

# **Designing Persuasively using Playful Elements**

by

Rina R. Wehbe

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# Examining Committee Membership

The Examining committee in attendance to jury the defense of this dissertation includes:

Supervisor:

**Edward Lank, Ph.D.**

International Research Chair, Inria Lille-Nord Europe  
Villeneuve d'Ascq, France  
Professor, Cheriton School of Computer Science  
Faculty of Mathematics  
University of Waterloo, Canada

Internal:

**Daniel Vogel, Ph.D.**

Professor, Cheriton School of Computer Science  
Faculty of Mathematics  
University of Waterloo, Canada

**Keiko Katsuragawa, Ph.D.**

Officer, National Research Council Canada  
Adjunct Professor, Cheriton School of Computer Science  
Faculty of Mathematics  
University of Waterloo, Canada

Internal-External:

**James R. Wallace, Ph.D.'**

Assistant Professor, School of Public Health and Health Systems  
Faculty of Health  
University of Waterloo, Canada

External:

**Nicholas Graham, Ph.D.**

Professor, Computer Science  
Queen's University  
Kingston, ON, Canada

## **Author's Declaration**

This thesis consists of material all of which I authored or co-authored: see Statement of Contributions included in the thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

# Statement of Contributions

## Association for Computing Machinery (ACM) Publications

This dissertation includes first-authored peer-reviewed material that has appeared in conference and journal proceedings published by the Association for Computing Machinery (ACM). The ACM's policy on reuse of published materials in a dissertation is as follows <sup>1</sup>:

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### Chapter 2: Incremental Difficulty Design in Platformer Games

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Rina R. Wehbe, Edward Lank, and Lennart E. Nacke. 2017. Left Them 4 Dead: Perception of Humans versus Non-Player Character Teammates in Cooperative Gameplay. *In Proceedings of the 2017 Conference on Designing Interactive*

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Chapter 5: Personal Space in Play: Physical and Digital Boundaries in Large-Display Cooperative and Competitive Games

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## Project Contributions

### Chapter 2: Incremental Difficulty in Platformer Games

As first author of this paper, I formulated the research question, conducted the literature review, and present a proposal for a study to my supervisor (Lennart E. Nacke). Following approval, I designed the study and research material requirements. After the requirements of the stimulus were set, I recruited the help of Mike Schaekermann (visiting research assistant Master level) and Eddie Sheerer (undergraduate research assistant) to develop the game. A special thanks to Jens Johannsmeier and David Rojas for their advice and support in the early days of this project. Data was refactored later after admission to Computer Science at University of Waterloo under the supervision of Edward Lank. At this time, Elisa Mekler (second author) joined during the re-writing phase and provide instruction alongside with my supervisors Edward Lank and Lennart E. Nacke. Edward Lank advised on the restructuring to a note (now flexible length paper) for CHI2017. This project was funded by Lennart E. Nacke (former supervisor) under his NSERC grant.

### Game Credits

The game used for the project was designed to Rina Wehbe's (first author) specifications and game design to complement the study design. All coding, implementation, and game art were completed with special thanks to Mike Schaekermann (third author), and Eddie Sheerer (during his research assistantship). Concept art illustrating the research ideas captured in the game design, was completed by the talented Mariam Ganaba under the funding of Nacke's HCI Games Group at the Games Institute, Waterloo.

### **Chapter 3: Biologically-Inspired Gameplay: Movement Algorithms for Artificially Intelligent (AI) Non-Player Characters (NPC)**

The paper started as course project work with my project partner, Megan Antoniazzi at University of Waterloo, CS898: Biologically Inspired Algorithms taught by Gladimir Baranoski. As first author of the paper, I formulated a research question and hypotheses by studying the user of biological algorithms with games. With the agreement of my project partner Megan Antoniazzi and course professor Dr. Baranoski, I was then able to move forward to gaining approval from office of research ethics. Antoniazzi worked on the implementation of the algorithms in unity, as I designed research study under the advisement of my supervisor (Edward Lank). Following, I completed a short project report with my project partner. Moving forward, with permission from Antoniazzi, I continued the project building on the pilot data. At this time, Giovanni Riberio also joined the project as a new Master's level researcher in Nacke's HCI Games group as an opportunity for learning and mentorship. With Riberio's help, part 1 of the data collection was completed. After analysing this data, I designed part 2 of the study with advice from Edward Lank. Part 2 of the study would run on Amazon's Mechanical Turk (MTurk). To provide fair wage for MTurk workers, I sought funding from my supervisors. In addition, Lennart E. Nacke provided funding for an research assistant, Kin Pon Fung, who assisted in creating the Mturk web platform to host the research samples and expanded the game code to include the calibrated algorithms I requested. Video samples of the bespoke game Tagorithms I and II, and samples from off the shelf games: Left4Dead2 (Valve) and Grand Theft Auto (GTA) (Rockstar Games) were used for the final study. I choose the samples and created the stimulus videos for participant comparison in the just-noticeable-difference (JND) study. Then I completed data collection via Mechanical Turk. Finally, I analysed the data and wrote the paper shadowed by Riberio and under the advisement of my supervisors.

#### **Game Credits**

The game, Tagorithms, began as a course project designed to the specifications of a user study by Rina R. Wehbe with Megan Antoniazzi. Following the course, the game was expanded by Kin Pon Fung. A special thank you to other HCI Games Group members Andrew Jin Lin Cen and Joe Tu who drew the ladybug assets.

### **Chapter 4: Leave Them 4 Dead: Perception of Humans versus Non-Player Character Teammates in Cooperative Gameplay**

As first author for this paper, I designed the study. After presenting a proposal to my M.Sc. supervisor (Nacke), I was allotted the needed research assistant hours needed to complete the data collection. At this point, I would like to thank the L4D2 confederate team, Eddie

Shearer and Jens Johannsmeier, who's support made this work possible. I completed the ethics application with special attention to the ethical procedures needed for a double blind study, which was complicated because the protocol called for deception of participants and research assistants. This research was approved by the University of Ontario Institute of Technology's Research Ethics Review Board during the first author's attendance there as a M.Sc. Graduate Student in Computer Science [260]. The analysis of the qualitative results, paper writing, and submission took place at University of Waterloo under the advisement of my PhD supervisor Edward Lank. A special thank you to Elisa Mekler (then Post-doctorial researcher at HCI Games Group) and Lennart E. Nacke for editorial feedback. Funding for this work was provided by [National Science Engineering Research Council of Canada \(NSERC\)](#), the Canadian Fund For Infrastructure (CFI), Mitacs, and the Social Sciences and Humanities Research Council of Canada (SSHRC).

### **Game Credits**

Thanks to Mike Ambinder at Valve Corporation for providing the games.

### **Chapter 5: Playing with Personal Space: Physical and Digital Boundaries in Large-Display Cooperative and Competitive Games**

This study underwent ethics review performed by the Office of Research Ethics, University of Waterloo. This study was part of a two-part research project with Terence Dickson. Dickson wanted to test elicitation of his interaction techniques in a more ecologically valid study environment where the techniques could be used by participants freely, instead of required by the study design. As a result, I was recruited due to my knowledge of Games User Research (GUR). During our collaboration, I saw an opportunity for testing the boundaries of territorial collaboration and branched the project as first author. I then began working on a study design and game design which would satisfy the hypotheses. The study was supported by Dickson (second) who refactored his interaction technique work to make a game and contributed to the designs. I collected the dataset for both studies. Following, I then analysed the dataset, wrote, and published the research paper. In the meantime, I also assisted on Dickson's paper as second author.

Funding was provided by NSERC, Social Science and Humanities Research (SSHRC) Councils of Canada, and the Canada Foundation for Innovation Infrastructure Fund.

### **Game Credits**

Game design was completed as a collaboration between Rina R. Wehbe (first author) and Terence Dickson (second author). Development of the game code and assets is thanks to Terence Dickson (second author).

## **Abstract**

Alongside productivity and communication, computers are a valuable tool for diversion and amusement. Game Designers leverage the multifaceted world of computing to create applications that can be developed persuasively; designs can be formulated to compel users towards actions and behaviours which range from engaging in the game's mechanics, micro-transactions, or in more complex manifestations such as encouraging reflection via the evaluation of the moral argument presented in the gameplay narrative. In my dissertation, I explore how to create compelling experiences during playful interactions. Particularly, I explore how design decisions affect users' behaviours, and evaluations of the gaming experience to learn more about crafting persuasive mechanics in games. First, I present research on calibrating aspects of difficulty and character behaviour in the design of simple games to create more immersive experiences. My work on calibration of game difficulty, and enemy behaviour contribute insight regarding the potential of games to create engaging activities, which inspire prolonged play sessions. Further work in my dissertation explores how players interact with in-game entities they perceive as human and explores the boundaries of acceptable player interaction during co-located gaming situations. My early work gives rise to deeper questions regarding perspectives on co-players during gaming experiences. Specifically, I probe the question of how players perceive human versus computer-controlled teammates during a shared gaming experience. Additionally, I explore how game design factors in the context of a tightly-coupled shared multi-touch large display gaming experience can influence the way that people interact and, in turn, their perspectives on one another to ask: '*how can games be used persuasively to inspire positive behaviours and social interaction?*'. Issues of perspectives are a theme I carry forward in my work by exploring how game dynamics – in particular the use of territoriality – can be used to foster collaborative behaviours. Further, I discuss how my work contributes to the study of persuasive game design, games with purpose, and cement my findings in relation to the games studies and computer science literature. Last, I discuss future work, in which I discuss my ambitions for using persuasive design for social good via Games4Change.

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With gratitude, I would like to acknowledge that the land on which I work and live today (*and for most of my degree*) is the land traditionally used by the Attawandaron (Neutral), Anishinaabeg and Haudenosaunee peoples. I recognize that the University of Waterloo is situated on the Haldimand Tract, the land promised to the Six Nations that includes ten kilometres on each side of the Grand River. I also acknowledge the enduring presence and deep traditional knowledge, laws and philosophies of the Indigenous Peoples with whom we share this land today.

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“A word after a word after a word is power.” - Margaret Atwood

1 “Don’t overload a study!” - Edward Lank

# Chapter 1

## Introduction

Video, card, and board games, collectively referred to as gaming, are extracurricular activities that have stood the test of time. Participation can be observed across age groups, cultures, and generations. The [Entertainment Software Association of Canada \(ESA\)](#)<sup>1</sup> reports that 23 million Canadians are gamers[1]. Moreover, we can see the pervasiveness of gaming is marketable and representative of a large consumer industry with complementary sales in merchandising, competitions, news, podcasts, bloggers and [vloggers](#). Therefore, it is unsurprising that there is a complementary academic field studying games as they permeate culture and society[2]; however, games are interesting to study not solely due to their financial impact on the economy.

Games can be studied from many different lens, angles, or viewpoints; hence, games research is a multidisciplinary area of study pulling in researchers from Engineering, Social Sciences (Psychology, sociology, anthropology, etc.), humanities, cultural studies, arts and more. Games also span the range of interests within computing research as well; topics include, and are not limited to: graphics, rendering, high-performance computing, and Human-computer interaction (HCI), among others.

Games can be studied as the primary foci of a study. For example, an industry researcher may look particularly at the player's experiences within a game being developed [36], or a researcher interested in high-performance computing for consumer applications may study the maximum resolution achievable on a typical hobby budget. Games can also be a test bed of a study, in which the game provides an environment for the researcher to observe a participant(s). For instance, a psychologist might use a game to study participant behaviour

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<sup>1</sup><https://theesa.ca/>

when confronting a difficult situation, or a researcher might explore reactions to police brutality via a virtual reality game [35].

Games are naturally persuasive and are designed to attract attention [86]. As a result, they have often been used as a mechanism to visually attract [87], prolong engagement [155], and encourage behavioural change [43].

Games need to be successfully persuasive because there is a need to convince players to spend time and effort learning new skills, controlling systems feedback mechanisms, and navigating the game environment. [201]. Specifically, the persuasive nature of games is needed to guide players to begin the game, compel action, and then reward players to entrench them into the game world [156]. From a narrative standpoint, the game must also convince players to learn things about the bespoke game world including the physics and logic, needed for movement and exploration [118] In turn, players might also need to spend time learning about the history and lore of the world to solve puzzles that can include social, moral, or political themes[109].

Research dissecting game mechanisms has revealed information on why games are an attractive platform. Firstly, games provide a safe environment for exploration given that for the majority of games, the consequences of actions taken in the game world are limited to the context of the game. In games, players can choose to express differences in moral alignment and personality, act, dramatize, and play imaginatively[23, 61]. Second, games allow us to make errors and free us from the consequences of the system [] However, it does not mean that time spent in the game world has no value or impact. For example, games can create a space for online social meetings. Social interactions in game are still perceived as time with friends [176, 104]. Games provide a space for friendship, and meeting friends online via gaming is a well studied phenomenon [208]. Therefore, in game relationships impact real-life relationships. As well, by leveraging knowledge of how people enjoy individual games and interact with other people in a gaming space, we can change the way we design games to influence player behaviour. For example, researchers can encourage the formation of a closer relationship using games [52].

Finally, even beyond individual connections, games can communicate deeper information about culture or people. For example, the game titled: ‘Never Alone (Kisima Ingitchuna)’ was made in collaboration with The Inupiat, a group of people native to Alaska<sup>2</sup>. Games can also communicate individual stories, grief, and trauma; as an example consider ‘That dragon cancer’<sup>3</sup> which was partially an autobiographical story based on the creators experience raising a child diagnosed with cancer at 12-months of age. Games can provide space to

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<sup>2</sup><https://neveralonegame.com>

<sup>3</sup><http://thatdragoncancer.com>

explore vulnerabilities [192], allowing the exploration of intimate and deeply personal topics like sexuality, gender, and orientation [93]. Games can therefore be used for learning in multiple ways including traditional education, as well as, driving thematic, moral, or empathetic arguments. Overall, games are multi-sensory, narrative environments which can be designed to closely reassemble real-life (RL) environments or simulations [77].

## 1.1 Thesis Statement

When we create games, our goal is to engineer compelling, immersive, playful experiences for players of the games. However, creating these experiences presents a number of challenges in user interface design, in the mechanics of game play, in the representation of characters, in the coordination between players, and in recognizing and measuring success. These challenges are applicable to all types of gaming including physical board games, digital video games, **Augmented Reality (AR)**, **Virtual Reality (VR)**, playful simulations, and other gaming types — referred to collectively as games.

My thesis focuses on digital game environments and computer augmented physical game materials. The conclusions of my work, although centred on computing entertainment applications, may also have application to traditional board games, the design of toys, and similar non-computing gaming applications.

My dissertation thesis research question is:

- **[RQ-T] How can we design persuasively using playful approaches within gameful environments?**

To begin, we discuss the meaning of ‘persuasive experiences’. Persuasion by definition denotes compelling an action, directing behaviour, convincing, or changing an attitude, or leading to a difference in direction. In design this might look like: compelling someone to spend time and money in an application, directing a course of action, or considering an alternative view point.

Games are naturally persuasive, and the goal of game design is de facto to create persuasive experiences. Games aim to encourage on-going play and to foster immersion, i.e. to persuade people to play and to persuade people to become invested in the game world. Game designers might aim to achieve these goals by design via reward structures, storytelling, action sequences, graphical rendering, among other game experiences, all of which motivate players to keep playing. Alternatively, designers might focus on directing

a course of action by unbalancing the system to favour cooperation. To inspire attention to new information, empathy for another viewpoint, or alternate approaches to the same problem, a game designer might design a game with a narrative focused on empathetic and emotional story lines, akin to having a teachable moral to the overall story.

The second piece of this question talks about playful approaches. One important aspect of the gaming experiences explored in this thesis is that the effort and time expended should not feel like work. While there exist many serious games where fun aspects are optional – military simulations, other training environments, virtual classrooms – the games that are explored in this thesis, those through which we want to create persuasive experiences, should be fun.

Finally, this thesis question identifies gameful environments as the overall context for this work. A computer game is, *ipso facto*, a gameful environment. However, many other environments such as work, e-learning, and social networking can include aspects of gamification, leading researchers to adopt the term ‘gameful’ to describe these environments [276]. Essentially, they constitute an environment where gamification and play are leveraged to accomplish goals. The goal can be the game, or, as in gameful learning environments [276], can be an external, real-world goal.

While my primary thesis questions asks how to design persuasively using playful approaches, this question is broad, and, in the interest of providing a more targeted approach within this thesis, I focus on a deeper exploration of two factors: 1) the quantitative design of games and 2) the effects of social entities in games. First, I explore how game mechanics can be dissected to understand how to manipulate quantitative factors of games.

### RQ1 How can quantitative game systems calibration enhance player satisfaction?

The motivation for this question is that, to encourage users to engage with a gameful environment (e.g. a game or other gamified environment), we must manage the environment in calibrated ways so that players gain skills, buy into the reward structure, i.e. that they feel encouraged and persuaded to play.

Second, I explore how we might leverage game mechanics and principles of design to change individual behaviours and/or attitudes toward others. I investigate how aspects of game design influence players toward behaviours, and how to leverage those mechanics to create more collegiate, collaborative gaming experiences.

### RQ2 How do players perceive other social entities in game?

The motivation for this question is that, in playing a game, players encounter other characters, either AI-controlled by the gameful environment or avatars of other human players that are interacting with the player within the gameful environment. How we interact with these entities is another aspect of creating compelling, engaging experiences.

To explore these questions, this thesis presents four of individual research projects:

1. Chapter 2: Incremental Difficulty Design in Platformer Games
2. Chapter 3: Biologically-Inspired Gameplay: Movement Algorithms for Artificially Intelligent(AI) Non-Player Charters (NPC).
3. Chapter 4: Leave Them 4 Dead: Perception of Humans versus Non-Player Character Teammates in Cooperative Gameplay
4. Chapter 5: Personal Space in Play: Physical and Digital Boundaries in Large-Display Cooperative and Competitive Games

Projects featured in Chapters 2 and 3, map onto Research Question 1 (1.1). Similarly, projects featured in 4 and 5.1 map onto Research Question 2 (II). In the following section, I will summarize the contributions of each of these projects; provide an overview of how they answer the individual research questions; and together address the overall thesis research question. Figure 1.1 provides a summary overview of research questions, research projects, and contributions both on a project level and mapped onto the two primary research questions on quantitative game mechanics and perceptions of social entities in games.

## 1.2 Contributions

The focus of my dissertation is to explore how games can engage players in playful yet compelling and rewarding gaming experiences. My thesis is divided into two primary parts. I begin by exploring, in Part I: how individual aspects of game design can be improved for the individual player. In Part II, I explore how multiplayer interactions influence player enjoyment and human interaction in playful settings. The thesis concludes with a discussion and presents a forward-looking research plan for ways that these results can be leveraged to elicit behaviours and to encourage pro-social behaviours.

	Thesis RQs	Study RQs	Research Materials	Study Contributions	Thesis Contributions
P1: Single player	<b>RQ1:</b> How can quantitative game systems calibration enhance player satisfaction?	<i>Can we calibrate the difficulty to make more challenging gameplay?</i>  <i>Can we calibrate Non-Player Characters (NPC) movement algorithms to increase user-reported realism?</i>	<b>Incremental Difficulty</b>  <b>NPC Movement</b>	Yes! Study demonstrates that designers can influence player experience (PX/UX) through incremental changes to game design mechanics which determine difficulty  Not really, differences are just noticeable; however, results indicate other factors will be better suited to persuasive design.	<b>Game mechanics and entities manipulate player experience but seem to have limited impact on player engagement</b>
P2: Multiplayer	<b>RQ2:</b> How do players perceive other social entities in game?	<i>What are characteristics of a human player? How do we differentiate humans and NPC-Teammates (NPC-TJs)? Can we use this persuasively?</i>  <i>What determines the actions that are acceptable when playing with other humans? Can we use this persuasively?</i>	<b>LT4D</b>  <b>Playing with Personal Space</b>	In our deception, players could be misled on the identity of their opponent. Yes! Players respond differently to entities perceived as human  Yes! Perceptions of 'Acceptable' social boundaries weigh heavily on players. Win conditions change the social environment, influences player beliefs, and subsequently, actions.	<b>Social contracts are created between valued collaborators &amp; we can make design decisions to influence behaviours and attitudes towards others</b>

Figure 1.1: Thesis and Chapter Contributions

### 1.2.1 Calibrating Games to Enhance Player Satisfaction

Unlike multiplayer games, which may rely on the joys (and irritations) of playing with another human, the single player game relies on the design of the game system to provide challenge, intrigue, and immerse the player in the narrative [116, 25, 53].

The calibration of difficulty in games is of importance because a player without experience may feel that a difficult game has a poor **User eXperience (UX)** and may no longer be interested in playing the game, series titles, or additional content (**Downloadable Content (DLC)**). Similarly, an experienced player may find a game too easy and again be less inclined to play the game. Csikszentmihalyi's [48, 47] work on the psychology of optimal experience is cited frequently when describing this phenomena. As a result, designers often discuss calibration of difficulty as part of keeping players in the **flow state** (i.e. a state of optimal experience where the task becomes its own reward).

In Chapter 2, the calibration of difficulty in games, through game mechanics, is studied [267]. In this work, game mechanics are the **dependent variables**: target size, jump lengths, scrolling speed and direction. These are varied to understand the difficulty of the game by measuring the **dependent variables**, errors made in game. Overall, the goal is to understand whether factors can be calibrated to adjust the challenge of gameplay. I find that we can calibrate difficulty.

Alongside the quantitative mechanics of gameplay, the other aspect of a game that is important for creating compelling experiences is the other entities that we find in the

game. In Chapter 3, *Biologically-Inspired Gameplay: Movement Algorithms for Artificially Intelligent (AI) Non-Player Characters (NPC)*, I focus on understanding the elicited UX of a game based on the behaviour of Non-Player Character (NPC). The study features a bespoke game called ‘Tagorithms’, which presents different calibrations or full changes of algorithms which affect the game’s NPC character movement patterns. The Artificial Intelligence (AI) NPCs’ actions dictated or controlled using computed algorithms or a series of instructions which dictate the behaviour of the game entity occupying and filling the artificial game world. The study uses a base of biologically-inspired algorithms because of the popularity of flocking algorithm as a basis for current ‘state-of-the-art’ NPC movement design. We demonstrate that small changes in game systems can affect the user’s ratings and opinions, and that players notice differences. However, there is a challenge: while players notice a difference, these differences seem to have little impact on overall player satisfaction or engagement.

Stepping back to our larger research question on game systems’ calibration, what I found in my explorations was ambivalent results. While game mechanics and aspects of NPC behaviour did seem to be important for usability of player experiences, their impact on overall player satisfaction and engagement – in creating persuasive experiences – was more difficult to discern. However, research on NPC movement algorithms did present a path forward. While the effect of different movement algorithms seemed to have little impact on creating more compelling experiences, players in our study ascribed meaning to the different behaviours of the NPC movement algorithms. In essence, NPCs seemed important as social entities in games, with differences in their behaviours described in human terms, leading us to an examination of player perceptions of social entities in games and their impact on creating compelling, persuasive gaming experiences.

### 1.2.2 Understanding Perception of Social Entities

In Part II of my thesis, I explore how both NPCs and other players as social entities within gameful environments.

To begin this exploration of relationships, I began by exploring the characteristics of human versus NPC teammates. In Chapter 4, I present a double blind study where I disguise the true nature of the participants’ teammates. For two-thirds of the participants, when the experimenter, who was also blind to the true nature of the study, informed participants that they were playing with a human or a computer-controlled player, this was actually true; however, the remaining third of the participants were given inaccurate information about their participants (i.e. they were told they were playing with people

but were, in fact, playing with NPCs or vice versa). The results of the study revealed information on how individuals categorize behaviours as socially acceptable based on their perceptions of whom they were playing with. The findings also reveal the factors which players felt were tied to the label of human and outlines acceptable interaction between human versus non-human game characters. In essence, I found both that players could be mislead, and that they responded differently to players that they perceived as human.

