantly influence the experienced social closeness [4]. The study mentions that interdependent tasks increase the need for communication leading to the belief that this increase in interaction between players can be responsible for stronger social bonds and that this increased number of conversational turns between players explains the increase in perceived interpersonal trust [4], further supporting previously mentioned studies. In contrast to the first study mentioned, the second focused on specifically establishing a new connection between two participants, who did not know each other prior to the study, in a brief game interaction. Consequently, how the results found extend to relationship maintenance or establishing deeper relationships, or of a different nature, would require future work [4].

Figure 2.1: Image from Emmerich et al. [20] of the developed digital game. This picture illustrates a level including four players, represented by the four coloured blocks at the bottom [20]. These players must navigate their blocks to their respective outlined locations in order to complete the level [20].

This perceived notion that cooperation is a necessary factor, alongside interdependence, for the generation of relationships is contrasted by the findings by Depping et al. [2], in a later study. The authors state that cooperation is not necessarily predictive of social capital and competition is an inherently interdependent experience, meaning that it is a valid method for the facilitation of social relationships [2]. This is supported by the findings by Vella et al. [21], which indicate that competitive play was highly

enjoyed due to experiences of competence and challenge, whereas cooperation produced similar appreciation regarding teamwork and trusting relationships [22]. Mixed play was found to be the most fun and the most satisfying of the three scenarios studied (cooperation, competition and mixed play) [21]. However, all scenarios, in a social play setting, can potentially lead to player toxicity, competitive play and play with strangers being the scenarios with more propensity [21].

Whenever there is interpersonal interaction between two groups, namely between players, there is always a chance for the interactions to lead to toxic behaviours, and it still tends to affect the quality of social bonds generated within or by the game, regardless of the player's tolerance to toxicity [2]. As such, although gaming can be a powerful tool for fostering interpersonal connectedness and togetherness through social interactions, it can still prove to be a double-edged sword which hinders its potential for feelings of teamwork, achievement, competence and synergy, even in a competitive setting [21].

2.2 Asymmetry in Games

A way of fostering communication, which can also be applied as a way of tackling skill, motivation and patience differences, is to introduce asymmetry in the design of games. Asymmetric games are games in which players are presented with different perspectives or tasks in the game. Asymmetry is then best described as a difference in one or more dimensions (e.g., camera view, abilities, roles, etc), explicitly designed in the game-making process. This genre of games explicitly recognises and accommodates differences in players' interactions with the game, as well as differences in their ability and knowledge within the context of the game [23], hence their capability of being designed for specific scenarios and to cater to specific player needs.

In the study by Harris et al. [24], the authors identify elements of asymmetric games and attempt to design a framework for such games. This framework uses the elements identified in asymmetric games to build upon the MDA framework and is able to identify the *mechanics*, *dynamics* and *aesthetics* of asymmetry [24]. The authors identify six types of asymmetry, making up the mechanics of asymmetry: *asymmetry of ability* (i.e., different players are able to do different things within the game), *asymmetry of challenge* (i.e., different players have different challenges within the game), *asymmetry of interface* (i.e., different players have different means of engaging with the game, regarding both input and output), *asymmetry of information* (i.e., different players have different knowledge within the game), *asymmetry of investment* (i.e., different players have different amounts of time invested to their role in the game), and *asymmetry of goal/responsibility* (i.e., different players have different objectives within the game) [24]. Regarding the *dynamics* of asymmetry, the authors identify the *directional dependence* of interdependence (i.e., the direction in which a player depends on another) and *synchronicity and timing* (i.e., the amount of time before the action performed by one player affects another) [24].

In a later study by Harris et al. [9], the game developed in the first study was improved with the feedback received, resulting in the game *Beam Me 'Round, Scotty! 2* (Figure 2.2), and thus the concepts and framework mentioned in the first study were also refined. This study introduces the concept of degrees of interdependence, where three levels are present: loose, medium and tight coupling (i.e., low, medium and high levels of interdependence, respectively) [9]. The results of the study showed that players not only felt more connected to, but also perceived a greater sense of social presence, with their

partners when playing asymmetric games together [9]. This shows that asymmetric play can be an effective catalyser in feeling more connected when playing with others, yet the role a player takes on in the game can be impactful on these feelings, for example playing a healer or support role and another playing an offensive or damage dealing role [9]. The feeling of connectedness was also found to have increased as the degree of interdependence also increased, yet can also lead to frustrating tedium if exaggerated, indicating that some fine-tuning is necessary when designing asymmetric games [9].

Figure 2.2: Image from Harris et al. [9] of the digital game developed, *Beam Me 'Round, Scotty! 2*. A and B are simultaneous screenshots of both game characters' perspectives, Scotty and Kirk respectively [9]. Kirk is more prominent in B, using its axe in order to kill an enemy, while Kirk is using two abilities - shock ability (white coloured radius in A and blue coloured lightning bolt in B) and bomb ability (yellow hexagon in A and red coloured glow in B) [9].

Building upon prior research and game theory frameworks, Rogers et al. [23] introduce an extended framework that significantly enriches our understanding of asymmetric gameplay in multiplayer virtual reality (VR) games. Through its systematic review methodology, it is able to incorporate additional dimensions such as patterns of shared control [25] (i.e., different players have control over different aspects of gameplay) and social asymmetries [26] in shared space, age, and abilities, providing a more nuanced perspective on the complexities of asymmetric game design [23].

In a mixed-ability context, Gonçalves et al. [13] further support these findings when stating that interdependent ability-based roles influence the players' perceived autonomy and competence. Considering the asymmetry of these roles creates an opportunity for game designers to explore the tradeoff between guaranteeing a challenging experience for all players and not sacrificing the interdependence and asymmetry that seems to be a significant catalyser of feelings of need, competence and trust. *Last Tank Rolling* [14] is an exciting exploration into the world of asymmetrical gaming, and an example of these design principles, focusing on shared motion-based play to empower individuals using wheelchairs. Through innovative design and technology, it aims to create inclusive gaming experiences that break barriers and foster social interaction in diverse communities.

In family gaming, introducing asymmetry has been theorised to be beneficial, since asymmetric games can explicitly incorporate and design game mechanics and scenarios for differences between players, and their respective player types [23, 27]. Khoo et al. [27] developed an asymmetric physical mixed-reality game, *Age Invaders*, as a platform for intergenerational family entertainment. In this game, the asymmetry enforced allowed elderly family members to adapt the difficulty of the game to their abilities, allowing them and their grandchildren to engage in physical activity, and allowing other family members, such as the parents, to remotely influence the game through bonuses in a game board [27].

Asymmetric play has been successfully implemented in other commercial instances as well. Games such as *We Were Here* [28] and *It Takes Two* [29] make use of asymmetry to foster interdependence and connection between players playing as different characters but ultimately working together towards a shared goal. In *We Were Here* [28], players start the game separated from each other in an old abandoned castle, with one player confined to a small section of the castle, and the other able to roam the castle halls in search of the first. Players are expected to manage an asymmetry in the information provided to them, thus communicating and collaborating to solve numerous puzzles located in each of the castle's rooms. In *It Takes Two* [29], on the other hand, the asymmetry is mostly present in the abilities at the player's disposal. Players encounter a series of witty trials that test their ability to communicate, coordinate, and collaborate, as they engage in very different gameplay from each other.

Regarding asymmetry of information, it has also become a deliberate design pattern in various games, showcasing its potential to enhance gameplay dynamics. Standout examples include the aforementioned *We Were Here* [28], *Tick Tock: A Tale for Two* [30], *Blind Trust* [31], and *Keep Talking and Nobody Explodes* [32]. Similar to *We Were Here* [28], in *Tick Tock: A Tale for Two* [30], players are transported to parallel worlds where they can only share fragmented insights about their respective environments, compelling effective communication and collaboration to progress through puzzles. *Blind Trust* [31] follows the same format but introduces an intriguing dynamic where one player is blindfolded while the other possesses sight but cannot speak, emphasising the importance of trust and communication. *Keep Talking and Nobody Explodes* [32], on the other hand, mixes the use of digital and analogue platforms in tasking one player with defusing a bomb while the other consults a bomb defusal manual, also requiring clear communication and efficient teamwork. These games exemplify how asymmetry of information can enrich cooperative experiences, fostering teamwork, strategic thinking, and immersive gameplay.

2.3 Defining Games

Games research has come a long way in formalising and suggesting a number of different structural models and frameworks to better understand, design, and communicate about games. A game is seen as a cultural artefact that is also a system which blends a made-up, imagined environment with real-time rules that the player interacts with and builds behaviour [33, 34]. The understanding and design of games hinges on the ability to approach analysis from two perspectives: taking the end result and refining the implementation, and taking the implementation and refining the end result [34]. As such, if game definitions are not strict, the experiences that the end result enunciates cannot be easily comprehended and extrapolated [34]. Games, the players that play them, and their contexts come in all shapes and forms. Because of this, the same artefact may produce completely different end results in different conditions. Despite this, attempting to universalise experiences in gaming allows designers to make more informed decisions and better formulate their artefacts according to their intent [34]. Previous research has explored the development of frameworks, theories, and models to support designers and researchers in the phases of ideation, iteration, and analysis [34, 35, 36, 37]. This body of work includes definitions and structural components of games, delineating formal elements including rules, experiential factors, such as story, and cultural dimensions [35, 36, 37]. Moreover, it has led to the formalisation of particular concepts, for example, asymmetry, enriching the understanding of game design [24].

The concept of a design space constitutes a structured framework built to encapsulate the diverse possibilities for the creation of a particular artefact [38]. For this, it encompasses foundational parameters and variables that designers may manipulate or contemplate throughout the iterative design process, in order to test different combinations of these to discern the most effective options for achieving a desired end result [39, 40, 41].

Hunicke et al. [34], in their work, formulate the concept of gameplay under three dimensions, suggesting the MDA framework: *mechanics*, *dynamics*, and *aesthetics*. This framework proposes a formal approach to understanding and communicating about designing games [34]. In it, *mechanics* refers to the operations and actions afforded (i.e., the rules of the game, such as shuffling or dealing cards in a card game), *dynamics* refers to emerged behaviours and strategies from the mechanics dimension (i.e., how mechanics behave according to user input and when interacting with each other, such as bluffing in a card game), and *aesthetics* refers to the perceived aspects by the player (i.e., the emotional response of the player to the behaviour of the *dynamics* dimension, such as the excitement from having a good hand in a card game) [34].

Other models also define and categorise specific design spaces such as the framework for asymmetry [24], its subsequent extension, a systematic framework tailored to analyse asymmetric gameplay in multiplayer VR games [23], both described above, and the framework for cooperative communication game mechanics [42]. The latter offers a structured approach to analyse and understand mechanics facilitating effective communication and teamwork in video games, by identifying and classifying them [42]. It aims to assist game developers in creating immersive cooperative gameplay experiences by emphasising strategies for effective player interaction and collaboration [42].

Another phenomenon relevant in the engagement with games is the motivation to play. There is significant work in this area, with one such example being the suggestion put forth in the form of Bartle's Taxonomy [43]. This taxonomy presumes players can be associated with four categories, *achievers*, *explorers*, *socialisers*, and *killers*, and that these categories belong to two spectrums, *acting versus interacting* and *players versus world* [43]. In this sense, *achievers* act on the world while *socialisers* interact with players [43].

Player satisfaction has been a studied concept as well. BrainHex [44, 45] is an example of a structured model, hinging on neurobiological research, that attempts to conceptualise player satisfaction by grouping players into seven possible archetypes: *seeker* (i.e., one that is curious about the world and enjoys moments of wonder), *survivor* (i.e., one who enjoys fear and terror), *daredevil* (i.e., one who seeks thrilling, exciting, and risk-taking activities), *mastermind* (i.e., one who enjoys puzzles, strategising, and efficiency), *conqueror* (i.e., one who seeks challenging experiences to overcome), *socialiser* (i.e., one who enjoys being, interacting, and helping others), and *achiever* (i.e., one who focuses on goals and their subsequent completion). This constitutes an improvement to Bartle's Taxonomy [43] as it assumes players may belong to more than one motivational class, meaning that these categories are not mutually exclusive [44, 45]. Instead, a primary and secondary class is attributed to the player according to a scoring system [44, 45].

As a follow-up to this work, the author behind Quantic Foundry [46, 47] conducted a survey on an extensive number of players, to formulate the Gamer Motivation Model. This model (Figure 2.3) qualifies players' motivation profiles under six dimensions, each with two possible subcategories: *ac-*

tion (*destruction* and *excitement*), *social* (*competition* and *community*), *mastery* (*challenge* and *strategy*), *achievement* (*completion* and *power*), *immersion* (*fantasy* and *story*), and *creativity* (*design* and *discovery*) [46, 47].

Figure 2.3: Gamer Motivation Model by Quantic Foundry [46, 47].

2.4 Summary

To summarise, gaming can prove to be an excellent venue for promoting feelings of togetherness and connectedness, the improvement of social skills and the creation and maintenance of relationships [2, 3, 4]. Digital gaming adds to these benefits, as it is a form of gaming which is often easier to start and engage in [5]. The dynamic and often fluid nature of digital games allows them to be engaging for a wider audience, thus being a tool which all can easily access. As such, it proves itself to be a growing industry and field, gathering both the young and the old [1], and with great potential to incentivise social interactions, both in the virtual world and the real world. Despite this, literature on digital gaming is still taking its first steps.

Asymmetric game design emerges as a promising avenue for enhancing social interactions and gameplay experiences. Studies like those by Harris et al. [24, 9] and Gonçalves et al. [13] demonstrate the effectiveness of asymmetry in catering to diverse player abilities and preferences, fostering collaboration, and promoting feelings of interconnectedness. Games like *We Were Here* [28] and *It Takes Two* [29] exemplify how asymmetry can create engaging cooperative gameplay dynamics, encouraging players to communicate, strategise, and work towards common goals. However, while asymmetric games offer exciting opportunities for enriching player experiences, there is still a need for further exploration and refinement of asymmetry's role in game design. Our research delves deeper into understanding asymmetry of information, the impact of different design choices related to it on player engagement, and the potential challenges and limitations associated with it.

Finally, regarding models, structures, and frameworks in gaming, considerable progress has been made in formalising and conceptualising various aspects of game design and player experiences. The MDA framework proposed by Hunicke et al. [34] provides a valuable lens for understanding the *mechanics*, *dynamics*, and *aesthetics* of games, while models like Bartle's Taxonomy [43] and BrainHex [44, 45] offer insights into player motivations and preferences. However, the landscape of gaming is continuously evolving, with new genres, technologies, and player demographics emerging. Therefore, there is a pressing need for the development of more sophisticated models and frameworks that can capture the complexities of modern gaming experiences. These models should consider factors such as player diversity, accessibility, and the dynamic nature of digital gaming environments. By advancing our understanding of gaming through robust theoretical frameworks and conceptual models, researchers and designers can better address the diverse needs and preferences of players, ultimately enhancing the overall quality and inclusivity of gaming experiences.

Chapter 3

Defining Asymmetry of Information

By presenting a framework for asymmetry of information, we seek to be part of the answer to the demand for more defined and conceptualised games, as well as more informed design decisions. As a result, the purpose of this framework is to provide structure for the conception, comprehension, and development of information-based asymmetric game mechanics. For this, we first present our procedure in the conception of this design framework, followed by the presentation of our discussion on the implications and design opportunities found and, finally, we detail the proposed framework and its possible values.

3.1 Procedure

In the design process of the proposed framework, we took into account related work, and game mechanics in commercial games that are built on asymmetry or that induce social interaction, and applied our own experience with digital and analogue games. Throughout this process, researchers met and discussed relevant topics regarding the framework, improving it. The several project phases served as tests of the framework and as time periods to reflect on its structure and applicability. This iterative progress was done through a shared table document where the researchers were able to visualise the framework's dimensions, subcategories, definitions, and possible values.

