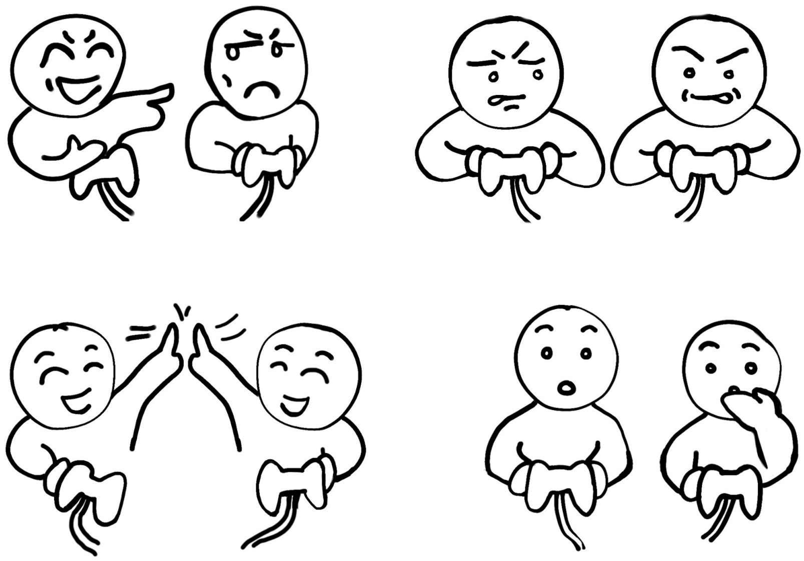
INVESTIGATING THE SOCIAL PLAYER EXPERIENCE: SOCIAL EFFECTS IN DIGITAL GAMES



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Investigating the Social Player Experience: Social Effects in Digital Games

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ABSTRACT

Playing digital games is nowadays a common pastime activity, which can take various forms. By incorporating co-players, spectators, or computer-controlled in-game characters digital games constitute social situations. The emerging social dynamics, such as players' communication and interaction, significantly affect whether players enjoy a game. Hence, knowledge about social effects that occur during play and the influence of game design elements on players' social experience and behavior can help game designers to create engaging games.

This thesis contributes to the research area of social player experience in digital games and the broader field of human-computer interaction. The goal is to examine the constituents of the social player experience and to investigate the relation between game design aspects, social entities, and the emergent social play. The results are supposed to provide actionable insights for the design of intended social experiences. By looking at the topic from various angles, this thesis entails considerations and studies guided by the main research question: how do social entities such as co-players and virtual characters affect players' experience of playing digital games?

The thesis is subdivided into three main parts with different foci. The first part contributes a research model of social player experience based on an extensive review of literature. The model provides the basis for systematic research in the field. The second part focuses on the social experience in multiplayer settings. It includes empirical studies that investigate the influence of diverse game aspects on players' social experience and interaction. The results emphasize that slight changes in game design can significantly change the way players interact and experience the game. Different methodological approaches to measure and analyze the social player experience are presented to provide suggestions for future research endeavors. The third part of this thesis addresses players' social experience induced by computer-controlled characters in singleplayer settings. The studies presented in this part test the hypothesis that virtual characters can have a social impact on players similar to real humans, if they are perceived as social entities. Whereas the results partly support this assumption, this thesis also points out by the example of the social facilitation effect that social phenomena and effects known from other areas of application cannot be transferred one to one to the context of digital games. This finding addresses game researchers and developers alike and calls attention to the complex design of social game characters.

KURZZUSAMMENFASSUNG

Das Spielen digitaler Spiele ist heutzutage eine beliebte Freizeitaktivität, die diverse Formen annehmen kann. Durch die Einbindung von Mitspielern, Beobachtern und computergesteuerten Charakteren erzeugen digitale Spiele oft soziale Situationen. Die entstehende soziale Dynamik, die sich beispielweise in der Kommunikation und Interaktion der Spieler manifestiert, ist ein entscheidender Faktor für den Spielspaß. Fundiertes Wissen über die sozialen Effekte, die während des Spielens auftreten, und über die Wirkung bestimmter Spielelemente auf das soziale Spielerleben und -verhalten, kann folglich die Entwicklung erfolgreicher Spiele unterstützen.

Die vorliegende Arbeit ist im Forschungsgebiet des sozialen Spielererlebens angesiedelt und allgemeiner dem Feld der Mensch-Computer Interaktion zuzuordnen. Ziel dieser Arbeit ist es, die Bestandteile des sozialen Spielerlebens zu analysieren und die Zusammenhänge zwischen Spielelementen, sozialen Entitäten und dem resultierenden sozialen Spiel zu untersuchen. Als Ergebnis präsentiert diese Arbeit Erkenntnisse, die genutzt werden können, um im Designprozess gezielt bestimmte soziale Erlebnisse zu kreieren. Um dieses Ziel zu erreichen, wird das Thema aus unterschiedlichen Blickwinkeln betrachtet und in einer Reihe von Studien adressiert, die der Hauptforschungsfrage folgen: Wie beeinflussen soziale Entitäten wie Mitspieler und virtuelle Charaktere das Spielerlebnis in digitalen Spielen?

Die vorliegende Arbeit ist in drei Teile mit unterschiedlichen Schwerpunkten unterteilt. Im ersten Teil wird auf Basis eines umfassenden Literaturüberblicks ein Forschungsmodell für das soziale Spielerleben aufgebaut. Dieses Modell stellt die Grundlage für die folgenden Studien dar und soll auch zukünftige Forschungsvorhaben unterstützen. Der zweite Teil umfasst mehrere Studien zum Spielerleben in Mehrspielerszenarien, die den Einfluss verschiedener Spielelemente auf die Spieler untersuchen. Die Ergebnisse verdeutlichen, wie schon geringe Änderungen im Spieldesign die soziale Dynamik und das Spielerlebnis verändern können. Zudem werden verschiedene Methodiken zur Erfassung und Analyse der sozialen Spielaspekte präsentiert. Der dritte Teil dieser Arbeit behandelt Einzelspielerszenarien, in denen soziale Aspekte des Spielerlebens durch computergesteuerte Charaktere hervorgerufen werden. Die Studien in diesem Teil adressieren die Hypothese, dass virtuelle Spielcharaktere einen ähnlichen sozialen Einfluss auf Spieler ausüben können wie echte Menschen, sofern sie als soziale Entitäten wahrgenommen werden. Während die Ergebnisse diese Annahme teilweise stützen, wird am Beispiel des Social Facilitation Effekts deutlich, dass sich nicht alle sozialen Effekte und Phänomene, die in anderen Anwendungsbereichen beobachtet wurden, eins zu eins auf digitale Spiele übertragen lassen. Dies unterstreicht die Komplexität der Wirkungsweise sozialer Charaktere in digitalen Spielen und eröffnet neue Perspektiven für deren Design und Erforschung.

PUBLICATIONS

The following list includes all publications that I established during the time of my PhD studies. The list is subdivided into two parts, starting with the publications that directly contribute to this thesis, followed by further work published in that time (each in chronological order).

PUBLICATIONS THAT ARE DIRECTLY COVERED IN THIS THESIS

This thesis summarizes my research on the social experience in digital games conducted since 2014. Hence, parts of this thesis, including ideas, studies, text passages, as well as figures have appeared previously in the following publications:

[A] Katharina Emmerich, Patrizia Ring, and Maic Masuch. "I'm Glad You Are on My Side: How to Design Compelling Game Companions." In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '18*. 2018.

[B] Katharina Emmerich and Maic Masuch. "Watch Me Play: Does Social Facilitation Apply to Digital Games?" In: *Proceedings of the CHI Conference on Human Factors in Computing Systems - CHI '18*. 2018.

[C] Katharina Emmerich and Maic Masuch. "The Impact of Game Patterns on Player Experience and Social Interaction in Co-Located Multiplayer Games." In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '17*. 2017.

[D] Stefan Liszio, Katharina Emmerich, and Maic Masuch. "The influence of social entities in virtual reality games on player experience and immersion." In: *Proceedings of the International Conference on the Foundations of Digital Games - FDG '17*. 2017.

[E] Philipp Sykownik, Katharina Emmerich, and Maic Masuch. "Exploring Patterns of Shared Control in Digital Multiplayer Games." In: *Proceedings of the 14th International Conference on Advances in Computer Entertainment Technology - ACE '17*. 2017.

[F] Katharina Emmerich and Maic Masuch. "The Influence of Virtual Agents on Player Experience and Performance." In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '16*. 2016.
(received the Best Paper Award)

[G] Katharina Emmerich and Maic Masuch. “Game Metrics for Evaluating Social In-game Behavior and Interaction in Multiplayer Games.” In: *Proceedings of the 13th International Conference on Advances in Computer Entertainment Technology - ACE ’16*. 2016.

[H] Katharina Emmerich, Natalya Bogacheva, Mareike Bockholt, and Viktor Wendel. “Operationalization and Measurement of Evaluation Constructs.” In: *Entertainment Computing and Serious Games: International GI-Dagstuhl Seminar 15283, Dagstuhl Castle, Germany, July 5-10, 2015, Revised Selected Papers.* 2016.

[I] Katharina Emmerich, Stefan Liszio, and Maic Masuch. “Defining second screen gaming: exploration of new design patterns.” In: *Proceedings of the 11th Conference on Advances in Computer Entertainment Technology - ACE ’14*. 2014.

FURTHER PUBLICATIONS

- Andrey Krekhov, Sebastian Cmentowski, Katharina Emmerich, and Jens Krüger. “Beyond Human: Animals as an Escape from Stereotype Avatars in Virtual Reality Games.” In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play - CHI PLAY ’19*. (accepted, to appear)
- Andrey Krekhov, Sebastian Cmentowski, Katharina Emmerich, Maic Masuch, and Jens Krüger. “GulliVR: A Walking-Oriented Technique for Navigation in Virtual Reality Games Based on Virtual Body Resizing.” In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play - CHI PLAY ’18*. 2018. (received an Honourable Mention Award)
- Andrey Krekhov, Katharina Emmerich, Philipp Bergmann, Sebastian Cmentowski, and Jens Krüger. “Self-Transforming Controllers for Virtual Reality First Person Shooters.” In: *Proceedings of the Annual Symposium on Computer-Human Interaction in Play - CHI PLAY ’17*. 2017.
- Andrey Krekhov, Katharina Emmerich, Maxim Babinski, and Jens Krüger. “Gestures From the Point of View of an Audience.” In: *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems - CHI ’17*. 2017.
- Carina Gansohr, Katharina Emmerich, and Maic Masuch. “Hold Me Tight: A Tangible Interface for Mediating Closeness to Overcome Physical Separation.” In: *Proceedings of the 8th International Conference on Intelligent Technologies for Interactive Entertainment: INTETAIN ’16*. 2016.
- Katharina Emmerich and Mareike Bockholt. “Serious Games Evaluation: Processes, Models, and Concepts.” In: *Entertainment Computing*

and Serious Games: International GI-Dagstuhl Seminar 15283, Dagstuhl Castle, Germany, July 5-10, 2015, Revised Selected Papers. 2016.

- Maic Masuch and Katharina Emmerich. "Digitale Spiele." In: *Gesundheit spielend fördern: Potenziale und Herausforderungen von digitalen Spieleanwendungen für die Gesundheitsförderung und Prävention*. Ed. by Kevin Dadaczynski, Stephan Schiemann, and Peter Paulus. Weinheim and Basel: Beltz Juventa, 2016.
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- Katharina Emmerich and Maic Masuch. "Helping Friends or Fighting Foes: The Influence of Collaboration and Competition on Player Experience." In: *Proceedings of the 8th International Conference on the Foundations of Digital Games - FDG '13*. 2013.
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During my studies, I had the honor to work with talented students and inspiring colleagues. Accordingly, some parts of this thesis are the result of successful collaborations, which is also indicated by the co-authorships of the underlying publications. I reflect this fact by the use of language: I am using "we" every time an implementation, study, or paper is described that was worked out in collaboration, whereas "I" is used when I express my very own ideas and conclusions.

What you get by achieving your goals
is not as important as what you become by achieving your goals.
— Henry David Thoreau

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Working on this thesis during the last couple of years was an exciting, formative, and challenging journey, which has finally come to an end. On my way, I was lucky to be accompanied by many people—both old and new friends—who supported me and my endeavor.

To begin with, I thank my advisor, Prof. Maic Masuch, for making this thesis possible in the first place. I always appreciated the freedom and flexibility he gave me as well as all his valuable feedback. I am greateful for getting all the time it took to come to this thesis in its current state, thereby ensuring that I am completely content with the result.

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Andrey has been through the best and the worst with me. He was a colleague, reviewer, co-author, and friend, thereby exerting a great influence on my work. But most importantly, he gave me love, peace, and distraction whenever I started going crazy.

My parents paved the way for me by always supporting me and by giving me the opportunity to study without pushing me. They also laid the foundation for my passion for games by giving me and my sister my first gaming console as one of the best Christmas presents ever.

My sister Alex was not only my first co-player, but has always been the most important person in my life. She was also the first person to read this thesis, offering feedback and ensuring its linguistic quality.

Thank you all so much.

CONTENTS

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ACRONYMS

ANOVA	Analysis of Variance
BFI-10	10 Item Big Five Inventory
CCM	Cooperative Communication Mechanics
CCPIG	Competitive and Cooperative Presence In Gaming
CSP	Cooperative Social Presence
EDA	Electrodermal Activity
EMG	Electromyography
FPS	First-Person Shooter
FUGA	Fun of Gaming
GEQ	Game Experience Questionnaire
GSR	Galvanic Skin Response
HCI	Human Computer Interaction
HMD	Head-mounted Display
IMI	Intrinsic Motivation Inventory
IPQ	Igroup Presence Questionnaire
ITQ	Immersive Tendencies Questionnaire
LOM	Locus of Manipulation
MMOG	Massively Multiplayer Online Game
MMORPG	Massively-Multiplayer Online Role-Playing Game
NMQ	Networked Minds Questionnaire
NPC	Non-Player Character
PENS	Player Experience of Need Satisfaction
PfS	Preference for Solitude Scale
RPG	Role-Playing Game
SDT	Self-Determination Theory
SPGQ	Social Presence in Gaming Questionnaire
SSQ	Simulator Sickness Questionnaire

SUS System Usability Scale

UCLA University of California, Los Angeles

VR Virtual Reality

1 INTRODUCTION

Playing games has always been an integral part of human life. We play for various reasons: we learn, establish social bonds, make new experiences, test our abilities, and—not least—have fun and engage in an enjoyable pastime [140]. Traditional games usually require more than one player to take part and, thus, facilitate social get-togethers. This social component is a strong motivator and an important aspect of the experience of playing. However, the introduction of digital games (i.e., all games mediated and operated by a computer system) led to new ways of playing. Real co-players are no longer necessary to take the role of opponents or teammates. Instead, the computer system creates the conflict, presents the game world and challenges, simulates co-players, and monitors the compliance with the rules. In this way, one person can play even complex games as singleplayer instead of spending time with other persons.

Due to that, in public discourse digital games have been discussed as antisocial media with the potential to promote social isolation [358]. Although singleplayer games are common among digital games, this concern is neither supported by current research nor reflected in most recent figures of the gaming industry [81, 240, 358, 359]: many players play and appreciate multiplayer games, including both co-located and online social settings, due to their social nature and the possibility to spend time with others. Even singleplayer games can lead to highly social situations fostering a lot of social interaction and communication, if observers are involved and start to engage in the game without having direct control [271]. The current trend of game live streaming promoted by platforms such as *Twitch* confirms that people do not only enjoy playing digital games, but also like to watch others play and comment on their actions. According to a recent market study [291], the audience of digital game content is bigger than the audience of popular streaming platforms for movies and series. The rising popularity of esports [292] is another indicator for the multilayered social context created by digital games.

Furthermore, in this thesis I argue that playing digital games often includes social features, even if only one real human is involved in the setting. An evolving strength of many games is the integration of interesting characters inhabiting the game world. Such characters can induce the feeling of social presence, even though they are not real but controlled by the computer. Reeves and Nass [226, 249] imposingly discussed the phenomenon that people tend to treat computers and related media like real persons by applying social rules and showing social reactions [153]. I will investigate whether similar effects occur with regards to virtual companion characters in digital games.

1.1 MOTIVATION

Today, both singleplayer and multiplayer digital games have become an established leisure time activity and an important part of the entertainment industry [81]. They provide interactive experiences, exciting challenges, fascinating virtual worlds, as well as interesting stories. Accordingly, both researchers and game developers are eager to drive forward the advancement of game design and development techniques to further improve the players' experience. The social aspects of the experience have become a well-considered part of games research. Many researchers are concerned with investigating the complex effects and correlations of experience dimensions when people are playing digital games together [152, 166, 177, 240, 358]. A positive social experience can increase players' enjoyment as well as their motivation to play the game [47, 108].

Still, it is not known how certain game design aspects influence the social experience and how intended social dynamics can be created by design. Although findings from the field of social psychology are considered to also apply to the gaming context, more research on the effects occurring in game-specific social situations is required to confirm this assumption. The effectivity of basic sociopsychological phenomena in digital games has to be proven before being used as rationale for game design decisions. Digital games are complex interactive systems that define their own rules and boundaries. Players entering the magic circle [2] of a game adopt its meanings and rules, while intentionally suspending those of the real world. Hence, playing digital games may differ significantly from social situations in real life. Without investigating the social processes of digital gaming, false assumptions regarding social effects may lead to game designs that induce unintended experiences and player behavior. For this reason, I will investigate the impact of specific game characteristics on players' social experience.

In this thesis, I follow the definition of Salen and Zimmerman, according to which "a game is a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" [265, p. 80]. The definition shows that the player's interaction with the game system is the core of playing a digital game. Hence, the game design and the main game mechanics significantly frame the experience. However, the context in which the game is played also matters. This includes co-players and spectators, the time and location, and the devices used. If we gain more insight into the interplay between game design, social effects, and the resulting experience, we will be able to design intended social experiences. This can not only help to increase a game's entertainment value, but furthermore provides the basis for games with a social purpose: digital games can be applied to foster social relationships, for instance as part of team building measures [63]. A positive social in-game interaction in groups may increase personal trust, understanding, and a team's efficiency [66, 86, 225]. Moreover, positive social experiences are supposed to contribute to a person's well-being [66, 103]. An improved performance of player groups is also relevant for crowdsourcing games. Such games, sometimes also called human computation games or games with a purpose [272], aim at generating knowledge drawing from the intelligence of the crowd to solve complex real-world problems (e.g., image tagging [4, 163] or protein folding [58]). Social mechanics can be applied in this context to foster players' motivation and increase the quality of their contributions, while at the same time effects such as social loafing have to be prevented [163]. Besides, virtual characters who are capable of inducing human-like social effects offer new design spaces: they might be used to support persons suffering from social isolation and loneliness or as efficient tutors for problem-solving and in learning contexts. Players may also train social skills by interacting with virtual characters in different situations.

1.2 MAIN RESEARCH QUESTIONS AND MAJOR CONTRIBUTIONS

This thesis deals with the social experience of players of digital games. In this context, the overarching research question of this thesis is:

> **How do social entities, such as co-players and virtual characters, affect players' experience of playing digital games?**

Accordingly, the main goal of the research presented here is to investigate the social dynamics in different gaming scenarios to contribute to the field of social player experience research. In particular, this thesis is going to address the following sub-questions:

- Which aspects constitute the social player experience?
- How do game mechanics influence players' social interaction and communication in multiplayer games?
- How can we measure the social aspects of the player experience?
- Can virtual companion characters have social impact on players comparable to co-present humans?

To answer these questions, I will present a comprehensive review of literature as well as several studies that shed light on the social player experience in different scenarios. During the course of the work presented in this thesis, I guided the development of seven prototypical testbed games and the conduct of nine empirical laboratory studies as well as one online survey. The results have been published in eight conference papers. In sum, this thesis contains the following main contributions:

1) A social player experience research model:

   The thesis provides a comprehensive research model summarizing the factors that should be considered when investigating the social player experience. The model points out all the constituents of game settings which are supposed to influence the emergent social play and the social experience. It is based on an extensive review of related literature and can be used to motivate, facilitate, and structure future research in the field.

2) Findings regarding the influence of different game aspects on players' social experience and interaction:

   In the second part of this thesis, I present the results of two empirical studies and further considerations about the influence of four specific game design aspects: player interdependence, time pressure, shared control, and second screens. By addressing such different game aspects, I point out that single design decisions can significantly change players' social experience. I discuss how the findings can inform the design process of multiplayer games and how they can be used to foster certain social interactions.

3) Evaluation of methods to assess players' social interaction:

   All studies presented in this thesis include the investigation of social aspects such as social presence, communication, and social interaction. Hence, it was important to consider which methods are most suitable to measure such aspects. Whereas questionnaires are quite well established, this thesis also presents other methods that can provide further information: In one study, a specific observation scheme is applied to classify players' verbal communication. Another study deals with the development of social gameplay metrics, which assess specific social aspects directly during play. This thesis, thus, also contributes useful methodological knowledge for future studies.

4) A design space of virtual companion characters:

   In this thesis, I consider both multiplayer settings and singleplayer settings with regard to social aspects of gaming. In the third part, I focus on the potential social influence of virtual characters. As a basis, I classify different types of virtual characters and present a comprehensive design space of game companions. That work is expanded by an online survey to assess players' opinions about companion characters. In sum, this thesis provides design implications and recommendations for game designers to foster the development of engaging social game characters.

5) Findings of six studies on the social impact of virtual characters:

   Finally, this thesis includes a thorough investigation whether virtual in-game characters can elicit social effects like real humans do. I present the results of seven studies that were conducted with bespoke games to test the applicability of established social effects to the context of digital games. In different teams we developed testbed games that allowed us to modify single game aspects such as the presence of a virtual companion character and investigated the resulting differences in the player experience. One study focuses on the difference between real and virtual co-players and their influence on players' feelings of loneliness, whereas the other studies deal with the social facilitation effect. I chose this effect as an example of socio-psychological effects and show that established social effects do not necessarily apply to the activity of playing digital games.

1.3 THESIS OUTLINE

This thesis is divided into three main parts. Part I summarizes related work and theories that are relevant for social player experience research. It elaborates on the construct of player experience in general in Chapter 2 by explaining its different components and discussing models of player experience currently used in research. The chapter also includes information on the methods that can be used to measure and analyze player experience in concrete gaming situations.

Based on the concept of player experience, Chapter 3 focuses on the social aspects of playing digital games. The chapter deals with the questions why players enjoy social play and what differentiates singleplayer and multiplayer settings in terms of the player experience. This also includes a discussion of different social effects that are considered to emerge in the context of games. Moreover, this chapter aims at identifying the constituents of social play settings that can influence players' experience by providing a comprehensive compilation of related research findings. It concludes with the introduction of my research model of social player experience, which comprises the information gathered so far and serves as a framework for all studies presented subsequently.

In this way, the first part of this thesis lays the theoretical foundation of the research conducted during my PhD studies, which is then presented in the following parts II and III. The difference between these two parts lies in their focus on different social play settings: whereas part II summarizes all studies on multiplayer settings, part III includes the work regarding the social influence of virtual characters in singleplayer settings.

The first chapter of part II, Chapter 4, presents a study on the influence of three game aspects on the social player experience: player interdependence, time pressure, and shared control. In a two-player setting, it is systematically investigated how different implementations of these aspects change the way players communicate and interact with each other by recording playing sessions on video and classifying all communication acts.

The subsequent Chapter 5 focuses on game interfaces and their impact on the social experience. This includes a second study on shared game control, which expands on the evaluation of the previous chapter by presenting a comprehensive classification of shared control settings as well as the results of a study comparing four different implementations. Based on that, a discussion of the potentials and risks of giving players collective control over single game characters follows. Moreover, the chapter includes detailed considerations on second screen gaming, which refers to settings that include more than one screen to display game content at the same time. The chapter provides a compilation of design patterns to inform the design process of second screen games and demonstrates their applicability in three case studies. It also points out the main challenges that have to be considered before using second screens.

The last chapter of part II, Chapter 6, addresses the question how social aspects of gaming can be measured during play-testing sessions. In particular, it includes the exploration of the potential and applicability of gameplay metrics to assess social behavior and interactions of players. I present the conceptualization, application, and evaluation of three social gameplay metrics that aim at measuring social presence, cooperation, and leadership, respectively. A comparison of the metrics' data with scores of self-reports shows high positive correlations, which indicates that the metrics can be used as a reliable measure of social aspects.

In sum, the three chapters of part II provide findings regarding the design of multiplayer games, the social influence of certain game aspects, and the measurement of the social player experience in social play settings which include human co-players. In contrast, I consider the influence of virtual characters in singleplayer settings in part III of this thesis. To give an introduction to this topic, Chapter 7 deals with different types of virtual characters and introduces game companions as a special sub-type with potentially high social influence. I analyze the design space of companion characters in games and discuss their influence on players' experiences and expectations. Additionally, the chapter presents the results of an online survey to provide insights into players' opinions and perceptions regarding game companions. In this way, the chapter points out design implications and suggests ways to improve the believability of virtual characters.

Companion characters are also the subject of the studies reported in the subsequent chapters. Chapter 8 focuses on the comparison of the impact of a co-player and of a virtual companion character on the player experience with a special focus on enjoyment, perceived loneliness, and social presence. I present the results of a comprehensive study, which indicate that social entities can decrease the perception of loneliness and that their influence on player experience is moderated by their degree of agency and interactivity. Based on the results, the chapter discusses the potential positive effects of virtual companions, but also highlights the risk of impeding game enjoyment in case that the character does not meet the player's expectations.

Chapter 9 is centered around an exemplary socio-psychological effect, the social facilitation effect, which describes an unconscious change in performance due to the presence of others. The chapter deals with the question whether the presence of a virtual companion character is capable of evoking the effect similar to the presence of a real human. A study addresses this question by evaluating the impact of a companion's presence on players' performance and experience using a specifically developed testbed game. The chapter points out potential mediating variables and discusses the inconclusive study results, which indicate a social effect only under certain conditions.

Chapter 10 directly carries forward the investigation of the social facilitation effect in digital games. It presents the findings of a large-scale evaluation including four studies with four different games, which extend the original study setting presented in the previous chapter by including a real human observer and different game genres. The results lead to the conclusion that social facilitation does not generally apply to the context of playing digital games, indicating that basic socio-psychological phenomena are not necessarily applicable to digital games and require further investigation.

The thesis concludes with the final Chapter 11, which summarizes the work presented in this thesis and reflects on the main findings and contributions.

Part I

PLAYER EXPERIENCE: THE IMPACT OF DIGITAL GAMES

2 THE PLAYER EXPERIENCE CONCEPT

Research that is centered around the experience of players that evolves from interacting with digital games is called games user research or player experience research [75]. The overall player experience can be seen as the main determinant of game acceptance and success and is, thus, of high interest to both researchers and game developers. However, it is difficult to predict this experience, as it is formed by various aspects of the game, the individual player, and the context of playing. Similarly, it is also a complex task to fully describe and assess this experience, because it is the result of a variety of cognitive, emotional, and behavioral processes [18, 340]. With growing interest in identifying the factors that shape a positive experience, researchers identified the need for a shared taxonomy [237, 340]. This chapter provides an overview of models and concepts which are currently used in games user research to describe the various facets of the player experience. Based on that, the chapter also discusses methods and approaches to measure and investigate the player experience.

2.1 DEFINITION OF PLAYER EXPERIENCE

The term player experience (sometimes abbreviated as PX or PE) is related to the broader concept of user experience from the field of human-computer interaction (HCI). User experience is applied to all possible usages of interactive systems and is defined as "a person's perceptions and responses that result from the use or anticipated use of a product, system or service" according to ISO standard [145]. It is commonly regarded as dynamic, context-dependent, and subjective [187]. Player experience can be seen as the specific user experience when the system the user interacts with is a digital game.[1]

According to Wiemeyer, Nacke, Moser, and Mueller, player experience "describes the qualities of the player-game interaction and is typically investigated during and after the interaction with games" [340, p. 246]. In contrast to the concepts game usability and playability, which are mainly concerned with the functionality of a game to ensure a positive experience on a technological level, player experience covers the feelings, thoughts, and reaction of the individual user [18, 340]. Hence, the player and his/her individual experience is in the focus of the investigation, not the game sys-

1 In game research literature, sometimes authors also use the term *game experience*. In this thesis, the terms *player experience* and *game experience* are treated equivalently, because in most publications either the one or the other term is utilized to describe basically the same concept. Following the opinion of Wiemeyer et al., who state that "player experience is the more appropriate term as compared to game experience, because it is the person of the player who makes this specific experience" [340, p. 244], I consistently use the term *player experience* unless the terminology of a theory or model states differently.

tem as such. Therefore, player experience primarily addresses (socio-) psychological factors of the experience of interacting with the game. Besides, research regarding player experience often also includes the investigation of the player's behavior and physiological responses, as these factors are observable reactions of the player to the game, which might give some additional indication of the personal experience. Accordingly, Wiemeyer et al. [340] propose to distinguish three levels of player experience: (1) the (socio-) psychological level, (2) the behavioral level, and (3) the physiological level. This differentiation is particularly useful for deriving different methods to measure player experience and will therefore be revisited in section 2.3. However, the psychological level is the constituent aspect of player experience. Hence, the next section first discusses psychological components of player experience.

2.2 COMPONENTS OF PLAYER EXPERIENCE

Player experience clearly is a multifaceted concept. Accordingly, researchers try to break it down into several, more tangible psychological subcomponents in order to enable the assessment and investigation of player experience. Currently, there exist several models of player experience, which partly overlap but offer different perspectives and foci. Wiemeyer et al. [340] provide a comprehensive overview of the following eight prominent psychological models that are relevant for player experience:

1. Self-determination theory (SDT) [263]
2. Attention, relevance, confidence, satisfaction (ARCS) [168]
3. Presence and immersion [96, 204, 283], including the presence-involvement-flow framework ($PIFF^2$) [297]
4. Flow [62]
5. GameFlow [293]
6. Fun of gaming (FUGA) [238]
7. Core elements of game experience (CEGE) [48]
8. Heuristics of Playability (PLAY) [68].

Discussing all of these models in detail is beyond the scope of this thesis. However, a comparison of the underlying theories and concepts used to describe player experience shows that many ideas come up repeatedly, though they might be labeled or clustered differently. Based on that, Wiemeyer et al. [340] summarize twelve components of player experience: (1) competence, (2) autonomy and control, (3) immersion, (spatial and social) presence, flow, and GameFlow, (4) involvement and (enduring) engagement, (5) social relatedness and social interaction, (6) challenge, (7) tension, (8) curiosity, (9) fantasy, (10) positive and negative emotions, (11) intrinsic goals, and (12) feedback and evaluation. Further, the authors emphasize that some components interact with each other or are quite similar, thus hardly separable [340].

The order and clustering chosen above is neither definite nor necessarily all-embracing. The list, however, gives a fair impression of the complexity and multifacetedness of the player experience concept. In current studies, some components are considered more in-depth than others depending on the research focus. The same applies to the thesis at hand. The main component that is investigated in all studies of this thesis is the social aspect of gaming, i.e. social relatedness and social interaction. Due to its specific significance, the entire next chapter is dedicated to it (see Chapter 3). Other components of player experience relevant for this thesis will be briefly introduced in the following sections. These are:

1. Fun, positive affect, and negative affect
2. Flow
3. Immersion and presence
4. Motivation

The description of these components of player experience (sections 2.2.1 to 2.2.4) is adapted from the book chapter *Operationalization and Measurement of Evaluation Constructs* [94], in which my co-authors and I elaborate on components of player experience and how they can be measured and evaluated.

2.2.1 *Fun, Positive Affect, and Negative Affect*

When people talk about their evaluation of a digital game, they often use phrases like "it was a lot of fun" to describe a positive experience. In everyday understanding, fun is a rather generic construct that is associated with positive feelings such as enjoyment, pride, excitement, or relaxation. Such an intense, positively valenced emotional state is commonly seen as the main objective of entertainment games. Hence, fun has also received attention in games user research. Since it is a rather fuzzy concept without clear definition and hardly to grasp or measure as such [99, 143], researchers have established diverse theories about the emergence and manifestations of fun.

Koster [176] takes a specific cognitive perspective on fun by relating it to the functionality of the human brain and to learning processes. Our brain is continuously faced with new stimuli and searches for interesting patterns in order to be able to process and interpret the stimuli information while resolving all uncertainties. According to Koster's theory of fun, fun can be attributed to the feeling of joy and relief resulting from mastering such new patterns. Digital games can present unknown patterns in the form of rules, challenges, and unknown scenarios to players. By offering players new things to learn, games keep players entertained and thereby provide a fun experience [2, 176]. However, this theory does not account for individual preferences of different players: every human brain generally works similarly, but still not every player enjoys the same games. Hence, whereas learning and pattern solving may be one factor contributing to fun, it is not a sufficient condition for fun in itself.

Another perspective on fun is provided by Lazzaro [188, 189]. Based on field study data, she differentiates between four different kinds of fun, called the "Four Keys" of fun: (1) hard fun, (2) easy fun, (3) altered states and (4) people fun. Each key is suggested to lead to certain emotions, thereby providing an enjoyable overall experience. Hard fun arouses from overcoming meaningful challenges and is associated with feelings of control, progress, success, and pride. Easy fun, on the other hand, is attributed to the investigation of interesting stimuli provided by a game. It is about the sensation of the game world and game activities that result in feelings of wonder and surprise, addressing the curiosity of players. Altered states describes the effect games can have on the internal, mental state of players. This fun key accounts for the potential of games to arouse different emotions and to let people feel something new or different, also including the aspect of distraction. Finally, people fun emphasizes that also the interaction with other players and a shared experience may lead to enjoyment.

Dillon [71] proposes that fun can be achieved by triggering different instincts and emotions in his 6-11-framework. The framework describes six basic emotions in games (e.g., pride) and eleven related instincts (e.g., survival). It is based on the idea that instincts and emotions influence each other and are evoked by specific gameplay dynamics. Accordingly, different games may produce different emotions due to their individual game design, but can still all result in fun. Dillon points out that emotions leading to fun are not necessarily positively valenced. This accounts for the fact that, for instance, sad scenes in a game can also be experienced as enjoyable.

The theories of Koster, Lazzaro, and Dillon are three examples of fun theories emphasizing that fun is not a single emotion but comprises several feelings as well as cognitive processes and can be induced in manifold ways. Hence, it should be considered as a multidimensional factor during evaluation. Accordingly, in many player experience models (e.g., see [238, 263, 297]) fun is not included as a single component. Instead, it is differentiated between positive and negative affect, as well as feelings of challenge, tension, competence, and curiosity [340].

2.2.2 *Flow*

Flow is a popular concept in player experience research and comparable to the idea of hard fun. The term was coined by the work of Csikszentmihalyi [62], who described flow as the mental state of total engagement a person can achieve while performing actions that are challenging and at the same time intrinsically motivating. Playing digital games can be seen as such an activity, hence the flow concept can be applied [166, 293]. The flow experience is characterized by an altered sense of time and a loss of self-consciousness due to a narrow focus on the activity [62, 224]. The main prerequisite for reaching the flow state is that there has to be a proper balance of challenge and individual skills [62, 224]. Hence, regarding games, flow theory suggests that a game's level of difficulty has to fit the skill level of the player in order to be engaging. Cowley, Charles, Black, and Hickey [60] additionally point out that low levels on both axes do not result in a positive flow experience but rather in apathy. To achieve a positive experience, the additional condition that both factors (challenge and skill) exceed a certain minimum level has to be fulfilled.

The general flow concept is often applied to digital games and integrated into most player experience models as one of several sub-components [238, 281, 297]. Sweetser and Wyeth [293] have taken flow as a basis to develop a concise model of player enjoyment, called GameFlow. They have synthesized current game evaluation heuristics from the field of usability with those from the field of user experience research. As a result, they define the following eight interrelated core elements of GameFlow: (1) concentration, (2) challenge, (3) skills, (4) control, (5) clear goals, (6) feedback, (7) immersion, and (8) social interaction.The authors describe a set of criteria for player enjoyment for each factor derived from the analyzed game design heuristics. It is assumed that a game which supports all those criteria is most enjoyable [293]. Most of the listed core elements are also considered in other player experience models, what underlines their importance.

Sinclair, Hingston, and Masek [281] also focused on the relation between flow and digital games and introduced the dual flow model (DFM). The model relates the idea of flow to exergames (games that foster physical exercise) and points out that an exergame's attractiveness can be explained by the experience of flow. As a second layer, the authors define the dimension effectiveness as the "physiological counterpart of flow" [281, p. 2]: it suggests that there also has to be a balance between a player's fitness and the intensity of the game's exercises to make the game successful.

In a recent study, Kaye and Bryce [166] investigate flow in the context of games with the focus on the influence of social interaction in multiplayer settings. Results indicate that flow can also emerge when two or more players play together. This specific type of flow is called group flow. As it is directly related to the social aspects of gaming, this concept will be discussed in more detail in Chapter 3.

Due to its prevalence in player experience models and related research, flow (including the aspects challenge, control, and feedback) can be seen as an important part of the player experience. It is also intertwined with immersion and presence, which will be discussed in the following.

2.2.3 *Immersion and Presence*

Originating from the field of teleoperators [256], the concepts immersion and presence are nowadays widely discussed among game researchers. Both concepts relate to the process of projecting one's mind into the game world and to immerse in a virtual environment. However, both terms are not uniformly defined. They are defined divergently, often mixed up, and sometimes even used synonymously [96, 204, 256].

2.2.3.1 *Immersion*

Slater [283] presents an approach to disambiguate both concepts and defines immersion as the objective quality of an interactive system to deliver sensory cues to the human sensory system. A system is more immersive, if it occupies large parts of a person's perception. For instance, a system containing a head-mounted display (HMD) and earphones shields a person's visual and auditory senses from stimuli of the real world and, thus, features higher immersion than an ordinary monitor display. This kind of immersion is sometimes also called *perceptual immersion* [202].

Contradicting Slater's opinion, some researchers propose other types of immersion that describe a psychological component of the experience of use instead of an objective quality of the system. This *psychological immersion* refers to a person's feeling of involvement [202] and absorption [96]. In the context of digital games, Ermi and Mäyrä [96] present a model of immersion as a component of player experience and differentiate three dimensions: (1) sensory immersion, (2) challenge-based immersion, and (3) imaginative immersion. Sensory immersion corresponds to perceptual immersion. It is related to the user's perception of the audiovisual representation of games. Challenge-based immersion evolves from the engagement with the game's challenges. Ermi and Mäyrä state that this feeling of immersion is highest if challenges and the player's abilities are in balance. In that sense, challenge-based immersion corresponds with the flow state as defined above in section 2.2.2. Imaginative immersion describes the player's involvement in the game's narrative and world, as well as the identification with the characters.

In a similar way, Cairns, Cox, and Nordin define immersion as the level of "engagement or involvement a person feels as a result of playing a digital game" [46, p. 340]. The aspect of involvement in the game world and story is specific to games as compared to general virtual environments that do not include a narrative or virtual characters (e.g., simulations or communication scenarios). Hence, it is not considered in most more general conceptualizations of immersion (such as [283]). It is, however, an important aspect of the player experience that is not sufficiently covered by other components [46, 238]. Hence, in this thesis, it is differentiated between sensory (perceptual) immersion [96, 202, 238, 283] and imaginative immersion [46, 96, 238].

2.2.3.2 *Presence*

Presence, in contrast, can be described as a reaction to immersion [283]. But how can it be defined? In a recent article, Lombard and Jones [204] address the issue of overlapping and divergent definitions of presence. Instead of proposing a general, merged definition, the authors present a framework of current presence conceptualizations and provide a standardized terminology for discussing presence. According to their review of literature, most researchers see presence as a "subjective quality—usually a perception or experience—of an individual person" as compared to presence being a property of the medium, technology, or mode of communication [204, p. 19]. Two definitions of presence that are very common describe presence as the experience of "being there" [133, 256, 283, 340] or the "illusion of nonmediation" [96, 202, 255]. The first definition focuses on the feeling of actually being in the scene or "place" that is provided by a medium, although the scene is artificial and the user is aware of that to some degree [340]. The second definition highlights the fact that the user does not perceive or acknowledge the existence of the medium and, thus, behaves as if it was not there and the experience was nonmediated [202]. Taken together, these two definitions comprise the most common idea of the presence concept, which is often referred to as spatial presence, physical presence, or telepresence [204, 343].

Riva and Mantovani [255] extend this idea by assuming that presence is directly linked to the user's capacity for action. With higher feelings of presence, the user is more likely able to transform his/her intention into action in the simulated world. Accordingly, Slater [283] states that persons who experience presence behave in the virtual world in a similar way as they would in a comparable real life situation, including cognitive and emotional responses. Hence, for digital games that are designed to provide an intense experience, presence can be considered as an important factor.

Finally, experienced realism and engagement are further aspects that are linked to presence [202, 204]. However, most researchers agree that presence has to be distinguished from related concepts such as involvement, interest, absorption, and emotions [256, 283]. For that reason, those aspects of the experience are often considered as separate (yet related) subcomponents in player experience models (e.g., see [238, 297]). Takatalo, Häkkinen, Kaistinen, and Nyman [297] combined the three concepts presence, involvement, and flow in an integrated model of player experience, the Presence-Involvement-Flow Framework (abbreviated: $PIFF^2$, see Figure 1). In sum, the model includes a set of 15 subcomponents of player experience. The structure of the framework supports the notion that presence comprises several aspects such as physical presence and narrative engagement, but that it is not equivalent to involvement or flow. Involvement includes the motivational aspects importance and interest, which define the personal meaning and value that a player attributes to the game and its story. Flow as defined in the $PIFF^2$ is similar to the flow concept described above (section 2.2.2) with an additional focus on emotional outcomes of gaming.

Due to the divergent views on the definition of presence as described above, Lombard and Jones [204] advise researchers to clearly state what they understand by the term presence if they use it in their research. Accordingly, in this thesis presence refers to a subjective, spatial experience that is mediated by virtual technology (a game system). It describes the feeling of actually being in the virtual world, being part of it, interacting with it and perceiving it as real. It is seen as a result of sensory and imaginative immersion, because high immersion is supposed to support a higher feeling of presence.

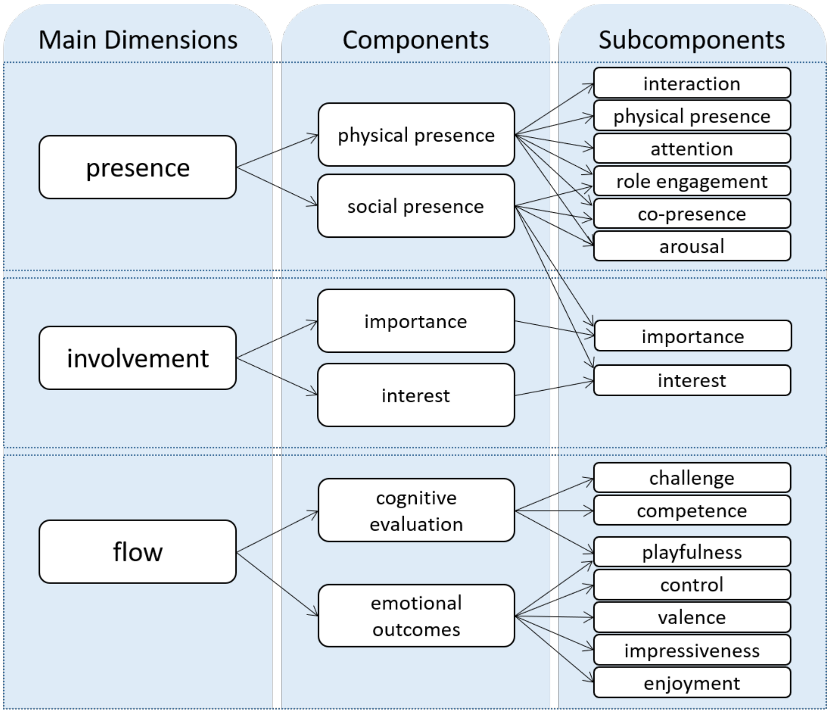


Figure 1: Summarized components of the PIFF² by Takatalo et al. [297]. The framework combines the three main player experience dimensions presence, involvement, and flow and further divides them into subcomponents based on the analysis of several data sets.

Closely related to spatial presence, the notion of social presence considers the perception of the presence of other persons in the virtual world [204, 255, 297]. Social presence is one key aspect of the social experience of gaming, hence it is discussed in detail in the following Chapter 3.

2.2.4 *Motivation*

Another factor that is often considered as a component of player experience is motivation [263, 340]. Diverse game mechanics such as progress visualization, immediate feedback, rewards, and challenges constantly motivate the player to engage in the game and to master it [69, 115, 300]. Hence, motivation can make players keep playing the game and is linked to game enjoyment [298]. In general, motivation is seen as a theoretical construct describing the active pursuit of an (individually) positively rated target state [252]. It can be distinguished between intrinsic and extrinsic motivation, which refers to the source of motivation. While extrinsic motivation emerges from external rewards and impact factors (for instance, if someone is paid for doing something), intrinsic motivation describes the individual, inherent willingness to do something that is rated as interesting or enjoyable [262]. Digital games are supposed to particularly trigger the latter form.

In the context of digital games, motivation can be seen from mainly two different points of view. On the one hand, it is an antecedent of playing, because only persons with a sufficient level of motivation will decide to start (and keep) playing a game [98]. This is the more general view on players' motivation to play digital games and is covered in models of player types. Such models try to shed light on the question why a person plays digital games by offering different kinds of motives. On the other hand, motivation can be investigated as a component of the actual experience while playing a game [263, 340]. Game events and features can increase or decrease the motivation during play and the satisfaction of basic psychological needs can foster enjoyment. The perceived motivational quality of a game and the current motivational level of a player will probably influence the way the game is evaluated. To investigate this kind of motivation, general theories of motivation can be applied to digital games. In the following, both kinds of motivation (general player motivation and perceived motivation during play) are shortly discussed.

2.2.4.1 *General Motivation to Play: Player Types*

Regarding the general motivation to play a digital game, diverse motives have been researched and assembled into so-called player models, which classify players in terms of the main reasons why they play games. Popular player models include Bartle's player taxonomy [12, 13], Yee's model of player motivation [348, 349] and the BrainHex model [221]. Bartle proposed one of the first player models in his early work by defining four main player categories based on the analysis of multi-user dungeon games [13]: achievers, explorers, socializers, and killers. The player types are characterized by different main interests and playing styles. For example, achievers are trying to master all game challenges and seek for success, while explorers like to immerse in the game world and explore it without focusing on the main goals. In a similar way, Yee [348] classified three main categories of player motivation, namely achievement, immersion, and social. His model is based on the analysis of a large survey with players of massively-multiplayer online role-playing games (MMORPGs). The BrainHex model differentiates further subcategories, resulting in seven archetypes of players [221] that are related to a specific playing style: seeker, survivor, daredevil, mastermind, conqueror, socialiser, and achiever.

The idea behind all those player taxonomies is the same: they classify abstract and rather stable motivations of players [301]. While such player categories are non-exclusive and simplify the construct of motivation to some degree, they provide a first understanding as to how motivation influences a player. They indicate which playing style a player prefers and why players enjoy some games more than others. In their recent work, Tondello, Wehbe, Orji, Ribeiro, and Nacke [301] propose a framework of player preferences, which links specific game elements to game playing styles. This mapping between general playing styles and game elements is supposed to support game designers in tailoring games to specific target audiences.

2.2.4.2 *Perceived Motivational Quality of a Specific Game*

Besides general models of player motivation, which try to explain why players prefer certain playing styles, the actually perceived motivational quality of a game is another interesting aspect regarding the construct of motivation. In this context, a basic theory of motivation, namely the self-determination theory (SDT), has been applied to games by Ryan, Rigby, and Przybylski [263]: SDT comprises the main factors that are supposed to facilitate or undermine motivation, focusing especially on intrinsic motivation. Those factors are based on the psychological needs for autonomy, competence, and relatedness. According to the application of SDT to digital games by Ryan et al. [263], a player's intrinsic motivation is supported by five aspects:

- Perceived autonomy: a sense of own volition and freedom of choice.
- Perceived competence: appropriate challenges and the sense of efficacy.
- Perceived relatedness: the feeling of being connected with others.
- Perceived presence: a sense of actually being within the game world.
- Intuitive controls: controls that are easy to learn and apply.

Based on SDT, Tamborini, Bowman, Eden, Grizzard, and Organ [298] define game enjoyment as need satisfaction and support the appropriateness of this definition with the results of a large study, in which perceived competence, autonomy, and relatedness could explain over 50% of the variance of enjoyment. The authors suggest that the integration of other needs will further strengthen the model.

Another basic psychological model of motivation that can be applied to digital games is the ARCS Model by Keller [168, 340]. Its name is an acronym for the four suggested major conditions that have to be met to motivate players and to keep them motivated [340]:

- Attention: a game has to get and sustain the attention of the player (e.g., by surprising events or sound effects).
- Relevance: the player has to experience game activities as meaningful and functional.
- Confidence: the player should have the expectancy of success if enough engagement is shown.
- Satisfaction: the player should feel proud and good about accomplished objectives, which is supported by the feeling that the achievement is based on the player's own effort.

In line with the aspect of confidence and satisfaction, an empirical study by Trepte and Reinecke [308] indicates that players' subjective experience of accomplishment and competence is an influential factor for overall game enjoyment.

2.2.5 *A Comprehensive View on Player Experience*

The sections above show the multifaceted nature of the player experience and provide insights into single subcomponents. Though the decomposition of the player experience into subcomponents facilitates research, it has to be taken into account that many components cannot be completely separated from each other. As the example of presence, immersion, and flow demonstrates, the lines between single concepts are sometimes blurred and many subcomponents are interacting with each other. It is therefore recommended not to consider only one component in research studies, but to take into account a variety of aspects of the player experience. A multilayered approach allows the inspection of significant relationships and interactions. At this point, comprehensive models of player experience can be regarded as a good reference for planning surveys. In this thesis, most studies refer to the FUGA model of player experience [238]. This model includes the seven components (1) sensory and imaginative immersion, (2) tension, (3) competence, (4) flow, (5) negative affect, (6) positive affect, and (7) challenge. Furthermore, it also accounts for social presence in a separate module for multiplayer games [359] (which will be described in Chapter 3).

Now that the subcomponents of player experience are posed, it has to be discussed how the player experience can be measured in order to investigate its manifestation in playing sessions. Hence, the following section addresses the operationalization and measurement methods regarding player experience which are currently used in games user research—and also in the studies that constitute this thesis.

2.3 METHODS TO MEASURE THE PLAYER EXPERIENCE

It is important to develop and deploy reliable methods to assess the player experience in order to understand the appeal of digital games and to be able to investigate the impact of certain game aspects and their relationships. For that purpose, the abstract concept player experience has to be mapped on measurable and representative variables. As my co-authors and I discussed in detail in the book chapter *Operationalization and Measurement of Evaluation Constructs* [94], this process is called operationalization: the process of defining how to quantify a phenomenon or concept which itself is not directly measurable. Operationalization is based on the assumption that an abstract construct under examination—here player experience or certain subcomponents–can be inferred from its observable effects. Hence, methods that are supposed to measure the player experience have to define observable indicators that are closely related to aspects of the experience and, thus, allow for drawing conclusions. The measurement of such indicators has to be "as accurate a representation of the construct as possible" [182, p. 153].

During the last decades, several methods—often derived from the broader field of HCI—have become established in player experience research [18, 75]. In the following sections, the methodological approaches self-reports, biometrics, gameplay metrics, and observations are introduced based on the content provided in our book chapter [94] to provide insights into the general "toolbox" of a player experience researcher. As described at the beginning of this chapter, the different types of methods can be linked to the three levels of player experience defined by Wiemeyer et al. [340]:

- Self-reports: address the subjective, individual experience (psychological level).
- Biometrics: measure physiological responses of the body (the physiological level).
- Gameplay metrics and observations: refer to the behavior of players, both in-game and in the real world (behavioral level).

Subsequently, the methodological approach of this thesis as well as the concrete measures (mostly questionnaires) which were administered in the studies presented later in this thesis are described in detail to give an overview of applied methods.

2.3.1 *Self-reports*

Self-report measurements directly ask the players to give their opinion on certain aspects. Such methods are mainly used to assess the feelings, thoughts, or intrinsic motives of a player, which are not directly observable. The resulting data is always subjective by nature. Common self-report methods are focus group discussions, one-on-one interviews, the think-aloud protocol, and questionnaires.

Except for questionnaires, all self-report methods mainly result in qualitative data, because they allow for free (and long) answers. In focus groups, several participants extensively discuss topics of interest under the guidance of a moderator [84]. This technique is usually applied at early stages of the development and evaluation process and helps to investigate the general acceptance and opinions of players on a game or a specific feature [116].

In contrast to such group interviews, one-on-one interviews are more focused on the individual thoughts and experiences of a single player. Gill, Stewart, Treasure, and Chadwick [116] differentiate three major types of interviews: structured, semi-structured, and unstructured. A structured interview is a verbalized questionnaire with predetermined questions and usually a set of possible answers. On the opposite, unstructured interviews do not strictly follow a predefined plan, but are adapted to the evolving interview situation and previous answers. Such interviews can take an unlimited amount of time and, although they do not require much organization, they require a lot of skill from the interviewer to make results useful. Semi-structured interviews are more common in most sciences and combine the features of both other types. They have a structure (a number of key questions, outlining important areas of the research), but they are also flexible enough to discover some essentially new data if the dialog goes that way. Semi-structured interviews require more skill than fully structured ones, as well as more time and general effort. General guidelines on planning, conducting, and evaluating interviews within player research are provided by Bromley [35] as well as Cote and Raz [59].

The think-aloud protocol is different from interviews, to the effect that players are not asked specific questions about their experience after playing. Instead, participants are prompted to verbalize any of their thoughts immediately during play [175]. This way, researchers can gain insights into players' cognitive processes with direct link to game events and situations. However, participants' responses can be very unstructured or unspecific. Moreover, the process might interfere with gameplay by influencing the way players play and experience the game. To reduce this interference, think-aloud can also be applied retrospectively by using a video recording of the gaming session [175].

Standardized questionnaires consist of carefully formulated, validated items and provide quantitative data. In general, a questionnaire is an instrument to quantify subjective constructs like feelings, attitudes, and thoughts. As it can be extracted from the name, questionnaires are made of questions or statements that participants are required to answer or comment. The questions can be either closed or open-ended [41]. Closed questions can be answered by choosing a response from several given alternatives. Open-ended questions require broader answers. The participants need to add something to the answers or create answers by themselves. Open-ended questions can be more informative, and in some studies they are shown to provide more valid data [180]. However, they are more difficult to analyze and to be used in statistical calculations, as the answers are not standardized. Many questionnaires, especially those that use statements as their items, use interval scales (more precisely, Likert scales) to evaluate participant agreement or disagreement with the statements. Such scales consist of an odd number of points (to have a neutral answer in the middle) [117], ranging in meaning from "strongly disagree" to "strongly agree". Likert scales usually have five to nine points; longer scales give the participants better opportunity to specify their attitude to the statement, but too many variants can be confusing [117]. The same rule applies to the number of answers on closed questions—there should be enough answers to cover all possible or at least common alternatives, but not too many.

If there is already a validated, well-established questionnaire that fits the research question and the psychological concept of interest, it is advisable to use it instead of developing an own questionnaire to ensure objectivity, reliability, and validity [41]. Furthermore, such questionnaires are rather easy and convenient to use, whereas the development of a new questionnaire is challenging and complex. However, sometimes it is necessary to create own sets of questions to either complement existing scales or to establish a new scale for a specific concept. In any case, questions have to be easy to understand and well-conceived. One of the most important problems while creating a questionnaire is the actual wording. You cannot explain or reframe the questions during use, if the participant does not understand it, so the question or the statement must be as simple as possible [41]. Moreover, characteristics of the target group have to be considered before creating the questionnaire: if the question is quite simple for a psychologist or computer-science specialist, it is not necessarily understandable for a common user with no scientific background. This is the reason why pilot studies are needed before using new questionnaires on large groups of people. Goodwin [117] provides seven guidelines on phrasing good questionnaire items: he advises to prefer simplicity over complexity, to use complete sentences instead of some short phrase, to avoid any abbreviations that are not completely universal, to avoid slang and jargon, to avoid negatively phrased questions, and to make questions as balanced as possible, without favoring one position and without giving the participant any clues on the desired answer. This will help avoiding bias and making the results more objective. In a similar way, Brühlmann and Mekler [41] provide valuable advice on the planning, wording, and conduction of surveys in games user research.

2.3.2 *Biometrics*

Another approach to assess player data is to measure the physiological reactions of their body while they are playing the game. Such data is often called biometrics [220]. Based on the assumption that the processing of any stimuli always provokes physiological reactions, biometrics are used to draw conclusions about psychological phenomena [172, 220]. This data is objective and measured in real-time in contrast to self-report measures. However, biometrics are sensitive to noise (for instance, facial EMG measurement can be confounded by related muscle activity such as speaking) and mostly ambiguous with regard to interpretation: most relations between certain psychological states and physiological outcomes are not one-to-one but many-to-one relations, turning the interpretation of data into a challenging task [172, 220, 288]. Therefore, in practice biometrics are often combined with other types of measures in mixed method approaches [220].

There are various ways to assess physiological reactions. The currently most common biometrics are listed in the following:

- Skin conductance: The electrodermal activity (EDA) can be assessed with sensors attached to the fingers. It is supposed to be related to arousal, stress, and both emotional and cognitive activity [172, 208, 209, 220].
- Cardiovascular metrics: An electrocardiogram (ECG) or a peripheral pulse oximeter can be used to measure heart rate and pulse. These biometrics are indicators for arousal, attention, or stress [172] and can help to differentiate between positive and negative emotions [220].
- Electrical activation of muscles: Electromyography (EMG) measures the electrical activation of muscles. In game user research, it is commonly used to measure facial expressions by means of the electrical activation of facial muscles. This data gives information about the valence and arousal of emotional reactions [172, 208, 220, 245].

- Brain activity: brain waves are measured by electroencephalography (EEG) and allow for deriving cognitive processes, the degree of attention and the use of mental resources [172, 220].
- Respiration: the rate or depth of breathing provides an indication of relaxation, stress, or negative emotions [208].
- Eye movement: to investigate which elements are recognized, focused and paid attention to by the player, eye tracking systems can be used to record viewing direction and movement of gaze [250].

2.3.3 *Gameplay Metrics*

Gameplay metrics provide information about the interaction between the player and the game in terms of numerical data [74]. Compared to the other measurement types, this method gathers objective, quantitative, real-time data from the game system and not from the player. While playing, the player's status and in-game behavior is automatically tracked by the system and related to certain game events or locations (for instance, by time-stamps and labels) [74]. Most commonly, gameplay metrics are applied to gather information on players' actions and status inside the game or to log certain game events and the players' corresponding reactions [89, 210]. Results allow conclusions about the player experience, as they offer insights into the way people are actually playing the game under examination [75, 76, 210]. The concrete events and behavior that are relevant for the evaluation process differ with respect to the research question and the type of game (see the work of Drachen, Seif El-Nasr, and Canossa [76] for an overview). For instance, gameplay metrics can be used to quantify how many times the player performs a certain action (e.g., shooting) or triggers a certain game event (e.g., dying).

However, this behavioral data does not inform about the reasons why players are acting the way they do. Thus, gameplay metrics are often used in combination with other methods to gain additional insights into the course of the game session and relevant events and actions. A proper visualization of gameplay data can reveal patterns of player behavior that otherwise would have been undetected [219, 277, 331].

2.3.4 *Observations*

Besides asking players directly, measuring their physiological reactions or logging their in-game behavior, researchers might also gain valuable insights by simply observing players during play. Although observations are not easy to conduct and to analyze properly, they are often used in games research [266]. Body language, gestures, interactions, control inputs, facial expressions as well as verbal communication are supposed to be rich data sources for evaluating the player experience [208, 266].

Observations can be conducted in different ways. For instance, there is a difference between observations that take place in the everyday environment of people (e.g., console players in their living room) and observations in an artificial lab setting. Moreover, the observation can be concealed or revealed, depending on whether subjects are supposed to be aware of being observed.

There are also different strategies to take notes during observation [266]: free-form (no guidelines regarding form or content), semi-structured (global structure with freedom to adapt on the fly), and structured (notes have to follow a pre-defined protocol and template). Observation templates reduce the complexity for the observer, but they require the researcher to be able to identify all relevant observation events beforehand and should, thus, be considered carefully. Often observation is focused on a few specific aspects in order to facilitate the process and to support the evaluation of other measures [208]. Another practical way to support observation is video recording. By recording playing sessions, the analysis can be more detailed and every session can be annotated repeatedly by more than one examiner to increase inter-rater reliability and decrease observer bias [117].

2.3.5 *Methodological Approach of this Thesis*

In the following course of this thesis, I will present a couple of laboratory studies conducted to investigate specific aspects of the player experience. These studies all follow the same approach: A custom testbed game is implemented in several versions that differ according to one specific aspect under investigation (e.g., the presence of a virtual companion character). Participants play one of these versions and their behavior and player experience is measured and subsequently compared between groups (comparative study designs). This way, the impact of single game aspects on players' experience or their behavior can be investigated, as differences between the groups can be ascribed to the manipulated variable.

One limitation of this approach is that no "real" off-the-shelf games are used. Thus, it could be criticized that the games developed for evaluation purposes are not representative. To counter this limitation, our game designs are always oriented towards existing, successful games and established game mechanics. Moreover, whenever possible, our custom games are complemented by commercial games in the studies. However, many research questions can hardly be addressed by using off-the-shelf games, because such games usually cannot be adapted and provide only very limited possibilities to compare different game versions. Comparing two different games instead, which differ with regard to the variable of interest, is not appropriate, because in this case differences in the experience cannot definitely be attributed: any two games are supposed to differ in more than one single aspect, for instance in terms of game mechanics, art work, pace, difficulty, or interface design, which may all account for potential changes in the player experience. Overall, the use of specifically developed testbed games has three main advantages [90]:

1. Targeted manipulation: an independent variable of interest can be purposefully manipulated, while all other game aspects are kept constant to ensure comparability among game versions.

2. Reusability and comparability among studies: A custom game can be further modified anytime to systematically investigate various aspects in various studies in a comparable environment. This way, results of all studies using the same testbed game can be assembled and checked against each other.

3. Logging of gameplay metrics: In a custom game the automatic logging of every variable of interest can be implemented. All relevant game events and states can easily be captured and the form of recording can be customized to support the analysis.