After gaining this nuanced understanding of human behaviour, social obligations, and acceptable in-game actions. I began to question the relationship between humans influenced by playful gaming environments in the physical world. As a result, the next study presented in Chapter 5 explores how humans engage in playful activities together in physical space. Specifically, Chapter 5 investigates the implicit social rules and limits of acceptable behaviour in competitive and cooperative gameplay challenges. From research, we identify information about how humans negotiate boundaries, police their own behaviours, and apply expectations of acceptable behaviours to other humans during play. The research in the chapter extends this by exploring how the social nature of the game environment, i.e. cooperative or competitive, causes a re-evaluation of acceptable behaviour within the context of the gameplay condition.

Overall, synthesizing my results from these two studies, what I found was that there was a social contract between valued collaborators. For NPC characters, this social contract meant that you would work with the characters, would look after them as a benefit to you, but that your behaviour was coloured by the understanding that it was less essential that they truly enjoy the game, i.e. it was your enjoyment that was paramount. In contrast, the contract between human players, and particularly human collaborators, is coloured by an obligation that, alongside your enjoyment, other human players should also enjoy the game. I also found that aspects of game design may influence how interactions between human players will be perceived.

### 1.2.3 Summarizing Contributions

Consider the research question which motivated this thesis: “How can we design persuasively using playful approaches within gameful environments?” I break this down into two aspects of game design: the quantitative and the social. I find that, while the mechanics of game design through difficulty adjustment and through movement algorithms are important to playability, they have limited overall impact on how compelling or engaging the game is. As a result, I believe that there is little avenue here to foster persuasive design, i.e. design that encourages changes in behaviours or attitudes. In contrast, one thing that does create

engaging experiences is the inter-player interactions within these environments. Depending on who we believe we are playing with and on how aspects of games are designed, my results identify concrete ways that player attitudes and experiences are impacted.

### 1.3 Organization of this Thesis

In the remainder of this document, I present the three parts of my thesis. As noted earlier, the thesis is divided into two primary contribution parts, followed by an overall discussion and a roadmap for future work.

Part I discusses calibration of the mechanics of the gaming experience, and presents two chapters that highlight, in turn, difficulty adjustment and NPC movement algorithms. However, as I note in the introduction to Part I, if the goal is to create compelling, engaging, persuasive experiences, then the quantitative and algorithmic aspects of gaming explored in Part I fall short. These quantitative aspects are important for creating playable games, but they have limited impact on our ability to influence player attitudes.

One aspect of Part I that was interesting was the take-away, from chapter 3, that participants ascribe underlying motivations and emotions to observed behaviours in games. Part II begins with an introduction that highlights how these anthropomorphic perceptions leads to a question of how we perceive other players. This, in turn, leads to two studies, one of which seeks to disentangle what is different about playing with other people within a gaming environment, and a second that seeks to explore whether it might be possible to influence our perceptions of and behaviour toward other players.

Finally, after presenting Part I and II, in Part III of this thesis, I discuss the implications and contributions of my work. I also highlight planned projects which, due to the COVID19 pandemic, have been delayed, but which leverage insights from, particularly, Part II with the goal of extending ideas of persuasive design through interaction with others in gaming contexts.

## **Part I**

### **RQ1: Quantitative Game Systems**

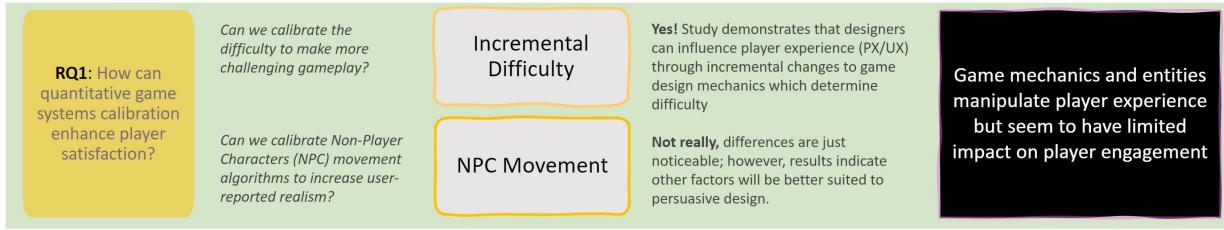


Figure 1.2: Part 1 Contributions

Figure 1.2 provides a road-map to the contributions of Part I of my dissertation. In Part I, I focus on the quantitative factors in game systems and explore how calibration of these factors can affect the player experience with the goal of understanding how these factors can be leveraged to moderate reported factors in play that are known to affect player experience. The studies in this section correspond to the following research question:

### RQ1 How can quantitative game systems calibration enhance player satisfaction?

I begin by exploring the calibration of difficulty in games. Early in my Ph.D. journey, I was motivated to study the errors that players made in games as a topic for my thesis. To get advice, I attended a Doctoral Consortium[261] where I was guided to look at errors made as a measure of difficulty, based on player performance, as a way to improve the gaming experience. This motivated my initial work in incremental difficulty.

Difficulty is one of the defining differences between games and other application types (e.g. productivity, creative, social networking platforms, etc.), because games provide difficulty for entertainment [108]. As such, the design and calibration of difficulty in games continues to be an area of focus for many academics focusing on game studies, Games User Research (GUR), and game designers [21, 187, 244]. In the early 1980's researchers including Malone et al. were discussing difficulty as a defining factor in game reception [137] and as a foundation for motivating the gameplay [136]. Therefore, in Chapter 2, I explore difficulty experienced by players based on number of errors made. In this chapter, I use a bespoke game featuring a cat jumping gaps. The game's in-house name is 'Fit-Kitty'.

In Chapter 3, game difficulty calibration is explored by investigating the movement patterns of the AI-controlled NPC characters occupying the game world in the bespoke game 'Tagorithms'. Movement of enemy characters in games is a detail that adds realism to

increase player engagement [14, 121]. As a result, a large body of work explores algorithm implementation; we contribute to this body of work in Chapter 3.

As noted in Figure 1.2, the challenge presented to this research progress is the negative answer to the research question that motivates this section. A need to explore other directions arises based on the results of the two studies in Part I revealing that game mechanics have limited impact on player engagement.

Inspiration for the new direction presented itself in Chapter 3 when reviewing the qualitative data. While the actual player movement algorithms had limited impact on engagement, the *differences* in how algorithms were perceived may have impacted engagement. To explain, when describing their experiences during gameplay players both identified differences between algorithms and ascribed human-like traits to those differences. Given that there are ascribed differences in the qualitative findings, the affect of these algorithmic decisions on player experience may still be present. Even if the differences did not result in greater or lesser engagement, the existence of differences between NPC movement algorithms, the fact that different swarms moved differently and that players saw multiple algorithms, allowed the players to ascribe different behaviours. This thread of inquiry forms the bridge to Part II of the thesis.

# Chapter 2

## Testing Incremental Difficulty in Platformer Games

### 2.1 Introduction

Difficulty in platformer games or platformers is easily adjusted because it is influenced by only by a few dimensions like speed or complexity of jumps. The main challenge in these games is to jump onto platforms while avoiding the holes that separate them. Popular platformers like Super Mario Bros. [153], are well-known by a variety of different players with different skill levels, age groups, and hardware generations.

There are currently few guidelines and parameters to aid game designers in the creation of difficulty levels, because we lack a thorough understanding how difficulty is generated and perceived in platformers. The result is that evaluation and manipulation of difficulty is frequently accomplished through continuous player testing, a post-hoc, time-consuming, and resource-intensive mechanism [83] for tweaking difficulty to create an optimal player experience.

We report a study of platformer difficulty, where we manipulated *Scroll Speed*, *Target Size*, *Jump Task Complexity*, and *Perspective* in a bespoke game. As we expected, our results show that errors increase as platform size decreases and speed increases. We also found that the relationship for errors and complexity might not be as linear as one could assume because jump task complexity showed triple-jump tasks to be as difficult as double-jump tasks. We also found that vertical and z-axis scrolling both had similar difficulty levels, but are both more difficult than horizontal scrolling (i.e., errors were most prevalent in the

forward running scroll (z-axis) and the vertical (y-axis) scroll condition, compared to the horizontal scroll (x-axis)). Alongside error measurements, our measures of self-reported levels of confidence in performance correlates well with quantified measures. To the best of our knowledge, the characterization of the relative difficulty of these factors is novel in the literature, and the implications of these results are useful to level designers creating content for their game, researchers developing automatically generated game levels, and Dynamic Difficulty Adjustment (DDA) system designers. Thus, our study results contribute a better understanding of these parameters for difficulty adjustment and balancing in platformers.

Difficulty adjustment of games is important to the player experience [137]. Researchers have found that changing the levels of difficulty elicits different emotional responses in the player [30] and input difficulty leads to different cognitive demands [167].

Moreover, game difficulty can be argued to be a defining factor of gaming applications. The intentional addition of task difficulty and desire to create an experience is the heart of game design.

Intentional addition of game difficulty is a contained factor, the game platform itself should still interface with the user to provide a playable game experience. Nacke *et al.* have argued that intentional difficulty added via the game's challenge is a distinguishing factor from other digital design domains[166]; i.e., making tasks harder to accomplish while the interface still remains easy-to-use. Other contributors [137] stated that difficulty is important because it can cause players to believe that their success is uncertain, contributing to in-game challenge, alongside hidden information, randomness, and multiple goals[137]. It has even been argued that the overall game feel is affected [223].

Platformers are particularly affected by difficulty adjustments. To define an acceptable difficulty level, game design teams invite playtesters and observe the play sessions. By watching the play sessions, designers balance game difficulty. Although effective, watching play-throughs by multiple players is a time-consuming challenge for game designers [12]. Moreover, the changes made to the platform are dependent on the opinion of the game design team, in other words, it relies entirely on expertise.

Following this, difficulty balancing has emerged as a subject of study of academics [10, 12, 103, 211], and practising game designers [21, 76, 45]. As a result, academics have attempted to aid the design of games by creating automatically adjusting difficulty [92, 103, 127], exploring parameter adjustments [96] or by changing the shooting mechanism in a First-Person Shooter (FPS) to provide target assistance [10]. Most notably, Wheat et al. [275] collected data on 2D platformer difficulty by testing a self-made game and then analysing the data to inform their classification system for adaptation. The study compared many factors (e.g., slope of curves, enemy difficulty) and provided important

pointers for the selection of the difficulty criteria in our study. Following Smith et al. [207], who defined that platformers have avatars, collectibles, movement aids, obstacles, and triggers, we focused specifically on obstacles and movement aids in our study. We refrained from adding triggers or puzzle elements due to their less deterministic nature.

## 2.2 Methodology

### 2.2.1 Study Design

Our independent variables were selected to coincide with commercial game elements and literature on the platformer genre [207]. These include Scroll Speed, Target Size, Jump Task Complexity, and Scroll Perspective. Dependent measures include different measures of difficulty in platformers such as different types of errors, time on task, and perceived difficulty. To analyze effects of independent variables, we created a bespoke auto-scrolling Jump-N-Run platformer game in the Unity 3D game engine that isolates game design strategies that may be used to create difficulty in platformers. Simple platformer games like the one we created may be found on the mobile app stores (e.g., Temple Run [228] or Super Mario Run [154]). We created a bespoke game to allow careful control of experimental conditions; inserting new conditions into an existing game maybe confounded with existing expectations, e.g. Mario Bros. does not traditionally have double jump and may be a confound for participants familiar with Mario.

In our bespoke game, players played as a cat that had to run in one direction to avoid a black abyss chasing it (Scroll Speed). To traverse this auto-scrolling world, the cat needed to amplify its jumping abilities by bouncing off trampolines (Target). Sometimes a single jump was not enough, and the cat needed to further its reach by bouncing off balloons (Jump Task Complexity), and found itself changing directions (Perspective). For clarity, the x-axis scrolls along the horizontal plane, (i.e. left-to-right), the y-axis on the vertical plane (i.e., up-and-down), and the z-axis on the foreground/background plane. In our game, an error occurred when a player failed to make a jump by missing the targets or fell too far behind the necessary scroll speed. Content in the game was procedurally generated (PCG) and fully randomized for each session. The platforms appear ‘just in time’, using a pseudo-random number generator. We pick platform length and distance within a playable range based on the constraints of the jump which is controlled. The PCG levels provides a test of endurance for players: How long can the player keep moving forward before they miss a jump? If the player failed to make a jump, they lost a life. The game session ended if the player lost all five of their lives or reached the maximum time. Arc length and

momentum were controlled. If the jump was executed with error, immediate feedback was given and corrections were not allowed. Throughout the study, each level of the game served to present a different condition. Game levels were pseudo-randomized by the computer to minimize practice effects between levels.

### **2.2.2 Procedure**

Sixteen participants' data were analysed for our study, 8 male and 8 female. All participants were over 18-years-old, with a mean age of 24 years.

Participants completed nine trials of the game, which presented different game design decisions created by the modification of the game's elements. Each trial was composed of two phases: a practice phase that consisted of five lives, and a gameplay phase that consisted of one minute of play with unlimited lives. After each trial/condition, participants were asked to rate the perceived difficulty of the condition played on a scale from 1 (least difficult) to 9 (most difficult). After they played all nine game levels representing the different levels of the independent variables, participants were interviewed about their in-game experience.

Conditions were counterbalanced to control for ordering and learning effects. We used a partial-block design to test each independent variable. For each independent variable, there were three levels of difficulty: The easiest level was always the baseline level, and the same baseline level was used for all conditions. This baseline included the slowest scroll speed, the largest platform size, only single jumps, and horizontal scroll perspective. For each independent variable (i.e., speed, target size, jump complexity, and scroll perspective) there were two levels of difficulty. Each independent variable was varied independently from the baseline level (i.e., when varying target size to smaller targets, we used the slow rate of scrolling, horizontal scroll, and single jumps only). For example, to test the smallest target size condition, the factors were: smallest target size, slow speed, single jump, and x-axis scroll—in this example only the target size is different from the baseline condition. Without the partial block design, participants would have been required to play many more permutations of the variable resulting in an extremely long session.

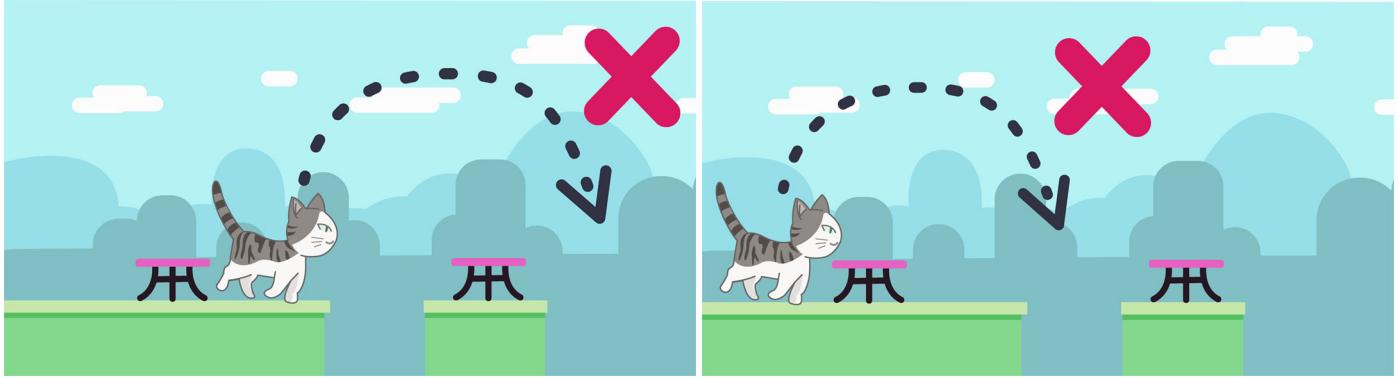


Figure 2.1: Overshooting and Undershooting

### 2.2.3 Parameters and Measures

The following values were used for levels of independent variables in game units (in Unity 3D): scroll speed in units/second (10<sup>1</sup>, 15, 20), target size (4, 2, 1), jump task complexity (single jump, double jump, triple jump) where targets of additional jumps (balloons) were 1 unit, and perspective (horizontal scrolling, vertical scrolling, or z-scrolling).

We measured players' perceived difficulty rating of each condition on a scale of 1 to 9, easy to difficult. Additionally, the following in-game events were captured:

- Start of a jump (target acquisition)
- Continuation of a complex jump combination
- Errors, distinguished by their cause:
  - Jump was missed (classified as overshoot or undershoot errors as shown in Figure 2.1)
  - Player ran from a platform
  - Player was outrun by the camera
  - Jump was not continued due to insufficient timing

### 2.2.4 Hypotheses

Our experimental design tested the following four hypotheses stemming from our review of the literature and discussions with platformer players and designers:

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<sup>1</sup>Vertical scrolling was set to 7.5 units/second because 10 units/second was found too difficult during player testing.

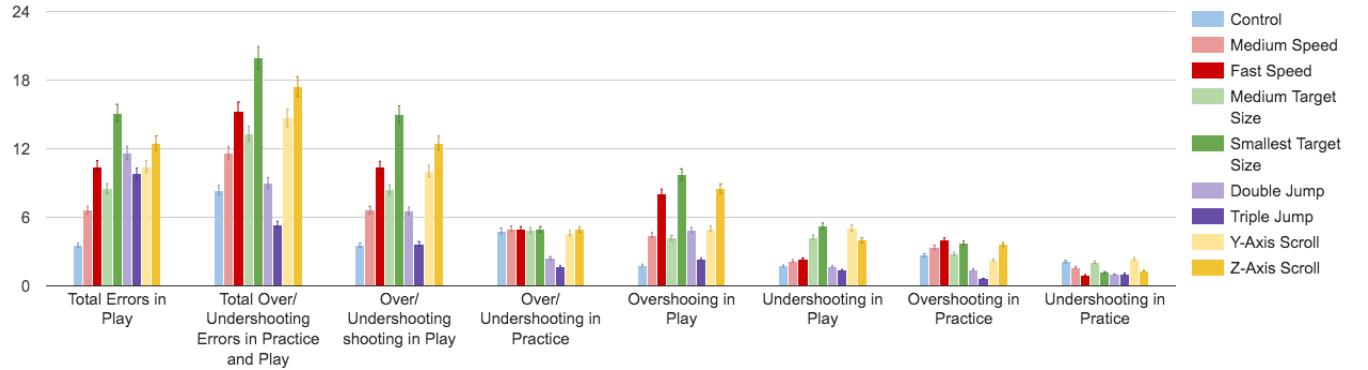


Figure 2.2: Error Count in Practice and Play Conditions

1. Increasing scroll speed increases game difficulty as measured by error rate, time, and player subjective ratings.
2. Decreasing platform size increases game difficulty as measured by error rate, time, and player subjective ratings.
3. Increasing jump complexity increases game difficulty as measured by error rate, time, and player subjective ratings.
4. Scroll perspective does not have a statistically significant effect on game difficulty as measured by error rate, time, and player subjective ratings.

## 2.3 Results

Errors, recorded as a count of the errors the participant made in each condition, are depicted in Figure 2.2. We see that faster scroll speed, decreasing target size, and changing perspective increase difficulty. Surprisingly, triple jumps were less error prone than double jumps.

The first question we explore is whether our dependent variables are linked to game difficulty. A Poisson regression (see Table 2.1) was run to determine whether Scroll Speed, Target Size, Jump Task Complexity, and Scroll Perspective were predictive of an increase in error rate. The goodness of fit test passed for the model for a Pearson  $\chi^2$  with  $t(135) = 223.315$ ,  $Value/df = 1.648$ , indicating that our model fit the data well, that is, the model is predictive. Additionally, an analysis using a Likelihood Ratio  $\chi^2$  with  $\chi^2(8) = 162.700$ ,  $p < 0.001$ ) indicated that the regression was statistically significant, i.e.

<i>Experiment Condition</i>	<i>Wald <math>\chi^2</math></i>	<i>Exp(B)</i>
Baseline Scroll Speed	49.104*	0.341
Medium Scroll Speed	13.398*	0.635
Baseline Target Size	96.447*	0.236
Medium Target Size	28.916*	0.562
BJT Complexity	42.929*	0.363
DJT Complexity	2.446	1.185
Horizontal Perspective Scroll	69.895*	0.285
Vertical Perspective Scroll	2.959	0.835

Table 2.1: Parameter estimates of the Poisson Regression (df(1), \* $p < 0.001$ )

that the tested variables were predictive of game difficulty. Test of individual variable effects on difficulty were also significant for each independent variable via Wald  $\chi^2$  tests: Scroll Speed (0-2)  $\chi^2(2) = 51.461, p < 0.001$ , Target Size  $\chi^2(2) = 104.896, p < 0.001$ , Jump Task Complexity  $\chi^2(2) = 62.139, p < 0.001$ , and Perspective Scroll  $\chi^2(2) = 70.868, p < 0.001$ .

A post-hoc analysis of independent variables' effects on dependent variables was conducted. Table 2.1 includes parameter estimates from the Poisson analysis (Column *Exp(B)*). Interpreting these results, our model predicts the following (based upon our 16 participants): Given that a user makes a certain number of errors in the most difficult (high) condition, then *Exp(B)* represents the fraction of errors for medium and baseline values of that independent variable. This means that for scroll speed, participants would make 0.635 errors in the fastest scroll speed condition and 0.341 errors in the slowest scroll speed condition (the baseline) for every error in the most difficult condition. Of particular interest in Table 2.1 are parameter estimates for Jump Complexity and Scroll Perspective. Consider, first, Jump Complexity: While the baseline jump is statistically easier than the triple jump, we see no statistically significant difference between the double jump and triple jump, though comparatively double jump results in 1.185 errors per error in the triple jump condition (double jump results in slightly more errors in our predictive model). Furthermore, the horizontal (x-axis) scroll perspective is statistically significantly different than the vertical or z-axis perspective but the difference between vertical and z-axis perspective falls just outside statistical significance ( $p = 0.085$ ).

We recognize that calling attention to comparative differences may be of concern to the reader at this point, but we highlight it here because the data triangulate well with other measures below.

Table 2.2 summarizes the results of participants' rating of game difficulty (9 = most

difficult). We see, again, that the baseline condition (Control) was considered easiest by participants and parity between double-triple jump and between vertical-z-axis scroll perspective.

<i>Condition</i>	<i>M</i>	<i>SD</i>
Control	3.13	1.78
Medium Speed	4.06	2.44
Fast Speed	6.00	2.11
Medium Target	4.50	2.16
Small Target	7.09	1.42
Double Jump	6.31	1.85
Triple Jump	5.69	1.74
Vertical Scroll	6.28	1.57
Z-Axis Scroll	6.94	1.65

Table 2.2: Reported Difficulty: A summary of descriptive statistics which illustrates the perception of difficulty of each player through self report. In this graph, the highest difficulty is represented by 9.

## 2.4 Discussion

Overall, we find that scroll speed increases difficulty proportionately in a platformer game, decreasing target size results in increasing difficulty, increases in jump complexity initially raise the difficulty (but only until players adapt to what we believe is the rhythm of the game and complexity plateaus), and changes in perspective moderate game difficulty (horizontal/x-axis) scrolling is easier than forward-running/z-axis and vertical/y-axis perspectives).

Our data allows us to reject the null hypotheses for our first two hypotheses. Hypotheses three (jump complexity) is partially supported by our data, but our fourth hypothesis—the lack of effect of perspective—is not supported. Our first two hypotheses, the effects of scroll speed and platform size, were an expected result of speed-accuracy trade-off in task performance. The confirmation of these results validates our experimental design and baseline values for independent variables.

For our third hypothesis—increasing jump complexity increases difficulty—while double jump is, in fact, harder than single jump, triple jump showed no statistically significant increase in difficulty over double jump based on an analysis of error rate. Furthermore,

comparatively in both our error rate and in self-reported difficulty, there may be triangulated evidence that triple jump is at least as easy as double jump, a result of lower error rate and lower rated difficulty in the average value of these statistics from our experimental measures. While we do not fully understand why triple jump is no more difficult than double jump, one explanation that merits further investigation is the notion of repeated key sequences becoming easier because players are able to get into an interaction rhythm. The idea of player actions falling into a rhythm, similar to the idea of a musical rhythm was discussed in Smith et. al.’s work on classifying platformer games [207], though not as it intersects with difficulty.