The conceptualisation phase of the framework took into account the Asymmetry framework by Harris, et al. [24] as a starting point. From there, the researchers aimed to detail the concept of asymmetry of information by discussing examples known from past experiences and other instances. For instance, our discussion centred on topics such as the need for informed design decisions in gaming based on research, the use of cooperative gameplay mechanics in gaming (e.g., shared objectives, complementary abilities, resource sharing), or the use of dynamic events and challenges in gaming which encourage spontaneous social interaction (e.g., information puzzles, world bosses). This allowed us to formalise our understanding of asymmetry of information through the identification of gaps in the original framework [24] which sparked discussion on how to best integrate the identified concepts. This step generated a framework with the concept of information possession (i.e., one has the information) and awareness (i.e., one knows the purpose of the information).

With the first version of this framework designed, we started the design and development of a digital game prototype informed by it. Throughout this process, the framework was iterated over, based on conceptual obstacles and inconsistencies found. This process constitutes a very hands-on approach to the

iteration of formalised concepts, which allows us to better define the applicability of the framework and practically identify and tackle inconsistencies found during the development of the combinations of the categories regarding information asymmetry. This generated two relevant evolution states of the framework: one where the concept of information pieces was introduced and the awareness of information was refined; and another where the framework achieved its current state. This final version of the framework is detailed in the section below.

3.2 Framework for Asymmetry of Information

Informed by prior literature on asymmetric game design and through multiple iterations within the research team, we propose an extension to our understanding of the asymmetry of information in games. Expanding from the concepts proposed by Harris et al. [24], we argue that asymmetry of information can be further divided into *Implementation* and *Awareness*. Below, we present the definition of each dimension, subcategory and their corresponding possible values. A detailed description of each dimension can be found in Table 3.1.

Table 3.1: Framework for asymmetry of information.

ASYMMETRY OF INFORMATION							
Implementation							
Possession				**Utility**			
Single	Combined		Split	Single	Multiple		None
Awareness							
Possession				**Utility**			
Single	Combined	Split	None	Single	Combined	Split	None
Location				**Consequence**			
Single	Combined	Split	None	Single	Combined	Split	None

3.2.1 *Implementation*

Refers to who has the information and who will have to use it. This dimension comprises the following subcategories: *Implementation of Possession* (i.e., who has the information or who has access to it) and *Implementation of Utility* (i.e., who uses or needs the information).

The *Implementation of Possession* can be *Single* (i.e., only one of the players has or has access to the information), *Combined* (i.e., multiple players have or have access to parts of one information that overlap), or *Split* (i.e., multiple players have or have access to parts of one information that do not overlap).

The *Implementation of Utility* can be *Single* (i.e., only one player uses or needs the information), *Multiple* (i.e., multiple players use or need the information), or *None* (i.e., no player uses or needs the information).

3.2.2 *Awareness*

Refers to who knows about different aspects related to the information. This dimension comprises the following subcategories: *Awareness of Possession* (i.e., who knows who has the information), *Awareness of Utility* (i.e., who knows who needs the information), *Awareness of Location* (i.e., who knows where the information is used), and *Awareness of Consequence* (i.e., who knows the consequence of using the information).

The *Awareness of Possession* can be *Single* (i.e., only one player knows who has the information), *Combined* (i.e., multiple players know parts, that overlap, of who has the information), *Split* (i.e., multiple players know parts, that do not overlap, of who has the information), or *None* (i.e., no player knows who has the information).

The *Awareness of Utility* can be *Single* (i.e., only one player knows who needs the information), *Combined* (i.e., multiple players know parts, that overlap, of who needs the information), *Split* (i.e., multiple players know parts, that do not overlap, of who needs the information), or *None* (i.e., no player knows who needs the information).

The *Awareness of Location* can be *Single* (i.e., only one player knows where the information is used), *Combined* (i.e., multiple players know parts, that overlap, of where the information is used), *Split* (i.e., multiple players know parts, that do not overlap, of where the information is used), or *None* (i.e., no player knows where the information is used).

The *Awareness of Consequence* can be *Single* (i.e., only one player knows the consequence of using the information), *Combined* (i.e., multiple players know parts, that overlap, of the consequence of using the information), *Split* (i.e., multiple players know parts, that do not overlap, of the consequence of using the information), or *None* (i.e., no player knows the consequence of using the information).

3.2.3 Application

The presented framework encapsulates the choices for introducing asymmetry of information in multiplayer games. Much like past proposed models, it can be used as a tool by researchers and designers, whether in the context of game analysis or game design. It also aims to contribute to the discussion of knowledge on games, such that it contributes to better communication on gaming aspects between researchers, designers or just enthusiasts.

Games are a complex medium and, as such, complex are the possible mechanics and systems therein. When applying this framework, the granularity of what constitutes information within an information-based system must be taken into account, as more intricate information-based systems may challenge the framework's constitution. For example, the knowledge of where information is used can be considered a piece of information in itself, or the consequence of using it can be inferred from past experience if the game's patterns are repetitive enough. With this in mind, we encourage researchers and practitioners to take into account these possibilities and adapt this formalisation to their needs, with a level of scrutiny that is based on a well-defined context and objective, thus applying this conceptualisation accordingly.

Chapter 4

Designing for Asymmetry of Information

The following natural step in our work was to operationalise the proposed framework so as to explore different combinations of values and how this affects players' perspectives. As such we sought to gather perspectives on a selection of game mechanics built using the framework.

To achieve this, a proof-of-concept digital two-person cooperative game was designed and developed containing six information-based asymmetric mechanics. These mechanics correspond to different combinations of values for each of the previously presented subcategories of the framework, where some values were varied and others fixed. The decision to fix values for certain subcategories while varying others was made due to the great number of potential combinations that would arise if all values were left open to variation. Additionally, this approach was taken to ensure a cohesive and immersive experience for players that aligns with expectations of the chosen genre of the game, while also maintaining a controlled and incisive experiment. These mechanics correspond to puzzle challenges the players must surpass by articulating their efforts in identifying and sharing relevant information.

In the following sections, we begin by describing the procedure followed for the design of the game, followed by a brief description of the prototype, and culminating with the detailing of the implementation in terms of the game's systems and the information-based asymmetric mechanics.

4.1 Procedure

The design and development of the digital game lasted for eight months. The design phase was the sole focus for the first month, while the development started in the second month. The development of the game and the reiteration of the proposed framework led to the iterative refinement of the design of the prototype. Below we detail the design and development procedures.

4.1.1 Design

The design process for the digital game prototype made use of the proposed framework as a basis for the ideation of its core gameplay mechanics. Researchers met regularly over the course of a month, and discussed design decisions and implications, iterating over a game design document that was shared amongst all. This document served as an ideation and visualisation tool for the game's evolution. In it, we kept a record of the various evolution phases of the mechanics built from combinations of values for the

subcategories of the proposed framework. Moreover, aspects such as abilities, enemies, and environment were also detailed in this document.

The game took inspiration from the idea of a hypothetical two-person roguelike dungeon crawler game[1]. The choice to create a roguelike dungeon crawler game was based on its widespread appeal as a cooperative experience and its potential for scalability. Furthermore, the team's existing proficiency in this genre and access to pre-existing assets made it a practical decision. In the early stages of design, the idea was that players would require effective collaboration in order to do well in the game. The dungeon crawler aspect of the game enunciated the need for dynamic dungeon generation, with varied dungeon rooms, multiple different enemies, and, optionally, a level and ability systems, as we sought to design a gaming experience on par with what is expected of this genre of game, not a game featuring only asymmetry of information, to ensure that perspectives gathered were representative. Although the game features replayability in the sense that players may explore dungeons repeatedly, the roguelike aspect of the game (i.e., permanent death) was dropped, as it did not align with the requirements of the subsequent laboratory study that aims to ensure that players come in contact with all the asymmetric mechanics.

The integration of the aforementioned game structure with the needs of the project at hand was done through the introduction of puzzle challenges that appear to the players at the end of every dungeon floor (i.e., the dungeon is composed of four floors which in turn are composed of several dungeon rooms, including the challenge room). These challenges are required for effective progression in the game and, to complete them, players are required to collaborate. This merge of ideas led to the refinement of previously designed and implemented systems (e.g., dungeon generation system, ability system, stat system) so as to accommodate the new requirements.

4.1.2 Development

For the development of the digital game, we made use of the *Unity Game Engine* [48]. The game was built on top of the *Top-Down Engine* [49], an asset provided to us through the *Unity Asset Store* [50]. To handle communication between game instances, as well as authentication and logging features, we made use of *Google's Firebase Realtime Database* [51]. The game's graphics were either adapted from free-licensed assets found on *itch.io* [52], graphical assets from the *Top-Down Engine* [49], or made from scratch, all using *Aseprite* [53]. Sound files were curated from various examples put forth by tools such as *ChipTone* [54], *jsfxr* [55], or *Abundant Music* [56], and post-edited. Below we detail the various systems in the game.

4.2 *Parallel Realms: Asymmetry United*

In *Parallel Realms: Asymmetry United*, players must articulate their efforts in identifying and sharing relevant information. The game is a cooperative top-down dungeon exploration experience where players combat enemies throughout the dungeon and, at the end of each dungeon floor, are presented with an information-based puzzle challenge. The objective of the game is to traverse the dungeon, clearing every

[1] A roguelike dungeon crawler game is a procedurally generated adventure where players explore dungeons, facing permanent death and randomised encounters, aiming for progress through tactical gameplay.

room and completing every floor, by surpassing each challenge, so as to reach the end with the highest possible score.

The dungeon is composed of four floors, and each floor corresponds to a different information-based asymmetric mechanic. Both players are expected to traverse and explore each of the dungeon's floors, defeating enemies, collecting loot, levelling up through experience gathered, and interacting with the environment. On each floor, players may encounter unidentified information rooms and clues for the solution to the given floor's puzzle. Moreover, the final room of each floor always contains a puzzle challenge the players must overcome by articulating the knowledge they have gathered.

In total, there are six different challenges for the players to encounter. On the first and third floors, both players encounter the same challenge but with different perspectives, whereas on the second and fourth floors, each player encounters a different challenge. Each player is aligned with a faction, angel or devil, which has no impact on mechanical gameplay but is there to differentiate and reference the two players.

The game was developed for PC, with the expectation that players would control their characters using a combination of mouse and keyboard inputs. Movement is facilitated through the W, A, S, and D keys, aiming is controlled via mouse movement, and attacks are executed through mouse clicks. See Appendix A for more information on key binds. Both players and enemies have health values, with characters being defeated when their health reaches zero. Players can also destroy in-game objects like pots or interact with relevant puzzle challenge game elements.

Defeating enemies awards players with experience points, allowing them to level up and choose one of three random abilities to enhance their character. Similarly, upon completing a dungeon floor, players are presented with a choice of one of three random special abilities to further empower their character. These selections contribute to the customisation and strategic development of each player's character, with no relevance to the asymmetry of information.

4.2.1 Map Generation System

The game bolsters a Hub and a Tutorial Dungeon that were both handmade by us. However, the main dungeon in the game is randomly generated according to a different seed every time.

Apart from the tutorial dungeon which only has one floor, a dungeon in the game consists of several floors and each floor has several dungeon rooms. These dungeon floors are generated one at a time, as the player progresses between floors, using a modified version of the random-walk algorithm [57]. The algorithm was refined by adding map boundaries, which determine the valid spaces for dungeon rooms within a specified width and height. Moreover, a rule was implemented to restrict each room to a maximum of two neighbouring rooms, contributing to a more structured and coherent layout. The dungeon layout is different for each player and each of the floors is associated with a difficulty which determines the possible room contents of each dungeon room.

The room contents of each dungeon room dictate how many enemies are in a room and possible environmental objects and hazards, such as pots, spikes or holes. The selection of the contents for each dungeon room is made according to the difficulty level of the dungeon floor as well as the disposition of the possible environmental hazards (i.e., a room with uncrossable holes all along its foremost left side cannot have a connection to a room to the west of it).

The generation of a dungeon follows a pre-made recipe that details which dungeon floors are to exist in it, as well as the possible room contents for each non-special dungeon room (i.e., rooms that are not the initial, final or special rooms). Each dungeon floor in turn also follows a pre-made recipe which dictates the challenge to be found and its corresponding room contents, special room contents that must be included (i.e., rooms containing information), and the total number of rooms the floor should have.

The initial room is always the first room to be generated. Using a modified version of the random-walk algorithm [57], the generator then determines positions, relative to the initial room, for the normal (i.e., non-special) rooms. The number of these rooms corresponds to the floor's maximum number of rooms minus the total indicated special rooms and the initial room. The generator then determines the furthest normal room from the initial room and deems it the final room, where the challenge room contents will be instanced. To place the mandatory special rooms, the generator finds dead-ends in the dungeon's layout, placing a special room at each dead-end, and totalling the requested number of rooms for said floor. Finally, the rooms are connected using teleportation gates and populated with their corresponding determined room contents. Figure 4.1 shows an example of a generated dungeon floor.

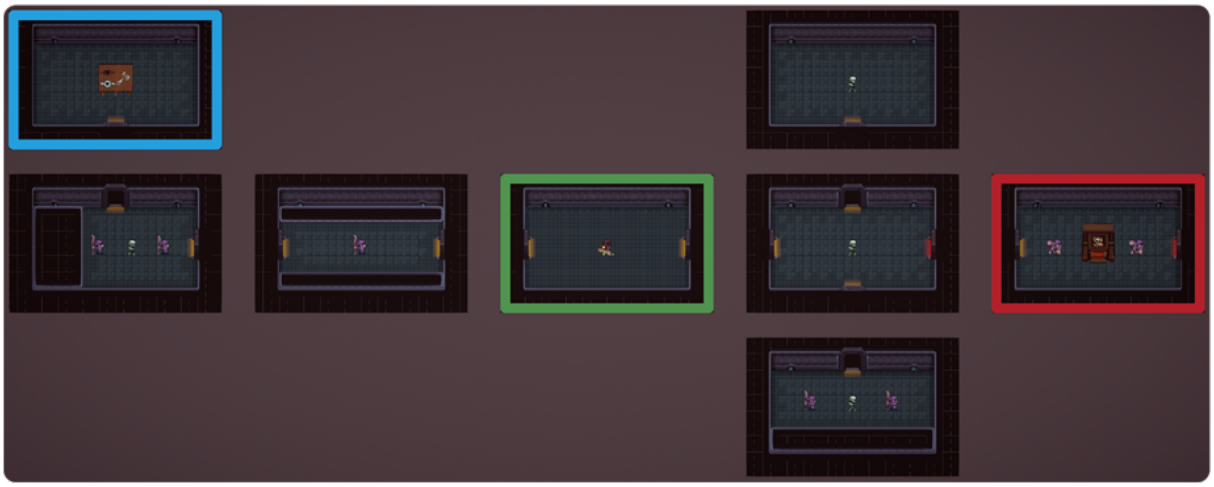

Figure 4.1: Example of a generated dungeon floor, where the initial room is highlighted in green, the information room in blue, and the final room (i.e., challenge room) in red. All other rooms correspond to normal rooms.

4.2.2 Loot System

When defeating enemies, players can hope to find dropped loot. This loot can correspond to coins, hearts or experience. Coins are one of the key factors in the determination of the player's score throughout the dungeon. They are also spent when reviving and have a base fifty per cent chance of dropping from a defeated enemy, in stacks between one and three. Hearts are items that, when picked up, restore some health to the player. These have a five per cent chance to drop, in stacks of one to two. Experience, on the other hand, corresponds to experience points the player can gather to level up and power up their character. Experience is always guaranteed to drop from a defeated enemy in stacks of two.

4.2.3 Level System

Through the defeat of enemies throughout the dungeon, the player is expected to gather dropped experience and level up. Levelling up rewards the player with the choice between three possible abilities which

power up their character.