To measure the player experience and to analyze players' behavior in my studies, a set of appropriate measures had to be compiled based on the review of available methods. The different types of methods to measure the player experience as described in the previous sections all have advantages and drawbacks as summarized in our book chapter [94]. The first important aspect to discuss is objectivity. Self-reports always provide subjective data, whereas the other methods enable the acquisition of more objective data. The challenge regarding subjective data is to avoid biases due to personal sensitivities or social effects (such as social desirability). Therefore, participants should be made aware that there are no wrong or right answers when reporting about their experiences, feelings, and thoughts. Furthermore, the certainty of anonymity can increase participants' sincerity. Concerning observation, objectivity depends on the existence (and quality) of an observation scheme. Ambiguous observation categories or untrained observers who interpret occurring events differently might harm objectivity and the overall quality of the results. Gameplay metrics and biometrics, in contrast, are hardly manipulable and, thus, most objective. Data gathered with these methods is not blurred by personal sensitivities or social effects and, thus, more reliable. However, the two methods provide only limited insights regarding a person's thoughts, feelings, and motives. Results are suitable to describe players' behavior and reactions, but fail to give reasons. At this point, subjective data can help to find explanations and relations between observable behavior, physiological reactions, and psychological processes.

Another aspect that distinguishes self-reports from the other methods is the immediacy of the measurement, meaning the moment of assessment. Questionnaires and interviews are obtained after the gaming session, because asking questions while participants are playing the game would interrupt the game flow and severely influence the experience. Hence, participants are asked to rate their experience retrospectively. Results may be influenced by memory effects or a retrospective cognitive evaluation. Observations, gameplay metrics, and biometrics enable immediate assessment of data while players are interacting with the game. Whereas data collection via gameplay metrics is unapparent for participants and, thus, not distracting, observations and physiological measures are not in any case

Table 1: Overview and comparison of the four main methods used in player experience research regarding the characteristics objectivity, immediacy, and gameplay interference.

	Objectivity of data	**Immediacy of measurement**	**Interference of gameplay**
Self-reports	subjective	post-hoc (except from think-aloud)	no interference
Observation	objective but prone to observer bias	immediate	possibly interfering
Gameplay Metrics	objective	immediate	no interference
Biometrics	objective	immediate	possibly interfering

unobtrusive. If the observation is not covert, the feeling of being observed might influence the behavior of players, and the attachment of measurement tools to the body might also have impact. This shows that the degree of interference depends on the way measures are applied in those cases.

In sum, the types of methods differ regarding aspects of objectivity, immediacy of measurement, and gameplay interference (see Table 1 for an overview). Therefore, a combination of different methods is chosen in the studies of this thesis as recommended in the literature [195]. In most studies, several questionnaires as well as gameplay metrics are applied, in some cases complemented by observation.

Regarding the selection of concrete questionnaires to measure the player experience, there are several approaches commonly represented in games user research and there is no consensus which of these are most valid [42, 65, 230]. In all but two studies of this thesis the player experience is measured by the core module of the Game Experience Questionnaire (GEQ) [141, 238]. This questionnaire was developed within the FUGA EU-funded project and is based on the same named model of player experience (see section 2.2.5). In the latest project report [142], the core module of the GEQ consists of 33 items in total, which represent seven subcomponents: competence, sensory and imaginative immersion, flow, tension, challenge, negative affect, and positive affect. Mean scores of the items of each scale are computed to determine the score for each of the seven subscales. Items are phrased as statements about feelings and experiences during play (e.g., "I felt happy") and participants have to rate their agreement on a scale ranging from "not at all" to "extremely". The questionnaire has to be administered directly after the gaming session.

The GEQ is a rather long questionnaire that covers different concepts of player experience. In the study described in Chapter 4, player experience was measured several times repeatedly, which cannot conveniently be done by such a long questionnaire. Furthermore, the studies in Chapter 4 and Chapter 5 were focused on collaborative play and the effect of co-located playing on players' behavior and motivation. Therefore, another measure was used here instead of the GEQ: the Player Experience of Need Satisfaction (PENS) questionnaire [159, 254, 263]. The PENS is based on the SDT. Accordingly, it contains five subscales that represent the five factors supposed to influence a player's intrinsic motivation: autonomy, competence, relatedness, presence, and intuitive controls (cf. section 2.2.4). Particularly the first three scales were of interest, as these can indicate a change in the individual player experience related to different game versions or in repeated playing session with the same game. Each scale consists of three items and participants have to rate their agreement on a scale ranging from "do not agree" to "strongly agree". Our research group received official permission to use the PENS scale in academic research by Immersyve[2]. Based on the same idea of the SDT, the Intrinsic Motivation Inventory (IMI) [49, 261] can be used to assess dimensions of the intrinsic motivation related to a game, particularly enjoyment [218]. Hence, we applied the subscale related to enjoyment to additionally assess general game enjoyment, which includes seven items.

In the studies which included the use of virtual reality systems in terms of HMDs (i.e., Chapter 8 and Chapter 9), the degree of perceived presence and related aspects are considered to be a specifically important factor of the experience. The GEQ does not directly include presence, thus, the GEQ was complemented by the Igroup Presence Questionnaire (IPQ) [273, 274] in those cases. The IPQ was developed in an iterative process (two survey waves) and is based on a large pool of items from presence literature. For instance, it includes items from the Presence Questionnaire by Witmer and Singer [344] and from the work by Slater and Usoh [285]. In total, the IPQ includes 14 items which are clustered in three subscales as well as one general item ("In the computer generated world I had a sense of 'being there'"). The three subscales are spatial presence, involvement, and experienced realism and participants rate their agreement on a 5-point scale.

For most of the research questions under investigation in this thesis, the presented questionnaires provide sufficient insight into the experience of players. However, the value of additional methods such as gameplay metrics and observation is accounted for as well. Logging algorithms were implemented in all of the custom testbed games, which allowed for the analysis of gameplay metrics to gain additional insights into the behavior of players. The study described in Chapter 6 is particularly focused on gameplay metrics, as it investigates the development of innovative gameplay metrics about the social interaction of players. Moreover, the value of observational data for analyzing player behavior in multiplayer contexts is addressed by the study which is presented in Chapter 4. Biometrics, in

2 Immersyve is a market research company founded by Edward Deci and Richard Ryan, who also established the self-determination-theory in research and practice. Website: http://immersyve.com/

contrast, were not applied in this thesis, as no research question is directly related to physiological reactions of players. Hence, we refrained from the rather complex implementation and processing of physiological measures, which may also interfere with gameplay due to the attachment of sensors to the players' bodies.

In their framework of player experience, Nacke and Drachen [222] point out that player experience research has to consider three layers of abstraction—the game system, the player, and the context—as well as the temporal progression of the experience. The framework emphasizes that individual characteristics such as personality, prior game experiences, expertise, and mood can influence the overall experience. That is why a couple of further questionnaires were administered in the studies of this thesis to regard potential moderator variables. In all studies, participants' demographic data and their gaming habits (hours spent gaming per month and game expertise) were requested. Moreover, in the two VR studies (see Chapter 8 and Chapter 9) the Immersive Tendencies Questionnaire (ITQ) [312, 344] was used to assess players' individual capability and tendency to become immersed by media. The Simulator Sickness Questionnaire (SSQ) [169, 313] was administered to test whether participants were physiological affected by the VR simulation (e.g., feeling fatigue, headache, or eye strain). There are also questionnaires to assess generic personality traits, which may also be interesting for investigating a game's effect on players. In the study presented in Chapter 4, the short 10 Item Big Five Inventory (BFI-10) [243] gave insight into the five main dimensions of personality according to the Big Five model, namely openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism.

Regarding the context of playing, another aspect that is supposed to have significant influence on the player experience is the social setting, i.e. the presence of other players or observers and the way they interact with the player. This thesis is focused on the investigation of social effects in digital games, thus, the main part of each presented study concerns the social player experience. The next chapter therefore discusses the important theoretical concepts, current findings, as well as methods to measure the social player experience.

3 SOCIAL PLAYER EXPERIENCE AND SOCIAL PLAY

The dimensions of the player experience described in the previous chapter are focused on the individual experience of one single player interacting with the game system. However, playing games is not a solitary activity. Many gaming situations involve other persons as co-players or observers. In such cases, an additional social layer is supposed to strongly influence the overall experience [287, 358]. Hence, to understand players' experience and their behavior, the social context has to be considered in addition to the characteristics of the player and the game system.

This chapter comprises the diverse facets of social play. Isbister defines social play in the context of digital games as "active engagement with a game (through use of its controls or through observation and attention to ongoing game play) by more than one person at once" [152, p. 12] and points out that it can take various forms. In this chapter, I will discuss which social-psychological effects can be induced by the presence of others, how such effects can influence the player experience, and how social aspects can be included in general models of player experience. Furthermore, the components that constitute the social context of gaming as well as methods to measure and analyze the social player experience are discussed. The chapter concludes with a research model of social player experience which lays the foundation for the studies in the following chapters.

3.1 THE APPEAL OF SOCIAL PLAY

In contrast to most traditional board games, which are collective in nature and used as facilitators of social interaction, a high amount of early digital games was focused on the individual experience of a single player [287, 353]. Though singleplayer digital games are still popular, they are no longer prevalent. Many current games feature multiplayer modes to enrich the experience with social components, or are even completely focused on the social play with others. In addition to so-called couch co-op games, which are played co-locatedly on one console system by several players, the advancement of internet and gaming technologies led to the establishment of multiplayer online games as a major—and still growing—branch of the games industry. The current *Essential Facts* report of the Entertainment Software Association about the computer and video game industry [81] confirms the popularity of multiplayer gaming. It states that in 2018, 56% of frequent gamers in the U.S. played multiplayer games at least once a week. Thereby, players did not seem to clearly prefer a specific game mode: on average they spent seven hours per week on playing with others online and also six hours on playing co-locatedly. When playing with others, almost half of the players (42%) played with friends, which indicates that both playing with friends and with strangers is popular. Apart from the quality of graphics, story, and the price, online gameplay capability is among the top reasons for purchasing a game [81], further emphasizing the interest of players in social gaming.

During the past decades, also new forms of gaming emerged in addition to common console and PC gaming. Due to the establishment of mobile games and portable gaming platforms, the contexts in which games are played became much more diverse, expanding from the private space at home to public spaces [296]. Szentgyorgyi, Terry, and Lank [296], for instance, found that players use the portable Nintendo DS console to play in places and context which have not been associated with gaming or were even hostile to it (e.g., the office). The authors also observed that playing in such public spaces often leads to adhoc social play when players interact with other active players or involve spectators in the gaming activity. The availability of casual games on smartphones and social network sites has also brought people to play games who have not been keen on digital games beforehand [8, 146], thereby further disseminating games in our everyday life. In this context, research suggests that social features of such games (e.g., sending in-game gifts to another player) are highly appreciated and contribute to players' engagement in the game and, thus, to the game's success [8].

It becomes apparent that social play is an engaging, favored activity. The appeal of multiplayer games and of gaming in social contexts is undeniable. But where does this great appeal stem from? Why do players engage in social play and which gratifications do they expect? The following sections sheds light on these questions by integrating motivation theory and findings of diverse studies which address this issue.

3.1.1 *The Social Experience as Intrinsic Motivation*

One common approach in games research to answer the question about players' motivations to play is to simply ask players. Accordingly, a great deal of player surveys has been conducted to find out what players like most about multiplayer games and which aspects contribute to a positive social experience. A notable part of this research is focused on MMORPGs, probably due to their high popularity and comprehensive social structures. The model of player motivation in MMORPGs by Yee [348, 349], which was mentioned earlier in the context of general player motivation (see section 2.2.4), is one example. Yee's analysis of 3000 online survey responses of MMORPG players identified the social component as one of the three main motivations to play (in addition to immersion and achievement) [348]. It includes the three sub-factors socializing, the building of relationships, and teamwork. Hence, players play MMORPGs because such games allow them to chat with other players, foster the establishment of meaningful relationships, and provide satisfaction by feeling as part of a social group. In a subsequent online study, Williams, Yee, and Caplan [341] collected self-report data in combination with in-game behavior of 7000 players of the specific MMORPG EverQuest 2 [324] to investigate players' characteristics, motivations, and interaction patterns. This data confirms the three factors achievement, sociability, and immersion as the key motivation to play as found by Yee [348]. The results also highlight the importance of the social aspects by showing that the motivation to play with others is a strong predictor for actual playing time. The more players are motivated by social interaction, the longer they play the game. Another large online survey with EverQuest players by Griffiths, Davies, and Chappell [118] presents similar results: asked about their favorite features of the game, the majority of participants refers to social features. Hence, the main reason to play EverQuest for most players is the possibility to interact and communicate with other players.

To further investigate the social interactions and relationships that emerge in MMORPGs, Cole and Griffiths [54] asked players of different online games about their in-game and real-life relationships with other players. Only 26,3% of their 912 respondents played the games with real-life friends or family members, that is to say with persons they knew before they started to play the game. Accordingly, the majority played online with persons they did not know before. About 75% of the players reported to have made good new friends within a MMORPG and almost half of them had also met with people in real life who they got to know online. Almost half of all respondents also rated the quality of their online friendships as comparable or even better than their real-life relations and many of them were willing to discuss sensitive private issues online. Yee [349, 350] report comparable results. 39.4% of male respondents and 53.3% of female respondents in Yee's study stated that their online friendships were at least equivalent or even better than their other relationships. Regarding the types of relationship that are established between online players, Yee found that not only platonic friendships but also romantic relationships frequently occur in MMORPGs [350]. All these findings indicate that MMORPGs enable the establishment of new social ties which are by no means inferior to relationships built offline. It can be derived that online games offer rich social interactions, which are supposed to have a significant influence on the overall experience and the motivation to maintain playing.

Several studies show that this social impact is not limited to online role-playing games. Kim and Ross [170] found the same for digital sport games. Trepte, Reinecke, and Juechems [309] conducted an online survey with players of online e-sports games about social capital that is gained by playing such games. Their results also confirm that online gaming can help to instantiate and foster social ties. Moreover, the data revealed a significant relation between these social ties and perceived social support. Strong social ties led to an increase in offline social support. This is a promising result, as it indicates that online social gaming may even promote players' psychological wellbeing [309]. These results are confirmed by two recent studies about social support in e-sports [101] and social capital provided by digital games in general [66].

An online survey by Jansz and Tanis [155] focused on the appeal of online first-person shooter (FPS) games, another game genre that is very popular among multiplayer games [81]. Results reveal that social interaction is a strong motive to spent time on playing FPS games, as well. The social motive was found to be the strongest predictor of the time spent on playing such games. By interviewing players, Clarke and Duimering [53] investigated what players like and dislike about online first-person shooters in more detail, also comparing singleplayer and multiplayer modes. All participants consistently pointed out that they like to play with other players—particularly with friends—because of the social interaction in terms of camaraderie, chatting, teasing, taunting, and joking. They prefer human co-players to bots, because the latter are more predictable and may lead to unfair matches (too easy or too difficult). However, participants also pointed out that the scheduling is more complex for multiplayer gaming and that anti-social behavior and cheating of other players can ruin the experience [53].

Whereas the diverse surveys mentioned above focus on online gaming, there are also studies particularly investigating the experience in co-located multiplayer settings. The social interaction with others has been shown to be the main motivation to play console games together at home [327], to use portable consoles in social contexts [296], and to participate in LAN events [154]. Voida and Greenberg [327, 328] observed existing groups of players while playing together in their typical gaming settings at their homes. Their results identify console games as "meeting places", which bring people together both physically and socially [327]. In the groups under investigation, players often had diverse demographics, expertise levels, and preferred playing styles. Hence, console games allow for diverse playing styles and facilitate social interaction between generations by providing different roles and possibilities to participate in the gaming activity (group members can also take passive roles, e.g., as spectators or advisors) [328]. Current figures provided by the ESA report [81] confirm that more than half of all active players (55%) feel that digital games help them to connect them with their friends and 46% of the respondents use games to spend time with their family.

Further studies emphasize that social interaction is a main motivation to play multiplayer games in general, independent of game genre or gaming system [57, 166, 280, 321, 322, 327]. Sherry, Greenberg, Lucas, and Lachlan [280] investigated the reasons why players spent time on video games following the uses and gratification paradigm by asking players why and in which situations they play games and how they feel in certain gaming situations. In iterative studies, they found that social interaction is one of six dominant gratification traits of video games and that it is a strong predictor of hours spent playing games. Players use digital games as a reason to get together. Competition was identified as another important factor, as players wanted to prove that they are better than their co-players. These two forms of gratification can explain the great appeal of multiplayer games: they facilitate social interaction and offer the possibility to prove one's skills and abilities in a secured setting.

Vella, Klarkowski, Johnson, Hides, and Wyeth [322] conducted an online survey and follow-up interviews with regular players to gain insights into what players like and dislike with regard to different social contexts. They differentiated between solitary play and social play configurations (i.e., playing with other persons) and asked with whom people play (friends or strangers) and how they play with each other (cooperatively, competitively, or both). For each of the resulting social context configurations, participants described what they liked and disliked about it. Results indicate that the contexts differ significantly regarding the motivation to play and the perceived uses and gratifications. Solitary play was mainly associated with autonomy, immersion, escapism, relaxation, and the absence of performance pressure. However, players disliked the lack of relatedness with others and some described solitary play as being less fun than co-play. In contrast, playing with others was characterized as an entertaining activity providing social relatedness and the opportunity to meet new people.

By analyzing the results of focus groups with regular players, Kaye and Bryce [166] identified four social processes that can take place in social game settings and be a reason to play:

1. Being seen: In multiplayer games, players are aware that their actions and performance are (at least partly) visible to others. This awareness can enhance the emotional investment, as they experience the game as a relevant social situation. Hence, the presence of other players can intensify the feelings that evolve during play, which can be both positive (e.g., enjoyment of performing better than the others or being a good team) and negative (e.g., frustration due to bad performance).

2. Social connectedness: Multiplayer games, especially online modes, offer the possibility to keep contact with friends over a distance and spent time together. This can heighten the sense of social belonging with friends.

3. Social integration: Social integration particularly occurs in co-located settings and describes a multiplayer game's capability to provide a good positive mood for social interaction among both friends and strangers. Games can "break the ice", create common ground, result in shared experiences, and give a group something to talk about. Hence, they facilitate social integration with others.

4. Social networking: In online gaming sessions, players also appreciate the possibility to engage in social networking. During play, players can exchange personal information that is not game-related, and thereby also make new friends and maintain strong relationships.

These results underline the complexity of social processes that might take place during social play and, moreover, indicate that different game modes, particularly online gaming and co-located gaming, can lead to very different social effects and experiences.

However, all the surveys discussed so far share a common result: players engage in digital games with other players because they appreciate the social interaction that is facilitated by games and, moreover, enjoy the feeling of being socially connected. This finding is reflected in both general player typologies and motivational theories about the motivational pull of games. All player models discussed in the previous chapter (see section 2.2.4) include at least one player type that is mainly motivated to play games due to their social qualities (e.g., the "socializer" [13, 221]). In the SDT, relatedness is the third basic psychological need (besides autonomy and competence) and its satisfaction has been shown to significantly contribute to overall game enjoyment [263, 298]. To satisfy the need for relatedness, a person has to feel connected with others [263]. Tamborini et al. [298] conducted a study to investigate the satisfaction of needs in different gaming settings. They compared the experience in a singleplayer mode with a co-playing mode of a bowling simulator game. Participants played either cooperatively with a human co-player or with a computer-controlled partner. Results showed that a co-player satisfies the need for relatedness significantly more than a virtual co-player, and this need satisfaction contributes to overall game enjoyment. Vella, Johnson, and Hides [321] also investigated need satisfaction in games based on the SDT. They conducted an online survey and asked players to remember their last gaming session for a game of their choice. Results confirm the finding of Tamborini et al. [298]: Participants reported higher autonomy for solitary play sessions, whereas relatedness was higher for social play.

A concept that is closely linked to the need for relatedness is the need to belong. The term was coined by Baumeister and Leary [14, 15] and describes an individual's wish for meaningful interpersonal relationships and social attachment [103]. This strong motivation to form and maintain relationships significantly influences a person's cognition, emotion, and behavior in most situations of everyday life [15]. The importance of the need to belong has been confirmed in many studies: research has shown that a lack of satisfaction of the need to belong is linked to ill effects on self-esteem, well-being, and health [14, 15]. Accordingly, a person's social motivation has to be considered as an important factor influencing human's behavior and experiences, also in the context of playing digital games. As demonstrated in the studies described above, multiplayer games particularly address this need, while they can still support the needs for competence and autonomy as well. Hence, the social motivation of players is one main reason for the great appeal of multiplayer games. While the need to belong is a basic need of every human [14], some players seek its satisfaction in games more explicitly than others, as indicated by different player types.

3.1.2 *Social Aspects as Part of the Player Experience: Comparing Singleplayer and Multiplayer Gaming*

Apart from conducting online surveys, another common approach to investigate how multiplayer gaming affects players is to directly observe players during play and assess their experience and behavior. This can be done by using diverse methods as described in detail in section 2.3. Accordingly, several studies were conducted to investigate the differences between singleplayer and multiplayer gaming. In an early study, Inkpen, Booth, Klawe, and Upitis [144] compared the performances of children playing a puzzle solving game either alone or as a pair and found that players solved significantly more puzzles when playing together on one computer compared to playing alone. Players' motivation to continue playing was also higher in the co-playing condition. In a more recent study, Peng and Crouse [235] also observed higher motivation of players when they played a physical movement game with a co-player in contrast to solo-play. Li and Counts [194] developed a mobile multiplayer game with puzzle elements that could be played either solo, in teams, or individually against each other and tested players' motivation and gaming behavior during a one-week experiment. The authors report that also in this study, participants in the social conditions had a higher interest and motivation to actively take part in the game, while solo-players did not engage in the game over time.

The increased motivation in multiplayer settings might result from higher experienced game enjoyment: several studies focusing on the social player experience indicate that playing with another player leads to higher positive affect and enjoyment than playing the same game alone (i.e., against or with the computer) [108, 190, 209, 235, 298, 338]. These studies comprise diverse game genres and social settings, providing evidence that the positive effect of co-players on enjoyment is not limited to some exceptional cases. Increased enjoyment is supposed to be linked to the satisfaction of social needs [166, 298] and socio-psychological effects which intensify the experience and add another layer [152, 166, 287, 358].

Despite this positive effect on enjoyment, researchers have also stated more critical considerations regarding the effects of co-players on the experience of the gaming situation. Involvement, presence, and flow are important aspects of the player experience (cf. section 2.2). At the same time, these aspects are related to the player's absorption into the game world. Co-players may interfere with this individual involvement in the game [105, 293]: they can be seen as a potential distraction as they are part of the real world and not the game. Thus, co-players—and particularly direct communication and interaction with them—may remind players of the fact that the game is just a virtual environment, thereby impeding flow and involvement. Following this line of argument, the question arises whether the presence of other players does affect the overall player experience negatively compared to solo-play.

A couple of studies address this issue and provide partly conflicting results. Lee, Wyeth, Johnson, and Hall [190] investigated the differences between solo-play and cooperative play in a custom puzzle-based game. In contrast to the concerns raised above, they found that both enjoyment and flow were higher if two players played the game cooperatively in the same room, indicating that a co-player might even increase game involvement. Similar results are reported by Weibel, Wissmath, Habegger, Steiner, and Groner [338]. In their study with a customized level of the role-playing game Neverwinter Nights [23], they tested how the player experience changes dependent on the type of opponent. Participants were told that they had to fight online against either a human-controlled opponent or a computer opponent, while in fact everyone played against the computer AI. Though the behavior of the opponent did not differ in the two conditions, participants reported higher feelings of presence, enjoyment, and flow when they thought that their opponent was another human. Thus, the results indicate that the mere belief to be in a social situation can positively influence the player experience.

Gajadhar, de Kort, and IJsselsteijn [105] conducted a study investigating the effect of co-players on the involvement of players in a simple casual game (WoodPong [72]). Participants played the game in two conditions, against another participant (remote) and against the computer. The results also counter the concern that flow and involvement could be reduced by a social game setting. However, though some respective self-report scales did show modest improvements in the co-playing conditions, all differences were not significant. Hence, the study does not support the positive impact of a social setting found in other studies, either. Interestingly, participants were deceived regarding the social context of gaming like they were in the study of Weibel et al. [338], but the other way round: all players in fact played against a second participant (i.e., a human player) in all conditions, whereas Weibel's participants all played against an AI opponent. The lack of differences between the study conditions may therefore be attributed to the realistic, human-like behavior of the opponent in both groups and a similar level of challenge.

Based on the study by Gajadhar et al. [105], Cairns, Cox, Day, Martin, and Perryman [47] further investigated the potential influence of the social setting on the player experience in a couple of experiments. Using the same game (WoodPong), they compared the experience of players playing against each other co-locatedly, online in different locations, or against the computer (who was in fact the other participant, as well). The authors report that feelings of presence were higher for human co-players than for the computer opponent, whereas location of the human player had no significant influence on immersion. Hence, the non-significant trends of Gajadhar's study [105] manifest in significant differences in the replicated study of Cairns et al. [47]. In their second experiment, participants played a racing game in groups of three players in the same room and either against each other, or concurrently against the computer. In both conditions, all three players were in the same room, hence the playing setting always had some kind of social component. Still, reported immersion was significantly higher when participants played against the others instead of computer opponents. This indicates that direct social competition does not interfere with involvement, but may instead increase it. One possible explanation for this result is that human competitors add to the value of the game's outcome, because winning and loosing have social relevance in a group of players [47].

Taken together, the studies so far [47, 105, 190, 338] provide evidence that co-players do not necessarily interfere with presence and immersion. In this context, Kaye and Bryce [166] transfer the concept of group flow to digital games. Group flow describes situations in which more than one person engage in an activity and experience a comparable level of flow. Kaye and Bryce [166] addressed this concept in focus groups with regular gamers to gain insight whether group flow does occur in social play situations as well. The authors identified several factors that can lead to group flow such as collective competence and comparative personal competences (knowing the skill of each other and showing off one's competence), interdependence, task-relevant knowledge, and complementary participation. Players also reported that success in social situations feels particularly rewarding, supporting Cairn's assumption that the gaming outcome has increased relevance in multiplayer settings [47, 166]. In a subsequent online survey, Kaye [165] further investigated the emergence of group flow in cooperative games compared to flow in singleplayer games. Participants consistently mentioned several aspects that are important for a positive experience in cooperative games and facilitate group flow experiences: effective communication, effective teamwork, and task-relevant knowledge of group members (i.e., the awareness of competencies among the team). These results affirm the results of the prior study and indicate that group flow is likely to evolve given certain facilitators. However, when asked to rate the experience of flow in both multiplayer and singleplayer settings, participants reported higher feelings of flow for solo-play situations. These retrospective ratings contradict other study results as reported above and support that feelings of absorption and involvement may be interfered by the presence of others. At the same time, a further analysis of Kaye [165] shows that participants report no significant differences in positive or negative post-game mood, indicating that the overall quality of the two settings is still experienced equally positive. Hence, even if flow may be reduced in social play settings, this does not necessarily lead to a worse overall experience.

Another study that reports higher flow experiences for solo-play is provided by Johnson, Wyeth, Clark, and Watling [160]. They asked participants to play the game *Payday: The Heist* [233], a team-based FPS game for four players, in two conditions. In one round, they played together with three human co-players, though no verbal communication was enabled. In the other condition they were supported by three computer-controlled AI agents. Self-reported flow and competence were significantly higher when the teammates were artificial, whereas perceived relatedness was significantly lower. The authors suggest that the decrease of flow and competence might be caused by the worse performance of real teammates compared to computer-controlled agents. Due to a lower predictability and reliability of human players' behavior, working together with them demands more cognitive resources for information processing, for instance for considering the goals, plans, and next steps of all teammates. In addition to self-reports, Johnson et al. [160] also administered physiological measurements of players' brain activity to assess the player experience. Results support the hypothesis regarding higher cognitive demands in social cooperative situations, as related brain activity was significantly higher in that condition.

Overall, findings regarding flow and presence in singleplayer and multiplayer games are ambiguous, though more studies show an increase of such experiences in the presence of other players. The effect seems to be moderated by other variables such as the concrete constellation of the social play situation or the kind of game that is played. Studies by Kaye [165] and Johnson et al. [160] indicate that co-players may interfere with individual presence and flow under certain circumstances, but even in those cases overall game enjoyment does not decrease. It can be concluded that individual absorption into the game world might become less important in multiplayer settings or be compensated by other positive experiences resulting from social effects and interactions. The other studies suggest that the presence of co-players or the mere belief that one is playing with another human can increase flow and presence [47, 190, 338]. The effect of group flow may be one explanation for that. In any case, it becomes clear that multiplayer settings result in experiences which differ from playing the same game alone and that, furthermore, the experience is equally or even more positive.

Besides the study of Johnson et al. [160], further studies compared singleplayer and multiplayer games by measuring players' physiological reactions during play and revealed interesting differences. Mandryk, Inkpen, and Calvert [208, 209] assessed biometrics (GSR and EMG) and self-reported player experience of participants playing the sports game NHL 2003 [79]. The game was played in two conditions: alone against the computer and against a co-located friend. The majority of participants stated that they preferred playing against a friend. Their physiological data showed higher GSR values and higher EMG values along the jaw when playing against a friend. These measures indicate increased levels of arousal and perceived challenge for multiplayer games.

In a study with a larger sample size, Ravaja et al. [245] asked participants to play two different games on the GameBoy Advance in three conditions: in singleplayer mode, against a stranger, and against a friend. The games were selected to represent different genres, namely a first-person shooter (Duke Nukem Advance [302]) and a dexterity jump 'n run game (Super Monkey Ball Jr. [247]). In both games, participants showed higher anticipated threat, challenge, and arousal (both self-reported and measured by biometrics) when playing against a human co-player compared to solo-play. In line with results reported by Mandryk et al. [209], players seem to be more engrossed in multiplayer settings and show increased bodily reactions. The presence of others might enhance players' awareness of their own performance due to the higher evaluative potential in competitive social situations, thereby increasing arousal and perceived challenge [245]. Moreover, co-playing elicited more positively valenced emotional responses and enjoyment than playing the singleplayer modes of the games. This, again, suggests a positive impact of co-players on the overall game experience. Moreover, results are in line with those of Shahid, Krahmer, and Swerts [279], who observed that children who played a simple digital card game in pairs were more expressive in terms of showing positive and negative emotional responses to success and failure in the game than children who played the game alone. In a follow-up study, Ravaja [244] found that even if the human co-player is not co-located (as they were in the first study), the knowledge that the opponent is another person led to higher arousal and enjoyment as compared to solo-play against the computer.

Wehbe and Nacke [337] investigated players' arousal in different team-based competition settings, including either human or virtual teammates and opponents. In this study, no significant difference in physiological arousal was found. However, there was a significant difference in perceived arousal reported by players: in the conditions involving human co-players, arousal was rated higher than in the singleplayer mode (in which all other game characters were controlled by the game system). Hence, though the physiological findings do not support the difference, human co-players seem to have affected the player experience in this case as well.

Lim and Lee [196] as well as Lim and Reeves [197] also investigated the aspect of physiological arousal in different gaming scenarios. They report that participants' arousal was higher if they were playing with a real human compared to a computer-controlled agent [197]. They further differentiated between several kinds of tasks. Arousal was higher for competitive gaming tasks [197] and non-violent collaborative navigation tasks [196]. In contrast, the company of another human player decreased arousal in a collaborative fighting task [196]. These studies show that the impact of co-players is not consistent across all gaming scenarios, but dependent on the kind of game task and the way players interact. In competitive settings, co-players may increase perceived pressure, challenge, and arousal, while collaboration can decrease such feelings due to the supportive role of the co-player. In other cases, a collaborative co-player might not be perceived as a source of support, but instead as a source of additional effort to coordinate actions, which in turn is reflected in increased arousal [196]. In this context, Wehbe, Lank, and Nacke [336] investigated how players perceive and evaluate human-controlled and computer-controlled team members in the first-person shooter game Left 4 Dead 2 [319]. Participants showed a general preference for human co-players and a consistent negative bias towards virtual teammates.

Another topic that is often discussed in the context of multiplayer games is aggression, including related cognitive and emotional states. Researchers assume that playing against other human players elicits higher aggression and hostility compared to solo-play against the computer due to increased competitiveness [82, 83, 269, 342]. Eastin conducted several experiments using the first-person shooter game *Unreal Tournament* [95] to investigate the impact of co-players on aggressive thoughts [82] and state hostility [83]. He particularly considered the potential influence of the number of co-players and their gender. In line with the hypothesis, players reported more aggressive thoughts when they played against a human opponent [82]. Moreover, a higher number of human co-players led to higher postgame hostility [83]. In contrast, Williams and Clippinger [342] observed that their participants tended to show a higher aggressive affective state when they played a digital version of Monopoly against a simulated computer opponent. Playing against a co-located, unknown human opponent was related to lower aggression. While on first sight this result contradicts Eastin's findings [82, 83], the differences could be explained by the different kinds of games. The game used in Eastin's studies is a fast-paced, highly competitive shooter game, whereas Monopoly is rather passively competitive and turn based. Furthermore, the social situation of gaming differed: playing against a co-located stranger may be more affected by social norms of politeness and the friendly small talk communication occurring during play [342] than online competitive gaming.

Two other studies underline that the way players interact does influence their aggressive state [157, 269]. Schmierbach [269] compared solo-play, cooperative play, and competitive play in the FPS *Halo* [43]. Participants reported more aggressive cognition in the competitive mode, least aggressive cognition in cooperative play, and higher aggressive affect (anger) and frustration in solo-play and the cooperative mode. Findings of Jerabeck and Ferguson [157] confirm that cooperative gameplay with human co-players can reduce post-game aggression compared to playing alone.

In summary, all described studies demonstrate that the player experience of multiplayer gaming and singleplayer gaming differs significantly, even if the game that is played is the same. Research findings emphasize that the social presence of other persons changes the way a game is played and experienced by creating a social situation. In such social settings, a number of social effects and phenomena can occur, significantly framing the experience. The following section elaborates on such effects, as they serve as the basis for explaining the impact of co-players on the player experience.

3.2 SOCIAL EFFECTS IN THE CONTEXT OF GAMES

In the broad field of social psychology, many effects and phenomena have been observed to occur in social situations. In the presence of others, a person is likely to be influenced by the other person(s) in a number of ways. Mostly, people are not even aware of the degree to which they are influenced by others. Some effects relate to a person's task performance, like the social facilitation effect and social loafing, whereas others influence self-perception and the evaluation of the other present person(s), such as social comparison, social reinforcement, and the halo effect. Moreover, the presence of other persons can affect emotions in terms of emotional contagion and mimicry.

In general, research regarding social effects is diverse and cannot be covered completely in this thesis. Hence, in the following, only the social effects most relevant in the context of digital games are summarized.

3.2.1 *Social Facilitation*

The social facilitation effect is one of the most established and researched socio-psychological effects. It describes the phenomenon that one's performance on a task is unconsciously influenced by the presence of another person [92]. Researchers became aware of this effect over hundred years ago while observing people performing tasks in different social situations. Early observations of racing cyclists and children who should turn a fishing reel as fast as possible showed significantly increased speed if the tasks were performed next to each other compared to being alone [310]. Subsequently, increased performance in social settings was observed for other activities as well, for instance for co-working and writing tasks [7]. These initial studies led to the conclusion that individuals perform significantly better and faster if another person is present in contrast to attending to the same task alone, and this effect was therefore termed social facilitation [121].

However, as research on this phenomenon was intensified, it was found that the presence of another person can not only increase performance, but often has the opposite effect, depending on various aspects like the kind of task and the performance measure. Comprehensive overviews of social facilitation research are provided by Guerin [121], Bond and Titus [30], as well as Aiello and Douthitt [5] and underline that the presence of other persons can facilitate but also inhibit task performance. Hence, while in the narrow sense (and as implied by the wording) the social facilitation effect describes an enhancement of performance in the presence of others, it is today rather used as a broader term for any kind of change in performance, also inhibition, due to the fact of not being alone [5].

While the occurrence of social facilitation effects has been observed and investigated in diverse contexts, the question why people are influenced by the presence of others is not yet conclusively answered. Moreover, the conditions under which co-presence acts facilitating or inhibiting still are not defined entirely. Several theories have been put forward to propose explanations for social facilitation. These explanations can be classified into three groups of basic mechanisms: arousal, attention, and social valuation (see Guerin's work [121] for a detailed overview). Early research was highly influenced by Zajonc, who postulated the first comprehensive theory particularly accounting for the opposite effects of social facilitation [354], the drive theory. In this theory, he explains the contradictory effects of facilitation and inhibition with an increased level of arousal elicited by the presence of other persons. This arousal, in turn, influences task performance and behavior, as it leads to an enhancement of quick dominant responses. Dominant responses are those which are well-learned or automatically executed. Such responses are often not adequate in new or difficult situations and, thus, result in worse performance. In contrast, they are usually appropriate in easy or learned situations, leading to an increased performance. Hence, Zajonc puts emphasis on the quality of the task as an indicator for facilitation or inhibition, respectively.

Although Zajonc's drive theory provides a possible explanation for the conflicting findings, it does not conclusively explain all findings about social facilitation effects. It thus caused a widespread discussion. Alternative theories attribute social facilitation effects to attentional processes. It is argued that the presence of others provides physical or cognitive distraction and thereby narrows cognitive capacity and the resources spent on task solving [121]. Similar to an increase of arousal, a decrease of attention and cognitive resources is supposed to inhibit performance in difficult tasks and to facilitate easy tasks due to dominant responses.

Finally, some other theories emphasize the potential role of evaluative social processes in determining task performance. Such theories suggest that the presence of others can rise a person's self-awareness and induce evaluation apprehension and processes of social comparison (see section 3.2.3), if the person perceives the situation as evaluative [121]. Depending on the perceived valence of evaluation (e.g., whether the observer is favorable or censorious) performance can be supported or impeded. Furthermore, a meta-analysis of Uziel [317] implies that personality traits and the individual expectations of a person moderate the effect.

Still, there is no consensus as to which theory explains the social facilitation effect best. There is also some recent work investigating and refining different theories, for instance by Blascovich, Mendes, Hunter, and Salomon [27] and Ukezono, Nakashima, Sudo, Yamazaki, and Takano [315]. Nevertheless, it can be concluded from literature review that processes of arousal, attention, and social valuation in some combination are very likely to determine social facilitation effects [121]. Though the source of the effect is ambiguous, its occurrence has been demonstrated in various contexts. This implies that social facilitation also applies to digital games: the presence of another person while playing a game is likely to influence the performance of the player. There are many play settings in which several persons are involved, for instance as co-players or observers, hence the social facilitation effect is very relevant for game research. However, so far the effect received little attention in the field.

The investigation of the social facilitation effect in the context of digital games is one focus of this thesis and will be addressed in detail in Chapter 9 and Chapter 10, which are based on two of my publications [90, 92]. Social facilitation was selected as an example for social effects that may be induced by co-players and virtual social entities in the game world to test the applicability of such effects to social play situations.

3.2.2 *Social Loafing*

Another phenomenon that describes behavioral changes concerning a person's performance due to the presence of others is social loafing. Social loafing describes the decrease of the effort an individual exerts to achieve a goal when working in a group compared to working alone [186]. This effect first became known as the Ringelmann effect based on a simple study by a German psychologist, in which participants had to pull on a rope as hard as possible alone or in groups of different sizes [186]. In the following, social loafing was found for various tasks such as brainstorming, shouting, clapping, swimming, and evaluative processes [162]. The effect is thus considered as being robust and generalizable across tasks and situations [162].

Social loafing is sometimes seen as a complement of the social facilitation effect [124]. While for social facilitation the mere presence of other persons is supposed to be sufficient to have an impact on performance, social loafing is a group phenomenon that requires a group of people working on the same task together. It has been shown in a variety of studies that people tend to be less motivated and exert less effort if their individual contribution in a team effort is not identifiable [124, 162]. Theories regarding the reasons why social loafing occurs are comparably manifold as theories about social facilitation and include a decrease of social impact, the reduction of arousal, the loss of evaluation potential as well as the dispensability and matching of individual efforts [162]. In a comprehensive meta-review, Karau and Williams [162] furthermore identified a couple of moderator variables that have a significant impact on social loafing, such as the expectations of co-worker performance, task meaningfulness, and culture.

Social loafing is also relevant in the context of digital games. It is supposed to occur in cooperative multiplayer games in which players are working towards a shared goal and the individual input of single players is not apparent. In such cases, effort and motivation of players may drop, hence the effect should be considered during the design process to avoid negative consequences. As the effect mainly concerns players' performance, current research particularly focuses games with a purpose, such as crowdsourcing games [163] and educational serious games [264], which aim at maximizing players' performance more than entertainment games use to. With two studies, Kaufman, Flanagan, and Punjasthitkul [163] demonstrate that social loafing can lead to reduced contributions in crowdsourcing games, if the social context of the game is framed in a way that players think they are part of a large group of players who are all contributing to the same result. Based on their findings, the authors present various strategies for counteracting social loafing. Sailer, Schäfer, and Groh [264] also show that making individual contributions visible can increase players' motivation to cooperate.

3.2.3 *Social Comparison*

Social comparison theory was introduced by Festinger [100] and describes how other persons can influence a person's self-evaluation. It is based on the observation that individuals tend to constantly evaluate themselves based on different sources of information. If no objective information is available, a comparison of own abilities or opinions with those of other persons is performed for evaluation. This is called social comparison.

Since being a process of self-evaluation, social comparison contributes to self-regulation in general [299]. It helps to properly assess one's abilities and can serve as a basis to adapt attitudes as well as future behavior. According to Festinger [100], the drive for social comparison is higher for abilities or opinions that are of importance to a person or that have relevance to immediate behavior. In this case, people have the need to evaluate their standing. In contrast, if a subject is perceived as irrelevant or unimportant, social comparison is less likely to occur. Taylor, Neter, and Wayment [299] further discuss why people evaluate themselves and summarize four motives that are supposed to guide self-evaluation: self-assessment (gaining accurate information about oneself), self-enhancement (achieving and maintaining a positive self-view), self-verification (confirming existing self-conceptions by consistent cognitions), and self-improvement (improving specific skills).

Social comparison can address several of these motives, depending on the direction of the comparison [299]. The comparison person can either be similar regarding the dimension under evaluation and related attributes (lateral comparison) or different (vertical comparison). If the comparison person is performing better than the self, it is an upward comparison, whereas a downward comparison is performed with a person who performs more poorly. In his basic theory, Festinger [100] notes that persons tend to particularly compare themselves with other persons who they estimate to be rather similar. Such comparisons are supposed to lead to stable evaluations, whereas comparisons with persons who are seen as rather different are avoided or lead to unstable evaluations. However, though Festinger emphasized the importance of similarity between a person and the comparison other with reference to the self-assessment motive, he did not specify the basis of similarity [290]. Therefore the social comparison theory was gradually modified and extended to clarify why social comparison is used and with whom people tend to compare themselves in different contexts. Studies have shown that such aspects are determined by the self-evaluative question that underlies the comparison and depend on whether an ability or an opinion is evaluated [290]. For instance, one model referring to the evaluation of abilities is the proxy model by Wheeler, Martin, and Suls [339]. According to the model, people compare themselves with so-called proxies, who have performed similarly on a relevant task in the past, to evaluate the likelihood of success on a new task. Other task-related attributes of the proxy are taken into account only if it is not known whether the other has exerted maximum effort on the preliminary task. If the effort is ambiguous, proxies who are superior in related attributes will lead to a worse predicted own performance, and vice versa.

It can be concluded that individuals compare their abilities with those of a similar person, i.e. lateral comparison, if the dominant motive is self-assessment [290, 299]. Vertical comparisons, in contrast, can serve different purposes: downward comparisons can contribute to self-enhancement, because they provide feelings of superiority, whereas upward comparisons can motivate persons to improve their abilities, supporting the motive of self-improvement [290, 299]. Initially, it was assumed that downward comparisons are preferable and that upward comparisons are related to negative outcomes and threaten a person's self-esteem [290]. However, more recent studies have shown that the direction of comparison does not directly influence the affective outcome and that both directions can be positive or neagtive [45, 290].

Social comparison is directly related to competitive behavior: due to the basic drive to compare one's abilities with others, there is an "unidirectional push to do better" [100, p. 125] and to reach or protect a superior relative position [100, 114]. Hence, competitiveness is a consequence of social comparison concerns, which are influenced by diverse situational and individual factors [114]. An upward comparison can have a positive influence on the motivation to improve oneself and to become better than the other, triggering competitive behavior. Still, there are comparison targets (particularly superior ones) for which a social comparison is expected to be too unfavorable and, thus, not motivating. In such cases, the comparison is usually avoided. However, in some situations, this is not possible, because people have no control regarding their comparison persons like in organizational structures or official competitions with random competitors. In those cases, people choose different strategies to avoid a decrease of self-esteem, for instance by exaggerating an outperformer's ability or downgrading the relevance of the compared dimension [6].

Social comparison theory is relevant in diverse context of everyday life and is also applicable to digital games. Especially ranking systems and leaderboards, which are common game design elements, are supposed to trigger social comparison processes, even in games which are played alone [287]. They provide social competition and challenges, which can increase players' motivation to play the game [329]. The effect of leaderboards was investigated in several studies for game contexts [32, 56] and gamification applications [52, 123, 357] and can significantly influence the experience. Moreover, based on social comparison theory, it can be assumed that players seek competition with players who have similar abilities to assess their skill level and to gradually improve. Hence, precise matchmaking systems in online competitive games are meaningful to avoid unfavorable comparisons. In sum, accounting for social comparison theory is important for designing compelling multiplayer games, particularly competitive ones.

3.2.4 *Social Learning and Reinforcement*

Social learning theory implies that learning takes place in a social context and new behavior is adopted by observing and imitating other persons [11]. Hence, persons can learn from the experiences of others. Social learning can also happen in social gaming settings. For instance, inexperienced players can observe more experienced ones and thereby learn how to play the game and improve their abilities. In cooperative games, players can share ideas and directly learn from each other. Moreover, recent research has revealed that information seeking and learning about game strategies are strong motives for watching gameplay videos and gaming live-streams, which is very popular today [282]. This kind of observation also supports social learning.

Game designers can take advantage of social learning theory by implementing mechanics that allow players to monitor other players, thereby supporting social learning [152]. This may lead to an easier onboarding of new players to increase the number of users. Moreover, social learning can be used as a technique for game tutorials, educational games, and other game-based learning applications [345]. Thus, designers of such applications should consider the use of multiplayer mechanics or the inclusion of virtual characters that can serve as a model for observational learning.

The learning process can be supported by direct and vicarious reinforcement, i.e. the enhancement of behavior due to rewards. In a social setting, social incentives are one type of rewards which can lead to so-called social reinforcement [110]. These include encouragement, cheering, and smiling of others. Such social rewards provide a positive social experience and can increase a players motivation to play and maintain playing the game.

3.2.5 *First Impressions*

Social effects also influence the way another person is perceived and rated at first sight. Based on available clues such as the physical appearance people tend to form first impressions quickly, which are rather enduring and affect ongoing interactions [151]. Examples in this context are the babyface effect and the attractiveness halo effect [151, 356]. According to the babyface effect, a person whose face has childish features (e.g., large eyes, small nose) is perceived as more friendly, trustworthy, and vulnerable than a person with a mature face. The attractiveness halo effect leads to the attribution of other positive qualities if a person is perceived as attractive, though the other characteristics are not rationally derivable, like intelligence or reliability.

Effects leading to the formation of first impressions also apply to the evaluation of game characters [149]. Hence, social effects like the two examples above are relevant in the process of game character design. If a virtual person should embody certain characteristics, the designer can purposefully design its physical appearance to trigger such effects [149, 151]. This is also important for creating the right player expectations regarding a character's role and personality [93]. As virtual characters and their social impact on the player are main topics of this thesis, the design of virtual characters and related social phenomena will further be discussed in part III.

3.2.6 *Emotional Contagion*

The presence of others is also supposed to directly influence the emotional state of a person due to the effect of *emotional contagion* [129, 130]: if a person expresses an emotion (e.g., showing happiness by smiling beatifically), another person seeing this tends to imitate the expression (e.g., smiling—at least slightly) and will thereby feel the same emotion (e.g., be happy). Hatfield, Bensman, Thornton, and Rapson define primitive emotional contagion[1] as "the tendency to automatically mimic and synchronize facial expressions, vocalizations, postures, and movements with those of another person and, consequently, to converge emotionally" [129, p. 5]. The process of emotional contagion is subtle and subconscious. It can be divided into three stages: mimicry, feedback, and contagion [130]. Hence, mimicry and physical feedback are the basic mechanisms leading to emotional contagion. Mimicry describes the imitation of another person's expressions and movements and is an innate, ubiquitous, and instantaneous behavior [130]. It is supported by properties of the human brain: so-called mirror neurons fire if a person observes another person taking an action that expresses emotions (e.g., smiling) as if the person is taking the same action herself [151]. Mimicry then results in emotional contagion due to the fact that a person's feelings are to some degree determined by physical signals of the own body, called physical feedback loop [151]. If a person smiles as a result of mimicry, the person might subconsciously conclude that he/she is apparently happy.

There is considerable evidence that emotional contagion occurs in diverse social contexts [130] and that the effect is also relevant to joint media consumption such as watching videos [242] and playing digital games [110, 151, 152, 358]. Isbister [151] points out that game designers can take advantage from such effects by creating game characters that express emotions which should be elicited in the player. For instance, feelings of joy might be intensified if the player's avatar visibly celebrates a victory. Moreover, in multiplayer settings, emotional contagion is likely to occur if co-players are able to see and observe each other.

3.3 CONSTITUENTS OF SOCIAL PLAY SETTINGS

The previous sections have elucidated the underlying social effects as well as consequences associated with social play and diverse reasons why players engage in multiplayer games. However, while basic social effects are supposed to apply to all social situations to some extent, the facets of multiplayer settings are manifold, leading to different interplays of effects and resulting in different player experiences. Social play settings vary regarding the type and number of others involved, game-defined goal structures and social interaction patterns, Players' roles and interdependence, the spatial-temporal-systemic configuration, communication channels, and the relationship between players. In the following, these aspects are discussed in detail and brought together in a comprehensive model of the constituents of social gaming.

1 The term *primitive emotional contagion* is here used to describe the observable "contagious" effect of emotions, whereas emotional contagion in a broader sense is seen as a "multiply determined family of cognitive, psycho-physiological, behavioral, and social phenomena" [130, p. 160].

3.3.1 *Social Entities: Real Humans and Virtual Characters*

Regarding the presence of others in addition to the player, it can be differentiated between two main types of social entities[2]: real humans and virtual characters. Real humans can further be classified as either co-players, who are actively taking part in the game, or bystanders, who do not directly participate in gameplay but are nevertheless part of the social context, for instance by observing the player and/or the events on the screen.

Co-players are the most obvious social entity in social play settings. As already described at the beginning of this chapter, the presence of co-players significantly influences gameplay and brings along unique social experiences (cf. section 3.1). Due to direct interaction and communication, it can be assumed that co-players have the biggest influence on players' experiences. Bystanders, on the other hand, have no control inside the game, hence they cannot directly influence the course of action. In modern online settings such as game live streaming and e-sports, spectators are not even in the same location. However, they may be able to communicate with the players (e.g., by cheering, giving advice, or writing comments) and, thus, their presence might influence the experience of players [287]. Even if there is no communication at all, players can still be affected by the mere knowledge or feeling of being observed. Effects like social facilitation indicate that bystanders who observe the player without being actively involved can also have social influence, for instance on player's performance [34, 39, 171]. It can be concluded that players are sensible to the presence of spectators, hence spectators should be considered as an important part of the social setting [198]. In this context, Kappen et al. [161] investigated the effect of different types of audiences on the experience of the players in a co-located, competitive multiplayer game. In each session, two participants played against each other in front of an audience that was either cheerful (positive), booing (negative), or silent (neutral). A control group played without an audience. The researchers reported that both positive and negative audiences increased players' engagement, whereas a silent audience, in contrast, was perceived as uncomfortable.

It can be concluded that any form of presence of real persons in the play setting, regardless their active involvement in the game, can influence the social experience of players. Besides co-players and bystanders, many games also feature virtual characters. Virtual characters or agents are artificial social entities provided by the game, who are not controlled by humans (in contrast to avatars, who represent real players in the game world). Often, all computer-controlled characters are called non-player characters (NPCs) [360]. However, I distinguish between NPCs and game bots. An NPC can be defined as "every kind of character found in the game that is diegetically represented in the world, is not controlled by the player, and that is actively involved in portraying some kind of character" [335, p. 40]. NPCs populate the game world and are different from the player. In con-

2 Social entities in digital games can be defined as real or simulated others who "are or seem to be alive" [203, p. 29] and who are actively or passively engaged in the gameplay.

trast, a bot is a special type of intelligent agent that emulates a player instance of the game. Bots are represented like player avatars and are meant to play the game just as a human player would do, i.e. using the same mechanics and pursuing the same goals [53, 134]. This way, bots simulate opponents in games that are usually played against another person to make them accessible to single players, but are also used to provide teammates in team-based games.

Whereas it is plausible that real co-players and bystanders can evoke social effects, the impact of artificial characters is less clear. Several studies have addressed the questions how the influence of a human co-player and a bot differ with regards to the player experience [160, 197, 298, 336, 338]. As discussed in section 3.1, results indicate that a real co-player has a greater social impact in terms of perceived relatedness [160], higher physiological activity [160, 197], as well as increased presence and enjoyment [338]. However, in these studies researchers did not include conditions in which no character (neither controlled by another human nor by the computer) was present. Hence, it cannot be ruled out that the virtual characters had some social influence as well, though less than the human co-players. In fact, there is evidence that virtual characters in virtual environments can trigger basic social reactions as well, provided that they are identified as social entities [28, 286]. According to Blascovich et al. [28], the social influence of a character mainly depends on two aspects: its perceived agency and behavioral realism. Agency describes the belief that the character is in fact another sentient human being, whereas behavioral realism means the degree to which the character behaves as it would in the real world [119]. The authors assume that there is a threshold of social influence resulting from an interaction effect between the two aspects agency and behavioral realism, meaning that a high degree of one aspect compensates a low degree of the other. Hence, even if a virtual character is not perceived as being controlled by a real human (low agency), a high level of behavioral realism can still lead to high social influence. Interestingly, the studies of Wehbe et al. [336] and Weibel et al. [338] show that players' perception of a character's agency can also be manipulated. In both studies, some participants were deceived about the nature of their co-player: they were told that their teammates were human-controlled, though actually they were computer-controlled bots. This manipulation was not noticed by participants, but led to increased social influence of the characters [336, 338].

Regarding the use of game bots in team-based games, Wehbe et al. [336] found that players still tend to prefer human co-players and that there is a consistent negative bias towards bots. This is in line with prior findings by Clarke and Duimering [53] and Hingston [134], who observed that often bots are still perceived as being either too dumb or too perfect, both leading to annoyance and thereby decreasing their social impact. However, believable behavior, such as context-sensitive communication and sarcasm, can increase perceived sociality [336].

In contrast to bots, which are designed to simulate player behavior and "play" the game, NPCs take diverse roles in the game such as vendors,

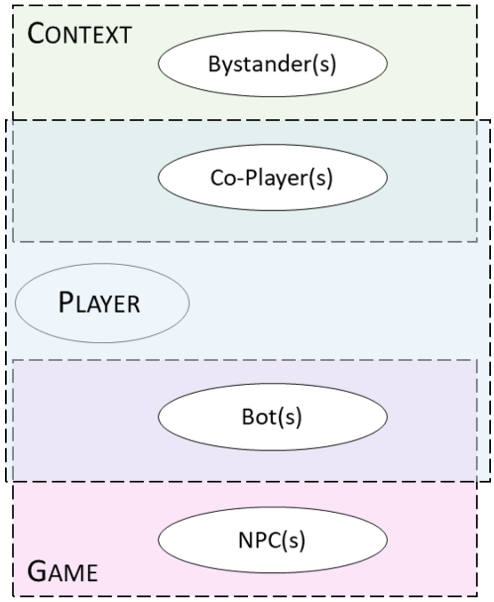


Figure 2: Types of social entities in a social play setting assigned to the three layers context, player, and game.

opponents, or allies [333]. NPCs should have some form of individuality and thereby stand out from the background population of the game [236]. Such characters are an important element in creating believable virtual worlds [148, 184, 191] and well-designed, socially capable characters are assumed to significantly increase game enjoyment [70, 191, 275]. Lazzaro [189] points out that people fun (the fun resulting from the interaction with others, cf. section 2.2.1) can also be induced by in-game characters. However, whereas advances in the field of computer graphics enable the creation of real-looking characters, this realism in appearance contrasts with the rather primitive, unnatural behavior that many game characters display [70, 207]. Schumann [275] conducted focus groups and a large subsequent online survey about quality expectations and perceptions regarding the behavior of NPCs in RPGs and FPS games. She reports a significant gap between the expectations and the actual perceptions of players regarding NPCs. Hence, they have to be carefully designed, especially in terms of behavior, to not fall short of the player' expectations.

Based on research findings so far, it is assumed that social effects of playing digital games are not limited to the presence of other real persons, but can also be triggered by the presence of NPCs or bots to some degree. Hence, virtual characters should be considered as social entities in the context of social play just as real humans. In summary, I differentiate four types of social entities that can be involved in a social play setting in addition to the main player (see Figure 2): co-players, bystanders, bots, and NPCs. These entities can be assigned to the three layers of abstraction of player experience proposed by Nacke and Drachen [222], namely the game system, the player, and the context. NPCs and bots are provided by the game, hence they belong to the game layer. Co-players and bystanders represent real humans who are present (local or mediated) in the context of the game, thus being part of the context layer. Yet, both co-players and bots have in common that they are taking the role of an active player in the game, thus they also belong to the player level—just like the main player—so their layers overlap (see Figure 2).

3.3.1.1 *Social Presence*

De Kort and Ijsselsteijn [358] have investigated the socia-spatial context of games and presented a framework that comprises various *sociality characteristics* of social game settings as well as the underlying social processes. In line with the assumptions made above, the authors point out that the presence of virtual characters has to be considered as a source of social influence in addition to the mediated and local co-presence of other persons. The framework proposes that characteristics of the game system in combination with the presence and characteristics of local, mediated, and virtual co-players define the *social affordances* of the setting, which include social communication and social effects like those described in section 3.2. According to de Kort and Ijsselsteijn [358], those social affordances determine the sense of social presence perceived by the player, which in turn determines the psychological impact of the social context on the player's experience. Thereby, the authors use the term social presence to describe "the extent to which the social affordances of the game setting are effective in eliciting awareness of another social entity" [358, p. 6].

Social presence is a prevalent concept in the context of social player experiences. In contrast to spatial (or physical) presence (cf. Chapter 2), it does not focus on the feeling of being in a virtual space, but on the social component of an experience. In general it describes the "sense of being with another" [24, p. 456]. The term is widely used in HCI research to study the effects of interfaces and new technologies on computer-mediated social communication and interaction. Riva and Mantovani [255] relate the sense of social presence to the biological function of mirror neurons, which enable someone to understand what another person is doing and the underlying intentions by experiencing the same neuron activity (similar to the process of emotional contagion, cf. section 3.2.6). Moreover, the authors define three different layers of social presence:

1. Other's presence: a person recognizes the intentions of another individual.
2. Interactive presence: a person recognizes that the intentions of another person are directed towards him/her.
3. Shared presence: a person recognizes that the intentions of another person correspond with his/her own (enabling empathy).

In digital multiplayer games, players can interact and communicate in various ways, also in remote settings by means of in-game actions and communication channels. In this regard, social presence is a key component to describe how players perceive each other and how their experience is influenced by the social setting [137, 138, 358, 359]. The concept is considered as a continuum with different levels, ranging from a complete lack of social presence, over the simple perception of the co-presence of other entities, to a sense of deep psychological and behavioral involvement [138]. High perceived social presence is supposed to be related to a high social influence. The number of co-players or bystanders, their proximity, as well as their form of representation is supposed to affect the intensity of perceived social presence. Due to real co-presence, perceived social presence is supposed to be highest in co-located settings. Moreover, as explained above, eliciting the perception of social presence is not limited to real humans: social presence is supposed to be induced (to some degree) by any representation of intelligence, including artificial forms like virtual characters and robots [24].

Due to the described characteristics, social presence is considered as an appropriate indicator of the social richness and quality of a play setting and often assessed in studies regarding the social player experience. As there have been many different approaches to define subdimensions and to measure social presence, which are often influenced by the field of study they are applied in [136], there is the need for valid and reliable measures of social presence in the context of digital gaming. De Kort, Ijsselsteijn, and Poels [359] developed a questionnaire to measure social presence in digital games based on the work of Harms and Biocca [24, 125] and focus group discussions. The resulting Social Presence in Gaming Questionnaire (SPGQ) defines three subdimensions of the social presence:

1. Psychological Involvement - Empathy: the experience of positively toned emotions towards the co-player(s).

2. Psychological Involvement - Negative Feelings: the experience of negatively toned emotions towards the co-player(s).

3. Behavioral Engagement: the experience that one's actions are dependent on the actions of the co-player(s).

This notion is often followed in social player experience research and the SPGQ is a commonly used questionnaire in this context. Besides, Hudson and Cairns [138] provide another questionnaire to measure social presence, which is focused on the differentiation of collaborative and competitive play (both questionnaires will be described in section 3.4.1).

3.3.2 *Social Qualities of the Play Setting*

So far, we have discussed that different social entities can influence players' experiences by eliciting various social effects and inducing the feeling of social presence. In the following, we will examine further characteristics that shape the social play setting and are supposed to contribute to the final social experience. These are characteristics of the game, of the social entities that are involved, and of the context the game is played in.

3.3.2.1 *Number of Co-Present Social Entities*

One aspect that can influence the social experience is the number of co-present social entities. A game that is played by at least two persons is called a multiplayer game[3]. Many multiplayer games, particularly on game consoles, are designed to be played by a small group of up to four players in the same room. Some games are designed for a specific number of players, whereas others can be played by a range of players [104]. By the integration of game bots, a game can also provide artificial co-players. Due to modern network technology, the number of players who can theoretically take part in a game simultaneously is almost unlimited. Massively Multiplayer Online Games (MMOGs) offer large game worlds for thousands of players at the same time [78, 287]. Accordingly, the number of players in current digital games can vary to a great extent and, thus, has to be taken into account as a potential influence on the quality of social interaction and the experience.

A large number of players might support social effects like evaluation apprehension, but can also lead to the sensation of higher anonymity [83]. Studies focusing the impact of different group sizes on players of digital games are still scarce, but indicate significant differences in players' behavior and experience [83]. Supporting results of research in related fields [17], Eastin [83] reports that a higher group size is especially associated with competition: players who competed or collaborated in a group of six players in a first-person shooting game (Unreal Tournament [95]) showed higher competitiveness and hostility than players in smaller groups. The author supposes that this is linked to a perception of greater anonymity, which allows open competition and dominance without the risk of offending a specific other player [83].