Finally, for our fourth hypothesis, we believed that horizontal scrolling and vertical scrolling would not be statistically significantly different from one another, and that z-axis scroll perspective might result in statistically significant differences. However, we formulated our hypothesis as scrolling having no statistically significant effect on difficulty, and, based on our data, we cannot support this hypothesis. We found that y-axis (vertical) scrolling and z-axis scrolling were statistically more difficult than horizontal scrolling, but, interestingly and counter-intuitively, z-axis and vertical scrolling had similar difficulty levels. Issues of scrolling and difficulty have implications for the design of both platformer games and other movement-based games. Scrolling perspective is, at heart, an issue of camera placement, so the increase in difficulty can be manipulated by allowing a user to control the camera; however, providing users with more variables to control could increase the difficulty, similar to perspective puzzler platformers (e.g., *Fez* [42] or the 2D mobile game *Monument Valley* [239]). Beyond scrolling perspective, our findings can apply to other game genres as well. For example, a shooter game can balance target size based on target-shooting difficulty, similar to work done by Bateman [10] that employed target assistance.

#### 2.4.1 Future Work & Limitations

Finally, our study results have interesting conclusions for both automatic level design and Dynamic Difficulty Adjustment (DDA).

Work on creating dynamic systems can be found in both industry and in academic applications [152]. In games, dynamic systems can be used in response to players’ actions and progression within game to calibrate the desired pace of the game [91, 131]. For instance, DDA systems focus on mediating enemy characters, the appearance of items, the availability of resources (e.g., health resources), and other small tweaks to the design of the game. Another potential way to add or mediate difficulty may be by automatically manipulating the level design (or camera perspective) by incremental factors.

To use the results found in this paper to produce an algorithm for dynamic difficulty-adjustment games, the system would need to collect information from multiple players to create a global average performance scale per varied difficulty factor. To set a desirable game difficulty, the game system will need to have an algorithm or adaptable model which weighs the number of errors made by players as a measure of the level of difficulty, e.g. the number of errors made vs. size of the target. Further, input from designers will be needed to determine how outcomes of the weighed data (i.e. player errors x factors) will modify the game's design. For example,

With the collected player data, the game system will need to create an adaptable model that can be updated when new data is obtained via additional playthroughs.

Finally, a player's performance would need to be assessed by the system in real time to determine how the current player's performance compares to the Gaussian curve indicating the percentage quartile of the player. Based on the result, the system would then do nothing, incrementally increase or decrease difficulty. The threshold for performing the change would need to be stated by the system developer; for example when a player is performing two standard deviations or higher from the global average of participants, increase speed.

Continued work, citing this paper has been pursued by other researchers. Tsujina et al. [234] expands on this work by calibrating another genre of games: rhythm and dance. Other research groups further this work with continued analysis of player death which may be used to further the work towards modelling player error and difficulty [49, 147].

#### 2.4.2 Conclusion

This chapter is a focused exploration of how platformer game parameters can be used to manipulate difficulty in game design. Our data reveal that Scroll Speed, Target Size, Jump Complexity, and Scrolling Perspective all affect difficulty and also provide guidance on the ways that some of these factors impact difficulty.

Our study results have implications for the understanding of how these game design decision affect difficulty and player experience. Additionally, findings of this study may be useful for the design and selection of variables in dynamic difficulty adjustment systems and automatic level design, a result that is described in future work.

More saliently from the perspective of this thesis, our goal is to study how these factors impact the compelling experience provided by games. Past research on flow [48] argues that calibration of difficulty allows us to ensure that games are appropriately challenging, where the rewards of improving are both sufficiently apparent and present a sufficient challenge to keep players engaged.

However, even in our study, one thing that was clear is that task difficulty is only one aspect impacting the design of compelling experiences. In the next chapter, we explore another factor in game design, the movement of in-game characters, to understand how this impacts difficulty and enjoyment during playful experiences.

# Chapter 3

## Biologically-Inspired Gameplay: Movement Algorithms for Artificially Intelligent (AI) Non-Player Characters (NPC)

### 3.1 Introduction

Our previous chapter was motivated by the idea that, in gameful environments, developers need to make decisions to ensure the game is both challenging and entertaining keeping players in the state of optimum flow experience [48]. Alongside adjusting the difficulty of tasks in the game, a second challenge presented to developers is the creation of algorithms that control non-player characters (NPCs). Among many other parameters, one of the primary aspects of NPC behaviour involves how these characters move during gameplay. The creation of realistic movements is necessary for individual NPCs whose movement can be inspired by some individual character goal. On the other hand, if the NPC is a member of a group of NPCs, some form of group-based algorithm for movement is necessary to give the appearance of purposeful group behaviour. These group-based movement algorithms have collectively been labelled *flocking algorithms*.

While significant research effort has gone into the design of flocking algorithm variants (blocks, particle swarms, and firefly, for example), it is difficult to determine how important these algorithms are in gameplay. By design, their goal is to create more realistic NPC group behaviours, but do they? And if they do, does that affect player perception of

character realism and intelligence? Is engagement and enjoyment in games also affected? Do players even notice the change in NPC behaviour? While it is true that these algorithms have been contrasted with realistic group behaviours to validate their efficacy[282], we are aware of no work that has actually asked the above fundamental questions about the effect of these algorithms on the player experience. This question is particularly interesting given that the ultimate goal of these algorithms is to enhance realism. Therefore, the contribution of our work is to test if the changes between the flocking algorithms affect user experience.

In this chapter, we explore player response to flocking algorithms through two experimental studies. First, we invite users to play a game where enemy types are controlled by four different algorithms: Flocking, Particle Swarm Optimisation (PSO), and Firefly Algorithms, and a control condition where NPCs in groups move in a straight line toward their objective. We do this to assess the effect the algorithms have on the player’s experience. Our results reveal differences between algorithms. Players identified the particle swarm optimisation (PSO) algorithm as their most preferred algorithm, but it was also ranked as the easiest algorithm. In contrast, flocking was less preferred by users but rated as the most difficult algorithm; they felt that groups of enemies whose movements were controlled by Flock were not as predictable, thereby improving realism. However, the differences were not enough to cause a significant difference in measures of engagement in gameplay. Players seemed little impacted by the differences between the different group behaviour algorithms in-the-moment.

To determine whether algorithms were truly of limited import or if potential confounds in experimental design (e.g. players preferred conditions that were easiest because their success increased, algorithmic parameters were poorly tuned, or the game design was lacking) were resulting in limited impact on measures of immersion in game play, we conducted a follow-on Mechanical Turk study. The follow-on study further validates the limited utility of NPC coordinated movement algorithms within our game platform, and provides additional evidence that aspects of game play such as story and aesthetics seem more important to overall measures of enjoyment in gaming than do flocking algorithms.

While a superficial interpretation of our results might, at first, argue that flocking algorithms have limited impact on game play, it is the case that algorithms created significant differences in perceived difficulty. One challenge with game play is the calibration of difficulty levels to player skill, and flocking algorithms, with their impact perceptions of difficulty, may be useful in engineering incremental difficulty adjustments in games, thus preserving challenge and engagement in the long term.

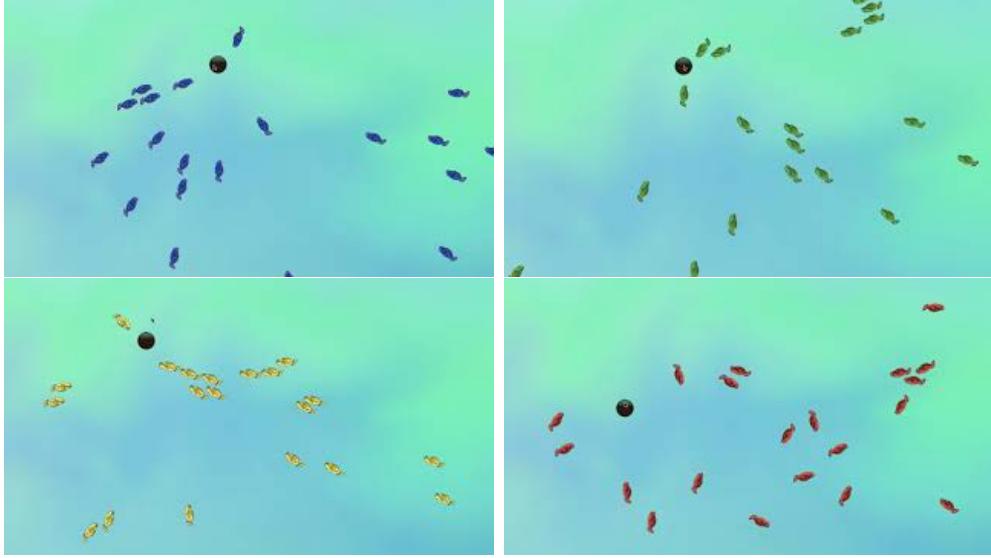


Figure 3.1: Movement Algorithms In S1 users played the game. These algorithms were recorded for gameplay videos in S2.

## 3.2 Related Work

Maintaining presence and immersion in computer games is a core component of creating a positive Player Experience (PX)[282]. Previous research has demonstrated the importance of the behaviour of artificial intelligence (AI) on maintaining immersion in games [282, 225]. For Game AI, this has meant developing the (often imperfect) behaviour of non-player (usually enemy) characters [282]. Examples of these behaviours include character movement behaviours such as navigation or pathfinding.

The creation of game environments has been separated into two distinct design approaches in past literature [109, 221]. The first is *scripting*, which requires game developers to pre-specify every path of movement, interaction, and game objects that a player will experience throughout the game. The content for this gameplay must be created and include NPC behaviour, scripts, location in area, among many other factors. In pre-created, scripted interactions the linearity of progression causes a direct path through gameplay limiting the ability to create open worlds, flexible game play, and rich combinations of human and NPC characters. The negative factors of this static content approach extend beyond game play: they actually begin at preconception of the game narrative and through the development process. Overall, because scripting must fully specify all in-game behaviours of NPCs, the process creates a high resource cost in both programmer hours, and development time.

In contrast, another approach developers can take towards game design is called *emergence* [109]. Emergence involves developers defining general, global rules for interactions between game objects, and then allowing the gameplay to emerge as the player proceeds through the game. As a simple example, consider Conway’s *Game of Life*[40] which illustrates the advantage of created emergence in games. An algorithm can be a simple rule set which can mimic complexity of a life form, and thereby leading to more emerging gameplay. Advantages of emergent design can be balanced with static content generation. Commonly, the spawning of enemy characters in an area can be randomly generated with enemies moving in accordance to predefined algorithms. For example, the Left 4 Dead series [243, 242] combines NPC movement and horde behaviour with narrative elements, and atmospheric game environments.

### 3.2.1 Biologically-Inspired NPC Movement Algorithms

Biologically-inspired algorithms are designed to mimic behaviours found in the natural world to solve optimization problems. The Flocking algorithm was developed by Craig W. Reynolds in 1987 [190]; this algorithm aims to simulate the movement of a flock of birds or school of fish. To decide movement direction, an agent (boid) must calculate at every iteration three factors: **alignment**, **cohesion**, and **separation**. Alignment is defined as an agent wanting to move in the same general direction as it’s neighbouring agents. Cohesion dictates that an agent wants to move towards the average position of it’s neighbours. Separation is the property that the agent does not want to be too close so as to avoid collisions and hence, the agent will want move away from the average position of any neighbours to which it deems itself too near. Reynolds’ later (1999)[191] added steering factors to his agents, allowing for them to seek roosts (i.e., function optima) in the search space.

In 1995, Kennedy and Eberhart developed the Particle Swarm Optimization (PSO) algorithm [114], which took some inspiration from Reynolds’ work and modelled after the way in which insects swarm. The PSO algorithm determines an agent’s direction of movement by considering two factors:**Best Position** and **Global Best**. The first is the best position the agent has found at some point in the past, and the second is the global best position that has been thus far determined by all the agents as a unit.

The Firefly algorithm, developed in 2009 by Xin-She Yang, [280] was built upon the PSO algorithm and partially inspired by the way in which fireflies flash their lights to communicate. In this algorithm, each agent is assigned a **Brightness** value which directly corresponds to how good that agent’s current solution is. Agents are then attracted to other

agents who are brighter than they are. Agents move towards these brighter agents; however, this attractiveness of one agent to another is proportional. Two agents that are further apart will appear less bright to each other and hence will find each other less attractive.

Games have taken advantage of the research on biological algorithms to simulate enemy movements. Flocking, PSO, and Firefly were all algorithms developed to simulate natural movement phenomena. In contrast to the mechanical approach for scripted movements, algorithms allow for emergence, or dynamic behaviour [150]. The use of emergence is strategically employed by game developers to create more unpredictable, immersive, and believable enemy characters and worlds.

### 3.2.2 Forced Choice Experiments

Our goal is to assess the effectiveness of a set of biologically inspired algorithms used to define movement for collaborating groups of characters in video games. Overall, we wish to determine whether or not there exists a difference between these algorithms, and, in particular, if that difference has a meaningful impact on game play. To do this, we conduct two studies: A first study explores gameplay and finds limited effects on immersion. A second study seeks to determine whether differences are observable in real-world gameplay. In psychology, the experimental protocol that determines whether discrimination between phenomena exists, even at a subtle level, is a just-noticeable difference (JND) study or signal detection study [171, 222]. We leverage these concepts in a forced choice protocol for our second study.

A noticeable difference is the minimum change in a stimulus that can be detected 50 percent of the time [283]. This protocol measures the confusion of the subject as they try to discern small stimulus differences [230, 217]. In the past, this protocol has been used in the HCI literature for a multitude of reasons from graphical fidelity [32, 64] to lag control [279, 278]. JNDs in games user research (GUR) is found in studies of game performance. JNDs were used to select appropriate tempos for a thesis on the effect of music tempo on game performance[122], and used as performance indicators in discrimination tasks which showed video-game players to possess benefits in multi-sensory processing[57]. JNDs have also been used in the development of serious games which aim to motivate the calibration of HCI tools [63]. More recently it has been proposed that JNDs can be used to help create meaningful variations of game constant by creating cognitively-grounded procedural content[29].

JNDs leverage force choice for signal detection [222, 171], a concept we leverage to assess algorithmically guided enemy behaviour have, to the best of our knowledge, not been

explored to date.

### 3.3 Evaluating In-Game Algorithms

One challenge with assessing end-user perspective on AI in games is that each game includes slightly different AI behaviours and each game also has different story lines, graphics, and gameplay characteristics, all of which significantly influence realism in the game. To control for individual game characteristics, this section first introduces a bespoke game, a simple game of ‘tag’, which is then leveraged during both phases of the study. Next we describe the study protocol for our first study.

Our study is structured as a 4-factor within-participants mixed-methods study. We explore four algorithms as our independent variables (Control, Flocking, PSO, Firefly). We measure the dependent effects on user-experience, immersion, feelings of realism through self-report questionnaires, and interviews.

#### 3.3.1 Game

The bespoke game created for this study is called Tag-o-rithms, so named due to the testing of different algorithms in a tag-like game. The game consists of four levels, each of which has its own distinct enemy behaviour based on a biological algorithm. The levels contain 20 *boids*, rigid-body objects with applied steering algorithms, which are pursuing the player’s character in an attempt to ‘tag’, i.e. make contact with or collide with, the player’s character. The player’s character is represented as a black circle.

Every level consists of one minute of gameplay in which the user evades twenty enemy characters by dragging their player character around the screen with the mouse. Mouse tracking leverages the standard cursor acceleration algorithm. Each time the player is hit by an enemy, the hit counter is incremented by one and the enemy that made contact with the player vanishes and then ‘respawns’, i.e. reappears, at a random on-screen location. If an enemy moves off the side of the screen, it reappears on the opposite side at the same relative height it disappeared. The player character cannot move off screen. Should the user move their mouse off their character at any point, the character will remain stationary until the user reacquires their character by moving the mouse cursor to their character and begins dragging again. Figure 3.1 shows four different levels of gameplay, each with a different flocking algorithm.

Enemies in each level all move at the same speed. The vector representing the velocity of an enemy can be defined by the equation

$$v' = \alpha \frac{(1 - \beta)v + \beta dir}{\|(1 - \beta)v + \beta dir\|} \quad (1)$$

where the new velocity,  $v'$  is a normalised combination of the old velocity and the new direction of movement,  $dir$ , which is determined by the algorithm governing each respective enemy type.  $\beta$  is a constant that determines the weight of the contribution of the new direction and  $\alpha$  a constant that is multiplied by the normalised direction to give speed. The github repository of the game is available at [github.com/rinarene](https://github.com/rinarene)

To maintain consistent scale across platforms, the game is defined based upon its width and height. The boids were  $0.066\text{width} \times 0.059\text{height}$  game units (gu), large relative to the overall width and height of the display. Move speed for boids was  $0.1\text{width gu/sec}$ . The applied unity-Rigidbody 2D had  $0\text{gu/sec}$  Linear Drag,  $0.05\text{width gu/sec}$  Angular Drag,  $0\text{gu/sec}$  Gravity Scale.

### 3.3.2 Participants

Participants ( $n = 21$ , 5 female) were recruited from our university and our local community. Participants were required to be over the age of 18: Ages ranged from 18-40. The majority ( $n = 10$ ) of participants were between 21-25 years of age, with the second highest majority - 26 to 30 years - consisting of 6 participants. No restrictions were made based on skill, gameplay experience, or level of education. All but one participant, reported playing daily(10) or weekly(10). Three self-described as causal or infrequent gamers, 11 as recreational or regular gamers, and 7 as avid gamers.

### 3.3.3 Independent Variables

The algorithm applied to each boid (one enemy character in the group) is the independent variable of the study. For simplicity and to control for bias, variations in condition were denoted by enemy colour. In review: blue is the Control condition, green the Flocking algorithm, yellow the PSO algorithm, and red, the Firefly algorithm. For consistency, in game-design we measure games as proportional relationships (e.g. this object is twice the size of object one). This allows for games to be scaled and displayed on multiple screens of different sizes, resolutions, and configurations. Therefore we present our measurements in game-units.

### **Control: Blue**

In the control condition (blue) at every iteration each enemy determines the direction of the shortest straight path to the player character and moves in that direction. An enemy character in this level is unaware of the other enemies and it's behaviour is in no way influenced by other enemy characters' motion. The control condition is representative of the kinematic movement control algorithms that were once commonly implemented [150].

### **Flocking: Green**

The Flocking algorithm is implemented for the green enemies. The direction of movement in this case is controlled by four factors; alignment, cohesion, separation, and target seeking. The first three are weighted equally. Target seeking is weighted slightly more than the other three as we found this was necessary in order to have the enemies sufficiently interested in moving towards the player character's location.

### **Particle Swarm (POS): Yellow**

The yellow enemies are our implementation of the PSO algorithm. Each enemy is aware of its own previous best position and the global best position and uses these factors to determine direction of movement. A position is determined to be best if the distance between the enemy and the player when calculated is shortest. As the player is constantly moving, the distances of all best positions must be recalculated at every increment.

### **Firefly: Red**

Lastly, we have the red enemies. In this condition, enemy movements are dictated by the Firefly algorithm. The 'brightness' of every enemy is determined by the enemies distance to the player; the closer an enemy is, the brighter they are. As previously stated, the attractiveness of one agent to another is proportional to the distance between them. An agent that is further away will appear less bright. We have simplified this into a neighbour radius and enemies are only able to see other enemies that are within their radius. Therefore, enemies will not be attracted to other enemies that are far away, regardless of their brightness. It should be noted, that the radius used is same size as that used earlier in the Flocking algorithm.

Table 3.1: Semi-Structured Interview Questions

Semi-structured Interview Questions
Q1: What did you think of the game?
Q2: Can you tell me about about how you felt about the different levels?
Q3: Was there a difference between the [red, blue, green, yellow] enemies?
Q4: Was any level harder or easier?
Q5: Did the game remind you of any off-the shelf/released/popular games? Or games you have played previously?
Q6: Do you think there was a difference between the enemies' movement patterns?
Q7: Can you describe in one word, or supply a name for the different enemy types?
Q8: We built the game to reflect different biological algorithms (straight at you, flocking, swarm, and firefly). If you had to match the movement patterns to an algorithm which would you pair?
Q9: Any other overall feelings about the game?

### 3.3.4 Protocol

Before receiving consent, participants were given a brief introduction to the game and controls. After written consent was obtained, participants played each condition (Control, Flocking, PSO, and Firefly) which were presented in a random order. Participants were asked to fill out two standard GUR questionnaires after each play period.

After all conditions were played, participants were asked to fill out a bespoke exit questionnaire. Immediately after completing the exit questionnaire participants took part in a one-on-one semi-structured interview with the researcher. The researcher asked the nine questions displayed on table 1; the semi-structured nature of the interview, however, allowed the interview to probe for additional details, clarifications, or relevant life-experience data to fully explore perceptions of flocking algorithm behaviour.

### 3.3.5 Quantitative Measures: Game Score and Questionnaires

One obvious measure of game play efficacy is the overall score a player obtains in any game. In this game, each time a boid made contact with a player, the player’s score was incremented, meaning that the goal was to score as low as possible. Alongside scores, we also wish to capture player experience in the game, and we do this using two standard questionnaires and an exit questionnaire.

To measure a self-report of player experience after each level (flocking algorithm), we use the Self Assessment Manikin (SAM) [24] and the Player Experience of Needs Satisfaction (PENS) [196, 197, 51]. Both the SAM and the PENS are established questionnaires that have been shown to correlate well with aspects of immersion and enjoyment. The SAM allows players to give a rating of Pleasure, Arousal, and Dominance by asking players to identify the emotions they feel by selecting the best fitting picture on a visual Likert scale. The SAM allows for a break down of complex emotions. For example, high pleasure, high arousal, and low dominance may indicate a happy and excited player with a low feeling of self efficacy.

PENS [198, 199, 51] measures overall satisfaction with gameplay along dimensions of immersion, challenge, satisfaction, and usability via a set of 20 questions. For example questions ask: “When playing the game, I feel transported to another time and place.” (immersion), “My ability to play the game is well matched with the game’s challenges.” (difficulty and challenge), or “Learning the game controls was easy.” (satisfaction and usability). We focus particularly on the sections that correlate with immersion and presence. Again, we operationalise immersion and presence to refer to the feeling of being involved in the game and of being in the game world respectively. [199].

Participants completed by the SAM and PENS after each level of the game, i.e. after experiencing each individual flocking algorithm.

After participants completed all four levels, the participants were asked to fill out a final exit questionnaire. This custom questionnaire collected comparisons between conditions. Specifically, participants were asked which condition was most preferred versus least preferred and which condition was hardest versus easiest.

## 3.4 Results

The results of study 1 included game metrics in the form of enemies hit, questionnaire data, and interview data.

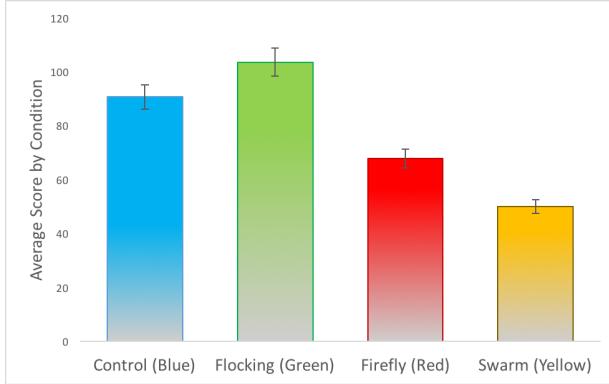


Figure 3.2: Average in Game Scores by Condition.