The experience required to level up is determined at each level up, according to the current level, except for the level up from level zero to one, which requires five experience. From level one to level fifteen, each time the player levels up, the experience required to level up is increased by ten. From level fifteen to level twenty-five, each time the player levels up, the experience required to level up is increased by fifteen. From level twenty-five to level thirty, each time the player levels up, the experience required to level up is increased by twenty. Finally, from level thirty-one onwards, each time the player levels up, the experience required to level up is increased by thirty.

4.2.4 Stat System

Each character in the game (i.e., player characters and enemy characters) bolsters a set of stat values. Enemy characters do not have all the stats a player character does. Each stat has a possible base value. Each character type (i.e., player and chaser, light, heavy, and ranged enemies) has predefined stat base values. These stats can be further altered by applying modifiers to them through abilities picked when levelling up. Appendix B describes the possible stats on the game's characters.

4.2.5 Ability System

When levelling up, the player is presented with a choice between three possible abilities to acquire (Figure 4.2). These abilities are divided into tiers, which are explicit in the ability's name (e.g., *Health Increase I* is a tier one ability, while *Health Increase II* is a tier two ability). The ability pool that determines possible ability choices when levelling up is separate from the ability pool that determines possible ability choices when completing a challenge (i.e., completing a dungeon floor). The latter ones are considered to be more special and character-defining. Being given the option to pick a higher-tier ability requires first acquiring its lower-tier counterpart (e.g., *Health Increase II* will not be an option until the player first picks *Health Increase I*). Appendix C describes the acquirable abilities in the game.

4.2.6 Score System

A dungeon run corresponds to the conclusion of a dungeon, meaning the completion or forfeit of the dungeon's final floor challenge. At the end of a dungeon run, the player's individual and combined score is presented to them (Figure 4.3). The individual scoring in the game is determined according to the player's coins at the end of the run, as well as how long it took to complete it. This time takes into account only the time when the game was not paused (i.e., times when the player was navigating the pause menu or the ability screen do not count). Each coin collected translates to one hundred points added to the score value, while the total seconds taken to complete the run are subtracted from the score value. The score can happen to be zero but never less than zero. The combined score of the two players corresponds to the sum of the individual score values of each.

4.2.7 Log System

Every relevant game event is captured and stored in our instance of *Google's Firebase Realtime Database* [51]. Each event, whether it involves acquiring a new ability, picking up a coin, entering or exiting a

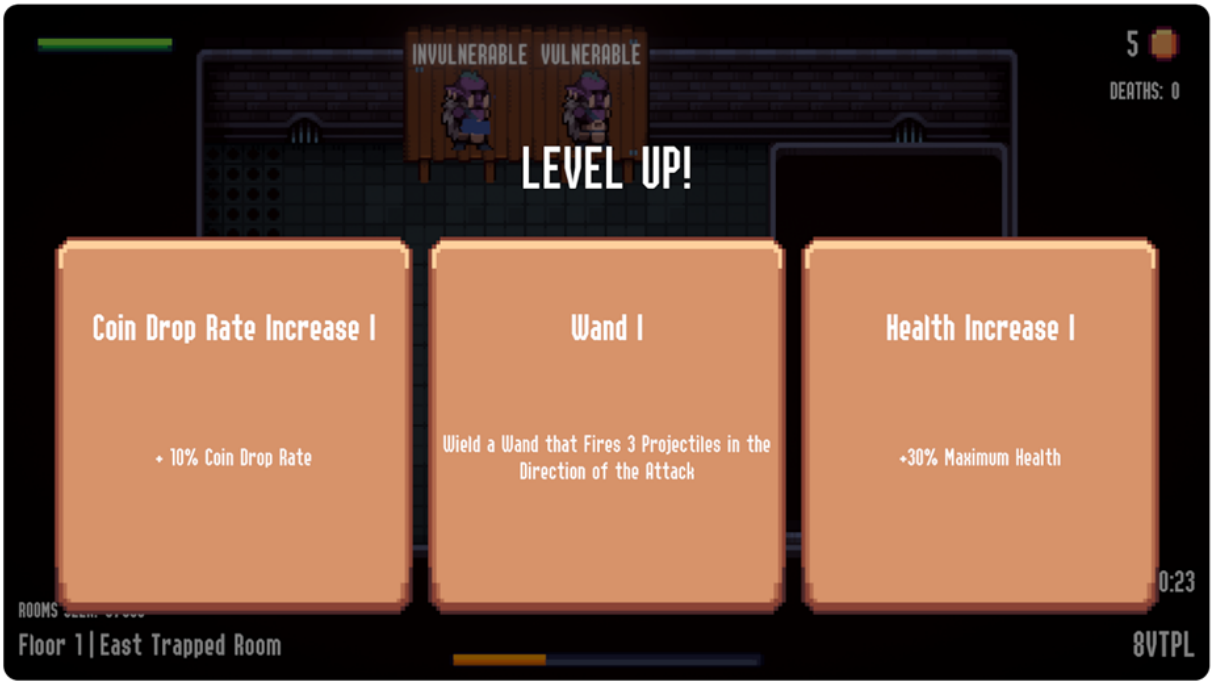

Figure 4.2: Ability menu displayed upon character level-up, presenting a choice of one out of three available abilities.

Figure 4.3: Dungeon complete menu displayed upon completing a dungeon run, presenting statistics such as coins collected, deaths, time taken, and individual and cumulative score of both factions (i.e., both players).

room, or any other significant occurrence, generates a detailed labelled log entry. Each log entry bolsters an identification label, a description of the event, and a timestamp. This meticulous documentation ensures that a chronological record of all in-game actions is preserved, enabling thorough analysis at the data analysis stage. See Appendix D for more information on the logs stored.

4.3 Asymmetric Mechanics

The main objective of the game is to successfully complete the dungeon. To do so, players must traverse all the dungeon's floors and successfully clear the puzzle challenges at the end of each floor. These challenges were designed based on the aforementioned asymmetry of information framework, where each challenge corresponds to a different combination of values for each of the framework's subcategories. Players are thus expected to collaborate by identifying and communicating relevant information to find the solution to puzzles.

Given the multitude of possible combinations of values for the various subcategories of the asymmetry of information framework and the inability to conduct a controlled study which evaluates each possible combination, we decided to explore a subset of said possible combinations, focusing on the ones we identified as the most common and promising candidates to contribute to our objective: investigate how different types of information asymmetry impact the player experience. As such, we fixed and paired multiple subcategories and explored the possible variations between them, resulting in a total of six different puzzle challenges (i.e., six different combinations of values from the asymmetry of information framework (Table 4.1)) implemented in the game. The *Awareness of Location* subcategory was fixed on the *Combined* value since players, a priori to experiencing the game, already knew that the challenges would be found in the final room of each floor. The *Awareness of Consequence* subcategory was fixed on the *None* value since players did not know what possible abilities they might receive by completing a challenge, even though they knew, after having encountered and completed the first challenge, that they would receive an ability choice. If players failed to complete any of the challenges, they would be killed and forced to respawn back at the floor's initial room. This design choice discourages participants from resorting to a trial-and-error strategy in solving the challenges. Finally, the *Awareness of Possession* and *Awareness of Utility* subcategories were paired, meaning that the player who knew who had the information, would also know who needed the information. The order in which the mechanics appear for each player is described in Table 4.2.

4.3.1 Skull Challenge

On the floor corresponding to the Skull Challenge, the player encounters a challenge room (Figure 4.4 - B), which contains an interactable station, two invulnerable enemies and a sign displaying a skull symbol. When interacted with, this interactable station prompts the player to choose a colour symbol out of ten different colour symbols. The correct colour symbol can be found by the play partner in an information room (Figure 4.4 - A), present somewhere on the play partner's dungeon floor. This information room contains a sign with the player's symbol, a skull symbol and a specific colour symbol. The answer to the puzzle corresponds to this specific colour symbol.

Taking into account the Asymmetry of Information framework (Table 4.3), the play partner is the

Table 4.1: Combinations of values from the asymmetry of information framework considered.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
I	Single (Player A)	Single (Player B)	Single (Player A)	Single (Player A)	Combined	None
II	Single (Player A)	Single (Player B)	Single (Player B)	Single (Player B)	Combined	None
III	Single (Player A)	Multiple	Single (Player A)	Single (Player A)	Combined	None
IV	Single (Player A)	Multiple	Single (Player B)	Single (Player B)	Combined	None
V	Split	Single (Player B)	Single (Player A)	Single (Player A)	Combined	None
VI	Split	Single (Player B)	Single (Player B)	Single (Player B)	Combined	None

Table 4.2: Order in which the asymmetric mechanics appear for each player.

Dungeon Floor	Mechanic	
	Player A	Player B
1	Weapon Challenge	
2	Skull Challenge	Chest Challenge
3	Pots Challenge	
4	Wolf Challenge	Sequence Challenge

Table 4.3: Combination of values from the asymmetry of information framework considered for the Skull Challenge.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
I	Single (Player A)	Single (Player B)	Single (Player A)	Single (Player A)	Combined	None

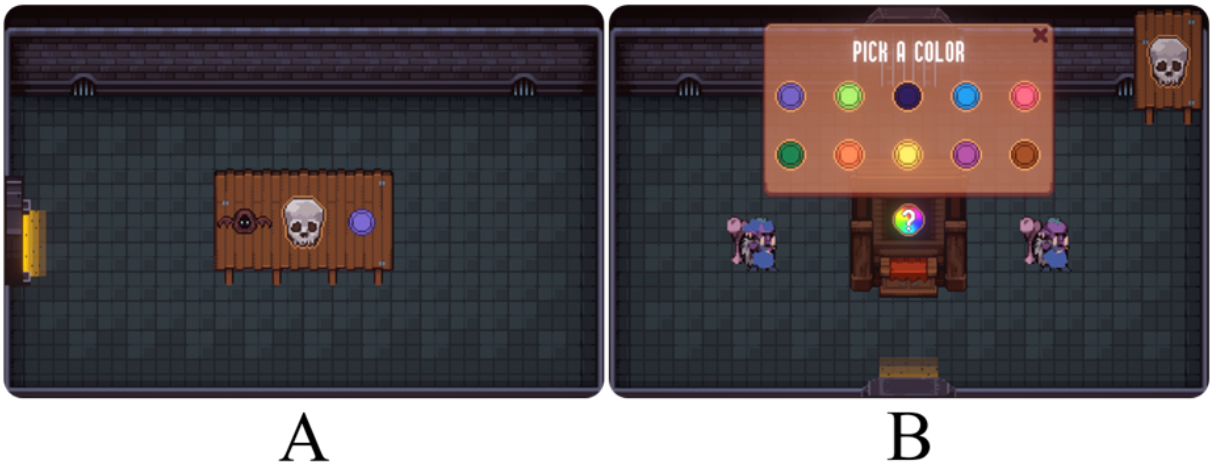

Figure 4.4: Dungeon rooms related to the Skull Challenge. A - Information room; B - Challenge room.

only one who has access to the information room that contains the information necessary to complete the challenge, yet it is the player who makes use of this information since it is the only one who encounters the challenge room. Since the play partner is the one who can encounter the information room, it automatically knows that it is the one with access to the information, and it is also the only one who can deduce that the information inside is relevant for the player (i.e., the sign displaying the player's symbol, the connection to the skull challenge room, and the answer to the puzzle).

4.3.2 Chest Challenge

Table 4.4: Combination of values from the asymmetry of information framework considered for the Chest Challenge.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
II	Single (Player A)	Single (Player B)	Single (Player B)	Single (Player B)	Combined	None

On the floor corresponding to the Chest Challenge, the player encounters a challenge room (Figure 4.5 - B), which contains an interactable chest. When interacted with, this interactable chest prompts the player to choose a colour symbol out of ten different colour symbols. If an incorrect symbol is chosen, the player is killed and forced to respawn back at the floor's initial room. The correct colour symbol can be deduced by the play partner in an information room (Figure 4.5 - A), present somewhere on the play partner's dungeon floor. This information room contains a sign with the player's symbol, a key symbol, and a boot symbol. The answer to the puzzle corresponds to the colour of the player's avatar's boot.

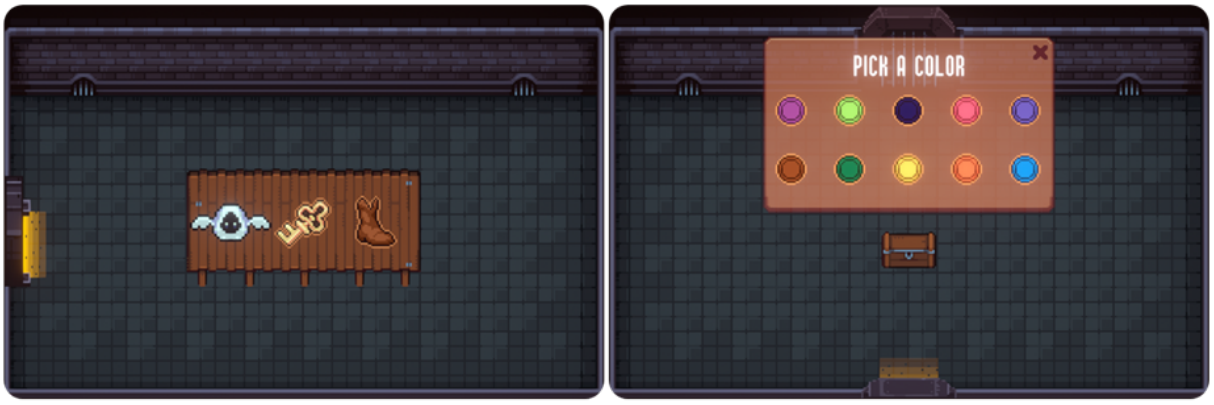

Figure 4.5: Dungeon rooms related to the Chest Challenge. A - Information room; B - Challenge room.

Taking into account the Asymmetry of Information framework (Table 4.4), the play partner is the only one who has access to the information room that contains the information necessary to complete the challenge, yet it is the player who makes use of this information since it is the only one who encounters the challenge room. Since the player is the one who has the relevant coloured boots, it is the one who knows who has the information, and, since it is the one who encounters the challenge room it is also the

one who knows who needs the information (the sign in the information room only indicates that it is the player's boot that is the key to the chest, not who needs it).

4.3.3 Weapon Challenge

Table 4.5: Combination of values from the asymmetry of information framework considered for the Weapon Challenge.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
III	Single (Player A)	Multiple	Single (Player A)	Single (Player A)	Combined	None

On the floor corresponding to the Weapon Challenge, both players individually encounter the same challenge room (Figure 4.6 - B). This challenge room contains an interactable station and two invulnerable enemies. When interacted with, this interactable station prompts the player to choose a weapon symbol out of six different weapon symbols. If an incorrect symbol is chosen, the player is killed and forced to respawn back at the floor's initial room. The correct weapon symbol can be found by one of the players in an information room (Figure 4.6 - A), also present somewhere on the said dungeon floor. This information room contains a sign with both player's symbols and a specific weapon symbol. The answer to the puzzle corresponds to this specific weapon symbol.

Figure 4.6: Dungeon rooms related to the Weapon Challenge. A - Information room; B - Challenge room.

Taking into account the Asymmetry of Information framework (Table 4.5), the player is the only one who has access to the information room that contains the information necessary to complete the challenge, yet both players must make use of this information since both players individually encounter the same challenge room. Since the player is the one who can encounter the information room, it automatically knows that it is the one with access to the information, and it is also the only one who can deduce that the information inside it is relevant for both players (i.e., the sign displaying both player's symbols and the answer to the puzzle).