MMOGs as a special form of multiplayer games bring together very large groups of players. However, this social potential is not necessarily used for rich social interaction: Research of Ducheneaut, Yee, Nickell, and Moore [78] shows that only few players of MMOGs actively interact with each other. They rather appreciate the game as a social environment, in which they play on their own while still being in the presence of other people. In line with this, Stenros, Paavilainen, and Mäyrä [287] point out that a higher number of players does not necessarily lead to more social interaction and that, moreover, the interactions taking place are not necessarily more meaningful. Therefore, in addition to distinguishing between social play contexts based on the amount of involved players, the authors also take players' in-game relationships (as defined by the game) into account, because this aspect is supposed to significantly frame the experience [287].

3.3.2.2 *Goal Structures and Social Interaction Patterns*

The main interaction pattern between players is predefined by the goal structure of the game. The goal structure determines how players are re-

3 More precisely, a game can either be a singleplayer game, a multiplayer game, or it can feature several game modes combining both approaches

lated to each other inside the game world, for instance whether they are opponents or on the same side. There are two basic types: competition and cooperation [330]. In a competitive setting, players have individual, mutually exclusive goals. If one player attains his/her goal, the other players lose. In a cooperative setting, players have a collective goal, and either all players obtain this goal or they fail together. Some game researchers further subdivide cooperative settings and differentiate between cooperation and collaboration [287, 326, 353]. In these cases, collaborative games are described as games in which all players work together towards the same, shared, long-term goal. It can be seen as the "purest" form of team play. In contrast, cooperative games are understood as games in which players may have different, individual overarching goals and just work together to reach short-term goals on the way. Hence, such games are less strictly focused on teamwork. In the thesis at hand, this differentiation between cooperation and collaboration is followed, except where the terminology of related work states differently.

Games can also have hybrid goal structures that contain both cooperative and competitive elements, for instance if different teams compete against each other. Besides, there can also be a neutral relationship between players. This kind of goal structure is rather seldom and—according to Adams—if players are neither competing nor cooperating, one could argue that "they are not really playing the same game" [2, p. 14]. However, the phenomenon that players play a game rather in parallel than together, is dominant in social network games, which are played on social network sites such as Facebook and treat other players like resources without inducing real in-game interaction [214, 287]. Mäyrä, Stenros, Paavilainen, and Kultima [214] call this social interaction pattern massively single player. The findings of Ducheneaut et al. indicate that similar patterns also occur in MMOGs, described as playing "alone together" [78, p. 415]. Without direct social interaction between players, the social context is still supposed to influence the experience of players in these cases. However, in the more common social playing settings—collaboration and competition—social effects are even more likely to occur with growing interactivity and direct social contact.

Adams [2] as well as Fullerton [104] describe different player interaction patterns for collaborative and competitive settings (in addition to single-player scenarios), which differ according to the number of players and their in-game relationship:

1. Two-player competitive [2]: This mode describes the competitive play between two players. Adams mentions this specific number of players, because a two-player setting is very common in ancient games (e.g., chess). It resembles a duel with a winner and a looser in the end. Starting with games like Pong, one on one matches are still present in current digital multiplayer games (e.g., racing games, fighting games, and online battle arena games).

2. Multiplayer competitive [2]: In competitive multiplayer games, three or more players each try to outplay the other participants, while ev-

eryone is concentrated on one's own benefit and goal. Fullerton [104] further decomposes competitive multiplayer modes differentiating between three types:

a) Multilateral competition: this interaction mode is in accordance with Adam's multiplayer competitive mode, where all players directly compete against each other.

b) Multiple individual players versus game: In contrast to multilateral competition, Fullerton also identifies multiplayer games in which players do not directly compete against each other, but are focused on their individual battle against the game system. Hence, players share the game world but only marginally influence each other.

c) Unilateral competition: In case of unilateral competition, one player is the opponent of all other players. That is to say, a group of players shares the same main goal and may cooperate in order to defeat this single player. Thus, unilateral competition describes the competition between one individual and a group.

3. Multiplayer cooperative [2, 104]: In contrast to competitive settings, a group of players can also engage in cooperative play. In cooperative games, players all pursue the same goal and have to collaborate in order to achieve it. In this case, the game itself is the opponent.

4. Team-based modes [2, 104]: team-based modes combine both cooperative and competitive elements as players form teams and work together inside one team (cooperation), while competing against the other team(s) (competition).

5. Hybrid competition modes [2]: some games allow players to choose and switch between cooperative and competitive play, for instance by forming temporary alliances.

Several studies investigate the different experiences that are related to cooperative and competitive goal structures. In their large player survey about social play settings, Vella et al. [322] also asked players about their experiences in competitive and collaborative games. The authors report that competitive play is mainly related to positive experiences of challenge and competence. On the other hand, losing and toxicity were often mentioned as negative aspects of that mode of play. For collaboration, teamwork was the dominant positive aspect attributed to collaborative play. At the same time, a lack of teamwork as well as a mismatch of player skills or playing styles negatively influence collaborative settings according to the participants. The findings indicate that designers of competitive games should consider strategies to prevent toxic behavior. In team-based games, players should be supported either by matchmaking system that match players with comparable skills or by handicap mechanics that adjust players' capabilities.

Vorderer, Hartmann, and Klimmt [329] focused the role of competition in games. They defined competitive elements as necessities to act, and social competition as a process in which players perform competitive actions based on their own interests and to the disadvantage of others. In two studies, the authors observed that players prefer game situations that feature both many possibilities to act and a strong necessity to act, with the necessity to act seemingly being the more important factor. Moreover, there was a correlations found for an individual's motivation to compete and the use of certain competitive game genres. This indicates, that individual preferences and personality traits are one factor that influences the social value orientation of players and, thus, whether they prefer competitive or cooperative games. Results of two experiments by Kivikangas, Kätsyri, Järvelä, and Ravaja [173] suggest that there are also gender differences: Males seem to prefer competitive games and, moreover, exhibit more positive emotional responses when playing competitively compared to cooperative play. In contrast, females do not show clear preferences, but react similar to both competitive and cooperative play situations.

To investigate the potential differences in the player experience of collaborative and competitive play, I also conducted my own study as part of my Master's thesis [88]. I did not find any gender differences regarding game mode differences and experiences, but identified competitive attitude as an influential trait factor. This supports the assumption that personality characteristics can frame players' experience in social play settings. In my study [88], I compared players' experiences in a collaborative and a competitive mode of a custom two-player game, that was played co-locatedly. I found a couple of differences regarding the player experience in both modes. Perceived competence and positive affect were both higher in the competitive mode. Competence might be higher because players could focus on their own performance, whereas in the collaborative mode they also had to coordinate their actions with their partner. A higher positive effect of competition was reported in studies before [167, 270, 329] and might indicate that competitive play provides a more intense experience. In contrast to these findings, empathy and behavioral involvement as indicators of perceived social presence were higher in the collaborative game mode. This result fits in with the finding of Vella, Johnson, and Hides [321] that players perceived significantly more relatedness in cooperative settings and with the finding of Depping and Mandryk [67] that cooperative game mechanics can be used to foster social bonds between players. Waddell and Peng [330] observed that cooperative gameplay increased post-game cooperative behavior in a prisoner's dilemma task and trust in the co-player. In sum, this indicates that the linkage between players is closer and the social interaction richer when playing collaboratively as opposed to playing competitively. In my study this increased social experience did not correspond with higher enjoyment [88], whereas other studies suggest that cooperation increases game enjoyment [67]. Results regarding enjoyment are, thus, inconclusive, which might be due to different individual player preferences.

Besides, I found that all subscales of state aggression turned out to score significantly higher in the competitive mode [88]. In consideration of the fact that positive affect was higher as well, the level of state aggression was not perceived as negative. It can be suggested that a certain degree of aggression positively contributes to the challenge and conflict proposed by the game. This may result in higher arousal and, thus, make the game more fun. On the other hand, aggression could also be the result of higher arousal in the sense that it works like an outlet for high arousal and tension [88].

Higher arousal and aggression in the competitive mode are in line with previous findings. Lim and Reeves [197] report that participants in their study showed higher physiological arousal in a competitive game task than in a cooperative task. Schmierbach [269] found more aggressive cognition in a competitive game mode and suggests that this is because the competitive game mode rewards aggressive behavior more than the cooperative mode. In fact, Jerabeck and Ferguson [157] report that cooperative gameplay can reduce post-game aggression. Findings of Eastin [83] indicate that individuals who compete against a group of other players show more aggression and hostility compared to players who collaborate within a team. There seems to be a positive correlation between competition and aggression, while cooperative elements, in contrast, are supposed to negatively correlate with aggression and to rather arouse empathy.

Finally, in my study I also found that players' behavior and communication differs in competitive and collaborative settings [88]. The participants focused on creating shared awareness and developing common strategies when playing together, whereas they mainly engage in trash talking and interference when competing against each other.

To conclude, competition and cooperation can lead to very different player experiences, both having potential advantages and disadvantages for players' overall enjoyment of the game.

3.3.2.3 *Roles and Interdependence*

Besides the general goal structure of the game, which defines the basic interaction pattern between the players, the relationship between them is further shaped by the roles and dependencies that are assigned by the game. In multiplayer games, players can either all have the same role, or they can choose between several roles [104]. Some games require every role to be filled, for instance if one player is the evader and the other is the chaser, whereas other games offer a range of roles to choose from based on individual preferences, such as many role-playing games.

Roles are usually linked to basic abilities and opportunities of action [104]. In this regard, it can be differentiated between symmetrical and asymmetrical games [104, 267]: symmetrical games provide equal resources and powers for all players, whereas asymmetrical games give players different resources and abilities. There are several reasons to implement asymmetric player roles, for instance to create more interesting, less predictable situations and to support different playing styles. Players appreciate the possibility to choose between different roles and show higher satisfaction regarding asymmetrical game design [97]. However, asymmetrical game design bears the challenge of right balancing. It has to be ensured that each combination of roles and abilities is fair. If players perceive one role as being superior by design, this lack of fairness may result in frustration and demotivation. Thus, balancing is one key challenge of good game design [2, 104, 267]. If implemented properly, asymmetric roles are supposed to be a valuable game mechanic to foster cooperation and successful teamwork in collaborative and team-based games [113].

Particularly in cooperative games, a concept that is closely related to player roles is interdependence, which describes the degree to which players are dependent on each other and how closely they have to work together to reach their goal. Beznosyk, Quax, Lamotte, and Coninx [22] distinguish between loosely-coupled and closely-coupled interactions. The authors investigated the influence of interdependence on player experience in casual games and found that players prefer closely-coupled interactions, meaning a high interdependence. Participants rated such games significantly higher regarding excitement, engagement, replayability, and challenge. Research of Harris, Hancock, and Scott [126] supports this finding. In their survey, players reported that they did not like the feeling of being useless in situations in which their actions were not actually required to succeed. Players seem to prefer being dependent on each other to feel the necessity of every player's contribution, rather than being self-sufficient. However, it has to be considered, that high interdependence may interfere with feelings of autonomy, which might also negatively affect players' experience, especially if they have a strong need for autonomy. Moreover, the studies of Beznosyk et al. [22] and Harris et al. [126] also indicate that closely-coupled interactions increase the level of challenge and may cause frustration if players fail to coordinate themselves properly. Depping and Mandryk [67] identified interdependence as a game mechanic that can be used to foster team building and a positive player experience. In a study comparing game modes with high and low interdependence, the authors found that high interdependence is associated with high experienced relatedness and increased game enjoyment.

The design of roles and interdependence is not only relevant for real and virtual co-players, but also to determine the relationship between the player and NPCs. Different player roles may come along with different reactions of NPCs, for instance if roles feature different basic convictions. Moreover, believable NPCs have elaborated social roles and relationships towards the player [150]. Interdependence between the player and an NPC may increase perceived relatedness and sociality, thus increasing the social experience.

3.3.2.4 *Spatial Proximity*

Besides the relationship and number of players, Stenros et al. [287] identify the *spatial-temporal-systemic configuration* as an important aspect of the social context of gaming, highlighting the three constituents place, time, and system: social settings can differ regarding the physical location of the players (co-located or in different places), the temporal immediacy and dependency of actions (simultaneous play or non-simultaneous play), and the systems they use to play a game (same systems or different systems).

The first aspect is the physical location and proximity of players and bystanders. This aspect is considered to significantly shape the social experience in multiplayer games [152, 166, 179, 358]. De Kort and Ijsselsteijn [358] differentiate between local and mediated co-presence, indicating a main difference between co-located and online gameplay. The proximity of players is considered as a determinant of social presence, with co-located setting eliciting the highest feelings of co-presence. This is confirmed by results of several studies [47, 105, 108]. Based on a pre-study reported in [111], Gajadhar, de Kort, and Ijsselsteijn [108] compared three different two-player settings: their participants played a simple version of the game Pong against the computer (virtual co-player), a co-located co-player or a mediated co-player who was not present in the same room. They found that real co-players elicited more social presence, being highest in the co-located setting. Moreover, playing against a co-located co-player led to significantly more fun, challenge, and perceived competence. The authors report that these differences in player experience seem to be mediated by the differences in perceived social presence. In a similar, subsequent study [105], the authors focused on perceived involvement and flow experiences in the different social settings. Again, they found the same differences in social presence, and also indications that co-located settings also lead to higher flow and immersion. Conducting the same experiment with elderly participants revealed that older players show a clear negative bias towards online co-play, experiencing no difference between mediated human co-players and virtual co-players [109]. This result shows that the experiences in different social settings may also be dependent on individual player characteristics such as age.

Inspired by the work of Gajadhar and colleagues, Cairns et al. [47] conducted a series of experiments to further address the potential influence of the social setting on the player experience. A replicated study setting confirmed prior findings regarding social presence in mediated and co-located settings. However, the authors found no differences regarding immersion. In another study, Cairns et al. [47] had participants play Mario Kart Wii [229], a simple racing game, against each other either in the same room or online in two separate rooms. In this study, there was no significant difference in immersion, either.

The main difference of co-located and mediated play, thus, seems to be the level of perceived social presence, which in turn may be a mediator for further aspects of the experience. Similar effects may apply to co-located and mediated bystanders. Besides the differentiation of co-located and online play, the spatial play configuration can also further be analyzed in co-located settings. Players can sit together in different constellations, for instance sitting next to each other or face-to-face. Kauko and Häkkilä [164] investigated players' interaction in a face-to-face scenario created by using mobile phones as gaming platform compared to a typical console gaming setting, in which players sat next to each other in front of a shared screen.

They also varied the physical distance between the players. The authors report that there were differences regarding players' communication and perception of the social situation. Participants felt that the face-to-face setting facilitated communication and the feeling of relatedness.

3.3.2.5 *Timing*

The second aspect mentioned in Stenros' *spatial-temporal-systemic configuration* is time, meaning the temporal immediacy and dependency of players' actions. Games can be classified by the way they use time, for instance real-time games or turn-based games [311]. In general, it can be differentiated whether players play a game simultaneously, meaning at the same time, or non-simultaneously, meaning asynchronous gaming at different times. Whereas simultaneous games are more common, non-simultaneous gaming is possible if it takes place in persistent game worlds, such as the large worlds of MMOGs. Here, players can play the same game at different times and see the results of the other players' actions as changes in the world. Asynchronous play is also possible if players take turns and have to wait till every co-player performed another action. This might just take several seconds and players might not even perceive this as non-simultaneous play, as their attention is usually still focused on the game all the time. However, turn-taking can also take long, if players return to the game just sporadically to make their next move or if the decision takes time to be transferred, like in a game of remote chess via letters [287]. Tychsen and Hitchens [311] provide a comprehensive model of game time and name different layers like real-world time, engine time, and progress time. The authors also include perceived time as one important layer, emphasizing that the perception of time and temporal relationships is a subjective matter. In a multiplayer scenario, it should be ensured that all players have a similar understanding of game events and time [311].

Different temporal relationships of player actions can lead to very different perceptions of the social situation. For instance, a co-located turn-based game can create an atmosphere of high social awareness, because players can observe their co-players and engage in game-related as well as not game-related conversations. In contrast, perceived social presence in a game of letter chess is supposed to be comparably low. Harris, Hancock, and Scott [126] discuss synchronicity and timing as one aspect that determines interdependence between players. High interdependence results from certain requirements of timing, for instance if players have to perform actions at the same time or in a defined order. This way, developers can use timing mechanics to increase players' interdependence and, thereby, to increase the awareness and attention players have to pay to each other.

3.3.2.6 *Game System and Interfaces*

The game system is the third aspect of Stenros' *spatial-temporal-systemic configuration* of the social context of gaming. According to the authors, it has to be considered whether players use the same gaming platform and devices to play the game. The system is supposed to determine both interaction and communication possibilities during play, as well as the physical context the game is played in [152]. Isbister [152] points out that the form factors of the gaming platform and the physical context the game is played in are often intertwined due to different possibilities and requirements of the system. For instance, mobile phones and portable hand-held consoles allow for location-independent gaming in public places, whereas gaming consoles such as the PlayStation 4 require a rather complex home entertainment setup.

Besides portability, there are more aspects of the system configuration that might influence the social player experience. Of particular interest are the user interfaces, including both input and output devices. In their model of play in a socio-spatial context, de Kort and Ijsselsteijn [358] also include the game interface and emphasize the influence of opportunities for monitoring the performance and actions of the co-players. The type and number of displays is one influencing factor in this case. Players can either share one common screen (e.g., in a typical TV console gaming setting) or have their own, personal screens (e.g., playing a casual game by connecting several mobile phones). In case of personal screens, players might have different views on the game world. This mechanic can be used to create interesting game situations by disseminating information only to some players. However, this setting may also interfere with some social processes due to the missing shared visual reference [152]: It is more difficult for players and bystanders to follow game events and to engage in observational learning. This is particularly true for VR settings, in which one player wears an HMD and is highly immersed in the game world, while observers cannot see the game content and, thus, often do not understand what the player is doing.

Szentgyorgyi, Terry, and Lank [296] conducted interviews and observations with owners of the Nintendo DS handheld console to investigate in which contexts players use this portable console and how social gaming emerges. Their results confirm the difference between shared and private screens: the authors observed that the shared screen of consoles makes the player experience more social than individual Nintendo DS screens, because there is no private gaming space and there is more potential for spectators to engage in play. A study of Xu et al. [347] also demonstrates that different screen settings can change the way players interact with each other. The researchers developed a multiplayer handheld augmented reality game and compared three different interface configurations. Results of the experiment showed that the use of augmented reality technology can increase the sense of sociality due to the shared space and shared context in contrast to individual screens. An interesting scenario can be created by combining the social advantages of a shared screen with the design possibilities of private screens. Equipping players with private screens and adding a big shared screen is referred to as second screen gaming. In Chapter 5, this innovative social gaming scenario is discussed in detail based on our work presented in [87].

The visibility of players' actions and performance can also be enhanced by certain input mechanics. In contrast to common interfaces such as controllers or keyboard and mouse, motion-based embodied input devices increase players' activity and make in-game actions visible not only on screen but also on the players themselves [358]. Thereby, observing players becomes much more interesting and adds another layer to the social setting. Vanden Abeele, de Schutter, Gajadhar, Johnson, and Geurts [361] present a study on the effect of naturally mapped controllers in a social setting. Participants played a racing game in dyads against each other using either a classic controller or the Nintendo Wii steering wheel controller. Players experienced the steering wheel as more natural, which is also reflected in higher reported spatial presence. At the same time, controlling the game with the wheel was perceived as more difficult, resulting in lower feelings of competence and worse performance. This indicates that naturally mapped controllers can have advantages and disadvantages. Interestingly, female participants showed increased social presence when playing with the steering wheel, supporting the hypothesis that this kind of controller can enhance the sociality of the play setting. The lack of increased social presence for male players might be due to a more performance-oriented, competitive attitude of male players compared to female players, who tend to be more socially oriented [361].

Besides motion-based input mechanics, another input mapping technique relevant to multiplayer scenarios is shared control. Shared control is understood as a game control mode in which players collectively control a single game character, either simultaneously or by control alternation [295]. The sharing of a character is supposed to influence players' interaction and experience compared to having distinct characters, because interdependence is increased and players' destinies are closely intertwined. The work of Loparev, Lasecki, Murray, and Bigham [205] provides an initial distinction of basic shared control principles. The authors present a middleware solution (the *WeGame*) that allows players to play existing singleplayer games collectively in a co-located setting. It includes two different modes: an alternation of control corresponding to traditional gamepad passing, as well as simultaneous control that allows players to simultaneously control a shared character by merging all inputs into one result. In our own study, which will be discussed in Chapter 5, we further elaborate on the possible manifestations of shared control and their influence on players' experience.

3.3.2.7 *Communication Channels*

Closely related to the input and output devices provided by the game system are the available communication channels, which can be considered as another part of the user interface configuration. However, the way players can communicate is not solely defined by the game itself, but also by the general gaming setup. In co-located settings, any kind of communication and interaction outside the game between players and spectators is theoretically possible. If players are remote, communication is more dependent on channels offered by the game. However, players can still use third-party communication channels (e.g., Skype or TeamSpeak) as an add-on to enrich the social setting [287]. There may also be multiple channels in parallel, each defining a certain group of participants such as a team chat for all members of the same team or one-on-one chats with just one other player. Only communication with virtual characters is completely determined by the game.

In any case, possibilities to communicate have to be considered as a highly influential aspect of the social setting, because it can influence social presence, enjoyment, and players' behavior [287, 358]. This seems to be particularly important in remote settings and if there is a high interdependence between players: if players have to coordinate their actions or form mutual strategies, sufficient communication channels are required to be successful. Gajadhar [106, 107] tested whether live audio and/or video communication channels affect social presence and the player experience in a remote play setting. Dyads of participants played the FPS game Unreal Tournament [95] either cooperatively or competitively. The availability of audio (hearing the other player) and video cues (seeing the other player) was varied as well. Results indicate that audio cues (especially laughing and cheering) significantly enhance the social experience and game enjoyment, mediated by increased social presence. Visual cues, in contrast, had little effect on the player experience. Hence, the possibility to communicate seems to be more important than visual representations of co-players, at least in this kind of fast-paced game. Moreover, in the cooperative condition, an audio channel also reduced perceived challenge and frustration, indicating that player coordination was facilitated significantly.

Focusing communication in cooperative games, Vaddi, Toups, Dolgov, Wehbe, and Nacke [318] analyzed the use and usefulness of cooperative communication mechanics (CCMs). CCMs are game mechanics that can be used by players to share information or to direct attention to something without (or in addition to) synchronous verbal communication [303]. An example is a built-in ping system that can be used to indicate points of interest the co-player should pay attention to. In Vaddi's experiment [318], participants played the two-player cooperative puzzle game Portal 2 [320] with varying communication channels being enabled: voice and in-game CCMs (e.g., location pings), only voice, only CCMs, and no communication at all. Like in the study of Gajadhar [107], the authors found that verbal communication was preferred by players and led to better performances overall, because players were able to discuss puzzle solutions and strategies. Moreover, if available, players also used CCMs a lot and though voice was considered as being more important, the usefulness of CCMs was highly appreciated by players in certain game situations. If no location pings were available, the researchers observed that players tried to use other in-game mechanics and developed their own conventions about their meanings (e.g., they used portal shots excessively to point to a certain place or guide a way). In sum, the study emphasizes the importance of verbal communication channels in remote settings and also points out how gameplay mechanics can be used to further enhance player communication in addition to the typical audio and video channels. Hence, when considering communication channels, also in-game communicative mechanics should be included in the analysis.

3.3.2.8 *Real-World Relationship Between the Player and Social Entities*

The aspects discussed so far are mainly determined by the game's design and the system infrastructure. However, for the social dynamics of multiplayer settings it is also important to consider the relationship of players that is established in the real world. Playing with friends and family members is supposed to create different experiences than playing with casual acquaintances or strangers. Though playing games used to be an activity that was pursued either alone or in established groups of friends, online gaming has significantly extended the circle of potential co-players. In many online games, for instance in MMORPGs and multiplayer online battle arena games, players frequently interact and team up with complete strangers without knowing anything about each other except from nicknames and in-game information (e.g., level, rank, avatar representation). Even in co-located settings play between strangers can occur, for instance if people engage in party games, public game installations, or crowd games.

The impact of familiarity between players on players' interaction and experience was investigated in a number of studies. Li and Counts [194] found that familiarity between players can increase players' motivation to play and maintain playing a game. Participants in their study were more motivated if the game was also played by other persons they knew. Cooperation in teams was mainly appreciated by acquainted players, wheres teams with unknown players were comparably uninteresting for participants. In contrast, Peng and Crouse [235] studied players' motivation in exergames in different social settings and did not find any significant difference between friends and strangers with regards to player motivation and enjoyment. These conflicting results indicate that the influence of familiarity may be moderated by other characteristics of the social setting. One aspect might be players' general motives for playing: if players are driven by a need for relatedness, familiarity and rich social interactions might be more important for them than for players who want to engage in physical exercise and satisfy their need for competence. In this context, Vella et al. [322] have investigated how players characterize social play with friends and strangers: playing with friends was mainly characterized as an activity that provides fun and social relatedness. The main concern of players was that social play with friends is related to logistical issues (e.g., having to wait until a friend has time to play). Playing with strangers, in contrast, was appreciated as an opportunity to meet new people and to challenge oneself by competing others, resulting in experienced competence. In this case, participants mainly disliked the higher chance of social toxicity (e.g., harassment or cheating) and the lack of relatedness. These impressions are confirmed by another study [321], in which players report highest experienced relatedness for playing cooperatively with friends, and lowest relatedness for solitary play and competitive play with strangers.

Effects of familiarity on player experience are also reported by Ravaja et al. [244, 245]. In two studies, playing against a friend compared to a stranger led to higher spatial presence, engagement, positive emotional responses, and arousal, both in a co-located [245] and in a remote play setting [244]. The authors assume that competitive gaming against a friend increases the importance of performing well, because a friend may have certain expectations and the result will be part of a shared history in the future. Strangers, in contrast, will probably not be seen again, so that the player will not be reminded of a defeat or bad performance afterwards.

Other studies addressed players' behavior in groups of friends compared to strangers. Mason and Clauset [211] investigated the effect of friendships on cooperative and competitive in-game behavior in the team-based online FPS game Halo: Reach [44] by analyzing gameplay metrics as well as data from a large online survey. The authors report that players' social behavior changes with the number of friends (as compared to random strangers) on the team: player exhibited more cooperative behavior and less defection if more teammates were friends. Moreover, there was a significant increase of players' performance in teams of familiar players. Gajadhar, de Kort, and Ijsselsteijn [108] observed that in a competitive setting, familiarity among players led to more verbal aggression and hostility than playing against strangers. It seems that familiarity can intensify the social experience by fostering the sense of competition or cooperation that is introduced by the game's goal structure. Regarding post-game effects, Waddell and Peng [330] report that players' familiarity did neither affect post-game state hostility nor cooperative behavior in a subsequent prisoner's dilemma task. Interestingly, this might be due to the fact that players in this study played co-locatedly and had the chance to get to know each other while playing. The authors suggest that the shared task of playing the same game might have led to mutual affiliation quickly, increasing the probability of cooperative post-game behavior.

Though partly conflicting, the studies regarding the influence of familiarity indicate that the real-world relationship between players can indeed impact the overall player experience and change the social effects that occur.

Besides familiarity, similarity can also be a determining factor for social processes. As explained in social comparison theory, perceived similarity with another person can influence the direction of comparison and, thus, affect processes of self-assessment, self-improvement, and self-enhancement (cf. section 3.2.3). A lack of similarity may result in less social influence of the co-players. Perceived similarity in terms of prior experience and gaming expertise is supposed to form players' expectations and their sense of fairness, particularly in competitive games. If players' skills differ significantly, the game's outcome becomes too predictable, which can increase frustration and decrease motivation and enjoyment. This effect was observed by Klastrup [174] while studying the social dynamics of player groups with different levels of expertise playing a competitive game in a co-located setting. An unequal level of competence in a group led to lesser social interaction and communication such as yelling and shouting at each other, and players reported less interest in the game afterwards compared to a group with balanced expertise. This indicates that for competitive games to be fun and to have rich social interaction evolve, players should have comparable competence or should be supported by the game somehow, for instance by handicap systems.

Another aspect that can be adduced to determine similarity is demographic information, including age, gender, and nationality. As shown in several studies discussed above (e.g., [109, 173]), differences on these dimensions indicate possible differences regarding motivations and gaming preferences.

3.3.3 *Summary: Constituents of Social Play Settings*

The previous sections shed light on the constituents of social play settings that form the social player experience. These constituents are either part of the context the game is played in or determined by the game—except from the types of social entities, which are part of the context if they are human, or provided by the game in case of virtual characters. To summarize the previous sections, the social setting of a gaming session is defined by the following aspects (see also Figure 3):

1. **Types of social entities**: The types of social entities that are co-present during play. They can be humans or virtual characters in different roles. I differentiate between human co-players, bystanders, bots, and NPCs.

Context aspects:

2. **Number of social entities**: The number of social entities (co-players, bystanders, bots, and NPCs) that are co-present during play. The numbers can vary from single co-present characters to large groups.
3. **Spatial proximity**: The spatial proximity of co-present social entities in relation to the player. The main differentiation is made between co-location (being at the same place) and distributed settings (being at different places). Furthermore, spatial proximity also refers to the specific alignment of co-located persons (e.g., sitting next to each other) and the in-game proximity of character representations (e.g., seeing another player's avatar on the screen).
4. **Familiarity**: The familiarity between the player and co-players or spectators as defined by their relationship established in the real world. The degree of familiarity can vary from strangers over acquaintances to close friends.
5. **Similarity**: The similarity of co-present social entities in relation to the player. Similarity can manifest in terms of general characteristics such as age and gender, but also in terms of gaming-related aspects such as game preferences, playing styles, and experience.

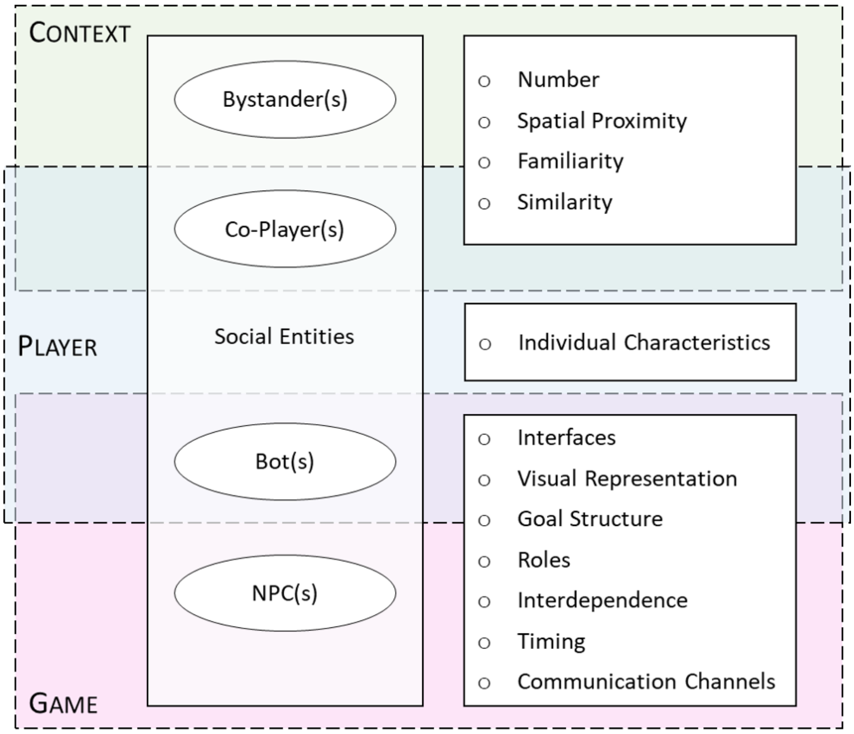


Figure 3: Overview of the constituents of social play settings, assigned to the layers context, player, and game. Each aspect is supposed to influence the emerging social dynamics during play.

Game aspects:

6. **Interfaces**: The input and output devices that are used to play the game and determine how players interact with the game as well as the opportunities for monitoring their performance and actions. Regarding output devices, there can be shared and/or multiple private displays. Input devices can be common abstract game interfaces such as controllers, keyboard and mouse, or motion-based embodied input devices that more naturally map players' movement on in-game controls.

7. **Visual representation**: The way co-present social entities are represented in the virtual game world on screen. Characters can have a direct visual representation (e.g., avatars of co-players) or be just implicitly present.

8. **Goal structure**: The predefined goal structure of the game which determines the interaction patterns between the player and the social entities. The main categories are collaboration, cooperation, and competition. Games can also feature hybrid goal structures, such as team-based competition.

9. **Roles**: The roles of the player and of the social entities as defined by the game. Roles determine a character's abilities and opportunities

of action as well as the in-game relationships to other entities. Player and co-players (human or virtual) can either have symmetric roles or asymmetric roles, i.e. the same or different abilities.

10. **Interdependence**: The degree to which the player and social entities, particularly co-players, are dependent on each other and how closely their actions have impact on each other.

11. **Timing**: The temporal relationship of player actions and events. It can be differentiated between real-time and turn-based games. Moreover, player and co-players/bots play the game either simultaneously (at the same time) or non-simultaneously (at different times).

12. **Communication channels**: The available communication channels that allow the player to communicate with other social entities. These include video and audio cues, text chats, as well as specific in-game communicative mechanics.

In addition, the review of literature revealed that in several studies the social player experience was also influenced by certain characteristics of the players themselves. These include general characteristics such as the player's age, gender, personality, needs, and competitive attitude. Moreover, there are also game-related characteristics such as game preferences, playing motivation, player type, expertise, and competence. Hence, individual characteristics of the main player should also be taken into account as a constituent of the social setting of play:

13. **Individual characteristics**: Individual characteristics of the player that can influence his/her social player experience such as age, gender, personality, needs, competitive attitude, game preferences, playing motivation, player type, game expertise, and competence.

3.4 STUDYING THE SOCIAL PLAYER EXPERIENCE

After having identified all the constituents of the social play setting, this information can be used to analyze and compare gaming sessions by reference to these 13 factors. In study settings, these factors represent the independent variables that should either be controlled for or can be actively manipulated to test which configurations result in which player experiences.

However, in order to come to a comprehensive research model of social player experience, I also have to consider how the influence of the social setting can be measured.

3.4.1 *Methods to Measure the Social Player Experience*

In addition to more general measures of player experience as introduced in Chapter 2, researchers have established several methods to particularly assess social aspects of play by using self-reports, biometrics, observation, and gameplay metrics. The following sections are based on a previous discussion of such methods in my paper *Game Metrics for Evaluating Social In-game Behavior and Interaction in Multiplayer Games* [89].

In the category of self-reports, questionnaires are often used to measure social presence, such as the SPGQ [142, 359]. As explained above (see section 3.3.1.1), it distinguishes three dimensions of social presence: empathy, negative feelings, and behavioral engagement. The Competitive and Cooperative Presence in Gaming questionnaire (CCPIG) [136, 138] distinguishes social presence in competitive and cooperative settings and includes the subscales awareness, engagement, perceived team cohesion, and team involvement. The Networked Minds Questionnaire (NMQ) [125] can also be applied to assess players' experience of social presence and includes several subdimensions, such as co-presence, attentional allocation, and perceived behavioral interdependence. Furthermore, more general questionnaires that have not directly been developed to be used in the context of games, can be applied in order to measure social presence and related concepts [24]. For instance, perceived relatedness can be measured using the PENS [254, 263] (cf. Chapter 2). Finally, there are also questionnaires focusing the perceived social interaction and behavior of co-players, like the Sociality in Multiplayer Online Games (SMOG) scale [139], which assesses perceived anti-social and pro-social behavior in online games. In the studies presented in this thesis, we applied several of these measures, namely the SPGQ, the CCPIG, the NMQ, and the PENS.

Self-reports help to gain insights into how the social interaction was perceived during play. However, due to their retrospective and subjective nature, questionnaires cannot assess the concrete interactions and communication that evolve during play. The related work reviewed so far shows that differences between social play configurations manifest in the emergent gameplay, particularly in players' communication and interaction, which in turn shape the overall player experience. Hence, processes of communication and interaction that occur during play are important factors to be considered while investigating the impact of certain factors. This is why the method of observation becomes particularly important in the context of multiplayer games.

Specific observation schemes can be used to assess and categorize social interaction events during play. Observation allows for registering both verbal and non-verbal behavior [213] as well as the behavior of observers [152] and can, thus, provide data about the social richness and mood of the play situation. To allow for a detailed analysis, observation is often accompanied by videotaping. Based on the work by Voida, Carpendale, and Greenberg [326], Bromley, Mirza-Babaei, McAllister, and Napier [36] describe eight key types of social behavior of players that may occur in co-located gaming sessions: (1) shared awareness, (2) requesting information, (3) shared history, (4) shared success, (5) shared failure, (6) team optimization, (7) trash talk, and (8) self-indulgence. These behavior patterns are a useful basis for assessing social interaction during play by observation, as shown in the study by Bromley et al. [36].

In a similar way, Seif El-Nasr et al. [278] present six cooperative performance metrics as a result of a comprehensive study of gaming sessions: (1) laughter or excitement together, (2) worked out strategies, (3) helping, (4) global strategies, (5) waited for each other, and (6) got in each others way. These metrics are supposed to be related to game mechanics and events. The authors therefore suggest to apply them as a basis for video annotation of cooperative play sessions.

Observation and self-reports are often combined with one another and/or with a third type of method, namely the measurement of physiological data. Combined with other methods, like the observation of interaction patterns, biometrics can be used to investigate the impact of certain social interaction events on the players. This was, for instance, done bv Bromley et al. [36], who correlated GSR data with player types and interactive behavior patterns. Similarly, physiological measures can be linked to self-reports: Ravaja et al. [245] investigated the difference between playing with friends, strangers and a computer-controlled unit by applying self-reports for spatial presence and cardiac inter-beat intervals for physiological arousal. Besides, Ekman et al. [85] present an interesting innovative approach of combining and comparing physiological measures of several players in a social play situation in order to draw conclusions about the experienced social presence and players' correlations, called physiological linkage. In a follow-up study, Järvelä, Kivikangas, Kätsyri, and Ravaja [156] compared physiological linkage in different social play settings and found a high general linkage between co-players, whereas differences in cooperation and competition did not lead to different linkage scores.

Finally, gameplay metrics can also provide valuable insights regarding players' social interaction, as they can log players' in-game behavior and communication. Like the observation of real-world social interaction, information about in-game social events can help to understand players' experience and the social quality of the game. Ducheneaut et al. [77, 78] used gameplay metrics to log player-to-player interaction in a MMOG to identify different patterns of interactivity and to be able to formulate design recommendations for supporting social activities within multiplayer games. This work demonstrates that, while observation often focuses the external player interaction, dedicated gameplay metrics provide the opportunity to detect indicators of interaction inside the game itself. However, till today the potential of gameplay metrics to assess and analyze social aspects of gaming remains rather untapped. For this reason, we have introduced our own approach on social gameplay metrics, which will be presented in Chapter 6.

3.4.2 *A Research Model of Social Player Experience*

The previous review of studies and methods used for assessing social aspect of playing digital games reveals that players' communication and interaction in a multiplayer setting is a key element to frame the social player experience. Different social settings as described in section 3.3 can elicit different social effects, thereby changing the way players interact, and, in turn,

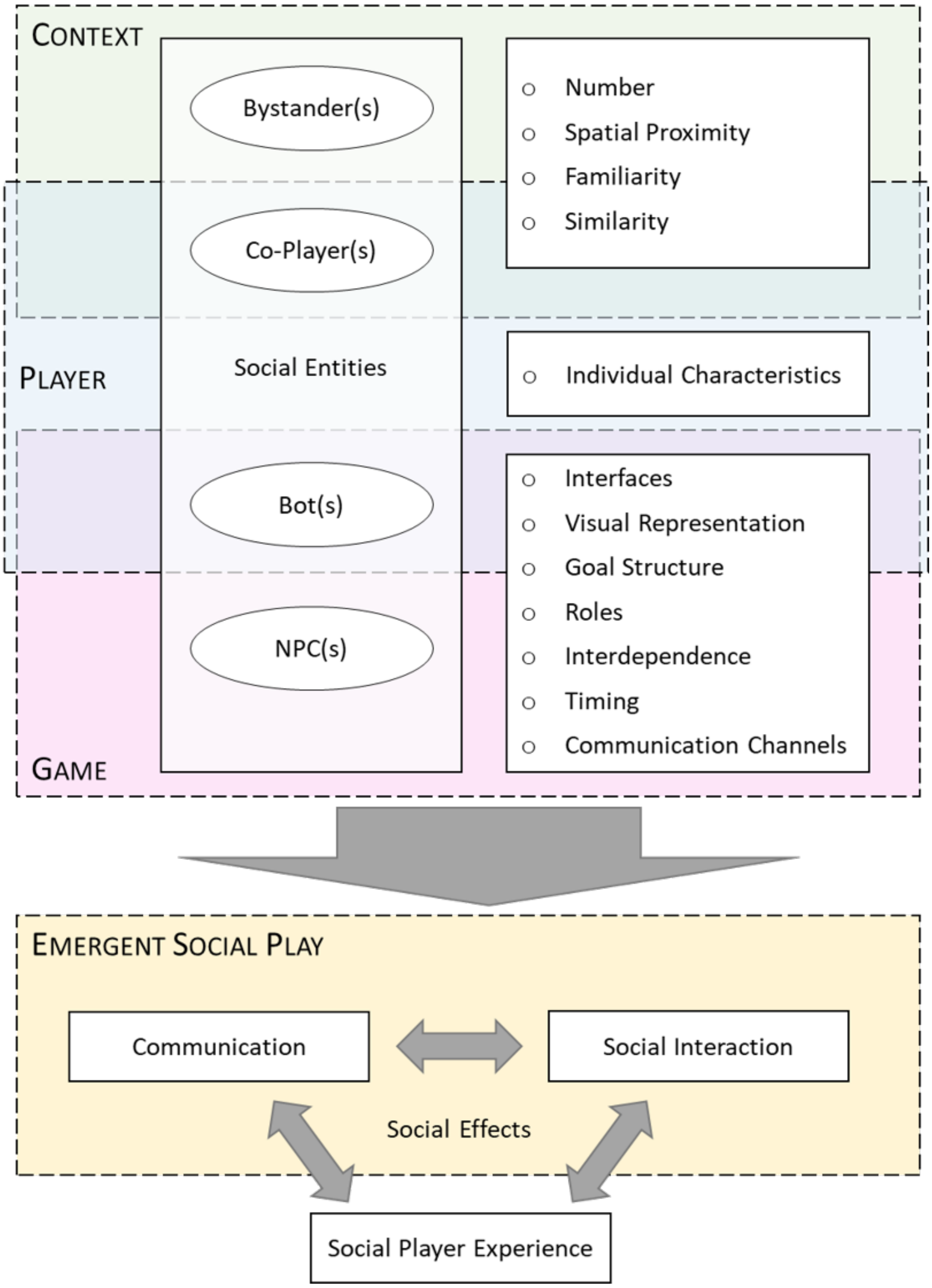


Figure 4: A comprehensive research model of social player experience: The constituents of the social play setting (on the layers context, player, and game) determine the emergent social gameplay, which includes communication and social interaction, both inside the game and in the real world. Moderated by social effects, social play evolves and results in the social player experience. In longer sessions, the experience during play also shapes further interactions.

affecting their whole experience. In this context, it can be differentiated between internally derived social interactions, which stem from the rules of the game, and externally derived social interactions, which are induced by the social context [327]. Moreover, communication and interaction occur either inside the game (e.g., shooting at each others' avatars) or around the game in the real world (e.g., giving a high five) [179, 287].

I suppose that communication and social interaction during play evoke social effects and are influenced by such effects at the same time. Together, these aspects frame the social player experience, which includes social presence as a main construct, but also feelings of relatedness, aggression, and related concepts. Finally, the interplay of emergent social gameplay, social effects, and the social player experience significantly contribute to the overall player experience. All these considerations in combination with the comprehensive review of literature presented in this chapter allow the compilation of a research model of social player experience as depicted in Figure 4.

The upper part of the model depicts the constituents of the social play setting as defined in section 3.3. These aspects define the social configuration the game is played in by considering both game-related and context-related social characteristics. Each aspect is a variable that can be varied in systematic studies to assess its impact on social play. The lower part of the model shows that the social play setting determines the social play that emerges during a play session. Players may communicate and interact with each other, both inside the game world and in the real world. This interaction is moderated by social effects such as emotional contagion or social comparison (see section 3.2) and finally results in the social player experience. This individual experience how player's perceive the presence of other social entities and their relationship can, in turn, further shape the emergent social play.

This model is the first contribution of this thesis. It is supposed to motivate, structure, and facilitate future research on social player experience by bringing together all important factors that have to be considered. Moreover, this model will be used to classify the different play settings that are investigated in the next parts of this thesis.

3.4.3 *Research Focus of the Following Chapters*

At the beginning of this thesis, I have pointed out the main research questions that I wanted to address (cf. Chapter 1):

- Which aspects constitute the social player experience?
- How do game mechanics influence players' social interaction and communication in multiplayer games?
- How can we measure the social aspects of the player experience?
- Can virtual companion characters have social impact on players comparable to co-present humans?

This chapter—and the research model in particular—provides answers to the first question by analyzing the constituents of social play. Additionally, it summarizes the theoretical background for the following studies.

In part II I will consider different multiplayer scenarios to investigate how specific game mechanics influence players' social interaction and communication and how this interaction can be measured. Thus, the second part addresses the research questions two and three. With reference to my research model, the studies presented in Chapter 4, Chapter 5, and Chapter 6 all include play settings with real co-players and focus on the game-related aspects of the social play setting. Different game aspects such as the interdependence of players and the game interfaces are varied to test how the social experience changes.

Part III comprises my work on virtual characters, more precisely on persistent NPCs. Current research is concerned with the question under which conditions such virtual characters are perceived as social beings and how they can activate corresponding social responses of the player to provide a rich social experience even in singleplayer games. I present studies in which the presence of NPCs is compared to game scenarios without any social entity as well as to settings with real co-players or observers. In this way, I test the social influence of virtual characters, addressing the last research question. The focus of the studies in the third part, thus, lies on the effect of different types of social entities on the emergent social play and the player experience.

Part II

PLAYING TOGETHER: HOW GAME DESIGN DECISIONS IMPACT PLAYERS' SOCIAL INTERACTIONS AND EXPERIENCES

4 THE INFLUENCE OF GAME ASPECTS ON SOCIAL PLAY

The first study of this thesis investigates player experience and communication in a collaborative multiplayer setting. The study addresses the question how players' interaction is influenced by specific game design aspects. With reference to our research model (cf. Figure 4 in Chapter 3), the study is focused on the game-related constituents of the social play setting and their impact on the emergent social play in terms of social communication as well as on the player experience. Whereas the context of play cannot directly be controlled by the ones who implement a game, knowledge about the social influence of certain game aspects can support game designers to purposefully design the social interaction of players to achieve a positive social experience.

The study investigates the influence of three particular game aspects—*player interdependence*, *time pressure*, and *shared control*—on the communication and experience of players. For that purpose, we developed a co-located collaborative game in a group project to systematically test variations of those game design aspects and analyzed the resulting social communication and player experience.

The work of this chapter was presented at the CHI Play conference 2017 and published as a full paper in the conference proceedings with the title *The Impact of Game Patterns on Player Experience and Social Interaction in Co-Located Multiplayer Games* [91]. The following text is adopted from the published paper and partly modified to fit the structure of this thesis.

4.1 DEFINITION OF THE RESEARCH SETTING

In order to systematically investigate the impact of certain game design aspects on players' communication and interaction, different game versions that feature variants of such aspects should be administered in a comparative study.

4.1.1 *Selection of Game Aspects as Independent Variables*

As implied by my research model (cf. Figure 4), there are a couple of game aspects that can potentially influence players' social interaction, some of which have been more in the focus of previous research than others (cf. section 3.3). In a collaborative project, we decided to pick three exemplary design patterns with distinct foci to investigate their impact. The goal of this investigation is twofold: It is aimed at gaining insights into how those concrete game aspects influence the player experience and interaction, thereby creating new knowledge as well as reinforcing previous findings. Moreover, we want to demonstrate that those aspects can purposefully be used in game design to shape the social player experience and to foster intended social behavior of players.

As first game aspect, we chose *interdependence*, which refers to the degree to which players are dependent on the other player's actions (cf. section 3.3.2.3). In a collaborative game, there is always some level of interdependence due to the shared goal and destiny: players either win or loose together. However, there are several ways to increase player dependencies, for instance by distributing different abilities, shared and individual rewards, or the necessity to align actions [22, 26, 126, 251]. In this study, we focus on using the cooperative design patterns *complementarity* and *abilities that can only be used on another player* [257] to design closely-coupled interactions of players [22]. The resulting high interdependence is compared to a game version in which players still share the same goal, but have to perform independent actions to achieve it.

Second, we want to investigate the influence of the game's input interface. More precisely, we focus on the concept of shared control. As indicated by Loparev et al. [205], shared control is an interesting design pattern for cooperative games, giving players simultaneous control over the same characters (cf. section 3.3.2.6). In this study, shared control is compared to the more common distinct character control in terms of social communication and player experience.

Finally, we picked a partial aspect of timing as the last game design pattern to be examined in our study, namely time pressure. Time pressure is a kind of limited resource [26] and not necessarily related to multiplayer games. The impact of time pressure on player experience in singleplayer games has recently been investigated by Yildirim [351], indicating influences on perceived flow and competence. We assume that it can also significantly shape players' interaction in multiplayer games. For instance, with time pressure there is only limited time for discussing strategies or giving feedback.

4.1.2 *Defining the Social Play Setting*

To investigate the impact of these three game aspects on players' communication and experience, a study setup has to be created in which all other relevant characteristics of the play setting can be kept constant or at least be controlled for. Hence, the context of play as well as all other game-related aspects should not differ between our study groups.

As co-located gaming allows for the richest social interaction compared to distributed scenarios due to the immediacy of communication (both verbal and non-verbal), we chose this setting as a starting point for our research. Kröger and Quandt [179] emphasize that despite existing examples of interesting and relevant work in this area, there is still a need to focus more academic attention to it. In order to reduce interaction effects between participants to the possible minimum and to achieve a manageable multiplayer setup, the number of players in each session was limited to two. Dyads of participants should play the game in a rather classical home entertainment scenario, sitting next to each other on a couch, while the game is displayed on the wall via a projector (shared screen) .

As two of the game aspects under investigation—interdependence and shared control—require some form of cooperation between players, it was decided to implement a game with a clearly collaborative goal structure. Players have a shared goal and have to collaborate to achieve it. As opposed to competitive games, this interaction pattern allows the implementation of shared control and the easy variations of the level of interdependence between players. The game should not include any bots or NPCs, to keep the focus on the two-player social interaction.

4.1.3 *Testbed Game Development*

We developed a testbed game using the Unity3D game engine to systematically investigate the influence of the three game aspects on players' interaction and communication. It was designed as a collaborative, co-located two-player game, with simple rules to enable an easy access. We did not use an off-the-shelf game, as a bespoke game allows us to vary single game aspects and compare game versions under controlled conditions. To ensure a compelling basic game design, it was oriented towards the successful commercial game *Thomas Was Alone* [25], which is a 2D indie puzzle platformer game released in 2012. The key feature of this game is the integration of four different kinds of player characters represented by colored blocks (see Figure 5). These blocks have specific shapes and related strengths and weaknesses: The cyan block is slim, tall and has the highest jumping power. Due to its size it does not fit through small passages. The orange block is a small square with medium capabilities to jump. It fits through all gaps, but cannot reach high platforms without help. The other two blocks, red and dark blue, both have very limited jumping power. Instead, the red block is flat and can be used as a trampoline by the other blocks, while the blue block is voluminous and able to float on water, whereas all other blocks are destroyed by water contact. The blue character can thus serve as a boat or island to cross water basins.

The original game *Thomas Was Alone* is a singleplayer game, and the player can switch between all the blocks. In contrast, we adapted the mechanics so that our game can be played by two co-located players. The game is displayed on one single screen, and both players can simultaneously control their distinct characters via wireless controllers. In each level, two or more of the player blocks are present and have to be navigated to predefined target positions which are indicated by the blocks' silhouettes. To reach this goal, players have to overcome obstacles like water basins, laser barriers, and closed doors that can be unlocked by activating switches (see Figure 5). Due to their distinct shapes and abilities, the blocks can use different ways and reach different parts of the levels. Sometimes players have to effectively synchronize their blocks' activity and interact with each other, for instance by jumping on each other. If more than two blocks are present in a level, players can switch control between the blocks anytime to

Figure 5: Screenshot of the testbed game: This level includes all four player characters (colored blocks at the bottom). To complete the level, players have to navigate all blocks to their respective destinations in the upper part of the level (indicated by the unfilled shapes of the blocks).

arrange all of them as necessary. If a block is destroyed by an obstacle, it is reset to its starting position.

We used this basic game design to implement several levels with different foci to investigate the impact of the game aspects *interdependence*, *shared control*, and *time pressure* on players' social experience. The according level designs are described in the following subsections.

4.1.3.1 *Interdependence*

One important aspect in collaborative games is the degree of dependence between players. To create a high interdependence in our game, we implemented mechanics of *complementarity* and introduced *abilities that can only be used on another player* [257]. Two levels were implemented, each in two versions: one version with low interdependence between players and one with a strong coupling of player actions. In both levels, players' characters are separated by a wall and cannot interact directly. In the high interdependence condition, players can use switches to open gates and activate platforms in the other player's area of the level. Thus, they have to thoroughly coordinate actions. In the low interdependence condition, players have to overcome the same obstacles, but they can control their own level parts by switches and, hence, are not dependent on the co-player's actions.

4.1.3.2 *Time Pressure*

Time pressure is supposed to influence the social player experience as well as the communication between players: if players are forced to make decisions quickly and do not have time for comprehensive discussions or the trying out of different strategies, they may interact and communicate differently. Hence, we wanted to test the influence of game mechanics that induce this pressure. We designed two respective levels that have to be solved within a limited time frame. In the first level, water is rising from the bottom and gradually fills the screen. Players have to navigate to the top before the water can reach them. In the second level, a row of thorns is slowly coming down from the ceiling and thereby impends to block the only way to the level's end. In both cases, players can see that they have to act quickly to complete the level due to the advancing threat (water/thorns).

4.1.3.3 *Shared Control*

In our game, by default, both players have control over distinct blocks in every level. They may have control over more than one block and switch control between their blocks anytime, but they cannot take control over the blocks of their co-player. This distribution of control is supposed to also increase player interdependence. An alternative is the concept of shared control: in this case, all blocks can be controlled by all players simultaneously. Thus, one player could theoretically solve the level alone by switching through all blocks instead of waiting for the other player to take actions. On the other hand, the wider range of opportunities of action for both players may also increase communication to coordinate strategies. We implemented another two levels to investigate the impact of the type of control distribution on the interaction between players. Both are complex levels including all four blocks. Each player either has control over two distinct blocks (default distributed control) or can switch between all blocks (shared control).

4.2 EVALUATION

We conducted an exploratory, comparative study to investigate the communication between players and their experience related to the different game design patterns implemented in our game. We invited participants to play our game and administered questionnaires to assess their player experience. Furthermore, we videotaped players during the complete gaming session to be able to analyze players' communication and non-verbal interaction. We used a mixed study design. All participants played levels referring to all game patterns (i.e., *interdependence*, *time pressure*, and *shared control*), hence, game aspects are a within-subjects factor. However, participants only played those level sets in one of the two conditions each (control vs. treatment condition) as between-subjects factor.

4.2.1 *Hypotheses*

With regard to the implemented game aspects under investigation, we assume influences on the communication of players. Moreover, we want to investigate how the variations of the game aspects affects the player experience. Thus, we want to test the following hypotheses.

Player interdependence:

H1 *Players will communicate and interact differently in the two conditions of high and low interdependence.*

Due to the need of coordinating actions, we expect players to communicate more and to be more focused on common strategies in the high interdependence condition.

H2 *Player experience will differ in the two conditions of high and low interdependence.*

We assume that higher interdependence leads to higher social presence and feelings of relatedness, because players are supposed to interact more closely and pay more attention to each other. At the same time, high interdependence may negatively effect perceived autonomy, because in this condition players' success is significantly depending on the performance of the co-player.

Time pressure:

H3 *Players will communicate and interact differently when exposed to time pressure.*

In case of time pressure, we expect more commanding and shorter discussions between players, because they have to react quickly and have no time to discuss different strategies in detail. They might also express more frustration, while there is no time for off-topic conversations.

H4 *Player experience will differ in the two conditions with and without time pressure.*

We expect players to experience less competence due to an increased level of challenge in the game version with time pressure. The shared experience of threat might also increase players' perceived relatedness.

Shared control:

H5 *Players will communicate and interact differently in the two conditions of distinct character control and shared control.*

We expect players to communicate less when they are both able to control all game characters on their own in the shared control condition, as there is less need to give commands or discuss strategies.

H6 *Player experience will differ in the two conditions of distinct character control and shared control.*

We assume that players perceive less relatedness in the shared control condition, because they can follow their own strategies by taking control of all characters. They are less dependent on each other. Hence, perceived autonomy may be higher in the shared control condition.

Figure 6: Exemplary picture of two participants playing the testbed game together, recorded by the camera that was installed to videotape all playing sessions.

4.2.2 *Study Procedure and Measures*

The study took place in our gaming lab at the university of Duisburg-Essen. In each session, two participants had to play together. Participants could apply directly in pairs or were randomly assigned to another participant as gaming partner. An overview of the procedure is depicted in Figure 7.

After being introduced to the study's procedure, participants were asked to fill in a questionnaire regarding demographic data, their prior experiences with digital games, their current gaming habits, and the relationship to their co-player of the study session (referring to their degree of familiarity and shared prior game experiences). The questionnaire also included three evaluative questions to rate trust, sympathy, and the co-player's competence in relation to digital games. Furthermore, the BFI-10 [243] was applied to assess basic personality traits on the dimensions *openness*, *conscientiousness*, *extraversion*, *agreeableness*, and *neuroticism*. By applying these questions, we controlled for several factors of my research model of social player experience, including context aspects (familiarity, relationship, and similarity of co-players) and individual player characteristics (age, gender, gaming expertise, personality).

After that, participants were introduced to the game's rules and the game was started. It was projected on the wall and participants sat next to each other on a sofa, using wireless Xbox 360 controllers to play the game (see Figure 6). Participants were told that they were videotaped during the playing sessions. However, the camera was placed on the side so that it was not in their direct view. As intended, the majority of subjects reported that they had quickly forgotten to be videotaped and did not pay any attention to the camera while playing. In addition to the recording of players, we also captured the game screen of each session for our later analysis.

The game began with five short tutorial levels allowing to familiarize with the controls and to learn about the characteristics of the different blocks. The examiner assured that after playing the tutorial, there were

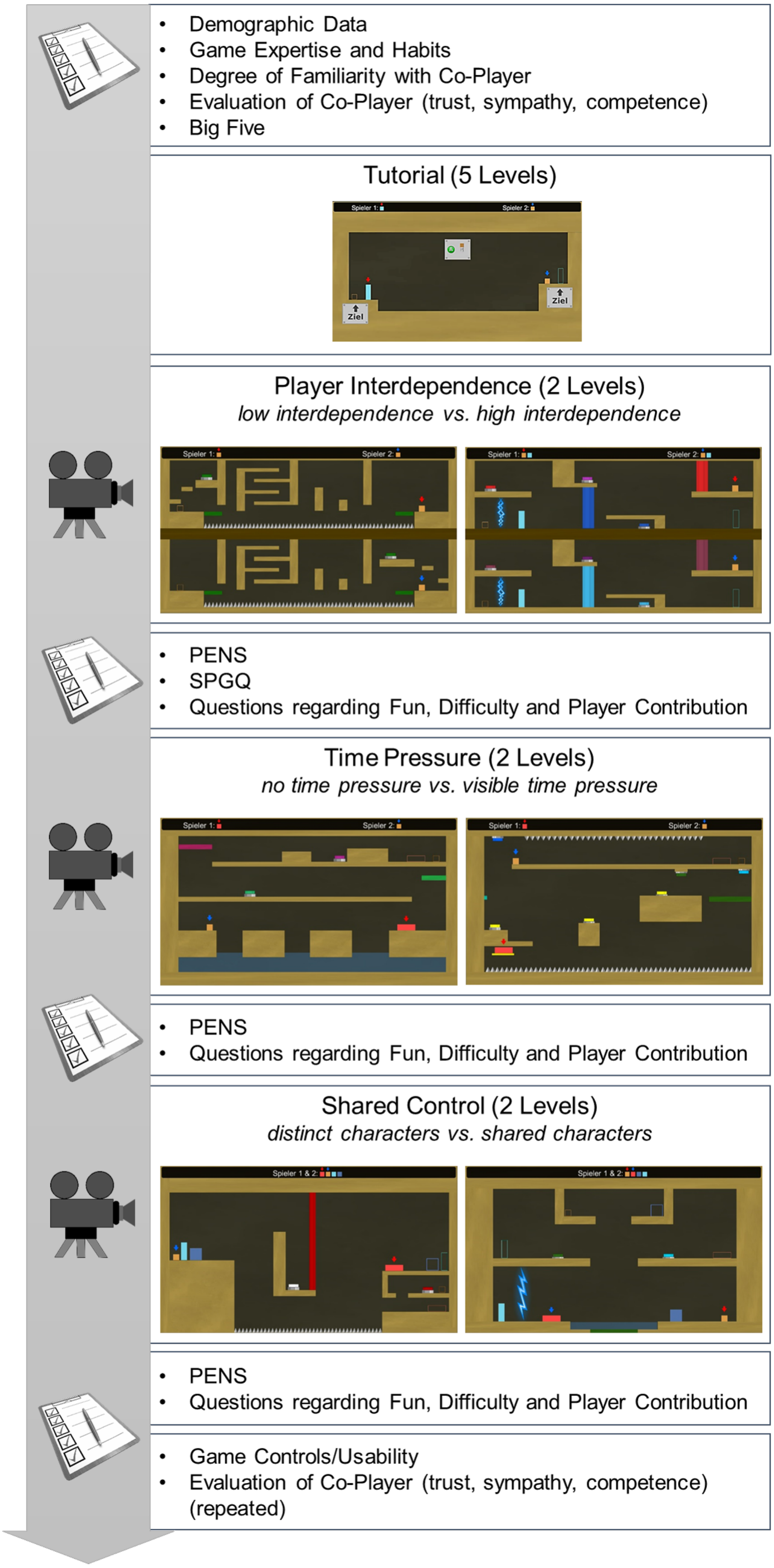


Figure 7: Overview of the study procedure, showing the sequence of gaming sessions and the applied questionnaires.

no questions left regarding the game's controls or goals. Then, participants played the three level sets referring to the different game aspects *interdependence*, *time pressure*, and *shared control*. The applied condition in each level set was randomized to avoid sequence effects and interference between level set conditions. In total, playing all levels took about 25 minutes. After each level set (i.e., every two levels), the game was paused and participants were asked to fill in questionnaires. The PENS questionnaire [254, 263] was used to assess the player experience in terms of the three subdimensions perceived *autonomy*, *competence*, and *relatedness* on a 5-point Likert scale (coded 1 - 5). Furthermore, we asked players to rate four additional aspects on a 5-point scale ranging from 1 ("not at all") to 5 ("absolutely"):

- the *difficulty* of the two levels,
- how much *fun* they had,
- how satisfied they were with *their own contribution* to the completion of the levels, and
- how satisfied they were with *their co-player's contribution* to the completion of the levels.