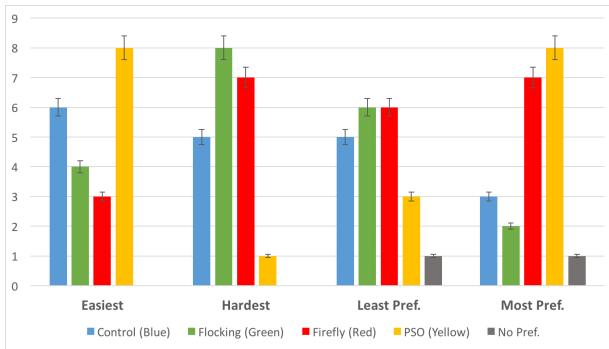


Figure 3.3: Participant Rankings

### 3.4.1 Scores

The object of the game was to avoid being hit by the NPC enemies in the different algorithm conditions. Figure 3.2 graphs the average scores by condition.

To analyse the scores (categorical discrete count data) for significant differences within participants, we used a repeated measures Analysis of Variance (ANOVA) in IBM SPSS Statistics v24. Given that the sphericity assumption was violated, we applied a Greenhouse-Geisser correction. Corrected ANOVA was significant ( $F(2.347, 12357.008) = 18.260, p < 0.0001$ ). The differences were further supported by a Poisson regression ( $\chi^2(3) = 27.894, p < 0.0001$ ). Scores were best (lowest) in swarm followed by firefly and worst (highest) in flocking.

### 3.4.2 Questionnaires

Recall that there were two questionnaires tested after each condition, the SAM and PENS, that rated in-the-moment immersion and enjoyment, and an exit questionnaire that asked participants to contrast algorithms. Considering, first, the SAM and PENS data, we tested the data collected using all of a Poisson Regression, a test for the significance of the fit of the discrete data model, and Friedman's ANOVA. In all cases, we find that both the PENS and the SAM scores are not significantly different for each algorithm tested. Given the within-subjects design of our experiment, we find it unlikely that algorithms are resulting in meaningful in-the-moment differences in game play.

On the exit questionnaires, we do find a difference between algorithms in overall ranking. Participants reported liking the PSO the best, followed closely by Firefly enemies. Enemies liked least were almost equally divided (Flocking and Control). When asked about the hardest enemy, participants reported that the Flocking enemies were most difficult, followed by the Firely. PSO was reported to be the easiest to defeat, followed by Control. Figure 3.3 details this information.

### 3.4.3 Interviews

The interviews reveal some insight into the player experience associated with each algorithm tested.

Given our exit questionnaire data, one factor we explored in our interviews was whether the Firefly algorithm (2nd most preferred and 2nd most difficult) might be a good compromise between preference and challenge. Although participants felt that the Firefly algorithm was salient, the general consensus did not indicate that the effect of the Firefly algorithm on player experience would be positive. Players were very divided in their feedback. P6 describes:

*“The red enemies for some reason caught more my attention because they will move themselves their individual movement was more quickly and I feel more tension, I need to focus more on specific groups of fishes where they were moving around where I could not even touch them or be in their way of moving.”* P6

In contrast, it was also reported that: *“The red ones were very peaceful for me, very relaxing. I did not even notice if they were move individually; I just saw them move around the screen. I didn’t pay much attention to their individual movements. The yellow ones make me feel more happy more active, even friendly like if they were my friends and I can touch them and they will not do anything bad to me but then red ones were like dangerous.”*

*Don't even get close to me because they were like. I saw them as very, very dangerous . I try to look at the specific figure of the fish and I think I saw they were having like teeth like piranhas. Different kind of fish and enemies then the red and the yellow. I don't know if they are different or not but I saw they looked a little different. And then the blue ones were not dangerous but I feel mad at them. It was anger that I felt when I played against them.”*

Participants also felt that the salience of the red enemies made them unnerving. Dialogue conveyed frustration with the novelty they perceived coming from some of the algorithms. P8 was quoted saying: “...well I'd call the red the 'crazies' or the \*\*\* fish.”

The mixed reports were also evident in feedback regarding the necessary skill needed to avoid each enemy. “*It seemed like very much up to chance a lot of the time, just hoping that there wouldn't a ton of fish coming at me from all different directions ... you know, I couldn't handle it. I didn't feel like skill is involved too much, except for the yellow level I felt like I was able to use skill but for red and green I felt like I was just overwhelmed had no choice but to hit the fish all the time.*” P4

### 3.4.4 Synthesis of Results

In synthesising our results from this section, we find that PSO was considered the most-preferred condition for game play, but was also ranked as the easiest. In contrast, Flocking was the least preferred (even below control), but was also considered to be the hardest condition.

Recall that the goal of our experiment was to analyse which algorithms increased user engagement in games. Interestingly, the more realistic an algorithm is – particularly in a tag-style game of the kind we created – the more challenging that algorithm should be. The challenge with interpreting data from our initial game-play study is, therefore, as follows: *Are participants ranking PSO highly because it is the most engaging algorithm, or because it is the easiest algorithm to defeat?*

More generally, conventional wisdom in game design would indicate that artificial intelligence, and, in particular, NPC character behaviour, is very important for player engagement and enjoyment [265]; this then begs the question of whether algorithm effects or other confound (e.g. player dominance, algorithm tuning, game design) are impacting questionnaire data such that the SAM and PENS data are unremarkable. To explore this question in detail, we present a follow-on study that eliminates gameplay and instead focuses on perceptions of NPC group behaviours.

Gaming Frequency		n
Often	At least 1 hour a day	11
Moderately	At least 1 hour a week	5
Sometimes	At least 1 hour a month	2
Seldom	At least 1 hour every 6 months	1
Never	I almost never or don't play ...	2
<b>Total</b>		21

Table 3.2: Study II participants' self-reported gameplay frequency

## 3.5 Study II: Understanding User Preferences

To further understand the results of Study 1, we conduct a second 3-part study. First, we seek to understand if there is a noticeable difference between the algorithms using a forced choice method. Forced choice is a common psychological testing protocol, it is where absent a real preference all groups would be equally likely. If there is a noticeable difference, force choice detects subtle deviations between categories[171, 222]. Using this protocol, we assess if optimisation of two of the preferred algorithms (Flocking and PSO) creates a better user experience. Furthermore, since games are rich complex environments, we wish to test ecological validity by also offering game examples from two real world games (an earlier version and the most recent version of a specific game series) and contrasting these real world games with our simple bespoke game. The study is performed on a crowd-sourcing platform, Mechanical Turk (M.Turk), for convenience.

### 3.5.1 Participants

Participants were recruited from M.Turk. The participants identified as being from the USA. On average participants were 34 years of age with a range of 22 – 57 years. Since our primary goal was to cross-reference results with our first study, we recruited 21 participants, which is a sufficient number to determine whether, and if, confounds exist in our initial study data. Participant were remunerated \$4/*hour* for their participation.

### 3.5.2 Protocol

As noted above, in this chapter we explore three aspects of algorithm design. First, to further validate our first study with additional participants, we repeat the algorithms and

design from our first study on the Mechanical Turk platform but using video rather than game play (to eliminate easiness of condition as a factor that increases preference). Next, we examine in more details algorithmic parameters of two algorithms from the first study, the most preferred (PSO/Swarm) and the most challenging (Flocking). Finally, to test whether game attributes might colour judgements, we ask participants to assess AI algorithms as they exist in two popular computer games.

## Study Protocol Overview

We test noticeable difference using the a forced choice protocol; we present two algorithmic options to participants and then forces participants to choose one algorithm.

We deployed our study through Amazon’s Mechanical Turk <sup>1</sup>. Participants were first given the information letter and consent form. With participant consent, the game was presented as a series of minute long gameplay videos with a micro-questionnaire between rounds.

The MTurk task had an embedded Google form with link provided. After asking basic demographic questions (age, gender, gameplay experience), the form allowed for users to view videos of two of the tested algorithms and choose the most convincing algorithm by asking participants to choose “*the videos that have AI which seems more realistic, intelligent, or have intention.*” We begin with pairwise comparisons of each algorithm and then do one final overall rating question in each section. The sections were:

- **Algorithm Comparisons** Comparison of the algorithms of s1 (Control, Flocking, PSO, Firefly)
- **Flocking and PSO Variations** here we contrast parameters associated with Flocking and Swarm
- **Game Examples** Finally, we contrast two Off-the-Shelf Game Examples (L4D series and Grand Theft Auto Series) with two different levels of AI sophistication (from an early release and a recent one) for each game are contrasted.

For example, as per a JND experimental design, every permutation of pairs of videos was presented to the user to choose between (e.g. Flocking vs. Control, Control vs. PSO, etc.). At the end of the section, users must rate all options (e.g. Control, Flocking, PSO, and Firely) into 1st, 2nd ... n’th placements. This two-part rating process verifies consistency in user ratings.

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<sup>1</sup><https://www.mturk.com/>

Table 3.3: Specification Adjustments in Game Units

Video	Type	Neighbour	Swarm Speed	Separation
1	PSO	3	6	1
2	Flocking	4	6	2
3	PSO	3	6	1
4	Flocking	4	6	2
5	PSO	3	6	1

## Flocking and PSO Variations

A second confound associated with realism in algorithms designed to control groups of NPCs during game-play is the specific tuning of individual algorithms. In this section, we focus on two standard algorithms, PSO and Flocking, and we explore how individual parameters of the algorithms might impact their realism, again using a JND design.

Both PSO and Flocking have a set of variables, subject to manipulation, that are common between the two algorithms. While Neighbour Radius, Swarm Speed, and Separation Radius can all be varied, we focus on the density of NPC's within the vicinity of the player by varying the neighbour radius and the separation radius. Table 3.3 defines the variations in variables we explore in Game Units. By changing the weight factors we hypothesize that the algorithm can be optimized to find a point which results in the best user feedback.

As a control condition, the PSO in Video One weightings were not set (all equal weights of 0) for alignment, cohesion, separation, and target seeking. For all other iterations of flocking and PSO (video 2-5) alignment, cohesion, separation, and target seeking were set to 0.6, 0.6, 0.2, 0.4, 0.5 game units respectively. In all cases forward movement was set to 0.4 game units.

Identical to the first phase, algorithms were evaluated in pairs, head-to-head, with forced choice followed by an overall ranking to assess consistency in participant responses.

## Game Examples

For ecological validity, we last test off-the-shelf published games to understand if a user's perceptions of algorithms may be impacted by the overall aesthetics of the in-game experience to such an extent that minutia of character movement becomes unimportant. Since games offer a rich environment, we choose two main series from two different genres. The first series: Left4Dead (L4D) is a post-Apocalypse zombie first-person-shooter (FPS). From this series we choose L4D1 and L4D2. The second series, Grand Theft Auto (GTA), features

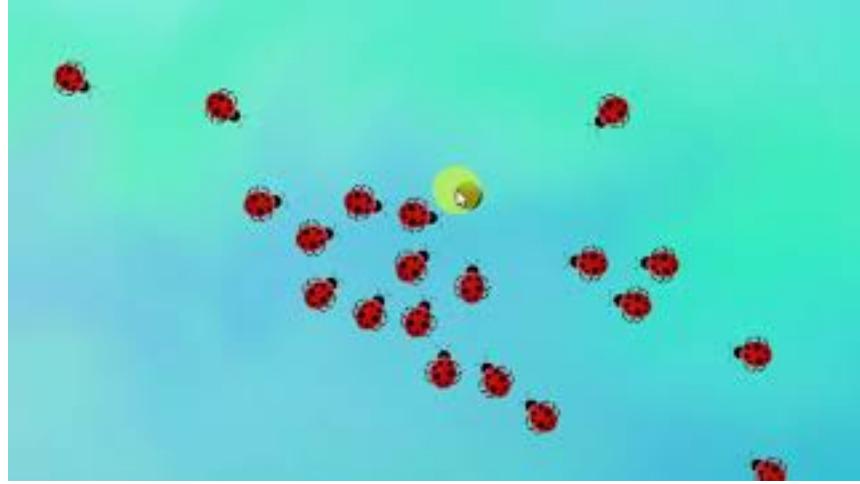


Figure 3.4: Boid Presentation

an approximation to a real-world crime story line. From this series we choose GTA San Andreas (third-person shooter) and GTA5 (FPS). Both these series have one updated and one original AI configuration. While it is difficult to map the AI algorithms from the games onto our specific, research-based AI algorithms, there are clear differences in AI behaviour, and we wanted to determine whether these differences were detectable by our participants.

## 3.6 Mechanical Turk Results

### 3.6.1 Algorithm Comparison

For the algorithms: Control, Flocking, PSO, and Firefly; we begin with a pairwise assessment. Figure 3.7 illustrates the voted placements. The votes reveal noticeable differences between algorithms. In first place: blue or the control condition; Yellow (PSO) in second; followed by Green, Flocking; and last Red - Firefly.

To test if the rankings are significantly different, we used a Friedman's test. We found significant differences across values  $X^2(3) = 31.686, p < 0.01$ . All algorithms differed significantly from one another in ranking (there were no ties). Posthoc tests (Wilcoxon Signed Ranks Test) reveal the following for Flocking and Control  $z = -3.891, p < 0.001$  Negative signed rank (-) for PSO-Control a non-significant relationship of  $z = -1.628, p > 0.103$  (-), Firefly-Control  $z = -3.757, p < 0.001$  (-), for PSO-Flocking  $z = -2.611, p = 0.09$

(+), Firefly-Flocking  $z = -1.954, p = 0.051$  (-), and finally Firefly-PSO  $z = -3.170, 0.002$  (-).

### 3.6.2 Flocking and PSO Variations

We compare the variations of the PSO algorithm and the Flocking algorithm. Testing Flocking against PSO reveals that the relationship between the two algorithms established in SII original algorithm comparison stands: Flocking is second to PSO according to user rating. Figure 3.7 (PSO in yellow and Flocking in Green) illustrates the relationship with the PSO in yellow predominant in 1st and 2nd places and the green Flocking algorithms dominating 4th and 5th place. Using the same protocol as above, a Friedman's test was used to look for significant differences between ratings. One participant was excluded due to not following instructions. Differences were significant for the different optimizations:  $n = 20, \chi^2(4) = 19.080, p = 0.001$ . Regardless of the specific parameter values we use, PSO consistently performs better than flocking. The post-hoc Wilcoxon Signed Rank Test reveals significance between videos 1 and 2  $z = -19.79, p = 0.048$  (-) based on negative rankings, videos 1 and 4  $z = -2.462, p = 0.014$  (-), videos 2 and 3  $z = -2.774, p = 0.006$  (+), videos 2 and 5  $z = -2.487, p = 0.013$  (+), videos 3 and 4  $z = -3.014, p = 0.003$  (-), and finally, videos 4 and 5  $z = -2.486, p = 0.013$  (+).

### 3.6.3 Game Examples

To test that the game itself was not confounding the results of the study, we test off-the-shelf game examples. From the chosen examples, we see that the L4D series AI is preferred over the GTA AI. This finding is illustrated by Figure 3.7. Comparing the game series with each other, we can see that L4D1 and L4D2 are equally rated by players; similarly, GTASA and GTA5 have similar ratings despite the differences in AI behaviour. Using the same protocol to test with a Friedman's test, significant differences were found between ranking of game examples:  $n = 21, \chi^2(3) = 16.486, p = 0.001$ . The post-hoc Wilcoxon Signed Ranks Test demonstrates not noticeable differences between series franchises, and reveals significant differences between game series with GTASA-L4D  $z = 0.344, p = 0.001$  (-), GTASA-L4D2  $z = -2.833, p = 0.005$  (-), GTA5-L4D  $z = -2.686, p = 0.007$  (-) GTA5-L4D2  $z = -2.554, p = 0.11$  (-).

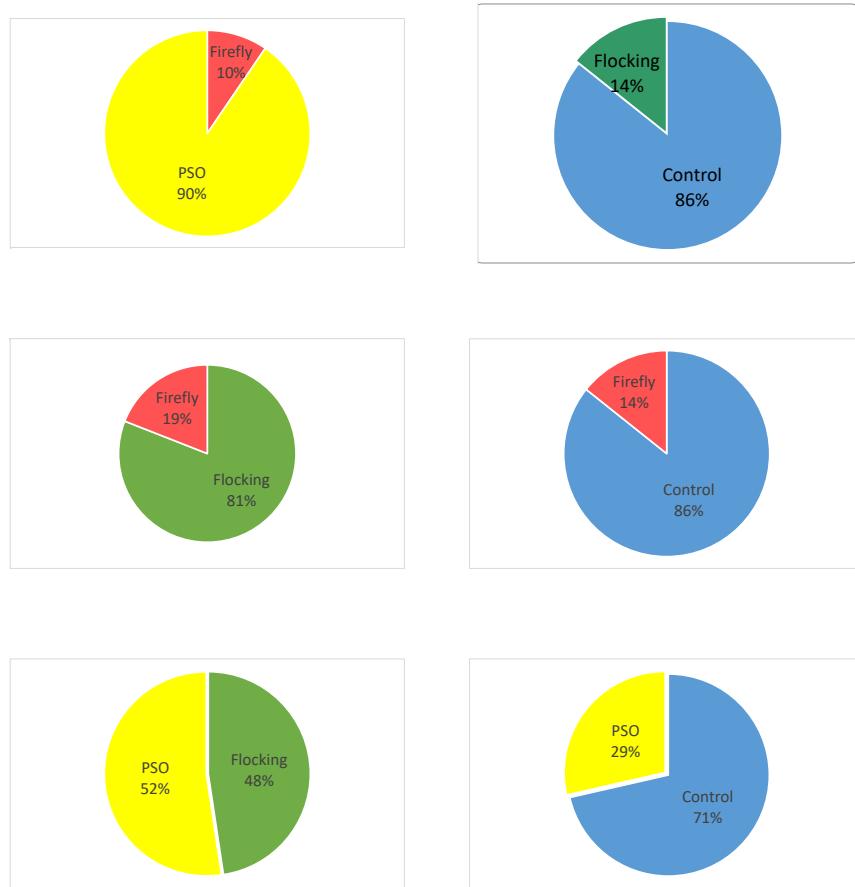


Figure 3.5: One-on-One comparison of the Algorithms

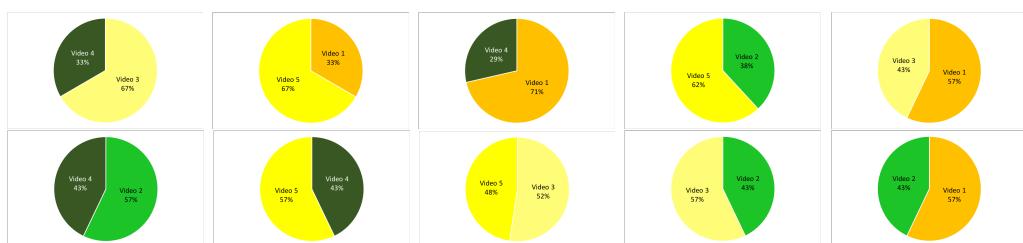


Figure 3.6: One-on-One Comparisons of Flocking and PSO variations.

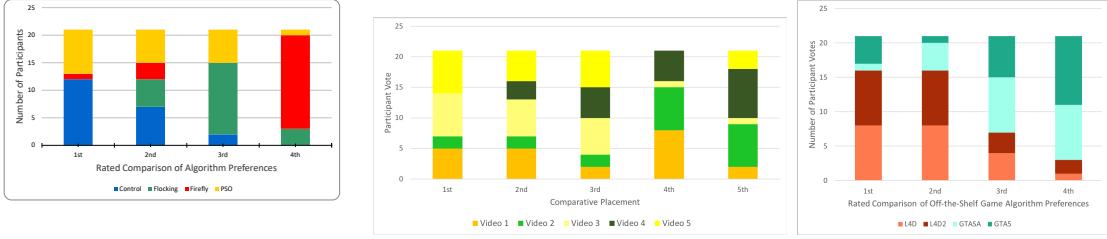


Figure 3.7: Comparison of the different (a) Algorithms, (b)Weighted Optimizations of the Swarm and Flocking Algorithms, and (c) off-shelf Game Algorithms

## 3.7 Discussion

Many interactive systems are designed such that the user interacts with or is affected by AI systems. In games, these systems frequently underlie the behaviour of NPCs, and, in particular, enemy NPCs. Research effort into these algorithms is premised on the assumption that improvements in AI algorithms that control NPC behaviour will improve the in-game experience.

### 3.7.1 Difficulty is Not a Direct Predictor

In our initial study, our participants reported liking the NPC opponents controlled by the particle swarm optimization algorithm (i.e. the yellow enemies) the most, followed by NPC opponents controlled by the firefly algorithm (red enemies). The PSO enemies were also considered the easiest to defeat. The PSO enemies may have been the easiest because the PSO algorithm directs movement according to best global position, not according to player trajectory or position. This may give players more room when fleeing these enemies. Despite the correlation between preference and low difficulty indicated by game scores and ease ratings, interview data in our first study focuses on the salience of movement. Our results indicate that further study may show that difficulty alone does not fully account for ratings of enemy intelligence. Following up with Study 2 provides perspective on the aforementioned results of study 1. Players do notice differences (even modest ones). Despite the fact that our studies demonstrate that these differences are not easily articulated. Unlike productivity applications, games purposefully need to create challenge that is calibrated to player skill [267]. Calibrated challenge in games keep players in a state of flow or optimized experience. The concept of optimized experience from psychology [47] describes a state

where the task is its own reward, with a reduced sensation of time. Over time during gameplay, if enemies become too predictable, the game will not properly calibrate challenge and the experience will become less optimized, too easy. We believe that our studies – particularly the difficulty rankings of algorithms noted in study 1 – demonstrate that NPC flocking algorithms may be an effective tool for preserving this balanced difficulty and therefore, a sense of flow.

### 3.7.2 Direct Movement Can Be the Best Initial Choice

Study 2 results articulate clearly that participants do see discernible differences between algorithms of movement. However between the optimized algorithms, when asked to identify which algorithm seemed to be most intelligent or purposeful in movement participants consistently rated the control condition as most realistic, intelligent, or intentional. In the control condition the boid-enemies move directly towards the player. Any addition of a biological algorithm movement pattern gave the perception of decreased intelligence. Participants in our second study also did not significantly differentiate between L4D1 and the updated AI of L4D2 [37]. Games are rich environments (with sound, art, textures, etc.). The systematic higher ratings for the L4D series supports the idea that AI algorithms matter less to players' perceptions of intelligence. Furthermore, in S1 the lack of notice or comprehension seen in the qualitative data indicates that game players may not be able to fully comprehend the distinction between different AI behaviours in-the-moment. In the absence of distinction, an early instantiate of group behaviour can be direct movement toward an objective. This seems purposeful to a player, is immediately understandable, and can therefore represent early agency by NPCs. Undoubtedly, over time, this algorithm would become too basic, but initial game encounters can and should be immediately obvious and sensible. Anticipation, ambushes, and other subtle, indirect forms of NPC coordination can wait until players develop increased familiarity with the subtleties of interaction.

## 3.8 Future Work & Limitations

Similar to work Chapter 2, the study aimed at investigating incremental changes that can be made to numerical factors in the game world to create more engaging gameplay. In particular, the study first focused on movement algorithms from the perspective of the player experiencing the game world. Both the algorithm type and calibration of the variables which comprised the algorithm, were explored.

As the project developed, the results of the variations between character movement were not as robust as expected. As presented in Chapter 3 Study 1, players noted differences between the presented variations of movement algorithms, but the data did not point to a clear determination of how movement algorithms affected player opinions. Instead, the study indicated that there was a need for investigating further using more game samples and research approaches. Therefore, the next study included samples from industry, off-the-shelf games. In addition, the next study investigates further by testing using a [Just-Noticeable Difference \(JND\)](#) study.

The completion of the study in Chapter 3 resulted in further information on choosing algorithmic movement patterns for enemy characters. The study suggests that player perceived difficulty is not directly predicted by the algorithm choice. Therefore, a direct movement pattern (simple movement algorithm implementation) may be the best initial choice for game development. Given that programming development of large games takes huge time and cost investments, the findings of the study may help game designers make informed choices during development of their games.

### 3.9 Conclusion

As we note in the introduction, artificial intelligence is increasingly applied in computer games to simulate agency and intelligence in artificial characters, i.e. non-player characters or NPCs. This chapter specifically explores one aspect of NPC behaviour, flocking algorithms, that control the coordination among members of a group of NPCs. We present, to the best of our knowledge, a first study examining how the contrasting behaviours of three different flocking algorithms affect player perception of realism, player preference, and player evaluation of difficulty. Overall, our initial results argue that one cannot simply assume that any individual algorithm is better than any other algorithm; instead, these algorithms exist as one tool for game designers as they seek to create realistic end-user experiences during gameplay.