Table 4.6: Combination of values from the asymmetry of information framework considered for the Pots Challenge.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
IV	Single (Player A)	Multiple	Single (Player B)	Single (Player B)	Combined	None

4.3.4 Pots Challenge

On the floor corresponding to the Pots Challenge, both players individually encounter the same challenge room, but with some differences (Figure 4.7 - B, C). This challenge room, for both players, contains six breakable pots, each with a random symbol on them. For the player, the challenge room contains a sign with additional information. If an incorrect pot is destroyed, the player is killed and forced to respawn back at the floor's initial room. The correct symbol that indicates the pot to be destroyed can be found by one of the players in an information room (Figure 4.7 - A), also present somewhere on the said dungeon floor. This information room contains twelve pots located in batches of three at each corner of the information room, all displaying the same symbol. The answer to the puzzle corresponds to breaking the pot with this specific symbol.

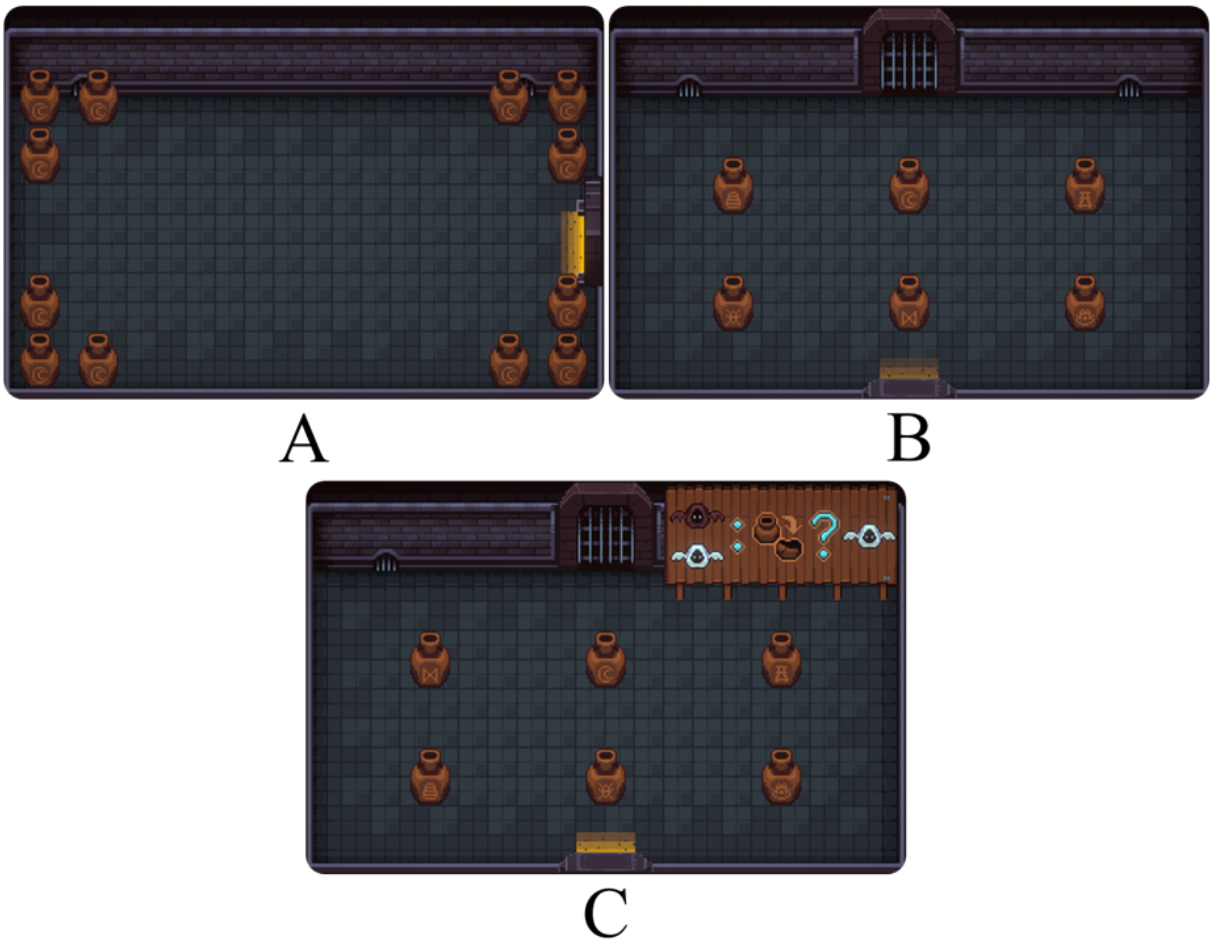

Figure 4.7: Dungeon rooms related to the Pots Challenge. A - Information room; B - Challenge room without additional information; C - Challenge room with additional information.

Taking into account the Asymmetry of Information framework (Table 4.6), the play partner is the only one who has access to the information room that contains the information necessary to complete the challenge, yet both players must make use of this information since both players individually encounter the same challenge room. In the player's challenge room, there is a sign that tells it that both players must destroy a pot and that the correct pot is known to the play partner. Because of this, the player knows that it is the play partner who has the information, and it is also the only one who can deduce that the information inside it is relevant for both players.

4.3.5 Wolf Challenge

Table 4.7: Combination of values from the asymmetry of information framework considered for the Wolf Challenge.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
V	Split	Single (Player B)	Single (Player A)	Single (Player A)	Combined	None

On the floor corresponding to the Wolf Challenge, the player encounters a challenge room (Figure 4.8 - B), which contains six interactable plates with different colours and a sign with a wolf and a spacebar symbol. When interacting with one of the plates, if it is a correct plate, the player will hear a howling sound, but if it is an incorrect one, the player is killed and forced to respawn back at the floor's initial room. The correct coloured plates to interact with can be deduced by the play partner in an information room (Figure 4.8 - A), present somewhere on the play partner's dungeon floor. This information room contains two signs, one with a wolf symbol and the player's symbol, and another with three colour symbols. The answer to the puzzle corresponds to pressing the spacebar to interact with the plates that have the same colour as these three colour symbols.

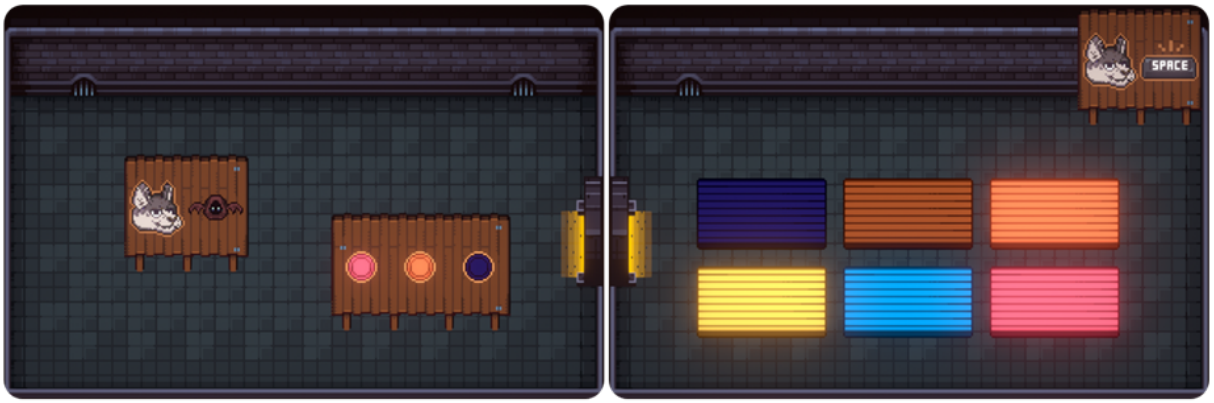

Figure 4.8: Dungeon rooms related to the Wolf Challenge. A - Information room; B - Challenge room.

Taking into account the Asymmetry of Information framework (Table 4.7), the information is split between the player and the play partner, as the player knows that they must use the spacebar to interact with the plates and the play partner knows which plates to interact with. Only the player makes use

of the information, since it is the only one who encounters the challenge room. Since the play partner encounters a sign with the player's symbol in the information room, it knows that it is it who has the necessary information and that the player is the one who needs it.

4.3.6 Sequence Challenge

Table 4.8: Combination of values from the asymmetry of information framework considered for the Sequence Challenge.

Combination	ASYMMETRY OF INFORMATION					
	Implementation		Awareness			
	Possession	Utility	Possession	Utility	Location	Consequence
VI	Split	Single (Player B)	Single (Player B)	Single (Player B)	Combined	None

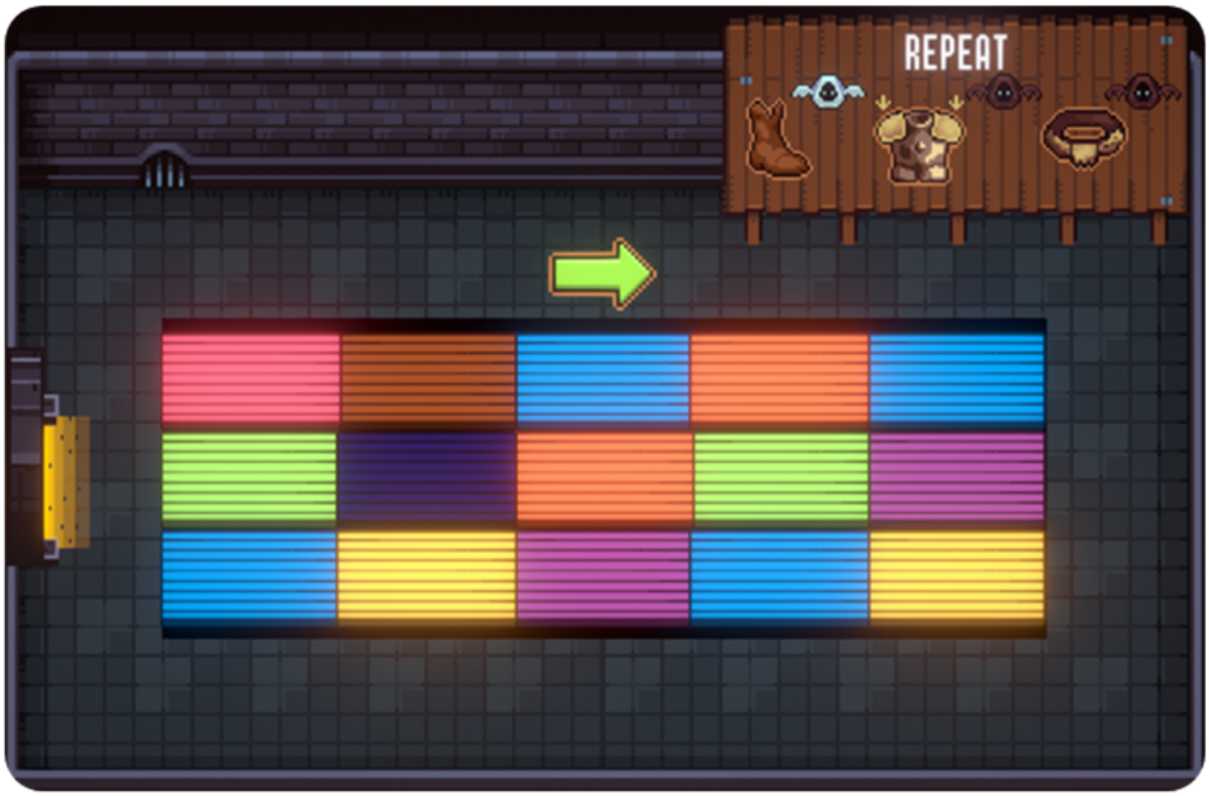

Figure 4.9: Challenge room related to the Sequence Challenge.

On the floor corresponding to the Sequence Challenge, the player encounters a challenge room (Figure 4.9), which contains a three-by-five matrix of coloured floor plates with an arrow pointing east on top, and a sign with three clothing symbols, each associated with a player symbol, and with the keyword "repeat". When stepping on one of the plates, if its colour does not obey a predefined colour order, then the player is killed and forced to respawn back at the floor's initial room. The correct colour order to step on can be deduced by the players according to the existing sign. This mechanic does not have an information room associated with it, as the relevant information is present on the play partner's avatar. The answer to the puzzle corresponds to stepping on the coloured plates according to a specific colour order which corresponds to the player's boots colour, the play partner's shoulder pads colour and the play

partner's belt colour, in that order. This sequence is then repeated until the player goes from the left side of the matrix and leaves on the right side.

Taking into account the Asymmetry of Information framework (Table 4.8), the information is split between the player and the play partner, as the player knows how to order and execute the colours and the play partner has the relevant colours on their avatar. Only the player makes use of the information, since it is the only one who encounters the challenge room. Since the player has the player symbols displayed in the sign, it knows that both players have the necessary information and that it is it who needs it, as it is the one who encounters the challenge room.

Chapter 5

Evaluating Asymmetry of Information

A controlled laboratory study was conducted with player pairs. The goal of this user study was to evaluate the applicability of the framework proposed, as well as understand the potential to design games centred around information asymmetry as a catalyst for social interaction. As such, our research questions focus on the application of information asymmetry and the outcomes of its use in the design of games. As a tool to answer these questions, a digital game artefact was designed and developed based on the Asymmetry of Information framework. To evaluate the experience provided, participants were asked to complete several questionnaires, before and after playing the game, as a way to understand their user profile and gather their perceptions of the experience. A mixed-methods approach was applied to the analysis of the data, which bolsters qualitative, descriptive and statistical results. The research questions we aimed to answer are as follows:

- **RQ1:** How do players perceive asymmetry of information in cooperative games?
- **RQ2:** How do different types of asymmetry of information shape social interaction between players?

5.1 Participants

Participants were gathered through recruitment announcements in specific venues. Most participants were contacted within the context of a game-related curricular unit at our university, while other participants were gathered from departments of our university and research institute. The sample is constituted of 20 participants, aged 19 to 42 (M = 23.9, SD = 4.79), mostly university students with varying levels of gaming experience (Table 5.1). Participants were encouraged to enrol in the study in pairs, thus attempting to guarantee some level of acquaintance, however, this was not a mandatory requirement. From here on, participants will be referred to by a letter that identifies their corresponding pair, and a number that identifies the participant (e.g., C2).

5.2 Procedure

Participants were recruited through recruitment announcements on specific venues. Participants who wished to enter the study were asked to fill out a recruitment form where they were required to state their

Table 5.1: Participant demographics, including their identifier (ID), age, playing frequency in any platform (occasionally/monthly/weekly/daily), playing duration in any platform (short/standard/extended/long), self-reported investment profile (casual/mediumcore/hardcore/non-gamer), self-reported competitive profile (not competitive/slightly competitive/moderately competitive/very competitive/extremely competitive), game type preference (singleplayer/multiplayer PvE/multiplayer PvP/multiplayer PvEvP), and affinity preference with play partners (family/friends/acquaintances/strangers).

ID	Age	Playing Frequency	Playing Duration	Investment Profile	Competitive Profile	Type Preference	Affinity Preference
A1	23	Daily	Extended	Mediumcore	Very Competitive	Multiplayer PvEvP	Friends
A2	24	Daily	Extended	Mediumcore	Very Competitive	Multiplayer PvE	Friends
B1	21	Daily	Standard	Mediumcore	Slightly Competitive	Multiplayer PvEvP	Friends
B2	21	Daily	Standard	Mediumcore	Moderately Competitive	Singleplayer	Friends
C1	21	Weekly	Standard	Casual	Slightly Competitive	Multiplayer PvE	Friends
C2	22	Weekly	Standard	Casual	Slightly Competitive	Multiplayer PvE	Friends
D1	24	Weekly	Standard	Casual	Slightly Competitive	Singleplayer	Friends
D2	42	Occasionally	Short	Non-gamer	Slightly Competitive	Multiplayer PvEvP	Friends
E1	22	Daily	Extended	Mediumcore	Very Competitive	Singleplayer	Friends
E2	23	Daily	Extended	Mediumcore	Slightly Competitive	Multiplayer PvEvP	Friends
F1	23	Weekly	Standard	Casual	Very Competitive	Singleplayer	Family
F2	19	Weekly	Standard	Mediumcore	Moderately Competitive	Singleplayer	Family
G1	27	Weekly	Short	Casual	Very Competitive	Multiplayer PvEvP	Strangers
G2	29	Daily	Standard	Mediumcore	Extremely Competitive	Multiplayer PvP	Friends
H1	23	Daily	Extended	Casual	Slightly Competitive	Singleplayer	Friends
H2	23	Daily	Extended	Casual	Extremely Competitive	Multiplayer PvEvP	Friends
I1	25	Daily	Standard	Mediumcore	Very Competitive	Singleplayer	Friends
I2	22	Daily	Long	Hardcore	Moderately Competitive	Multiplayer PvE	Friends
J1	22	Monthly	Standard	Casual	Very Competitive	Multiplayer PvEvP	Friends
J2	22	Daily	Extended	Casual	Very Competitive	Multiplayer PvEvP	Friends

name, age, e-mail, self-perceived digital game experience (yes/no), and if they had a play partner who also enrolled in the study. If so, the form requested the other participant's e-mail address.