Regarding the game aspect *interdependence*, we were also interested in its impact on perceived social presence. Hence, after the first level pair, the SPGQ [359] was additionally administered to measure social presence on the three subdimensions *empathy*, *negative feelings*, and *behavioral engagement* on a 5-point Likert scale (coded 1 - 5).

After having played all levels and having answered all level-related questions, a final questionnaire was administered. It included questions about the game's general usability and the perceived quality of controls. Additionally, the three evaluative questions that were asked about the co-player at the beginning of the study were repeated. This way, it was tested whether the ratings of trustfulness, sympathy, and the other person's competence was influenced by having played together.

4.2.3 *Sample Description*

In sum, 50 subjects (25 gaming dyads), aged 18 to 33 ($M = 23.84$, $SD = 2.86$), took part in the experiment. Most participants were students from the local university (92 %) and the majority was familiar with digital games: 36 participants stated that they played digital games frequently, most of them several times a week ($N = 17$). Gender distribution was relatively balanced (30 females, 20 males) and there were 15 same-sex dyads as well as 10 mixed dyads. The distribution of gender, game expertise, and age in the single condition groups was balanced as well, showing no significant differences. The majority of participants stated that they were friends ($N = 29$) or even best friends ($N = 14$) with their co-player. However, when the game partners were asked if they had ever played a video game together, the results were rather balanced (yes: 28, no: 22). This can be related to the fact that 14 participants claimed not to play video games at all.

4.2.4 *Preparation and Conditions of Data Analysis*

Before being able to analyze the impact of the three game aspects on players' communication and player experience, the data—particularly the recordings of the gaming sessions—had to be prepared and conditions for parametric calculations had to be tested.

4.2.4.1 *Iterative Annotation and Analysis of Videotaped Sessions*

For the analysis of all videotaped gaming sessions we used the tool ELAN, which is a professional tool for the creation of complex annotations on video resources [40] created by the Max Planck Institute for Psycholinguistics[1]. We synchronized videos of the players with the respective screencasts of the game to be able to evaluate players' communication and behavior considering their in-game behavior and game events (see Figure 8).

The goal of analysis was to annotate every social event between players, which includes both verbal and non-verbal communication, whereas the focus was on verbal communication acts. We did not transcribe what players said, because we did not aim for performing a literal text analysis. Instead, the beginning and end of every communication event was identified and then it was assigned to one or more categories of social interaction based on its content and context. We started with the categories suggested by Bromley et al. [36] and Seif El-Nasr et al. [278], such as "laughter or excitement together" and "team optimization".

All videotaped gaming sessions were annotated in an iterative process. First, all 25 sessions were equally distributed among two examiners. They performed the first round of annotation by analyzing their video material independently from each other based on the observation categories by Bromley et al. [36] and Seif El-Nasr et al. [278]. Communication events were marked with the abbreviation of the appropriate category (e.g. "TRASH" for *trash talk*) and with their duration. Hence, we counted each communication in form of periods (in seconds), not just single points in time, because we consider each communication act as a process. Subsequently, examiners discussed their experiences and pointed out communication events that could not properly be assigned to one of the existing categories due to semantic mismatch. Based on those insights, annotation categories were revised, resulting in the final coding scheme presented in Table 2. This was used to annotate all videos once again in a second iteration. A third examiner, who was not involved in the previous process, annotated all video material from scratch based on the supplemented scheme. Deviations between annotations from this examiner and the other two were investigated. There were little discrepancies, indicating high inter-rater reliability. Annotations that did not coincide were discussed and adjusted. The final annotations serve as the basis for our analysis of participants' social interaction. The length of all annotations of the same category was summarized for each level set.

1 The Language Archive: `http://tla.mpi.nl/tools/tla-tools/elan/`

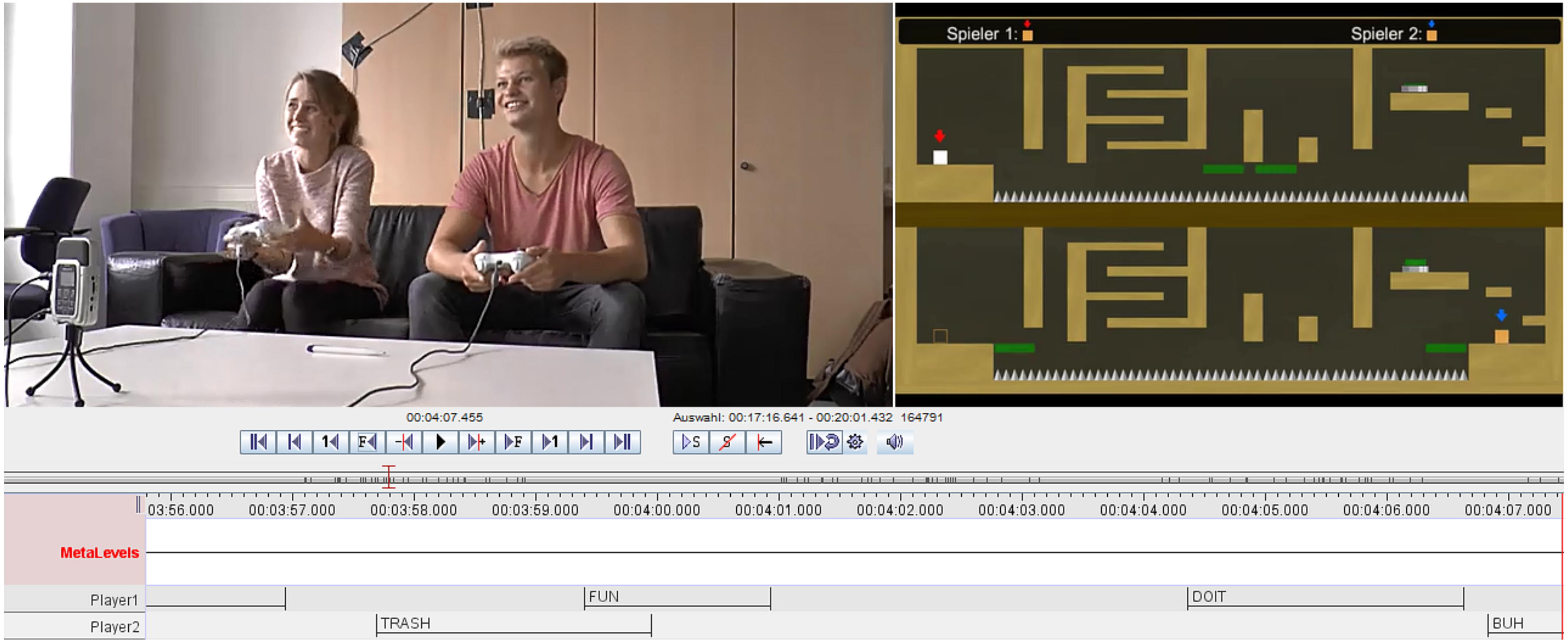


Figure 8: Example screenshot of the ELAN video annotation tool, including the videotaped gaming session (left), the corresponding screencast of the game (right), and the annotations and duration of social interaction events for each player (bottom).

Table 2: Social interaction categories for social interaction events that were used to annotate the videotaped gaming sessions (based on the work by Seif El-Nasr et al. [278] and Bromley et al. [36].

Category (abbreviation)	Description	Related resource
Enjoying *(FUN)*	Laughing, expressing fun or pleasure, showing enjoyment due to game events	Laughter or excitement together [278]
Swearing *(BUH)*	Expressing frustration or annoyance, also as spontaneous reaction to failure in the game	— *(new)*
Commanding *(DOIT)*	Imperative call for action: telling the other player what to do (or not to do) without further explanation or discussion	— *(new)*
Strategizing *(STRAT)*	Working out strategies to overcome the games challenges; suggesting actions for both players, explaining what should be done	Worked out strategies [278]
Synchronizing Actions *(SYNC)*	Co-ordinating own actions with the other player's actions while performing them	— *(new)*
Helping *(HELP)*	Giving advise about how to control the game; hints to pay attention to some game object or event; explaining the rules and mechanics of the game	Helping [278]
Waiting *(WAIT)*	Expressing impatience while waiting for the other player to perform a certain action or to accomplish a certain goal	Waited for each other [278]
Blocking *(BLOCK)*	Pointing out that the other player retains one from doing something, e.g. by blocking her avatar's way	Got in each others way [278]
Creating Shared Awareness *(STATE)*	Exchanging information about the game's state, current game events, or the presently performed action	Shared Awareness [36]

Table 3: Continuation of Table 2: Social interaction categories for social interaction events that were used to annotate the videotaped gaming sessions (based on the work by Seif El-Nasr et al. [278] and Bromley et al. [36].

Category (abbreviation)	Description	Related resource
Shared History *(PAST)*	Talking about priorly shared game experiences, relating common experiences to the current situation	Shared History [36]
Sharing Success and Failure *(SHARE)*	Celebrating group success or agreeing that failure was not an individual fault but the result of bad collaboration	Shared Success and Shared Failure [36]
Talking Trash *(TRASH)*	Insulting the other or talking the other's performance down, put the blame for failure on the other player	Trash Talk [36]
Giving Feedback *(FEEDBACK)*	Appreciating the other's contribution to the game, judging their actions or performance	Team optimization [36]
Off-topic comments *(OFF)*	Talking about something that is not related to the game or the current gaming situation	Off-topic [36]

4.2.4.2 *General Indications of the Following Analysis*

In general, participants expressed that they liked the game and rated their fun in all level sets as very high on average (all mean values above 4 on a scale from 1 to 5). No participant reported any problems with the game's controls. Hence, the game was implemented successfully and the following analysis is not biased by usability issues or bad game design.

To investigate the impact of certain game patterns on the social interaction between players and on the player experience, results of the different experimental groups are compared. Regarding player experience measures, the requirements for parametric calculations (homogeneity of variances and normal distribution) are tested with Levene's and Kolmogorov-Smirnov tests. If violated, Mann-Whitney U tests or Wilcoxon signed rank tests are reported instead of independent samples t-tests for hypotheses predicting a difference. Pearson's r is calculated as effect sizes of Mann-Whitney U tests ($r < 0.3$ = weak effect, $0.3 < r < 0.5$ = medium effect, $r > 0.5$ = strong effect). For t-tests, Cohen's d is reported ($0.2 < d < 0.5$ = weak effect, $0.5 < d < 0.8$ = medium effect, $d > 0.8$ = strong effect). To test for correlations, data is analyzed using the Spearman's rank correlation coefficient (Spearman's rho), due to a lack of normal distribution.

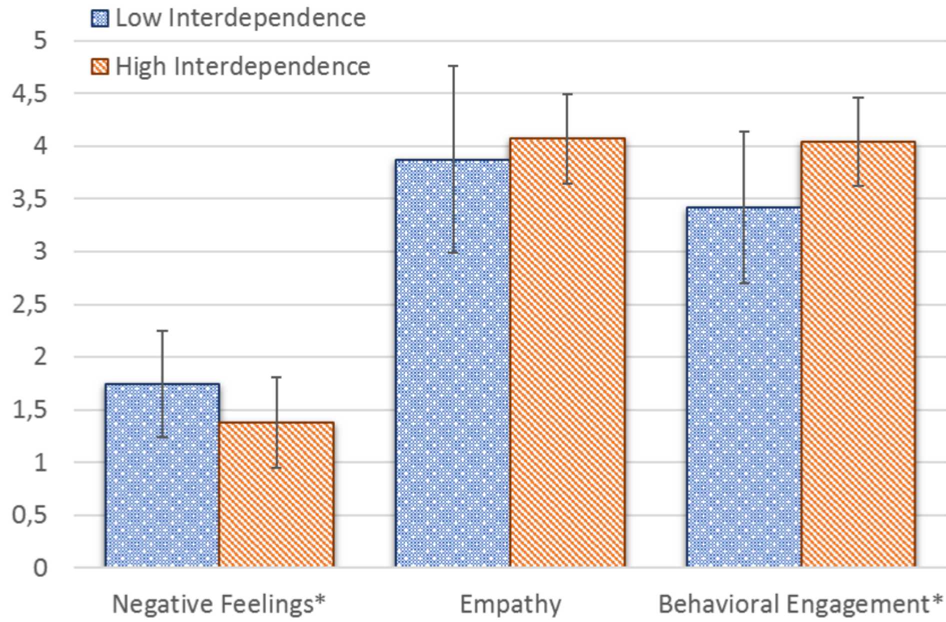


Figure 9: Results of the SPGQ compared for the low interdependence and the high interdependence condition (significant differences indicated by *).

Our video annotations are count data, thus, we investigate the effect of study condition on annotated player interaction by using a generalized linear model method. As data of dependent variables does not have a Poisson distribution due to overdispersion, we used negative binomial regression with estimated dispersion parameters. The duration of every level depended on the performance of participants and, thus, differs between sessions. Hence, we considered the variable time in play sessions as offset in the regression.

In the next sections, the single level sets are analyzed with regard to the impact of the specific game aspects on players' experience and communication.

4.2.5 *Results Regarding the Impact of Player Interdependence (H1 & H2)*

The analysis of the annotated communication events shows significant influences of player interdependence on the behavior of players in terms of swearing (BUH) and commanding (DOIT). Negative binomial regression modeling indicates that players in the high interdependence condition spent about 70% less time on utterances of frustration or swearing than independent players ($B = -1.208$, $Exp(B) = .299$, $p < .001$). In contrast, highly interdependent players gave over twice as much DOIT commands compared to players who were not dependent on each other ($B = .777$, $Exp(B) = 2.175$, $p = .049$). Negative binomial regression modeling of the other twelve social interaction categories reveals no significant influence of player interdependence.

Table 4: Mean scores and standard deviations of the PENS sub-scales for the two study conditions of each level set. Significant difference of mean values between conditions (based on Mann-Whitney U tests reported in the text) are marked by * (marginally significant) and ** (significant).

	Interdependence		Time Pressure		Shared Control	
	low	high	without	with	distinct	shared
PENS Dimension	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Competence	3.83 (0.82)	3.86 (0.85)	3.50 (0.88)	3.68 (1.02)	4.21** (0.86)	3.81** (0.72)
Autonomy	3.14 (0.90)	3.32 (0.85)	3.29 (0.90)	3.13 (0.88)	3.83** (0.90)	3.30** (1.01)
Relatedness	4.55 (0.86)	4.58 (0.60)	4.63 (0.76)	4.45 (0.67)	4.97* (0.63)	4.61* (0.65)

*$p < .10$, **$p < .05$

To investigate the impact of player interdependence on player experience, values of the PENS and the SPGQ measured after the first two study levels were analyzed. The comparison of the SPGQ sub-scales shows significant differences between the low and the high interdependence condition (see Figure 9). Participants reported higher scores for *negative feelings* in the low interdependence condition (M = 1.74, SD = 0.51) than in the high interdependence condition (M = 1.38, SD = 0.43) according to a Mann-Whitney U test (U = 175.0, p = .009, r = -.38). Results also indicate that high interdependence led to higher perceived *behavioral engagement* (M = 4.04, SD = 0.42) than loose coupling (M = 3.42, SD = 0.72; U = 146.0, p = .001, r = -.76). The difference regarding *empathy* (high interdependence: M = 4.07, SD = 0.42; low interdependence: M = 3.87, SD = 0.88) is not significant (t (40.55) = -1.05, p = .301, d = -.28).

A comparison of the player experience in terms of perceived need satisfaction (PENS) shows no significant differences between conditions (all p > .417). Values for the dimensions *competence*, *autonomy*, and *relatedness* are fairly equal for low and high player interdependence (see Table 4). Furthermore, participants' evaluation of level difficulty, fun, and the contribution of each player does not differ significantly (all p > .170, see Table 5 for all mean scores).

4.2.6 *Results Regarding the Impact of Time Pressure (H3 & H4)*

In the second level set, we varied the urgency of action by implementing time pressure. Half of the dyads played the levels with time pressure (induced by rising water and approaching thorns), the other half without it. However, the video analysis does not indicate any influence on players'

Table 5: Mean scores and standard deviations of the questions regarding level difficulty, fun, satisfaction with one's own contribution, and satisfaction with the co-player's contribution, displayed for the two study conditions of each level set. Significant difference of mean values between conditions (based on Mann-Whitney U tests reported in the text) are marked by **.

	Interdependence		Time Pressure		Shared Control	
	low	high	without	with	distinct	shared
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Difficulty	2.39 (0.88)	2.77 (0.92)	3.17 (0.96)	3.54 (0.86)	3.32 (1.04)	3.79 (0.74)
Fun	4.43 (0.63)	4.14 (0.89)	4.42 (0.65)	4.00 (0.94)	4.59 (0.73)	4.43 (0.69)
Own Contribution	4.21 (0.92)	4.36 (0.66)	4.21 (0.93)	3.62 (1.36)	4.55** (0.80)	4.04** (0.84)
Co-player Contribution	4.39 (0.79)	4.68 (0.48)	4.46 (0.83)	4.31 (0.84)	4.68 (0.48)	4.36 (0.83)

**$p < .05$

communication and interaction. For all observation categories, negative binominal regression modeling does not show significant relations.

Measures of the player experience show similar results: Mann-Whitney U tests do not indicate any significant difference between the two study conditions regarding perceived competence, autonomy, and relatedness (all $p > .420$). Mean scores of players playing under time pressure and of those who did not face time constraints are rather similar (see Table 4). The same is true for values of fun, perceived level difficulty, and the evaluation of the contribution of each player to the completion of the levels (all $p > .116$, see Table 5 for all mean scores).

4.2.7 *Results Regarding the Impact of Shared Control (H5 & H6)*

The third level set varied the control scheme of the game (distinct characters or shared characters). With regard to social communication acts, the regression analysis indicates no significant influence of control mode on the fourteen interaction categories.

The analysis of the PENS subscales shows significant differences (see Table 4). Players in the shared control condition reported significantly less perceived competence ($U = 205.50$, $p = .042$, $r = -.28$) and autonomy ($U = 192.50$, $p = .022$, $r = -.32$). Scores for relatedness show a similar tendency, but the difference is not significant in this case ($U = 213.50$, $p = .061$, $r = -.26$).

Furthermore, participants who could control all blocks in the shared control condition were significantly less satisfied by their own contribution to the completion of the level than players with distinct game characters

Table 6: Mean scores and standard deviations of the evaluation of the co-player based on three questions addressing competence, sympathy, and trust. Statements were rated before playing the game and at the end of the study. Significant differences between both measurement time points (based on Wilcoxon signed rank tests reported in the text) are marked by **.

Statement	before playing *M* (*SD*)	after playing *M* (*SD*)
My game partner can satisfactorily solve the challenges in the game. (competence)**	3.92 (0.94)	4.62 (0.64)
I think my game partner is likeable. (sympathy)**	4.78 (0.55)	4.90 (0.30)
I can confide in my game partner. (trust)	4.68 (0.59)	4.80 (0.49)

**$p < .05$

(U = 194.00, p = .016, r = -.31). Mean values regarding the contribution of the co-player, fun, and level difficulty do not differ significantly (see Table 5 for all mean scores).

4.2.8 *Further Results*

We also investigated the potential confounding effect of personality and familiarity on players' communication. We analyzed the correlation of players' personality assessed by the BFI-10 and their individual communicative behavior to see whether personality traits have a basic impact on how players interact. We found only few significant correlations, all concerning the dimension *extraversion*: extraversion correlates positively with swearing (r (50) = .30, p = .039), off-topic comments (r (50) = .32, p = .028), and trash-talk (r (50) = .35, p = .015).

Furthermore, we also tested for the influence of the degree of familiarity of players on their communication by integrating the factor into the negative binomial regressions. Model fit was not improved and no significant influence was found.

Finally, we investigated whether the mutual playing experience has an impact on the evaluation of the co-player. To test this, we compared the values for trust, sympathy, and competence assessed prior gaming to the measurements at the end of the study. Table 6 shows all mean values. Wilcoxon signed rank tests expose significant differences. The evaluation of the item *my game partner can satisfactorily solve the challenges in the game* is significantly higher after the game session compared to the first evaluation at the study's beginning (z = -3.88, p < .001, r = .55). The evaluation of *I think my game partner is likeable* shows significant differences as well (z = -2.12, p = .034, r = -.30): sympathy was rated higher after the game session compared to the evaluation prior to it. Ratings of trust show the same tendency, but do not differ significantly (z = -1.54, $p < .124$).

4.3 DISCUSSION

The main goal of the study was to investigate the communication between players and their experience dependent on the different game patterns implemented in our game.

4.3.1 *Interdependence Affects Social Play*

Our first hypothesis stated that players will communicate and interact differently in the two conditions of high and low interdependence. Results show that player interdependence indeed has an effect on the way players communicate. High player interdependence led to less utterances of frustration. Instead, players communicated significantly more to coordinate their strategies. They used more time for commands, telling the other player what to do (e.g., "Now, jump!"). Other communication events, like the coordination of common strategies, were not significantly predicted by study condition. This might be explained by the observation that players tend to cooperate and discuss level solving strategies in all levels, no matter whether they were dependent on each other. The significant increase of commands, however, indicates that players were more focused on the success of their partner if there was a high level of interdependence. Hence, results (at least partly) support hypothesis 1.

The second hypothesis postulates that player experience will also differ in both conditions. Scores of the SPGQ confirm that players experienced social presence differently in both conditions. High interdependence is reflected in higher values regarding behavioral engagement. Thus, the variation of player interdependence was actually perceived by players. They were aware that their actions were tightly coupled in the high interdependence condition. Furthermore, players reported less negative feelings related to the other player when being dependent on each other. This result corresponds with the difference found for expressed frustration. Overall, the interaction between dependent players seemed to be more positive and collaborative. Results indicate that dependent players were focused on their shared goal and did not blame each other for mistakes, whereas independent players experienced the levels rather as individual challenges. In fact, the design of the levels in the low interdependence condition may have conveyed a competitive atmosphere, as players had to overcome the same obstacles simultaneously and could observe, but not influence, the progress of the other. In this way, it was obvious who is performing better and will reach the goal first. That is a possible explanation why negative feelings like schadenfreude or envy were more likely to occur for independent players.

We did not find significant differences concerning need satisfaction or fun. However, values of the PENS sub-scales and fun ratings are high in both conditions, indicating a very positive experience overall. This might be the reason why significant differences between the two study conditions did not manifest. The social setting of the gaming session—playing a collaborative game co-locatedly—seems to already foster perceived relatedness between players. Contrary to our expectations, perceived autonomy was not negatively affected by high interdependence. Interdependence in terms of complementarity and closely-coupled player actions did not seem to reduce players feeling that they have freedom in the game and are provided with interesting choices. Though being dependent on the co-player, players could still unrestrictedly navigate their own characters and tell the other what should be done. Hence, the form of interdependence implemented in our study has no negative impact on the player experience.

Overall, results indicate that the integration of player dependencies is a suitable way to foster internally derived social interaction among players in order to enhance their social experience. Designers should be aware that the degree of player interdependence can change the way players communicate and pay attention to each other and that low interdependence can even create an atmosphere of competitiveness in collaborative games.

4.3.2 *Inconclusive Results for Time Pressure*

Regarding time pressure, the video analysis did not indicate significant influences on players' communication. Hence, hypothesis 3 is not supported by the results. Furthermore, time pressure did not influence players' experience, either, according to results of the questionnaires. This contradicts hypothesis 4. This lack of effect surprises us, as we expected players to be affected by time pressure in some way, for instance in terms of increased arousal or less feelings of competence and autonomy due to the fact that the game urges them to react without being able to plan or discuss strategies.

Our findings can point in two different directions: they either indicate that time pressure does not significantly contribute to the emergent social gameplay and player experience, or they result from the fact that participants did not perceive any time pressure at all. Therefore, it was necessary to investigate whether our implementation of time pressure worked as intended. We took another look at the videotaped sessions. Less than half of the pairs playing with time pressure did actually address this aspect in their communication (e.g., "look, the water, we have to hurry"), whereas the others did not seem to notice (or care about) the imminent threats. Hence, we cannot make a clear statement whether (and how) time pressure impacts social interaction and player experience, but will have to revise the game design of the corresponding levels to address this question in future studies.

4.3.3 *Shared Control Reduces Need Satisfaction*

The video analysis did not indicate significant influences on players' communication by different control modes, either. Players seem to communicate and interact in the same way for both distinct and shared character control. Thus, hypothesis 5 is not supported.

However, significant differences were found for several aspects of the self-reported player experience, partly supporting hypothesis 6. Although the observable social interaction of players did not differ, players in the shared control condition reported lower PENS scores: giving players communal control over all player characters led to a decrease of their perceived autonomy and competence. Although it could be assumed that having more options of control will result in higher perceived autonomy, results indicate the opposite. We suggest that players in the shared control condition did not perceive the wider range of options for action, but instead missed to have exclusive control over one (or more) characters. Notionally, all actions performed by one player could be reversed by the other player in the shared control game mode.

Perceived competence was also lower in this condition. Moreover, participants were also less satisfied by their own contribution to the collaboration. All these findings indicate that players might have perceived the other player as being more dominant or that they had general problems to adapt to the new control scheme of switching between all blocks. In contrast, relatedness was very high in both conditions and did not differ significantly. Though there is a tendency for lower relatedness in the shared control condition, shared character control does not seem to have affected the social experience of our participants. Nevertheless, in future studies the possible impact on social presence should be investigated in more detail, to determine if (and how) social aspects of the experience besides the feeling of relatedness are influenced by shared control.

Our current results indicate that game designers who consider to implement shared control as an interesting feature should carefully account for needs of autonomy and competence, for instance by giving clear instructions how to use the feature properly and how to divide responsibilities to achieve the game's goals.

4.3.4 *Limited Influence of Personality and Familiarity*

To summarize, we found effects on player interaction only for one of the three patterns under investigation. Player interdependence is supposed to be strongly connected to players' communication and interaction, whereas shared control does not impact observable communication, but has significant influence on the player experience nonetheless.

We further investigated the influence of player personality and familiarity on the social interaction during play. Extraversion, a personality dimension comprising aspects of sociability and communicativeness, is positively correlated with swearing, trash-talk, and off-topic comments. This is consistent, because all these categories of communication are related to expressiveness without being dependent on the concrete game content. Those correlations indicate that player personality may contribute to the social behavior of a player. However, no other significant correlations were found, hence we assume that it is not the predominant factor determining players' social interaction during play.

In terms of familiarity, we could not find any influence on social interaction events. However, other studies suggest that familiarity is an influential factor in multiplayer gaming [138]. We did not focus our study on the impact that different levels of familiarity might have on players' interaction, hence we did not recruit participants with respect to that aspect. Being randomly composed, our sample is unbalanced in terms of familiarity, including mostly friends and only few groups with players that have not met before. Therefore, low levels of familiarity are underrepresented and we cannot reasonably analyze differences between groups of high and low familiarity in our current data set. We propose that familiarity has to be considered in future evaluations of multiplayer scenarios, although we did not find significant influences in our sample.

4.3.5 *Advancement of Social Relationships*

Finally, the pre- and post-game evaluations of the gaming partner indicate interesting effects on the relationship of participants: they tend to rate competence, sympathy, and trustfulness of the co-player significantly higher after the gaming session. This indicates a positive team-building effect of playing collaborative games. Generalizability of this finding is limited due to the fact that most participants already knew each other well and defined their relationship as friendship. They already showed high values before playing. Still, the playing interactivity was able to increase ratings of competence and sympathy. Our results are in line with other studies that report a positive effect of playing together on players' social bonds [66, 67, 101, 309]. Hence, these findings provide a promising starting point for further research on how games can be applied to foster the establishment of positive relationships.

4.3.6 *Limitations of the Study*

Generalizability of results is limited due to the specific study design. We used a bespoke platformer game to test the impact of three different game aspects. Decisions regarding game genre and design were based on the application context: the game should be fun, short, and easy to understand, yet rather complex in its capabilities to foster collaboration. Moreover, a bespoke implementation enabled us to investigate variations of the game in a controlled way. Thus, we consider the implemented testbed game to be a good choice for our research approach. However, it only represents one of many game genres and social settings, which might differ regarding their affordance of social interactions and possibilities to implement the game patterns. Whereas we assume that results can be transferred to games that similarly rely on players' collaboration, dexterity, and reaction, we admit that future studies should consider other game genres, slow-paced games, competitive games, and games played by more than two players. Moreover, co-located settings can be compared to remote gaming, in order to investigate the importance of communication channels and non-verbal communication.

Besides, the game aspects under investigation can be implemented in very different ways. Our specific implementations are just examples. The discussion of our time pressure mechanic illustrates that differences (not) found between game modes have to be interpreted with respect to the specific pattern implementation. Other forms should be applied in future studies to confirm the results presented here.

Despite those limitations, we are confident that our work provides valuable insights into the interplay of game mechanics and social player interaction and presents impulses for future research endeavors.

4.4 CONCLUSION

In this study, we examined the impact of the three specific game aspects interdependence, time pressure, and shared control on players' social experiences. Our evaluation shows how slight changes in game design can significantly influence the communication between players and the social player experience in collaborative multiplayer games. In particular, we found that high player interdependence implies more communication and less frustration. With respect to shared control, enabling this feature results in less perceived competence and autonomy.

Our results underline the importance of considering game aspects related to player interdependence and the control scheme in the design process of multiplayer games. To design positive social experiences, our results should motivate game designers to consider the interplay of the three factors game design, player characteristics, and the social context of play as proposed in my research model of social player experience (cf. Chapter 3). This may also enable us to purposefully design games that are meant to foster social relationships, for instance in the context of team-building actions.

We plan to apply our testbed game in future studies to investigate the impact of other game patterns on the social interaction in detail, for instance the kind of feedback players are provided with (individual vs. communal) and the type of reward and penalty system. Moreover, the model is not limited to collaborative games and can also be applied to team-based and competitive games. In that context, the application of games in team-building activities can be further evaluated. In the case of completely competitive games, other game patterns and player characteristics are supposed to be relevant, like the proportion of player skills, the influence of winning and loosing as well as the visibility of actions and strategies.

Our study methodology is supposed to serve as an inspiring example of how to assess and analyze real-world player communication in co-located settings, moving forward the approaches of Seif El-Nasr et al. [278] and Bromley et al. [36]. Further research should address possibilities of automated analysis of video data, as the process of annotating video material and classifying player interaction events is still very time-consuming and error-prone. Improving these aspects by automated analysis would allow for significant advances in that research area.

5 INVESTIGATING INTERFACES: SHARED CONTROL AND SECOND SCREEN

The last chapter investigated the influence of three different game aspects on the social player experience. This chapter builds on this approach by further elaborating on the significance of game interfaces for social play. The first part deepens our work on shared control input mechanics by classifying different types of shared control and presenting a comparable study of different implementations. The second part of this chapter is focused on the other side of game interfaces, namely the output devices. It will be discussed how the integration of second screens can change multiplayer settings and create innovative gaming scenarios. This includes the illumination of design challenges and potentials, which will be underpinned by three case study game implementations.

5.1 A SECOND STUDY ON SHARED CONTROL

In the study described in Chapter 4, the way character control was distributed among two players was varied: they either had control over distinct characters, or each player could switch between all present characters. The latter type of control was called *shared control*. However, on closer consideration there is not only one way to implement shared character control in multiplayer games. Another approach is to give several players control over one single game character. This may lead to completely different social interactions and ways a game is played compared to games in which all players have distinct characters to control.

A prominent example of this kind of shared control is the implementation of *Twitch Plays Pokémon*[1]. Originally, it was a social experiment: in 2014, the game live streaming platform *Twitch* was used to stream the game *Pokémon Red Version* [112] while the comments of all viewers were processed as input controls. This way, the whole audience was able to simultaneously control a single game instance by typing game commands into the integrated chat system such as "up". With over one million active players, Twitch Plays Pokémon was a great success and finally led to the establishment of an own "Twitch Plays" category of the Twitch service in 2016[2]. Till today, a variety of different games were played using this mechanic and the concept of crowd control in game live streams has been subject to current research [192, 193].

Games like Octodad: Deadliest Catch [352] and TrackMania Turbo [223] demonstrate that shared control over one single character is also applicable to smaller groups of players. However, the positive response of players

1 http://twitchplayspokemon.org/
2 http://blog.twitch.tv/announcing-the-twitch-plays-game-category-55149935ad79

to the pattern of shared control in general raises questions regarding the motivation of players and their resulting player experience. The sharing of control over a single game character constitutes an extreme situation in terms of interdependence between players and often the resulting gameplay is rather chaotic. As already discussed in the last chapter, shared control may reduce perceived autonomy and competence, especially if several players input contradicting commands and the result is not what was intended. According to SDT, such an experience can interfere with game enjoyment. The reason why people still engage in shared control games like Twitch Plays Pokémon might be the social aspect of the experience such as an increased sense of relatedness. Findings reported in Chapter 4 indicate that high interdependence can, furthermore, foster social presence. Hence, shared control games seem to be capable to induce highly interesting and motivating social experiences. An imbalance of player experience dimensions due to limited autonomy and competence apparently does not necessarily impair game enjoyment. Hence, it is promising to further examine the concept of shared control and the related interplay of different aspects of the player experience.

The following work contributes a systematic approach in this context. It arose from the Master's thesis of Philipp Sykownik, which was written under my supervision. The following text is based on our collaborative paper *Exploring Patterns of Shared Control in Digital Multiplayer Games* [295]. The text of the published paper was adapted to the structure of this thesis to focus on the main findings: We provide a classification of different forms of shared control in digital games, which points out the wide range of design possibilities. Based on that, we developed a shared control testbed game with four different game modes and applied it in a comparative study. Results provide insights into how different forms of shared control can influence need satisfaction and game enjoyment. This work is supposed to inform researchers and game designers interested in designing compelling social experiences based on the concept of shared control.

5.1.1 *Towards a Classification of Shared Control*

Shared control can intuitively be understood as a game control mode, in which players collectively control game characters. However, the possibilities to implement shared control are manifold. Therefore, we argue for a more precise definition and suggest a systematic categorization of shared control patterns based on the review of commercial games and the related literature.

As already indicated above, shared control can be implemented either by giving all players control over all existing game characters or by enabling player to control one single character simultaneously. The game Lego Star Wars [304], for instance, provides a pool of several characters between which players can actively switch, as long as the desired character is not controlled by someone else at that moment. Thus, players have to collaboratively coordinate who should control which character. In contrast, in the game TrackMania Turbo [223] two players share control over a single character: they can control the speed and direction of the same car simultaneously, as their inputs are averaged.

Yet another form of shared control is introduced in the game Octodad: Deadliest Catch [352]. Here, up to four players can collectively control one single character as well, but their control is distributed among the extremities of this character. This way, every player has control over a distinct part of the main character (e.g., left leg), whereas the overall movement is directly dependent on the input of all players.

In this context, it is important to note that not all games are avatar-based. Some games provide no living characters but objects as player representation (e.g., cars in TrackMania Turbo [223]) and other games such as Tetris [234] do not have any explicit player representation at all. Since it should not be important what type of player representation is collectively controlled, a neutral term should be used to prevent discussion on shared control from being biased against a specific type of player representation. A term that ensures this independence from types of representation is *locus of manipulation* (LOM). The LOM is defined as the "in-game position of the player's ability to assert control over the game-world" [16]. In other words, any perceptible in-game instance that proves a player's manipulation of the game world. In the context of shared control, it can thus be differentiated whether players share control over a mutual LOM (e.g., complete control over one game character) or over several distinct LOM (e.g., different characters or different body parts of one character).

The work of Loparev et al. [205] points out, that, besides the type of shared LOM, another aspect to consider regarding shared control is the timing. Players can either share control by a mechanic of control alternation (like the traditional gamepad passing), or they can have simultaneous control. In alternating control modes, only one player has control at a moment and players switch between phases of active control and passive participation.

Based on the distinction between alternating and simultaneous control and the concept of LOM, we propose a classification of shared control types as depicted in Figure 10. Shared control is basically defined either as the sharing of distinct LOM, or as the sharing of a mutual LOM (Figure 10 type a and type b). Within these two types, several variations are imaginable that differ regarding timing and the related degree of player interdependence.

5.1.1.1 *Shared Control of Distinct Loci of Manipulation (a)*

Sharing the control of distinct LOM describes a game control mode in which each player of a multiplayer game controls at least one LOM that is not simultaneously controlled by another player.

By varying the degree of simultaneous player interdependence, two specific implementations of sharing distinct LOM are imaginable as the extremes of a continuous dimension. The part a1 in Figure 10 illustrates the lower end of this continuum, a pattern that is implemented for example in Lego Star Wars [304], where each player controls a distinct character, with

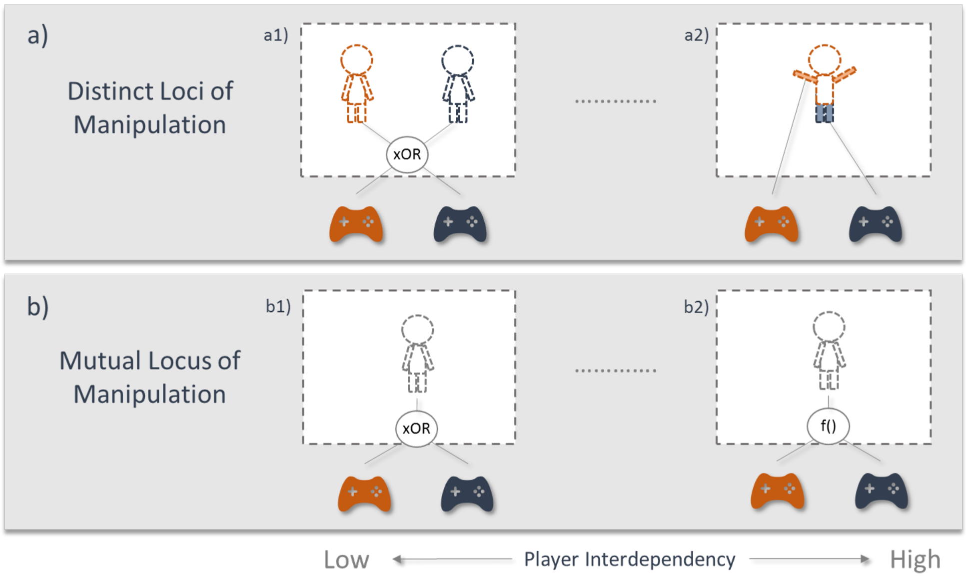


Figure 10: A classification of shared control modes in digital games: a) Players share two distinct LOM. b) Players share a mutual LOM. Based on this differentiation, several subtypes can be defined taking into account different degrees of player interdependence: a1) Sharing control of distinct LOM through control alternation. a2) Sharing control of distinct LOM that establish a coherent entity. b1) Sharing control of a mutual LOM by control alternation. b2) Simultaneous control of a mutual LOM through an automatic input processing function to merge all inputs.

the possibility to switch between various shared characters. This reflects a low degree of player interdependence, since players are able to manipulate the game world rather autonomously through their individual LOM. Nevertheless, they are not completely autonomous, because they cannot simply switch to an LOM that is controlled by another player. This type of shared control was implemented in our first study on shared control discussed in Chapter 4.

A high degree of player interdependence is illustrated in Figure 10 part a2, where each player indeed controls a distinct LOM, while their LOM establish a coherent entity that disables them from acting completely autonomously. This control pattern is for example implemented in Octodad: Deadliest Catch [352], where each player controls a limb of the protagonist and individual opportunities to manipulate the game world significantly depend on the other players' actions.

5.1.1.2 *Shared Control of a Mutual Locus of Manipulation (b)*

Sharing a mutual LOM describes a shared control game mode, in which at least two players control the same main LOM at the same time.

Again, a variation of player interdependence by varying the timing can lead to two extreme implementations of this pattern. On the one hand, there is sharing a mutual LOM with low player interdependence as illustrated in Figure 10 part b1, where control alternates between players. Players who are not in control have no other LOM to control, but have to wait until control alternates again. This pattern is implemented, for instance, in the WeGame's *sequential* mode [205].

Figure 10 part b2 illustrates a high degree of player interdependence, where players simultaneously control a mutual LOM. In this mode, players give commands at the same time and all input have to be processed by the system and merged into one final reaction. Hence, the resulting manipulation depends on a specific processing function that defines how the individual parts of collective input are represented in the final manipulation. For example, in TrackMania [223], the direction of player inputs is averaged, resulting in a combined movement direction . In contrast, in WeGame's *legion* mode [205], individual player inputs are weighted based on their similarity to the other players' inputs. Hence, the final command that does not equally represent all incoming inputs.

5.1.1.3 *Further Variables in Designing Shared Control*

Our classification of shared control as visualized in Figure 10 points out four main types. However, games can feature hybrid forms of these types as well. Hence, they are not meant to be exclusive.

Additionally, certain design aspects of shared control allow for further variation. The alternation of control can be varied by the sequence of alternation (*who will be the next player in control?*), the frequency of alternation (*when does control switch to the next player?*), and the use of feedback mechanics (*can players see the duration of control?*). Simultaneous forms of shared control could differ between their implemented input processing function (*how are individual inputs merged?*), the transparency of individual contributions (*can players see the others players' inputs?*), and the enforcement of collective input (*do all players have to input something?*).

5.1.2 *Shairit - A Shared Control Testbed Game*

The shared control game Shairit was developed to systematically evaluate the differences in terms of player experience of different types of shared control. The game includes just one LOM and features four different control modes, which represent varying degrees of player interdependence. Hence, all modes can be categorized on the continuum of sharing control over a mutual LOM (see Figure 10 part b).

Shairit is a four-player collaborative local multiplayer game played on a shared screen. All players share the control over a single LOM that is represented as a white sphere (see Figure 11). Throughout 13 levels players have to collect several orbs by navigating the sphere. The source of conflict arises from different types of cubes that have to be used or bypassed to reach the orbs. Touching yellow cubes destroys the sphere and the level is restarted. White cubes can be moved or jumped on to reach all orbs.

The game is controlled by Xbox One gamepads, utilizing only two or three input modalities of it, depending on the control mode. Players nav-

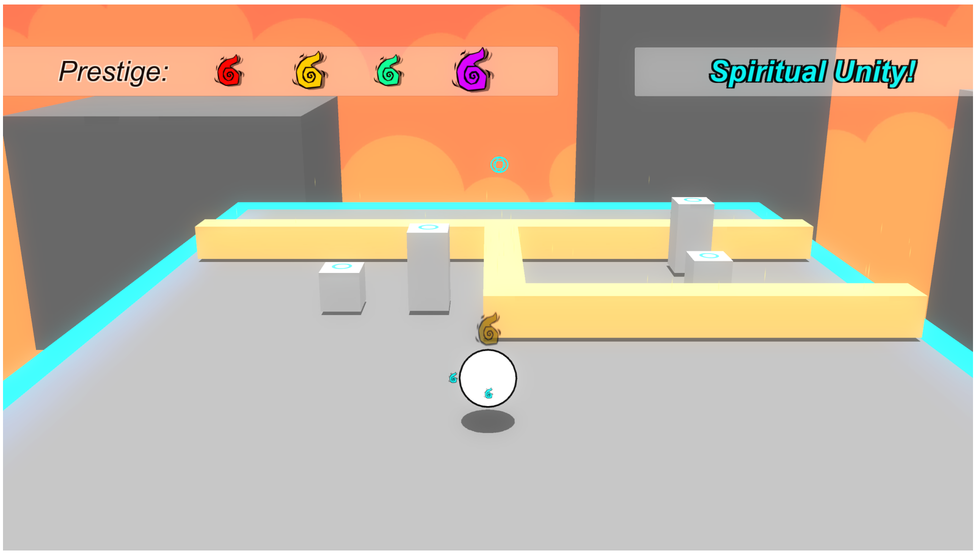


Figure 11: In Shairit players have to collect all turquoise orbs in each level. This screenshot shows the alternating control mode with high player interdependence. To reach the orb in the back of this level players have to get over the yellow cubes by jumping from white cube to white cube.

igate the sphere with the left analog stick and jump by pressing "A". The shoulder button is used to conduct special actions in two of the modes.

5.1.2.1 *The Four Control Modes of Shairit*

As stated above, in all four game modes of Shairit players share a single LOM and differ in terms of timing and the degree of player interdependence. The four modes include two modes with alternating control and two modes with simultaneous control, each combined with high or low interdependence, respectively.

- Alternating control modes

  In the alternating control modes, control over the sphere alternates between players, which refers to the pattern shown in part b1 of Figure 10.

  M1) **Alternating-Low:** Alternating control with low player interdependence

  In the alternating control mode with low player interdependence, control over the sphere alternates every five seconds between players in a fixed sequence. To indicate which player has control over the LOM, player-specific icons appear above the sphere (see Figure 11). Interdependence is assumed to be rather low, because individual actions do not directly affect each other.

  M2) **Alternating-High:** Alternating control with high player interdependence

  The alternating control mode with high player interdependence alternates control in randomized order every five seconds. Due to the randomized order, players cannot anticipate the next active player and consequently should pay more attention. Furthermore, interdependence is increased by a voting system. It allows players who are not in control to vote for the currently controlling player. If the active player receives votes from all others, he is granted another time frame of control, in which players can vote again. Thus, the mode allows players to manipulate the control sequence. As in the Alternating-Low mode, icons above the sphere visualize which player currently has control. Additionally, it indicates the remaining control time by slowly vanishing (see Figure 11).

- Simultaneous control modes

  In the simultaneous control modes, players simultaneously control the sphere, which reflects the pattern shown in part b2 of Figure 10.

  M3) **Simultaneous-Low:** Simultaneous control with low player interdependence

  In the Simultaneous Control mode with low player interdependence, players can navigate the sphere simultaneously. Their input values are averaged each frame and processed into a combined movement direction. This input processing can lead to situations, where diametrical inputs do result in no movement at all. Player interdependence is assumed to be rather low (but higher than in the alternating control modes), because the mode does not require collective contribution to win the game. Theoretically a single player could play and master the game alone, if the other players refrain from giving any input. Thus, collective input actually increases the difficulty.

  M4) **Simultaneous-High:** Simultaneous control with high player interdependence

  Simultaneous Control mode with high player interdependence allows players to simultaneously navigate the sphere, and additionally requires collective input to overcome certain obstacles in the game. This is caused by a special input processing function that increases movement speed for each player who conducts input. Thus, if only one player is giving input, the sphere is moving with just one fourth of its maximum speed. Consequently, this mechanic is assumed to induce high player interdependence.

5.1.3 *Evaluation of the Shared Control Modes of Shairit*

The game Shairit was used to systematically evaluate the player experience induced by its different implementations of shared control. Therefore, our investigation was guided by the following question: Do different shared control modes induce different player experiences in terms of enjoyment, need satisfaction, or social presence?

5.1.3.1 *Study Design*

To answer our research question, we used a between-subject design with four study conditions in accordance with the four game modes of Shairit. Hence, the form of shared control serves as independent variable. As dependent variables, we assessed diverse dimensions of player experience including enjoyment, need satisfaction, and social presence.

5.1.3.2 *Procedure and Measures*

The study was conducted under controlled conditions in our laboratory at the university of Duisburg. As the game is designed for four players, participants were required to participate as groups of four people. Participants could either directly register as groups of acquainted people, or as singles that were organized to form a quartet by the examiner. All groups were randomly assigned to one of the four study conditions.

First, participants were asked to individually complete a pre-play questionnaire that assessed demographic data as well as their experience with digital games ("no experience at all" (1) to "highly experienced" (5)), and their familiarity ("stranger" (1) to "close friend" (5)) with each other as potential confounding variables. After that, the examiner explained the game's objective, rules, and control principle. Then participants had to play all 13 levels consecutively. The game was projected on a wall via beamer and players sat on a sofa during play, using wireless Xbox One gamepads to control the game. As such, the laboratory provides a rather homelike atmosphere for the multiplayer setting. The examiner sat in the back and did not interfere in gameplay unless being asked direct questions. If progress in a level stagnated for more than five minutes, the examiner offered the opportunity to skip the current level. On average, the game was completed in about 20 minutes and only few groups had to skip the most difficult level. Conclusively, participants completed a post-play questionnaire that assessed their player experience in terms of enjoyment, need satisfaction, and social presence.

As a measure of enjoyment and intrinsic motivation the corresponding subscale of the IMI [49, 261] was applied. The subscale consists of seven items that have to be rated on a 7-point Likert scale (e.g., "I enjoyed playing Shairit very much"). The PENS [254, 263] was applied to assess levels of psychological need satisfaction. On three subscales it refers to the satisfaction of *competence* (PENS-C), *autonomy* (PENS-A), and *relatedness* (PENS-R). Furthermore, the subscale *intuitive control* (PENS-IC) was included in the study, because it seemed adequate to evaluate how far shared control as a control pattern is perceived as intuitive. The PENS asks participants to reflect on their player experience when playing Shairit and to rate all items on a 7-point Likert scale.

Finally, the experience of social presence and the perceived quality of the social interaction between team mates was assessed by the Cooperative Social Presence (CSP) subscale of the CCPIG questionnaire [138]. It is designed for the evaluation of collaborative digital games and is divided into

Table 7: Descriptive statistics regarding the distribution of age (*M (SD)*), gender, familiarity (*M (SD)*), and game expertise (*M(SD)*) among condition groups.

	Alternating		Simultaneous	
	Low	High	Low	High
	(*N* = 24)	(*N* = 32)	(*N* = 19)	(*N* = 19)
Age	25.38 (3.29)	21.03 (2.62)	22.11 (3.07)	25.32 (3.73)
Gender	14 male	4 male	8 male	14 male
	9 female	27 female	11 female	5 female
Familiarity	2.83 (1.53)	3.56 (1.31)	2.79 (1.44)	2.95 (1.25)
Expertise*	3.71 (1.04)	2.31 (0.93)	2.95 (1.18)	4.00 (1.00)

* significant differences between certain groups were found

the two dimensions *perceived team cohesion* and *team involvement*. Team cohesion represents the level of perceived effectiveness and successful collaboration of the team. Team involvement refers to the degree of involvement, investment, and dependency in a team. The questionnaire asks respondents to indicate their agreement with each statement on a 5-point Likert scale.

5.1.4 *Results*

In sum 96 subjects (24 groups) participated in the study. However, data of two participants was excluded from the analysis due to incomplete data sets. Hence, the final sample includes 94 participants (40 male, 52 female, 2 prefer not to say). Age of participants ranged from 18 to 33 years (M = 23.22, SD = 3.67). Participants were students recruited at the university, who received certification of participating required for certain lectures.

The distribution of participants among study groups and corresponding mean scores of their attributes age, gender, game expertise, and familiarity is presented in Table 7. The distribution of male and female participants among the conditions is notably unequal and will be considered when controlling for potential confounding effects of game expertise and familiarity. For all following analyses, preconditions for parametric procedures were tested in advance. In case of violated assumptions of normality or homogeneity of variances, corresponding non-parametric tests were applied. If relevant, further assumptions of methods are specified in the following.

5.1.4.1 *Differences Between Conditions*

In order to test if groups differ in terms of the player experience, analyses were conducted to compare mean values regarding enjoyment, need satisfaction, and social presence. All mean values can be found in Table 8.

In general, scores for enjoyment (IMI) tend to be rather high in all groups. A Kruskal-Wallis test shows no significant difference between the groups (χ^2 (3) = 5.017, p = .16). Mean scores for perceived competence (PENS-C)

Table 8: Mean values and standard deviations regarding all investigated dependent variables in the four study conditions. Bold values indicate significant group differences based on pair-wise comparison.

	Alternating		Simultaneous	
	Low	High	Low	High
	(*N* = 24)	(*N* = 32)	(*N* = 19)	(*N* = 19)
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
IMI	5.35 (1.19)	5.21 (1.29)	4.63 (1.60)	5.58 (1.20)
PENS-C	4.46 (1.56)	4.13 (1.68)	4.25 (1.49)	5.00 (1.35)
PENS-A	3.43 (1.19)	4.08 (1.23)	4.02 (1.45)	4.32 (1.34)
PENS-R	3.96 (0.97)	3.98 (1.15)	3.40 (1.35)	4.12 (1.16)
PENS-IC*	6.01 (1.12)	**5.76** (1.04)	6.18 (0.75)	**6.53** (0.60)
CSP-TC*	4.10 (0.57)	**4.28** (0.63)	**3.73** (0.82)	4.31 (0.47)
CSP-TI	4.23 (0.49)	4.27 (0.44)	3.66 (0.93)	4.23 (0.45)

* significant differences ($p < .05$) between certain groups were found

are all moderately high and highest in the Simultaneous-High condition. Autonomy (PENS-A) means are also moderately high except for a medium score in the Alternating-Low condition. Scores for relatedness (PENS-R) are rather moderate in all conditions, with the Simultaneous-High mode showing the highest score. To test the significance of these descriptive group differences in need satisfaction, analyses of variance were conducted. Results indicate that the type of game mode had no main effect on perceived competence (F (3, 90) = 1.36, p = .26), autonomy (F (3, 90) = 1.94, p = .13), or relatedness (F (3, 90) = 1.48, p = .23).

Control (PENS-IC) was perceived as highly intuitive in each mode, as illustrated in Table 8. Only control of the Alternating-High mode tended to be rated as less intuitive compared to other modes, but still high in general. A Kruskal-Wallis test was calculated to compare measures of intuitive control between groups. The test indicates that there is an overall significant difference (χ^2 (3) = 9.21, p = .027). Post hoc Dunn-Bonferroni tests reveal that players experienced higher intuitive controls in the Simultaneous-High condition than in the Alternating-High condition (z = 3.02, p = .015). All other pairwise comparisons are not significant.

Social aspects were investigated by comparing scores of the CSP subscale of the CCPIG for perceived team cohesion (CSP-TC) and team involvement (CSP-TI). Mean scores for both dimensions are lowest in the Simultaneous-Low condition, as compared to rather high means in the other three conditions. A Kruskal-Wallis test partly validates this descriptive impression and reveals a significant difference between groups in terms of team cohesion (χ^2 (3) = 8.34, p = .04). According to a Bonferroni post hoc analysis participants perceived a significantly lower degree of team cohesion in the Simultaneous-Low condition compared to the Alternating-High condition

(z = -2.674, p = .045). Contrarily, a Welch ANOVA shows no main effect of game mode on perceived team involvement (F (3, 43.55) = 2.37, p = .084).

5.1.4.2 *Controlling for Gender, Game Expertise, and Familiarity*

As indicated by our research model (cf. Chapter 3), both game expertise and familiarity of players are factors that might have affected perceived need satisfaction and the social experience. To investigate whether these aspects have influenced the analysis of group differences, we included them in our analysis as potential confounding variables. Hence, we tested for preconditions and assumptions of an analysis of covariance. For both variables, we analyzed group differences and associations with dependent variables in each group.

In terms of mean familiarity, differences between groups are not significant according to a Kruskall-Wallis test (χ^2 (3) = 5.204, p = .16). To check for a potential confounding effect, associations between familiarity and the dependent variables were investigated based on scatterplots and Pearson's r. We assumed a linear relationship, if scatterplots and correlation coefficients indicated a linear association. Familiarity is only significantly correlated with relatedness in the Simultaneous-High condition (r = .486, p = .035) and with team cohesion in the Alternating-Low condition (r = .623, p = .001). Since a systematic linear relationship between familiarity and the dependent variables in all conditions is a main precondition for the analysis of covariance, it can be concluded that familiarity seems to have no general confounding effect on the dependent variables in our study.

The distribution of gender and game expertise among the four study groups is rather uneven as indicated by mean values (see Table 8). Both aspects seem to be closely related. An independent samples t-test reveals a significant difference between male and female participants in terms of game expertise (t (90) = 8.61, p < .001), indicating that men had significantly more experience in playing digital games (M = 4.05, SD = .845) than women (M = 2.4, SD = .955) in our sample. Correspondingly, a one-way analysis of variances shows a general significant difference between the four study conditions regarding the reported expertise (F (3, 90) = 14.06, p < .001). Dunn-Bonferroni post hoc tests indicate that participants in the Alternating-High condition, which also is the group with the smallest number of male players (4 males, 27 females), reported significantly less game expertise than participants in the Alternating-Low condition (p < .001) and in the Simultaneous-High condition (p < .001), which are the two groups that contained considerably more male than female players.

To control for potential confounding effects of game experience on our dependent variables, correlations between game expertise and those variables were examined. Pearson's r values and scatterplots show only two significant correlations: game expertise is positively correlated with competence in the Alternating-High (r = .381, p = .032) and the Simultaneous-Low condition (r = .545, p = .016). Thus, the assumption of a linear relationship between the potential covariate game expertise and the dependent variables in each condition is violated. Accordingly, no further analysis of covariance for game expertise was conducted, as no confounding effect is indicated.

5.1.5 *Discussion*

Generally, playing Shairit proved to be an entertaining experience. This conclusion is justified by the reported high enjoyment scores as well as by observations made during the gaming sessions. Consequently, it can be stated that shared control can provide an enjoyable experience not only as an extension for existing singleplayer games (as was done in the work of Loparev et al. [205]), but also as a core mechanic of gameplay.

5.1.5.1 *All Shared Control Modes Provide a Positive Experience*

The shared control modes of Shairit provide high levels of enjoyment and, furthermore, do not differ significantly from each other in terms of player experience as measured by IMI and PENS. Therefore, the implemented patterns of shared control seem to induce an entertaining player experience equally well. This qualifies each of them as a recommendable multiplayer game mechanic.

Further, we suppose that the entertainment value of Shairit is indeed a result of the interdependence between players that is established by the sharing of control, as Shairit's entire game design is focused on the requirement of coordinating the collective control or the alternation of individual control. Hence, there are no other game mechanics that could be additional sources of game enjoyment (such as special abilities, story, or customizing).

5.1.5.2 *High Experienced Intuitiveness of Controls*

Interestingly, players reported high perceived intuitiveness of control for all game modes. This is surprising, because we assumed that players could be confused by the input processing on the game system side, especially in the simultaneous modes. In these modes, the resulting movement of the sphere may not correspond to a player's individual input and, moreover, the same individual input may result in different outcomes in different situations due to the dependency on the other players' inputs. This is supposed to reduce predictability and comprehensibility of input outcomes. However, perceived intuitiveness was not lower compared to the alternating control modes, and very high in general. Hence, the loss of individual control did not impair ease of control, but rather seems to be acknowledged as an essential part of the game challenge by players, as was intended. Moreover, it has to be noted that—despite the novel input processing—Shairit features a rather simple input interface that only requires players to control the analog stick and one or two buttons.

The significant difference found regarding perceived intuitiveness of control between the Alternating-High group and the Simultaneous-High group may be caused by differences in players' game expertise. Though we did not find a general confounding effect of game expertise on players' experience, it is noticeable that the Simultaneous-High group had significantly higher values in both game expertise and perceived intuitive control. Participants who are used to video game controls may have had less struggle to adapt to the novel input scheme compared to rather inexperienced participants. Hence, we conclude that the four different forms of shared control are not perceived as differently intuitive by players with comparable game expertise.

5.1.5.3 *No Differences in Need Satisfaction*

We did not find any significant differences regarding need satisfaction between the four game modes. Hence, the variation of the shared control pattern (alternating control vs. simultaneous control) does not affect the overall player experience induced by the game. Our findings invalidate our initial concern that loosing exclusivity of control (particularly in the simultaneous modes) automatically undermines perceived autonomy and competence. To the contrary, a detailed look at the results reveals that Shairit tends to provide moderately high levels of competence and autonomy satisfaction, independent of the control pattern. Maybe these needs were not primarily addressed by the game itself, but rather by the social processes induced by it. For instance, it can be a source of competence and autonomy satisfaction if a player takes on a leading role in team coordination, something that was previously reported by Rozendaal, Braat, and Wensveen [259].

Thus, a lack of in-game mechanics that foster individual feelings of competence and autonomy might be compensated by social processes. Additionally, team success and the impression of team competence is supposed to influence the individual experience of competence, as well. Thus, being successful as a team in a highly interdependent task may contribute to the impression of one's own competence. Interestingly, scores of relatedness satisfaction tended to be lower than scores of competence and autonomy. This contradicts the initial assumption that the social experience plays a more essential role in shared control settings than individual feelings of competence or autonomy.

5.1.5.4 *Necessary Collaboration May Foster Team Cohesion*

For a more in-depth investigation of the social dynamics during gameplay we also compared feelings of cooperative social presence. In sum, the scores for team cohesion and team involvement were high in all groups and support the assumption that team-related experiences are an essential part of the player experience in shared control games.

However, team cohesion was significantly lower in the Simultaneous-Low mode than in the Alternating-High mode. This difference can be explained by looking at the items of the corresponding team cohesion scale. Team cohesion includes aspects of effective team communication, goal-sharing, commitment to work together, and feeling like being a part of a team. By comparing the control mechanics of the two modes, it becomes apparent that the Simultaneous-Low mode does not require players to work together, or to participate at all. Players do not have to communicate with each other or be equally committed to the game's goal in order to succeed. In contrast, in all other game modes progress is negatively affected if individual players decide to refrain from participating. Given that team cohesion was rather high in all other modes, we suppose that the Simultaneous-Low mode in general tended to foster less feelings of team cohesion than all other modes.

Although no significant difference was found regarding the degree of team involvement, a detailed look at the means and standard deviations of team cohesion and involvement reveals that both dimensions tend to be experienced in a similar manner. Issues of the data distribution (a lack of normal distribution and variance homogeneity) and the resultant use of different tests may have caused one dimension to differ significantly and the other not. This inconsistency should be addressed in future evaluations of the modes. Support for assuming that team involvement could actually differ in the same way as team cohesion can be found in its operationalization. Since it reflects the individually experienced cognitive investment to and dependency from one's team mates, we would again argue, that the Simultaneous-Low mode failed to foster such experiences as sufficiently as the other modes, due to the fact that it does not enforce cooperation.

Comparing items for relatedness and the CSP scales indicates that they represent different qualities of sociality in games. Relatedness is supposed to assess the building of emotional relationships. In contrast, CSP scales focus more on the functional aspects of relationship building with regard to the game's goals and challenges. Consequently, we suggest to consider both instruments in studies of social play to gain a more comprehensive insight into the social dynamics during gameplay.

5.1.5.5 *Highest Scores for the Simultaneous-High Mode*

In sum, it is notable that the Simultaneous-High mode tend to induce the highest scores regarding nearly every examined facet, indicating that it may be well balanced in terms of potential advantages and disadvantages of shared control regarding social and individual experiences. Additionally, compared to the other modes it probably represents the most consequent and intense implementation of shared control. Thus, our results validate the value of this interaction pattern, even if it seems unintuitive at first glance.