In Part I of my dissertation, I presented the work on [1.1](#) which focused on the quantitative factors of game design specifically game difficulty and NPC movement.

#### RQ1 How can quantitative game systems calibration enhance player satisfaction?

To answer this research question I include two research materials in Chapters [2](#) and [3](#) where, I explored ways to make the game more enjoyable for the individual player, including

by managing difficulty and by creating more believable behaviours for **NPC** characters as they move in a group. From my research, we can see that factors studied in Part I are necessary for game balancing and do have some effects on the player's perception; however the results from the research materials as they correspond to RQ1 are limited. From my research, I conclude that RQ1 does not culminate in factors that can be used to design persuasively, instead these adjustments are necessary more for playability (think usability) of the game.

## **Part II**

### **Part2: Designing for a Group**

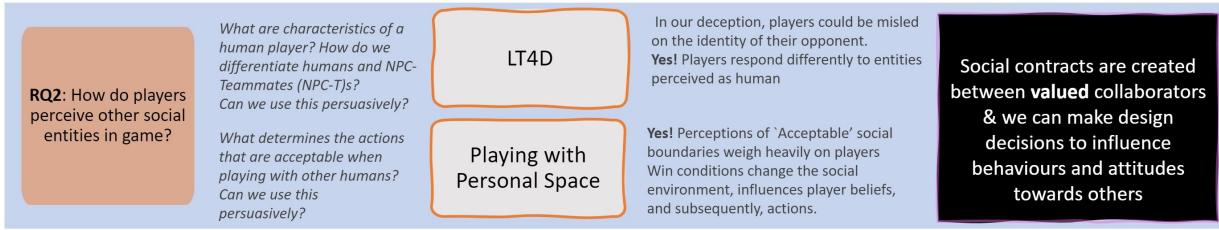


Figure 3.8: Part 2 Contributions

In Part I of my dissertation, I explored ways to make the game more enjoyable for the individual player, including by managing difficulty and by creating more believable behaviours for **NPC** characters as they move in a group. As I note in the introduction to Part I, while I was unable to identify ways that these quantitative mechanics increased engagement, but Chapter 3 presents an interesting finding: specifically, participants in our study identified human-like characteristics behind differences in the movement algorithms.

The responses to **NPC** characters in Chapter 3 raises the question: '*how do social entities affect the player?*' and leads to the question: '*can the design of social entities in game be used to design persuasively?*'. In this section, I transition to II which focuses on social entities in games. I begin Part II, by first asking '*what is the difference between a human co-player and a **NPC** co-player?*', with the goal of exploring the effect another social entity can have on reported experience. Specifically, I explore the perception of other social entities on reported experience, i.e.:

### RQ2 How do players perceive other social entities in game?

To understand how the presence of another player influences the gaming experience, it is necessary to understand how the social environment surrounding the game influences the success. Work done in collaboration Kappen et al. highlights potential ways that an observer may influence a single player game [111].

During my initial foray into this area of research [268], I asked 'does the presence of other people regardless of the bystander's level of attenuation to the game affect the behaviour of the player? I conducted a small-scale study that confirmed that even with minimal interaction, having another individual co-present during gameplay does affect the single player [268]. Complementary to these findings, the literature demonstrates that the effects

of another person nearby or, more formerly an audience member, affects the UX[208, 173], which lead to a new line of thought: What if the player only thought they were in the presence of another human?

To explore this question in more detail, I again subdivide this question into two parts, as shown in Figure 3.8, and this thesis presents two research projects that probe the question of perception of other social entities in game and explores whether or not we can change perceptions of others and of others' actions through game design. First, in chapter 4, I explore the relationship between human presence and the player's expectation of human behaviour. I question the need for a human vs. an AI-controlled NPC via a deception study, where I misinform gamers about the nature of their co-player and I find that the social contract between human-controlled teammates and AI-controlled teammates in the context of one gaming environment is impacted by whether we deem another entity in game to be a person or a NPC (even if both assume an identical role of teammate and even if we have no relationship with the other human player before gameplay).

While chapter 4 explores effects of another player in-game, we can also question how the impact of another player in the same environment co-located affects player experience. To probe this question, to see whether aspects of co-located game design can impact player interactions, chapter 5 explores shared display gaming in the context of a single, large display to understand acceptable social conduct during physically and virtually shared context gaming.

Overall, the two contributions presented in Part II of this thesis argue that social contracts are created in games – a known result but one that this thesis expands upon both by analyzing differences between perceptions of human and NPC teammates in a game. I further analyze in one context – a shared display, loosely coupled, common goal gaming context – how design decisions in a territorial game and their impact on player interactions.

# **Chapter 4**

## **Left Them 4 Dead: Perception of Humans versus Non-Player Character Teammates in Cooperative Gameplay**

Why do we care if our teammates are not human? This study seeks to uncover whether or not the perception of other players as human or artificial entities can influence player experience. We use both deception and a between-participants blind study design to reduce bias in our experiment. Our qualitative results show that people do care about the perceived nature of other players, even though they are not always able to correctly identify them as human or as non-player character teammates. Interview data suggest believing that one is playing with other humans can positively affect a player's subjective experience. Furthermore, our qualitative results indicate that players view their non-player character teammates as humanized entities, but adopt a neo-feudalistic (i.e., an unequal rights) view of them. Based on our results, we establish game design guidelines for non-player character teammates leading to stronger, emotional human-computer relationships in video games.

### **4.1 Introduction**

Major publishers of next-generation console games are focusing on the development of multiplayer, multi-character gaming experiences. Consequently, players engage more often

with both human and computer-controlled opponents and partners. Regardless of the proximity and number of human players, computer-controlled characters are an important part of video games. They add depth to the player experience (i.e., the experience of interacting with human players and virtual characters during play).

A character we encounter in a gaming environment may be a human-controlled character, i.e. an avatar [105, 70, 124, 128] or a computer controlled character, i.e. a **NPC**. The term **NPC** covers many virtual characters—opponents, acquaintances, collaborators—and the player’s relationship with each of these may range from non-existent to highly valuable. The specific focus for this research is to explore how **NPC** Teammates [148] or NPC-Ts—a sub category of **NPCs** that we define for this chapter—are perceived and valued in comparison to human teammates.

Unlike other **NPCs**, a player’s NPC-Ts assist, support, and cooperate with them. NPC-Ts sometimes replace human players entirely. Sometimes, game missions are impossible without NPC-Ts, which makes them valuable to the player. However, when NPC-Ts replace human teammates, players have a clear preference for human teammates [188, 123, 105].

Two research opportunities follow from this dissatisfaction with NPC-Ts. First, one could continue to seek improving in-game **AI** so that **NPCs**—in particular NPC-Ts—reach a sophistication level where humans feel NPC-Ts are as competent as human teammates [172]. However, we also have to ask a related question about **NPC** competency: Will **NPCs**—regardless of their sophistication—ever be perceived on par with human-controlled characters in a game? Said differently, imagine the only way to tell **AI** apart from a human-controlled character is if you are told your teammate is an **NPC**: How similar or different would the interaction with a human player be?

Answering this question depends on context. At present, people approach **AI** in games, especially **NPCs**, with biases and expectations triggered by the limitations of **AI**. While acknowledging present-day limitations, research seeking to understand current perspectives and practices regarding NPC-Ts and human-controlled teammates is worthwhile on two fronts: First, it may help us understand *a priori* biases that condition reactions to **AI**, which contextualises what users report when they evaluate NPC-Ts in particular, **NPCs** in general, and **AI** in games overall. There is psychological evidence that pre-conceived biases are hard to overcome: For example, the *Pygmalion Effect* (i.e., higher expectations lead to higher performance) is well-established in psychological research [195]. Second, understanding the effects that improved **AI** has on players can reveal how enhancements to **NPC** behaviour affect human perception of these characters. In particular, we want to understand how our perspectives change when we fully grasp the ‘lived experiences’ of players interacting with these characters.

While researchers are aware that human players prefer other humans and look down on NPCs, understanding the rationale for value judgements of NPCs warrants more research, particularly for NPCs with whom players collaborate (i.e., NPC-Ts). To explore these questions, we designed a single-blind, qualitative, deception experiment to examine attitudes toward NPC-Ts and human collaborators in games. First—to explain the deception part—we occasionally deceived human players in our experiment about the nature of their teammates, indicating they were AI when they were humans playing with the participant, or indicating they were human when they were AI. Alongside deceiving participants, the experiment was conducted by a facilitator, and during the multiplayer experience, both the player and a research assistant (interacting with and observing the player during the experiment) were not aware they were being deceived. This ensured that, during gameplay, no one was aware of the presence or absence of human players. The truth was revealed during post-experiment debriefing and interviewing by a second researcher.

Overall, two primary theories arise from an inductive analysis of our interview data. First, regarding power dynamics of in-game relationships, we compare tendencies toward NPC-Ts with the social-contract negotiated power dynamics between human teammates [60, 97, 277]. Within these dynamics, it is important to recognise that, as with any power structure, human players can be better or worse at collaborating with other humans as peers and the same holds true for NPC-Ts. Second, regarding perception, we look at issues of humanisation and competence with respect to discursive interactions between participants and NPC-Ts and human teammates. We observed a double standard: when viewing teammates as human, compassion is given for errors; however, NPC-Ts are judged on their humanness based on competency.

## 4.2 Related Work

Much literature is focused on improving NPC behaviour through development of AI [281]. Techniques such as evolutionary learning [183] and scaling for difficulty [212] are common. Research has sought to improve AI including attempting to create believable movements and behaviours [14, 106, 133, 160, 159, 184], design of characters [99, 97, 121], and programming reactions to the environment [95].

The literature spans diverse topics including machine consciousness [5] and imitation of human players [185]. In addition, programming game AI has been the focus of books and edited volumes [26, 20]. The goal of improved AI is making NPCs in a game more believable; thus, development of AI for control of NPCs, especially for conversational interactions with players resembles the Turing test [235, 168]. Livingstone [129] reviewed literature

about creating more believable computer characters. Assuming characters have a sufficient level of believability to enhance player experience, an emerging question—particularly in co-operative games—is the socialisation with NPCs: if and whether this socialising differs from socialising among human players [256, 257, 255].

Outdoor games as well as board and card games are considered a social activity. Stenros *et al.* [216] argue that even single-player computer games are social because of the surrounding social interactions, including discussing the content of the game. Leveraging this understanding of games as a social interaction, researchers including Szentgyorgyi *et al.* [224], Voida and Greenberg [248], and Linderoth et. al. [126] discuss social aspects of multiplayer, in-person gaming.

Some game types, including many handheld and console games, are skill tests where the social experience is not core to the game itself [224, 248]. The social components in these games improve player experience, but other games require socialisation and communication among participants to successfully play. These latter games are called cooperative games and plenty of them exist and are popular among players. The goal of our research is to explore this field of cooperative gaming, particularly in an online gaming context. When judging the effectiveness of a cooperative game, it is important to understand the sociability of the game. Sociability depends on the players. We must understand the characteristics of video game players as well as the design of NPC-Ts when investigating NPC-Ts. Lastly, the attitudes of players towards their computer-controlled teammates or Non-Player Character (NPC) teammates, commonly referred to as AI, is an important component of cooperative games—particularly when cooperation with [NPCs](#) is necessary.

One main difference between human and [NPCs](#) is how they socialise. Many researchers have studied social aspects of gaming [216, 224, 248]. Many studies have investigated socialization in games: We learn game techniques from other humans [264] and enjoy couch-cooperation. We find that people’s co-presence and attention to the same stimulus changes our experience [262]. Additionally, we are encouraged by on-looker feedback [112]. Overall, the literature on cooperative gaming is extensive and accounts for many different game types (e.g., exergames [161]).

Generally, we accept the intuitive idea that differences between human-human and human-AI gaming exist. Disentangling whether these differences are because of AI efficacy or other social factors is challenging. In a study by Lee *et al.* [123], *Flow*, the optimal experience characterised by the feedback of the task as the reward [?], was found to be higher when playing with other people cooperatively, as opposed to playing alone. DeKort *et al.* [50], reviewed video game sociability and human interaction in games. They state that players can be influenced by a feeling of involvement in another player’s social group, or by

social affordances allowed by the interaction. Both DeKort *et al.* [50] and Stenros *et al.* [216] discuss the differences between conditions of co-location and mediated interaction (i.e., whether or not the players are in the same place), for example, if the players are co-located, but not situated in a traditional face-to-face interaction model.

While characterising human-to-human engagement tells us much about social gaming, much of this work is orthogonal to distinguishing differences between human-human and human-AI sentiment. It is acknowledged that NPCs are valuable for player experience. NPCs populate the world and increase the frequency of interactions available to players [84]. NPCs are also valuable in console gaming [248] where—without NPCs—one could only play with another human player, and in handheld gaming [224] where many games are primarily designed with NPC opponents in mind.

More recently, games such as Pokemon Go are based primarily around the collection of ‘living’ in-game characters. We hypothesise that differences in value may not solely be caused by NPCs not being ‘real’ people: Players often assign meaning and value to game objects [231, 232]. Research also demonstrates players have emotional empathic reactions to works of fiction [140, 139], which can extend to game narratives [16] and players’ relationships with in-game avatars [9, 128].

When comparing playing with humans versus playing with NPCs, prior research has leveraged physiological measures to try to determine if there are distinctions and what those physiological distinctions might be [138, 188, 105]. Recent results in this area [105] found playing with humans increased relatedness (i.e., relation to others) and increased brain activity in the alpha, beta, and theta bands. The researchers believe playing with human players was therefore more work which they referred to as ‘mentalising’. In contrast, video game players tended to elicit greater feelings of competence. The researchers concluded that flow was higher in this condition. This work echoes earlier work by Weibel *et al.* [272] reporting that—compared to playing with computers—playing online with humans increased presence, flow, and enjoyment.

Given past work—particularly using physiological measures—existing differences seem indisputable. Alongside quantitatively measured differences, we have conducted analyses that argue for higher levels of engagement and flow during human-human gaming, providing guidance as to what those differences are between human-human and human-NPC gameplay. *Why* these differences exist remains less clear to us in our exploration of past work. We lack knowledge on what motivates different engagement and flow. It could be the efficacy of the AI alone. Whether it is or it is not, is solely a question of AI efficacy, but how do these differences manifest with respect to perspective on game characters?

## 4.3 Methodology: Attitudes Toward NPC-Ts

Our interest is in probing the attitudes and experiences of players working collaboratively with computer-controlled characters to understand how perspectives toward human teammates and NPC-Ts differ. To begin answering this question, we need both a context of study and an experimental design which will allow us to compare these factors while controlling—to the extent possible—confounds associated with *a priori* biases that arise when one knows the nature of one’s teammate. In this section, we describe the study design setup, the gaming environment chosen, and the experimental methodology. We justify each in turn with respect to our study design.

### 4.3.1 Setup and Deception

We evaluated three possible study scenarios to determine differences in attitudes toward human versus toward computer-controlled collaborators. First, we considered providing full awareness of whether one is playing with a human or a computer and then elicit a reaction. The challenge was that pre-conceived biases may play a role in the assessment of the game and of the interaction with in-game characters, a casual “human primacy”. The next option was to simply not tell users and allow them to play with an undefined collaborator which may be human or computer. The problem with this setup is that issues of competence and efficacy of AI within the game may come to dominate perspectives. Players may also be tempted to ascertain whether they are playing with humans or AI through on-going evaluations of interactions, a form of quasi-Turing-testing. Our third option, and the one we adopted was to leverage deception to understand whether differences in treatment arise from an awareness that it is the AI or from the efficacy of the AI making decisions for computer-controlled collaborating in-game characters (i.e., NPC-Ts).

We studied 30 participants divided into two groups. Half of the participants played with the human confederate team, the other half played with the NPC-T. We deceived one third of participants (five from each group) by falsely informing them that they were playing in the opposite condition. This study design allowed us to see if they were reacting to their perception (who they were told they were playing with) or the true condition (who they actually played with). In summary, ten people played with humans and were informed they were playing with humans, ten played with NPC-T and were told they were playing with NPC-T. Finally, ten were deceived into believing they were playing with the opposite condition.

### 4.3.2 Game and Modification

We used *Left4Dead2* (*L4D2*)<sup>[243]</sup> played on Steam (Valve Corporation) as a stimulus. The game is a first-person shooter (FPS) that involves four players escaping from a Zombie apocalypse. The game is rated M for violence, and only participants 18 years and older were invited to participate. The level played was titled "No Mercy", a level echoing the original *Left4Dead* [242]; as a result, the original game characters were used.

The researchers added modifications <sup>1</sup> to ensure that the game protocol did not reveal the social environment (i.e., to preserve the unawareness of the deception). These modifications included the prevention of game end upon death of the participant's character. Additionally, the characters' names were always their default names (no Steam user names were used).

Our choice of L4D2 was motivated by several characteristics of the gameplay. L4D2 is a game where teammates are required to rely on each other to complete tasks, meaning coordination and collaboration are important. This coordination and collaboration peaks when a teammate—near the end of the game—is required to sacrifice themselves so that the mission can be completed.

### 4.3.3 Participants

Overall, 30 participants completed our experiment, 15 males and 15 females. All participants were older than 18 years (Mode = 20-24 years; Range = 18-45+ years). Skill level or experience with the game was not an exclusion criterion.

Out of the 30 participants, two identified themselves as complete beginners, four as novice players, four as moderate, nine as intermediate, eight as advanced, and three as skilled. Twenty-five participants were PC gamers, and twenty-five claimed to have at least one game console in their household that they use regularly for games. Sixteen participants had played a first-person shooter game before, and twenty-four participants played at least one other genre of games. Fourteen of the participants had previously played *Left4Dead1*, while another fourteen, with some overlap, also played *Left4Dead2* prior to participating in the study.

### 4.3.4 Study Structure with Deception

Our 30 players were divided into two groups, one an AI group and one a human group (15 players each, with near gender parity or 8/7 within groups and with skill parity between

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<sup>1</sup>Dzigg (2013). Improved Bots (Advanced) <http://www.14dmaps.com/details.php?file=15461>

groups). Players were informed, if in the **AI** group, that they would be playing with **AI** and, if in the human group, that they would be playing with humans on their team. To incorporate deception, one third of the players in each group were deceived (i.e., 1/3 of players in the **AI** group were actually playing with human teammates, and 1/3 of the players in the human group were actually playing with **AI** teammates).

#### 4.3.5 Controlled Experimental Setup and Communication

Participants were unaware of the deception involved in the study. As a result, we used human confederates during gameplay in every condition to ensure that **AI** and human conditions were as similar as possible. Human (confederate) players were of different skill levels. One player acted as a beginner, one as an intermediate, and one as an advanced player. They were told to activate game events at specific points, such as triggering certain enemies. They were asked to stay within reasonable range of the player because of the team-like nature of the game. Confederates were also instructed not to communicate with the participant in any way. At the same time, within game they were told to play competently to their ability. In other words, they should react as their human responses dictated to in-game events.

A blind facilitator, unaware of the deception, conducted the study. This ensured that the blind experimenter could not subtly bias conditions of the study. Further precautions were taken to ensure the blind facilitator could not observe confederate gameplay; the blind facilitator was asked to stay near the participant, observe gameplay and note significant game events (e.g., the appearance of “special infected” unique enemy variants in the game).

The study proceeded as follows. Players were introduced to the confederates during the walk-through of the study by the blind facilitator and informed on whether they were playing with our L4D2 team or with **AI** depending on whether they were playing with human teammates or **AI** teammates. Upon consent, players were informed (correctly or incorrectly) of the condition in which they would play for their first game. No verbal, messaging, or out-of-game exchanges were allowed between players and confederates and the environment was physically configured to prevent the blind facilitator or participant from peeking at confederates’ screens to prevent revealing the placebo condition (see Figure 4.1). Major in-game events were scripted, such as triggering main enemy waves, activating special encounters. This was done to ensure consistency of basic game progression across participants.

All players, including confederates, were asked if they were ready before playing. The human confederates were needed in all conditions to control the environment, preventing

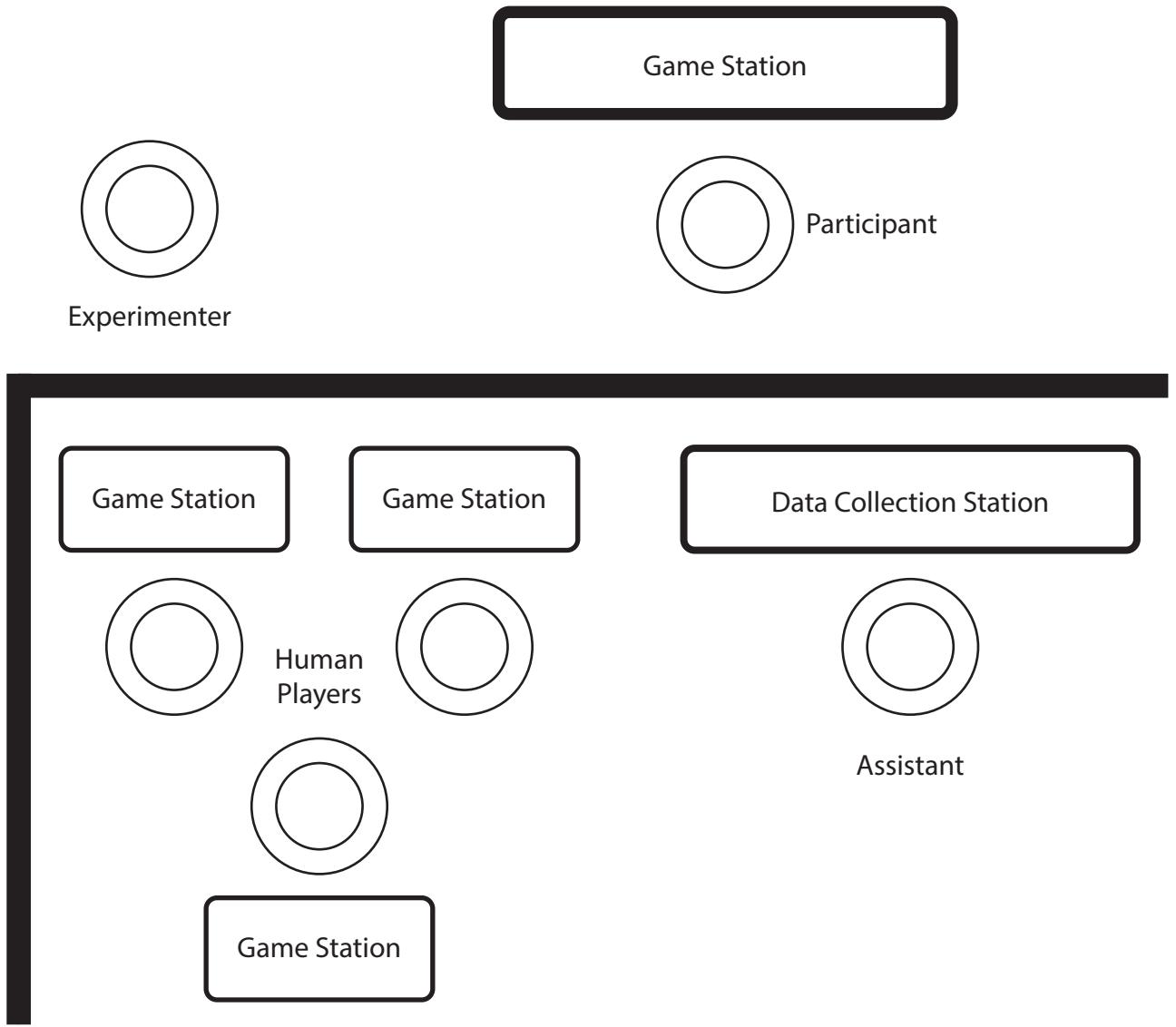


Figure 4.1: The (Blind) Experimental Room Layout

differences in audible player activity or number of co-located individuals from affecting the participant perceptions. To control between conditions (e.g., sound of mouse and keyboard, observation of the game, presence of the human players), human confederates always played a game; if the condition was truly a computer-controlled condition, the confederates played

a game individually.