After submitting the recruitment form, participants were then contacted through e-mail requesting them to disclose their and their play partner's availability to participate in the study with the help of a scheduling tool. Participants who did not state having a play partner to participate were also requested to disclose their availability to participate in the study with the help of a scheduling tool so that they could be paired with other participants who also did not have a play partner.

After their submission, they were again contacted to confirm their appointment. The study took place at our university and on the research centre's laptops. Participants were asked to meet in a specific room for the study. In this room, participant pairs were seated opposite and facing each other, with screens positioned between them to prevent visual access.

When starting, participant pairs were debriefed and requested to fill out and submit a consent form (Appendix E). If both participants agreed to all the listed terms, they were then asked to fill out a demographic form where their name, e-mail, age, playing frequency, playing duration, self-reported investment profile, self-reported competitive profile, preferred game type and preferred affinity level with play partners, were requested.

Participant pairs were then given a brief explanation of the game's structure and theme and given the opportunity to experience it. Participants were informed they could communicate with each other throughout the study and playing sessions were audio, video and screen captured, as well as game events and player actions (e.g., player death, room entering or exiting, challenge completion) were logged into a database, for later possible replication and analysis. To play the game, participants were required to identify themselves by logging into the game with their corresponding participant ID. Participants were told that, if at any point there were any questions regarding the game that the researchers could answer without tainting the viability of the study, they could do so.

After experiencing the game, participant pairs were asked to individually fill out another form regarding their experience. This form was composed of two parts: the first corresponded to the miniPXI Questionnaire [58] with a modified scale, and the second was a custom-made questionnaire asking participants for their perspectives on the different asymmetric mechanics (Appendix F). The latter prompted participants on their perspectives regarding connection with play partner promotion, strong communication promotion, fun, challenge, and satisfaction with the play partner's performance. Moreover, the most liked and disliked asymmetric mechanic was also requested.

Finally, participants were asked to participate in a group interview with their play partner and the researchers. This step was audio recorded. In this interview (Appendix G), participants were asked about their general experience (i.e., experience with games of the same genre, which parts of the game the participants enjoyed or frustrating moments), their perspective on the collaboration throughout the game (i.e., moments participants felt they needed to communicate, moments were participants felt they were missing information, perspectives on how the game supported their collaboration), their perspective on the various asymmetric mechanics (i.e., perceived differences or similarities between mechanics, most liked and disliked mechanics, perspectives on the order of difficulty of the mechanics), their perspective on their communication throughout the game, game elements they perceived to have influenced their communication, and, finally, suggestions on how to promote high-quality communication as well as on

how to improve the game in general.

5.3 Data Analysis

A descriptive and statistical analysis of the quantitative data provided by the questionnaires was conducted. The results from the demographics form were analysed in order to give an overview of the sample present in the study. The results from the miniPXI Questionnaire [58] were also analysed in order to get an informed overview of the participants' perceived experience during the user study. Moreover, the results from our custom-made experience form regarding the various asymmetric mechanics were curated and verified for normality. Since the data was not normal, we applied a Friedman Test to analyse relations and implications between each asymmetric mechanic regarding dimensions such as perceived connection with the play partner promotion, communication quality with the play partner promotion, fun of the mechanic, challenge of the mechanic, and satisfaction with the play partner's performance.

All audio recordings from each interview were transcribed, including reactions and interventions in the dialogue, such as laughter, shock or hesitation. A deductive and inductive thematic analysis [59, 60] was then performed over these interview transcriptions. The codebook that informed this step was iterated throughout the process, based on iterative readings of the interviews and notes taken by the researchers during the user study. The codebook was first created with deductive codes, which were informed by our readings, interview script, and research questions (e.g., strategy, asymmetry, collaboration, communication). These codes were then discussed amongst the researchers involved, revised with some removed and others added. With the deductive codebook completed, the next step was to code the interview transcriptions, adding relevant inductive codes to the codebook as needed. The final codebook is available in Appendix H.

Finally, the codification of the interviews originated the discussion of relevant relationships and themes perceived from the codes. This discussion led to the rationalisation and determination of the overarching themes present in our study and discussed below in the Findings section.

5.4 Limitations

The developed game constitutes a proof-of-concept prototype which, although high-quality, still does not match the quality of a fully fleshed-out commercially released game. The time and resources used to produce *Parallel Realms: Asymmetry United* were limited, and, as such, it might not correspond to what participants were accustomed to. This generated some inconsistencies in some participant pairs' experiences. In cases where the game was stuck, due to technical issues, and the participants were unable to progress, it was required that the game be closed and rebooted. In other cases where the playable character was stuck yet administration controls were able to fix it, it was required that the researchers intervened and manipulated the game. This affects the logging capabilities of the prototype, the experience of the participants, and possible results.

Finally, although efforts were put into recruiting participants who met the advised minimum requirements for the study, this was not possible at all times. The level of affinity of each participant pair was not attested, especially since some participant pairs had to be matched by the researchers, and specific digital

game experience with games in the same genre as the one developed was not verified. In the case of one participant, no experience with digital games was reported. The miniPXI Questionnaire [58] applied in our study constitutes a modified version that, instead of a 7-point Likert scale, bolsters a 5-point Likert scale by a misstep in reappropriating a previous questionnaire.

5.5 Findings

In this section, we present the results of our analysis. Firstly, we present an overview of the participant pairs' experiences through a descriptive summary of data from the game logs as well as from the miniPXI Questionnaire [58]. Secondly, we present the results from the Friedman and Wilcoxon Signed-Rank Tests applied to the answers to our custom-made experience form. Finally, we present the themes resulting from the qualitative analysis.

Table 5.2: Participants' gameplay logs summary. * - missing deaths due to administration controls for forced killing. ** - extra deaths due to game reset.

ID	Type	Faction	Total Deaths	Total Backtracks	Total Deaths After Final Room	Total Failed Attempts	Total Successes	Final Coins	Time Taken
A1	A	Angel	12	5	3	9	4	15	34:22
A2	B	Devil	7*	13	7	11	3	0	34:14
B1	A	Angel	8	11	5	5	4	34	33:00
B2	B	Devil	15	23	15	15	2	0	33:09
C1	A	Angel	13**	15	5	5	2	16	35:26
C2	B	Devil	22	8	11	4	3	0	35:30
D1	A	Devil	10	10	4	3	3	4	42:43
D2	B	Angel	16*	5	3	3	3	54	42:25
E1	A	Angel	31	5	3	2	4	0	42:55
E2	B	Devil	9	12	4	4	3	6	42:59
F1	A	Devil	12	6	3	3	3	14	28:46
F2	B	Angel	5	2	1	1	4	36	28:45
G1	A	Devil	4	5	2	1	4	32	25:07
G2	B	Angel	17	21	14	12	2	0	25:00
H1	A	Angel	1	4	1	1	4	64	34:23
H2	B	Devil	20**	13	11	9	3	0	34:21
I1	A	Angel	1	7	0	0	4	77	22:10
I2	B	Devil	4	9	3	3	4	51	22:16
J1	A	Angel	8	2	2	1	4	21	40:20
J2	B	Devil	11	17	9	8	2	0	40:21

Participants took an average of 33 minutes and 54 seconds to complete the main dungeon in the game, with the fastest completion time being 22 minutes and 10 seconds, and the slowest being 42 minutes and 59 seconds.

On the first floor, where both type players encountered the Weapon Challenge (Combination III), they displayed relatively low mortality rates, averaging 0.50 deaths (SD=0.53), compared to type B players, who averaged 0.90 deaths (SD=0.88). Backtracking was minimal for both groups, with type A averaging 1.00 backtracks (SD=0.47) and type B averaging 1.40 backtracks (SD=1.17). Furthermore, deaths after encountering the final room were infrequent, with type A averaging 0.50 (SD=0.53) and type B averaging 0.50 (SD=0.53). Failed attempts at challenges were also relatively rare, with type A averaging 0.70 failures (SD=1.89) and type B averaging 0.70 failures (SD=1.25). Success rates in

completing dungeon floor challenges were consistently high at 100% for both groups.

Moving to the second floor, type A players faced the Skull Challenge (Combination I) while type B players encountered the Chest Challenge (Combination II). Here, death rates increased significantly for both groups, with type A averaging 2.20 deaths (SD=1.87) and type B averaging 4.30 deaths (SD=1.42). Backtracking intensified, particularly for type B players who averaged 5.20 backtracks (SD=2.90), while type A players averaged 3.50 (SD=2.17). Additionally, deaths after encountering the final room increased, with type A averaging 1.50 (SD=1.27) and type B averaging 3.10 (SD=1.60). Failed attempts at challenges also rose, with type A averaging 1.60 failures (SD=1.26) and type B averaging 3.00 failures (SD=1.49), leading to success rates dropping to 80% for type A and 50% for type B on this floor.

On the third floor, type A players encountered the Pots Challenge (Combination IV). Here, type A faced higher mortality rates, averaging 4.00 deaths (SD=3.40), whereas type B averaged 3.20 deaths (SD=3.05). Both groups showed relatively low levels of backtracking, with type A averaging 0.80 backtracks (SD=1.14) and type B averaging 1.90 backtracks (SD=1.37). Deaths after encountering the final room remained low for type A (M=0.20, SD=0.63) and slightly higher for type B (M=1.70, SD=2.11). Failed attempts at challenges were minimal for type A (M=0.20, SD=0.63) but increased for type B (M=1.00, SD=1.49), leading to success rates of 90% for type A and 80% for type B.

Finally, on the fourth floor, type A players faced the Wolf Challenge (Combination V), while type B players encountered the Sequence Challenge (Combination VI). Here, both groups faced elevated mortality rates, with type A averaging 3.30 deaths (SD=4.99) and type B averaging 4.20 deaths (SD=2.39). Backtracking levels varied, and deaths after encountering the final room were observed, but failed attempts at challenges were common, particularly for type B who averaged 2.50 failures (SD=2.37). Despite the challenges, both type A and type B maintained relatively high success rates on this floor, with 90% and 60%, respectively. A summary of the gameplay logs is presented in Table 5.2, while a summary of the gameplay logs according to player type and floor is presented in Table 5.3.

Table 5.3: Participants' gameplay logs summary, according to player type and floor. * - existence of error factor due to administration controls for forced killing or game reset.

Dungeon Floor	Mean Deaths*		Mean Backtracks		Mean Deaths After Final Room		Mean Failed Attempts		Successes (%)	
	Player A (SD)	Player B (SD)	Player A (SD)	Player B (SD)	Player A (SD)	Player B (SD)	Player A (SD)	Player B (SD)	Player A	Player B
1	0.50 (0.53)	0.90 (0.88)	1.00 (0.47)	1.40 (1.17)	0.50 (0.53)	0.50 (0.53)	0.70 (1.89)	0.70 (1.25)	100	100
2	2.20 (1.87)	4.30 (1.42)	3.50 (2.17)	5.20 (2.90)	1.50 (1.27)	3.10 (1.60)	1.60 (1.26)	3.00 (1.49)	80	50
3	4.00 (3.40)	3.20 (3.05)	0.80 (1.14)	1.90 (1.37)	0.20 (0.63)	1.70 (2.11)	0.20 (0.63)	1.00 (1.49)	90	80
4	3.30 (4.99)	4.20 (2.39)	1.70 (1.49)	3.80 (3.05)	0.60 (0.52)	2.50 (2.37)	0.50 (0.53)	2.30 (2.36)	90	60

Ratings resulting from the administration of the modified miniPXI Questionnaire [58] averaged M=4.22 (SD=0.87) for type A participants, M=3.91 (SD=1.05) for type B participants, and M=4.06 (SD=0.97) in total, which indicates an overall positive player experience: "*Genuinely, I liked it a lot. I thought it was a lot of fun. It reminded me of another game I'd played with my brother some time ago.*"

(B1). On average, the best-rated components were Audiovisual Appeal (M=4.60, SD=0.50) and Enjoyment (M=4.50, SD=0.51), while the worst-rated one was Mastery (M=3.20, SD=1.11). This audiovisual appeal and enjoyment factors were reported by participants who mentioned wanting to keep on playing the game: "*It was really fun, I enjoyed the game. I felt involved in the game itself and wanted to keep going to see where it would end up.*" (D1). See Table 5.4 for a summary of the results.

Table 5.4: Results from the administration of the modified miniPXI Questionnaire [58], according to player type and total.

Item	Mean Results		
	Player A (SD)	**Player B (SD)**	**Total (SD)**
Playing the game was meaningful to me	4.30 (0.67)	3.50 (1.18)	3.90 (1.02)
I wanted to explore how the game evolved	4.70 (0.48)	4.40 (0.52)	4.44 (0.51)
I felt I was good at playing this game	3.30 (0.95)	3.10 (1.29)	3.20 (1.11)
I felt free to play the game in my own way	4.30 (0.82)	4.10 (1.10)	4.20 (0.95)
I was fully focused on the game	4.60 (0.52)	4.20 (0.79)	4.40 (0.68)
The game gave clear feedback on my progress towards the goals	4.30 (0.82)	3.50 (1.27)	3.90 (1.12)
I liked the look and feel of the game	4.70 (0.48)	4.50 (0.53)	4.60 (0.50)
The game was not too easy and not too hard to play	3.70 (0.82)	3.90 (1.10)	3.80 (0.95)
It was easy to know how to perform actions in the game	3.80 (1.14)	4.10 (0.99)	3.95 (1.05)
The goals of the game were clear to me	4.00 (1.05)	3.40 (1.17)	3.70 (1.13)
I had a good time playing this game	4.70 (0.48)	4.30 (0.48)	4.50 (0.51)

Regarding the results from our custom-made experience form, in terms of connection, the highest-rated asymmetric mechanic was the sequence challenge (M=4.65, SD=0.59), and the lowest-rated mechanic was the skull challenge (M=3.80, SD=1.06). In terms of communication, the highest-rated mechanic was the sequence challenge (M=4.65, SD=0.59), and the lowest-rated mechanic was the weapon challenge (M=3.70, SD=1.38). In terms of fun, the highest-rated mechanic was the sequence challenge (M=4.05, SD=1.19), and the lowest-rated mechanic was the chest challenge (M=3.75, SD=1.16). In terms of challenge, the highest-rated mechanic was the sequence challenge (M=4.42, SD=0.69), and the lowest-rated mechanic was the weapon challenge (M=3.40, SD=1.23). Finally, in terms of partner performance, the highest-rated asymmetric mechanic was the weapon challenge (M=4.30, SD=0.80), and the lowest-rated mechanics were the skull challenge (M=3.50, SD=1.28) and the chest challenge (M=3.50, SD=1.36). A summary of the results for connection, communication, fun, challenge, and partner performance is presented in Table 5.5, and a visual representation in Figure 5.1.

Table 5.5: Mean and standard deviation for ratings of connection, communication, fun, challenge and partner performance for each asymmetric mechanic.