5.1.5.6 *The Influence of Familiarity and Game Expertise*

In our evaluation we controlled for degrees of familiarity and game expertise. We investigated whether they systematically influence potential main effects of our experimental manipulation on the player experience. Since the degree of familiarity probably determines the quality of social interaction between players, we expected familiarity to impact the extent to which our game fosters social player experience. Interestingly, our results did not indicate a systematic confounding effect of familiarity. However, significant correlations between familiarity and relatedness, as well as familiarity and team cohesion in some modes indicate that strangers and friends may experience different qualities of sociality in certain control modes. Probably most surprising is the lack of an association between familiarity and enjoyment, which emphasizes that shared control sufficiently induces an entertaining experience independent of group composition in terms of interpersonal relationships.

Besides familiarity, we assessed game expertise because we expected it to represent players' experience with diverse game mechanics and controls. We assumed that it may determine to what extent they are able and willing to adapt to novel interaction patterns. Hence, participants with more expertise are supposed to adapt faster to the game context of shared control than inexperienced players, allowing them to experience higher need satisfaction, particularly in terms of competence.

Game expertise significantly differed between some groups. This may be related to the unequal distribution of male and female participants, who differed in their reported game expertise. Nevertheless, inconsistent associations between game expertise and player experience contradict a systematic influence of game expertise on potential main effects of our experimental manipulation. In fact, game expertise was only found to be positively associated with competence satisfaction in the Alternating-High and the Simultaneous-Low condition. These correlations can be intuitively interpreted. Since in the Alternating-High mode players could vote for other players, it is reasonable to expect less experienced players voting for more experienced players in order to overcome difficult passages. Accordingly, more experienced players would have increased time of control and thus more opportunities to feel competent. Similarly, in the Simultaneous-Low mode experienced players could simply take over control if a challenge becomes too hard (while the other players do not provide any input). Hence, despite not systematically influencing need satisfaction in our different shared control settings, correlations between game expertise and competence in certain modes indicate that game expertise may influence competence satisfaction if opportunities to withdraw from or to overtake control are provided. Since game expertise was not correlated with enjoyment, neither, the evaluated shared control patterns seem to be enjoyable for experienced and inexperienced players likewise.

5.1.5.7 *Limitations*

Some limitations have to be mentioned regarding the experimental evaluation of our game Shairit. Since our four study groups included different numbers of participants, the validity of our statistical analysis may not be optimal. We accounted for that in specific cases by choosing adequate test statistics, but lastly analysis would benefit from equal sample sizes.

Though familiarity and expertise did not have a confounding effect in our study, we still suggest to consider them as potential influences that have to be controlled for and further examined in future studies. Studies focusing their effects should include a systematic manipulation of those variables by deliberately assembling player groups beforehand to test different constellations of players and compare their experiences and interactions. Moreover, we recommend to think about more sophisticated ways of assessing players' familiarity and expertise. As it was not the focus of our study, we measured both aspects by simply asking players to rate their game expertise and familiarity with their co-players on a custom scale. These subjective scales may have been interpreted very differently by participants (e.g., "close friend" might mean different things to different people). In sum, subjective assessment and unsystematic distribution of experienced and inexperienced as well as familiar and unfamiliar participants could have affected our findings.

Moreover, we investigated shared control in just one game. Whereas this bespoke setting allowed us to implement different types of shared control and investigate them under controlled conditions, findings are limited to similar game concepts. It has to be considered that other game genres may trigger different forms of social interaction and offer distinct design spaces that require other implementations of shared control to create a good game. Given the fundamental differences between shared control and traditional game control, we decided not to include a control condition in our analysis (comparing shared control to a common individual control pattern). Nevertheless, comparability of the two concepts can be further examined.

5.1.6 *Conclusion: The Potential of Shared Control*

As the evaluation of our shared control game Shairit has proven, it sufficiently provides an entertaining experience. The complex interplay of specific degrees of input enforcement, exclusivity of control, and visibility of individual contribution is supposed to shape the social player experience and is worthwhile to be investigated in future analyses. The different implementations of shared control evaluated in our study provided equally high levels of enjoyment and need satisfaction and none of them did significantly interfere with individual experiences of competence and autonomy. Hence, our work emphasizes the potential of shared control patterns for developing innovative, compelling, and highly social games.

At first glance, the results of this study seem to contradict the findings regarding shared control of the study presented in Chapter 4. In that study, a shared control mode was compared to a game mode with traditional distinct character control and was found to decrease perceived competence and autonomy. As there was no control group featuring a game mode without shared control mechanics in the Shairit study, we cannot determine whether autonomy and competence would be higher in such a mode as well. Game developers should, thus, still pay special attention to the individual need satisfaction of players in shared control games. However, in both studies mean values of perceived autonomy and competence were satisfactorily high in the shared control conditions, indicating that these factors are no general weak points of shared control. This is supported by the fact that in all shared control modes players experienced high enjoyment and fun, and this experience was not higher in the distinct control mode of the first study.

Moreover, it has to be noted that Shairit's control modes all differ from the shared control mode implemented in the study in Chapter 4: with reference to our classification (cf. Figure 10), players in Shairit always share control over one mutual LOM (the white sphere), whereas in the other game players shared four distinct and independent LOM (the four different blocks). It is possible that the latter type of shared control is less favorable in terms of player experience than the sharing of a mutual LOM. We observed that players of Shairit appreciated the shared control technique as the main game challenge and as an entertaining social experience, whereas players in the other study did sometimes not even make use of their ability to switch between all characters. The experience of sharing a common resource was less clear in the latter case. Further research is needed to systematically compare such game modes to examine this assumption. To support game designers and researchers alike, we provided a comprehensive classification of types of shared control, that is supposed to guide and expand game design approaches of future collaborative multiplayer games.

5.2 investigating second screen gaming

Our studies regarding shared control patterns have demonstrated that different forms of player input in mutliplayer settings can change the social experience. In the following, we also consider the other side of the game interface: the output devices. Traditionally, multiplayer games are either played on one shared screen (e.g., in co-located living room settings) or with each player having an own display (e.g., in online gaming settings). However, a combination of several screens can be implemented as an innovative gaming setting that allows for new gameplay mechanics. This approach is followed by recent developments in the games industry: In 2012, Microsoft announced the introduction of Xbox SmartGlass. This companion application allows connecting a mobile device to the game consoles Xbox 360 or Xbox One. Players can then use their mobile device as a remote controller to enhance interaction with the console, or as a second screen, which displays additional content while watching TV or playing games. In a similar way, some games are enriched by specific companion apps which offer additional gameplay features. Examples are the companion apps for Watch Dogs [314], Tom Clancy's The Division [212], and Beyond: Two Souls [241]. Such apps allow direct game interaction and transform the player's mobile device into an alternative controller, as well as a second screen.

Nintendo's Wii U game console released in 2012 provides players with a second screen in addition to the TV display, which is integrated into the special Wii U gamepad. The two screens can show different information or views on the game world and the gamepad display can either be a shared resource or a private screen for one player. The *PlayLink* games series for the PlayStation 4 console, which started in 2017, also focuses the integration of second screens: players can connect their smartphones and tablets and use them both as private screens and input devices.

My colleague Stefan Liszio and I investigated the potentials and challenges of second screens as an upcoming gaming setting during a one-year research project[3]. We presented our findings 2014 at the International Conference on Advances in Computer Entertainment Technology and in the corresponding paper *Defining Second Screen Gaming: Exploration of New Design Patterns* [87]. The following text is extracted from that publication and adapted to this thesis. In the following, we define second screen gaming and smart gaming, and discuss challenges and design opportunities.

5.2.1 *Defining Second Screen Gaming*

In order to consider the concepts of second screen gaming from a scientific point of view, it is first necessary to give a proper definition of the term. In contrast to common digital gaming scenarios, which usually include one display (PC monitor, handheld device, or TV screen) and one or multiple control devices, second screen gaming refers to the idea of adding one or more additional displays. Further, the additional displays can be either external or added to the gaming control device itself. The resulting new setting and constellation of devices offers a plethora of possible applications from simply adding additional information, over dynamic and situation-depended controls, to fully integrated game design features. Thus, we define second screen gaming as a field of game design solutions, where more than one screen is used to display game content. Although interesting singleplayer designs are imaginable in second screen scenarios, second screen gaming particularly allows for highly dynamic social experiences and is, hence, mainly considered in the context of multiplayer games in the following.

5.2.2 *Smart Gaming as a Special Type of Second Screen Gaming*

We further want to define *smart gaming* as a special game setting which implements the idea of second screen gaming by including smart mobile devices. Smart devices are active, digital and networked entities, which can operate autonomously with control over the resources needed, e.g. personal computers, mobiles phones or tablet PCs. Furthermore, these devices are characterized as being mobile and multi-functional [239]. In this work, we narrow the definition of smart devices to the subset hand-held devices, meaning especially smartphones and tablet PCs. Labeled as smart gaming, we introduce a constellation of hardware in a gaming context, in which each player interacts with the game using a smart device. As it is a main characteristic of these devices to feature a touch display, they act as both a game controller and private screen. In addition to these private devices,

3 This research was carried out within the context of the European Regional Development Funds (ERDF) co-founded operational program for North Rhine-Westphalia "Ziel 2 – Regionale Wettbewerbsfähigkeit und Beschäftigung" (2007-2013).

another public display, for instance a TV screen, is included to the game scenario as a main screen. By setting up a constellation of hardware like this, it is possible to create console-like game experience without the need for additional special hardware. In the following section, we will focus on Smart Gaming as a special form of Second Screen Gaming and illuminate different design aspects, as well as challenges and opportunities for game designers in this novel category of games.

5.2.3 *Design Patterns in Smart Gaming Settings*

As already mentioned, introducing one or more additional screens to the gaming environment can be done in very different ways. Smart gaming scenarios can differ regarding the integration and use of the smart devices as well as their relation to the public display. Pointing out the design opportunities is supposed to inform game designers about how they can best benefit from the smart gaming concept for designing engaging, innovative games. We thus introduce several kinds of functions that the second screen device can feature.

5.2.3.1 *Mere Control Device*

First of all, the smart devices can be used as mere control devices: input of the touch screen, of the acceleration sensor, or of the absolute position transducer can be mapped to certain game actions, for example the motion control of an avatar. However, if the display of the device is not supposed to show any game content, or just presents control interfaces like buttons, this kind of usage of the smart device does not fully correspond with the idea of smart gaming as stated above.

5.2.3.2 *Duplicated Screen*

In contrast, one possibility of actually integrating a smart device as a second screen into a gaming scenario is to simply replicate the content of the public screen. In this case, all screens show exactly the same game content and feature the same perspective. Nevertheless, this does not necessarily mean that all players can interact in the same way with the game environment. They may have distinct roles or abilities, and different input mappings.

Although these first two forms of second screen implementations are respectable and may contribute to the fun of certain games, they do not yet tap the full potential of the innovative setting. One unique characteristic of second screen gaming is the opportunity to present different aspects on distinct displays. Again, there are several possibilities to implement this feature as shown in the following.

5.2.3.3 *Additional Non-Secret Information*

The second screens can be used to show additional information that cannot be found on the public screen. The content of the second screen can be the same for all players, for instance a map of the surrounding game environment can be displayed. In this case, the main benefit is to enable the organization of different game information and to support the clarity of the graphical user interface on all screens.

5.2.3.4 *Different Information*

The feature of additional information becomes more complex considering the fact that it is also possible to display different information on the private screens of the players. This information can be considered as secret information, because only the owner of the display can access it. The resulting asymmetric information distribution allows for the introduction of different player roles and adds a considerable social component to the game: By spreading different information among players, for instance different personal goals, assignments, abilities, or knowledge about the game world, social processes such as bluffing and bragging are triggered. Hence, novel strategic elements can be included in the game concept.

5.2.3.5 *Different Perspectives*

Thinking further in the direction of different information, the second screens can also support the implementation of completely different player perspectives. There can be several points of view on the game world, for instance if players' avatars are present in different locations or have different abilities to observe the game world. Thereby, opposed player roles can be emphasized.

5.2.3.6 *Different Game Mechanics*

A second screen setting even facilitates the combination of different game mechanics, resulting in different player actions. For instance, one player may take the role of a soldier in the style of a first person ego shooter, while another player becomes a commander, who has to make strategic decisions and sent certain combat units to support the soldiers (cf. *Battlefield 4* [80]). While these are completely distinct player actions, which demand own controls and strategies, they both fit the theme of the game and thus complement each other well. In this way, it is possible to support several playing styles and preferences in one game, offering more opportunities for action and participation than usual. The feature of different game mechanics and perspectives can also be used to enable spectators to join a running game session and enabling them to indirectly influence the game, for example by adding user-generated content or manipulating the game world while the main players are interacting within it.

5.2.3.7 *Conclusion: The Degree of Embeddedness*

The main difference between the presentation of the same additional information for all players and the implementation of distinct private information or perspectives is the importance and embeddedness of the second

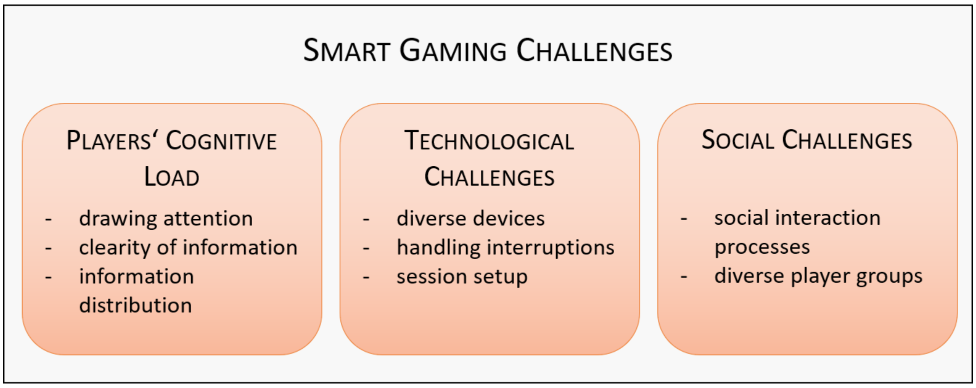


Figure 12: The design challenges related to the smart gaming approach can be categorized into three main topics: (a) players' cognitive load, (b) technology, and (c) social challenges.

screen feature for the overall gameplay. In the first case, the second screen serves more as an additional feature, whereas in the latter case, it is necessary for the gameplay to work, and thus becomes an integral part of the game. We argue that particularly those games which address the opportunities of second screen gaming as a key feature of game design can tap the full potential of the setting. The implementation of different perspectives, player roles, actions, and information allows for novel innovative game ideas and, hence, may become a unique selling point. At the same time, it is very challenging to develop such games, because the uneven distribution of information and abilities results in asymmetric game designs, which demand sophisticated balancing and well-conceived game concepts (cf. [2, 104]). Simply adding second screens as a selling feature without thinking about ways to interweave setting and game design reasonably is insufficient and there are many potential pitfalls, as the rather minor success of current approaches on the market demonstrates. Thus, we illuminate the special challenges that have to be faced in more detail and illustrate possible strategies to overcome them in the following section.

5.2.4 *Design Challenges*

While the smart gaming setting offers a wide variety of novel game design opportunities, there are also several new challenges to be met resulting from its unique characteristics. We identified three main categories of challenges, which have to be considered when designing games in this context: design challenges regarding players' cognitive load, challenges regarding technology, and social challenges (see Figure 12).

5.2.4.1 *Players' Cognitive Load*

In second screen settings, players are confronted with more than one screen and, thus, have to switch their focus of attention between them. The result is a higher cognitive load, which may significantly impede information-processing (cf. Cognitive Load Theory [294]). This negative consequence is also dependent on the degree to which a player is overwhelmed by the amount of information presented on both screens and by the degree of uncertainty about which screen displays the currently important information and, thus, should be focused. If information processing is impaired and a game requires quick reactions and complex input at the same time, the player is probably unable to cope with the situation. Consequently, the player will experience frustration or anger and is supposed to have a negative game experience. Hence, the challenge for game designers is to guide players' attention smoothly and to support their information processing.

We provide the following recommendations to avoid unnecessary strain of players. First, it is important to reduce the complexity of game content and information that is displayed on the screens. Important pieces of information—particularly those which have to be assessed and processed quickly—have to be clear, in focus, and dominant, so that they strike the eye as soon as the player looks at the screen. This allows players to quickly check on relevant aspects without having to scan the whole screen. Besides, attention should be paid to a comprehensible and consistent organization and structure of the graphical interface, which means that certain kinds of information (e.g., a status bar) should always be displayed in the same place so that the player can easily learn where to find it. Similar information should be clustered and presented on the same screen.

In order to reduce uncertainty about on which screen players should focus their attention during the game, it is recommended to implement special attention cues. Sound effects and speech output are particularly suitable to indicate the availability of new information or relevant changes, as acoustic cues do not depend on the current focus of the user. Furthermore, regarding the structure of the game, a game session can also be split into different temporary phases, each clearly being linked to one of the two screens, so that players just have to change their focus in the event that a new phase starts.

One related aspect is information distribution. It has to be carefully considered which player receives which information. As described in the previous section, it can be a core game element to provide different players with distinct information units. In this case, it has to be ensured that players are aware of this concept and do actually understand why some aspects are intentionally withheld from them. They need to recognize what kind of information they are faced with (private or public) and which value is associated with it. Besides, it is important to thoroughly balance the game in case of asymmetric information distribution and to make this feature as transparent as possible; otherwise, players may feel unjustly treated.

5.2.4.2 *Technological Challenges*

Technology challenges refer to the setup of a game session and the consequences resulting from the use of smart devices. The first thing to keep in mind is that there is a broad range of smart devices out there, varying with regard to screen size, processing power, operating system, features, and integrated sensors. Accordingly, care has to be taken that the game runs stably and smoothly on different devices irrespective of their inherent capabilities. Only by this means, it can be guaranteed that players are not excluded due to unsuitable hardware. This consideration also affects the decision which features of the smart device should be utilized in the game. The integration of new technological functions such as near field communication can lead to exceptional new game mechanics and experiences, but at the same time reduces the amount of applicable devices. In such cases, it is necessary to weigh the costs and benefits of such a feature carefully with respect to the overall game experience.

Furthermore, game designers have to ensure that the characteristics of the devices, such as the size of its display, do not significantly influence certain properties of the game, for instance the level of difficulty or the chance to win. The possession of a specific device must not be detrimental or advantageous compared to other devices. Accordingly, the challenges of the game should be independent from device properties wherever possible.

In contrast, a property most devices have in common is the relatively short battery service life. This may be obvious but is nontrivial, as it effects design decisions regarding the complexity of the game as well as the constitution of game sessions. Sophisticated graphics and complex game logic computations demand a lot of resources and processing power. Hence, the complexity should be reduced. Additionally, short game rounds forestall the risk that a battery runs dead during the session. Another technical aspect, which also indicates that the duration of one game round should be rather short, is the fact that smart devices usually serve other purposes than gaming. Especially smartphones are used for mobile communication and, thus, incoming calls or instant messages may interrupt the game. The game should include corresponding strategies for handling such interruptions, for example the automatic pausing of the game on all connected devices.

Finally, as smart gaming is a rather new form of gaming and supposed to support spontaneous and straightforward play, the setup (meaning the connection of all devices and the start of the game) has to be as uncomplicated as possible. Users should not be bothered with details about server-client-connections, that is to say the connection process should be preferably fully automatic. This allows for an easy entry and prevents frustration and the loss of motivation. Besides, if a player wants to exit the game, this should be as simple as the process of joining. In a multiplayer session with more than two players, the leaving of one player does not necessarily have to result in the termination of the complete game. Ideally, the game system is able to handle the change in the group of players and to permit the remaining players to seamlessly continue playing.

5.2.4.3 *Social Challenges*

Social challenges relate to the multiplayer setting and the diverse social processes and experiences that can result from it. As soon as more than one person is involved in the game—which probably is the case in the majority of smart gaming settings—the playing session becomes a social situation. In such situations, the game experience is supposed to be significantly influenced by the interaction between the persons who take part in the playing session. My research model of social player experience shows that this social interaction is a complex process evolving from the interplay of player characteristics, game design, and the context (cf. Chapter 3). That implies that game designers may influence social processes to some degree by certain game design decisions, as was already shown in our two studies presented earlier.

Hence, during the design process, intended social performances should be considered in order to work out strategies how to trigger them by game elements and events. For instance, by assigning different player roles a game defines the relationships inside the game world, thereby also provoking certain social processes such as bluffing, bragging, and trash talking in competitive settings or team building, construction of shared awareness, and helping in collaborative games [26, 278]. At the same time, aspects have to be avoided which may foster unwanted interactions such as harassing or emotional contagion of negative emotions.

Another social challenge is the diversity, which might be present in the group of players. Due to the fact that the smart gaming setting is supposed to attract a lot of different people without focusing on one special target group, the participants of one gaming session may differ significantly regarding gender, age, and expertise. Consequently, players in one gaming session may make different demands of the game concurrently, for instance, experienced players may be bored by a level of difficulty that is perfectly matching the abilities of novices or does even overstrain them. While this challenge is hard to meet completely, several strategies are recommended to address the basic problem: First of all, it is possible to introduce different player roles with differing properties, representing several playing styles or levels of experience and difficulty. Furthermore, players may be given the opportunity to individually adjust game aspects like the level of difficulty or pace. This can also be automatized by implementing algorithms for dynamic difficulty adjustment, which take into account the current performance and behavior of a player.

5.2.5 *The Potential of Second Screen and Smart Gaming*

The previous sections illustrated that designing compelling second screen games is a challenging task. However, with the design patterns and possible pitfalls in mind, it is possible to create innovative and highly social games. Especially the use of smart devices allows the creation of console-like gaming situations, where no other hardware is needed than what we all have in our pockets nowadays. This easy setup and the resulting low priced possibility to play digital games with friends are supposed to appeal to a wide range of potential users. In addition, consoles are usually closed systems and scientific or independent game development is not supported.

In contrast, developing for mobile platforms like Android or iOS is open source by nature.

The smart gaming setting is particularly beneficial for innovative multiplayer game concepts. Due to the manifold design patterns (e.g., the possibility to provide single players with secret pieces of information or different perspectives on the game world), all imaginable kinds of player interaction patterns from "team vs. team" to "all vs. one" can be implemented (see Chapter 3, section 3.3.2.2 for a detailed overview of social interaction patterns). More precisely, second screen gaming supports team building, secret communication, bluffing, as well as the development of common and private strategies and is, thus, supposed to intensify the social experience.

Moreover, smart gaming bears the potential of customizability and adaptability. Since each player is equipped with a private controller and screen, it becomes possible to personalize the game experience for individual players easily. Hence, even larger groups of diverse players are able to play together irrespective of differences regarding expertise and abilities. For instance, it is possible to adapt certain game mechanics dynamically according to the in-game performance and behavior of single players. Thereby, the game experience for players of different gender, age, and expertise can be enhanced [50]. In addition, the game interface and controls can be configured manually or even dynamically adapted to the players' taste or physical and cognitive conditions [183, 325]. In the following, we present three game concepts, which were developed to explore the possibilities and advantages of smart games. Each of these games is a case study that demonstrates different aspects of this novel type of games.

5.2.6 *Three Case Study Games*

Based on our considerations regarding the variety of design possibilities and challenges, we designed and implemented three game prototypes, each integrating the smart gaming setting in different ways. The prototypes demonstrate an exemplary constellation of hardware, featuring multiple smart devices are connected to another device, which serves as a game host. In the three case studies, the host device is a tablet PC or notebook, which is connected via HDMI to a large TV screen. Anyway, with the upcoming of SmartTVs it is imaginable to run the game application directly on the TV.

5.2.6.1 *Catch a Thief*

The first game prototype we developed is the multiplayer casual game Catch a Thief (see Figure 13). In this game one player is in the role of a security guard whose task it is to protect the art treasure of a museum by catching thieves. All other players are thieves and try to capture as many of the goods hidden in the exhibition rooms as possible. On their private screens, the players can see everything that belongs to the room they are currently located in, while on the main screen a complete map of the mu-

Figure 13: Screenshots of the multiplayer smart game Catch a Thief. The TV screen shows the complete map of a museum, but only players on the public corridor are visible. The content of the rooms is hidden. The private player screens show the part of the museum where the individual player is currently located and also reveal what is inside the current room.

seum is displayed. However, the public map does not show the content of the rooms; instead, only a corridor that connects the different rooms and players how are crossing this corridor are visible. Hence, the players have to observe the main screen to figure out the security guard's position and to avoid being caught red-handed. The security guard, on the other hand, can use the main screen to see which rooms are entered by the thieves. The thief who captures the highest amount of goods wins the game. If a thief is caught, he loses everything and starts again with an empty bag. The thieves can save their values by leaving the museum, but if they have done so, they cannot enter it again. Thus, they have to estimate how much art treasure the other thieves have captured. If all thieves are caught at least once, the security guard player wins.

The game demonstrates how the second screen setting can be integrated into game design as a main part of the gameplay. The different screens are used to distribute different player roles and private information. The active gameplay is mainly focused on the private screens. However, the main screen is an important source of information regarding the location of the other players. Players are supposed to switch their attention from one screen to the other, when they plan where to go next.

From a technical perspective, Catch a Thief is a cross-platform game that allows multiple players with smart devices to connect and play together locally via WiFi. It is possible to combine devices with different operating

Figure 14: Impressions from our booth at the CeBIT exhibition 2014.

systems, and the connection is managed by the game application to keep it simple for the users. Additionally, it is possible for new players to join the game ad hoc - that means, while a current game session is running. This is supported both by the technical implementation and by the game design. We have demonstrated the easy setup and game entry by exhibiting the game at the CeBIT 2014 in Hannover (as part of the communal booth of the Ministry of Innovation, Science and Research of the German State of North Rhine-Westphalia). Impressions are provided in Figure 14. During this exhibition week, diverse player groups tested the game and provided feedback regarding our game design and the smart gaming setting in general. Most visitors had fun while playing the game and no problems to control the game by different devices (smartphones, tablet PCs). The innovative game setting was appreciated and many persons reported that they could imagine playing games that use this setting in the future.

5.2.6.2 *Data Theft Algorithm*

The casual game Data Theft Algorithm is designed for up to eight players and addresses the current debate about data security and digital spying. Players each take the roles of a special algorithm and have to navigate through a data stream and in doing so collect data objects that appear on the screen. The algorithms can be controlled by using the gyroscope of the players' smart devices.

Besides serving as an intuitive control device, the second screen is used to display private information about the current ranking of the players and the availability of special abilities, while the main game including the representation of the game world, player avatars, resources, and game events is only displayed on the public screen (see Figure 15). Hence, most of the time players have to focus on the rather fast-paced real time happenings on the public screen. Due to that, the information on the second screens is kept very simple and visualized by big symbols in order to be easily recognizable. Additionally, acoustic cues are played each time there is a change of information that might be of interest for the player. This way, players

Figure 15: Screenshots of the multiplayer smart game Data Theft Algorithm. The TV screen shows the main game elements and game events in real-time, while the private player screens display secret information regarding the individual player status.

get a hint when they should switch their attention to their private screen. Furthermore, we implemented a special game feature that is supposed to guide the attention of players by structuring the game session: One level consists of so-called "data waves", meaning time phases in which new data objects enter the screen, and short periods of rest when no collectible objects are available. These kinds of pauses on the public screen are expected to enable players to concentrate on their private screens and to check the status information displayed there, without being concerned to miss any important game events.

Apart from this focus on attention guidance, Data Theft Algorithm is also aimed at investigating the social interaction among players that is associated with certain game elements and the social experience that arises while playing. It is supposed to foster certain social interaction patterns like the formation of alliances and bluffing by its uncommon winning conditions: In this game, there is not necessarily only one winner. In fact, players are categorized into two groups at the end of a game session, the winners and the losers. Accordingly, there may be one or several winners. Hence, every player can decide whether he wants to play alone against the others or forge an alliance with another player.

Figure 16: Screenshots of the multiplayer smart game The Mole Rush. The larger TV screen shows the entire game world. The two players need to explore the world to find hidden boxes and tunnel entries that are displayed on the main screen only for a short time.

5.2.6.3 *The Mole Rush*

The game The Mole Rush is a two-player game, in which both players take symmetric roles. They both control a mole that is searching for resources in the ground by touching their private smart device (see Figure 16). The game was developed to demonstrate how the individual game experience for diverse players can be enhanced by making the game dynamically adapt to the players' in-game performance and behavior. The game world and mechanics are independently adjusted in order to balance players of unequal gaming skills and expertise.

To classify the game into the design patterns suggested early, the game implements the feature of different information. The players have to collect boxes and find tunnel entries hidden in the ground. Everything in the ground is visible on the player's private screen, while the main screen shows the entire game world. Every time a new box appears, it is visible on the main screen for a short amount of time. The player who collects a maximum number of boxes at first wins the game. Thus, when a box is displayed on the main screen, the players have to remember the position of the box and try to be the first reaching it. Accordingly, it is necessary to keep the eyes on both screens. To guide the player's attention, several textual, haptic (vibration), and audio cues are implemented.

5.2.7 *Conclusion: Second Screen Gaming as a Social Play Setting*

Our analysis of the possible design patterns and challenges of second screen gaming demonstrates that this setting can create interesting social experiences. Classic co-located gaming settings usually only contain one big public screen that is shared by all players. By adding private screens, the whole social dynamic can change. As demonstrated in our three case studies, game mechanics that are based on the distribution of information can trigger interesting social interactions. Players may be encouraged to hide information from the others or even deceive their co-players to reach their goal in competitive games. In collaborative games, different individual information can create a need to communicate and, thus, foster players' social interaction.

If players have different perspectives on the game world due to distinct player roles, they may also be eager to understand the other players' views, roles, and intentions. One challenge that has to be met in this context is that players can have very different foci of attention during play. Hence, players have to find efficient ways to discuss certain aspects of the game, for instance if they want to hint to certain locations or point the other players' awareness to a game event.

Our research on second screen gaming is supposed to support the establishment of a common terminology and to raise awareness for the related challenges and opportunities regarding innovative game designs. In the context of this thesis, we can conclude that second screen gaming is a good example to demonstrate how the interface configuration of the game can frame the social player experience.

5.3 CHAPTER CONCLUSION: THE IMPACT OF GAME INTERFACES

In this chapter, the potential impact of the interface configuration of a multiplayer game on players' social experience was demonstrated by investigating two exemplary aspects: shared control and second screen gaming. Our research points out that both game aspects can be used to create player interdependence and increase the social experience if designed carefully. Shared control is an input pattern that particularly fosters communication and coordination of players, because they need to develop a common control strategy. Without having the same intentions and sharing the same ideas, players will probably fail to align their actions and reach their goal.

Second screens, on the other hand, extend the common output interface. This, as well, can influence the social dynamics between players if the setting is combined with certain game design aspects. Game designers can create uncertainty by asymmetrical roles and information distribution, thereby allowing social game strategies such as bluffing or secret alliances. Hence, the output interface as such may not be the trigger of social impact, but opens the design space for unique game mechanics that can affect the social interaction and experience.

In conclusion, the analyses in this and the prior chapter support the assumption made in my research model of social player experience (cf. Figure 4) that game aspects are one factor that can significantly frame the interaction and experience of players.

6 DEVELOPMENT OF SOCIAL GAMEPLAY METRICS

Studies in the previous chapters took a look at specific game aspects and investigated their influence on the social player experience by varying their implementation. The effect on players was assessed using a variety of measures, mostly in form of questionnaires and observations. In all of our studies, we also used to log gameplay data to gain insights into the way players actually play the game. Such data can include information regarding players' performance and progress (e.g., points, level completion time, number of deaths), the actions they perform (e.g., using items or special abilities), and the game events that are triggered during play (e.g., activating a trap). This way, gameplay metrics can reveal general usability issues of the game or provide explanations for certain player experiences. For instance, if players die repeatedly at the same point, the situation might be too difficult and the ongoing failure might be reflected in high reported frustration in post-game self-reports. Though screen capture can support the analysis of in-game behavior, interpreting this material is a time-consuming task, just like the analysis of video records of players. At this point, automatically logged gameplay metrics present a compelling alternative.

Gameplay metrics provide some advantages over other methods such as self-reports or biometrics, because they

- can be applied without disturbing the player (who might not even be aware of the fact that measurement takes place),
- can be applied over a distance in a real-life playing setting (players do not have to come to a laboratory, but players can just easily play the game at home with friends connected over the internet),
- and provide objective data about player actions.

However, as already pointed out in Chapter 2, gameplay metrics are currently rarely used to measure social aspects of gaming. As digital games are often played in social contexts, social phenomena and processes are an important part of games user research and supposed to have significant impact on the overall player experience. Therefore, we explore the potential and applicability of gameplay metrics to assess social behavior and interactions of players in multiplayer games in this chapter. The aim is to add to the opportunities of assessing aspects of social play by using social gameplay metrics, thereby extending the spectrum of available measures without trying to replace existing ones.

The work described in this chapter is based on the paper *Game Metrics for Evaluating Social In-game Behavior and Interaction in Multiplayer Games* [89], which was presented at the International Conference on Advances in Computer Entertainment Technology in 2016.

6.1 CONCEPTUALIZATION OF SOCIAL GAMEPLAY METRICS

Social play consists of various dimensions and elements and is, thus, difficult to measure. However, we suggest that gameplay metrics offer the possibility to identify indicators and behavioral patterns of the social behavior of players inside the game. Logging in-game communication and interaction of players can support our understanding of players' social experience.

To be able to assess social aspects via gameplay metrics, it has to be considered which game events and metrics provide related information. Hence, one main challenges of developing social gameplay metrics is to identify the relevant data that allows drawing conclusions about the social experience. Aspects that have been investigated before are grouping patterns, persistent relationships, and the use of social gestures in the MMOGs World of Warcraft [29] and Star Wars Galaxies [323] [77, 78]. In contrast, we wanted to focus social aspects that apply to smaller player groups and specifically aim at the relationship between players as it is reflected in their in-game behavior.

Hence, we picked out three exemplary concrete social aspects to attempt the development of respective gameplay metrics for multiplayer games: *social presence*, *cooperation*, and *leadership*. As this is a first approach aiming to find out whether such social concepts can be automatically measured by gameplay metrics, the developed metrics are intentionally rather uncomplex and supposed to lay the foundation for more sophisticated metrics in subsequent work. Furthermore, the metrics are not directed to a certain game genre in order to be more generic and flexible regarding application. However, they do indeed make assumptions about some game design aspects, which are defined as prerequisites for the metrics to be applicable, namely that the players are represented by avatars (for the social presence metric), that the game offers cooperative player actions (for the cooperation metric), and that there is a predefined path players have to follow or a predefined order of actions to take place (for the leadership metric).

6.1.1 *Social Gameplay Metric 1: Social Presence*

As described in Chapter 3 in detail, social presence is often considered as one key element of social play and as a main part of the social player experience. Being a complex concept itself, social presence can be further subdivided and measured in terms of certain subdimensions, as it is done in existing questionnaires that address social presence (e.g., the SPGQ [359]). However, the main prerequisite for social presence to evolve is the fact that one player perceives that another player is actually part of the play situation, which we call a sense of co-presence.

Co-presence can be fostered by different aspects. Research suggests that even the mere belief that one is playing with another human player in online settings elicits a sense of social presence [47, 108, 197]. This sense is supposed to be increased if the other player is also visible, either in real-life or as an avatar on the screen. Accordingly, we propose that a very simple version of a social presence gameplay metric can assess the amount of time in which one player's avatar is visible on the other player's screen, as a visual indicator of co-presence. It is presumed that the more often a player sees the other player's representation, the higher are feelings of social presence. Hence, this is the first metric that we developed and evaluated.

It is admitted that this metric does not at all account for all impact factors of social presence. As explained earlier, it is meant to provide a good starting point for the development of social gameplay metrics. Later revision of this metric should also include auditory indicators of co-presence, like the amount of verbal communication between players. Furthermore, it can be enriched by identifying certain player actions that are supposed to express emotions or can be interpreted as communicative acts, such as gestures performed by the avatars. Moreover, if players perform actions that attract a lot attention (e.g., due to striking visual animations), such moments could be weighted stronger than the mere presence of the player's avatar.

6.1.2 *Social Gameplay Metric 2: Cooperation*

As the second social aspect of player interaction we address cooperative behavior and investigate how it can be assessed with gameplay metrics in collaborative games. Cooperation between players is characterized by supportive actions in order to achieve the game's goals. Cooperative behavior is usually reciprocal and aimed at a win-win condition for all cooperating players [353]. It can be distinguished between necessary and voluntary cooperation. If the game includes necessary cooperation, players who do not work together will not be able to win. In contrast, voluntary cooperation is characterized by the fact that it does not offer significant benefits for the one who helps the other.

In terms of players' in-game behavior, cooperation can take various forms. A typical interaction pattern showing cooperation between players is the construction of shared awareness [326], for instance by using pings to give the other player some hints or advise. Moreover, players can directly help each other by performing supportive actions. Examples for such actions are healing the other, sharing resources, and protecting the other by eliminating threats. In this context, the willingness to help another player can also be influenced by external factors of the social play context such as the player's personality or the real-life relationship between players. Thus, some players show supportive behavior, although it might lead to disadvantages for themselves in terms of game achievements and performance. Such behavior has been observed during play sessions, and was described as selfless decisions [353] or self-sacrifice [326].

Our social gameplay metric for cooperation is similarly simple as the social presence metric and generally accounts for all possible types of cooperative behavior in games. To achieve a score for the degree of cooperation, the metric simply counts the number of cooperative actions a player performs. This way, the result is one main score for cooperative behavior. Of course, for this metric to be applicable, it has to be defined which player actions have to be interpreted as being cooperative. This is, however, specific to the game in which the metric should be applied. We suggest to identify cooperative actions based on the characterization of cooperation as stated above and give some concrete examples in the testbed game of our study described below. Moreover, in order to allow for some differentiation of the value of actions, the metric can distinguish between small cooperative gestures (e.g., giving a hint) and severe cooperative support (e.g., saving the other or sacrificing oneself) by counting the latter twice. Of course, this could be refined in future revisions of the metric by integrating further gradations.

6.1.3 *Social Gameplay Metric 3: Leadership*

The third aspect we wanted to investigate are the social power dynamics between players in terms of leading and following behavior. In cooperative games, often one player is more dominant and coordinates the team, resulting in leadership behavior. In general, the term *leadership* has very different connotations depending on the context. Here, we use it to describe the tendency that one player takes the lead in a cooperative game: the player significantly influences the behavior of another player by determining a certain course of actions. In this case, the other player aligns his/her behavior to the one in the lead. This adaptation can be both voluntary or forced.

Reeves and Malone [248] have investigated the aspect of leadership in games and found that the Sloan Leadership Model, which is an approved model regarding the characteristics of successful leaders and their behavior, does also apply to digital multiplayer games. The model defines four main capabilities needed for effective leadership:

- sensemaking: identifying and understanding different sources of information
- relating: understanding the perspectives of others and being able to express own views
- visioning: planning the future and being able to describe such visions
- inventing: leading and supervising the team's progress and inventing new ways to reach goals

According to Reeves and Malone [248], these features are also shown by players in games and, thus, can be used to identify the leaders of the gameplay. It was also found that games by design often enforce the forming of leadership structures, while at the same time the role of a leader is usually not static, but on the contrary fluctuates quite rapidly and often depends on the current game task [248].

Based on these insights, leadership behavior in games can be derived from the four core capabilities of the Sloan Model and defined as concrete actions that can be measured by a metric. Accordingly, a leader in a game

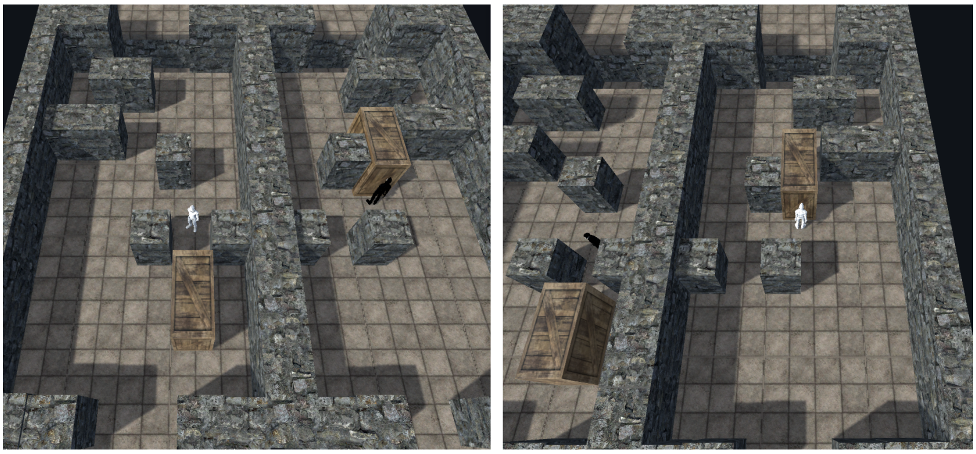


Figure 17: Screenshots from a scene of the first level of the testbed game, showing the screens of player one (left) and player two (right). The respective own avatar is displayed in white, the other player's avatar in black.

gives instructions, explains situations, finds new ways and strategies, and takes the lead on a path or the first action in uncertain situations. Hence, our social gameplay metric for leadership is comparable to the metric for cooperation in terms of functionality: every activity that is defined as leadership behavior is counted and summarized in a leadership score. It can also be distinguished between actions with low impact (e.g., suggesting a strategy) and actions with high impact (e.g., forcing a player to perform a certain behavior), being weighted differently respectively. It has to be noted that verbal communication can also be used to show leadership behavior. In case that verbal communication is possible, this should also be accounted for.

6.2 Implementation of the metrics in a testbed game

In the last section, we introduced the theoretical concepts of three social gameplay metrics. The next step is to implement these metrics in a game and test them in practice regarding their applicability, validity, and explanatory power. In order to be able to validate whether the metrics properly assess aspects of social game interaction and player experience, a testbed game was developed. This game includes three levels, each implementing one of the three metrics.

6.2.1 *Testbed Game Design*

We implemented a simple 3D cooperative two-player platformer game with the Unity3D game engine, which can be played online by two remote players. Each player is represented by an avatar that is always focused by the camera, so that both players have distinct third-person top-down views on the game, although they are located in the same area (see Figure 17). The main goal of players in this platformer game is to reach the end of the three levels together by solving puzzles (e.g., sliding blocks to clear the way as shown in Figure 17), overcoming obstacles (e.g., big rolling rocks), and mastering dexterity tasks (e.g., jumping over platforms). Players can interact with certain objects in the game world such as boxes and switches, which constitute puzzles blocking the way. Moreover, players have to pay attention not to fall into gaps and avoid traps. If a player walks into an obstacle or trap, the avatar respawns at the last checkpoint.

The controls are kept simple and easy to learn in order to be suitable for inexperienced players in the short playing session within the scope of a study. There is no opportunity of verbal communication between players, as direct communication is supposed to influence social interaction in general and feelings of social presence. This may interfere with the testing of the metrics—especially the one regarding social presence—and is therefore excluded.

This basic game setting allows for all three metrics to be integrated and tested. Three distinct levels were designed, each dedicated to one of the metrics. This way, each metric can be tested separately and interfering effects are avoided. Accordingly, every level was designed with respect to one of the metrics and, thus, contains specific game elements that are shortly described below.

6.2.2 *Level 1: Focus on Social Presence*

The first level aims at investigating social presence. To create situations with different expected levels of social presence, we implemented two variations of this first level. The basic idea is that feelings of social presence are supposed to increase if players see each other on screen, and that varying the possibility of seeing each other during the level will lead to different results in experienced social presence.

Hence, in the first version of the level, the ways that both players have to take through the level are separated by a wall, but close together so that most of the time players see each other running through the game (see Figure 18, left side). This way, players can observe each other, but not interact. To ensure that players do not move apart from each other for too long if one player is faster in overcoming all obstacles than the other, several gathering gates were integrated into the level design: at such gates, both players have to stand on a switch to open a door, otherwise they cannot proceed.

In the other version of the level, players see each other at the beginning, but then their paths run in different direction and they lose sight of each other for the rest of the time. Except from their closeness, the ways both players have to overcome in this level are designed completely equal in terms of obstacles and puzzles, so that there is no other difference than the one regarding visible co-presence of players on screen. Figure 18 gives an overview of the level structures for both versions.

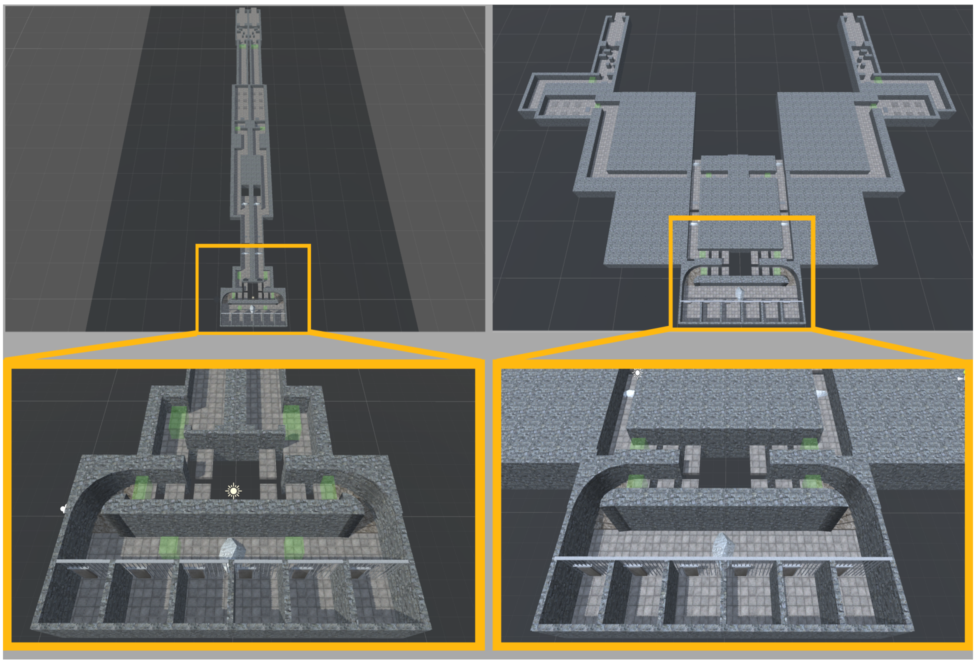


Figure 18: Complete overview of the map of level 1 in the two variations (top left: close paths; top right: separated paths) and a detailed zoom on the beginning of the level (bottom).

6.2.3 *Level 2: Focus on Cooperation*

The second level of our testbed game is focused on cooperative behavior and does not exist in different variations but is designed in a way that players are encouraged to show cooperation. Both players walk on the same path together, hence they see each other most of the time and do not have separate paths. A special feature of level 2 is that there is a timer and players are told that they should try to go through the level as fast as possible, because the fastest players will be rewarded at the end of the study.

Based on that time goal, there are some game elements that are supposed to trigger cooperative behavior integrated in this level or at least give players the opportunity to behave supportive and selfless. First, there are little hourglasses scattered over the level that can be collected by the players. The one who collects an hourglass receives a time bonus of 10 seconds, thus giving players a better chance to win the overall time contest. However, a player can decide to not collect an hourglass when passing it, donating the bonus to the other player. This cooperative behavior is motivated by the fact that the value of the item increases and the second player receives a doubled time bonus. However, it has no direct advantage for the one who acts cooperatively. Every time an hourglass is reached but not collected, the player's cooperative metric score is increased. Besides, at some points of the level players can decide to activate switches that open shortcuts for the other player or grant the other access to enclosed hourglasses. Those actions increase the cooperative score as well, as they are not beneficial for the player who performs them, but on the contrary are linked to a loss of time while he/she waits for the other.

6.2.4 *Level 3: Focus on Leadership*

Similar to level 2 and in contrast to level 1, there is also just one version of level 3. The third level is designed to provoke and measure leadership behavior. Accordingly, it includes game elements that force one player to take the lead, but also allow for a switch of roles all the time during the level. Both players use the same path and navigate through the level as a team. However, the path is small and contains several narrow passages where one player has to go first while the other one waits. In order to determine which player shows leadership behavior, there are invisible checkpoints on the path and every time one of those is reach for the first time, the respective player triggers an event that is registered by the leadership metric as leadership behavior.

Furthermore, some puzzles are designed in a way that players have to take two different roles: one player can take the position in which the progress is controlled, while the other player just has to react to the actions and decisions of the leader. Accordingly, taking the first role leads to an increment of the leadership score. Finally, players also have the opportunity to "ping" the other player by placing a visual sign on the map to advise the other to go to a certain position. Every time a player uses this feature, the player's leadership score is also increased.

6.3 EVALUATION OF THE SOCIAL METRICS

The implemented testbed game was used to test our three social gameplay metrics in a laboratory study. To investigate whether the metrics are valid and provide valuable information about the social in-game behavior of players, we applied several self-report measurements to enable a comparison and first validation of the metrics.

6.3.1 *Method: Procedure and Measurements*

For each session, participants were invited in pairs to our lab at the university and directly separated by distributing them among two adjacent rooms. After being informed about the study procedure and the game's controls, participants were asked to play the testbed game against the participant in the other room. By playing in separate rooms, it was ensured that participants did not see each other and could not communicate (neither verbally nor non-verbally) except from their interactions inside the game.

According to the three levels of the game, the study consisted of three main parts, each dealing with one of the metrics: level 1 with social presence, level 2 with cooperation, and level 3 with leadership. Before each level, participants received a short introduction about the goal of the level, its specific rules, as well as special features. After each level, there was a pause and participants were asked to fill in a respective questionnaire about their player experience. As there are two variations of level 1, participants were randomly assigned to one of the versions, hence half of the pairs played the first level in the *high visibility* condition (the paths of both players being close together) and the other half played the *separated* condition (most of the time not seeing each other on screen). During all gaming sessions, the examiner waited outside the rooms to avoid any social influence by his presence.

The three main dependent variables social presence, cooperation, and leadership were quantified by means of our three social gameplay metrics directly during play. Additionally, these aspects were measured by questionnaires in order to be able to compare results and validate the metrics. Hence, the SPGQ [142, 359] was used to assess social presence on the three subdimensions empathy, negative feelings, and behavioral engagement. Regarding cooperation and leadership, there were not standard questionnaires available fitting the case of application, as most related work assesses those concepts as personality traits but not as characteristics of current behavior. Therefore, we compiled two sets of custom statements that all have to be rated on a 5-point scale ranging from "does not apply" to "totally applies".

Six questions addressed the cooperative behavior of the players (inverse items marked with i):

1. I supported the other player to reach a better time result.
2. For me, reaching the best time myself was most important. (i)
3. I tried to drop the other player hints that helped him/her to perform better.
4. I felt needed.
5. The other player supported me to reach a better time result.
6. The other player dropped me hints that helped me to perform better.

The last two items account for the other player's cooperative behavior and do not reflect the own cooperation. Hence, the overall cooperation score for each player is calculated as the mean of the self-reports of the first four items combined with the other player's responses to the last two items. The result is thus based on both self-evaluation and external assessment regarding shown cooperative behavior.

Perceived leadership and dominant behavior was measured by twelve items that referred to both the player's own dominant behavior and the other player's bearing (inverse items marked with i):

1. I decided what to do.
2. I allowed myself to be led by the other player. (i)

3. I significantly influenced the result of the game session.
4. My actions were dependent on the decisions of the other player. (i)
5. I better understood what to do than the other player.
6. I influenced the other player.
7. I took the initiative.
8. I waited for the other player to do something. (i)
9. I felt other-directed. (i)
10. The other player decided what to do. (i)
11. The other player took the initiative. (i)
12. The other player had significant influence on the result of the game session. (i)

Based on all items, a mean value was calculated for each player as an indicator for leadership.

After playing all three levels, participants had to fill in a final questionnaire including questions about socio-demographic data and about their relationship to the other player to get to know whether the two players were friends, acquaintances, or strangers. Furthermore, in order to account for possible interfering effects related to an insufficient usability or quality of the game itself, both the system usability scale (SUS) [37] and the core module of the GEQ [142] were applied. The SUS assesses aspects of usability and learnability. The term *system* was replaced by *game* in each item in order to better fit the application context. The GEQ addresses different facets of the subjective player experience on the seven subscales *immersion*, *flow*, *competence*, *positive* and *negative affect*, *tension*, and *challenge*. Finally, participants were debriefed and thanked for participation.

6.3.2 *Results*

In total, 38 participants (21 females) aged between 19 and 34 years ($M = 24.3$, $SD = 3.47$) took part in the study resulting in 19 pairs who played the game together. Most participants were students from the local university. 14 pairs were acquaintances, while the other five were strangers.

6.3.2.1 *Usability and Player Experience*

Results of the SUS reveal that the game was rated positively regarding its usability ($M = 81.76$, $SD = 11.90$), distinctly exceeding the average score of a usable system of 68 points as stated by Brooke [38]. Mean values of the GEQ (measured on a scale ranging from 0 to 4) indicate that players enjoyed playing the game (positive affect: $M = 3.02$, $SD = 0.50$; negative affect: $M = 0.58$, $SD = 0.53$), though scores of flow ($M = 2.22$, $SD = 0.63$), immersion ($M = 2.12$, $SD = 0.62$), and challenge ($M = 1.56$, $SD = 0.68$) are not remarkably high but rather mid-table.

Table 9: Mean scores and standard deviations of the SPGQ values and the social presence gameplay metric for both versions of level 1. Dimensions with a significant difference of mean values between conditions (based on Mann-Whitney U tests reported in the text) are marked by *.

	Level 1	
	high visibility (N = 20)	separated (N = 18)
Measure	M (SD)	M (SD)
SPGQ Empathy*	2.16 (0.97)	0.72 (0.94)
SPGQ Negative Feelings	1.28 (0.78)	0.85 (0.66)
SPGQ Behavioral Engagement*	1.84 (0.59)	0.41 (0.57)
Social presence gameplay metric*	213.17 (156.93)	36.04 (38.92)

*$p < .05$

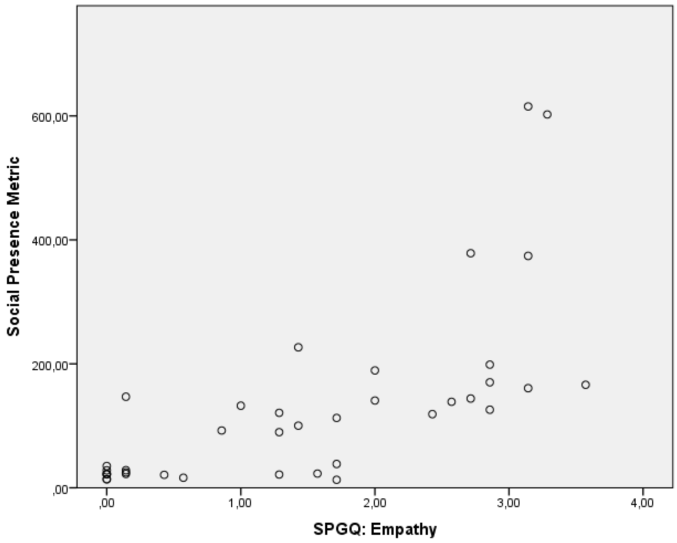
6.3.2.2 *Validation of the Metrics*

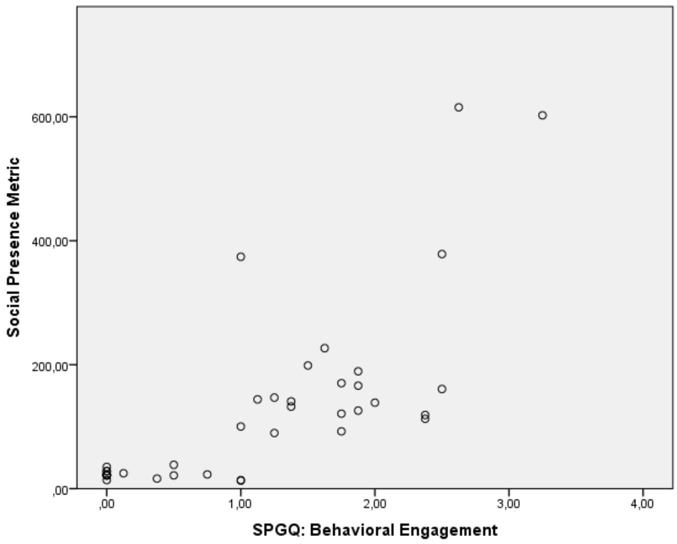
According to Kolmogorov-Smirnov tests, data of the gameplay metrics as well as the questionnaires is not normally distributed, hence in the following non-parametric tests are used to prove the validity of the metrics.

Regarding social presence, measures of the first level were analyzed. First, it was tested whether the two versions of level 1 did differ significantly in terms of social presence, proving the intended variation. Hence, both the scores of the social presence metric and the scores of the SPGQ subdimensions were compared between the two study conditions. Table 9 shows all mean values for both versions of the level.

Mann-Whitney U tests were conducted and indicate a significant difference between the two conditions regarding the social presence metric score (U = 17.00, z = -4.76, $p < .001$), which was significantly higher in the *high visibility* condition, as was intended by design. Furthermore, results of the comparison of the SPGQ subscales empathy (U = 52.00, z = -3.76, $p < .001$) and behavioral engagement (U = 18.00, z = -4.77, $p < .001$) also show significantly higher scores for the *high visibility* level condition. In contrast, there is no significant difference with respect to the negative feelings subdimension (U = 133.00, z = -1.38, p = .176).

To gain insights about the validity of the social presence metric, Spearman's rank correlations were calculated to examine the relationship between the subjective SPGQ data and the data that was automatically logged by the metric. Results show a significant positive correlation between empathy and the metric (r_s = .759, $p < .001$), as well as between behavioral engagement and the metric (r_s = .765, $p < .001$). In contrast, the correlation between negative feelings and the social presence metric is not significant (r_s = .181, p = .276). Figure 19 visualizes the relation between the social presence gameplay metric and the three SPGQ subscales.





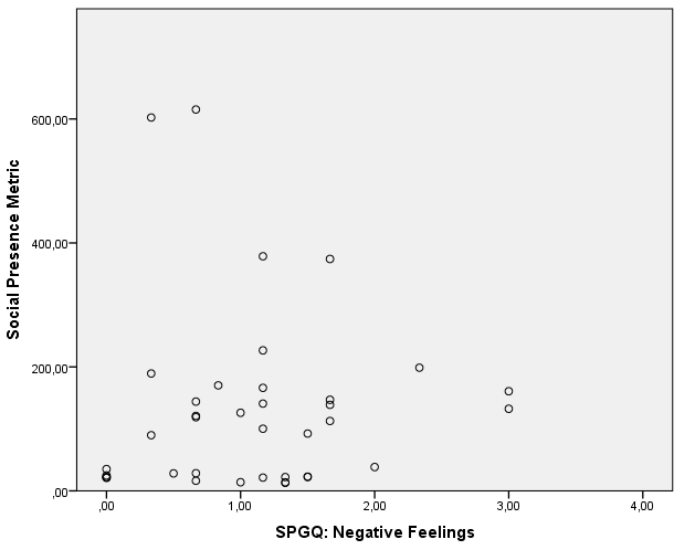


Figure 19: A scatterplot visualizing the correlation between the SPGQ subscales (self-reports) and the data measured by the social presence metric.

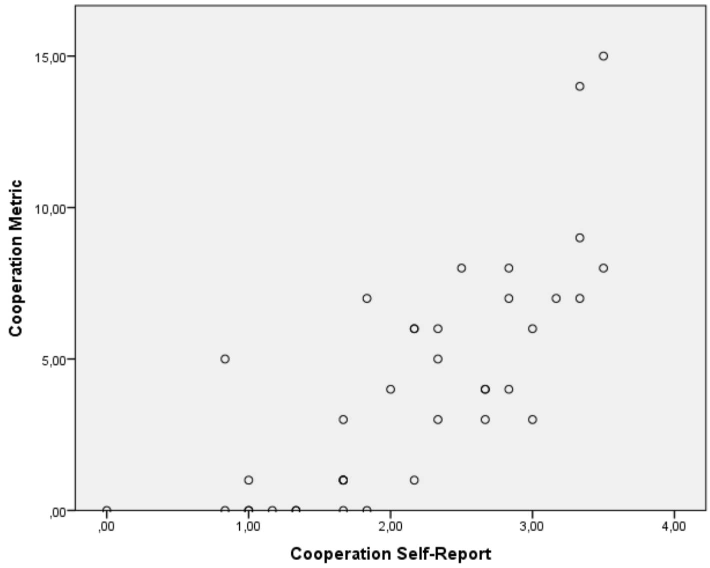


Figure 20: Scatterplot visualizing the correlation between cooperation self-reports and the data measured by the cooperation metric.

In order to validate the cooperation metric, the Spearman's rank correlation between the metric data and the mean values of the cooperation questionnaire was calculated. The analysis shows a significant positive correlation ($r_s = .799$, $p < .001$). The relationship is plotted in Figure 20.

Finally, regarding dominant behavior and leadership, the Spearman's rank correlation between the leadership metric and the mean values of the questionnaire about perceived leadership is significantly positive as well ($r_s = .445$, $p = .005$). This relations is visible in the scatterplot of the data as depicted in Figure 21.

6.3.3 *Discussion*

Results of this first exploratory evaluation of the three social gameplay metrics are promising. Although our metrics were rather simplified, the high correlations found between the scores that were automatically measured by the metrics and the scores of players' self-reports regarding the concepts social presence, cooperation, and leadership indicate that both methods assess data about the same construct. This supports the hypothesis that aspects of social play can be investigated by using gameplay metrics.

Furthermore, the three specific gameplay metrics provide interesting information about the social player experience. Concerning social presence, the significant correlations of our metric with scores of the SPGQ indicates that players' feelings of social presence—particularly empathy and behavioral engagement—are increased if the co-player is visible on screen most of the time. Since players were not able to interact with each other or provide support in this level, the mere visual co-presence seems to affect perceived positive psychological involvement. Consequently, designers of multiplayer

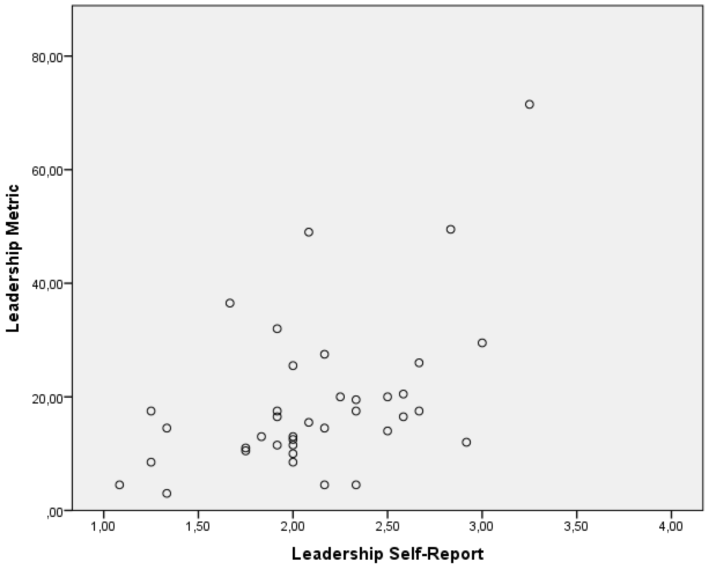


Figure 21: Scatterplot visualizing the correlation between leadership self-reports and the data measured by the leadership metric.

games should consider this possibility to foster social presence in order to support a positive player experience.