#### **4.3.6 Data and Measures**

We collected the following data: Observations of the blind experimenter to gameplay, video of gameplay and reactions, and an interview of players post-treatment. The interview focused on the thoughts and feelings of the player regarding the social experience as well as their perceptions of fellow players. Once the deception was revealed to the deceived players, the interviewer asked about their thoughts and feelings following the reveal of the condition in the placebo group. The purpose of this line of inquiry was to determine if the debriefing would change the players' retrospective views of their player experience. For example, two of the areas of questioning explored whether players had any awareness of the deception and—in light of the deception—whether the identity of their teammates affected their enjoyment of the game. Participants indicated they were unaware of the deception involved in the study.

#### **4.3.7 Debriefing the Blind Facilitator**

One challenge with any study based on deception is the need to ensure the deception was effective. While deception may be effective in a discrete case for any one participant, different study conditions could not be sufficiently similar to provide a true measure of masked differences. Fortunately—alongside participants—in our study the facilitator of the experimental session was unaware of the deception.

To evaluate the success of our experimental design with respect to similarity of conditions, the blind facilitator was interviewed and debriefed. The interviewer asked the facilitator if he was able to differentiate between human and computer-controlled conditions after repeated exposure to the game and questioned his perception of the true hypothesis.

The blind experimenter was not aware of the presence of deception, but was able to identify points of suspicion in retrospect:

”I may have suspected something, but I always thought that they played AI and I didn’t know any different.”

In discussion, the blind experimenter notes, in particular, post-hoc suspicions based on aspects of competency, suggested in the preceding quote and expanded upon as follows:

”I remember a few occasions where I thought, the AI; why are they spreading out so much? Because I thought this is what humans do, but I don’t know the game that well, so I don’t know what the AI is really capable of. [...] You told me AI and I thought it was AI but they would just go off to the next screen and start shooting people and I thought well ok whatever. Sometimes, you told me humans and there were some of these [participants] who got stuck and they may have needed a little pushing in a certain direction and then I thought ‘why are the guys not helping her?’”

## 4.4 Results

In our attempts to understand the in-game experiences associated with NPC-Ts, a consistent negative bias toward NPCs as confederates was observed. We found an immediate preference for human-controlled players, among all participants in the studies. Then—with respect to beliefs, behaviours, and outcomes—we wanted to understand the different perspectives applied to NPC-Ts and human confederates, especially the behaviours that are valued in both characters.

Interview data, field notes, and video observations were analyzed using open coding to extract low-level themes from the data [219, 218, 41]. Low-level clusters were agglomerated collaboratively by the researchers into ten central clusters: Negative Sentiment to AI, Anthropomorphism, AI Skill, Communication, Leadership, Teamwork, Social Expectations, Variable Human Skill, Playful Interaction, Romanticized View, Gameplay Behaviour, Person-Display Discourse.

### 4.4.1 Coding Clusters

For the analysis, 10 coding clusters were identified and then synthesized into the larger theme categories. For clarity and transparency, the clusters are explained below.

#### Negative Sentiment to AI

When asking players - “with whom do you prefer to play with”, most can provide a clear answer. Often this answer is biased in favour of other human players. In fact, the on going sentiment towards Non-Player Character Teammates (NPC-Ts) is negative.

“[Humans are] The best, because at times I really needed saving, so I’m really glad I had a team of people and not like computers or robots or whatever; because yeah they really saved my ass.”

Participants also viewed them as tools for use.

“Objectively they’re not going to help you that much, and essentially they are just walking ammunition boxes. But for a sense of character, or atmosphere, they’re people right. Sure they are controlled by AI, but they’re not completely devoid of any meaning. So I’m going to kind of keep them alive or whatever.”

### **Anthropomorphism**

Players tended to Anthropomorphise or Humanize their computer-controlled teammates. At a simple level, aspects of NPC-Ts such as the pre-programmed speech of the characters which may include statements of thanks, negative or positive reactions to game events, or encouragement to hurry through the game. These, in turn, made players feel more connected to the computer-controlled characters.

As part of the anthropomorphic attributes, the fact that NPC-Ts were teammates provided a further encouragement for participants to humanize them. For example, multiple participants felt that the computer-controlled and human teammates had personalities and play styles. In one case, a participant in our study felt that one NPC-T was defensive, one was aggressive, and one held back.

“I could almost see which behaviour they were acting in. Like Zoey had the aggressive behaviour, Louis had the whole defensive behaviour and was constantly behind, and Bill [he means Francis] was kind of in the middle there. So... like I could definitely tell who was showing which characteristic.”

Interestingly, in this case, the participant was told that the NPC-Ts in the game were human players. At the end of the game, after the truth was revealed, the same participant stated, “I still hold to my point that Zoey knew where she was going, Francis was in the middle, and Louis kind of held back.”

## NPC-T Skill Level

We found that humanness was determined based on levels of competence. Where computer-controlled teammates may have been humanized or anthropomorphised, they still did not reach the level of thought and subtly and richness in behaviour typical of humans. The more skill and competency playing the game a character demonstrated, the more likely a player was to begin to their humanity. One player asserted that because of the skill level, it must be human because computer-controlled characters were not “capable of being this good.”

Competency is a multi-faceted concept for our players. At the simplest level, players make the negative assumption that computer-controlled teammates are useless in times of need.

“[Humans are] The best, because at times I really needed saving, so I’m really glad I had a team of people and not like computers or robots or whatever; because yeah they really saved my ass.”

However, alongside this low-level attribute of skill, more complex issues of self-preservation indicated a higher likelihood of human control for our players.

“Well I noticed sometimes they would move away from a dangerous area, which seemed a little weird. Like the thing that shot green stuff like they would move away from it after so they wouldn’t get injured. Which I thought was a kinda unusual for an AI. They just sort of ‘Oh I’m getting shot now, might as well just die.’”

## Communication

Players often cited the lack of voice communication as a deafening factor to the sociality of the experience. The lack of voice communication made it hard to feel that either condition was different. In contrast, the pre-programmed speech of the characters which may include statements of thanks, negative or positive reactions to game events, or encouragement to hurry through the game, made players feel more connected to the computer-controlled characters.

“The fact that there was some dialogue in there I think was a big one. So I could hear someone telling me to get into a room that I couldn’t get into. And reminding me, I think that they heard things around the corner... Someone in there sounded like they had a crabby attitude, so that was kind of more real. It wasn’t just that they all acted the same. They used names a lot so it seemed a little more personal.”

Participants would also react to dialogue spoken by avatars in the game. In one example, a character in the game said, “Let’s do it”, prompting the participant to reply, “Wait what are we doing? Ok what do you people want me to do? I’m just going to start following you around”, despite the fact that the participant was told (accurately) that they were playing with computer-controlled players.

## **Leadership**

Leadership was also a determining factor in humanness. If participants felt that the other player was unable to lead they were less likely to perceive them as human. One participant stated that the reason they were not fooled and believed it was AI because he felt in control and a leader. A participant also reflected that at the beginning of the game, the ‘humans’ should have directed her but no one moved, therefore it felt like computer-controlled characters.

## **Teamwork**

Another factor that was of importance was teamwork, which was perceived as something particular to humans despite the fact the sole purpose of NPC-Ts are to substitute for helpful human teammates.

“Because they were supporting their team members [...] It didn’t seem like they were out for themselves. They seemed more like a team kind of.”

## **Social Expectations**

Despite the narrative of superiority of human players, participants found some advantages to playing individually. Often participants which advocated for playing with NPC-Ts cited the social expectations set by other human players as a discouraging factor.

“A couple times I reflected on the game, and I’m like: ‘Oh this is just so generic that I’m playing a level with AI for some data collection.’ But if I would’ve known they were people I probably would’ve felt more like [...] you know the team needed me, like I needed to actually [...] I guess you could say play more seriously.”

Players also felt the need to not negatively impact other human player’s experiences.

“If you were to say there’s just AI playing, I still feel the obligation, just not as strongly. If there’s an actual human player, I’m ruining someone else’s experience if I just go out there and die.”

“A lot of the games you play nowadays online, or you play with headsets, so you don’t physically know the person but you know that there’s a person behind it. As opposed to selecting a game that it’s you versus the computer, and you know no one’s going to get hurt in the long run. But when there’s an actual person there that you’re supposedly teaming up with, collaborating to come to the same result, it puts a little more pressure on you to step up and do better.”

They also felt powerful and important as the only human player.

“It’s fun to play on your own and feel that ‘Oh my gosh I can be the best one that I can be!’ With my friends it’s like, yeah no, I’m not the best one here.”

## Variable Human Skill

Although as humans, we understand humans make mistakes. Human level of skill may vary and is more forgivable.

“I wouldn’t feel as angry because people make mistakes. Computers are programmed. It’s like taking power away from me, and if it’s say giving it to the computer I’ll be angry, if it’s giving it to another person I’m like ‘Well people make mistakes’ empathy sort of thing.”

## **Playful Interaction**

Players also felt that human-human interaction is more playful.

“Humans are always more chaotic and a bit more silly so I feel the unpredictable factor, like what makes humans a bit unpredictable. I like that.”

## **Romanticized View**

Players tended to romanticize the NPC-T actions. Citing that they felt that there was a presence protecting them, and watching over them.

A participant who incorrectly believed that they played with humans because “the experimenter said so”, or “they seemed to know everything”, expressed a more complex manifestation of their companions feeling ‘human’. One participant felt that their teammates were helping them, and providing the player with cover. Participants also felt accompanied, stating that with the NPC-Ts they did not feel all alone.

“I trust that you’re telling me the truth, so I knew there were people that knew how to play the game ... So if you weren’t telling me the truth, and it was computer-generated people that I was working with ... I would just feel the same. Knowing they were covering my back kind of thing.”

At a low-level, the notion that these characters exist to support you seems to do less to differentiate from other human confederates:

“They’re programmed to help you, which your friends would probably do I assume.”

## **Gameplay Behaviour**

The behaviour of the participants during gameplay revealed information about their experiences with NPC-T’s. There were participants that engaged in social interaction with the on-screen game characters regardless of the experiment condition; this includes players who constantly spoke aloud to the monitor. Interactions ranged from a short-lived “Hi Francis” or “Aww Zoey” when observing teammates, to laughter and guilt when

characters complained about incidents of friendly fire. One participant was healed by a computer-controlled ally, at which point they turned to face the back of the room and said, “Thank you” to the experimenters. The participant was told that they were playing with computer-controlled teammates, yet was still compelled to direct their gratitude towards a human. This same participant also expressed shock while nearly shooting their on-screen teammate in the process of learning the game’s controls. Some players expressed that they felt that they would have talked to the screen regardless.

“I would’ve talked to the screen no matter what. Like, ‘Thanks Zoey, or Thanks whatever.’ I would have.”

### **Person-display Discourse**

Determining the humanness of a players teammate was difficult for the majority of players. In part we see this through the success of our study design; players rarely questioned whether their teammates were computer controlled or human confederates, despite the fact that in half of the cases in our study, players were being deceived. However, alongside the success of our deception study, we also saw that players anthropomorphised or humanized computer-controlled teammates.

From these thematic clusters, collaborative axial coding produced two over-arching constraining themes that unify the data: Power Dynamics and Social Obligations; and Humanism, Anthropomorphism, and Competency. We discuss each of these in turn in this section.

#### **4.4.2 Larger Themes**

From our results, we combine our themes into two theories. One theory emerged from the players’ attitudes towards the NPC-Ts. To the players, NPC-Ts were both valuable and disposable. Players perceived themselves as more important and we can see this power dynamic emerge from the data. In contrast, with human-teammates, players felt a need to negotiate more carefully. The second emerging theory is that of humanization of the NPC-Ts and the expectation of competence. Incompetence from NPC-Ts and humans was treated differently by the players. For an NPC-T to be perceived as human, competence was needed; however, when the participants were expecting a human player, they were more forgiving. The double standard of human versus NPC-T players was interesting because of the deception built into the study design.

#### 4.4.3 Power Dynamics and Social Obligations

The most obvious way humans distaste for NPC-Ts is articulated is the innate value assigned to these different characters in the game. In this subsection, we argue that NPC-Ts are viewed as a resource to be exploited whereas human confederates are viewed as collaborators. In analysing these concepts, the view of NPC-Ts as resources reminds us of the social ranking perceived by players towards one another based upon skill. Mediating against this perception in human-to-human player relationships, the negotiation and compromise required by human confederates evolves into a social contract for players.

##### Power Dynamics in Gaming

Power dynamics have been discussed within social structure of game communities. Social relationships between players in game can be influenced by this differential [99, 97]. The results of the study highlight the power differential between human and NPC-Ts, where NPC-T's are subordinate to the human player and their status as non-person negates the tools human players can leverage vis a vis other human players to mitigate against these different perceptions.

When analysing players attitudes toward NPC-Ts, there are many positive aspects that NPC-Ts bring to the gaming experience. NPC-Ts provide shelter and protection, i.e. they can “watch your back”. Given this idea of protection, the existence of NPC-Ts circumvents the trepidation experienced by players. Players essentially feel that, with their protectors willing to die for the sake of their goals, they can be more effective and aggressive in pursuit of those goals. In essence, the game is populated by human players with agency and NPC-Ts which are perceived to be a valuable resource for human players to exploit support and utilise to accomplish their ultimate mission. While NPC-Ts were viewed as a valuable resource, they were not viewed as peers and were not invested with decision-making authority.

We characterize behaviour toward NPC-Ts as nuanced benevolence because, while NPC-Ts were viewed as a resource, this is not to say that human players treated them completely as disposable. Many players adopted the perspective that it was useful to support NPC-Ts, and, in particular, to try to keep them alive as long as possible.

”If you tell me ‘Oh there’s no people playing!’ I still feel kind of obligated to pretend they’re people because I’m thinking that they’re my allies and they’re probably going to help me out later; because if I get hurt they help me out, right.”

”Objectively they’re not going to help you that much, and essentially they are just walking ammunition boxes. But for a sense of character, or atmosphere, they’re people right. Sure they are controlled by AI, but they’re not completely devoid of any meaning. So I’m going to kind of keep them alive or whatever.”

However, there remains a distinction. Players may feel varying levels of obligation to help human-players versus computer-controlled players, essentially expressing more willingness to leave computer-controlled players for dead. Human players exhibited a willingness to sacrifice a NPC-T where they would feel guilt taking the same actions were the player human.

”A couple times I reflected on the game, and I’m like: ‘Oh this is just so generic that I’m playing a level with [AI](#) for some data collection.’ But if I would’ve known they were people I probably would’ve felt more like [...] you know the team needed me, like I needed to actually [...] I guess you could say play more seriously.”

While this nuanced benevolence exists, the fact that NPC-Ts are not human results in some subtle differences in how these characters are perceived. Consider the following statement from a discussion on NPC-Ts:

”They’re programmed to help you, which your friends would probably do I assume.”

A superficial analysis of this statement might seem, at first, to articulate a similarity between NPC-Ts and human confederates. However, a second read of even this single quote highlights a profound difference. NPC-Ts are programmed to help you; friends “probably” would. Friends, human players, have agency and choice about helping you. This distinction between choice and obligation came up in many interviews around the difference between human and computer-controlled teammates. We probed this difference to understand why the distinction was important even with low-skilled teammates, and users highlighted the experience of their co-players.

”If you were to say there’s just [AI](#) playing, I still feel the obligation, just not as strongly. If there’s an actual human player, I’m ruining someone else’s experience.”

This, in turn, led us to examine how the larger obligation to other human players evolved.

## Social Obligations

The concern with other players' experiences noted above for human teammates highlights the obligation that exists between human confederates within a game, the negotiated compromise needed to preserve in-game experience for others. This obligation was expressed clearly by one participant in our study.

"So, again, having teammates to help you out [...] It kind of feels the same as when I go into a match of Battlefield with AI teammates. Like where I don't really know much about them, 'Oh there's somebody over there doing their own thing.' I kind of feel the same thing with Left4Dead, in a situation at least. If I was playing with people it would be much different. [With AI] it was kind of like [...]: They're a separate entity."

Okay, I'm here, but you know, I'm going to be doing my own thing, maybe get into trouble, and they're probably going to help me out because they're nice.

I guess if you have other people around you, especially in an atmospheric game like that, [...] I feel kind of safer. You know somebody else can screw up and you're like oh I feel good I helped them. Then if you screw up it's like ok that helps it's all good, somebody helped me out."

Between human players, there exists a social agreement that describes expected behaviours. Essentially, to continue working together, compromise between parties is necessary, be that compromise one that arises via discourse and consensus or one that arises through the will of the majority. There is an expectation that human confederates must be collaborators, not solely confederates.

While all players perceived the connection with and mediation required between human players, there were challenges. These challenges included the obligation placed on a player by other human players (and the potential benefit to playing with NPC-Ts when players perceived their skill as being insufficient), and the desire to occasionally violate social norms to create disruption.

First, mismatched skill levels were a significant challenge when navigating the obligation to human confederates. Players who felt their own skills were not comparable felt that social expectations on them were too high. They worried about feeling judged for their skills. They felt others would resent their errors. They also perceived a need to seek forgiveness when an error was made.

"It's fun to play on your own and feel that 'Oh my gosh I can be the best one that I can be!' With my friends it's like, yeah no, I'm not the best one here."

Insufficient skill articulated itself as a benefit to NPC-Ts for those players who felt their skills were too low.

“Because then if I mess up, the computer doesn’t get mad at me [...] People get mad at me if I mess up! So you don’t have to answer to [computers].”

In contrast, more skilled players found that the lack of ability to create social obligation on the part of NPC-TS hurt the game experience, leaving them feeling unable to punish, pressure, or yell at the NPC-Ts in an effort to improve their performance.

“Uh, if I was playing with people I would’ve yelled at you more because yelling is part of the fun.”

A second challenge observed in our data regarding the social contract between players involves a practice colloquially known as “trolling”. Humans are not always good collaborators. When playing a game with a human teammate and setting up the social contract, the player must remember there is a negotiation that is involved to set up collaboration but there is a trepidation that the player faces: Will this human cooperate with me? Humans are not as biddable as computer-controlled teammates, they may play pranks, act unexpectedly, or be silly.

“[I prefer] multiplayer with friends. Um, multiplayer with friends and single-player are kind of tied, it’s just that usually I like to play with friends. And the reason I like that more than playing with strangers or many people online is just because I have a good kind of relationship with my friends so it’s always fun to just be ridiculous.”

“Humans are always more chaotic and a bit more silly so I feel the unpredictable factor, like what makes humans a bit unpredictable. I like that.”

One participant trolled players in our experiment. This participant believed that they were playing with humans and made certain by looking at the ‘pings’ to other players, despite the instructions that communication tools were **not** allowed by the experimental protocol. Afterwards, they disrupted gameplay and ditched the team. When interviewed, they stated that ‘pings’ are only done with human players. The person checked because with **AI** they would not have taken the same actions. This participant prefers to play with humans because they enjoy creating chaos among human players; they would not derive the same enjoyment from doing so with the AI:

“I saw that the people were human, so I wanted to [mess] with you guys [...] Bots you know, they’re not real. People are real, so when you mess with people it’s funnier.”

The fact that our study was a deception study also provides for interesting insight into the behaviour of human players with respect to NPC-Ts. As one example, one participant was informed that they were playing with a NPC-T, despite the fact that they were playing with a human confederate. This player rejected NPC-Ts, freely overlooking, abandoning, or shunning the NPC-Ts. In debriefing the participant reacted to the reveal that they were playing with human confederates with an acknowledgement that their behaviour was incorrect, “Uh, I just assumed. Go figure!”. Others, particularly in the case where they were told AI but were actually playing with humans, expressed similar sentiments, using terms like “oops” and “oh well” to express post-hoc acknowledgement that they would have behaved differently. Participants deceived in the inverse direction (told human, actually AI) also noted how the perception that teammates were human altered interpretation of behaviour of NPC-Ts in gameplay.

“Because they were supporting their team members [...] It didn’t seem like they were out for themselves. They seemed more like a team kind of.”

Overall, this acknowledgement further illustrates the quid-pro-quo expected between human-controlled confederates versus the relatively reduced value that can be ascribed to NPC-Ts.

#### 4.4.4 Humanisation and Competence

“It was still like a person, right? It still stood out as behaviour of what a person would do instead of **AI** who knows where people are and just \*he gestures a motion of shooting something\*”

Determining the humanness of a player’s teammate was difficult for our participants. In part we see this through the success of our study design; participants rarely questioned whether their teammates were computer-controlled or human confederates, despite the fact that in one third of gameplay, players were being deceived. However, alongside the success of our deception study, we also saw that players anthropomorphised or humanised computer-controlled teammates.

On the other hand, while players humanised NPC-Ts, they did not expect competence from their NPC-Ts. As a further result, when computer-controlled teammates demonstrated

any competence or skill they were regarded as more human. The perception (and, indeed the reality) is that NPC-Ts lacked the subtlety of a human-controlled player, demonstrated by their typical inability to lead and work in a team.

Within our data, we perceive a hierarchy of engagement. At the lowest level, NPC-Ts are not perceived of as people, but may have human-like qualities, a phenomenon known as Anthropomorphism. Some characters perceived to be NPC-Ts were actually human confederates playing in the game (because of our double-blind study). The sophistication of these NPC-Ts did, at times, lead participants to humanise their AI-controlled confederates. Finally, levels of gameplay skill with regards to strategy and leadership/teamwork were perceived to more fully indicate a human confederate was playing collaboratively with the gamer. We expand on this theme as follows.

## Humanisation

Humanisation of NPC-Ts was frequently observed in our experiment. Aspects of NPC-Ts such as the pre-programmed speech of the characters—statements of thanks, negative or positive reactions to game events, or encouragement to hurry through the game—enhanced the tendency of participants to humanise NPC-Ts, (i.e., made players feel more connected to the NPC-Ts). We were surprised that the pre-programmed speech was cited by some players as causing the feelings of humanness and not actual actions taken by humans. More specifically, rather than the actions of teammates, the reactions or interactions between participants and their teammates were most effective at encouraging humanisation of NPC-Ts.

Because we were preserving parity between human and NPC-T conditions, there was no voice communication. Participants often cited the lack of voice communication as a factor that reduced the sociality of the gaming experience. The lack of voice communication made it hard to feel that either condition was different. Even in human-to-human play, however, the pre-programmed textual speech of the characters which may include statements of thanks, negative or positive reactions to game events, or encouragement to hurry through the game made players feel more connected to the NPC-Ts.

“The fact that there was some dialogue in there I think was a big one. So I could hear someone telling me to get into a room that I couldn’t get into. And reminding me, I think that they heard things around the corner...”

Alongside anthropomorphic attributes, the fact that NPC-Ts were teammates provided a further encouragement for participants to humanise the NPC-Ts. For example, multiple

participants felt that the computer-controlled and human teammates had personalities and play styles; In one case, one participant in our study felt that one player was defensive, one was aggressive, and one held back.

"I could almost see which behaviour they were acting in. Like Zoey had the aggressive behaviour, Louis had the whole defensive behaviour and was constantly behind, and Bill [he means Francis] was kind of in the middle there. So [...] like I could definitely tell who was showing which characteristic."

In this case, the participant was deceived. Initially she was told that the NPC-Ts in the game were human players. At the end of the game, after the truth was revealed, that they were actually AI (and would not have different tendencies), the same participant stated, "I still hold to my point that Zoey knew where she was going, Francis was in the middle, and Louis kind of held back."

Some players spoke aloud to the NPC-Ts. Interactions ranged from a short-lived "Hi Francis" or "Aww Zoey" when observing teammates, to laughter and guilt when NPC-Ts complained about incidents of friendly fire. One participant was healed by a computer-controlled ally, at which point they turned and said, "Thank you" to the experimenters. The participant was aware they were playing with computer-controlled teammates, yet was still compelled to direct their gratitude towards someone. This same participant expressed shock while nearly shooting their teammate in the process of learning the game's controls.