Measure	Mean Ratings					
	Weapon Challenge (SD)	**Skull Challenge (SD)**	**Chest Challenge (SD)**	**Pots Challenge (SD)**	**Wolf Challenge (SD)**	**Sequence Challenge (SD)**
Connection	4.00 (1.34)	3.80 (1.06)	4.00 (1.12)	4.05 (0.94)	4.45 (0.76)	4.65 (0.59)
Communication	3.70 (1.38)	3.95 (1.19)	3.85 (1.23)	4.15 (1.04)	4.35 (0.67)	4.65 (0.59)
Fun	3.95 (1.23)	3.79 (1.08)	3.75 (1.16)	3.95 (1.05)	3.90 (1.07)	4.05 (1.19)
Challenge	3.40 (1.23)	4.00 (1.21)	4.25 (0.91)	3.50 (1.10)	3.95 (1.10)	4.42 (0.69)
Partner Performance	4.30 (0.80)	3.50 (1.28)	3.50 (1.36)	3.90 (1.45)	3.75 (1.41)	4.00 (1.47)

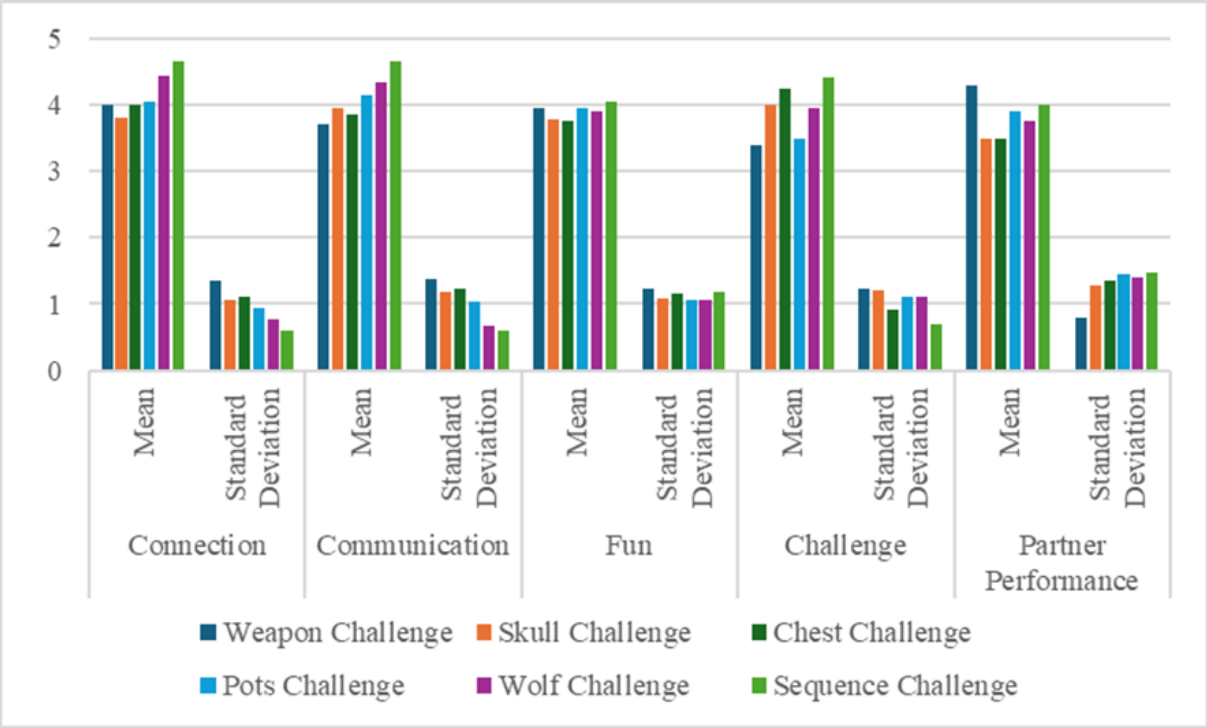

Figure 5.1: Bar chart portraying mean and standard deviation for ratings of connection, communication, fun, challenge and partner performance for each asymmetric mechanic.

The results from our custom-made experience form were subjected to a statistical analysis. There were no statistically significant differences observed in perceived communication ($\chi^2(2)$ = 12.204, ρ = 0.032), fun ($\chi^2(2)$ = 2.348, ρ = 0.799), or partner performance ($\chi^2(2)$ = 10.576, ρ = 0.060) based on the asymmetric mechanic. However, a statistically significant difference was found in perceived connection ($\chi^2(2)$ = 17.893, ρ = 0.003) and challenge ($\chi^2(2)$ = 17.893, ρ = 0.003), depending on the asymmetric mechanic.

Post hoc analysis with Wilcoxon signed-rank tests was conducted on these two measures, incorporating a Bonferroni correction with a significance level set at ρ ¡ 0.005. There was a statistically significant difference in perceived connection regarding the skull and sequence mechanics (Z = -2.871, ρ = 0.004), yet no other challenge pairs displayed significant differences regarding connection. Conversely, a statistically significant reduction in perceived challenge was noted regarding the weapon and sequence mechanics (Z = -3.256, ρ = 0.001). No other challenge pairs exhibited any significant differences regarding challenge.

5.5.1 Collaborative Prompting and Flow

The communication between pairs was encouraged by multiple factors. Most participants identified specific game elements that acted as triggers for communicating, such as signs, symbols or interactable objects: "*It was whenever I saw a colour or a symbol, anything out of the ordinary, that I felt I had to tell them.*" (B2). A participant, in particular, reported noticing the names of the dungeon rooms, which helped them identify the puzzle challenge at hand: "*I'd get to the room and see that down there, there was a 'Challenge... Something...'.*" (D1). Another factor that led participants to communicate was identifying that they were encountering an information or challenge room: "*In the red rooms. [...] When you got to a room and there was nothing to kill, you had to communicate.*" (G1).

Participants debated the introduction of more obvious collaboration prompts and aids. Some mentioned the inclusion of collaboration aids such as what information was relevant or what it meant, "*There needed to be some clues. What I could use from your side, I don't know.*" (G2). The need for these hints was sometimes associated with expertise, meaning that less expertise needed more hints: "*[...] I don't usually play this kind of game either, so it's not easy to identify these symbols. And maybe more obvious symbols, or you have an option to see a description of the symbols and colours. I think that was missing too.*" (G2). On the other hand, some participants' perspectives on the introduction of these prompts and aids were that it would make the game easier and thus less challenging and boring: "*[...] Because if it was, for example, a room where there was a symbol saying 'Pay attention'. [...] Exactly, the game would get boring. [...] I think that takes some of the fun out of the game.*" (H1). Some participants reported not paying enough attention to the game's elements and thus their success in completing certain challenges could have had a luck factor, however, that this is a way to enjoy and play the game and not necessarily something that needs to be fixed with extra collaboration prompts or aids: "*Was it luck? Yes, but I think it's also another way the game happens. We don't have that... 'Ask your friend for help', 'Tell your friend you see...'. It's about trying to get through the game.*" (H2).

The flow of communication was often reflected upon by the participants. Most participants reported a delaying strategy in the transmission of information, encountering clues that they would try to remember and later report to their play partner: "*I'd get to that room, make the connection: 'OK, I'm going to*

need this for later'. I'd try to remember and then when I got to the other room I'd tell them." (D1). This was recognised by some as a less dynamic and organic way of collaboration: "*It makes it a bit... less dynamic. [...] So we keep quiet and then eventually communicate.*" (B2). Some participants also reported the negative influence of frustration and stress stemmed from self-perceived poor performance, in the flow of communication: "*When you start performing poorly, you get frustrated and end up focusing on things other than communication.*" (E2).

5.5.2 Interdependence Dynamics

When interviewed, some participants, unbeknownst to them, reported some perception of the existence of the varying subcategories of the proposed framework for asymmetry of information. Some participants could not exactly pinpoint what changed between asymmetric mechanics, but that there were changes: "*It's almost the same thing, but it's not.*" (H1). In some cases, participants, despite not naming it, pinpointed the variation of the ***Awareness of Location*** sub-category: "*As I had to go to the chest anyway... In other words, it's not as if there was another puzzle room at the same time. I didn't necessarily need the key to know that I had to go to the chest. If there was another puzzle, then I needed an indication of which room I had to go to with that answer.*" (E2). In other cases, the ***Implementation of Possession*** was perceived: "*Unless I misunderstood, the key to solving the problem wasn't on both sides, it was only on their side.*" (I1). Moreover, the possible values of the sub-categories were also subconsciously mentioned by the participants, such as the ***Multiple*** value in the ***Implementation of Utility*** or the concept of the *Combined* value: "*For example, we might both have to choose the same thing in some cases.*" (J2); "*Although there already are, but for example patterns that we had to imagine side by side, and they had to write a pattern and I had to write a pattern, put them together, and they would represent something in the world, but it's a bit difficult to draw something like that. But partial information.*" (I1).

To manage the asymmetry of information, participants reported being dependent on their play partner's perspective of the game. This often meant that participants were required to prompt each other for information in order to understand how to complete their challenge, "*Whenever we came across something that we couldn't manage on our own. We always had to get information from our partner.*" (F1), which was not always effective as the complexity put forth by the **splitting of information** or the requirements to communicate it to the other player resulted in moments of confusion: "*They were completely different, and the information wasn't directly on either side, so I was a bit confused as to what I was seeing related to what [D2] was seeing and what the answer was [...].*" (D1). Nonetheless, participants reported a learning curve in the game - as players got used to the asymmetry of information, their performance and effectiveness would increase: "*Anyway, learning the little tricks: realising that, OK, if there's something here, and it didn't go well, the next one I have to pay more attention to.*" (H1).

5.5.3 Seeking Greater Interdependence

Participants indicated wanting more interdependence between them and their play partners, not just when progress was blocked. A participant in particular reported understanding that the game's structure included progress barriers in the form of the dungeon floors with their respective challenges and that to complete these challenges both players were required to contribute: "*[...] I realised that the game was*

more oriented towards... How should I put it... Barriers? Barrier style, in other words, you both have to pass the puzzles to be able to do it." (I2). This was perceived as a blocking of progress, which was portrayed in a negative light. The inclusion of information that would aid players but not be necessary for progress was suggested by a participant in particular: "*I think I could also use a bit more... [...] Something where the other person's information helps but isn't necessary for progress [...]*" (I2).

This desire for more interdependence was preferred by some on the exploration side of the game as well. Participants highlighted the **one-sided information location** nature of some challenges. The perception that certain challenges could only be completed with the **information that solely the play partner possesses**, and vice versa, was reported by some in a negative light: "*Well, the problem is that either they get all the information and give it to me, or I give it to them. So it would be, I'd say one thing, they'd unlock it. I'd say one thing and they'd unlock it.*" (B2). A few participants that reported having previous experiences with games such as *We Were Here* [28], compared these games to the study prototype in terms of the **combination of information** by the multiple players, saying that this necessary exchange of information, which is beneficial for both, is a positive point: "*In one sense there was information that one person didn't have and that the other didn't have, and they had to complement the information they had.*" (I2). A participant in particular highlighted not being bothered by **one-way transactions of information** that were required only by the receiving end, but that when **both sides require an information** and **only one side is in its possession**, then this was not enjoyable: "*I didn't like that. [...] If it's just a transaction, that is, I'm giving them information on a one-off basis, that's fine, but if you both need information, and it's only on one side, I think...*" (I1).

5.5.4 Managing Personal Exploration and Interaction

The need to wait for their play partner to catch up when traversing the dungeon was recognised by some participants. Participants would often reach either the information or challenge room and end up in the position of having to wait for their play partner to finish what they were doing without knowing what to do: "*I often waited for them to finish and didn't know what to do.*" (B1). On the other hand, participants who were still busy in the dungeon and their play partner was waiting for them, reported feeling some sense of duty in giving them the information they required, and that not being able to promptly do so induced some level of frustration: "*The thing is, I had to kill all the beasties to be able to give you the information. It was frustrating me.*" (E1).

Often times, when waiting for their play partner's progression, participants would explore the dungeon. When struggling to complete a challenge, participants reported doubting themselves in their previous explorations, double-checking previously seen rooms for more information: "*That's right. Because I was always like, I'm missing something, I was going back and forth, back and forth.*" (B1). In a particular case where a participant was having some trouble clearing the dungeon rooms, the idea that an unseen room, that was not reachable due to their character's power level, could contain relevant information for the completion of a challenge was a source of worry: "*And I thought: 'OK, if I have this information on my side, but I couldn't go to the other room because it was, like, a room with monsters that I couldn't defeat, the information could be in that room.'.*" (E1). This indicates that some participants were expecting information to be scattered across multiple rooms. Some participants suggested this feature as a way to make the dungeon exploration in the game more interesting: "*The various puzzle elements could be*

more spread out across the map. To make it more interesting to explore the map. Because the format was always a bit the same. You get the information from one place, and then you go to the final room and stick it there. Together with the colleague's information." (F1). Some participants reported understanding that, since the information was not scattered across the dungeon floor, whenever they realised they had already encountered both the information and challenge rooms, then there was no need for them to traverse the dungeon floor further: "*Yes, because, for example, if I'd already found the altar room and the other room with information, I'd completely lose the motivation to explore the other rooms that I know still exist.*" (F1).

5.5.5 Factors Influencing Complexity Navigation

Participants insinuated that the complexity of the game could be attributed to multiple factors, with one such factor being the familiarity with the game's genre. Some participants reported having previous experience with dungeon crawler-type games, "*[...] the dungeon crawler style of game, where you earn items, that's what I usually play.*" (B2), however, only a few reported having experience with asymmetric cooperative games, reporting games such as *We Were Here* [28] and *It Takes Two* [29]: "*I've played We Were Here. [...] I've played It Takes Two, too.*" (A2). Other than the rare mentions of having played *We Were Here* [28], almost no participant had experience with games with asymmetry of information. One participant, in particular, highlighted the perceived impact of genre familiarity on their expertise and performance, stating that people with more experience will be able to more easily and efficiently pinpoint relevant talking points or collaboration prompts, whereas people with less experience could take longer to complete the challenges: "*There will be someone who has played more similar games who will know that I have to talk about this. Who won't go, 'OK, it's going to take us an hour to get through the game'.*" (H2).

Another relevant contributor to complexity was the **splitting of the information**. The fact that players needed to articulate their knowledge with their play partner in order to progress in the game generated some confusion or worry for some: "*I don't know if it was me, I was always thinking... I was missing something and that I wasn't telling them what I was supposed to.*" (B1). The insecurity of having information that is relevant for the play partner and not knowing how to describe it and how it would be perceived was also an effect caused by the **splitting of information**: "*My biggest difficulty was describing things and I couldn't understand how it would have an impact on the other side.*" (G2).

Some challenges relied on certain communication requirements, such as properly describing the information to the other side or making covert associations between information. By some, this was perceived through their perception of their communication quality: "*We should have communicated better. Some parts. There was something missing there. A better explanation of what we saw and so on. And then that makes it very difficult to move on.*" (B2). Many participants reported finding it especially hard to describe colours or, at times, symbols to their play partner: "*And then there are the symbols and colours, which are not easy for me to distinguish or describe.*" (G2). Some participants reported that the importance of certain information was difficult for them to convey when communicating: "*The only problem I had was the difficulty in explaining how important the colours were.*" (I2).

5.5.6 Game Language Interpretation

Many participants reported difficulty in interpreting the game's information language. The game utilises symbols as a way to convey the information to the players. In some instances, not understanding these symbols, their meaning or their importance led to confusion: "*It was a bit hard to understand the symbol.*" (A2). To associate information rooms on the player's side to the challenge room on the play partner's side, and vice versa, the game utilises key symbols such as a wolf or skull symbols. Some participants did not understand the connection which made them associate these symbols with other scenarios, generating confusion: "*I mean, for example, the challenge, the skull mechanic and the wolf mechanic, was the only thing that confused me. Because I thought I was looking for some kind of skull or a wolf, but I don't know if it was to differentiate the two challenges or not.*" (A2). Despite this, some participants still reported understanding the meaning behind these key symbols: "*You could tell it belonged to the same room. So, as I had found the wolf, I knew you had to do something in that room too.*" (A1). A particular participant pair reported moments of confusion due to the order in which the symbols were presented: "*[...] as it was in the middle between the angel and the boots, I thought that the key was saying that I had to find a key or...*" (E2). Certain challenges had certain communication requirements that made it hard for participants to complete them. One such case is the challenges where participants are required to make the association between the clothing item symbols and the clothing colours of the players' avatars: "*My boots were the ones I saw were the brown ones. I didn't even think to look at my character's boots.*" (J1).