However, results regarding the social presence metric also show that it does not correlate with all subscales of social presence as defined by De Kort et al. [359]. Results suggest that the psychological involvement regarding negative feelings is not directly related to the visibility of the other player. Hence, further tests should follow refining the metrics and testing them in different contexts in order to be able to specify which aspects are actually assessed.

Moreover, our results also show that players perceive different degrees of cooperation and leadership based on their in-game behavior. Hence, players are responsive to such social aspects of the gameplay. As they have not been in the focus of social player experience research yet, we propose to further investigate the impact of cooperative and dominant behavior in future studies. Our metrics provide a basis for measuring these aspects of the social experience.

In general, this study shows that social gameplay metrics are a promising new aspects of assessing player experience and in-game behavior. The method is linked to specific advantageous features of the data like objectivity and directness. This distinguishes gameplay metrics from subjective post-game self-reports, which are often used in game user research, and thus, metrics provide a valuable source of unbiased information. However, gameplay metrics also have some shortcomings and challenges that have to be considered before applying them. For one thing, gameplay metrics have to be defined precisely and must not interfere with aspects of game design or other metrics. One big challenge is to operationalize social aspects into appropriate measurable game events or player actions. For instance, if the leadership metric should be applied to an existing game, it first has to be elaborated which events and player behaviors can be defined as dominant or following behavior. While this was easy in our testbed game, because we specifically designed scenarios to test this behavior, full-fledged games are more complex and it becomes more difficult to clearly classify player's in-game behavior. Therefore, we suggest performing pretest to assure that a metric is appropriately defined.

Moreover, as already pointed out in Chapter 2, gameplay metrics only gather behavioral data, but do not provide insight into the users' minds or their thoughts and feelings related to certain game events and interactions. This means that metrics do not inform about the reasons why players are acting the way they do. Hence, we do not propose to replace other methods by social gameplay metrics, but suggest to use them as an additional source of objective gameplay information. Besides, they can be deployed in cases where other methods fall short or cannot be applied at all, for instance if data should be assessed from remote players or if players cannot be bothered with long questionnaires.

6.4 conclusion

It can be concluded that social gameplay metrics can be a powerful tool to gain insights about interaction patterns and player performance inside a game. Metrics thus enable deeper research regarding the social interaction of players and the relation between social aspects of the game and the overall experience. The three metrics presented in this chapter have been proven to be reliable in a first user study, meaning that results suggest that they are measuring what they are expected to measure.

However, this is just the first step on the way to develop useful and valid gameplay metrics for social interaction and behavior. The next step would be to test the metrics with other games and in other contexts. Besides, the very simple structure of the metrics can iteratively be refined to more complex metrics based on evaluation results, more strongly focusing on subdimensions of social constructs like social presence.

As a stand-alone measure, the metrics presented here only assess in-game behavior of players. In future studies, it will be interesting to also explore appropriate methods to investigate communication and interaction of players outside the game, especially in co-located playing settings, and to combine those with in-game metrics.

Part III

SINGLEPLAYER BUT NOT ALONE: THE SOCIAL INFLUENCE OF VIRTUAL CHARACTERS

7 VIRTUAL CHARACTERS AND COMPANIONS IN DIGITAL GAMES

In the previous part of this thesis, I have discussed different aspects of multiplayer games and the resulting social player experience. The reported studies were focused on the social experience with human co-players. In the following chapters, I am going to address another form of social entities in game settings, namely virtual characters. I pursue the question to what degree virtual characters can wield social influence on players in single-player games. More precisely, I investigate the effect of artificial characters on perceived loneliness, social presence, and players' in-game performance in Chapter 8, Chapter 9, and Chapter 10.

However, this chapter first of all discusses different types of virtual characters and draws up a special subtype that is at the center of the subsequent studies: game companions. Regarding computer-controlled social entities, I have already differentiated between NPCs and game bots in Chapter 3 (see also my research model in Figure 4): bots are used to resemble co-players, whereas NPCs are distinct, individual characters that are a diegetic part of the game world. Hence, bots and NPCs differ significantly regarding their intended purpose and the way they are perceived and evaluated by the players. For game bots, who take the same role as real players and either represent teammates or opponents, it is most important to imitate the behavior of real players as accurately as possible [53, 134, 336]. Bad experiences with bots are mostly attributable to inappropriate skill levels with respect to the player, which make the game either too challenging or too easy [53]. The main challenge is, thus, to implement bots that adapt to current player skills and are experienced as equal co-players.

In contrast, NPCs act as distinct characters different from co-players and can serve a wider range of purposes. For instance, they can embody a specific gameplay function (e.g., a vendor) or take an important role in the game's story (e.g., the main adversary). Accordingly, the main challenge of designing NPCs is to give them a unique personality and to align their behavior with it in order to make them appear believable. Due to their integration into the game world as autonomous characters, I assume that NPCs offer more possibilities for socially meaningful interactions and the building of relationships than game bots. Hence, my work regarding the social influence of virtual characters in games is focused on NPCs that take a main role in the game.

As will be elaborated in the following, game companions are a special type of NPC meeting this criterion. They are supposed to have a significant influence on the social player experience. This chapter presents a design space of companions that highlights important characteristics and design decisions. This overview supports the development of new companions by highlighting the design decisions that have to be made and by suggesting ways to improve believability. Moreover, it can be used as a classification system to describe, analyze, and compare existing companions. Furthermore, this chapter includes the results of an online survey to provide insights into players' opinions and perceptions regarding game companions. This work was supported by my co-author Patrizia Ring, presented at the CHI Play conference 2018 and published as a full paper in the respective proceedings with the title *I'm Glad You Are on My Side: How to Design Compelling Game Companions* [93]. The following text is adapted from this publication.

7.1 THE SIGNIFICANCE OF NPCS

NPCs foster the creation of believable game worlds [148, 184, 191] and their behavior forms an important part of the emergent narrative of a game [335]. They are an important game design element used in many games, because they can be implemented in diverse ways and for very different purposes [128]. Well-designed, socially capable characters can significantly increase game enjoyment [70, 191] and players often state the wish for more socially behaving NPCs [3]. However, whereas advances in the field of computer graphics enable the creation of real-looking characters, this realism in appearance contrasts with the rather primitive, unnatural behavior that many game characters display [70, 207]. They have to be carefully designed, especially in terms of behavior, to not fall short of the player' expectations.

As already mentioned in Chapter 3, Warpefelt and Verhagen define an NPC as "every kind of character found in the game that is diegetically represented in the world, is not controlled by the player, and that is actively involved in portraying some kind of character" [335, p. 40]. The last aspect of this definition distinguishes NPCs from merely decorative character representations, that do not offer any possibility to interact nor perform a specific function, such as generic spectators in a crowd. NPCs have to actively promote the role they have in the game. In line with that, Pinchbeck [236] defines NPCs as agents who have some form of individuality and thereby stand out from the background population of the game world.

This individuality can manifest in different roles. In general, NPCs can be classified as either opponents, allies, or characters who are neutral towards the player [246, 360]. Warpefelt and Verhagen [333] conducted an online survey asking players to classify NPCs of 13 games (varying in genre) based on screenshots and short videos of the scene the NPCs appear in. The results led to a typology of NPCs including 12 types summarized in the four metatypes *functions* (vendor, services, questgiver), *adversaries* (enemy, opponent), *friends* (sidekick, alley, companion, pet, minion), and *providers* (storyteller, loot provider). It is important to differentiate between these roles when researching NPCs, because different roles evoke different expectations on the player's side that have to be fulfilled [335].

Considering not the role but the temporal presence of NPCs, Pinchbeck introduces the notion *persistent NPC*, which describes an individual "who appears repeatedly or has a definable role in the world and plot" [236]. They can be allies or enemies, or even switch position over time, hence they do not necessarily be supportive to the player. However, persistent NPCs are mainly introduced as allies.

7.1.1 *Companions: A Special Type of NPCs*

Our work is focused on the special type of persistent NPC that accompanies the player throughout the whole game, as we suppose that this kind of character can have the strongest influence on the player experience. It thereby can greatly increase, but also impair game enjoyment. Popular examples are Elizabeth from BioShock Infinite [147], Ellie from The Last of Us [227], and the faithful dog companion Dogmeat from the Fallout series [19, 21]. Following the typology of Warpefelt and Verhagen [333], a persistently accompanying NPC is called *companion*. The authors point out that these characters support the player as *allies* do, but that they can be controlled by the player. However, we argue that the second aspect is not a mandatory property of companions. Several successful games demonstrate that a companion can also work without being controllable by the player. The companion Elizabeth from the first-person action game Bioshock Infinite [147], for example, is very involved in the gameplay (taking part in combats, leading the way, talking to the player's avatar, and giving advice) but thereby acts completely autonomously. Furthermore, in our understanding such a character can have similarities to both the types *sidekick* and *alley*: depending on its focus, it can provide the player with help in form of advice, directions, or resources as a *sidekick*, or it may fight alongside the player as an *alley*, or even do both.

Considering games like the Fallout series [19, 21], we reason that a companion does not necessarily have to be human. The dog Dogmeat, who can be chosen as persistent companion in the Fallout games, supports the player by searching items and by participating in combat. It is more than a simple decorative NPC that does not interact with the environment. Thus, it does not fit the definition of a *pet* by Warpefelt and Verhagen [333].

Summarized, we define a *companion* as a non-player character (human or non-human) which accompanies the player character over a large amount of time during the game, either in person or via means of constant communication.

In contrast to characters who only temporarily appear in certain scenes of the game, companions take an important, omnipresent role and are supposed to greatly contribute to the overall player experience. Hence, they hold high potential to increase game depth and success, but at the same time are particularly demanding in terms of believable design. Any design flaw can lead to great annoyance and spoil the whole game [120]. The integration of a companion into a game, thus, is supposed to be challenging and costly, but also offers considerable opportunities. Companions can serve as goal-givers and tutors, be used to add an emotional layer to the game, and deliver a certain atmosphere by demonstrating the player how to feel in a given situation [236]. By supporting the suspension of disbelief, they can increase perceived realism and immersion, and affect replayability [9]. Concerning the game mechanics, companions also offer a way to adapt the difficulty of the game to the skills of the player without having to manually set a difficulty level [307].

Moreover, companions increase the sociality of the game: They add a social component to singleplayer games and might evoke social effects similar to human co-players if they are perceived as real, believable characters [28, 128, 178, 286, 355, 358]. The perception as a social entity is provided by unconscious sublime attributions due to human-like social cues, outward appearance, and corresponding behavior (even if the user is aware that the agent is not a real person), and is reinforced by the immersion into the game world and the related suspension of disbelief.

There is a considerable collection of research on NPCs, but yet little work is focused on the special challenges of companion design. We assume that companions—out of all NPCs—can have the strongest influence on the player experience and thereby can either greatly increase or impair game enjoyment. Guckelsberger, Salge, and Colton [120] emphasize that players actually treat companions different than other NPCs and expect them to behave more thoughtfully. Hence, companions deserve closer attention in research to reveal how they influence players and their experience.

7.2 THE DESIGN SPACE OF GAME COMPANIONS

In the following sections, we review the literature on NPCs and companions in order to derive characteristics that are supposed to be important for the design of compelling companions. These characteristics will be summarized and categorized to provide an overview of the design space of companions in digital games (see section 7.2.9).

7.2.1 *Player Expectations and Believability*

One subordinate attribute that is dominantly discussed regarding the quality of NPCs is *believability*. It refers to "the size and nature of the cognitive gap between the character players experience and the character they expect" [191, p. 82]. Accordingly, a character appears as fully believable, if it matches the players' expectations [191]. Hence, the concept of believability stresses the importance of fulfilling the players' expectations that emerge during play [3, 128, 191, 335]. Which expectations a player has regarding a certain game character is highly determined by the context in which the NPC appears including the setting, place, and point in the story [335]. The narrative context can even justify behavior that may otherwise seem inappropriate and irrational. For instance, if the game is set in a fantasy world where animals can talk, a talking cat can be perceived as a believable character. As companions accompany the player the whole time in many different situations and settings of the game, they have to be able to adapt to the changing context to maintain believability. Besides the context, player's expectations regarding an NPC are also framed by the role the NPC promotes [335]. For instance, a character wearing the uniform of the security guards of a town is supposed to be sensitive to infractions of the law and to react if the player acts inappropriately.

In the context of player expectations towards NPCs, Harth [128] differentiates between four typical patterns that describe the mind-set of players, which are ordered by increasing attribution of sociality towards NPCs:

1. Primordial expectation of triviality: players are aware that they are playing a computer game that is completely determined and limited by mathematical operations. They do not expect any sociality of the system.

2. Rigorous attestation of triviality: the basic expectation of triviality is transferred to the interaction with NPCs by attributing their behavior to objective, predefined code.

3. Hybridization of players: players attribute some kind of "agency" to NPCs, blurring the dissociation of human and non-human players.

4. Temporary attestation of personhood: players see NPCs as persons, attributing a status of "personhood".

It becomes apparent that the more human-like a NPC is perceived, the higher are the player's expectations regarding its behavior. On the other hand, lower expectations are associated with perceiving the NPC as a game element merely serving a certain function (e.g., trading) and not necessarily as a social entity of the game world [127, 128]. A companion is supposed to intensify the player experience on a social and emotional level, and thus should be able to achieve the attestation of personhood by displaying believable behavior.

A survey by Afonso and Prada [3] indicates that many NPCs back in 2008 did not satisfy the needs players stated to have and, thus, showed a deficit in believability. In a more recent focus group study and a large subsequent online survey, Schumann [275] assessed the quality expectations and perceptions of players regarding the behavior of computer-controlled characters in RPGs and FPS games and concludes that the gap between players' expectations and experiences is still wide. At the same time, the results indicate that well-designed, life-like NPCs are appreciated by players and have the potential to contribute to feelings of presence and flow.

Lee and Heeter [191] present the results of another online survey that indicate that the believability of NPCs is related with general game enjoyment, again pointing out the potential of NPCs and the importance of their perceived believability. Moreover, they list five attributes that are supposed to contribute to believability: 1) *emotions*, 2) *personality*, 3) *appearance*, 4) *motivation*, and 5) *social relations*.

In a similar fashion, Lankoski and Björk [185] outline the following design patterns for believable NPCs: 1) *awareness of surrounding*, 2) *visual body damage and dissectible bodies*, 3) *initiative*, 4) *own agenda*, 5) *sense of self*, 6) *emotional attachment*, 7) *contextual conversational responses*, and 8) *goal-driven personal development*. These and related aspects are therefore discussed in the following sections.

7.2.2 *Appearance / Visual Representation*

A character's *appearance* is most crucial for building players' expectations, because it is the first aspect that is perceived by players and processed faster than the other character qualities [191, 332, 335]. This includes all visual hints regarding gender, age, ethnicity, status, as well as observable behavior (e.g., interacting with the environment or following daily routines). Players make conclusions about the role of the character and the ways they can interact with it based on these visual cues. Hence, these attributes should be designed carefully with respect to the character's planned role and personality. A mismatch will lead to false expectations and result in a negative experience with the NPC.

Pinchbeck [236] points out, that there are several possibilities how a companion can generally be represented in the game. He differentiates between characters who are visually present in the game world and those who are integrated by means of communication and, thus, only have an auditory presence. Furthermore, companions can also be excluded from the in-game space completely and instead just be featured in the cut-scenes of a game. However, the last strategy limits the presence of a companion and does not allow for any player-companion-interaction, which is supposed to reduce the emergence of a meaningful relationship between them.

If embodied in the game world, players expect NPCs to be aware of their surrounding and their own bodies [185]. Believability and immersion can easily break if NPCs do not appropriately react to influences acting on their visual representation, for instance if they are pushed or hit by the player. This can be avoided by introducing body awareness as well as visual changes of the body (e.g., displaying wounds in case of injury) [185].

7.2.3 *Companion Behavior*

Researchers agree that, besides the visual attributes of NPCs, their behavior—sometimes seen as part of the general appearance—is one of the most important determinants of a companion's acceptance and believability [191, 334, 335]. However, behavior in general is a very broad term and can contain several different aspects. To structure the diverse layers of NPC behavior, Warpefelt, Johansson, and Verhagen [334] developed the *Game Agent Matrix*. This matrix maps the behavior of NPCs on the two dimensions *complexity of the social context* and *complexity of the NPC architecture*: An agent that is capable to react to events and changes in the environment and even to interact with other agents has a more complex architecture than an agent that just acts without paying attention to the environment. Similarly, agents that are aware of social structures and goals and behave within those structures display a higher complexity regarding the social context than agents that are just acting on their own. Hence, the perceived believability is supposed to increase with growing complexity.

However, as indicated earlier, the context also matters. If, for instance, the game world does not include a rich social community, its NPCs do not require to feature complex social behavior to act believable. Based on the results of their online survey and with regard to their typology of NPCs, Warpefelt and Verhagen [335] describe that the NPC types *companion* and *sidekick* are the socially most complex friendly characters in terms of the Game Agent Matrix. Thus, successful companion design demands the consideration of the aforementioned aspects.

Whereas the companion's behavior has to match the player's expectation, that does not necessarily mean that their behavior has to be most effective or most realistic [316, 360]. It has to account for the situation and, moreover, predict what the human player desires [360]. That implies that a companion who is an active part of the gameplay should be able to adapt to the player's playing style. For instance, a companion should not attack nearby enemies if the player tries to sneak past them without being noticed. Adaptability can be achieved either by concealed learning algorithms and player modeling or by giving the player the possibility to explicitly set a few parameters that influence the behavior of the companion (e.g., passive combat behavior) [360]. In this context, Tremblay and Verbrugge [307] distinguish between full autonomous companions, who can not be controlled by the player, and semi-autonomous companions, who can be actively controlled by the player to some degree.

Several of the design patterns for believable NPCs introduced by Lankoski and Björk are directly related to behavior. They point out that believable NPCs have to be aware of their surrounding and react to changes, even if the player does not directly interact with the NPC. Moreover, the believability and enjoyment of a character is supposed to be increased by the ability of acting self-initiated. Performing actions that are not a direct consequence of a game event and following an own agenda (i.e., personal goals and motivations) brings the NPC to life. For a companion, these characteristics are important, as they correspond to the demand of being able to behave appropriate in varying contexts.

From an implementational point of view, a companion's behavior is dependent on the implemented artificial intelligence (AI). Game AI refers to algorithms and techniques for controlling the behavior of game characters and often aims at making human players believe that the NPC is actually controlled by another human [10, 181, 201]. This *illusion of intelligence* can be achieved by enriching the NPC with human characteristics regarding its behavior such as predictability and unpredictability, support, and surprise [276].

According to Umarov and Mozgovoy [316], AI research regarding game agents has to address two subproblems: believability and effectiveness of the character's behavior. The authors provide an overview of current approaches to successfully model and implement human-like behavior. In general, there are diverse techniques currently used in games or being researched to create game AI, which can be differentiated into non-adaptive game AI (e.g., decision trees, finite state machines, scripting) and more advanced adaptive game AI (often based on machine learning techniques) (cf. [10, 127]). Determined by the role of the companion, the companion's behavior can comprise different concrete actions and mechanics. In this context, Tremblay [305] roughly differentiates between combat behavior (aiming, shooting, evading) and non-combat behavior (gathering, sneaking, mapping). In a similar way, Johansson, Strååt, Warpefelt, and Verhagen [158] differentiate between combat behavior, non-combat behavior, as well as irrational behavior. The authors analyzed several games regarding the behavior of the integrated NPCs and report that while there seems to be great progress in terms of path finding AI, most NPCs still lack socially believable behavior. Recent AI research in games strives to develop efficient techniques to control the different forms of behavior and make it more believable: Regarding combat behavior, Xu and Verbrugge [346] present work on the performances of healing allies and incapacitating enemies and Tremblay, Dragert, and Verbrugge discuss strategies for target selection and adaptive behavior in FPS games [306, 307].

Furthermore, AI techniques are often used to build player models or opponent models [207, 289, 360]. These models are used to understand and model the player's characteristics and behaviors [207] in order to adapt the agent's behavior in various contexts. Guckelsberger et al. [120] present an approach to implement believable and highly adaptive behavior of game companions based on a model of intrinsic motivation. Bailey and Katchabaw [9] elaborate on an approach for an emergent framework for realistic psychosocial behavior of NPCs. Moreover, McGee and Abraham provide a comprehensive overview of the advances in team-mate AI approaches and conclude that there is significant progress in the field, but that there is still "much left to do" [217, p. 130].

Elaborating further on those different techniques for the implementation of game AI and intelligent behavior is beyond the scope of this thesis. For the purpose of our research questions, we focus on the players' impressions of game characters and their impact on the experience. However, we account for the fact that research on game AI constantly demonstrates that the illusion of intelligence is important for a compelling experience and a convincing game world [10, 289].

7.2.4 *Emotions*

Besides behavioral player modeling, another related way to improve a character's believability is to improve its emotional intelligence [289]. Ochs, Sabouret, and Corruble [232] present an approach to simulate dynamic emotions in NPCs and point out that the believability of NPCs is strongly dependent on their ability to appropriately express and understand emotions. This is supported by a recent study by Chowanda, Flintham, Blanchfield, and Valstar [51], who compared game companions with different emotional and social skills and found that such skills can enhance the player experience and facilitate player-companion relationships. Hence, for an emotionally convincing companion, three main things are important (cf. [51, 191, 232]): First, the companion should feature some model of emotional states and transitions, which enables to derive the appropriate emotional state from current game events and interactions. Second, this internal emotional state has to be clearly and convincingly displayed to the player (e.g., by facial expressions or changing pitch of the voice). Finally, to be able to build a social bond with the player, the companion should also account for the player character's emotional state and respond appropriately.

Ravenet, Pecune, Chollet, and Pelachaud [246] provide an overview of approaches and implementation techniques that can be used to model emotions and attitudes in NPCs. The authors emphasize that convincing emotional behavior fosters the development of a strong emotional bond with the character, thereby intensifying the whole experience. However, in recent games, NPCs tend to show powerful emotional behaviors in scripted cut-scenes, but fall short during interactive phases [246].

7.2.5 *Personality and Social Relations*

Approaches to model the emotional intelligence of NPCs often have in common that they refer to the related concepts *personality* and *social relations* [3, 191, 232], which usually influence the way a character reacts to certain events and encounters. Regarding personality, a companion should be unique and extraordinary [3, 191]. It is important that its personality is distinguishable from other characters in the game, so that it catches the player's attention and does not appear replaceable. The specific personality of a companion can be modeled by referring to personality traits from cognitive psychology, such as the popular five-factor model of personality [216] including neuroticism, extraversion, openness, agreeableness, and conscientiousness [3, 232].

According to Afonso and Prada [3] a personality model is a reasonable approach of modeling social relations with other characters. They assume that traits such as agreeableness, neuroticism, and extraversion determine if and how relationships are made. If the game world contains additional NPCs, the companion will be more believable if it features social relationships with other NPCs and seems to be an integral part of the game's social community [191]. To achieve that, companions need to be aware of other NPCs and their mental states and should be able to remember prior interactions. Social relationships can determine with whom the companion interacts and how much information it shares with the dialog partner [3].

7.2.6 *Relation to Player and Social Role*

Although social relations of the companion with other NPCs in the game-world are supposed to increase its social beliebvability, the relationship between companion and player can be considered even more important. Though companions are supposed to be somehow on the same side as the player, their relation can still manifest in various forms. Pinchbeck [236] points out that story-relevant NPCs often have ambiguous motives, which are intentionally revealed bit by bit as the player progresses in the story to increase suspense. A seemingly faithful companion might even turn out to be a traitor in the end, though this is rather seldom.

In general, the social roles of NPCs with respect to the player can be described in terms of three dimensions [150]: *interdependence*, *power dynamics*, and *obligations*. The degree of interdependence between player and companion is mainly defined by their abilities and goals. The companion may have abilities that the player has not, but that are needed to proceed, or it may provide significant assistance. On the other hand, the companion might also need the help of the player as a guardian or rescuer. Interdependence is related to the power dynamics of the relationship, as it influences who is the dominant character and who is represented as more powerful. Moreover, the level of agreeableness (as part of the personality) is also influential. Obligations between player and companion are often introduced through narrative elements: The back story of the characters provides information about what kind of relationship the player has to expect from the companion. For instance, the player may owe his/her life to the companion or they may have an unsolved conflict due to some incident in the past. Investment during the game can further increase the sense of obligation, either on the player's or on the companion's side.

Based on the social role, meaningful interactions and defining emotional moments can be created to foster the emotional bonding between player and companion [150]. This is particularly important to make the player care about the companion's fate and experience intense emotions.

7.2.7 *Story and Gameplay Significance*

A companion does not necessarily have to have a significant gameplay function but can still be very relevant for the story of the game [236]. A character might, for instance, play a major role in cut-scenes and dialogues without being active during gameplay. Conversely, a companion can take a leading in-game part by significantly influencing gameplay (e.g., being a proactive fellow soldier) without having diegetic significance. In this context, Aarseth [1] differentiates between three types of game characters: (1) *bots*, who have no individual characteristics or personality, (2) *shallow characters*, who feature individual traits like names and roles, but do not evolve or adapt to game events, and (3) *deep characters*, who show elaborated personalities.

Well-perceived companions are supposed to feature high significance with regard to at least one of the two aspects gameplay and story, or even both. However, companions that are merely focused on their gameplay functionalities are at risk of being perceived as trivial game elements instead of meaningful social entities [128], leading to less interest, decreased bonding, and lowered expectations on the players' side.

7.2.8 *Communication Capabilities*

The last aspect that is relevant to describe companions is their capability to communicate. The use of natural language can support the believability of a game character [185], if the character is supposed to be able to speak (e.g., due to being a human as opposed to an animal). Moreover, the content of conversations matters: contextualized conversational responses are preferable [185]. That implies that statements should not be repetitive and always relate to the current situation. Hence, there is a parallel to the challenges of general companion behavior as discussed earlier, for instance in terms of awareness and player models. To further increase the perception of sociality, a companion should not only be able to chat with the player character but also with other NPCs in the gameworld [70].

7.2.9 *Overview of the Design Space*

In the previous sections, we have discussed the characteristics that are considered as important for well-perceived NPCs and companions in the literature. To provide an overview of the design space regarding believable companions in digital games, we summarize these characteristics in the following. We clustered all aspects that became apparent during the literature review into six main categories: general characteristics, general capabilities, behavior, communication, relation to the player, and significance. Equipping companions with the listed characteristics and determining their behavior accordingly will result in high perceived believability and an increased game experience. Hence, by using this compilation of key characteristics, believable and enjoyable companions can be designed and evaluated.

General Characteristics

- **Appearance**: Visual cues that communicate basic characteristics such as gender, age, status, and role of the companion to guide the player's expectations.
- **Personality**: Personality traits like agreeableness, extraversion, and neuroticism. A defined personality is a prerequisite for social relations and influences the companion's behavior.
- **Own Agenda**: Personal goals and motivations of the companion, that influence its behavior and emotions.

General Capabilities

- **Awareness**: Capability to perceive and react upon events and changes in the surrounding environment. This also includes awareness of the self, e.g., whether the companion is low of health or in danger.
- **Emotional Intelligence**: Capability to express emotions based on internal states. High emotional intelligence also enables to understand and react to the emotions of other characters (especially of the player character).
- **Social Relations**: Capability to build relationships with other NPCs and to form a view on them. This way, the companion becomes part of the social community of the game.

Behavior

- **Context Sensitivity**: Capability to adapt the behavior to the current situation and changing contexts.
- **Autonomy**: Degree to which the companion's behavior can be controlled by the player.
- **Initiative and Activity**: Degree to which the companion acts on its own without being asked to do something and the general frequency with which the companion interacts in this way with the player and the environment.

Communication Capabilities

- **Communication with the player**: Capability to communicate with the player, preferably by means of natural language use.
- **Communication with other NPCs**: Capability to autonomously communicate with nearby NPCs, with and without the player.

Relation to the Player Character

- **Interdependence**: Degree of the dependency between player and companion, e.g., if the companion has to assist the player, has exceptional abilities, gives advice, or provides moral support. The companion may also need the help and protection of the player.
- **Power Dynamics**: Definition of the power balance between player and companion. They can either be coequal, or one character dominates the other due to an imbalance of abilities, knowledge, or influence.
- **Obligations**: The presence of a social connection between player and companion, which is introduced by narrative elements. This connection can be fostered by game events that represent social or personal investments of the companion or the player and thereby create a sense of obligation.

Significance

- **Story Relevance**: Degree to which the companion is integrated into the story, develops over time, and influences narrative game events.
- **Gameplay Relevance**: Degree to which a companion can actively influence gameplay by using game mechanics and incorporating gameplay functions.

7.3 AN ONLINE SURVEY ABOUT COMPANIONS

So far, we have compiled insights and design implications from the academic literature. The description of the design space highlights important characteristics of companions and is supposed to support the design process of future companion characters. Nevertheless, we are also interested in players' firsthand experiences with companions in digital games. Since there has not been much research about the emotional bond and relationship between players and companions, we conducted an exploratory online survey to gain some insight into players' opinions and preferences. We developed a questionnaire based on the lessons learned form the literature analysis to investigate which characteristics of companions are perceived positively and which are perceived negatively. The results highlight what aspects are most important from the viewpoint of players.

7.3.1 *Survey Questions*

The online questionnaire was divided into two main parts: one addressing game companions in general, and one specifically assessing the experience with the concrete companions from five different games. Moreover, questions concerning demographics (age, gender, gaming experience) were presented.

The first part of the questionnaire contained general questions about players' experiences with companions in digital games and their attitude towards the general concept of having a companion in a game. Subsequently, we asked players to evaluate several general characteristics of companions that are supposed to be perceived either positively or negatively based on the design space dimensions discussed in the previous sections. These 49 items were meant to give some indication of players' priorities and the size of impact of single design aspects. Tables 10 and 11 in the result section list the most interesting of those survey items ordered by their respective design space subdimensions. We also put two open questions, asking participants to describe what they perceive as particularly favorable or annoying about companions.

In the second, game-specific part of the questionnaire participants could additionally answer questions about the companions of five popular commercial games. They were asked to rate the game, the companion, and the companion's role in the game. These game-specific questions were only displayed if participants stated that they had played the specific game and

Figure 22: Three examples of dog companions in digital games: The screenshots show the nameless dog from Fable 2 (left), Dogmeat from Fallout 4 (middle), and Meeko from The Elder Scrolls V: Skyrim (right).

were able to remember their experience as well as the companion. The questions were accompanied by a screenshot of the game showing the respective companion to remind participants and to avoid misunderstandings (cf. Figures 22-24). This part also included two open questions asking what the participants had especially enjoyed about the specific companion and which characteristic had bothered them.

All questions of the questionnaire—except from demographic and open questions—were phrased as statements to which participants should rate their agreement on a 5-point Likert scale (coded 0-4).

The games referred to in the second part of the study were BioShock Infinite [147], The Last of Us [227], Fallout 3 and 4 [19, 21], The Elder Scrolls V: Skyrim [20], and Fable 2 [199]. The games were chosen based on their popularity, actuality, and comparability of genres, player characters, and the integrated companions. To find those games, we first compiled a list of games featuring a companion based on release lists, online research, and personal experience. We narrowed the list to those games that had at least three million sales (popularity) and were not older than ten years (actuality). From this list, five games were selected due to genre and companion comparability: three different kinds of dogs as well as two similar human companions. The companions from BioShock Infinite [147] and The Last of Us [227] are both females of similar age while the player character is male and middle-aged in both games. The companions in the other three games are all dogs, which are comparable in their appearance and differ mainly in regards to story relevance and interactivity.

The FPS game BioShock Infinite [147] contains the companion Elizabeth (see Figure 24), a young woman with supernatural skills. She accompanies and helps the player character, Booker DeWitt, whose task it is to free her from imprisonment at the hands of the antagonist. Elizabeth has the ability to open portals in space and time. Due to that, while Booker is older and more experienced, he is dependent on Elizabeth, whose fate is closely entangled to his.

The Last of Us [227] is a survival horror game centered around the companion Ellie (see Figure 23), a young woman, and Joel, the player charac-

Figure 23: Screenshot of the game The Last of Us, showing the companion Ellie who is to be protected by the player and in turn supports the player.

ter. During the game play, the player's task is to protect Ellie in a post-apocalyptic world. Whereas in some situations Ellie helps Joel, she is overall rather dependent on him. Joel, on the other hand, is reminded of his late daughter by Ellie and takes on a father role.

The post-apocalyptic RPGs Fallout 3 and 4 [19, 21] are set in the future United States, which are inhibited by different groups of survivors from a nuclear apocalypse. The player character has to fulfill different tasks and can choose to be accompanied by a dog named Dogmeat (see Figure 22) in both games. The dog will help the player character by finding objects and fighting enemies.

The Elder Scrolls V: Skyrim [20] is an open-world RPG in which the player character can choose to be accompanied by a vast number of different companions, one of them being a dog named Meeko (see Figure 22). The dog is found in a shack next to his deceased owner. The player can choose to take him along, but Meeko does not offer any skills of his own. It is often criticized that Meeko sets of traps—injuring or killing the player character—or gets himself killed by prematurely attacking enemies.

Fable 2 [199] is an open-world RPG set in a medieval fantasy world. The player takes on the role of the hero, who is tasked with different quests and is accompanied by a per default nameless dog (see Figure 22). The player character saves the dog from being mistreated who in turn stays at the protagonist's side, helps him by digging up treasures and even sacrifices himself.

7.3.2 *Sample Description*

The questionnaire was distributed among students of the University of Duisburg-Essen and via the online platform Reddit. It was addressed to players of digital games who had played at least one game featuring a companion in the past, in order to be able to speak from experience. Overall,

Figure 24: Screenshot of the game BioShock Infinite, showing the companion Elizabeth who accompanies the player throughout the game and reveals special abilities and a complex background story.

237 people (72 female, 160 male, 5 prefer not to say) from 30 different countries (mostly US, UK, and Germany) took part in the study. The mean age of participants was 24 years (SD = 6.99). The large majority reported to play digital games frequently, on average 20 to 30 hours per month, and to have played about four games containing a companion. Participants were also asked about their favorite game genres (non-exclusive): 72.2% preferred playing fantasy role-playing games, 62.2% adventure role-playing games, 61.1% first- or third-person shooters, and 41.8% strategy games.

7.4 RESULTS

The study was conducted to gain insights into players' opinions regarding companions and their characteristics. Therefore, the data analysis is not guided by concrete hypotheses, but is conducted in an exploratory way instead. In the following, the main findings are reported.

7.4.1 *Players' General Attitude Towards Companions*

In view of the general questions about companions, respondents agree that their prior experience with game companions is in general predominantly positive (M = 3.02, SD = 0.92). They also confirm that a companion can make a game more interesting (M = 3.34, SD = 0.76), that they wish for more games featuring compelling companions (M = 3.23, SD = 0.83), and that they rather do not feel alone while playing with a companion (M = 2.14, SD = 1.18). However, the availability of a companion does not necessarily lead to an increased interest in a game (M = 2.10, SD = 1.19). A well-made companion can be a reason to play a game (M = 3.17, SD = 1.03), but at the same time an annoying companion can make players quit playing (M = 2.43, SD = 1.21).

Table 10: An extract of the questions that were posed to assess players' opinions about different companion characteristics. Survey participants rated their agreement to each statement on a five-point Likert scale. Mean values and standard deviations are displayed.

Survey Items (ordered by design space subdimensions)	Mean (scale: 0-4)	*SD*
Appearance		
I prefer companions that are similar to me (gender, age, appearance, character).	1.25	1.03
I prefer human companions to animals/fantasy creatures.	2.01	1.13
Personality		
I like companions who have their own, unique personality.	3.82	0.58
I like companions who do not only obeys orders, but also contradict me and have their own head.	3.08	1.08
Own Agenda		
I like companions who follow their own objectives and goals.	3.25	0.86
Context Sensitivity		
A companion must be able to show realistic behavior.	3.53	0.80
I expect a companion to react appropriately to the current game situation and my actions.	3.64	0.63
Autonomy		
I want to be able to control what the companion does (and does not).	1.51	1.09
I prefer companions who act independently and on their own.	3.13	0.91
Initiative		
Companions who interact with me unrequestedly are bothering me.	1.58	1.04
I like companions that often interact with the game world and my character.	3.51	0.74
Interdependence		
I like it when a companion supports me to reach my goal in the game.	3.24	0.92
I don't like to be dependent on my companion.	2.89	0.94

Table 11: Continuation of Table 10: An extract of the questions that were posed to assess players' opinions about different companion characteristics. Survey participants rated their agreement to each statement on a five-point Likert scale. Mean values and standard deviations are displayed.

Survey Items (ordered by design space subdimensions)	Mean (scale: 0-4)	*SD*
Power Dynamics		
I like being responsible for the companion and having to protect him/her.	1.98	1.09
I don't like it when companions depend on me and need my help.	2.38	1.03
I like companion that are mentoring me and giving me advice.	2.53	0.99
I prefer companions that are coequal and able to assert themselves well.	3.22	0.78
Obligations		
I think it is exciting if the relationship between my character and the companion evolves during the game.	3.53	0.80
Story Significance		
I think a companion should be an integral part of the main story of the game.	3.70	0.66
I prefer companions with an interesting background story.	3.68	0.69

7.4.2 *Evaluation of the Companion Characteristics*

Tables 10 and 11 show an extract of the most interesting findings based on the questions used to evaluate which characteristics of companions are particularly important or annoying for players. The items are sorted by the subdimensions of our design space (cf. section 7.2.9).

Regarding general characteristics, results demonstrate that players do not seem to have clear preferences concerning the appearance and type of a companion, as long as it blends in well with the game world and story. In contrast, a unique personality is emphasized to be an important feature. Players show a clear tendency to appreciate companions who have an own agenda and do not completely consort with the player character. In line with this, players prefer companions with high autonomy, and do not claim to be able to control their behavior. In terms of the companion's behavior, results confirm the assumption that players prefer believable, contextual performances taking into account the current situation, the companion's personality, as well as the players' expectations. Moreover, players seem to expect companions to be proactive and to act on their own behalf.

At the same time, companions should support players in some way to achieve their goals. However, there is slight agreement among our survey respondents that the dependence of players on the companion should not be too substantial. Question about the power balance between player and companion indicate that players neither seek for inferior companions that have to be protected, nor do they show a strong favor for mentoring companions. The highest agreement is found for companions who are coequal and able to take care of themselves.

Finally, participants outstandingly agree that a companion has to take a significant role in the story.

7.4.2.1 *Results of the Open Questions*

An analysis of the responses to the open question about what participants particularly like and dislike in game companions indicate similar tendencies. The main aspect repeatedly mentioned ($N = 63$) was that companions should have a significant purpose in the game. Players desire a reason as to why the companion exists in the game.

This ties in with the preference for companions with an elaborate background story. 25 participants specifically stressed their interest in more complex companions who have their own opinion, objectives, and—not even necessarily positive—attitude towards the player character. Moreover, participants often appreciated the possibility to interact with the companion and to build a meaningful relationship.

48 participants expressed a high interest in being able to have meaningful conversations and interactions with their companion. They reported to perceive companions more positively if they can get emotionally invested in the companion. This is also reflected by the fact, that 20 participants specifically mentioned that playing with companions helps to lessen their feeling of loneliness in singleplayer games. Interestingly, another positive characteristic of companions that was mentioned several times ($N = 12$) was humor. Humor can lighten the mood in tense game situations and add to both the companion's believability and game enjoyment.

On the negative side, participants often complained about companions that get in the player's way ($N = 25$). In line with this, complaints were made about companions who sabotaged the player's playing style, for instance by forcing the player to fight rather than to sneak ($N = 22$). Another negative association with companions was mentioned by 37 participants, who remembered companions that were too weak to fare for themselves in a fight and had to be constantly protected. Finally, 22 participants complained about voice lines that are repeated too often, leading to annoyance. This seems to create the feeling that the game developers were not willing to invest enough time and money to implement more voice lines into the game. Generally, unrealistic behavior was criticized most for breaking a game's immersion.

Table 12: Mean values and standard deviation for the ratings of the five games BioShock Infinite, The Last of Us (TLoU), Fallout 3 & 4, The Elder Scrolls V: Skyrim, and Fable 2, and the respective companions (scale: 0 - 4).

	BioShock (N = 89)	TLoU (N = 89)	Fallout (N = 130)	Skyrim (N = 108)	Fable 2 (N = 41)
	M (SD)	*M (SD)*	*M (SD)*	*M (SD)*	*M (SD)*
Game Rating	3.45 (0.71)	3.71 (0.57)	3.16 (0.76)	3.78 (0.57)	2.93 (0.85)
Companion Rating	3.47 (0.89)	3.69 (0.58)	3.12 (1.00)	2.40 (1.16)	3.10 (0.94)

7.4.3 *Analysis and Comparison of the Five Companions*

In the second part of the survey, we asked players about their experience with five specific game companions. Our selection of the five games gave the possibility to compare three different kinds of dogs as well as two similar human companions. This analysis is meant to provide some additional clues regarding how players perceive companions and which characteristics players appreciate and dislike based on concrete examples.

The main difference between Elizabeth and Ellie is that Elizabeth has special abilities to support the player, whereas Ellie is more dependent on the player. The three dogs differ mainly in regards to their level of story relevance and interaction with the player character. While Ellie and Elizabeth are crucial to the story of their games, only the dog from Fable plays a relevant role in the narrative and the gameplay. Dogmeat and Meeko are both not story-relevant, but while Dogmeat can help the player to find and to carry items (gameplay relevance), Meeko offers no further assistance.

Table 12 shows the results of the questions (1) how much players have enjoyed the game (game rating) and (2) how much they liked the companion (companion rating), and also gives information how many participants have filled in the game-specific questionnaires. The mean values indicate that all games and companions were perceived rather positively in general.

To investigate whether the overall game ratings are related to the companions' ratings, Pearson's product-moment coefficients were calculated. Results show that the two ratings positively correlate for all games except from Fallout (r = .072, p = .416): BioShock (r = .714, p < .001), The Last of Us (r = .630, p < .001), Skyrim (r = .252, p = .009), and Fable (r = .353, p = .024). Hence, the overall player experience is not necessarily determined by the evaluation of the companion. Nevertheless, most ratings correlate, indicating that a well-perceived companion may contribute to general game enjoyment. Future research should thus address the question how much influence a companion can have on game enjoyment and whether this influence is moderated by certain companion characteristics such as story relevance or skills.

To compare the different dog companions and the two human companions, respectively, we tested for significant differences in their rating scores. Elizabeth and Ellie are both rated very positively. A t-test indicates that Ellie is rated even better than Elizabeth; t (194) = -2.09, p = .038. Given that the two companions seem rather comparable at first sight, this raises the question why Ellie is perceived slightly more positive. Clustered answers to the open question "What did you like most about this companion" reveal differences in players' perceptions of the two characters: Ellie is often commended for forming a meaningful emotional relationship with the player's character (N = 27), having great humor (N = 14), and being a believable and realistic character (N = 29). Elizabeth is mainly characterized as being helpful and reliable in battle (N = 26), having a great personality (N = 37), and being an important part of the story (N = 31). Hence, while Elizabeth is appreciated for being well-integrated into the game and its story, Ellie is often commended for adding an emotional level to the experience. This might be one reason why Ellie's companion rating is exceptionally high and significantly higher than Elizabeth's rating. However, factors such as their specific personalities, character arcs, different graphic styles, and roles in the game, as well as general differences of the games in terms of gameplay and fiction are further possible reasons. Our insights present a starting point for a future, in-depth comparison of the two games and characters.

An ANOVA comparing the ratings of Dogmeat, Meeko, and the nameless dog of Fable also indicates a significant effect; F (2, 276) = 19.93, p < .001. Post-hoc tests reveal that Meeko is rated significantly worse than Dogmeat and the Fable dog, but that there is no significant difference between the last two. Since Skyrim offers a lot of different companions, one reason might be that Meeko feels exchangeable. Another point might be that Meeko seems to be the least helpful of all companions and also does not offer a lot of interaction. Since he is also prone to accidentally dying without the player's fault, he combines several points that were criticized: Not being able to care for himself, not offering meaningful interaction, and not offering help during the course of the game.

7.5 DISCUSSION

Overall, the results of our survey are in line with the design implications provided within our design space and approve the potential of companions to enhance the player experience. The majority of players has a good opinion of game companions in general. They value well-written companions who show an unique personality, have their own head, own objectives, and an interesting background story. Furthermore, our study results highlight the importance of appropriate and believable behavior by identifying that most negative experiences reported can be attributed to inapt behavior like blocking the player character's way, interfering their strategy, or giving advice that is useless or inappropriate. Having to take the companion into consideration all the time proved to be a main complaint and fits in with the general preference for companions who are able to take care of themselves.

In order to build a relationship, many players expressed their wish for a complex companion that allows meaningful interaction and adds a certain social challenge. Companions thus seem to be able to add a social level of gameplay to a digital game. Another point that ties in with the wish for lifelike, intelligent companions is that many participants commended humor in certain companions. Generally, the emotional bond between player and companion is considered important by players. The majority prefers to build an emotional bond to a companion and also enjoys the development of their relationship during the game. This especially pays off in singleplayer games as most participants agree to not feel alone during play when being accompanied by a companion. Thus, companions seem to offer a way to make singleplayer games feel less lonely.

We can summarize, that from the players' point of view, the characteristics personality, own agenda, context sensitivity, autonomy, initiative, and story significance are crucial for well-perceived companions and, thus, should receive special attention in the design process. Interestingly, player do not seem to be interested in *controlling* the companion and its behavior. They prefer to play with companions who provide the illusion of intelligence and personality.

We have to admit that our findings are predominantly derived from experiences with companions in role-playing and action-adventure games, as companions are primarily found in such games to date. In other genres (e.g., puzzle games or strategy games) the importance of certain companion characteristics might differ. To establish companions in other genres as well, it has to be further investigated how they can be integrated and which roles and characteristics they should feature.

7.6 CONCLUSION

The design space of game companions presented in this chapter and the results of our survey lead the way to the design of compelling companion characters. We have discussed favorable characteristics and common design flaws both from the academic and the players' points of view. We suppose that these insights will support game designers to create fascinating experiences tailored to players' expectations.

Furthermore, our work provides a starting point for future research regarding companion characters in games and the evaluation of their impact on the players' experience. Based on the design space dimensions and the presented survey a questionnaire can be developed in order to be able to quantify and compare the characteristics of different companions. This endeavor will also account for current approaches of game AI implementation to explore the related design opportunities with respect to system capabilities, as the design and implementation of convincing companions is very demanding and increases the load in the system. However, with ongoing advances in the field of game AI, we believe that social game companions are a promising way to enrich the experience of digital gaming.

8 THE SOCIAL INFLUENCE OF REAL AND VIRTUAL CO-PLAYERS

The last chapter has introduced game companions as a special type of NPCs and discussed design challenges as well as players' attitudes and expectations towards them. Based on this first general investigation, which has pointed out the potential of companions to influence the player experience, the following chapters are focused on specifically examining their social impact.

This chapter presents a study on the social experience in virtual reality (VR) games. VR games are a special type of digital games due to their specific interface configuration, and thus offer an interesting case to investigate social aspects. Players of VR games wear an HMD and headphones, which isolates their visual and auditory sensory systems from real-world stimuli and replaces them by virtual cues. As a consequence, VR systems provide a high degree of sensory immersion, fostering the feeling of presence in the virtual world. This is supposed to be an important part of the experience. The presence of real-world co-players or virtual social entities who show unbelievable behavior might interfere with this immersion [105, 284, 293] (cf. section 3.1.2).

Moreover, due to the sensory isolation from the real world, VR systems have repeatedly been criticized in the media to provide a lonely and antisocial experience[1,2], because players are also separated from all other persons who are co-present. Though this criticism is not supported by grounded research, such discussions indicate that implementing social features and multiplayer modes into VR games can be a challenging task and at the same time is a promising approach to tackle the possible lack of sociability [133, 338]. Hence, this chapter addresses the potential benefits and issues of social entities with regards to the player experience when playing a VR game.

This chapter present a study of my colleague Stefan Liszio and me investigating whether playing a VR game with an integrated virtual character affects the player experience in the same way as playing with a real co-player represented by an avatar. Additionally, we compare both settings to a singleplayer experience. We assume that both playing with a companion and playing with a co-player changes the player experience and prevents the feeling of being alone in the virtual world. With regard to my research model (cf. Figure 4), this chapter addresses social play settings which include either a co-player, a companion NPC, or no social entity and investi-

1 Brian Crecente on polygon.com (2015): *Nintendo's Fils-Aime: Current state of VR isn't fun*; `https://www.polygon.com/2015/6/18/8803127/` (last accessed: 05. July 2019)

2 Maya Kosoff on vanityfair.com (2016): *Tim Cook Just Nailed the Problem with Virtual Reality*; `https://www.vanityfair.com/news/2016/09/tim-cook-just-nailed-the-problem-with-virtual-reality` (last accessed: 05. July 2019)

gates the differences in the associated social player experience in a VR game (special interface).

The study described in this chapter is based on our collaborative paper, that was presented at the Foundations of Digital Games conference in 2017. The following text is based on the paper version that can be found in the conference proceedings with the title *The Influence of Social Entities in Virtual Reality Games on Player Experience and Immersion* [200] and adapted to the scope of this thesis.

8.1 STUDY CONCEPTION

The aim of this study was to systematically investigate the impact of the presence of different social entities on players in VR games. Therefore, we conducted a comprehensive study comparing the player experience of a singleplayer game mode and four other multiplayer game modes that include different forms of social entities. In the following we present the hypotheses that guided our approach and the design of the custom testbed game that we developed to systematically test our assumptions.

8.1.1 *Hypotheses*

The study was aimed at testing several hypotheses that are based on current research regarding player experience and social aspects of gaming. First, we wanted to investigate the general influence of the presence of a social entity on the player experience in a VR game. Based on findings regarding the positive experiences in multiplayer games and the motivational pull of social gaming (cf. Chapter 3), we assume a positive influence of social entities on the player experience (H1). More precisely, we assume a positive effect on game enjoyment:

H1a *The presence of a social entity in the game enhances the player experience in terms of increased enjoyment as compared to a singleplayer game.*

Moreover, though findings in related work regarding the effect of social entities on player's immersion are partly contradicting, we assume that well-integrated social interaction can increase feelings of presence in the virtual world. Hence, we hypothesize that:

H1b *The presence of a social entity in the game enhances the player experience in terms of increased immersion as compared to a singleplayer game.*

As social entities can be implemented in various forms, we assume that certain characteristics significantly moderate their impact on the player experience. According to the threshold model of social influence [28], the main factors are behavioral realism and agency. Hence, those complementary factors should be systematically varied in the study to investigate their moderating impact. Agency is varied by integrating a real co-player or a virtual character. Behavioral realism is addressed in terms of interactivity, as appropriate responsive behavior is supposed to appear realistic and human-like. Thus, the social entity's behavior is either implemented as responsive and interactive or as unresponsive and non-interactive. Accordingly, we assume that the characteristics *agency* and *interactivity* of the social entities are supposed to influence their impact on the player experience.

H1c *The characteristics agency and interactivity of the social entity influence its effect on the player experience.*

Furthermore, we wanted to test whether agency and interactivity are also related to the experience of social presence. If players perceive the other player or the virtual character as a social entity, they are supposed to have feelings of social presence. The intensity of this experience is supposed to depend on the characteristics of the social entity. Hence, we assume the following:

H2 *The characteristics agency and interactivity influence the experience of social presence aroused by a social entity.*

Related to social presence is the concept of loneliness. A player is supposed to feel less lonely in the presence of others. On the other hand, VR technology is often criticized as being isolating and may, thus, increase feelings of loneliness if no other social entity is present. We consider loneliness as a counterpart of social presence and test if the players' perception of loneliness is influenced by the presence of a social entity. We assume:

H3 *The presence of a social entity diminishes the perception of loneliness in the virtual world.*

8.1.2 *Testbed Game Design*

To test our hypotheses, we implemented a simple first-person VR game that can be played in a singleplayer mode and at the same time allows for the plausible integration of another social entity. Based on our research questions, we decided to implement five different game modes:

(1) Singleplayer

(2) Non-interactive virtual character

(3) Interactive virtual character

(4) Non-interactive co-player

(5) Interactive co-player

In every game mode, the player's goal is to reach the other side of a lake (see Figures 25 and 26). To cross the lake, the player can move over wooden planks, which are scattered all over the water. Some platforms are occupied by hostile crabs. If the player tries to step on one of these, the crabs push the player into the lake and the level is restarted from the beginning. Thus,

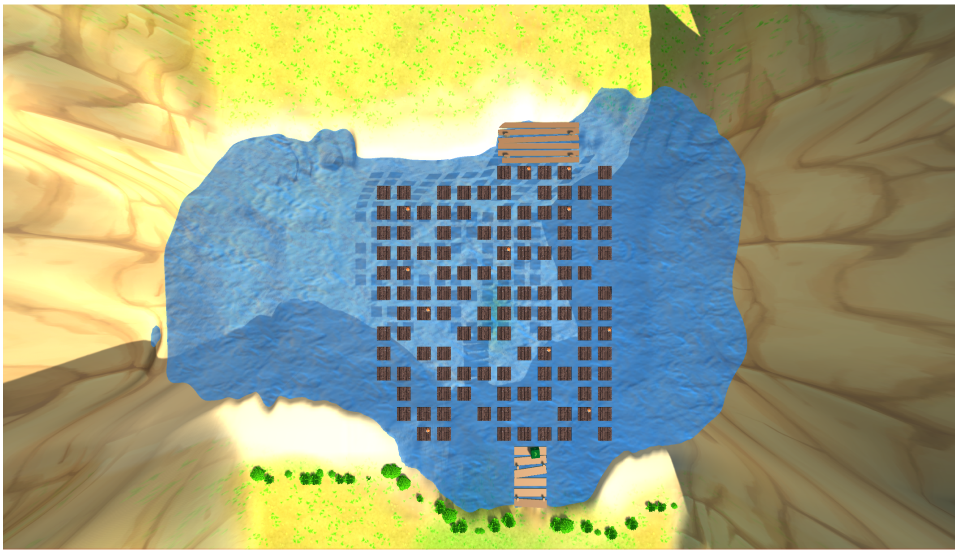


Figure 25: Overview of the game world from above. The first player starts at the bottom side of the lake and has to find a way over the wooden planks in the water to reach the other side of the lake.

the challenge is to find the right way to the other side without encountering crabs and falling into the water. The game is played with the Oculus Rift CV1 and a common Xbox One gamepad. Controls are kept simple and limited to one thumbstick and one button so that players can quickly learn them without prior experience.

This basic game concept was implemented in five different game versions as stated above. The singleplayer mode features no further adaptation, whereas the other four game modes all additionally include a little tortoise swimming in the lake (cf. Figure 27). The tortoise represents the social entity which is either controlled by a second player or by the game system. This form of representation was chosen because it can be integrated well into the game's setting. Though the social entity has no human-like appearance, it is supposed to be perceived as a social entity and to elicit social influence to some degree, as research has shown that anthropomorphic physical appearance is not a necessary prerequisite for high levels of perceived behavioral realism and social presence [28, 178].

The tortoise has the ability to dislodge crabs from the wooden platforms, thus it can help the player to cross the lake without being attacked. Accordingly, in all social game modes there are more platforms that are occupied by crabs than the singleplayer mode in order to make the help of the tortoise necessary and to keep the game's difficulty constant across all conditions. In the game modes that include a second player, the co-player navigates the tortoise and selects platforms to remove the crabs and to make them accessible. The co-player uses a tablet device to play and takes the tortoise's first person perspective. If the tortoise is controlled by the game system, its behavior is based on predefined rules.

As stated above, the tortoise was varied not only in terms of agency but also in terms of interactivity. In the interactive versions, the main player

Figure 26: Screenshot from the game showing the game world from the main player's perspective at the beginning of the game.

can throw little berries on nearby platforms to indicate that the tortoise should free this specific platform from crabs. If the tortoise is a virtual character, it reacts directly to the player's hint, swims to the corresponding platform and makes it accessible. This appropriate reaction is supposed to increase perceived behavioral realism. Moreover, the tortoise introduces itself at the beginning of the game, comments the proceeding of the player, always stays near the player, and turns to always look at the player in order to indicate awareness. This way, the tortoise becomes the player's game companion. If the tortoise is controlled by a human co-player, the co-player receives a clear sign whenever the first player uses berries and can react appropriately, as well. Furthermore, both players can communicate via the voice-chat software *TeamSpeak* (the first player is wearing headphones) and, thus, are able to directly coordinate their strategies.

In contrast, the non-interactive game modes do not allow for any direct interaction with the tortoise. Thus, the main player cannot influence or control the tortoise's actions. Instead, the non-interactive virtual character automatically dislodges crabs from the occupied platform that is nearest to the first player's current position. The non-interactive second player has to decide which platforms to choose without any hints from the first player. No verbal communication is possible in this condition.

8.1.3 *Procedure and Measures*

The experience of players in the different game versions was compared in an empirical study. We chose a between-subject study design with the type of accompanying social entity as independent variable, resulting in five study groups in accordance with the five game modes. As dependent variables the study focuses on players' experiences of immersion, social presence, enjoyment, and loneliness.

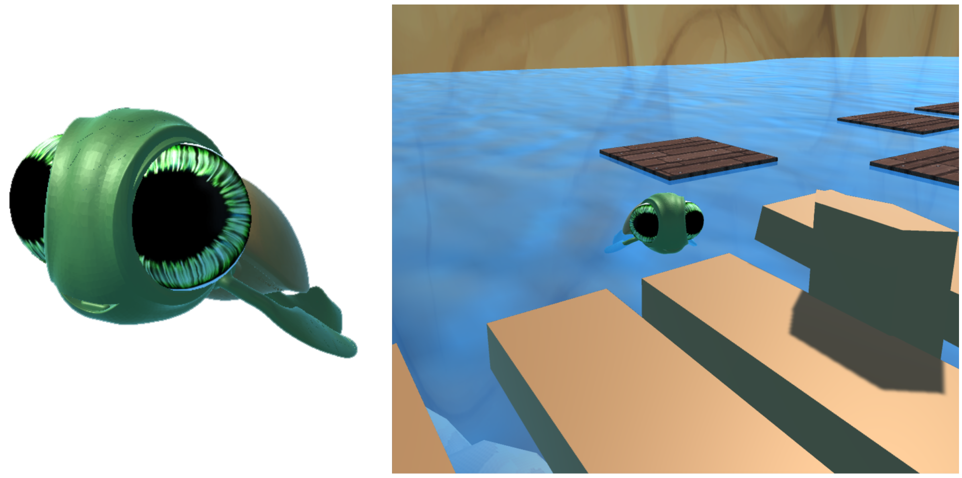


Figure 27: Picture of the tortoise that serves as the second player's avatar in the two-player versions of the game and as computer-controlled game companion accompanying the player in the versions with a virtual character (whereas it is not included in the singleplayer mode). The left picture shows the tortoise model, which was originally created by Verislav Mudrak and accessed via the Unity Asset Store. The picture on the right side shows the tortoise in the game scene, from the point of view of the main player.

The study took place in our lab at the University of Duisburg-Essen. Participants were randomly assigned to one of the five conditions. After being welcomed and informed about the study's procedure and goal, participants were asked to fill in some questionnaires about demographic data as well as relevant individual attitudes and traits. The Preference for Solitude Scale (PfS) [228] and the UCLA Loneliness Scale [260] were applied in order to be able to assess participants' general attitude towards loneliness and their experience with it. The PfS describes to what extent a person appreciates to be alone or seeks social company on the three subscales *enjoyment*, *need*, and *productivity*. All items are formulated as pairs of opposing statements coded with 0 or 1, and participants have to decide to which statement they agree more. The one-dimensional UCLA scale provides insights into participants' general perception of loneliness and social isolation in their current every day life. The 20 items are rated on a scale ranging from 0 to 3 and added up for an overall score ranging between 0 (very low) and 60 (very high). Furthermore, the ITQ [312, 344] was used to measure how easily participants get immersed in certain activities. It includes the four subscales *involvement*, *focus*, *games*, and *emotions*, and items are rated on a 7-point scale ranging from 0 to 6.

After these first questionnaires, the rules and controls of the testbed game as well as the Oculus Rift system were introduced. After becoming adjusted to the HMD and the controller, one of the five game modes was started according to the study condition. In the two co-player conditions, the examiner took on the role of the co-player to assure consistent behavior in all study runs. In those cases, the examiner sat next to the participant playing with the tablet (see Figure 28). During all gaming sessions participants were

Figure 28: In the setup of the co-player conditions, the examiner played with the participant by controlling the virtual character on a tablet PC in a co-located setting. Participants wore headphones and verbal communication was only possible in the interactive co-player condition via TeamSpeak.

wearing headphones and participants and the examiner did not communicate, except from the interactive second player condition. All participants played as long as the goal was reached, which took about 7 - 8 minutes on average.

To test our hypotheses, a couple of questionnaires were applied after participants had finished the game. Several dimensions of the player experience were assessed using the core module of the GEQ [142]: *positive affect*, *negative affect*, *immersion*, *flow*, *challenge*, *tension/annoyance*, and *competence*. Each dimension is measured by several items in form of statements to which participants have to rate their agreement on a 5-point Likert scale (coded 0 - 4).

As immersion and presence are supposed to be particularly relevant for the player experience in VR games, the IPQ [273, 274] was applied to further investigate these concepts. The IPQ contains the three subdimensions *spatial presence*, *involvement*, and *experienced realism* as well as one single item to assess perceived presence in general. All items are phrased as statements that participants have to rate on a 7-point Likert scale (coded 0 - 6).

To get insights regarding the social influence and perception of the social entity, three questionnaires were applied: the SPGQ [142, 359], the CSP scale, which is part of the CCPIG [136, 138], and the relatedness scale of the PENS [254]. The SPGQ measures the construct social presence in terms of the three dimensions *empathy*, *negative feelings*, and *behavioral involvement* on a 5-point Likert scale (coded 0 - 4). Hence, this questionnaire provides information about the perceived emotional and behavioral relation between the player and the social entity. The CSP also uses a 5-point Likert scale and assesses social presence in cooperative environments, focusing the cooperative aspect of the interaction with the subdimensions *perceived team cohesion* and *team involvement*. The *relatedness* scale of the PENS contains three further items regarding the perceived quality of the social relationship to the social entity, which have to be rated on a 7-point Likert scale (coded 1 - 7). SPGQ, CSP, and PENS were not applied in the singleplayer condition, as there was no social entity to refer to.