Participants would also react to dialogue spoken by avatars in the game. In one example, a NPC-T character in the game said, "Let's do it", prompting the participant to reply, "Wait what are we doing? OK what do you people want me to do? I'm just going to start following you around", despite the fact that the participant was told (accurately) that they were playing with computer-controlled players.

### **Competency Makes it Human**

The study design calls for the deception of the participant, allowing us to determine their opinions on human versus computer-controlled teammates. When their assumption that the blind-experimenter gave accurate information about their teammate was pressed, participants revealed information about the nature of their assumptions.

We found that humanness was determined based on levels of competence. Where computer-controlled teammates may have been humanised or anthropomorphised, they still did not reach the level of thought and subtlety and richness in behaviour typical of humans.

The more skill and competency playing the game a character demonstrated, the more likely a player was to begin to infer human tendencies.

Competency is a multi-faceted concept for our players. At the simplest level, players make the negative assumption that computer-controlled teammates are useless in times of need.

“[Humans are] the best, because at times I really needed saving, so I’m really glad I had a team of people and not like computers or robots or whatever; because yeah they really saved my ass.”

However, alongside this low-level attribute of skill, more complex issues of self-preservation indicated a higher likelihood of human control for our players.

“Well I noticed sometimes they would move away from a dangerous area, which seemed a little weird. Like the thing that shot green stuff like they would move away from it after so they wouldn’t get injured. Which I thought was a kinda unusual for an AI. [AI] just sort of ‘Oh I’m getting shot now, might as well just die.’”

At the highest level, issues of skilled teamwork and leadership were significant indicators participants were playing with a human. NPC-Ts were perceived as being poorer team players with respect to working with others. Participants also looked to their companions for leadership. When given a leadership position, some participants felt this was proof that their teammates were not human. In other words, being ceded control leads participants to believe they were the only human—particularly when that control is ceded too easily.

Alongside skill within the game and skill at teamwork and leadership, communication was a large determining factor in the humanness and competency of a teammate. Instructions given by another player, reactions to the in-game actions (e.g., accidentally shooting another teammate), caused players to feel more sociable towards the teammate. Players cited speech as the determining factor towards feel sociable, despite the fact that this dialogue was pre-programmed and present in both human and computer-controlled conditions.

“Someone in there sounded like they had a crabby attitude, so that was kind of more real. It wasn’t just that they all acted the same. They used names a lot so it seemed a little more personal.”

Communicative competency, however, remains a big indicator for our participants of when they might be playing with human confederates. In particular, sarcasm and bile were perceived to be less likely from NPC-Ts than from humans, and when characters exhibited this type of speech, it increased the likelihood for deceived participants of post-hoc rationalisations that NPC-Ts were actually humans (i.e., participants could identify these actions as being indicative post-hoc of the deception though they did not identify the deception during gameplay).

## 4.5 Discussion

Better AI in games does matter, but can we answer the question whether it changed the relationship to NPCs within games, particularly NPCs who are our collaborators? We suspect the relationship will not change any time in the near future. To understand the limits of playing alongside NPC-Ts requires an understanding of the social dynamics of gaming and gamers.

There is a significant body of work that has studied gamer communities and the social dynamics of these communities both with respect to online interactions [60, 97, 277] and real-world perceptions [33, 192] of gamers toward each other. This past work has included studies of the dynamics of power and prestige within these communities. While some authors have focused on specific actions within the community [33], much of the writing on status focuses less on specific acts of dominance and more on perceptions of pervasive empowerment. Obviously, notions of pervasive empowerment are not new; they have simply been applied within the study of social structures in gamer communities.

Historically, Foucault [69] writes extensively on power structures and their maintenance, beginning with notions of power being perceived of as a “right” ascribed to specific individuals. He also comments extensively on the instability of power structures that are maintained by specific actions of individuals:

“In certain societies, of which the feudal regime is only one example, it may be said that individualization is greatest where sovereignty is exercised and in the higher echelons of power. The more one possesses power or privilege, the more one is marked as an individual . . . . [However], neither the residual forms of feudal power nor the structures of the administrative monarchy, nor the local mechanisms of supervision, nor the unstable, tangled mass they all formed together [can maintain these pre-specified social hierarchies].” Foucault, 1995 [69]

His argument culminates with the claim that societies maintain these hierarchies less through explicit action and more through pervasive interactions between people – discourse, common knowledge, pervasive behaviours.

These results align well with studies of power dynamics within many communities, including gamer communities [33, 192].

Our work, however, is not about human-to-human conceptions of power; instead it focuses on distinctions between NPC-Ts and human confederates. We find that NPC-Ts have both similarities and differences with human teammates. From the perspective of similarity, we find issues of competence that promote NPC-Ts as more closely considered peers by human players. Competence is also an important aspect of status and value within online communities, as explored by Ducheneaut et al. [60] in World of Warcraft guilds. However, players also noted the differences, including an inability to yell at or bully NPC-Ts in contrast to human players. In other words, with ranking between human players comes a need to preserve those ranks or ascendant individualism, and the mechanisms by which it is maintained. Mitigating against this social stratification—biasing the game too heavily toward one player or another—are issues of social contract that arise between human players. Human players know they need to preserve the enjoyment of other players to ensure they have teammates who continue to help them and play the game.

One significant difference between NPC-Ts and human teammates is the lack of need for a maintenance of power imbalance. When one’s teammates are NPC-Ts, there is an obvious expectation that the human player matters and the NPC-Ts serve a subservient role. Alongside this, because social hierarchy is automatically maintained, the interactions become more autocratic, more feudal, between human player and NPC-Ts. In our data, NPC-Ts were both cared for and disposable to players. This has similarities to the power structures of feudalism or monarchies as noted by Foucault, with the added reinforcement that the power imbalance does not need to be preserved through specific action. The fact that the NPC-T does not resist makes these power differentials stable. We characterize this overall impression of interaction between human player NPC-Ts as quasi-feudalistic. The primary characteristic that differentiates role is a distinction in control and agency. In some ways, our observation of feudalistic impressions of NPCs aligns with results on utility characters, or alts, by Livingston et al. [128] in World-of-Warcraft. These alts were considered ephemeral, existing to satisfy a specific goal, whether short-term—for a raid, to quest with another—or long term—as a bank to store items of value. Rather than representations of self, alts were tools.

Can we and should we moderate these quasi-feudalistic aspects of the relationship between human players and NPC-Ts? We do note that the (lack of) humanness of the

computer-controlled teammate was moderated by a hierarchy of humanisation extending from NPC-Ts with anthropomorphic tendencies through to higher levels of competence leading to a greater likelihood of acceptance as a collaborator. Underlying all of these observations is the sense, throughout our data collection, that NPC-Ts matter: They enhance the gaming experience and add realism; they protect and support the human player; they respond and interact in ways that create atmosphere. This observation drives a set of design recommendations.

## Design Implications

We now leverage our observations of NPC-T behaviour to drive design implications and recommendations.

**Encourage altruistic quasi-feudalism toward NPC-Ts by rewarding humanisation of the computer-controlled characters.** Players want to feel central to the game. Recognising and celebrating altruistic feudalism can significantly enhance the centralisation and importance of the human player. In the same way that fictional protagonists care for the "others" written into their stories without parity existing between parties [56, 193], games can reward behaviours where NPC-Ts are managed, guided, and valued. We hypothesized that magnifying the benefits of effective interaction between NPC-Ts and human player can foster attachment between human and NPC-Ts. For example, designers could make the NPC-Ts better collaborators depending on the positive interactions with the player. NPC-Ts could be more aware of their surroundings and provide better information, for example, if well treated.

**Simulate a social contract between NPC-Ts and human players.** Game designers could also simulate the development of a social contract between NPC-Ts and the human player. Obviously, the question of who will lead is already decided between NPC-Ts and humans, but justifying the decision based upon in-game actions makes the NPC-Ts appear to have more agency. Alongside the negotiation of social dynamics with NPC-Ts, one can further emphasise the relationship between NPC-Ts and each other during emotional in-game decisions. As one example, strategies involving sacrifice of a NPC-T could affect other NPC-Ts.

**Support Anthropomorphism and humanization of Computer-controlled teammates by encouraging reactive actions towards the narrative of the game.** We found that players want to humanize NPC-Ts. Supporting this humanization tendency by making the computer-controlled teammates react to the situation in the games—shots taken by players, the need to hurry through a stressful area—connects the computer-controlled

teammates to the player. In our data we see that these naturalistic reactions enhance the narrative of the game. Furthermore, games could seek to preserve information on past interactions or past missions that NPC-Ts have participated in with the human player. NPC-Ts who are killed could be replaced by new recruits. Overall, developing a shared history with a team of NPC-Ts could make more subtle the line between human-controlled and human-like.

**Encourage self-efficacy through supportive NPC-Ts.** The NPC-Ts and player's avatar in *Left4Dead2* converse with each other to indicate direction, healing of teammates, polite exchange, and strategic planning. In this sense, the AI are creating the simulated feeling of togetherness. Participants reported feeling as if they were being supported or part of a group, even in the AI conditions. From the results of the study, we note that company of AI in a game setting can emotionally affect players, empowering and encouraging them. Supportive NPCs reduce trepidation and influence perceived difficulty. NPC-Ts could provide an engaging alternative to traditional methods of challenge mitigation; rather than weakening enemies or strengthening the human player, more competent NPC-Ts could serve the purpose of difficulty adjustment.

A simplified form of this technique to empower the player has been used in the fitness game Zumba Fitness (Zumba, 2010): Increased effort allows one to increase background dancers on one's screen. In this sense, as a player's skill progresses, their character and their adversaries do not change; instead, their team changes. Perhaps they have fewer teammates, for example, requiring increasing efficacy on the part of the human player.

**Consider lying by omission about the nature of teammates.** In the field of **Dynamic Difficulty Adjustment (DDA)** one recent result notes that, if one uses dynamic difficulty to increase the parity between players, it is best to not directly inform players of its use [52]. Players can react negatively both when DDA is applied to their actions (because of the assumption of their incompetence) and when DDA is applied to their opponents (because it makes the playing field not level between competitors). This is true despite the fact that parity of skill enhances the playing experience. It seems that, most importantly, the parity of skill—from the perspective of both parties—must be an accurate reflection of actual skill levels.

Similarly, one open question for future work is whether ignorance of the nature of teammates as NPC-Ts or as human teammates matters as much as we sometimes think it does. Perhaps games can be less explicit in communicating the nature of teammates. In a virtual world, there are significant advantages to leveraging NPC-Ts to complete game teams, particularly early in the game. Over time, the nature of the different teammates will undoubtedly become clear, but, given the fact that our participants simply accepted

the nature of the teammates and reacted accordingly during truncated gameplay argues that discretion may not be exceedingly negative.

## 4.6 Limitations and Future Work

This study did not test communication between players, but the primary goal of this study was to understand differing perceptions of human and **NPC** players. A large collection of literature already exists on side channel communication between human players and pre-existing relationships [241, 240, 248], and it may be interesting to leverage these studies to understand how we can leverage side-channels in future work.

Alongside communication, any game study is limited by the fact that only a finite number of game environments can be tested. We leveraged L4D2 because it requires close collaboration with teammates, whether human or NPC-T. Collaborative games provide the best opportunity to bond with NPC-Ts and to develop positive impressions. Given the goals of our study, we feel our platform choice was appropriate. Although some of the design guidelines are hypothesized to apply to competitive or single player games, further research is necessary.

Since publication, research conducted citing this work further explores player-choices in narrative rich environments[182]. Researchers probe emotions in-play during the decision to help or leave behind the **AI**-controlled **NPCs** to understand how meaning is assigned in games[17] and what decisions players make in games regarding **NPC** characters and even monsters[100]. Work by Iten et al. explores how players value the characters that are part of the game based on emotional attachments which can include feelings of respect, idolization, and concern for the well-being of their digital friends[100].

## 4.7 Conclusion

Why do we care if our teammates are human or not? Superficially, one can simply say players are aware that the world they are in is artificial, but—with human-controlled characters—the game intersects the real world. This intersection means impressions created in-game can persist when playing with human collaborators. In other words, humans are just protecting their potential social capital, whereas with NPC-Ts that altruism will never be repaid intentionally. Of course, this perspective ignores the observations of trolling, of variable competency, and of altruism toward NPC-Ts on the part of some of our participants.

More aptly, generalizing from our themes of quasi-feudalism and social obligation, or humanization and competence, what we found could perhaps best be grouped under an assumption of human primacy in games [61], which recognizes the need for negotiation with humans and a valuing of striving with and against humans more than “others” in the game.

Overall, given the transient nature of NPC-Ts, there is nothing wrong with this belief; we advocate in our design implications that celebrating the quasi-feudalistic tendencies of human players could be encouraged through game designs that placed effective collaboration and support of NPC-Ts as a more explicitly rewarded aspect of game design.

# Chapter 5

## Personal Space in Play: Physical and Digital Boundaries in Large-Display Cooperative and Competitive Games

### 5.1 Introduction

In the previous chapter, we explored a shared in-game experience, and probed the differences perceived between playing with a human controlled co-player and an AI-controlled co-player. However, another players presence need not be only virtual. Large touch displays are becoming an increasingly common feature of today’s public, semi-public, and private environments [31]. Alongside information and advertising, they are frequently used for entertainment and advergames (i.e., games used for advertising). For example, a store may put up a large display touch game to sell a product or keep children occupied while parents shop their products. As we continue to develop and deploy large touch displays, it becomes important to understand the social situations created by adding a large interactive display in various public, semi-public, and private settings as a gaming device.

My initial motivation for this study was to examine the use of space in the physical world versus in the virtual world. Researchers have demonstrated that during large display interaction with multiple users, territorial division of the display is present [204, 178, 78]. In past research in varied task domains, it is clear that users consider screen real estate of the display and distribution is made equitably between all participating parties. However, work on display territoriality has largely focused on shared productivity or urban informatics tasks [204, 178, 78]. Across contexts such as playful interaction and gaming, designers



Figure 5.1: Workspace. In the above figure, workspaces are visible: in the first image (top) we see two large rectangular workspaces that are **fixed** to the display; in the second (bottom), we see two circular workspaces that **float**, as in, the player can re-position and move around the display.

still lack information needed to understand *how* the users allot space based on physical (real-world) distance and digital (tool use) distance. Notably, research has demonstrated that the extended-arm metaphor does not lead to freely approachable space. In other words, simply extending the users' reach alone will not result in users' freely using a shared display [58].

Given the lack of information on issues of territoriality in public and semi-public large display gaming, and given the fact that we see advergames and edugames becoming more commonplace in public and semi-public spaces [169, 170], in this chapter, we set out to explore two related research questions.

*RQ1: Do the findings of territoriality from media sorting and urban informatics tasks apply similarly in a game situation?*

To understand the perceptions of player territory, we provide players with a visible differentiation of space and counterbalance two conditions. In the first condition, players are unable to physically move into another players' physical space, but may enter using a long range cursor technique. In contrast, our second condition allows for both physical movement of a players workspace, and digital long distance reaching. By studying the two levels of potential encroachment, we seek to understand players' perception of territoriality.

Alongside basic questions of territory, it is also the case that games are complex environments and affect social behaviour of players [71, 72]. Therefore, the collaborative environment around the large display may also be affected by the game content, leading to a second research question.

*RQ2: How do changes to the game's social collaborative environment change player behaviour?*

This question links back to the question in chapter 4, but with the added confound that the changes that we probe are yoked to the physical world. To explore this question, we explore two different social paradigms for gaming: a competitive game, and a cooperative game. In this way, we can explore how intentionality (to win versus to help) impacts territoriality, both physical and digital, in large public display gaming, and inter-player behaviors.

To probe both of these questions, we created a bespoke game. The game uses a large multi-touch display to allow two players to battle against incoming enemies to protect the earth. Each player has a dedicated workspace (their own ‘space ship’) in which they operate. Two forms of workspace conditions are shown in Figure 5.1. There are two conditions. In the cooperative condition, the players have a combined score (enemies killed & earth health). In the competitive condition, the game still focuses on a cooperative goal (earth health), with the addition of a competitive element (individual scores). Through a mixed methods analysis of physical positions, digital touches, and interviews with player pairs, we find that factors such as skill level with the device or input methodology and the application’s level of collaboration impact how users’ approach gaming interactions on a large, shared display.

The remainder of this chapter is organised as follows: we first review relevant literature. We then detail the game, the experimental methodology, and outline in detail our measures before proceeding to the results of the study. We conclude with a discussion of territoriality between co-located users playing a game on a large display and a discussion of the implications of our findings for co-located multi-touch large display games.

## 5.2 Related Work

In this section, we provide an overview of large display research, large display gaming, and gaming and territoriality.

### 5.2.1 Large Displays

Large, multi-touch displays ( $> 3m$ ) are increasingly common in private, semi-private, and public settings. For example, shared large displays can help workers collaborate on an idea in meeting rooms, provide status information in control rooms, or provide access to location-specific information in shopping malls. A significant body of work has been conducted on various components of the large display experience, including but not limited to, sensing multiple users [203, 200], interaction techniques [54], physical proximity [6, 246, 67], and how

collaborating users carve up large displays into personal and public territories [204, 251, 253]. The interplay of these factors are apparent in the observation of multiple user displays.

As users divide the display, we observe reaching and encroachment into claimed territory; this territorial division and practice of dividing space is what is referred to as territoriality [204]. While the interaction between users continues, we see an emergent pattern of movement called territorial flow [115], i.e. an evolution of personal workspace based on content accessed and created on the display. As we design displays for multiple users, territoriality on large display research become increasingly important as we begin to consider the larger topic of space surrounding large displays and how this surrounding physical space impacts perceptions of on-screen territoriality.

It is now inexpensive to tile large arrays of displays together and to support interaction with these displays [252]. Only a small number of studies have begun to look at how current theories and observations on territoriality hold as displays scale up – beyond 3m, for example. Consider, as one example, research on reaching techniques, specifically work in arm embodiment [58]. To motivate this work, researchers note that, in collaborative tabletop use, users avoid crossing others' arms, and so researchers leverage digital arm embodiments to support cross reaching, i.e. tools that allow users to digitally cross arms without physically encroaching. These *virtual arm* metaphors allow users to interact with distant content on a display, but then physical proximity and digital workspace becomes decoupled. The question then becomes: does digital workspace matter in this instance, i.e. do users reserve on-screen space [178, 89]? If not, then can users exert any ownership over display space? If so, then how is the digital workspace expressed? Is it space near the cursor, personalised content (regardless of position), or space physically proximal to the user (even if distant reaching is permitted)?

Hall's theory of proxemics [85] and concurrent work by Sommer [210, 209] may provide some insight into these questions. Hall's theory of proxemics [85] specifies ranges of personal space which radiate out, from intimate space, through personal, social, to public space. Sommer's work [210, 209] discusses how definitions of personal space are moderated (e.g. by relationship, culture, and environment). The study of proxemic and spatial relationships is an important component of multi-user technology design, because it has lead to a better understanding of design for spatial orientation of multiple devices[259], environmentally aware software [8, 149], and interaction techniques [258]. Additionally, work in this area reveals information about collaborative use [78, 251, 132], play[162, 44, 145], and the comfort of the individual user [205, 28, 144, 143, 142].

### 5.2.2 Large Displays and Gaming

A number of researchers examine shared-screen gaming. Within this space of shared screen gaming, Voda and Greenberg [248] examine console gaming in the home to discern issues surrounding shared, private setting, display use. They note that the shared nature of the gaming display creates a computational meeting place and fosters interaction across abilities. Similarly emergent research complements this finding by inspecting how the shared attention to a stimulus is capable of creating a cooperative in-person environment [269]. Benefits of gaming also include a social scaffold for communication [240, 174] and face-to-face interaction [111, 269]

Combining large multi-touch displays and games in a variety of contexts is a natural progression of these trends. Playful interactions on large displays help attract users, benefiting designers [87, 98]; in synergy, playful interactions on large displays can benefit users by allowing a space for social interaction [249, 31, 220]. Additionally, the platform of a game can be used as a technical probe [73] to explore the evaluation of natural user behaviour around multi-user technology and as a method for understanding user interaction and perception.

Designing the playspace is unavoidable in digital games. Specific organization and presentation of visual elements of a playspace are crucial for creating a game environment and guiding players on how to play the game. Furthermore, the design of playspace in multiplayer games gives players a sense of the expected and contextually appropriate social interactions. For example, giving players a large open space with limited resources in the middle arguably prompts competition. Meanwhile, dividing space with ample resources has a less competitive connotation.

Moreover, players will need to explicitly or implicitly negotiate space in the gameplay area. In other words, players need to establish a working space or territory [115]. As players begin to negotiate space, the concept of encroachment is unavoidable. Encroachment maybe intentional or unintentional, actively avoided or ignored, and occurs in every gameplay condition: including cooperative and competitive gameplay [101].

Consider that games are played in the ‘magic circle’ [201], which implies that the game provides a sand-boxed playspace providing rules and rewards that cause the user to take actions that they may not otherwise [144]. Simultaneously a game has to exist within boundaries of the real physical world. Additionally, even within games, boundaries of space can necessitate gameplay actions and enforce play styles based on the available territory that constrains gameplay actions. The combination of these two game factors creates both incentive for physical encroachment into another players territory and the social

permissiveness to do so (i.e. “I can do this because its ‘just’ a game”), thereby allowing researchers to understand physical encroachments in large display gaming. Past research shows that people using large displayed establish their own digital territories based on how they define their personal space on the digital device [204]. However, little is known about mechanisms of dynamic appropriation of one’s digital space and corresponding social perception of invasion behaviours in multiplayer games on large displays.

Moreover, multiplayer games imply players working synchronously or asynchronously towards common or conflicting goals. Thus, in a multiplayer game environment, establishing, maintaining, and crossing boundaries becomes part of the playful interaction. Correspondingly, exploring such game environments for co-located users presents interesting opportunities for understanding dynamic assignment and violation of one’s digital gamespace.

Often, game design itself facilitates the establishing of boundaries of a player’s digital space. For example, in Overcooked 2 [125], the design of the playspace augments the collaborative challenges of the game. Some areas of the game feature space purposely assigned by the game that imply the actions for each player (e.g., cutting, assembling, serving food). The delegation of tasks becomes the responsibility of individual players as the game progresses with open spaces where multiple players are able to access different tasks. Players are expected to self-delegate gameplay interactions.

In this chapter, we explore dynamic assignment of one’s playspace in multiplayer games. Specifically, we present results of an empirical study aiming to understand the mechanisms and social perceptions behind encroachments in digital (on-screen) and physical (off-screen) space.

### 5.2.3 Gaming and Territoriality

Understanding territoriality in games is important for understanding not only how users share resources in game, but also for understanding the user’s cognitive model of space. By better understanding the user, we may design games that are better suited for collaboration or competition.

Although previous literature has indicated that the physical placement or position of a large display can affect the play experience of the users [174], we see limited research on territoriality in games. Overall, the literature is not very conclusive with the largest area discussing violations of other people’s territory while playing Pokemon Go [4, 175] and in *exergames* [165, 162, 164]. In this chapter, we move forward to look at digital in game territory and physical meta-game territory.

Space is an identified resource in games (e.g. territorial acquisition games such as Risk [120]). In Cooperative or multiplayer games, space can also be unfairly shared. For example, when you can not keep up with the other player(s) in Spelunky [285] you will die in game, forcing the lead player to wait and creates challenge in the game. Another example is Smash Brothers Ultimate [189], in which players are essentially violently competing for screen space by attempting to kick other players off the screen.

## 5.3 Game Design

To explore our research questions, we designed a computer game based on the space invaders trope. We characterize our game as arcade-style with a single, shared task and view, i.e. a *tightly coupled, single-view, common-goal* gaming experience. The game was purposely designed to test the boundaries of personal space and encroachments (i.e., the game served as a technical probe) [73] meant to stress what we know about collaborative interaction behaviours to better understand collaboration and territoriality. Figure 5.1 captures participants playing the game.