Some challenges, such as the chest and sequence challenges, were perceived as more complex than the rest due to their information association requirements. Some participants found that not understanding the challenge due to its perceived complexity, led to them not enjoying it as much: "*We didn't like it because we didn't realise it at the time. There was this failure in communication. [...] It's our fault, obviously. But then that spoilt the experience a bit.*" (F1). Despite this, many participants reported enjoying this added complexity due to the feeling of being able to complete it: "*I liked the last one, although I didn't get there.*" (J1). Participants reported enjoying the process of being able to decipher and understand the challenges: "*It's just that it's not obvious, so it's always nice. To stand there for a while thinking and then...*" (H1). One participant, in particular, highlighted how they enjoyed it when they were facing the chest and sequence challenges and their play partner figured out the solution: "*When [F1] had the eureka moment, 'ah, maybe they're our boots', it was very funny.*" (F2).

5.5.7 Coherence Expectations

Participants pointed out how they were expecting some coherence in the challenges' configuration throughout the game, which, when not present, could lead to confusion and heightened difficulty. It was apparent that some participants had pre-established expectations regarding how the game would work, such as the information being scattered throughout the dungeon or getting rewards for breaking the pots in the game. When broken, these expectations led to some confusion: "*When I joined the game, I expected that each room would have a little piece of information hidden in a corner, that I'd always have to be on the lookout and that I'd have to go through all eight rooms to find it.*" (F2).

Another phenomenon that occurred was that participants, when encountering their first asymmetric

challenge, expected the game to behave similarly from then on. A participant in particular reported enjoying the first challenge more for this reason: "*The one with the weapon because it was the first one, and I realised more or less what the game was about.*" (C1). At times, this expectation of mechanical coherence was the cause for some confusion, such as when a participant expected the symbol of an arrow to indicate they had to press the arrow key on the keyboard, due to previously having been prompted to press the spacebar: "*In the other rooms, the spacebar appears exactly as the arrow did, so I thought I had to press the right arrow key to see anything happen. That's when I associated one thing with the other, but nothing happened either.*" (D2). Other times, this was beneficial for the participants, as they were able to draw from past experience to surpass certain obstacles: "*[...] the moment we passed the first puzzle we thought: 'OK, this must happen again.'. Or at least subconsciously we thought that this would happen again and when it did, it was the trigger for us to pass on that information.*" (I1). When beginning play, participants would often focus on irrelevant game elements, thinking they would be relevant for the challenges. As the game progressed, participants would fine-tune their awareness, focusing more on what was perceived as important, effectively picking up on design patterns: "*At first the holes weren't common, so it was communicated, but then, as the monsters, the traps, these things became more common, it was only the less common things that were communicated.*" (I2). Some participants highlighted how they enjoyed it when these perceived patterns were broken by the game: "*I really liked this one because I wasn't expecting it to be a puzzle, as I was used to the wooden sign format.*" (F2). A participant in particular discussed how having relevant information mixed with irrelevant information scattered throughout the game's levels would lead to them feeling lost or somewhat confused: "*No, because if it was like that in every room, I think it would be boring. For example, what you see in one, in the next I'll be like, 'Is it all for use or not?'.*" (H2).

Participants highlighted how they enjoyed the coherence in difficulty of the game. Most participants reported finding the order of challenges to be on par with the difficulty curve, "*Each of these challenges gets harder. So the first two weren't much of a struggle and the other two were more difficult.*" (D2), however, some still found certain challenges to be harder than others: "*The one with the weapon was relatively easy, then the second one with the skull was, unless I really missed something obvious, the hardest, so maybe that should have been left for last.*" (F1). Participants highlighted enjoying drawing on past experience to surpass more difficult challenges, such as when they encounter the chest challenge and are introduced to the possibility of their avatar's clothing being the answer to the problem, and later encounter the sequence challenge which draws on the same premise: "*I also liked the fact that you start with something simple and then use it later with a more complicated puzzle.*" (E2).

5.5.8 Player Dynamics and Communication

Participants highlighted how their familiarity with the play partner, insinuating also that the trust they felt towards them, could be relevant factors in shaping communication. In the instance where the participant pair did not previously know each other, participants discussed how the player connection was a relevant factor in the effective traversal of the game since it influences the deciphering of what the other is thinking or trying to convey: "*We didn't already know each other, so I think it's different from being with someone you already know and who, as [D1] said, you already know, you already know how they react... It's different.*" (D2).

Trust in the self or the play partner was also conveyed as a relevant factor. Some participants showed some worry in their ability to convey accurate and understandable information to their play partner, "*Then I was afraid whether the communication I was giving was the right one or not. So it affected my communication, and it also affected [A1]'s.*" (A2), while others were confident of their attempts at properly communicating: "*I was at least trying to help them with what they needed to do.*" (B1). On the other hand, a few participants reported being hesitant in applying what their play partner communicated to them, after having done so and dying the first time: "*When you then said yellow [...] I click on yellow, then I die. Then I'm afraid, based on that communication, to do anything else.*" (A2). Some participants felt very strongly about their play partner's communication capabilities, which would shape how they approached communication: "*But I was more frustrated with you than with the game itself. [Laughs]*" (E2). Other participants were more lenient, taking into account that their performance might not have been the most efficient as well or saying it happens sometimes: "*You must have understood this better than I did, I didn't like it at all, because I didn't think they were seeing everything, or maybe they were, but I don't know. And then I didn't manage to convey the colours either, which was the right colour, which symbol I was seeing. So I failed a little there.*" (G2).

Perceptions of communication quality were seen as a relevant factor in shaping communication. Many participants felt that, although their communication quality was not bad, it could use some improvements: "*I just... I thought... we should have communicated better. Some parts. It was missing there... A better explanation of what we saw and so on.*" (B2). In some cases, participants had conflicting views on their communication quality, with some reporting that it was poor while others stated it was decent: "*I think our communication, in general, wasn't bad. I think it was good, and I basically don't agree with what they were saying.*" (B1). A participant, in particular, highlighted how their emotional state would influence communication, saying that when they became frustrated, their communication quality would worsen: "*When I started to get frustrated, my communication started to worsen.*" (E1). Some participants suggested ways on how they could have improved performance through communication of abilities acquired, level progress or by taking time to think about the challenges: "*[...] I think it would have been good if we had communicated better, both when we were levelling up and what we were choosing. (...) Because it might have helped you to make some decisions. And maybe it would have helped me.*" (E2); "*Like, we stopped for five minutes and discussed the image. All I had to do was not run around and step on two and die. Just do that. Just stop for five minutes and 'I see this, this, this.'. We did that in the end, and it worked.*" (H2). When asked about how they would improve the communication and collaboration support in the game, some participants suggested alternate methods of communication in-game. These included the possibility of an in-game voice chat, text chat, or a method of communication through drawings or minigames.

5.6 Discussion

The digital game developed was received positively by participants, with many stating the experience as their first time engaging with an asymmetric game. This was seen by most as an enjoyable time for cooperation, regardless of performance or challenge.

In this discussion, we delve into the feedback provided by participants, highlighting their perceptions

regarding the asymmetry of information within the game. Additionally, we explore the observed impact of this asymmetry on social interactions among participants, drawing connections to our earlier findings. By delving into these aspects, we hope to gain a deeper understanding of how asymmetrical game design influences player experiences and social interactions within digital gaming environments.

5.6.1 Perceptions of Asymmetry of Information

The existence of asymmetry of information and its proposed subcategories was perceived by most participants, even if not consciously. In some cases, this perception is directly reported by participants, typically by participants who had previous experience with games built on asymmetry of information (e.g., *We Were Here* [28]) or a working knowledge of the concept of asymmetry. In other cases, even though participants could not explicitly identify the differences that we imbued in the challenges, these affected the way they perceived, collaborated, and progressed in them. For example, the mostly negative reception of the one-sided nature of information in certain challenges along with the fact that participants showed awareness that the same information is used by both players shows that subcategories of the framework such as *Implementation of Possession* and *Implementation of Utility* were perceived. Moreover, this presumes the understanding of split and multiple information that could overlap or be combined. The acknowledgement of the presence of asymmetry of information and its subcategories, by the participants, suggests that the proposed framework corresponds to a step forward in the conceptualisation and mapping of asymmetry of information.

The breaking of coherence expectations and the articulation of combinatorial values from the proposed framework have effects on players' experience. In most cases, participants devised expectations regarding the configuration of the challenges presented based on the first challenge they encountered. Since each challenge presumes a different combination of subcategory values from the asymmetry of information framework, this inevitably led to the breaking of these expectations, which could either cause confusion and frustration, or excitement and positive challenge. Moreover, certain combinatorial values for the subcategories produced different reactions in some cases. For example, the creation of scenarios in which one of the players detains an information, yet is unaware of it, while the play partner does know the player has it (e.g., covert information such as the colour of the avatar's clothing items), in most cases generated a challenging puzzle that, even if players failed to decipher, was exciting and positively received by participants. In other cases, it generated confusion and frustration. On the other hand, certain combinations of values were not perceived as being very distinct, or at all, from each other by most participants. These dynamics thus present themselves as design tools that designers may articulate in the design of games, offering opportunities to enhance player engagement and enrich gameplay experiences. By leveraging the intentional disruption of coherence expectations and the strategic arrangement of combinatorial values from the framework for asymmetry of information, designers can outline games that stimulate curiosity, encourage experimentation, and offer replayability, contributing to a more enjoyable and fulfilling player experience.

5.6.2 Impact of Asymmetry of Information on Social Interactions

Asymmetry of information was seen as a big catalyst for social interaction in cooperative games. Interdependent progress and asymmetry of information that is required to surpass obstacles inadvertently

already presume the need for communication and collaboration. However, the stark contrast between the communication displayed while engaging with the asymmetric mechanics and while engaging with the rest of the game suggests the capability of asymmetry of information to be a catalyst for social interaction, as well as to shape and lead it. This is indicated by the reporting, by participants, of the existence of collaboration prompts (e.g., game elements such as signs or symbols, or the presence of special rooms such as a challenge or information room). These elements were perceived by players as indicators of their need for collaboration through communication. In some reports, the delayed exchange of information or the prioritisation of exploration constitute strategies that players devised in the traversal of the game, often as an effort to strategise information sharing. In others, it just meant a reluctance to engage with their play partner. While it's clear that individual characteristics, player connection, trust levels, and performance, influence social interaction dynamics, it is important to recognise that asymmetry of information plays a crucial role in shaping the communication flow of players.

Different configurations of asymmetry of information for each challenge generated different reactions. The one-sided information exchange nature of certain challenges, or challenges that required little input from both participants, was reported in a negative light. These instances generated less interaction between players, as the solution for the puzzles was either only on one side of the game or very straightforward, requiring few transactions. On the other hand, covert information (e.g., clothing items' colours), for example, generated more and more meaningful collaboration through communication due to its inherent complexity. The ability to complete a challenge (i.e., performance) and the quantity and quality of interactions, typically associated with complexity, possibly influence perceived communication quality. When taking into account a specific asymmetry of information configuration to design for, this ultimately restricts the design space and tends to influence the complexity of a mechanic. This suggests that, despite the innate complexity of the designed mechanics, the complexity added by different types of asymmetry of information and by the need of players to learn and improve communication skills with their play partner has an impact on the number of interactions between players as well as the quality or depth of these interactions, influencing perceptions of communication quality and challenge complexity.

Chapter 6

Conclusion

The gaming industry continues to expand, offering an increasingly diverse array of experiences. Among its many benefits, gaming is recognised as a powerful tool for fostering feelings of togetherness, enhancing social skills, and nurturing relationships. Asymmetric game design has emerged as a particularly promising approach for enriching both social interactions and gameplay experiences. While asymmetry can manifest in various forms within a game, our focus lies specifically in the realm of asymmetry of information. Despite the social potential of this design strategy, there remains a notable gap in understanding the nuanced variations of information asymmetry and how they influence interactions among players, this being the emphasis of our study.

As a first step, we propose a framework for asymmetry of information, as an extension of previous research in the field and based on examples from the industry, with the potential to serve as an analysis, ideation, study design, and clearer discourse tool. This framework aims to encapsulate the possibilities in manipulating asymmetry of information, by deconstructing it into its perceived components, thus serving as a first step towards the understanding and formalisation of this type of asymmetry.

To operationalise the proposed framework, a digital cooperative game for two players, *Parallel Realms: Asymmetry United*, was designed and developed. The primary aim of this game is to investigate the effects of various types of asymmetry of information on player perspectives. Within the game, players collaborate to navigate through a dungeon, engage in combat with enemies, and tackle puzzle challenges. These six puzzles were designed based on a curated selection of asymmetry of information types, built using the framework, which constitute the focus of our study. Through gameplay, players must effectively communicate and share pertinent information to overcome said challenges, thus providing valuable insights into the dynamics of asymmetry of information.

The developed digital artefact was utilised in a user study involving 10 player pairs. The objective was to examine player perceptions of asymmetry of information in cooperative games and how various types of such asymmetry influence social interaction. This laboratory-based study enabled participants to experience the game, complete questionnaires, and engage in a group interview with their respective play partners. Analysis of the results employed a mixed-methods approach, drawing from gameplay data, questionnaire responses, and interview recordings.

The user study revealed that participants, even if not explicitly aware, perceived the existence of asymmetry of information and its subcategories, particularly those with prior experience in such games or knowledge of asymmetry concepts. This asymmetry influenced collaboration and progression, with

some challenges being negatively received due to their one-sided nature or the perception that both players had access to the same information. Furthermore, the breaking of coherence expectations and the introduction of combinatorial values from the framework impacted player experience, leading to either confusion or excitement. Certain combinations of values resulted in challenging yet positively received puzzles, while others caused frustration. These findings offer insights into how designers can use asymmetry and its subcategories as tools in game design to create diverse and engaging experiences.

Additionally, asymmetry of information proved to be a significant driver of social interaction in our cooperative context, inherently necessitating communication and collaboration to overcome obstacles. However, the contrast in communication patterns observed during asymmetric mechanics versus other game aspects highlights the role of this asymmetry in shaping and guiding social interaction in our context. Strategies, such as delayed information exchange or prioritising exploration, emerged as players navigated the game, reflecting varying levels of engagement with their play partner. This suggests that while asymmetry influences communication flow, individual factors, for example, player connection and performance also played a role. Different configurations of asymmetry elicited distinct reactions, such as instances with less interaction and others which fostered deeper collaboration due to their complexity. The complexity introduced by asymmetry ultimately influenced the quantity and quality of player interactions, shaping perceptions of communication effectiveness. In conclusion, our study emphasises the impact of asymmetry of information in cooperative gaming. Through our framework and game design, we explored its influence on player interactions. Understanding dynamics such as these is crucial for crafting engaging and socially enriching gaming experiences in the evolving landscape that is gaming.

6.1 Limitations

It is important to note that our findings and consequent discussed implications are based on a curated set of combinations of values for the subcategories of the framework for asymmetry of information, with these combinations fixing some values and varying others, and subjacent decisions regarding game genre, aesthetics, and other factors. Consequently, our observations might not generalise to every context and type of game. Our design decisions regarding game genre, aesthetics, and other factors, stemmed from attempting to provide a close to realistic game experience that features asymmetry of information. The results of this study relate to a two-person cooperative game, which does not cover cooperation in larger groups. The study was focused on the specific context of co-located casual shared play. We acknowledge that covering all possible design permutations and contexts would be impossible in one work.