To assess perceived loneliness during the use of the VR-system, we used an adapted version of the UCLA Loneliness Scale: items were rephrased so that they all referred to the concrete experience while being in the virtual world instead of asking for the general perception of loneliness in life. We tested reliability of this revised version of the UCLA scale by calculating Cronbach's alpha, which indicates a very high level of internal consistency ($\alpha = 0.92$).

Finally, we included the SSQ [169, 313] to look for negative influences and biases due to physical strains related to the use of the head-mounted VR-system. It assesses symptoms like nausea, headache, and disorientation on a rating scale ranging from 0 (none) to 3 (severe).

8.2 RESULTS

Seventy-five persons (41 females), aged 19 to 58 ($M = 25.1$, $SD = 7.27$), participated in the study. Subjects were randomly assigned to the five experimental groups. Distribution of age and gender was comparable in the groups. The participants were recruited in the context of the university, thus most of them were students ($N = 60$) or employees ($N = 13$). We did not observe any differences or influencing effects of participants' individual characteristics such as age, gender, preference for solitude, or immersive tendency. Moreover, groups did not differ significantly with respect to simulator sickness ($M = 24.4$, $SD = 28.8$), which was rather low in general.

In the following, we describe the data analyses according to the aforementioned hypotheses. For the sake of readability, means and standard deviations of the respective variables are summarized in Table 13.

8.2.1 *Test of H1a: Social entities enhance game enjoyment*

Game enjoyment was measured by the subdimensions positive affect and negative affect of the GEQ. An ANOVA showed significant differences between the experimental groups concerning participants' reported positive affect, $F\ (4, 71) = 5.69$, $p < .001$, $\eta_p{}^2 = .24$. Post-hoc analyses with Bonferroni correction indicate significant differences between the game mode including the non-interactive virtual character compared to the other game modes. Participants who played alone felt more enjoyment than participants who

Table 13: Means and standard deviations for the different variables describing players' experience while playing our testbed game.

Variable (Measure)	Single-player (N = 14) M (SD)	Non-int. Virtual C. (N = 12) M (SD)	Int. Virtual C. (N = 15) M (SD)	Non-int. Co-Player (N = 11) M (SD)	Int. Co-Player (N = 15) M (SD)
Positive Affect (*GEQ*)	3.11 (0.68)	2.15 (0.75)	2.80 (0.68)	3.14 (0.66)	2.93 (0.48)
Negative Affect (*GEQ*)	0.10 (0.13)	0.55 (0.52)	0.50 (0.44)	0.25 (0.27)	0.33 (0.28)
Immersion (*GEQ*)	2.82 (0.65)	1.83 (0.72)	1.98 (0.73)	2.47 (0.55)	2.10 (0.65)
General Presence (*IPQ*)	4.87 (1.51)	3.87 (1.36)	4.20 (1.32)	4.56 (1.50)	4.67 (0.49)
Experienced Realism (*IPQ*)	2.60 (1.06)	1.38 (0.93)	1.47 (0.76)	1.70 (1.19)	1.77 (0.95)
Loneliness (*UCLA VR*)	23.8 (12.5)	27.7 (12.7)	16.5 (8.00)	24.8 (12.5)	8.80 (5.61)
Empathy (*SPGQ*)	–	1.39 (0.82)	1.69 (0.75)	1.85 (0.92)	1.79 (0.82)
Negative Feelings (*SPGQ*)	–	0.24 (0.53)	0.44 (1.02)	0.35 (0.74)	0.11 (0.21)
Behavioral Involvement (*SPGQ*)	–	2.28 (0.94)	2.87 (0.66)	2.82 (0.67)	2.79 (0.67)
Team Cohesion (*CSP*)	–	1.45 (0.95)	2.41 (0.81)	3.00 (0.51)	2.70 (0.98)
Team Involvement (*CSP*)	–	1.62 (0.89)	2.51 (0.80)	2.85 (0.54)	2.45 (0.89)

played with the non-interactive virtual character (p = .002). Furthermore, subjects in the interactive co-player group experienced more positive affect than subjects in the non-interactive virtual character group (p = .016). The non-interactive co-player group also reached higher levels of positive affect than the non-interactive virtual character group (p = .001). Only the interactive virtual character condition did not differ significantly from the game mode with the non-interactive companion, or any other condition.

Additionally, we found significant differences between groups with respect to negative affect measured with the GEQ, F (4, 71) = 4.04, p = .005, $\eta_p{}^2$ = .19. The post-hoc analyses with Bonferroni correction indicate that participants who played alone scored lower on negative affect than subjects who played with the non-interactive virtual character (p = .009) or the interactive virtual character (p = .029). No other two groups differed significantly.

Beyond that, we did not find any significant differences between the groups with regards to the other GEQ dimensions competence, flow, tension/annoyance, and challenge.

8.2.2 *Test of H1b: Social entities enhance immersion*

To determine the effect of social entities on immersion, we performed an ANOVA and found a main effect of game mode on the immersion dimension of the GEQ, F (4, 71) = 5.65, p = .001, $\eta_p{}^2$ = .24. The Bonferroni post-hoc test indicates that the singleplayer group reached higher immersion scores than the groups non-interactive virtual character (p = .001), interactive co-player (p = .028), and interactive virtual character (p = .008). No significant difference between singleplayer and non-interactive co-player were found.

Regarding the components of the IPQ, we did only find a significant main effect of game mode on experienced realism, F (4, 71) = 3.56, p = .011, $\eta_p{}^2$ = .17. A Bonferroni post-hoc test suggests that singleplayers reported significantly higher values for experienced realism than players who played with a non-interactive virtual character (p = .013) or an interactive virtual character (p = .026). No significant differences were found for the remaining groups.

8.2.3 *Test of H1c: Agency and interactivity influence the effects on the player experience*

In order to further analyze the role of the two characteristics agency and interactivity of social entities, we grouped the actual experimental conditions according to their level of *agency* and their level of *interactivity*, respectively. Thus, the conditions interactive and non-interactive virtual character were treated as one combined group "virtual character" (low agency) and the conditions interactive co-player and non-interactive co-player were treated as one group "co-player" (high agency) as the two levels of the factor agency. The same was done for the factor interactivity: the conditions interactive virtual character and interactive co-player were combined to one group "interactive", while the conditions non-interactive virtual character and non-interactive co-player joined to one group "non-interactive". The singleplayer condition was treated as a third level in both cases.

We performed an ANOVA with agency as a factor and again with the components of the GEQ as dependent variables. We found significant main effects of agency on flow, F (2, 73) = 4.79, p = .012, $\eta_p{}^2$ = .12, positive affect, F (2, 73) = 6.74, p = .002, $\eta_p{}^2$ = .16, and negative affect, F (2, 73) = 7.94, p = .001, $\eta_p{}^2$ = .18. Comparing the three levels of agency by performing a Bonferroni post-hoc test, the singleplayer condition turned out to reach the significantly highest scores for each of the tested variables (the lowest score for negative affect, respectively). However, in this analysis we were more interested in the differences between virtual character and real co-player. The co-player group experienced marginally significant (p = .052) higher levels of flow (M = 2.28, SD = 0.62) compared to the virtual character condition (M = 1.91, SD = 0.71). Further, subjects playing with a human co-player scored significantly (p = .033) lower on negative affect (M = 0.29, SD = 0.27) than subjects who played with a virtual character (M = 0.52, SD = 0.48). Finally, subjects in the co-player group reached significantly (p = .006) higher levels of positive affect (M = 3.04, SD = 0.58) than subjects in the virtual character group (M = 2.47, SD = 0.58).

For interactivity as a factor, we did not find any significant main effect on any of the examined variables.

To test the effects on perceived presence, we performed an ANOVA with agency as a factor and the GEQ immersion dimension as well as the components of the IPQ as dependent variables. The only observable main effect was found for GEQ immersion, F (2, 73) = 9.62, $p < .001$, $\eta_p{}^2$ = .21. However, the higher immersion scores of the co-player groups (M = 2.28, SD = 0.62) compared to the scores of the virtual character group (M = 1.91, SD = 0.71) were not significant (p = .093). As for enjoyment, we did not find significant main effects of interactivity.

8.2.4 *Test of H2: Agency and interactivity influence social presence*

For the investigation of the influence of interactivity and agency on social presence, the singleplayer group had to be excluded from the analysis, since subjects in this group did not answer the SPGQ and CSP questionnaires. An ANOVA with the remaining four groups as a factor and the dimensions of the SPGQ as dependent variables did not reveal a significant main effect. Additionally, in the descriptive analysis no tendencies of the mean scores were identified (cf. Table 13).

However, as a supplement to the SPGQ, subjects in the four groups with a social entity answered the CSP questionnaire. Significant main effects were found for the two subdimensions team cohesion, F (3, 57) = 10.4, $p < .001$, $\eta_p{}^2$ = .35, and team involvement, F (3, 57) = 6.74, p = .001, $\eta_p{}^2$ = .26. The Bonferroni post-hoc test indicates that the non-interactive virtual character group experienced significantly lower levels of team cohesion compared to the conditions interactive virtual character (p = .013), non-interactive co-player ($p < .001$), and interactive co-player ($p = .001$). The same applies for team involvement: the non-interactive virtual character condition scored significantly lower than the conditions interactive virtual character ($p = .016$), non-interactive co-player ($p < .001$), and interactive co-player ($p = .028$).

8.2.5 *Test of H3: Social entities diminish the perception of loneliness in the virtual world*

The general perception of loneliness of participants in the current life situation was measured using the UCLA loneliness scale ($M = 15.8$, $SD = 10.6$). The groups did not differ significantly regarding mean general loneliness scores. As described above, we used an adapted version of this scale to assess perceived loneliness in the virtual world while playing our game ($M = 20.4$, $SD = 12.4$). An independent-samples t-test indicates that the difference between the general loneliness reported by the participants and their perceived loneliness while playing is significant, t (75) = 2.52, $p = .014$, $d = .40$.

Performing an ANOVA, a significant main effect of the game mode on perceived loneliness in the VR game was found, F (4, 71) = 7.82, $p < .001$, $\eta_p{}^2 = .31$. The lowest values for loneliness in VR were observed in the interactive co-player group, followed by the interactive virtual character group. The highest loneliness score was measured in the non-interactive virtual character condition (cf. Table 13). Post-hoc analyses with Bonferroni correction indicate that subjects who played with an interactive co-player perceived significantly lower levels of loneliness in VR than subjects who played the game as a singleplayer ($p = .002$) and subjects who played with the non-interactive virtual character ($p < .001$). Further, the interactive co-player group reported significantly lower loneliness values than the non-interactive co-player group ($p = .001$). Mean scores of loneliness of the interactive co-player condition compared to the interactive virtual character condition did not differ significantly ($p = .49$). Differences in the mean scores of the interactive virtual character condition and the non-interactive virtual character condition were marginally not significant ($p = .053$), either.

8.3 DISCUSSION

While testing our first hypothesis that the existence of social entities in VR games enhances the player experience in VR games in terms of enjoyment and immersion, we found significant differences between the five experimental groups regarding their mean scores for positive affect and negative affect (H1a), as well as immersion and experienced realism (H1b). For game enjoyment, positive affect was not higher and negative affect not lower in the game modes that featured a social entity compared to the singleplayer version of the game. This lack of difference indicates that the existence of a social entity does not increase game enjoyment *per se*, contradicting H1a. In contrast, the game mode including a non-interactive virtual character was the only one that was perceived significantly worse in terms of positive and negative affect compared to the other groups. Hence, a social entity with low agency and low interactivity seems to interfere with game enjoyment instead of enhancing it.

We further investigated how the characteristics of a social entity influence its effect on the player experience (H1c). Considering agency as a factor, we found significantly higher values of flow and positive affect, as well as lower values for negative affect for the co-player condition (high agency) as compared to the virtual character condition (low agency). Since we did not find significant differences between the groups regarding any of the observed dimensions when using interactivity as a factor, we conclude that agency might have a higher potential to affect a social entity's influence on the player experience. That is, playing with a human co-player leads to higher levels of enjoyment and flow than playing with a virtual character.

So far, our findings are in line with those of other authors [133, 209, 338]. However, a closer look into the results of the comparison of the experimental groups indicates a moderating and interacting effect of agency and interactivity of the social entity: whether the social entity is another human player or a virtual character has no impact on the player's positive feelings if the social entity is interactive. Conversely, if the social entity does not interact with the player, the player experiences more joy when playing with a human co-player compared to a virtual character. While playing with an interactive or non-interactive co-player does not impact negative feelings during play compared to playing the game alone, playing the game with a virtual character, regardless of its interactivity, increases negative affect. Playing with a non-interactive virtual character leads to the lowest values of positive affect. Thus, our findings are in line with the assumptions of the threshold model of social influence by Blascovich et al. [28]. We conclude that virtual characters tend to be subordinate as social entities compared to human co-players regarding their influence on enjoyment. If a virtual character should be included into a VR game, it has to be designed carefully. Hence, it seems preferable to omit virtual characters who are not interactive.

With regard to cognitive immersion (H1b), the scores in the co-player conditions and the virtual character conditions indicate that the existence of a social entity in a VR game affects immersion negatively, since the single-player group reached the highest score for immersion (as measured by the GEQ). Hence, H1b is not supported. Moreover, the comparison of the mean immersion score when playing with a human co-player reveals higher levels of immersion compared to playing with a virtual character. This may be due to the higher levels of experienced realism of the virtual world when the player is aware of the social entity being human. Low levels of experienced realism when playing with a virtual character may arise because the companion's behavior did not live up the player's expectation of naturalness. The sense of artificiality of the virtual character could then be associated with the entire VR experience.

Our results regarding immersion are in conflict with the findings of Cairns et al. [47], who observed increased levels of immersion in situations where social play occurs. The authors suppose that social interaction only impedes immersion if it is not integrated into gameplay. In our game, we integrated the interaction of the main player and the social entity as an integral part of the gameplay, as the game cannot be completed without the help of the other character. Hence, we assume that the social interaction was well-integrated into gameplay. However, it is possible that players perceived the interaction in our game as not being compelling and interesting enough, so that it did not contribute to their feelings of presence. It is up to future research with other game scenarios to further investigate the complex interplay of immersion and social aspects in VR games.

After examining the impact of social entities on the player experience, we further investigated the influence of interactivity and agency on the experience of social presence when playing with either a virtual character or a human co-player (H2). However, we did not find significant differences between the four experimental groups (note that we did not assess social presence in the singleplayer condition) concerning the dimensions of the SPGQ. This might be a result of the generally low values of emotional and behavioral involvement in the experimental groups. The social entity's visual representation was designed in order not to elicit specific emotional responses. Furthermore, interacting with the tortoise was equally necessary to win the game in all four conditions. Hence, the intensity to which the social entity was perceived by the players might be stable across the experimental groups. However, since the SPGQ dimensions mainly describe the intensity of perceived social presence in the game world, we also compared the groups with respect to both team cohesion and team involvement. These constructs describe the cooperative qualities rather than the intensity of the social interaction. Mean scores of both constructs were higher when the social entity was a human co-player compared to the virtual character. From the fact that the non-interactive virtual character reached the lowest values for team cohesion as well as team involvement and differs significantly from the other groups, we derive that high quality social interaction is only possible if both agency and interactivity are at sufficiently high levels.

Our third hypothesis regarding the diminishing effect of social entities on the player's perception of loneliness in VR (H3) addresses both the critic of VR being a lonely experience and the methodological issue of including the singleplayer condition in the analysis of the social aspects of the player experience. We observed increased values of perceived loneliness in the VR game compared to the general loneliness score. This could indicate that players felt more isolated and alone in the virtual game world than in real life on average. However, levels of both perceived loneliness in VR and general loneliness were rather low in our sample. Thus, we suggest that the isolating effect of VR on the user can be neglected. Counter-intuitively, the results show that subjects in the singleplayer condition did not perceive the highest level of loneliness, but subjects who played with a non-interactive virtual character or a non-interactive co-player. Lowest loneliness scores were found in the groups interactive co-player and interactive virtual character. From these findings we can draw the conclusions that the absence of social entities in the virtual game world does not lead to levels of loneliness as high as the dissatisfaction playing with a passive, non-responsive counterpart. Since we did not find a significant difference between the groups interactive co-player and interactive virtual character, we assume that interactivity of the social entity is more influential on perceived loneliness in VR games than agency. Setting these findings in line with the results found regarding H2, it is possible that interactivity elicits the experience of co-presence by stimulating a notion of mutual awareness, which is sufficient to prevent loneliness but is insufficient to provide a rich, comprehensive experience of social presence in terms of team cohesion and team involvement.

8.3.1 *Limitations of the Study*

In our study, we did not explore certain design aspects of social entities, that is, we did not vary the visual representation of the virtual character. The social entity in our testbed game was represented as a non-human tortoise in comic style. It is possible that specific visual characteristics like anthropomorphism model the various effects of the social entity on the player experience [231]. However, recent research indicates that some important behavioral cues (e.g., facial expression or gaze), which determine the realism of the representation of a social entity, can be compensated [258]. In future studies, the design of the social entity should be varied to further investigate possible differences. In line with the assumptions of the threshold model of social influence, our non-interactive virtual character, that is a social entity characterized by both low agency and low interactivity, tends to receive the lowest scores regarding all measures of the player experience.

Although it is often assumed that social play inherently leads to more fun and enjoyment in games, our results suggest that the interactive co-player condition is not superior to the singleplayer condition in the sense of high values indicating a positive player experience. Since player experience is a multifaceted concept [237] and people's motivations to play are manifold [348], it is up to future research to investigate the interrelation of the characteristics of the individual player, the incorporated social entities, and the VR game itself. We focused on the influence of social entities in a cooperative VR game, but did not research whether the effects are different in competitive games. Moreover, our testbed game was constructed as a causal game, which is easy to learn and of short length, in order to avoid our results to be biased by individual preferences or gaming skills. Results may not apply to complex games that are focused on long-term interactions.

8.4 CONCLUSIONS

In this paper, we examined the question of whether social entities in VR games influence player experience, immersion, and the feeling of loneliness and isolation in the virtual world. The results of our study presented here suggest that adding social elements to a VR game does not directly enhance the player experience. Players in the singleplayer condition experienced higher levels of positive affect, immersion, and presence than players who played with either a co-player or a virtual character. Furthermore, we observed that playing with a virtual character is not a full equivalent to playing with a human co-player with respect to enjoyment and immersion. Addressing the criticism of VR as being a lonely experience, we found that subjects in the singleplayer condition actually did not feel as much alone as expected. The existence of a social entity which does not react to the player, no matter whether it is a co-player or an artificial character, causes a higher perception of loneliness than its absence. However, our results strongly indicate that playing with an interactive co-player or an interactive virtual character can significantly reduce loneliness. In summary, whereas playing a VR game with other players or virtual characters does not increase the player experience in terms of enjoyment and immersion, the integration of social interaction in VR games seems to be an effective method to avoid loneliness in VR. It has been shown that the relation between player experience, immersion, and social aspects of play is complex and further research on social VR games is needed. This work should help researchers to understand the player experience in VR games and support game designers to provide a better experience to players of VR games.

9 EVALUATING THE SOCIAL FACILITATION EFFECT IN DIGITAL GAMES

The previous chapter has shown that artificial social entities in games can affect the player's social player experience. In this and the following chapter, I will further elaborate on that and focus on a specific social effect that is well-established in social psychology: the social facilitation effect (cf. section 3.2.1). With respect to my research model (cf. Figure 4), the work described in this chapter investigates the social player experience elicited by a companion NPC and its influence on the player's performance due to social facilitation. Additionally, as a game aspect, the interface is varied by comparing a usual desktop setting to a virtual reality HMD.

This study contributes a systematic research approach as well as findings of an empirical study conducted to investigate the effect. A testbed game was specifically developed to enable the systematical variation of single impact factors of social facilitation. The following text is based on the paper entitled *The Influence of Virtual Agents on Player Experience and Performance* [90], which was presented at the CHI Play conference in 2016 and awarded with the best paper award.

9.1 A DETAILED VIEW ON SOCIAL FACILITATION IN GAMES

As already explained in Chapter 3, section 3.2.1, the social facilitation effect describes the change in a person's task performance due to the presence of another social entity. Performance can either be enhanced or inhibited, depending on various factors such as task difficulty, type of observer, and the importance of the task.

We assume that the social facilitation effect also applies to virtual environments, and in particular to the context of playing digital games. In most games, players have to overcome challenges to be successful and receive feedback about their progress and achievements. Games provide indicators of the player's performance such as points, progress bars, or levels. In this sense, playing a digital game that has a clear performance-related goal can be classified as a task and, as a consequence, the player's gaming performance may be influenced by the presence of others.

9.1.1 *Social Facilitation in Virtual Environments*

Moreover, we assume that the social facilitation effect can be induced by diverse social entities. In virtual environments, social effects are supposed to also be induced by digital representations of social entities, including artificial virtual characters. The social facilitation effect of both real and virtual social entities has been investigated in several studies. Rickenberg and Reeves [253] found inhibition effects on users' performances in web searching tasks when a virtual animated character was displayed on the websites. The effect was accompanied by increased anxiety elicited by the presence of the virtual character. Besides, the authors compared an idle character (not reacting to the user's action or apparently paying attention to the user) to a reactive and monitoring one. Though both versions increased anxiety compared to a website without any character, the influence on both performance and anxiety was higher for the monitoring character. This indicates that the social impact of a virtual character in terms of social facilitation can be dependent on its perceived level of agency and awareness of the user.

Hall and Henningsen [122] also conducted a study to examine whether a computer icon is capable of triggering social facilitation. They investigated the impact of Clippy, the default animated paperclip computer icon of *Microsoft Word* on participants' performances in easy and difficult typing tasks. Compared to accomplishing the tasks without the presence of the virtual character, participants' performance was negatively influenced by Clippy in case of high task difficulty, while there was no significant effect on the easy task. Hence, an inhibition effect of the virtual co-presence was found for the difficult task, but no facilitation effect for the easy task. Furthermore, the authors recognized a difference between male and female participants, in the way that women displayed higher inhibition effects.

Hoyt, Blascovich, and Swinth [135] carried out a study to replicate social facilitation effects in an immersive virtual environment. They varied the perceived agency of an virtual observer by differentiating between avatars controlled by a human being and artificial virtual characters controlled by the computer system. Participants had to solve a novel or learned task of pattern recognition or categorization in a virtual laboratory environment using an HMD. An inhibition effect of the avatar was found in case of the unlearned task, while the artificial character did not have any significant effect in either condition. This indicates, that the perceived agency of a virtual social entity influences its social impact. The authors argue that the evaluative character of avatars may foster social effects on performance, while virtual agents with low perceived agency do not trigger evaluation apprehension and, thus, no social facilitation [135].

Zanbaka, Ulinski, Goolkasian, and Hodges [355] compared the influence of a co-present real person, a projected virtual character, and a virtual character displayed in a completely virtual environment using an HMD on task performance in math tasks. In contrast to the study of Hoyt et al. [135], social inhibition effects were revealed in all three conditions for the complex tasks, although no evaluation apprehension was provoked, implying that there is no difference between the influence of virtual and real persons. For easy math tasks, no facilitation effect was observed. In another comparable study presenting math tasks within a virtual environment, Hayes, Ulinski, and Hodges [132] varied the type of view of the users between first person and third person view as well as the gender of the co-present virtual character. Although there was no significant main effect of the audience type on task performance, trends were found indicating an inhibition effect in the case of complex tasks and a facilitation effect on simple task in the presence of a female virtual character. Thus, the gender of the audience might also be an influential factor.

In sum, these studies demonstrate that both real observers and virtual characters can take effect on task performance in virtual environments under certain circumstances. However, findings are inconsistent. At least some of these contradictory findings may be due to the variation in the design of the virtual characters. Differences in the visual appearance, voice acting, non-verbal behavior, agency, and behavioral realism of the different characters used in the studies may have mediated their impact on the participants' performance.

With regard to digital games, it has to be taken into account that the studies described so far were conducted using virtual environments that were not (or only slightly) interactive. Digital games, in contrast, offer a specific user experience, as they are highly interactive: The course of action is dependent on the player's input, while at the same time system-generated game events and riddles challenge the player. Moreover, digital games often also include some degree of unpredictability and a variety of different tasks. Hence, findings regarding the social influence of virtual characters in virtual environments may only partly be transferable to the special case of digital games.

In the current literature, there are only few examples for the investigation of social effects of co-present humans and virtual characters in the specific context of digital games. Bowman, Weber, Tamborini, and Sherry [34] report an increase of performance of players playing an easy version of a first-person shooter game in the presence of a real audience. They also refer to older studies of Brown et al. [39] and Kimble and Rezabek [171], who found indications for social inhibition effects while observing people playing the games *Pong*, *Tetris*, and *Pinball*. These results lead to the conclusion that real, co-present real observers can affect players' performance in terms of social facilitation effects.

In sum, though experiences so far indicate that social facilitation is likely to also occur in gaming scenarios, it is not yet studied regarding virtual characters in digital games. In order to be able to systematically investigate that, it is first necessary to identify the range of possible impact factors that may influence the effect in order to include them as variables in further research. With the following study, we present a first systematic approach to investigate the social facilitation effect evoked by virtual characters in the context of digital games [90].

9.1.2 *Possible Impact Factors: An Integrative Model of Social Facilitation*

A very suitable groundwork for summarizing possible impact factors of social facilitation is provided by Aiello and Douthitt [5]. They take up the theoretical classifications of Guerin [121], critically reflect the most popular theories regarding social facilitation (cf. section 3.2.1) and finally result in a comprehensive framework for examining social facilitation effects. Instead of favoring a single theory, the authors put emphasis on the importance of investigating the influence of different variables of the setting and distinguish five categories of potentially influencing factors:

- **Presence factors** include the type, salience, and length of presence as well as the role of the other person(s) and their relationship with the individual. Hence, this category comprises all aspects related to the co-present audience, that is supposed to cause the social facilitation effect.

- **Situational factors** define the setting in which a task is performed. These factors include sensory cues, the proximity and the feedback of the audience as well as the organizational climate, which all are supposed to mediate social facilitation.

- **Task factors** summarize the important characteristics of the task that has to be performed. They include the difficulty of the task, its specific characteristics and the type of task (like cognitive or motor tasks) and the associated time requirements. Task factors especially account for the inconsistent findings regarding social facilitation in different contexts and for different tasks.

- **Individual factors** relate to the person who performs the task. They are further differentiated into more stable characteristics like personality and performance capacity (defining to which degree the person is usually able to perform the task at hand) on the one hand and concrete perceptions and reactions in the current situation on the other hand. Perceptions include social processes like social comparison and evaluation, self-awareness and distraction, and thus account for many explanation theories of social facilitation. Reactions are subdivided into initial and subsequent reactions, where initial reactions also include physiological arousal and cognitive processes.

- **Performance factors** describe the kind of performance measure that is observed. While speed or accuracy have been investigated in diverse studies, other aspects like cooperation or helpfulness may be influenced differently.

Figure 29 gives an overview of the main impact factors regarding social facilitation and their influence on each other based on the integrative model by Aiello and Douthitt [5]. While the original model accounted for general aspects regarding social facilitation effects, we extended and slightly adapted it with a focus on digital games and virtual characters based on prior findings. We marked these adaptations in green and italic in Figure 29). The main change is proposed concerning the presence factors: a differentiation is suggested between attributes of the presence itself and particular characteristics of the audience. As the audience can also be represented by a virtual character, the aspects *perceived agency* and *anthropomorphism* are added to the model, as those factors are supposed to highly influ-

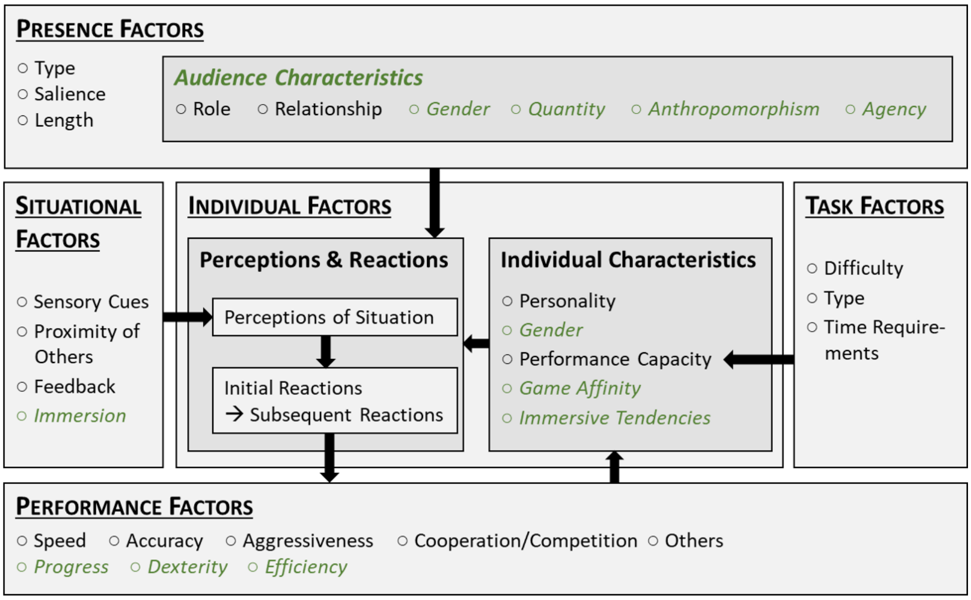


Figure 29: The Integrative Model of Social Facilitation by Aiello et al. (2001), adapted to artificial virtual characters in games; our changes to the original model are indicated by italic green font.

ence how a virtual character is perceived and evaluated [28, 135]. Anthropomorphism is not necessarily related to a human-like outer appearance, but can also be achieved by realistic behavior or appropriate voice implementation. Furthermore, the aspects *gender of the audience* (which might be male, female, or indistinguishable) and *quantity* (how many social entities comprises the audience) might influence social effects.

Regarding individual factors, the *gender of the task-performing individual* should also be accounted for, particularly in combination with the sex of the observing character (cf. [122, 132]). Furthermore, *game affinity* and *immersive tendencies* are considered as potential individual impact factors accounting for the special context of digital games and virtual environments. Immersive tendencies are supposed to effect the degree to which a person is immersed by an environment [312], while game affinity and expertise may mediate performance capacity.

Moreover, there are some more performance measures often found in games which have to be investigated, namely *progress*, *dexterity*, and *efficiency*.

Finally, an additional situational factor related to virtual worlds is *immersion*, as the degree of immersion is supposed to influence feelings of presence, that is to say the feeling of actually being in the virtual world [355] (cf. section 2.2.3). A higher feeling of presence, in turn, might increase the social influence of an audience. Therefore, immersion is considered as a situational factor in the adapted model of social facilitation, as it is supposed

Figure 30: Screenshot of the first-person perspective of the testbed game Spacetastic without companion. This version was used in our study.

to be an influential quality of the system that is used to play a game, while the feeling of presence is part of the resulting individual perception.[1]

9.2 A TESTBED GAME FOR THE INVESTIGATION OF SOCIAL FACILITATION

In order to investigate the impact of the presence of a virtual character on performance and player experience in digital games, a comprehensive game environment was designed and implemented using the *Unity3D* game engine. It allows to purposefully manipulate diverse independent variables of interest, while keeping all other aspects constant to ensure comparable results of dependent variables among game versions. The core of the testbed environment introduced here is a simple space shooter game, called *Spacetastic*, which can be adapted in various ways by manipulating a number of variables.

9.2.1 *Basic Game Design*

The singleplayer game Spacetastic resembles classic space shooter games (see screenshots in Figures 30 and 31). The player has to navigate a small, damaged spaceship through a determinate space corridor filled with asteroids. The main objective is to reach the Earth at the end of the corridor in a given time before the ship gets completely broken. The spaceship moves at a predefined speed, but every time the player collides with an asteroid speed is decreased for a while. Hence, the main task of players is to dodge

1 This notion of presence is not to be confused with the meaning of the term *presence factors* in the integrative model, because in the model the tern *presence* does not refer to the subjective feeling of the user but objectively describes by whatever means the audience is present.

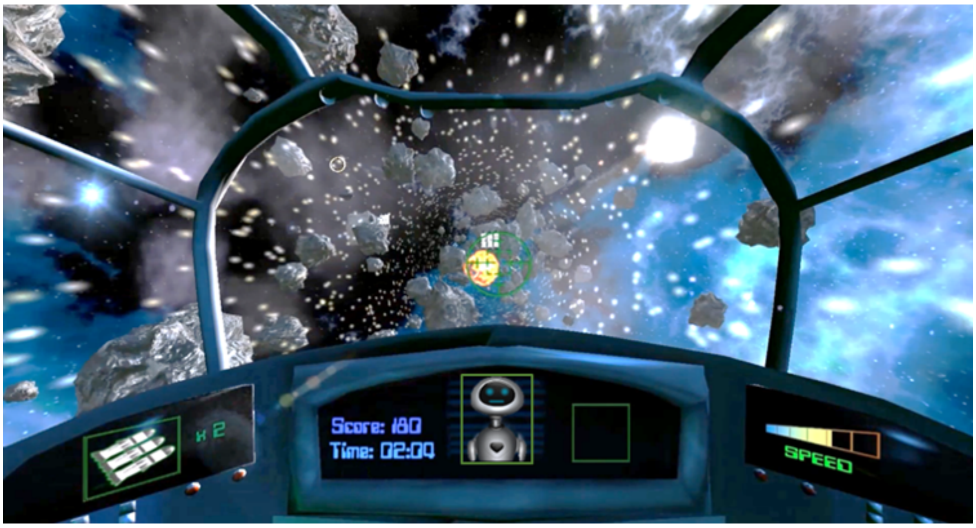


Figure 31: Screenshot of the first-person perspective of the testbed game Spacetastic with companion. This version was used in our study.

the obstacles and find a safe way through. Collectible items like speed rings, protective shields, and oxygen bottles support the player, furthermore rockets can be picked up and used to shoot and destroy single asteroids.

9.2.2 *Game Challenge and Performance Indicators*

One core aspect of the investigation of social facilitation is the assessment of performance. In the context of games, there are several kinds of possible performance measures such as speed, progress, efficiency, and dexterity. Mostly, the applied type of performance depends on the main mechanics and challenges of the game. In general, it can be differentiated between two main types of game challenges [31, 61, 268]: on the one hand physical challenges, which require physical skills such as dexterity and coordination, and on the other hand cognitive challenges, which require mental skills such as observation, memory, and puzzle solving. In recent works, this categorization of game challenges was extended by emotional challenges [31, 55] and social challenges [64, 268]. Emotional challenges force the player to cope with difficult themes and ambiguous emotional and narrative experiences [31], whereas social challenges can be seen as a sub-type of cognitive challenges related to co-players (e.g., read an opponent or predicting teammates' intentions).

Social facilitation research has addressed both cognitive and physical challenges, for instance performance of study participants was tested for math tasks, association task, cycling, and co-working [7, 121, 310]. Overall, the effect was found for both challenge types. For our testbed game, it was decided to focus on physical challenges, because they are very prominent in digital games. Moreover, we chose to operationalize performance by means of score and speed due to the consideration that a setting with a predefined timespan allows for comparable playing sessions between indi-

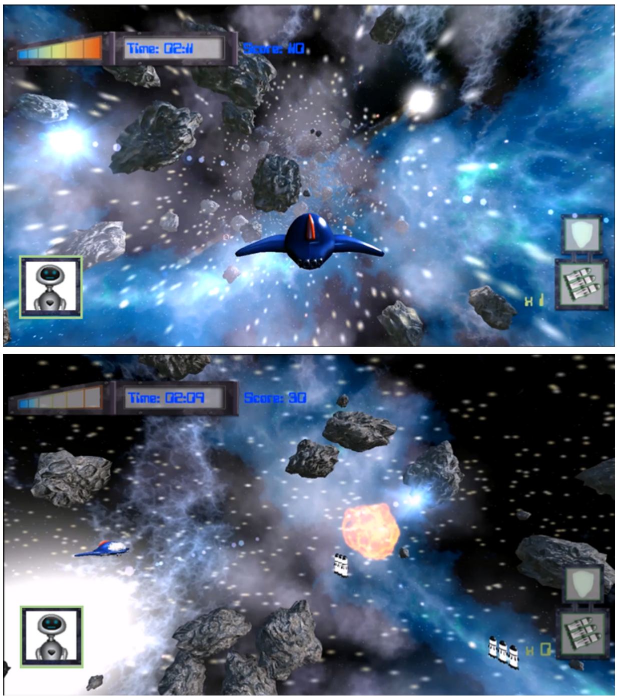


Figure 32: Exemplary screenshots of other versions of the testbed game Spacetastic that feature a third-person player perspective: one showing a 3D graphical perspective (top) and one showing a 2D perspective (bottom), both with companion.

vidual players. The problem with other measures like progress would be that playing time and challenge could differ significantly between players in a study and that might in turn effect the overall experience and confound results regarding social effects. Accordingly, a player score is calculated and displayed during the game. If the player reaches the goal before time runs out, the time that is left is converted into points. Besides, collected items and destroyed asteroids increase the score. Hence, the faster the player is and the more items are collected, the higher is the final score.

9.2.3 *Integration of a Virtual Companion Character*

In order to be able to test the social influence of a virtual character in this game setting, we designed a companion character who can accompany the player during the whole game like a digital copilot (but can also be disabled for control group game versions without social entities). We decided to integrate the companion as a digital projection in the bottom middle cockpit of the player (see Figure 31). This visual representation can be varied (see the following section for details) and is combined with auditory feedback: the character introduces itself at the beginning of the game and can comment on the progress and actions of the player as well as current game events. The way the companion is integrated is supposed to provide a salient presence of the character without distracting the player from the

Table 14: Overview of adaptable aspects of the testbed game Spacetastic.

Game aspect with related variables	**Range/Variation**
Difficulty *(Task factors)*	
number of obstacles	any number possible (0 - ∞)
number of resources	any number possible (0 - ∞)
speed	any level of speed possible (0 - ∞)
length of each play round	any length possible (0 - ∞ sec.)
Agent *(Presence factors)*	
presence	visible vs. not visible
animation	animated character vs. static character
valency of feedback	neutral vs. positive vs. negative
feedback type	visual vs. auditory vs. no feedback
gender	indistinguishable vs. female vs. male
Appearance *(Situational factors)*	
graphical perspective	2D sidescroller vs. 3D
player perspective	first person vs. third person
Interface *(Situational factors)*	
output device	Oculus Rift vs. monitor display
controls	controller vs. keyboard

actual gameplay. In our testbed game, the companion does not have any gameplay significance, that is to say it does not influence the course of the game.

9.2.4 *Adaptability and Variations*

Based on preliminary findings in social facilitation research, special focus was laid on the design and implementation of a highly adjustable game that can serve as a testbed for related studies. Hence, the simple game setting was enriched by a number of adaptable features as shown in Table 14. Those aspects for the most part correspond with the potential impact factors defined in the adapted integrative model of social facilitation (cf. Figure 29): it is possible to vary task factors by changing the level of difficulty (depending on the number of game objects and game speed) and time requirements. Presence factors are addressed by the customizability of the virtual companion character and its behavior. In this context, feedback type and animation do account for the factor of anthropomorphism, while the valency of feedback defines the role of the virtual character and may control evaluation apprehension. The gender of the companion can be male, female, or neutral. Besides, situational factors are variable in terms of the game's appearance and the interfaces that are used. For instance, the game can be played both in a 3D and a 2D mode, and the player's perspective can be varied between first-person and third-person view (see Figures 30, 31, and 32). Furthermore, it is possible to adapt the level of immersion of the game system by using a HMD, the Oculus Rift, as a highly immersive output device instead of an ordinary display.

9.3 EVALUATING SOCIAL FACILITATION IN DIGITAL GAMES

Our testbed game environment Spacetastic was used in a first study aiming at investigating the influence of a virtual character on players with special focus on social facilitation effects. In the following, we first describe the underlying hypotheses we wanted to test. Based on that, the study design, the applied methods, as well as the concrete game configurations used in the study were derived.

9.3.1 *Hypotheses*

As the adapted integrative model of social facilitation (cf. Figure 29) illustrates, there is a whole range of factors that might have an impact on social facilitation effects and, thus, should be considered and systematically investigated in experiments in order to assess their impact value. In order to make a first steps towards such an undertaking, a study was conducted focusing on two potential factors: the presence of a virtual character per se (presence factor), and the degree of immersion offered by the game setting (situational factor). Research has demonstrated that a person's performance is influenced by the presence or absence of others in many different contexts. The review of literature has shown that this effect seems to also apply to robots and virtual characters under certain circumstances, but prior results are inconsistent. Hence, the first intention of the study at hand is to generally test whether players' performance in the game is influenced by the presence of the virtual companion, hypothesizing the following:

H1 *The mere presence of a virtual character significantly influences players' performance in the game in the sense of social facilitation or inhibition effects.*

Furthermore, the influence of immersion is taken into account, since a higher degree of immersion is assumed to foster the social impact of virtual characters [355]. Accordingly, a highly immersive HMD interface is supposed to increase the feelings of presence and thereby to intensify effects of social facilitation or inhibition. It is thus hypothesized the following:

H2.1 *The use of a HMD leads to a higher perception of presence.*

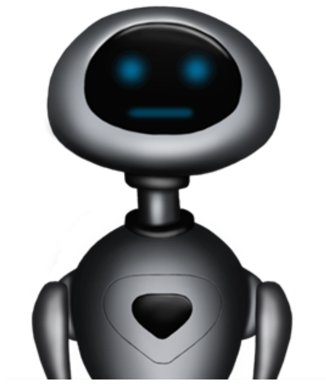


Figure 33: Robotic, gender-neutral companion representation used in the study.

H2.2 *The performance of players using a HMD is more strongly influenced by the presence of a virtual character in the sense of social facilitation or inhibition effects than the performance of players using no HMD.*

9.3.2 *Study Design and Methodology*

Based on the formulated hypotheses, a 2x2 between-subjects design was used to investigate the influence of the two variables *presence of companion* (no companion vs. visible companion) and *output device* (monitor display vs. HMD), resulting in four experimental groups.

9.3.2.1 *Generated Game Versions of the Testbed Game Environment*

With respect to the study conditions, four game versions of the testbed game were configured. These versions differ in terms of the two aspects under investigation, while all other variables were kept constant. Regarding game difficulty, a medium number of obstacles and resources as well as a medium speed level were chosen. For each game version, the same three levels were generated, each lasting three minutes. The structure of all levels (i.e., placement of obstacles and resources) was identical for all players. Due to the planned use of the Oculus Rift as a HMD, the 3D first-person perspective of the game was selected for all four conditions. Two versions were built as VR games for the Oculus Rift, while the other two were built to be displayed on an ordinary monitor. In every case, the game was controlled by a common Xbox360-controller as input device.

In the two experimental conditions which included the companion character, a visual and animated presentation of a robotic, gender-neutral character (see Figure 33) was displayed as a hologram at the bottom of the cockpit and delivered neutral auditory feedback regarding the course of the game (e.g., "What happened?" in case of collision with an asteroid). To test whether mere presence of a virtual character is enough to induce social facilitation effects, the companion did not directly interact with the player and had no influence on the course of the game.

9.3.2.2 *Procedure and Applied Measures*

Figure 34 gives an overview of the procedure of the study and the sequence of the applied questionnaires. Each participant was welcomed and randomly assigned to one of the four experimental conditions after signing a consent to participate. A first questionnaire assessed demographic data, gaming habits, prior experiences with the Oculus Rift (if provided) as well as relevant aspects of health to ensure unimpaired eyesight, appropriate concentration and the absence of any disease (e.g. epilepsy) that might endanger participants during the playing session, especially if the Oculus Rift was to be used.

Then, the game was introduced by a short text supplemented with screenshots and figures. It covered the short story of the game (why the ship is damaged), the game's goal (to reach the earth in the given time), a description of the game world and all objects as well as a short manual of the controls. After reading the instructions, participants were asked to play three levels of the game. In the two conditions with the Oculus Rift, the interface was adapted to the individual player and its functionality was also shortly explained. During the whole playing session the player was left alone, while the examiner waited outside the room in order to avoid any social facilitation effect due to his/her presence. The logging feature of the game was active all the time, hence score, collected items, and time were recorded automatically for each level. Score was assessed as the main indicator of performance. Players were allowed to make small pauses between the three game rounds and had to let the examiner know when the third level was finished.

Subsequently, another couple of questionnaires was presented about how players experienced the game. The first was the IPQ [273, 274] to assess the degree of presence, meaning the feeling of being present inside the virtual game world. The IPQ consists of the four dimensions *general presence*, *spatial presence*, *involvement*, and *experienced realism*. If the Oculus Rift was used, some questions about the experience related to the HMD were put, for instance whether the Oculus Rift was comfortable to wear or rather unpleasing, to which degree it added to a positive experience, and how impressive the sensory impression was. Following this, all participants were asked to complete the core module of the GEQ [142] to assess different aspects of the overall experience, including the seven dimensions *competence*, *sensory and imaginative immersion*, *flow*, *tension*, *challenge*, *negative affect*, and *positive affect*. In the two conditions that included the virtual companion, three more corresponding questionnaires followed: first, the SPGQ [142, 359] was used in order to assess how the presence and influence of the companion were experienced. Additionally, four scales from the NMQ [125] were applied. These included all questions regarding the dimensions *co-presence*, *attentional allocation*, and *perceived behavioral interdependence* as well as three items related to the dimension *perceived message understanding*. Altogether those companion-related questions are supposed to give insight into how players perceived the presence and relevance of the virtual character and their interaction with it. Furthermore, participants were asked to evaluate

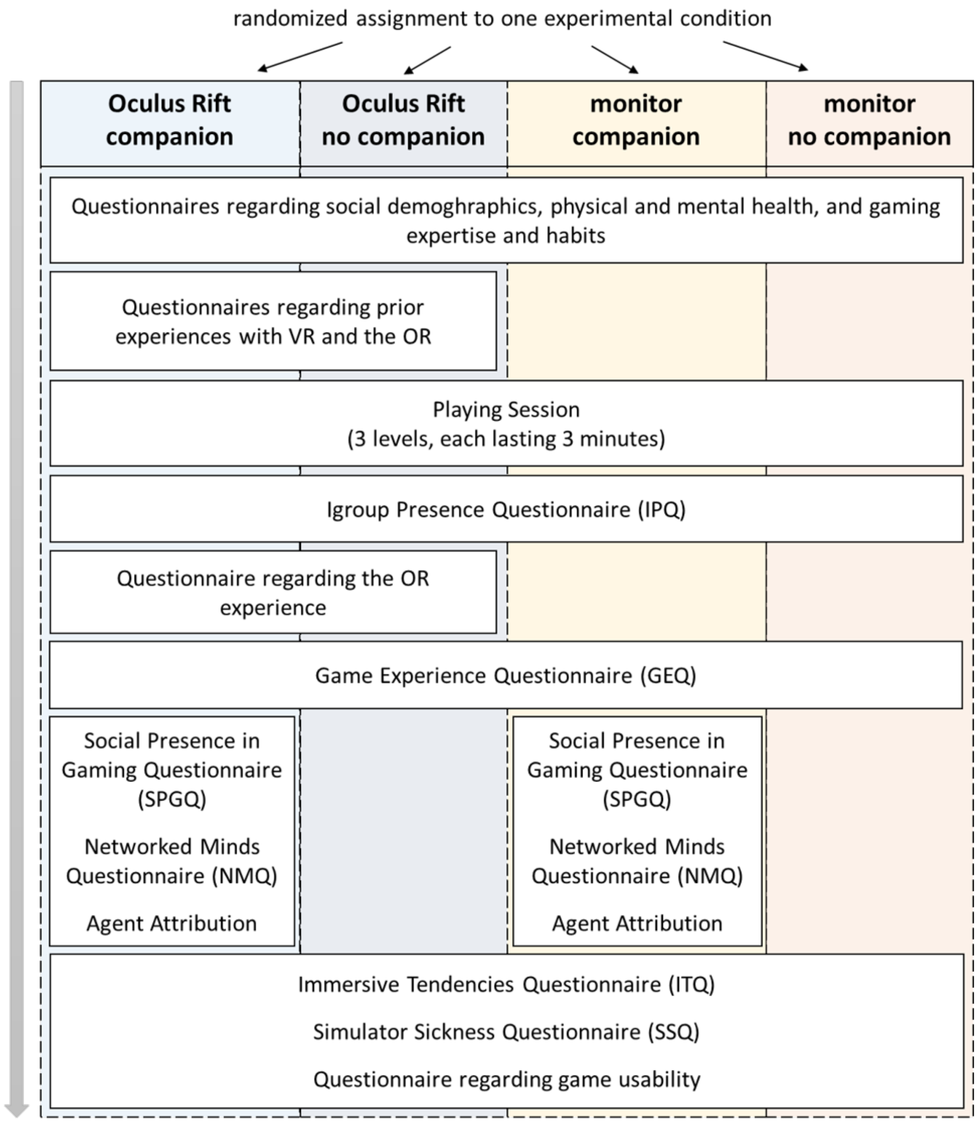


Figure 34: Overview of the study procedure and the applied questionnaires before and after the playing session (OR = Oculus Rift).

the companion's character by scoring a range of 30 single adjectives like *pleasant*, *supportive*, and *threatening*.

Besides, participants of all conditions completed the ITQ [312, 344] and the SSQ [169, 313]. Those questions were applied in order to control for individual differences regarding immersive tendencies and susceptibility, which may influence the overall results. Finally, some questions referred to the general quality and usability of the game to ensure that the gaming experience was not interfered by design flaws or inappropriate controls. Participants were then debriefed and released.

Table 15: Summarized mean values and standard deviations of the social presence measures (NMQ and SPGQ) of all players who played with the companion. The NMQ was measured on a 7-point Likert scale, the SPGQ on a 5-point Likert scale.

Questionnaire Subscales	Mean	*SD*
Networked Minds Questionnaire (NMQ)		
co-presence	4.18	1.23
attentional allocation	3.78	0.97
perceived behavioral interdependence	2.75	1.31
perceived message understanding	3.41	1.00
Social Presence in Gaming Questionnaire (SPGQ)		
empathy	1.46	0.48
negative feelings	1.31	0.36
behavioral involvement	1.70	0.57

9.3.3 *Results*

A total number of 81 persons (41 females) aged between 19 and 48 years (M = 26.06, SD = 5.53) took part in the study. All four experimental groups were comparable regarding gender and age distribution. Participants were recruited in the context of the university, hence most participants were students (N = 52) or employees (N = 22). Additionally, three apprentices, two school pupils, and two unemployed persons participated.

9.3.3.1 *Manipulation check*

In order to check the study manipulations and basic assumptions regarding the four different study conditions, two things have to be ensured. First, we have to control that participants noticed the presence of the virtual character in the two companion conditions. Second, we have to check if perceived feelings of presence were significantly higher in the two Oculus Rift groups as we expected due to higher immersion.

Social presence of the companion was assessed using the SPGQ and the NMQ. As related data was not normally distributed (indicated by Kolmogorov-Smirnoff-tests), non-parametric tests were used to test for significant differences. Mann-Whitney U tests comparing the two companion groups regarding all items of the SPGQ and the NMQ show no significant differences (all $p > .240$), indicating that the Oculus Rift did not significantly influence the perceived presence of the companion. Participants in both groups were aware of the presence of the virtual character and, moreover, experienced the companion's presence in a similar way. Due to that, mean values of both companion groups regarding SPGQ and NMQ are summarized for the further analysis.

In order to check whether the companion was noticed by the players, it is informative to have a look at single items of the NMQ, which were rated on a 7-point Likert scale (ranging from "*not at all*" to "*absolutely*"). The item "*I noticed the robot*" received a mean value of M = 4.37 (SD = 2.07) and the item "*The presence of the robot was obvious to me*" was rated with a mean value M = 5.02 (SD = 1.84). The mean values are slightly above average and, thus, imply that the companion was apparently noticed, but seemed to be not in the attentional focus of the players. Summed up mean scores of the sub-scales of the NMQ support this impression, as they are all rather low or neutral (see Table 15). Similarly, values of the three dimensions of the SPGQ—empathy, negative feelings, and behavioral involvement—which were assessed on a 5-point Likert scale, also tend to be low (see Table 15). Overall, it is concluded that although the companion was noticed, players did not seem to feel a strong connection to the virtual character or any kind of influence or distraction by its presence. Aside from that, results of the evaluation of the companion's character by scoring a range of 30 single adjectives indicate that the companion was perceived as rather neutral and passive altogether, as intended by design.

Perceived presence was measured using the IPQ. Results of a Mann-Whitney-U-test comparing the groups with and without Oculus Rift indicate that all dimensions of presence were rated significantly higher by Oculus Rift players: general presence (U = 479.00, z = -3.26, p = .001), perceived spatial presence (U = 367.50, z = -4.26, p < .001), involvement (U = 405.50, z = -3.93, p < .001), and experienced realism (U = 528.50, z = -2.74, p = .006). As those values are highly significant, it can be concluded that the Oculus Rift led to higher feelings of presence. The first part and precondition of hypothesis 2 (H2.1), thus, is supported. Besides, presence values tend to be slightly higher than average (except for experienced realism) in all conditions, indicating that the game in general was satisfactorily immersive. In sum, manipulations of both independent variables worked as intended.

9.3.3.2 *Control variables*

As it has to be precluded that potential differences in the four experimental conditions regarding the main hypotheses are caused by unintended interfering variables, a number of control variables has been assessed. As the Kolmogorov-Smirnoff-test indicates that data is not normally distributed regarding the following control variables, Kruskal-Wallis one-way analyses of variance were calculated for comparing all groups in terms of *prior gaming experience*, *immersive tendencies*, and *simulator sickness*. There were no significant differences found between groups for any of those variables. Hence, prior gaming experience (H (3) = 1.56, p = .668), all four ITQ sub-scales (focus: H (3) = 2.40, p = .494; involvement: H (3) = 1.10, p = .777; emotions: H (3) = 1.05, p = .788; games: H (3) = 1.81, p = .613) as well as both SSQ sub-scales (nausea: H (3) = 3.02, p = .388; oculomotor: H (3) = 1.19, p = .756) were comparable for all groups and may not account for any differences found in performance or immersion of players. In addition, simulator sickness values were rather low in general (the means for each item were lower

Table 16: Mean values of players' scores in all four conditions and results of the ANOVA (OR = Oculus Rift).

	Score Level 1	Score Level 2	Score Level 3	Score Total
Group 1 (OR, companion) (*N* = 22)	567.27	759.09	793.64	2120.00
Group 2 (OR, no companion) (*N* = 21)	727.62	956.19	985.24	2669.05
Group 3 (monitor, companion) (*N* = 19)	668.42	944.21	1005.26	2617.89
Group 4 (monitor, no companion) (*N* = 19)	703.68	913.68	970.53	2587.89
ANOVA *F*	1.260	1.416	1.389	1.592
Significance *p*	.294	.245	.253	.198
Eta squared	.047	.052	.051	.058

than the mean value of the scale, i.e. lower than 2). It can be concluded that player experience was not impaired by simulator sickness.

Besides, participants' ratings of the game's quality and usability indicate that there were no crucial problems with the controls. For example, the mean score of the item "*the controls were easy to handle*" was $M = 3.05$ ($SD = .77$) on a 4-point Likert scale. Overall, the game was rated rather positive, for instance indicated by the items "*I liked the game world*" ($M = 2.81$, $SD = .73$), "*I think the game is exciting*" ($M = 2.62$, $SD = .86$), and "*I would like to play the game again*" ($M = 2.84$, $SD = .94$). Kruskal-Wallis analyses of all single items show no significant differences between the experimental groups (all $p > .165$). Hence, all participants rate the game similarly positive.

Finally, it was tested whether the Oculus Rift device compromises players' well-being and comfort during play. All related items, which had to be rated on a 4-point Likert scale, indicate positive sensations, for instance "*I felt comfortable wearing the Oculus Rift*" ($M = 2.86$, $SD = .86$) and "*I think the Oculus Rift increased the fun of the game*" ($M = 3.35$, $SD = .92$). Thus, the device was accepted and not perceived as annoying. Moreover, there was no significant difference between the two Oculus Rift groups as shown by Mann-Whitney-U-tests for all related items (all $p > .286$).

9.3.3.3 *Test of hypotheses*

After having checked the successful manipulation of the experimental conditions and having precluded interference of results by confounding vari-

Table 17: Results of the Independent Samples t Tests comparing summarized mean scores of the two Oculus Rift groups (groups 1 and 2) and the summarized scores of the groups without Oculus Rift (groups 3 and 4).

	Score Level 1	Score Level 2	Score Level 3	Score Total
Oculus Rift Groups (Groups 1+2, N = 43)	645.58	855.35	887.21	2388.14
Monitor Groups (Groups 3+4, N = 38)	686.05	928.95	987.89	2602.89
t-Test t	0.605	0.923	1.149	1.020
Sign. p	.547	.359	.255	.311
Cohen's d	.135	.206	.256	.227

ables, the main hypotheses can be tested. Since an overall difference in performance among the groups is expected (H1), mean scores of participants are compared. As the Kolmogorov-Smirnov-test indicates normally distributed data, first a one-way ANOVA is calculated comparing scores of all three playing rounds as well as the total score among all four conditions (see Table 16). Contradictory to hypothesis 1, results show no significant overall difference between groups regarding the mean scores in round one (F (3, 77) = 1.26, p = .294), round two (F (3, 77) = 1.42, p = .245), round three (F (3, 77) = 1.39, p = .253), or the total score (F (3, 77) = 1.59, p = .198).

To examine the influence of the Oculus Rift on performance, summarized mean scores of the two groups playing with the HMD are compared to the summarized mean scores of the two groups playing without Oculus Rift by performing an Independent Samples t Test (see Table 17). Though there is a tendency that all mean scores are higher in the conditions without HMD, these differences are not significant, either, for scores in round one (t (65.214) = 0.61, p = .547), round two (t (79) = 0.92, p = .359), round three (t (64.164) = 1.15, p = .255) and total scores (t (79) = 1.02, p = .311).

Finally, with respect to hypothesis 2 (H2.2), scores in the Oculus Rift conditions and in the conditions without Oculus Rift are analyzed separately in order to focus on the influence of the companion without comparing different devices. An Independent Samples t Test comparing scores of both Oculus Rift conditions (see Table 18) indicates significant differences regarding the scores in round one (t (41) = 2.29, p = .027), round two (t (41) = 2.13, p = .040), round three (t (41) = 2.11, p = .041), as well as regarding the total score (t (41) = 2.39, p = .022). The calculated effect sizes indicate medium effects (all > .60). The same is calculated for comparing the scores of the two groups that played the game on an ordinary monitor (see Table 19), but in contrast no significant differences are found for round one (t (36) = 0.31, p = .757), round two (t (36) = 0.23, p = .818), round three (t (36) = 0.23, p = .817), or the total score (t (36) = 0.08, p = .934).

Table 18: Results of the Independent Samples t Tests comparing score values of the two groups that used the HMD: group 1 (Oculus Rift and companion) and group 2 (Oculus Rift and no companion).

	Score Level 1	Score Level 2	Score Level 3	Score Total
Group 1 (OR, companion) (N = 22)	567.27	759.09	793.64	2120.00
Group 2 (OR, no companion) (N = 21)	727.62	956.19	985.24	2669.05
t-Test t	-2.287	-2.125	-2.105	-2.387
Sign. p	.027	.040	.041	.022
Cohen's d	.698	.648	.642	.728

9.3.3.4 *Further results*

Data assessed by the GEQ is supposed to provide additional insights into the experience of participants during playing the game. Kruskal-Wallis-tests are applied to investigate whether there are any differences regarding the sub-scales of the GEQ between groups. Significant differences appear for the sub-scales flow (H (3) = 12.88, p = .005) and negative affect (H (3) = 10.99, p = .012). To further examine those differences, Mann-Whitney-U-tests with Bonferroni correction (significance level p = .0083) are calculated. Results show that participants who played with the Oculus Rift and the companion (group 1) scored higher on the flow scale (M = 3.70) than those who played on a monitor but with companion (group 3; M = 2.40) (U = 86.00, z = -3.22, p = .001). This is in line with the higher immersion found in the Oculus Rift conditions. In terms of negative affect, participants who played with the Oculus Rift and the companion (group 1) showed significantly lower values than participants playing without HMD but with companion (group 3; U = 108.00, z = -2.79, p = .005) and the group who played with Oculus Rift but without companion (group 2; U = 99.50, z = -3.00, p = .003).

After grouping and summarizing the values of the two conditions playing with the Oculus Rift and the two conditions playing on a usual monitor, respectively, Mann-Whitney-U-tests reveal that players in the Oculus Rift conditions felt significantly less competent compared to the other group (U = 607.00, z = -1.99, p = .047). The same was found for negative affect (U = 540.00, z = -2.72, p = .007). In contrast, flow was higher (U = 84.00, z = -2.83, p = .004) for Oculus Rift players, as already indicated above.

Table 19: Results of the Independent Samples t Tests comparing score values of the two groups that did not use the HMD but an ordinary monitor: group 3 (monitor and companion) and group 4 (monitor and no companion).

	Score Level 1	Score Level 2	Score Level 3	Score Total
Group 3 (monitor, companion) (N = 19)	668.42	944.21	1005.26	2617.89
Group 4 (monitor, no companion) (N = 19)	703.68	913.68	970.53	2587.89
t-Test t	-0.312	0.232	0.233	0.084
Sign. p	.757	.818	.817	.934
Cohen's d	.101	.075	.076	.027

9.3.4 *Discussion of Results*

Results show that there is no overall effect of the presence of the virtual companion on player performance: neither social facilitation nor inhibition effects could be detected based on the comparison of all four study conditions. Accordingly, our first hypothesis (H1) is not supported by our findings. However, further analyses revealed that the presence of the companion seems to have affected players' performance if they were wearing the HMD. The performance of players who played with the Oculus Rift was significantly worse if the companion was present, indicating an inhibition effect. This can be interpreted in line with our hypothesis that the performance of players using a HMD is more strongly influenced by the presence of the virtual character (H2.2). It can be argued that the lack of differences regarding performance between the two conditions without HMD indicates just a weak (or no) social influence of the companion, which is increased by the application of the Oculus Rift, leading to a stronger (detectable) effect in the two HMD conditions. Hence, H2.2 is not disproved but requires further investigation in future studies to test whether this assumption is true.

The question arises why there was a measurable social influence of the virtual character in the Oculus Rift conditions, while it could not be detected regarding players playing at a common monitor. Our manipulation of the independent variables was successful (see Section 9.3.3.1) and the interference of control variables was precluded (see Section 9.3.3.2). Hence, results can not be ascribed to a lack in conspicuousness of the companion, simulator sickness, problems with the game controls, or a dissimilar distribution of participants' relevant individual characteristics (e.g., immersive tendencies and prior gaming expertise).