6.2 Future Work

In our study, we focused on implementing asymmetry of information by considering a sub-set of combinatorial values derived from the proposed framework for asymmetry of information. Our research outcomes indicate that within our specific context, the presence of asymmetry of information significantly influenced social interactions among participants. Future investigations could investigate other combinatorial values and, additionally, examine their impacts on player perceptions, gameplay experiences, and interactions. Furthermore, we focused on exploring asymmetry of information within a cooperative

gaming context. However, other promising avenues for research warrant investigation. One such avenue involves examining how asymmetry of information interacts with various design decisions, such as non-co-located, asynchronous, or mixed-synchronous gameplay, as well as different game genres. While our study delved into asymmetry of information within cooperative gameplay, there's potential for exploring its implementation in competitive and team-based games, offering a fresh angle for further research.

Moreover, we posit that player connections and age differences may significantly impact gameplay experiences. Therefore, investigating asymmetry of information within the contexts of family play and intergenerational gaming could yield valuable insights into how these factors shape gaming dynamics.

Finally, our evaluation protocol relied on a laboratory-based study conducted under controlled and supervised conditions. While this approach provided valuable insights, its limitations in representing real-world gaming scenarios are acknowledged. Thus, a logical next step would involve investigating the application of asymmetry of information in more ecologically valid settings. This could include conducting interviews to capture players' pre-existing experiences or conducting in-the-wild, longitudinal studies to observe gameplay dynamics in naturalistic environments. Such approaches would offer a more comprehensive understanding of how asymmetry of information influences player behaviour, interactions, and relationships in real-world gaming contexts.

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Appendix A

Keybinds

Table A.1: Keybinds for *Parallel Realms: Asymmetry United*.

Keybind	Action
W	Move Up
A	Move Left
S	Move Down
D	Move Right
Spacebar	Interact
Mouse Movement	Aim
Mouse Button 1	Attack
Esc	Pause

Appendix B

Stats

Table B.1: Possible stats of a game's character (Part 1).

Stat	Character	Description
Health	Player, Enemy	The health value of a character. This determines the maximum health points of a character
Defence	Player, Enemy	The defence value of a character. This determines the defence points subtracted from non-elemental damage taken by a character. If damage taken is equal or below zero, a character always takes five damage
Attack	Player, Enemy	The attack value of a character. This determines non-elemental damage dealt to another entity. The base value of this stat is determined by the character's weapon
Movement Speed	Player, Enemy	The movement speed value of a character. This determines the movement speed of the character
Attack Speed	Player, Enemy	The attack speed value of a character. This determines the cooldown between attacks. The base value of this stat is determined by the character's weapon
Knockback	Player, Enemy	The knockback value of a character. This determines the knockback another character takes when being attacked by the character
Elemental Attack	Player, Enemy	The elemental attack value of a character. This determines elemental damage dealt to another entity. Elemental attack damage can not be reduced by defence points
Damage Over Time Duration	Player	The damage over time duration value of a character. This determines how long a damage over time effect is applied for in an attacked entity
Damage Over Time Speed	Player	The damage over time speed value of a character. This determines the time interval between the activation of damage over time effects on an affected entity
Slow Intensity	Player	The slow intensity value of a character. This determines how much slower an entity becomes when attacked
Slow Duration	Player	The slow duration value of a character. This determines for how long an entity becomes slowed after being attacked
Shield	Player	The shield value of a character. This determines the maximum shield points of a character. Shield points always revert to the maximum at the start of a new dungeon room

Table B.2: Possible stats of a game's character (Part 2).

Stat	Character	Description
Chain Range	Player	The chain range value of a character. This determines the distance for the detection of chain targets when attacking another character
Chain Times	Player	The chain times value of a character. This determines the number of chains between chain targets that happen when attacking another character
Instakill	Player	The instakill value of a character. This determines how many characters the character is able to instantly kill in a room
Invulnerability	Player	The invulnerability value of a character. This determines how many hits the character can take without taking damage in a room
Nova Cooldown	Player	The nova cooldown value of a character. This determines the time cooldown of the nova ability
Coin Drop Rate	Player	The coin drop rate value of a character. This determines the increase to coin drop chance when defeating another character
Experience On Hit	Player	The experience on hit value of a character. This determines the amount of experience the character gains each time it attacks and hits another entity

Appendix C

Abilities

Table C.1: Acquirable abilities in the game (Part 1).

Ability	Tiers	Source	Description
Attack Increase	I, II, III	Level	Increases the non-elemental attack damage of the character. Modifies Attack stat.
Health Increase	I, II, III	Level	Increases the maximum health of the character. Modifies Health stat.
Movement Speed Increase	I, II, III	Level	Increases the movement speed of the character. Modifies Movement Speed stat.
Attack Speed Increase	I, II, III	Level	Increases the attack speed of the character. Modifies Attack Speed stat.
Sword	I	Level	Changes the character's weapon to a sword that attacks in front of the character. Modifies the base value of the Attack and Attack Speed stats.
Hammer	I	Level	Changes the character's weapon to a hammer that attacks in a circle around the character, yet has reduced attack speed. Changes the base value of the Attack and Attack Speed stats.
Bow	I	Level	Changes the character's weapon to a bow that fires an arrow in the direction of the attack. Changes the base value of the Attack and Attack Speed stats.
Spear	I	Level	Changes the character's weapon to a spear that attacks in front of the character, has increased range and damage, yet requires charging the attack. Changes the base value of the Attack and Attack Speed stats.
Dagger	I	Level	Changes the character's weapon to a dagger that attacks in front of the character and has increased attack speed, yet has reduced range. Changes the base value of the Attack and Attack Speed stats.
Wand	I	Level	Changes the character's weapon to a wand that fires three projectiles in the direction of the attack, yet has reduced attack speed. Changes the base value of the Attack and Attack Speed stats.
Elemental Damage	I, II, III	Level	Allows the character to deal elemental damage, which is not reduced by defence points, to other characters. Modifies Elemental Attack stat.
Damage Over Time	I, II, III	Level	Allows the character to deal a percentage of their non-elemental attack damage over time. Modifies Damage Over Time Duration and Damage Over Time Speed stats.

Table C.2: Acquirable abilities in the game (Part 2).

Ability	Tiers	Source	Description
Slow	I, II, III	Level	Allows the character to slow attacked characters on hit. Modifies Slow Intensity and Slow Duration stats.
Chain	I, II, III	Level	Allows the character to chain their damage to nearby characters. Modifies Chain Range and Chain Times stats.
Experience On Hit	I, II, III	Level	Allows the character to gain experience on hitting other entities. Modifies Experience On Hit stat.
Knockback Increase	I, II, III	Level	Increases the knockback the character applies to other characters on hit. Modifies Knockback stat.
Coin Drop Rate Increase	I, II, III	Level	Increases the drop rate of coins when defeating other characters. Modifies Coin Drop Rate stat.
Projectile Nova	I, II, III	Level	Allows the character to automatically fire projectiles in a nova around it when hit. Modifies Nova Cooldown stat.
Shield Buffer	I, II, III	Level	Allows the character to have a shield that protects health and resets when entering a new dungeon room. Modifies Shield stat.
Blastwave	I	Challenge	Greatly increases the knockback the character applies to other characters on hit, yet reduces non-elemental attack damage. Modifies Knockback and Attack stats.
Close Quarters	I	Challenge	Greatly increases the attack speed of the character, yet reduces knockback. Modifies Attack Speed and Knockback stats.
Elementalist	I	Challenge	Greatly increases the elemental attack damage of the character, yet greatly reduces non-elemental attack damage. Modifies Elemental Attack and Attack stats.
Fast Hitter	I	Challenge	Greatly increases the attack speed of the character, yet reduces non-elemental attack damage. Modifies Attack Speed and Attack stats.
Glass Cannon	I	Challenge	Greatly increases the non-elemental attack damage of the character, yet reduces maximum health. Modifies Attack and Health stats.
Heavy Hitter	I	Challenge	Greatly increases the non-elemental attack damage of the character, yet greatly reduces attack speed. Modifies Attack and Attack Speed stats.
Shockwave	I	Challenge	Greatly increases the knockback the character applies to other characters on hit, yet greatly reduces attack speed. Modifies Knockback and Attack Speed stats.
Damaging Area	I	Challenge	Activates a damaging area around the character that deals a percentage of the character's non-elemental attack damage within fixed intervals to other characters inside it.
Flight	I	Challenge	Allows the character to fly over holes.
Instakill	I	Challenge	Allows the character to instantly kill the first character hit of every new dungeon room. Modifies Instakill stat.
Invulnerability	I	Challenge	Allows the character to take no damage from the first hit it receives in every new dungeon room. Modifies Invulnerability stat.
Level Up	I	Challenge	Allows the character to instantly receive two levels after choosing this ability, allowing it to pick two level-based abilities.
Room Clear	I	Challenge	Allows the character to have a chance at instantly killing all remaining other characters when half of a new dungeon room is killed.

Table C.3: Acquirable abilities in the game (Part 3).

Ability	Tiers	Source	Description
Room Freeze	I	Challenge	Allows the character to temporarily freeze all other characters when entering a new dungeon room.

Appendix D

Logs

Table D.1: Game logs description.

Log	Description
Room Entered	When the player enters a dungeon room.
Room Exited	When the player exits a dungeon room.
Health Gained	When the player gains health.
Damage Taken	When the player takes damage.
Revive	When the player revives.
Death	When the player dies.
Enemy Killed	When the player kills an enemy.
Room Cleared	When the last enemy in a dungeon room is killed.
Weapon Change	When the player changes active weapon.
Ability Acquired	When the player acquires an ability.
Heart Collected	When the player collects a heart.
Coin Collected	When the player collects a coin.
Experience Collected	When the player collects experience.
Level Cleared	When the player completes a challenge.
Level Failed	When the player fails to complete a challenge.
Dungeon Cleared	When the player completes a dungeon run.
Paused	When the player pauses the game.
Unpaused	When the player unpauses the game.
Scene Loaded	When a Unity game scene is loaded.
Scene Unloaded	When a Unity game scene is unloaded.
Logged In	When the player logs in.
Game Quit	When a player quits the game.

Appendix E

Informed Consent

1. I confirm that I have read and understood the information associated with the project.
2. I understand that my participation is voluntary and that I am free to withdraw from the study at any time, without having to give any explanations and without any consequences.
3. I understand that, should this research be published, all data will be kept anonymous and no information will be identifiable as mine. I authorise team members to have access to this data.
4. I agree to take part in this study.
5. I declare that I agree to play the game and authorise the session to be observed by the research team.
6. I agree to take part in the group interview with my study partner and authorise the recording of the session (audio, video and screen).
7. I would like the final report of the study to be sent to me.

Appendix F

Experience Form

1. Regarding the skull mechanic, please rate each item (from 1 strongly disagree to 5 strongly agree):
   (a) Promoted connection with the study partner.
   (b) Promoted strong communication.
   (c) It was fun.
   (d) It was challenging.
   (e) I was satisfied with my partner's performance.
2. Regarding the chest mechanic, please rate each item (from 1 strongly disagree to 5 strongly agree):
   (a) Promoted connection with the study partner.
   (b) Promoted strong communication.
   (c) It was fun.
   (d) It was challenging.
   (e) I was satisfied with my partner's performance.
3. Regarding the weapon mechanic, please rate each item (from 1 strongly disagree to 5 strongly agree):
   (a) Promoted connection with the study partner.
   (b) Promoted strong communication.
   (c) It was fun.
   (d) It was challenging.
   (e) I was satisfied with my partner's performance.
4. Regarding the wolf mechanic, please rate each item (from 1 strongly disagree to 5 strongly agree):
   (a) Promoted connection with the study partner.
   (b) Promoted strong communication.
   (c) It was fun.

(d) It was challenging.

(e) I was satisfied with my partner's performance.

5. Regarding the pot mechanic, please rate each item (from 1 strongly disagree to 5 strongly agree):

   (a) Promoted connection with the study partner.

   (b) Promoted strong communication.

   (c) It was fun.

   (d) It was challenging.

   (e) I was satisfied with my partner's performance.

6. Regarding the colour sequence mechanic, please rate each item (from 1 strongly disagree to 5 strongly agree):

   (a) Promoted connection with the study partner.

   (b) Promoted strong communication.

   (c) It was fun.

   (d) It was challenging.

   (e) I was satisfied with my partner's performance.

7. Which was your favourite mechanic?

   (a) Skull mechanic.

   (b) Chest mechanic.

   (c) Weapon mechanic.

   (d) Pot mechanic.

   (e) Wolf mechanic.

   (f) Colour sequence mechanic.

8. Which mechanic did you like the least?

   (a) Skull mechanic.

   (b) Chest mechanic.

   (c) Weapon mechanic.

   (d) Pot mechanic.

   (e) Wolf mechanic.

   (f) Colour sequence mechanic.

Appendix G

Interview Script

1. What are your thoughts on the experience?
    (a) Do you usually play games like this?
    (b) Which parts of the game did you enjoy most?
    (c) Which were the most frustrating moments?
        i. Were there any confusing moments?
2. What are your thoughts on cooperation in this game?
    (a) Throughout the game, were there moments when you felt you needed to communicate?
        i. How did you identify them?
    (b) At any point did you feel that you had missed any information?
    (c) How do you think the game supported your collaboration?
        i. What would you change to better support your collaboration?
3. In the game, you faced various challenges in the final rooms. Can you tell us about them?
    (a) Did you feel there were differences between them?
    (b) Did you feel there were similarities between them?
    (c) Which final room did you like the most?
    (d) Which final room did you like the least?
    (e) What would be the order of the mechanics in terms of difficulty level?
4. How do you think you communicated during the game?
5. What elements can you identify that affected the way you communicated and how?
6. What would you change/add to promote quality communication?
7. Final suggestions?

Appendix H

Codebook

Table H.1: Characterisation study codebook (Part 1).

Code	Description
1. Game	Game or genre of games is mentioned.
1.1 Parallel Realms	Parallel Reals: Asymmetry United is mentioned.
1.2 Tutorial	Tutorial mode is mentioned.
1.3 Other	Specific game other than Parallel Realms or Tutorial is mentioned.
2. Challenge	Game challenge is mentioned.
2.1 Weapon	Weapon challenge is mentioned.
2.2 Skull	Skull challenge is mentioned.
2.3 Chest	Chest challenge is mentioned.
2.4 Pots	Pots challenge is mentioned.
2.5 Wolf	Wolf challenge is mentioned.
2.6 Sequence	Sequence challenge is mentioned.
2.7 Symbol	Symbol challenge is mentioned (tutorial).
3. Penalty and Reward	Specific game element, feature, mechanic or system related to scoring is mentioned.
3.1 Death	Death is mentioned.
3.2 Sign	Sign is mentioned.
3.3 Information	Information or informative element is mentioned.
3.4 Interactable	Interactable is mentioned.
3.5 Score System	Score system is mentioned.
4. Strategy	Specific strategy is mentioned.
5. Asymmetry	Asymmetry is mentioned.
6. Collaboration	Collaboration during gameplay is mentioned.
7. Communication	Communication during gameplay is mentioned.
8. Connection	Connection between players is discussed.
9. Expertise	Player expertise is mentioned.
10. Difficulty	Game or challenge difficulty is mentioned.
11. Awareness	Awareness is discussed.

Table H.2: Characterisation study codebook (Part 2).

Code	Description
12. Agency	Agency is mentioned.
12.1 Customisation	Agency through character or game customisation.
13. Reaction	Reaction to something is described.
13.1 Interesting	Something is described as interesting.
13.2 Confusing	Something is described as confusing.
13.3 Frustrating	Something is described as frustrating.
13.4 Distressing	Something is described as distressing.
14. Preference	Player preference is mentioned.
15. Partner Performance	Partner performance is discussed.
16. Suggestion	Suggestion is given.