There were two noticeable differences found. One difference concerns immersion and perceived presence. Based on the analyses of the IPQ data and the flow values, immersion was significantly higher in the two Oculus Rift conditions compared to the two monitor conditions, as expected in our second hypothesis (H2.1). The higher immersion might have led to higher feelings of presence and an intensified perception of the companion, which, in turn, might have increased the companion's inhibitory effect. However, another difference was found regarding players' feelings of competence. Oculus Rift players felt less competent during play than the other participants. This experience of competence and control might also account for the performance results, as less perceived competence might be an indicator for higher experienced difficulty. If the difficulty of the task was higher due to the HMD, social inhibition was more likely to occur. The GEQ sub-scale for challenge, in contrast, displayed similar values for all groups, which does not support the latter assumption, but does not completely preclude it either. Whether the differences in performance are caused by varying perceived levels of difficulty or by differences in immersion (or both) in combination with the presence of the companion should be examined in a follow-up study.

9.3.5 *Limitations*

There are also some limitations of the study which have to be considered when interpreting the results and which especially have to be taken into account for the planning of future studies. First, the virtual character that was designed for the game has not been evaluated in a preliminary study. It was assumed that the companion appears as a neutral, non-evaluative social entity due to an indistinguishable sex and indifferent visual and auditory feedback. Though it seems that it worked out as intended in this case, future variations of the companion's appearance optimally should be verified before the actual experiment is conducted. Similarly, the level of difficulty should be assessed in pre-tests by measuring both perceived difficulty (self-reports) and actual performance in different variations of the game in order to be able to identify easy and difficult configurations. Since that was not done beforehand in this case, making a clear statement about the difficulty of the applied levels is not possible. Finally, a larger sample size might benefit the detection and clarification of effects.

9.4 CONCLUSION

The study presented in this chapter contributes relevant research results regarding social facilitation in digital games in particular and the complex field of social player experience in general. Findings indicate a potential impact of virtual characters as social entities on player performance and player experience under certain conditions, as social inhibition was detected in the immersive versions of our space-shooter testbed game. At the same time, this article illustrates the demand for the further systematical investigation of social effects in digital games.

The introduced testbed game is a promising approach for this purpose and offers various possibilities to examine social facilitation effects evoked by virtual characters. It can be applied in future studies, making use of the other adaptable aspects like the difficulty, the player's perspective, or the appearance of the companion. While the companion in the present study was designed as neutral as possible (no distinguishable gender, neutral feedback and comments regarding game events), other configurations may have different effects. For instance, a more human-like appearance and the degree of perceived anthropomorphism may result in higher attributed social features and, thus, in an increased social effect. Furthermore, future research should include different levels of difficulty, which was not accounted for in the experiment reported here. The following chapter (Chapter 10) will take up this aspect and use variations of easy and difficult levels of the testbed game.

However, the testbed game also entails some limitations. The genre chosen is just one of many existing game genres that feature very different characteristics. Hence, results are not generalizable to other games and genres. In this context, it might be particularly interesting to investigate whether other kinds of game mechanics and tasks show other results for social facilitation. While the testbed game presented here is focused on physical challenges which require physical abilities and dexterity, a player's performance in cognitive or social tasks might be influenced differently by the presence of others.

Interesting subsequent questions are whether or not the mere presence of a companion is really enough to cause significant social facilitation effects as once proposed by Zajonc [354] and if social effects are stable or rather short-termed. Potential wear-out effects should be investigated. All those research suggested here is supposed to be highly relevant as it may lead to new implications regarding the use of virtual characters in digital games as well as in virtual environments that might be applied for learning or training purposes and in working contexts. In general, the work presented in this chapter underlines the potential impact of virtual social entities and shows that virtual characters may indeed influence us like real persons do.

10 A SUBSEQUENT STUDY ON SOCIAL FACILITATION

Our first study regarding the social facilitation effect in digital games as reported in Chapter 9 has provided first insights and at the same time raised new questions which demand further investigations. According to the results, there seems to be some social effect of the presence of a virtual character on players' performance. However, this effect was not as distinctly detectable as expected and the overall results were inconclusive about the occurrence of social facilitation in a gaming context. Immersion was identified as one potential mediating factor, because social inhibition was only found in the highly immersive game versions. Related research on social facilitation in virtual environments has revealed a whole range of further impact factors such as task factors and presence factors (as summarized in the integrative model of social facilitation, cf. Figure 29), which should be considered in future research endeavors. Hence, we built on the results and lessons learned from the first study to plan a comprehensive follow-up evaluation.

The work described in this chapter is based on the paper *Watch Me Play: Does Social Facilitation Apply to Digital Games?* [92], which was presented at the CHI Conference on Human Factors in Computing Systems 2018 and published in the respective conference proceedings.

10.1 NEW CONSIDERATIONS

In our first study, we used an adaptive space shooter game and varied whether a virtual companion character was present in the game and whether the game was displayed on an immersive HMD or a common monitor. Based on social facilitation theories and related research, we assumed that the social presence of the virtual character would significantly influence players' performance. However, we did not find performance differences between all compared conditions: if participants played the game on a common monitor—which simulates a more common gaming setup compared to the use of an immersive HMD—their performance seemed to be unaffected by the companion's presence. As this finding contradicts our basic hypothesis, the first aim of the subsequent evaluation was to test whether this result can be replicated. Therefore, we limited the scope of our new study to the usual monitor setting and dropped the HMD conditions. Instead of once more investigating the moderating effect of immersion, we decided to include two other variables that are prevalent in social facilitation research: the difficulty of the task and the type of task. The impact of these two task factors on social facilitation has been shown in several studies [5, 30, 121]. Digital games can vary widely regarding their difficulty and the challenges they pose. In our first study, we chose a moderate level of difficulty and the game we deployed was a fast-paced space shooter, which mainly demands dexterity and quick responses. To increase the validity of our research and to allow for more general conclusions regarding social facilitation in digital games, we complemented our original setting by (a) implementing a second game that is focused on cognitive challenges as another type of task and by (b) creating a number of different levels of both games with varying degrees of difficulty.

Furthermore, we introduced another facet of social presence to extend the scope of our research. In our new study design, we differentiated between the presence of a co-located human observer and the presence of a virtual companion character inside the game world. A real human observer resembles the typical setup of classic social facilitation studies. By including this condition, we can investigate whether the lack of social facilitation found in our first study can be attributed to specific characteristics of the virtual character such as less perceived social presence or also pertains to the direct presence of a human observer. This way, our results are supposed to show whether a real observer or a virtual companion affects players' performance and whether there is a difference between both.

Finally, we accounted for the fact that our self-made games, which were specifically developed for research purposes, are probably less sophisticated and less well-engineered than successful commercial games. This might unintentionally affect players' experience and bias the results. Hence, we also chose two successful off-the-shelf games, which are representative of contemporary casual games, to complement our studies. This way, we used four different games in total. The number of different games is supposed to increase the validity of our results and confirm our findings if consistent.

10.2 EVALUATION OF SOCIAL FACILITATION IN FOUR GAMES

Following the considerations stated above, we conducted four separate studies (one study for each game) as a comprehensive follow-up evaluation of the social facilitation effect in digital games. Although the studies were conducted independently, they are similar in terms of focus and procedure. Thus, we present our method and results in an aggregated form. Beforehand, we describe the four games and their configurations in detail.

10.2.1 *Testbed: Selection of Games and Configurations*

We reused the testbed space shooter game Spacetastic of our previous study [90] (see Chapter 9) in study 1. Based on the assumption that the type of task might influence the social facilitation effect, we implemented a second game, called *Little Astronaut*. In contrast to the challenge of the space shooter, which mainly addresses dexterity and quick responses, this game is a low-paced puzzle game focusing on cognitive skills.

Considering that Spacetastic and Little Astronaut were bespoke games purposefully designed to investigate the social facilitation effect, we also

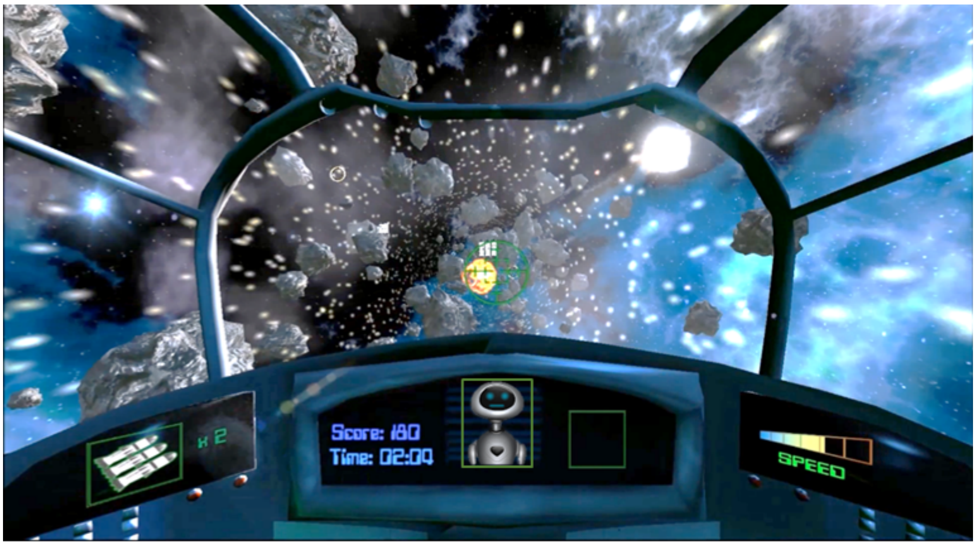


Figure 35: Screenshot of the game Spacetastic used in study 1. It shows the game version with the virtual companion character, which is displayed in the middle of the cockpit. In the version without companion, the space is simply black. We used the same game perspective as in Chapter 9, compare in particular Figure 31.

chose two successful off-the-shelf games to complement our studies. These games should resemble our custom games in terms of game mechanics. After researching successful indie games on the digital distribution platform Steam[1], we decided to use the Game of the Year Edition of Badland [102], an award-winning action sidescrolling game, as an equivalent of a game that is fast-paced and offers dexterity challenges. As a logical puzzle game, we used the popular indie game LYNE [33]. Both games received very positive ratings on Steam. Yet, their rules are inherently simple; thus, they are suitable to be used in short gaming sessions without training. All games are shortly described in the following.

10.2.1.1 *Spacetastic (Study 1)*

As already explained in Chapter 9, Spacetastic is a simple 3D first-person space shooter game (see Figure 35). The player controls a spaceship flying with predefined speed through a corridor of asteroids and has to reach the Earth within three minutes. Colliding with an obstacle decreases the spaceship's speed for a few seconds. Hence, too many collisions minimize the chance to win the game. A score is calculated based on the number of collected items like speed-ups and shields (positive points) and the amount of collisions (negative points). The player receives bonus points for every second that is left in the end, thereby increasing the motivation to reach the end as fast as possible. The final score serves as the main indicator for the overall player performance.

1 http://store.steampowered.com

The game offers several configurations to investigate the influence of different game elements (see Chapter 9 for details). For this study, we varied two aspects: the presence of a virtual companion character (on/off) and the degree of difficulty (by changing the number of obstacles and items). If present, the virtual companion is projected on the screen in the bottom middle of the cockpit in form of an animated, gender-neutral robot (see Figures 35). The companion reacts on game events by commenting on them verbally and with some animation (e.g., being frightened in case of collision). However, the companion just passively reacts and does not have any impact on the course of the game. For a game version without virtual companion, it is switched off, leaving the screen in the middle of the cockpit black.

We varied the game's difficulty to account for the fact that task difficulty can significantly determine the manifestation of social facilitation. In our previous study [90] difficulty was set to an assumed medium level. In contrast, we now created six different levels: level 1, 2, and 3 contained gradually less asteroids and items than the level used in the previous study [90], whereas in level 4, 5 and 6 the numbers were significantly increased. To determine the perceived difficulty of these different level configurations, we conducted a pre-study. 13 participants played all seven levels subsequently. After each level, participants rated the perceived difficulty on a 7-point scale. In order to avoid sequence or learning effects, the order of the seven level configurations was randomly compiled for each participant. Results of a repeated measures ANOVA show a highly significant difference between the seven level configurations (F (6, 72) = 18.43, p < .001). Bonferroni post-hoc tests reveal that levels 1, 2, and 3 (with mean difficulty ratings < 4) have been rated significantly less difficult than levels 4, 5, and 6, which all had mean ratings higher than 6.1 (all p < .033). This indicates that levels 1, 2, and 3 can be used as rather *easy* levels, while levels 4, 5, and 6 are grouped as *difficult*. However, as only two levels of each kind should be played in the main study due to their repetitive structure, both extremes—levels 1 and 6—were withdrawn. In sum, four different game versions, each containing two levels, were compiled and used in the main study:

a) easy with companion
b) easy without companion
c) difficult with companion
d) difficult without companion.

10.2.1.2 *Little Astronaut (Study 2)*

Little Astronaut is a simple 2D puzzle game in which an astronaut has to collect energy spheres with as few steps as possible (see Figure 36). Due to zero gravity, the astronaut can only be moved vertically or horizontally in a special manner: if the player presses one of the arrow keys, the astronaut flies in the respective direction until it is stopped by one of the blocks that are spread over the level. If no block stops the astronaut and the boundary of the screen is reached, the level is lost and restarted. Hence, the player

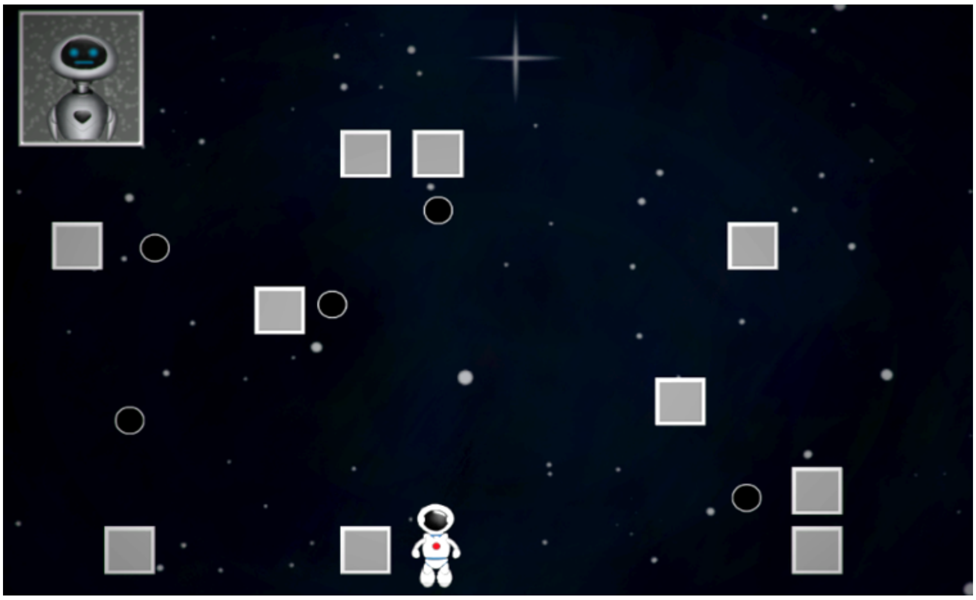


Figure 36: Screenshot of the game Little Astronaut used in study 2 in the version with virtual companion (top left). All black spheres have to be collected by navigating the astronaut from block to block without leaving the screen.

has to find a way through the level to collect all spheres without leaving the screen. The faster, the better. Hence, player performance is determined by the time a player spends on a level.

As with Spacetastic, we wanted to use the game to investigate social facilitation as a function of the presence of a virtual companion and game difficulty. Accordingly, we again varied these two aspects. The virtual companion is the same as in Spacetastic. It is displayed as an animated projection at the top of the screen (see Figure 36) and verbally comments on certain game events (e.g., the failure or success of the player) without giving hints about the solution. It does not have any impact on the course of the game. In the game versions without companion the screen space at the top is simply left black.

The number and arrangement of the fixed blocks and energy spheres define the movement abilities and the difficulty of a level. For each level, there is one optimal solution, which can be found by logical reasoning. As different degrees of difficulty should be included in our study, a pre-study was conducted here as well. Twelve levels were designed, differing in terms of the number of blocks, the number of collectible spheres and the resulting minimal number of steps that are required to solve the level. 15 participants took part in the pre-study and played all twelve levels subsequently. The order of levels was randomized for each participant to avoid sequence effects. After each level, participants had to rate its perceived difficulty on a 7-point scale. All levels were ranked regarding their mean scores of perceived difficulty. Based on that, the three most difficult ones (mean difficulty > 3.9) as well as the three least difficult levels (mean difficulty < 2.3) were selected

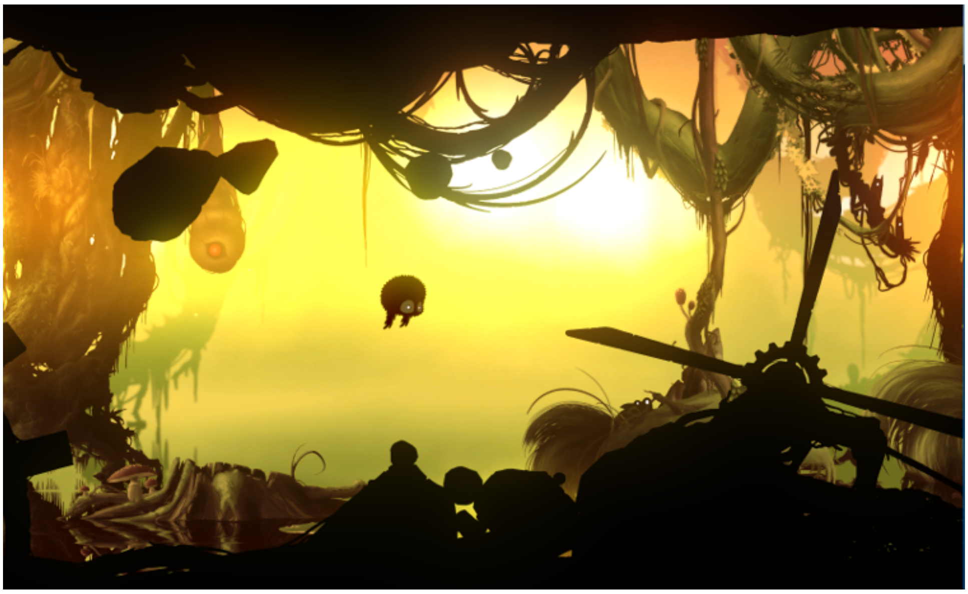


Figure 37: Screenshot of the game Badland by Frogmind Games used in study 3. The player controls the little black bird and has to reach the end of each level by evading all obstacles.

for the main study. As the time required to solve all levels is rather short, participants in the main study should play all six levels in a fixed order, first the three easy levels, then the three difficult ones. Hence, two different versions of the game were compiled to be used in the main study:

a) with companion (easy and difficult)
b) without companion (easy and difficult).

10.2.1.3 *Badland (Study 3)*

Badland [102] is a 2D sidescrolling game. The player has to navigate a little bird through the level without being destroyed or detained by obstacles (see Figure 37). The game is rather fast paced as the screen is constantly scrolling. If the bird is hit by a trap or leaves the screen, it respawns at the last checkpoint and the player has an unlimited number of trails to complete the level. The game is played with a common gamepad and controls are kept simple (joystick and one button).

In our study, we asked participants to play the first two levels of the game. The time they needed to complete these levels is used as the measure of performance. As Badland is a commercial game, we were not able to include a virtual companion or manipulate the difficulty of the levels. Hence, there is only the original game version that is used in the study to investigate whether a real observer impacts player performance.

10.2.1.4 *LYNE (Study 4)*

LYNE [33] is a minimalist 2D puzzle game, in which the player has to chain all objects that have the same shape between pre-defined endpoints (see

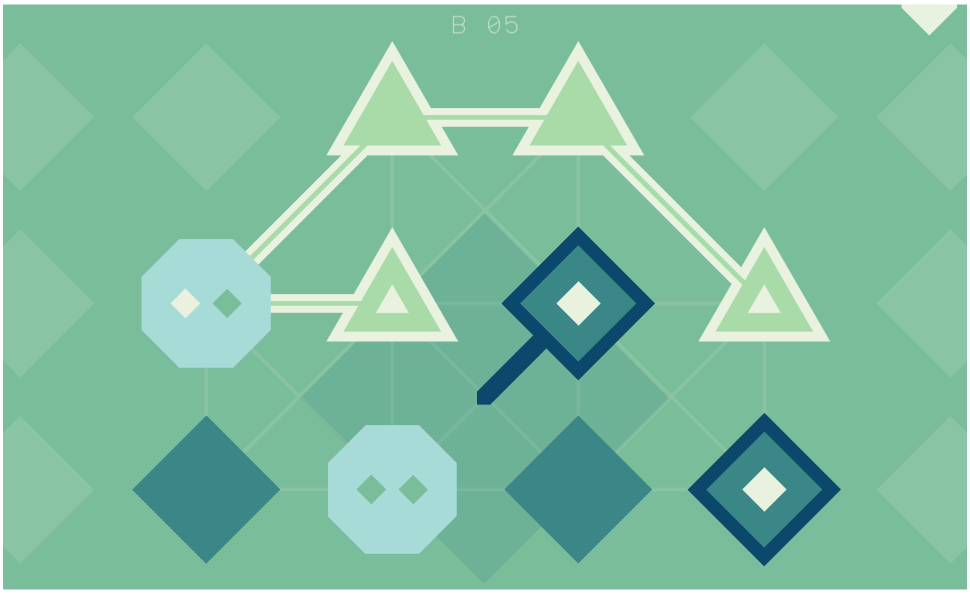


Figure 38: Screenshot of the game LYNE by Thomas Bowker used in study 4. In this level, the player has to link up all triangles (already done) and all diamonds to proceed. The two highlighted ends of each shape chain are pre-defined.

Figure 38). Due to limited possible linkages and certain conditions that have to be met (e.g., linkages must not cross each other), the solution is often not immediately obvious. Although the rules and artwork style are very simple, tricky combinations of shapes demand high concentration and reasoning power to be solved.

We selected seven consecutive levels from the beginning of the game (Set B, level 1 - 7) to be played in our study. To assess player performance, we measured the time players needed for each level. As with Badland, we could not integrate a virtual companion to the game or vary the degree of difficulty. We used the original game version and focused on the influence of a real observer on players' performance.

10.2.2 *Hypotheses*

As stated above, we conducted four studies to investigate the influence of observers and virtual companions on the performance of players in terms of social facilitation. The presence of an observer was tested in all four studies. In this context, Downs et al. [73] differentiate between the social roles an audience member can take when observing digital gaming sessions. According to their classification, we implemented a passive *spectator* (still more engaged in gameplay than a *bystander*), who focused on the player and took some notes (thereby also taking the role of a *documenter*). In line with general social facilitation theory, we hypothesize the following:

H1 *Players who play alone perform significantly different than players who are observed by a spectator during play.*

In studies 1 (Spacetastic) and 2 (Little Astronaut), we additionally implemented a virtual companion to test its social impact. For these cases, we assume:

H2 *Players who play alone perform significantly different than players who play a game version that includes the virtual companion.*

Both hypotheses focus on the variation of presence factors (cf. Figure 29) and are undirected because both facilitation and inhibition effects are possible. Prior findings regarding social facilitation suggest that the degree of difficulty determines the direction of the effect. An easy or already learned task is facilitated by the presence of others, while performance on a difficult or unlearned task is inhibited according to theory [121, 354]. Accordingly, we investigate the task factor *difficulty* (cf. Figure 29) and hypothesize the following:

H3 *Game difficulty moderates the effect of social presence (observer and virtual companion) on the performance of players with a change in direction of the effect:*

a. *Low game difficulty leads to an improved performance of players if a virtual character or an observer is present.*
b. *High game difficulty leads to a worsened performance of players if a virtual character or an observer is present.*

Beside testing these three hypotheses, we are also interested in possible differences between the impact of a real observer and of a virtual companion character. As there might be differences in perceived social presence and agency, we hypothesize in line with findings of Hoyt et al. [135]:

H4 *A real observer has a stronger influence on players' performance than a virtual companion.*

Another aspect we account for in our studies is the possible impact of observers and virtual companions on dimensions of the player experience apart from players' performance. Hence, we are also going to investigate group differences regarding the dimensions of player experience in each study.

Finally, we chose different types of games (puzzle games and action games) for the four studies to address two different types of tasks. A combined analysis of all four studies is supposed to reveal whether there are differences regarding the social facilitation effect for cognition-based tasks and dexterity tasks in digital games.

10.2.3 *Procedure*

All four studies used a between-subject design and followed the same procedure. They only differed regarding the applied game and the respective number of study conditions:

1. Study 1 (Spacetastic) contained six conditions in a 2x3 design with the two factors:
   (1) Difficulty: easy vs. difficult
   (2) Social setting: alone vs. observer vs. companion
2. Study 2 (Little Astronaut) was conducted with three conditions that varied the social setting: alone vs. observer vs. companion.
3. Study 3 (Badland) included just 2 conditions regarding the social setting: alone vs. observer.
4. Study 4 (LYNE) also included just 2 conditions regarding the social setting: alone vs. observer.

All studies took place in our gaming lab. Participants were recruited at the university and randomly assigned to one of the study conditions. After being informed about the study procedure and having signed a consent form for participation, participants filled in a short questionnaire about demographic data and their general gaming habits (hours spent gaming per month and genre expertise) to assess individual factors.

Then the examiner explained the game's rules and controls using a short written manual. After explicitly pointing out that the main goal was to finish the game as fast as possible, the game was played in one of the respective conditions on a common desktop PC with a common gamepad (Spacetastic, Badland), keyboard (Little Astronaut), or mouse (LYNE). If participants were observed, the examiner sat right next to them in front of the screen and focused on the player's activities. To increase the feeling of being observed, the examiner took notes during play. Apart from that, the examiner behaved neutral and did not assist in completing the game. If participants played alone or with the virtual companion, the examiner left the room for the whole gaming session, so that no social presence was induced by her. During gaming sessions, we assessed log data and screencasts to be able to precisely determine players' performance even if they were not observed.

After finishing the game (which took about three to ten minutes depending on the game and the player's performance), participants had to fill in another questionnaire. Its main part was the GEQ [142] to assess participants' general player experience in the seven subdimensions *competence*, *immersion*, *flow*, *annoyance*, *challenge*, *negative affect*, and *positive affect* using a 5-point Likert scale. Moreover, participants should rate the perceived difficulty of the game on a 10-point scale. In study 2 (Little Astronaut), players were additionally asked to rate the perceived difficulty after the first three levels, as we there differentiated between three easy and three difficult levels within subjects.

If participants played with the virtual companion, they were additionally asked to answer related questions to gain insights about their perception and evaluation of the character. For that purpose, two scales of the NMQ [125] were applied assessing the dimensions *co-presence* and *attentional allocation* using a 5-point Likert scale. If the real or no observer was present instead, participants were asked to rate their feeling of being observed during play (perceived presence of an observer) and their impression of being evaluated (evaluative character of being observed) on a 5-point Likert Scale. Finally, participants reported whether they had played this specific game before and received their certificate of participation.

10.2.4 *Results*

In a first step of analysis, we controlled whether the observer and the virtual companion were noticed at all. As expected, no participant reported that he/she did not feel observed at all or did not perceive any co-presence of the virtual companion in the respective conditions. In contrast, participants who played alone reported no feelings of being observed or evaluated during play (all mean values < 0.8). Hence, the study setting as such (being part of an experiment) did not seem to elicit feelings of social presence. Consequently, the manipulation of social presence worked as intended and no cases had to be excluded.

To test our hypotheses, results of the different experimental condition groups have to be compared. For all following analyses, we tested requirements for parametric calculations (homogeneity of variances and normal distribution of data) beforehand by applying Levene's and Kolmogorov-Smirnov tests. If violated, non-parametric tests are reported instead of one-way ANOVAs or independent samples t-tests, respectively, for hypotheses predicting a difference.

To test H3, which is predicting a moderation effect of game difficulty, we performed moderation analyses. We included the presence of an observer or virtual companion (study condition) as predictor variable, game difficulty as moderator variable, and the interaction between the two in a regression to predict players' performance. The PROCESS tool by Hayes [131] was helpful to calculate the analyses in IBM SPSS, as it performs the centring of variables and computes the interaction term.

10.2.4.1 *Results of Study 1 (Spacetastic)*

Study 1 was the most complex study including six conditions and 157 participants (90 females). Participants' mean age was 21.3 years ($SD = 4.24$, ranging from 18 to 56 years). Participants were nearly evenly distributed among the six study conditions (see Table 20) and do not differ significantly regarding their distribution of age, gender, genre expertise, and hours of playing.

To gain insights about how the observer and the companion were perceived in the four respective groups, we considered scores of the NMQ and the feeling of being observed. In the two virtual companion groups, mean scores of the NMQ dimensions co-presence (easy game version: $M = 2.32$, $SD = 0.65$; difficult game version: $M = 2.51$, $SD = 0.71$) and attentional allocation (easy game version: $M = 1.74$, $SD = 0.59$; difficult game version: $M = 1.68$, $SD = 0.50$) indicate that the companion was noticed, but did not

Table 20: Results of study 1: Mean scores and standard deviations of player scores in the six different study conditions of Spacetastic.

Study Condition					
Group	*Difficulty*	*Social setting*	*N*	*Score (M)*	*SD*
1	easy	alone	26	1180.77	437.83
2		observer	27	1249.63	417.05
3		companion	26	1223.08	395.34
4	difficult	alone	27	355.93	1051.49
5		observer	26	389.23	1184.72
6		companion	25	- 307.60	1296.51

receive much of the players' attention. This is reasonable due to the passive behavior of the companion. In the two observer groups, participants felt moderately observed (easy game version: M = 1.63, SD = 1.33; difficult game version: M = 1.62, SD = 1.47) and perceived the observer as being rather evaluative (easy game version: M = 2.26, SD = 1.35; difficult game version: M = 2.27, SD = 1.34).

To test hypotheses 1 and 2, we performed two one-way ANOVA to compare the first three study conditions (easy game version) and the other three conditions (difficult game version) in terms of the players' achieved total score (see Table 20 for mean values). Results show no significant differences in score due to the social setting for the easy game version (F (2, 76) = 0.183, p = .833) and the difficult game version (F (2, 75) = 2.832, p = .065), either. Accordingly, the presence of an observer or a companion does not seem to significantly influence player performance. H1 and H2 are not supported.

Although groups show no differences in score, the effect of social presence on performance might not become evident in the group comparison due to the hypothesized moderation effect of game difficulty (H3). Thus, we performed two moderation analyses (one for the easy and one for the difficult version of the game) including study condition and perceived difficulty as well as the interaction terms to predict player performance. However, both models are not significant (easy game version: p = .733; difficult game version: p = .077), and there is no significant interaction effect of study conditions and reported difficulty (all p > .163). Hence, H3 is not supported.

Taken together, all results indicate that there is no difference between the presence of a real observer and a virtual companion with respect to their impact on player performance. Accordingly, H4 is not supported, either.

To investigate the effect of social presence on other dimensions of the player experience, we compared the dimensions of the GEQ. Results of a one-way ANOVA show a significant difference regarding positive affect (F (2, 76) = 5.549, p = .006) and immersion (F (2, 76) = 3.058, p = .003): Positive affect was significantly lower in the observer condition (M = 1.84,

Table 21: Results of study 2: Mean scores and standard deviations of the time players needed (in seconds) to complete the three easy and the three difficult levels of the game Little Astronaut in the three study conditions.

Levels	*Condition*	*N*	*Time in seconds (M)*	*SD*
easy	alone	23	81.95	20.51
(1-3)	observer	24	89.23	34.32
	companion	26	93.54	19.29
difficult	alone	23	233.51	133.32
(4-6)	observer	24	238.26	137.87
	companion	26	239.58	125.79

SD = 0.80) than in the companion condition (*M* = 2.50, *SD* = 0.81) and the alone condition (*M* = 2.47, *SD* = 0.82). Immersion shows the same tendency (observer: *M* = 0.87; companion: *M* = 1.44; alone: *M* = 1.49). All other scales do not differ significantly. In the difficult version of the game (groups 4, 5, and 6) our analysis did not show any significant GEQ differences.

10.2.4.2 *Results of Study 2 (Little Astronaut)*

Study 2 included 73 participants (54 females). The mean age was 20.86 years (*SD* = 3.28, ranging from 18 to 40 years). Participants were nearly evenly distributed among the three study conditions playing alone (*N* = 23), with an observer (*N* = 24), and with a virtual companion (*N* = 26). The groups did not differ significantly regarding their distribution of age, gender (all groups consisted of more female than male participants), genre expertise, and playing hours per month.

We tested how the observer and the companion were perceived in the two respective groups. In the companion group, mean scores of the NMQ dimensions co-presence (*M* = 2.66, *SD* = 0.83) and attentional allocation (*M* = 2.13, *SD* = 0.57) allow the conclusion that the virtual companion was indeed noticed and considered, but did not receive the players' full attention. In the observer group, participants felt moderately observed (*M* = 1.83, *SD* = 1.27) and on average perceived the observer as being evaluative (*M* = 2.46, *SD* = 1.32).

To test if the presence of a companion or an observer results in a different performance of players (H1 and H2), we compared the time players needed to complete the three easy and the three difficult levels between the three conditions using Kruskal-Wallis tests (see Table 21 for mean values). The analysis indicates no significant differences between the groups regarding the time players needed to complete the easy levels (H (2) = 5.609, p = .061) and the difficult levels (H (2) = 0.365, p = .833). Hence, H1 and H2 are not supported.

As explained earlier, the effect of social presence on performance might not become evident in the group comparison due to the hypothesized mod-

Table 22: Results of study 3: Mean scores and standard deviations of the time players needed (in seconds) to complete the levels of the game Badland in the two study conditions.

Condition	*N*	*Time in seconds (M)*	*SD*
alone	49	220.49	85.75
observer	43	240.96	95.16

eration effect of game difficulty (H3). However, moderation analyses do not support H3. We included study condition and perceived difficulty and the interaction terms in two moderation analyses to predict player performance separately for easy and difficult levels. Both resulting models are not significant (easy levels: $p = .051$; difficult levels: $p = .173$). Neither for the easy levels nor for the difficult levels a significant interaction effect of condition and reported difficulty could be found (all $p > .450$). Again, both the results of the Kruskal-Wallis tests and the moderation analyses do not provide evidence that there is any difference between the presence of a real observer and a virtual companion in terms of performance. Hence, H4 is not supported, either.

With regard to player experience, we used one-way ANOVA to compare scores for competence, positive affect, immersion, and challenge. The other scales were not normally distributed, hence, we performed Kruskal-Wallis tests. All results indicate no significant differences between the groups.

10.2.4.3 *Results of Study 3 (Badland)*

92 participants (63 females) took part in study 3. On average, participants were 21 years old ($SD = 3.07$, ranging from 18 to 38 years). The two study conditions (playing alone vs. playing with an observer) included a slightly different number of participants (see Table 22). However, they did not differ significantly regarding age, gender, genre expertise, and hours playing games per month. Questions about the observer in the second condition reveal that participants felt moderately observed ($M = 1.65$, $SD = 1.34$) and perceived the observer as being rather evaluative ($M = 2.35$, $SD = 1.30$).

Regarding H1, the Mann-Whitney U test comparing both groups in terms of player performance is not significant, $U = 753.50$, $p = .328$. Hence, playing alone or with an observer did not make a difference in the time players needed to complete the game, contradicting H1 (see Table 22 for mean values).

We also performed a moderation analysis to investigate whether perceived game difficulty moderates the effect of the observer on players' performance to test H3. The regression reveals a significant effect of perceived difficulty on the time players needed ($p = .006$), but no significant effect of study condition ($p = .422$) or an interaction of both variables ($p = .913$). This indicates that players who perceived the game as more difficult performed

Table 23: Results of study 4: Mean scores and standard deviations of the time players needed (in seconds) to complete the levels of the game LYNE in the two study conditions.

Condition	*N*	*Time in seconds (M)*	*SD*
alone	38	259.69	132.65
observer	36	253.29	92.94

worse, whereas the presence of the observer had no impact. Hence, H3 is not supported.

Finally, we compared scores of the GEQ with Mann-Whitney U tests to investigate the influence of the observer on the player experience. The only significant difference we found concerns the subscale positive affect (U = 776.00, p = .029): observed players reported higher positive affect (M = 2.60, SD = 0.90) than players who played alone (M = 2.18, SD = 0.95).

10.2.4.4 *Results of Study 4 (LYNE)*

Study 4 included 74 participants (54 females) with a mean age of 20.82 (SD = 3.27, ranging from 19 to 40 years). Participants were almost evenly spread between the two study conditions (see Table 23). Both groups (playing alone vs. playing with an observer) are comparable in terms of age, gender, genre expertise, and gaming frequency of participants. Questions about the observer indicate that participants felt observed (M = 2.03, SD = 1.28) and perceived the observer as being fairly evaluative (M = 2.58, SD = 1.36).

An independent samples t-test was calculated to compare both groups in terms of player performance (H1). It shows that the time players needed to complete the seven levels did not differ significantly, t (72) = -0.221, p = .826.

Again, we performed a moderation analysis including the factors study condition and perceived difficulty to predict player performance. As in the other studies, the moderation analysis does not show a significant interaction effect of condition and perceived difficulty (p = .783). H3 is not supported.

To test for differences in terms of player experience, we compared the GEQ scores of both groups using Mann-Whitney U tests. The analysis revealed no significant difference between groups for any of the subscales.

10.2.5 *Discussion*

The main results of our four studies are congruent: there is no evidence that social facilitation takes effect in digital games. The performance of players did not differ significantly in the different study conditions, indicating that the presence of the observer and the virtual companion did not affect how successful players were in mastering the games.

We are aware that the social facilitation effect—although being in the focus of psychological research for decades—describes a rather complex phenomenon that is not yet completely unraveled regarding its causes. As shown in the integrative model of social facilitation (Figure 29), the effect can be shaped by diverse factors of the application context. Therefore, we planned and analyzed our evaluation with caution, keeping the diverse potential influences in mind. In particular, we accounted for the fact that the direction of the social facilitation effect—i.e., whether performance is facilitated or inhibited—is supposed to be dependent on task difficulty: we implemented several levels of our bespoke games Spacetastic and Little Astronaut with diverse degrees of difficulty. However, the lack of group differences in terms of performance might be due to individual differences in perceived difficulty of players in the same groups. For instance, some participants playing the difficult version of Spacetastic experienced the game as less difficult than some participants who played the game in the objectively easier condition. We considered this in our analysis by additionally performing moderation analyses to reveal whether there is some concealed effect of social presence on performance that is moderated by individual perceived game difficulty and, thus, did not become evident in the comparison of group means. These analyses, however, did not show significant influences, either.

We conclude that neither the observer nor the virtual companion induced social facilitation in our gaming settings, which contradicts all hypotheses. As there was no effect on performance at all, we also found no difference between the impact of an artificial companion character and a co-present human observer. Similarly, the variation of the type of task did not result in different findings. We included both fast-paced dexterity games (Spacetastic and Badland) and logical puzzle games (Little Astronaut and LYNE) in our studies, which are supposed to differ significantly in terms of their challenges. Although our four games are certainly not representative for all digital game genres, our results show that the lack of social facilitation is not an exception and rather applies to several distinct games.

We do not claim that our findings are generalizable to all gaming situations. Of course, our studies do not cover all possible constellations of factors that might influence the effect as comprised in the social facilitation model (Figure 29). Thus, social facilitation might still apply to gaming under certain conditions, for instance if there is more than one person as an audience or if the game is very low-challenge, which is also indicated by prior studies in this context (see [34, 39, 171]). However, we want to call attention to the fact that the social facilitation effect does not generally apply to digital games and, hence, should not be used to make design decisions without contemplation. The concrete preconditions for social facilitation to take effect in games are still unidentified.

Before interpreting the results of our studies in a broader context, we first have to discuss possible reasons for the lack of social facilitation that are related to our study design and setup. At first sight, one might suggest that the presence of our social entities (observer and virtual companion) was possibly not salient enough to be influential. Regarding the real observer, we object to that argument: the observer sat directly next to the player and was definitely present in the player's peripheral field of view. During play, almost all observed players directly or indirectly communicated with the observer, for instance by uttering "*Oops!*" or laughing embarrassedly when making a mistake. Moreover, data of the administered questionnaire indicates that players felt observed and that they in fact perceived the observer as being evaluative. According to the evaluation apprehension based approach to explain social facilitation (see [121]), such an evaluative audience is supposed to eminently induce social facilitation.

The presence of the virtual companion was assessed by the post-game questionnaire as well. According to the answers, the virtual character was noticed by all players, but they did not pay much attention to it. This is certainly due to the passive nature of the companion, as it has no impact on the course of the game and there was no possibility to interact with it. A more interactive character, or one that is more actively involved in the game, may have more social impact on players. Though results about the real observer indicate that a high feeling of presence is not intensifying the effect, an interactive virtual character might elicit social facilitation as it would be an integral part of the game in contrast to the real-world observer. If the player is focused on the game, a social character inside the game world might be more impactful than a real person who has no in-game relevance. However, this is an assumption that has to be investigated in future studies.

We also have to account for observer effects such as the Hawthorne effect [215]: all participants, regardless of condition, might have been influenced by a baseline social facilitation effect, because they were aware of being part of a laboratory study. However, participants in the "alone" conditions reported that they did not feel observed during play, indicating no direct impact of the study setting on feelings of social presence. Furthermore, we told participants that the goal of the study was to test game design issues (labeling it as a "playtest"), not to focus their individual performance. Participants were different for all studies, and they were not aware that the studies dealt with social facilitation till the debriefing. Hence, an impact of the general laboratory setting in terms of the Hawthorne effect is unlikely, though it cannot be excluded completely without replicating the studies in a natural setting.

Another crucial aspect in social facilitation research is the choice of the performance measure. In our studies, we assessed the time players needed to complete the games (and additionally collected items in study 1) as the main indicator of performance. This does not correspond to the inherent goals of the games we applied, particularly in the case of the puzzle games. Except for Spacetastic, which emphasizes time as a limited resource, the games do not display time and do not imply that speed of completion is important. To account for this discrepancy, we explicitly told participants that their main goal is to reach the end of the game as fast as possible.

However, in future studies, other measures of performance should also be considered to cope with the manifold goal structures of digital games.

Although our studies do not comprise all possible gaming situations, the lack of social facilitation in all four studies is striking. We suppose that the congruent findings are not completely attributable to the study design and setup, as discussed above. Therefore, we have to discuss why the effect of social facilitation does seemingly not generally apply to digital games, while it was found in many other social situations. We reason that this is due to specific characteristics of digital games. Games offer distinct universes with own rules and meanings. When playing, a player is inside this *magic circle* [2], and replaces reality by the pretended reality that is provided by the game. In this process, attitudes regarding performance and efficiency as well as social rules of the real world may become less effective.

In this context, the motivation of players is considerable as well. Though the essence of most digital games is to overcome a series of specific challenges, players may not be most interested in performing as good as possible. Besides achievement, there are other motivations for play like immersion (as explained in Chapter 2, section 2.2.4). If players mainly seek fun, distraction, and entertainment, they might not care much about their performance. A bad performance or even failure in a digital game, even in the presence of an evaluative observer, is supposed to be rather acceptable and not as embarrassing as failing in some more serious tasks like the solving of arithmetic problems. This assumption can explain the lack of audience effect in our studies: the games applied here were rather casual games that did not explicitly encourage players to focus on optimal performance. Despite being advised by the examiner to seek fast completion of the game, participants may not have perceived performance as being important in the context of gaming. We assume that in a more competitive setting, the evaluative effect of the observer has a higher impact on a player's performance. Hence, the influence of an observer in clearly competitive games (e.g., games that feature high score lists or contain explicit competitors or enemies) will be subject to future studies.

Finally, playing a digital game is most often a complex task including several micro-tasks. In contrast to other tasks that have been shown to be affected by social facilitation (e.g., cycling, math tasks, typing [121]), games often demand several cognitive and motoric processes at the same time: players have to plan and perform actions (e.g., chase an enemy), correctly recall the respective controls (e.g., move joystick), and often have to face sudden changes or unexpected events (e.g., a new enemy approaching from the side). In sum, most games require full attention of players. As Bowman et al. [34] explain by referring to Zajonc's drive theory, these challenges may act as a drive-producing force just as the presence of other persons. In other words, if the level of challenge induced by a game is high enough to push a person's level of arousal (drive) to a maximum, a ceiling effect prevents any further increase of drive by the presence of an audience. In this case, the presence of an observer does not influence performance. This can explain the lack of effect in our studies as well, particularly in the difficult game conditions. Following this argumentation, social facilitation might only apply to very simple games and not to the vast majority of contemporary games.

10.3 CONCLUSION

Our four studies do not provide evidence for the effectiveness of social facilitation in the context of digital gaming. Neither a virtual companion character nor the presence of a co-located human observer during play has significantly influenced the performance of players.

Although this finding is not generalizable to all kinds of gaming situations, we have discussed several reasons why the social facilitation effect is supposed to be less influential in most gaming scenarios compared to other social situations due to the special characteristics of digital games. These assumptions illustrate possible directions of future work in this area and can be addressed in follow-up studies. The different theoretical approaches to explain social facilitation (arousal, attention, social valuation, as explained in Chapter 3, section 3.2.1) can be further illuminated by measuring the physiological arousal of players while facing different challenges, testing their level of distraction as well as their feeling of being evaluated. Furthermore, the effect should be tested in other social settings with observers with different characteristics, which can be systematically varied according to the factors depicted in our model (see Figure 29).

Our work contributes to the understanding of social processes in digital games and provides guidance for game designers and researchers who seek to take advantage of social effects like social facilitation in their games. This is particularly useful in applied areas like digital game-based learning. Furthermore, our results demonstrate that the applicability of basic socio-psychological phenomena to digital games has to be proven before being used as rationale for game design decisions. Otherwise, false assumptions regarding social effects may lead to game designs that induce unintended experiences or unwanted player behavior.

Part IV

CONCLUSION

11 REFLECTIONS AND CONCLUSION

This chapter presents the conclusion of this thesis. I shortly summarize the work and reflect on the main contributions to the field of social player experience research.

11.1 SUMMARY

The first part (Chapter 2 and Chapter 3) of this thesis constituted the theoretical foundation. As the focus of all studies in this thesis lay on the concept of social player experience, the first chapters outlined theories and related work existing in this context. In general, research on the social player experience deals with the feelings, thoughts, and behavior of players while they are interacting with the game system and with each other. I derived a research model of social player experience from a comprehensive review of literature and defined three layers of the social play setting—game, player, and context—as well as communication and social interaction as parts of the emergent social play. The literature review indicated that the social aspect is an integral part of the intrinsic motivation of many players to play digital games and that the experience between singleplayer and multiplayer games differs significantly. This difference is due to socio-psychological effects which appear in contexts that include more than one social entity. Thereby, social entities can be either real persons or virtual characters. Their social presence in combination with game aspects, context aspects, and individual player characteristics determines the social experience. My research model of social player experience aggregated these aspects and served as a structure for all studies presented here.

Based on the research model, this thesis shed light on different facets of the social player experience. The general methodological approach underlying most of the studies was the comparison of players' experience and interaction in different versions of the same game. For that purpose, I developed custom testbed games together with colleagues and students, which were modifiable regarding certain game aspects to address specific research questions in controlled settings. Using such testbed games in comparative user studies allowed us to investigate the impact of single game aspects on players' experience and their behavior, as differences between the study groups could be ascribed to the manipulated variable.

The first studies presented in the second part of this thesis (Chapter 4 to Chapter 6) dealt with different multiplayer settings and related game mechanics. In the study presented in Chapter 4, we investigated the influence of three specific game aspects on players' communication and experience in a two-player scenario. We found that a high player interdependence induced by intertwined goals and enforced collaboration can increase players' communication and thereby foster their interpersonal relationships. Results regarding the impact of shared control indicated a negative effect in the form of reduced perceived competence and autonomy. Nevertheless, we assumed that different implementations of shared control might create positive and innovative player experiences. Therefore, we conducted another study comparing different types of shared control, which was described in Chapter 5. The participants experienced our game—which was explicitly focused on the mechanic of shared control—as highly enjoyable and intuitive. They appreciated the innovative social setting and the resulting close collaboration. In accordance with the results of the prior study, the relationship between cooperating players in terms of team cohesion seems to be intensified by the necessity to work together closely and to coordinate actions.

In addition to shared control input techniques, this thesis also considered the impact of different output devices on players' social experience in Chapter 5 as another game interface aspect. In a research project, we supposed that the use of additional displays, which we call second screen gaming, can significantly change the social dynamics of a setting. A combination of private (i.e., only one player has access) and public displays (i.e., all players see the content) allows for the distribution of information and different player roles. We elaborated on such new design opportunities as well as on the main technological, social, and cognitive challenges related to second screen settings. Our research pointed out that the choice of game interface types can support the design of game mechanics that foster player interdependence, interaction, and the general social experience, if designed carefully. In conclusion, our work emphasized that slight changes in game design—in terms of game mechanics, control schemes, or output devices—can significantly change the social player experience in multiplayer settings. In particular, game aspects which induce closely-coupled interactions between players seem to increase the social interaction and emphasize the sociality of the playing setting.

The final chapter of part II, Chapter 6, shifted the focus of investigation towards the methods used to measure social aspects of the player experience. The chapter introduced three gameplay metrics which we developed to assess different facets of players' social interaction in a cooperative two-player game. Such gameplay metrics are meant to provide objective data that can be measured immediately during play without disturbing the players. This way, gameplay metrics constitute a valuable source of information in addition to subjective measures (e.g., questionnaires). The chapter presented our approaches to implement three metrics that targeted players' social presence, cooperative behavior, and leadership characteristics. Based on the results of an exploratory evaluation, we were able to show that even simplified gameplay metrics provide interesting insights into social play and in-game behavior. Hence, we suggested to further work on social gameplay metrics and to consider them as a valuable supplement to established methods.

In the studies presented in the third part of this thesis (Chapter 7 to Chapter 10), we focused on the social influence of different social entities instead of varying certain game mechanics. In particular, we were interested in the social effects that are potentially induced by virtual, computer-controlled characters. The underlying assumption was that virtual characters may have an impact on players similar to real humans if they are perceived as social entities. The work comprised in this part aimed at testing this assumption by comparing the influence of artificial companion characters to human co-players, observers, and singleplayer settings in terms of different social effects.

To lay the foundations for all following studies with virtual characters, Chapter 7 introduced a discussion on different types of such characters. We pointed out that game companions are a special subtype that is supposed to have a great influence on the player due to the continuous presence during the course of the game. Based on the literature regarding virtual characters, we compiled an overview of the design space of game companions, which can be used for the design of future companions as well as the analysis of existing ones. We found that one key to successful companions is to meet the players' expectations. The results of our online survey emphasized that players appreciate companions with a unique personality, background story, and the ability to show appropriate and believable behavior. Besides, our participants reported that the presence of a companion decreases their feeling of being alone and adds a social layer to the play setting. This provided a first indication that virtual characters in games can induce social effects, which we further investigated in subsequent studies.

Chapter 8 presented a study addressing the social influence of different social entities in a custom collaborative game. In this study, we compared players' experience, immersion, and the feeling of loneliness when playing the game together with a human co-player, a virtual companion, or all alone. The comparison revealed that adding a social entity does not necessarily improve the player experience. In fact, our results indicated that co-present social entities can decrease players' enjoyment if they show a lack of interactivity and context sensitivity. In contrast, if they are designed carefully, they can decrease feelings of loneliness and increase the sociality of the gaming situation.

Finally, Chapter 9 and Chapter 10 focused on a concrete socio-psychological effect, the social facilitation effect, by presenting several subsequent studies. In these studies, we wanted to investigate whether the presence of a virtual companion character can influence players' performance in digital games. As a theoretical foundation, we used an integrative model of social facilitation that lists the different factors supposed to frame the effect in a certain situation. We developed an adaptive testbed game that allows for the variation of these factors to enable their systematic evaluation.

In a first study, which was described in Chapter 9, we used the testbed game to create four different game versions, varying the presence of a virtual companion character and the use of an HMD. Though we found some indications that the companion caused a decrease of players' performance in the conditions with high immersion (caused by the HMD), there was no overall effect. Contradicting to our hypotheses, the results did not show a clearly detectable social facilitation effect across all conditions. Therefore, we conducted further studies to test whether our results were replicable and to control for other potential confounding variables such as the game genre and the type of social entity.

Chapter 10 presented four additional studies on social facilitation with different games. We also included conditions with a human observer to test whether her presence induces social facilitation like the general theory suggests. The results of these studies also contradicted our hypotheses. We did not find any evidence for the effectiveness of social facilitation in digital games, as the performance of our participants was influenced neither by the presence of the virtual companion nor by a real observer. Hence, it seems that virtual characters have not less social influence than real humans, but that the social facilitation effect does not appear in gaming contexts anyway. We reason that games provide alternative worlds with their own rules and meanings. Therefore, social rules and effects that usually take effect in the real world might not apply to digital games.

11.2 LIMITATIONS

Like most empirical studies, our work has some limitations that have to be considered while interpreting the results. We gained most of our insights by conducting experiments in which we compared players' experiences in different versions of the same game. The advantage of this method is that it allows for the investigation of specific game aspects in a controlled setting. In contrast to other methods such as surveys, this method is also more objective: gameplay data can be logged and players can be observed during play and be asked about their experience directly afterwards. However, studies conducted in the laboratory can only partly resemble real playing situations. Participants do not choose the game themselves and initially have no intrinsic motivation to play it. Instead, they are instructed to play the game and are aware that the researcher wants to test something. Moreover, participants might feel observed during play and, thus, behave different than they would at home. Such biases can influence their experience and reduce the validity of the results [206].

We kept these aspects in mind while planning our studies and maintained their validity by resembling an informal, homelike atmosphere. Our gaming lab was equipped with a couch and a projector. During playing sessions, the experimenter usually left the room so that players felt less observed. Instructions and game tutorials were standardized. Nevertheless, it will be subject to future research whether our results can be replicated in more natural settings. In general, we described all our methods and procedures in detail, so that I encourage everyone who is interested to emulate the settings and repeat the studies.

We developed custom games and applied them in our studies to be able to create slightly different game versions. This facilitated the controlled investigation of single game design aspects. However, games that were particularly built to serve the purpose of research might be biased and different from off-the-shelf games. Clearly, we cannot guarantee the same quality as a games studio. We took this limitation into account during our research on the social facilitation effect by also including commercial games. In addition, all our custom games were pretested and their design was inspired by existing games to ensure that the main game mechanics were approved.

Finally, our study samples were limited in scope. We recruited at a university, thus, most of our participants were students in the respective age group. Players with other demographic backgrounds may have different game preferences and may react in different ways to social game mechanics. Accordingly, our findings should not be generalized to other demographic groups without further testing. Whereas we strived for sufficient numbers of participants in every study to allow for sound statistical analyses, a greater amount of participants may have led to even clearer effects.

Apart from limitations regarding the methodology underlying our studies, I also acknowledge general limitations regarding the thematic scope of this thesis. Social player experience research is a wide field with a lot of different focus areas. I considered many of them in the theoretical foundation and created a general research model (cf. Chapter 3) that is supposed to support diverse research endeavours. However, it was not possible to investigate all aspects that are included in this model in detail within my studies. I decided to focus on the aspects that I considered most important and at the same time underrepresented in current research. By means of some examplary game aspects, I showed the relation to players' social interaction and communication. Moreover, I focused on the differences between real and virtual social entities and used the social facilitation effect as an example for a classic social effect to be investigated in detail. In addition to investigating single game aspects in isolation, a next step will be to test the interdependencies between different variables. Furthermore, the question which game mechanics are potentially more influential than others will be subject to further research.

For future studies, my research model provides more starting points. I have to emphasize that this thesis mainly focused on cooperative game settings. The social dynamics of competitive settings might differ significantly, because aspects such as rivalry, performance, and leadership become more important than communication, coordination, and sympathy. Hence, competitive game settings constitute an own area of player experience research that holds a lot of additional questions.

11.3 CONTRIBUTIONS AND AREAS OF APPLICATION

Despite the described limitations, this thesis constitutes major contributions to the field of player experience research. It was guided by the main research question how social entities, such as co-players and virtual characters, affect the experience of players in digital games. To approach this question, I elaborated on the constituents of the social player experience, evaluated methods to measure it, and conducted a series of studies to investigate the relation between game aspects, social entities, and the emergent social play. As stated at the beginning of this thesis, the work presented here strived for five main contributions:

1) A social player experience research model:

   Based on an extensive literature review, this thesis summarized current findings and presented a general research model for social player experience in Chapter 3 (see, in particular, Figure 4). This model framed our work and is supposed to facilitate future research in the field. The studies included in this thesis were mainly focused on three factors of the model: the different types of social entities, game-related aspects, and social effects.

2) Findings regarding the influence of different game aspects on players' social experience and interaction:

   Chapter 4 and Chapter 5 presented two studies on the influence of the game aspects player interdependence, time pressure, shared control, and second screens on players' social experience in multiplayer settings. The results can support game designers in creating enjoyable social experiences in future games. Our studies show how the communication and interaction between players can be triggered by game design.

3) Evaluation of methods to assess players' social interaction:

   During the course of our studies, we also considered the question which methods are suitable to measure and analyze the social aspects of playing. We used established methods such as questionnaires, as well as more innovative approaches such as the classification of players' verbal communication and social gameplay metrics. By using and evaluating different methods, we contributed methodological knowledge to support researchers and improve future studies. We recommended a mix of methods to get best insights by combining different sources of information. Whereas established methods like questionnaires are very usable to understand players' subjective thoughts, feelings, and motives, the use of social gameplay metrics (as introduced in Chapter 6) and observation schemes (like in Chapter 4) provided additional, objective information about the player experience.

4) A design space of virtual companion characters:

   As outlined in Chapter 7, companion characters bear the potential to induce social effects during play. Thus, we considered their influence in our studies about the social player experience in singleplayer games and provided design implications and recommendations for game designers to foster the development of engaging social game characters. Based on the design space, we developed companions for custom games that were used in our studies to test their social influence.

5) Findings of six studies on the social impact of virtual characters:

   The results of the studies presented in the third part of this thesis (cf. Chapter 8, Chapter 9, and Chapter 10) contributed knowledge about the social impact of virtual characters in digital games. We discovered that there is some social effect due to the presence of virtual companion characters, for instance in terms of reduced loneliness and the experience of social presence. However, our findings indicated that a companion does not necessarily improve players' enjoyment and that, moreover, social effects may not apply to the context of playing digital games in the same way as they apply to other social situations. We have demonstrated this with our comprehensive investigation of the social facilitation effect, which is an established effect in social psychology, but could not be reproduced stably in our gaming settings. These results are striking, as they contradict the general theory, and should encourage researchers as well as game designers to carefully consider existing social theories and test them in the context of games before using them as design rationales.

Overall, this thesis advances the research regarding social play. Apart from enhancing knowledge and providing the evaluation of methods, our findings can also be applied in practice. By understanding the interplay between game design, social effects, and the resulting experience, it is possible to design intended social experiences. An obvious field of application is the entertainment sector. The design of enjoyable social interactions in games and the implementation of engaging virtual characters can enhance the attractiveness and success of a game. A game that includes social features can satisfy players' social needs, thereby providing another reason to play.

Moreover, our findings support the design of games with a social purpose. As multiplayer games can foster the social relationship between players, they can be used as means to promote new relationships and to help persons stay in contact with friends and family members. This is particularly important in situations in which persons are suffering from social isolation and loneliness. For instance, chronicle illnesses or impairments impede the participation in certain activities, which are natural for healthy people. Digital games, especially online games, can bridge the gap between socially isolated persons and the remaining community, thereby promoting their well-being [66, 103].

Besides expanding players' private social space, the establishment and improvement of social relationships by means of digital games is also relevant in the organizational context. Games can serve as icebreakers for new employees and business teams. By fostering trust and common ground, playing games is a suitable teambuilding activity that is supposed to improve group work [66, 86, 225], particularly in new teams or for those who work remotely. As we have shown in our studies, game aspects such as player interdependence and cooperation can be used to increase players' communication and relationships.

Another special application context is the design of human computation or crowdsourcing games. The aim of this kind of digital games is to generate knowledge drawing from the intelligence of the crowd to solve complex real-world problems [4, 58, 163]. The success of such games is dependent on players' voluntary participation and their willingness to contribute serious input. By means of social game mechanics players' motivation and the quality of their contributions can be increased. For instance, if players have to work closely together in a team, they might feel the social responsibility to take their game tasks seriously. At the same time, social effects such as social inhibition and social loafing can impede players' participation. Hence, we encourage designers of human computation games to take such effects into account and prevent them by respective mechanics.

In the context of serious games, our work regarding virtual companion characters is also relevant, because game characters who are capable of inducing social effects comparable to humans offer new design spaces. In games for learning and training, companions are often used to guide the player through the exercises. Designers should consider and test the potential social effects that can influence players' performance. Virtual companions can also be applied in games for training social skills. For this purpose, the character has to appear like a social entity that acts autonomously and reacts appropriately to the player's actions. Our design space regarding social companions can serve as a reference during the development process.

11.4 CONCLUSION

This thesis provided a diversified consideration of social effects in digital gaming contexts. I presented a social player experience research model as well as findings of nine laboratory studies and one online survey. The social player experience has to be considered during the design process of digital games, because it has high influence on the overall experience. For many persons, social aspects are the main motivation to play games and, thus, interesting social mechanics can increase a game's popularity and success. The studies presented in this thesis showed that slight changes in game design regarding certain game mechanics can result in differing social experiences. In particular, aspects such as player interdependence and meaningful interactions should receive special attention to foster positive social experiences.

In this context, social interaction can also take place in singleplayer games. Although multiplayer settings are very common and an important part of social player experience research, I have pointed out that virtual characters can also trigger social situations. Accordingly, the relationships between player and game characters, particularly game companions and characters that take significant roles in the game, can be considered as social relationships including respective emotions, cognitions, and effects. At the same time, social phenomena and effects known from other areas of application cannot be transferred one to one as shown here by the example of the social facilitation effect. The applicability of established social concepts has to be investigated in the special context of games before taking them into account in the game design process.

Overall, the social dynamics that evolve during play are complex and multilayered. Hence, the investigation of underlying causes and relations is a comprehensive task. Still more research is needed to fully understand players' behavior and experience in social play situations. The work summarized in this thesis significantly advances knowledge and research approaches in the field by providing both insights from empirical studies as well as a model and toolkit of methods for future social player experience research.

Part V

APPENDIX

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DECLARATION

I hereby declare that this thesis was compiled solely by myself and only with the references marked and cited.

Duisburg, November 2019

Katharina Emmerich

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