### Gameplay Walkthrough

**Room Setup:** The study was conducted on the Powerwall display, a custom build composed of 8 monitors under a glass overlay which uses cameras to capture user touch data. The size is a total of 413 x 117cm, with an overall resolution of 7860 X 2160 pixels and a dot pitch of 48 dpi.

**Workspaces:** Participants each get a workspace (spaceship). Workspaces could be fixed (top) or floating (bottom).

**Tools:** The goal of the game is to save Earth enemies that will ‘attack’. User’s defend the Earth by targeting the enemies using the colour-matched tools. Each tool has a different interaction method. The red tool (Canon) is a direct tapping tool, the blue tool (Black-hole) is a lasso tool, the green tool (Shield) is a drag tool, finally, the purple tool (Magnet) is used to steal weapons by tapping inside the other user’s workspace. Tools can be used short-range (within their workspace) or long-range (outside their workspace).

**Competition vs. Cooperative Play:** In competitive condition, individual scores are located on the boarder of the player’s workspace. In the cooperative condition, there is a shared score on the Earth. Each enemy is worth +5 points, enemies that hit the Earth are

worth -1, scores are not limited. The experimenter will remind participants of their score on breaks.

**Game Progress:** Enemies come in waves, there is a total of 12 waves with a break in the middle. The game ends when all enemies are defeated.

### 5.3.1 Game as a Stimulus

To explore personal space and encroachments, both digital and physical, we include two different styles of interaction: direct touch interaction, and distant reaching interaction. An encroachment is defined as either a digital encroachment, i.e. the use of a tool and distant reaching to destroy enemies on the side that the player does not originate from, or a physical encroachment, the physical movement onto the other player's side of the display in the physical world.

To encourage encroachments, we designed the game with multiple opponents and one set of shared tools needed to defeat those opponents. Different *weapons* (i.e., tools) were used to target different opponents: a green shield tool to target green opponents such that green opponents vanished when they touched the green tool; a red cannon tool to target red opponents such that red triangles vanished when the red cannon was used to click on them; and a blue black hole tool to target blue opponents such that a loop that self-intersected would eliminate all blue opponents within the loop. Finally, we designed a magnet tool which could be used to acquire a tool from an opposing player by placing the magnet on a tool within the other players workspace, thus *stealing* the tool.

To study how social factors influenced perception of encroachments, we included two different gameplay modes (cooperative and competitive). In cooperative mode, players worked together to defeat enemies attacking the earth. For each enemy targeted successfully, players would receive 5 points on their communal score. Each enemy that made it past the players defences and hit the Earth cost participants a point. Additionally, failure to stop enemies resulted in a reduction of the overall health of the Earth, causing the earth to turn from blue-green to grey-brown. Scores had no upper or lower bound. In the competitive mode, the goal did not change: players were still tasked with keeping the Earth safe from enemy invasion, but their scores were separated and the player with the highest score won. In the competitive condition, a player cannot win the game without encroaching on the space of another player - i.e. both players strictly adhering to their assigned sides will always result in a draw. These parameters resulted in a tightly coupled (joint task), single-view (one screen), common goal (save the planet) gaming experience.

Alongside encroachments using distant reaching tools, our experimental design seeks to probe whether personal digital space is perceived to be space proximal to the user [204], space at their point of interaction [178], or some combination of the two. To probe this, we designed two workspace conditions: fixed and floating. In the fixed workspace condition, as the name implies, the workspace containing user tools was anchored to a single physical location on the display. In the floating condition, participants could re-position themselves physically. Consequently, allowing researchers to restrict the types of encroachments that can occur. See Figure 5.1. The use of visual boarders and clear workspaces is an important design consideration of the study. The game is designed so that all encroachment is intentional – the middle of the screen is clearly delimited by the ‘neutral’ zone where tools are stored, again shown in Figure 5.1. This neutral zone remains present in both conditions of the game.

Workspace conditions are linked to encroachments as follows. In the fixed workspace condition, we allow digital encroachment by spawning a cursor in their area and digitally reaching to the other player’s side, but physical encroachments are ‘not allowed’ by the game rules. ‘Cheating’ by touching the other player’s space in the competitive gameplay condition increases the the opponent’s score, so physical encroachments are, in fact, penalised. In the floating condition, the player is able to make both physical and digital encroachments by either spawning a cursor in their area and digitally reaching to the other player’s side or by physically moving their workspace to the other player’s side.

### Direct versus Distant Interaction Techniques

As noted above, to allow both physical and digital encroachment on digital territory the task featured both direct and distant interaction techniques based on the hybrid pointing paradigm [66, 54]. The interaction techniques are shown in Figure 5.2. In this Figure, we see two different interaction techniques: direct techniques distant-reaching techniques. In the direct techniques, participants placed the tools using direct touch (e.g., by tapping on the display, dragging a tool to a location, or by performing a looping gesture around *opponents*). To perform distant interaction using hybrid pointing techniques, the player would use his or her non-dominant hand and place three fingers on the display at the location of the desired tool, invoking hybrid pointing mode. To demonstrate that hybrid pointing was active, the three contact points would be surrounded by a large circular region (see Figure 5.1, bottom). Then, using a finger of the dominant hand, players could move a telepointer around the display and perform actions by *casting* a cursor off-set from their finger position and with control-display gain adapted such that longer-range, indirect pointing movements could be performed.

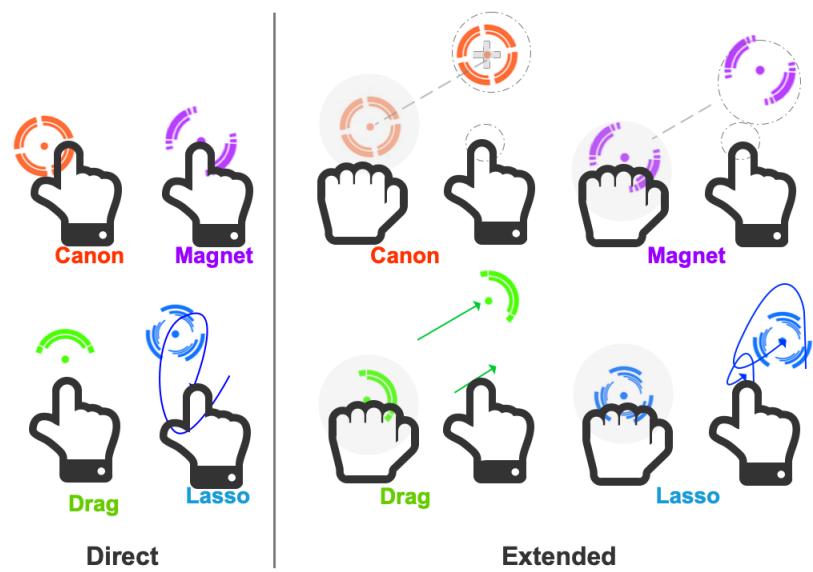


Figure 5.2: Interaction Techniques: Direct: a single handed direct touch technique b) long-range: two handed extended touch technique using one hand to anchor to a spot on the screen (three or more fingers), the single touch outside the exclusion zone (grey circle formed by the anchored hand) spawns a telepointer which can access distant display locations.

## **5.4 Methodology**

Our protocol includes the collection of both quantitative measures (e.g., participants' physical placement, touch points, and tool use in different conditions) and qualitative measures (e.g, semi-structured interviews and observations). The study was structured as a  $2 \times 2$  mixed experiment. The independent variables for the study are the game's cooperative mode and competitive mode (a within subjects factor) and the two workspace modes: fixed or floating (a between subjects factor).

### **5.4.1 Equipment**

Participants played the game on a Powerwall, assembled at University of Waterloo. The Powerwall is composed of 8 monitors for total dimensions of  $413x117\text{cm}$  with an overall resolution of 7860 pixels X 2160 pixels and a dot pitch of 48dpi. A PQ Labs infrared 32-point touch-sensing display frame was mounted on a plexiglass overlay and used to collect touch data from the participants. Three cameras (and audio) were set up to capture participant movements, and positions. Figure 5.3 illustrates the study setup.

### **5.4.2 Participants**

In total, 32 participants (16 adult pairs) from both the local community and the university participated in the study. For attribution of qualitative data, the participant numbering scheme in this chapter indicates both workspace condition, participant pairs, and starting position. Specifically, numbers beginning with  $10X$ ,  $X=[1,8]$ , are assigned to a playing pair (both participants in one pair have the same number) and indicate that the playing pair was assigned the floating or unanchored workspace condition. The fixed workspace condition participants have pair numbers in the  $20X$ . Furthermore, participants within a pair are denoted with A or B for either starting on the left or right side of the display respectively. Therefore, participant 102B would be, with participant 102A, part of a floating workspace playing pair, and participant 102B would have been assigned a starting position on the right side of the display.

Because players may approach a large display either with friends or individually, we allowed participants to sign up either as pairs (26/32) or individuals to preserve ecological validity. While aspects of social dynamics were impacted, we leave relationship analysis for future work because perceptions of territoriality – our current focus – generalized regardless of pre-existing relationship.

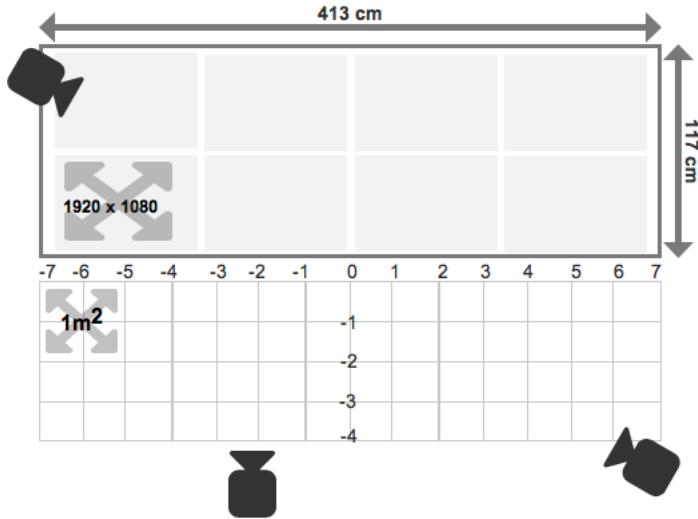


Figure 5.3: The setup of the experiment equipment. The x-axis represents the width and the y-axis the height of the display (cm). Major grid lines denote the boarders between two consecutive displays combined to make the overall large display.

### 5.4.3 Protocol

Participants were given a walkthrough of the experiment before written consent was obtained, and then filled out a pre-study questionnaire. Participants were given a tutorial and short practice session to that their choice between direct and long-distance touch techniques was driven by their willingness to move through space and/or to encroach digitally on space, not by skill or novelty effects. The ordering of cooperative and competitive conditions were counter-balanced between participant pairs, and workspace conditions were split equally between participant pairs (8 pairs in each condition).

### 5.4.4 Measures

We looked at three main areas of interest: a) the physical space in front of the display, b) the users finger touch points, and c) the digital in-game cursor.

## **Physical Position**

The grid pictured in Figure 5.3 illustrates the grid in which participants stood while interacting with the screen. The grid is representative of a Cartesian plane with the x-axis representing the position in front of the screen. Participants' position was coded using video footage sampled before play (T0), after 30 seconds of play (T0.5), and every additional minute after play (T1.5-T3.5) for a total of five samples. Each condition was coded after the half-way break point at the beginning of the level marked by the wave number appearing on the screen; this coding strategy was used to best represent participant performance, and to reduce learning effects and discomfort with the rule set. For distance between two participants, the number of units ( $\frac{1}{4}m^2$ ) to the nearest whole number was recorded. Participant's coordinate position was based on the position of participant A's right foot, and B's left foot. Coded times were accurate up to one second with the most stable (unmoving) position within the one second interval recorded.

## **Physical Touch Points on the Display**

We record physical touch points on the display to further compliment position data and understand proximity between players, technology, and their surroundings. The data was prepared for analysis by filtering for incomplete or unidentifiable touch points (e.g., not in the neutral zone where tools are stored). Following, the touch data was sampled for a random subset of the data in intervals of 50 samples per data point for a total sample of > 50000 data points.

## **Digital Position: Enemies Killed**

We recorded participants' interaction with the display and their actions within the game (spawning cursors, using direct touches or long-range interactions, where enemies were targeted, and by whom). We used the point of enemy defeat to determine locus of digital interaction. We designed our game to force the emergence of territorial behaviour, we gave users the option to use short-range interaction tools in the form of direct touch, and long-range interaction tools using extended touch with the cursor. Due to recording issues 29 participants were used in the quantitative analysis of digital targets (enemies killed) and from those participants two points of data were removed as outliers. Over 11000 points were analysed.

## **Behaviour: Interviews and Observations**

At the conclusion of the two game conditions, the researchers conducted a semi-structured interview aimed at understanding the relationship between personal *digital* space and personal *physical* space. The interview explored factors that contributed to observed behaviour and participants' self reported thoughts and emotional reactions; for example, participants were asked about their comfort level with the other participant and whether there was a pre-existing relationship. Participants were also asked about how the game conditions affected their use of space and comfort with their distance to the other player. Emphasis was placed on understanding how comfortable they felt traversing the digital and physical area and what factors contributed to these feelings of comfort or discomfort.

During gameplay the researcher also captured field notes and noted discussion points for the interview (e.g., strategy, explanations, 'trash talking'). This information was cross-referenced with full video coding to ensure data was consistent and complete. The results of these observations and coded video data complemented the interview data and contributed to the analysis conducted.

The qualitative data gained from the interviews and the observations were analysed using open coding [219, 218, 41] to cluster information. We labelled these clusters, then performed axial coding to identify higher-level themes. For axial analysis, we were particularly focused on themes that explored the interplay between physical and digital territories. Saturation occurred early in our qualitative data – after six pairs, three pairs per workspace condition – but sixteen pairs were necessary to ensure statistical power for mixed-methods analysis. The videos were coded based on user action tags. Videos were coded for physical and digital encroachments, visual consideration of the player's body as they perform tasks on the display, competitive (negative) social interactions and collaborative (positive) social interactions. The list of tags included: **Physical**: (Touching Workspace, Touching Person, Holding/Inhibiting), **Visual/Physical View**: Stepping Aside, Blocking, Mutually looking past each other (but remaining on respective sides). **Digital**: Cursor over, Workspace Over\*, Block with Workspace\*, Push/Repel with and Workspace\*. Note the \*symbolising Floating condition only. Exchanges between participants were also analysed for cooperative and competitive exchanges. Participants were reminded to speak in English (the language of the institution) and exchanges that were not in English were not coded. The list of social tags included: **Negative**: Encouraging Aggression, Insulting, Swearing or Trash Talking Opponent, Swearing (not directed at opponent), and Complaining. **Positive**: Discouraging Aggression, Collaborative Exchanges, and Coordinating.

### 5.4.5 Video Coding

During the experiment, the room was arranged with three cameras simultaneously recording the participants' interactions along the span of the large display, physical movements across the floor including the vertical space directly in front of the display, and touch points as participants made contact with the display surface.

#### Video Coding Protocol

To process the video data, the experimenter first watched all the videos of players in the cooperative and competitive conditions. Secondly, the experimenter re-watched the videos and took notes on the overall dataset to begin to produce tagged actions which revealed information in accordance to the goal of the study: "to gain insight into the mechanisms of establishing and maintaining users' physical and digital territories, we analyse territorial interactions in cooperative and competitive multiplayer gameplay". A final run through of the videos was done and details of participant actions were recorded with corresponding timestamps.

Codes used in the analysis of this data were based on user action. Each code was recorded with a time which corresponds to the action in the video. The tags used are summarised in the following categories:

**Physical:** Touching Workspace, Touching Person, Holding/Inhibiting **Visual/Physical View:** Stepping Aside, Blocking, Mutually looking past each other (but remaining on respective sides. Digital: Cursor over, Workspace Over\*, Block with Workspace\*, Push/Repel with and Workspace\*.

Finally, we look at the social interactions or exchanges between participants. We sort these social interactions into **positive** (cooperative) and **negative** (competitive) exchanges. The list of social tags included:

**Negative Social Interactions:** Encouraging Aggression, Insulting, Swearing or Trash Talking Opponent, Swearing (not directed at opponent), and Complaining. **Positive Social Interactions:** Discouraging Aggression, Collaborative Exchanges, and Coordinating.

In addition, observations in the form of notes and comments were recorded in a separate column to document the interaction in detail and explain the choice of tag. Tags were recorded as either A, indicating the participant who's starting side was on the left or B, on the right.

## **Analysis of Tags**

To understand the dispersion of actions across the competitive and cooperative game conditions, we analyze the data to understand the proportion as a percentage that the tag comprises all tags for each individual play session. We start by counting tags for both players as they appear over the course of the video. Then the number of occurrences for each category was added together and divided by the total number of tags. We repeat this process for every dyadic player pair. Lastly, the tags were presented by factors: workspace (Fixed or Floating) and social game condition (Cooperative or Competitive) to give a percent of in-game interactions labelled by the tag.

For example, In file 101 (Fixed), we count all instances of the Physical tags (Touching Workspace, Touching Person, Holding/Inhibiting) and divide it by the total number of tags in the session. After completing this for all sessions, we then average the proportion of the Physical tag across participant pairs. We present this number as a percentage.

**Summary Tables** The tables below summarize the tags by category. These results were used to triangulate the findings between multiple forms of data collected. Table 1: Summary of the proportion of tagged events for each combination of variables tested.

Table 2: Average of the proportion of tagged events for each combination of variables tested.

## **5.5 Results**

This study aims at understanding the perception of socially acceptable behaviours around invading one's digital and physical space in a multiplayer game. Thus, we first wanted to understand how people thought of their own space. We then focused on the permeability of the boundaries between physical and digital spaces; how it is affected by the style of player's interactions (collaboration vs. competition). We found that the perception of social appropriateness of invading one's space is nuanced and multi-faceted. Besides the interaction style, perception is affected by the means used for crossing the boundary, and the balance between players' achievement level. Finally, we looked at the players' social expectation on appropriate manners and perceptions of their violations.

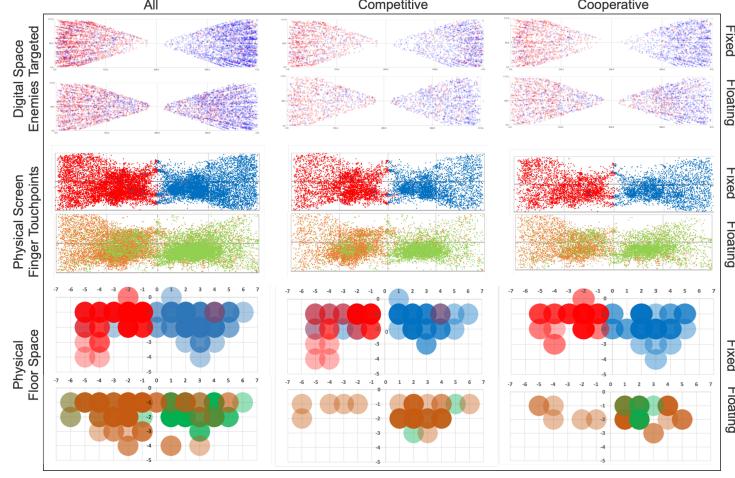


Figure 5.4: The visualizations of the participants position on the floor (bottom), finger touch point position (middle), and finally their digital position in the form of where they killed their enemies (top).

### 5.5.1 My Starting Side is *My* Side

We first looked at where people position themselves across the display. We found that participants thought of their starting side as ‘*their*’ side. The finding is visualised in the heat maps of figure touch positions, see [Figure 5.4](#).

Using an independent-samples t-test with variances unassumed, we found that distances in which participants targeted enemies based on their workspace centre  $t(11329.859) = -6.717, p < 0.0001$  demonstrating differences in targeting distance based on participant side with the right side targeting enemies farther away. Participants prefer to target enemies closer to the centre of their workspace  $t(11376.429) = 31.973, p < 0.001$ , suggesting that participants move their workspace to target enemies or wait for enemies to approach in the floating condition. In the floating workspace condition, participants were significantly more likely to target enemies nearer to their workspace’s starting location ( $F(1, 60) = 7.481, p = 0.006 < 0.05$ ). This means that personal digital space is linked to the physical location of the user. For fixed workspaces, we find even stronger adherence to separate sides. Significant scores demonstrate participants choosing to kill enemies on their side  $F(1, 6017) = 51.31, p < 0.001$  vs using the distant reaching tool to kill enemies on the other player’s side.

One goal of our game design was to ensure that participants felt a sense of ownership;

only with territorial ownership can encroachments be perceived. Our qualitative data highlights this sense of ownership: P107A “*I think of the left side as mine ... probably because I started there. even when he came over it was like: ‘ok, he is on my side’.* Both the floating and the fixed workspace condition divide the screen into perceived sides: P207B “*We were sharing the tools while we were competing and collaborating but I felt that we had two different parts of the screen, two different screens*”.

### 5.5.2 Physical Encroachment is Highly Disruptive

Participants felt that physical encroachments were to be avoided as much as possible. Participant 108A explains that they put in effort so they would not be physically disruptive. Some of this was based upon not contacting the other person:

108A “*So, if you are doing anything competitive with anybody else, often there is a physical space that you are going to occupy[...] you don’t want to step on anybody when you’re busy engaged in a task, right?*”

However, the idea of physical intrusion was stronger than this. Even in the floating workspace condition, where participants could choose to cross into the other person’s space, this encroachment was not desirable. P108B reported in the floating workspace condition: “*There was a moment when we changed sides, I felt really weird here.*”

From our qualitative interview findings, we note that participants had a strong expectation that boundaries would be enforced. On the other hand, the boundaries participants expected the game to follow and track were not digital boundaries, but instead physical ones, relative to their position

P102B “*I re-centered myself [on the right side] expecting my bubble to reappear and I saw the enemies already start, and I was like: ‘what! wheres my circle?!’ It was on [his] side!... and you go through that all in your head: ‘What if it’s stuck? What if [he] stole it from me!?’ ”*

### 5.5.3 Distant Reaching is Less Disruptive

Participants found distant reaching less disruptive and treated it as more of a tool than an intrusion into the other person’s workspace. In support of this, we see no significant differences for long range digital reaching, with similar numbers of enemies killed in each condition (43.75/ 35.7% competitive, or 43.54/51.8% cooperative). Qualitative data confirms that this was considered a lesser encroachment (“*I didn’t perceive it to being a distraction*

*or intrusive or I am bothering him*", P108A). Similarly, users feel that the digital cursor was far less disruptive than physically being in someone's space.

P107A "When he was directly in my space, it was like: 'get the hell out of here!' that was just more of taking up more of my perception of the game because the smaller thing [digital long range cursor], I could ignore but he was there or his giant workspace was there[...]."

#### 5.5.4 Cooperation Makes Boundaries more Permeable

One question we examined was whether our cooperative condition engendered different playing style than our competitive condition, i.e. did players truly compete. Analysis of the cooperative and competitive condition in both floating and fixed workspace conditions shows participants are less likely to target distant enemies in the cooperative condition. We calculate the distance between the targeted enemy (enemy killed) and the centre of the participants workspace and compare means for the two social conditions  $t(10928.942) = 7.757, p < 0.0001$ . Additionally, we see that enemies stay alive longer in the cooperative condition when analyzed with a t-test, equal variances unassumed  $t(11142.055) = -4.863, p < 0.0001$ . The combination of these two results suggests less aggressive play in the cooperative condition.

Observations of player's social behaviour reveals that in cooperative conditions 40% of behavioural exchanges were tagged positive. In contrast, in the competitive condition, the prevalence of this tag falls to 17%. For a summary of the observation, please see the supplementary material. The qualitative results further complement these findings. When participants discussed their experiences playing cooperatively, they often discussed a division of responsibility, or a partitioning based on game mode.

"Division of responsibility, right? You take care of that side, I'll take care of this side." ... "As soon as it's competitive, everything is everyone's responsibility." [P205A]

Following from the above perceptions, the cooperative and competitive condition made a difference for how many times players would cross the border. In general, more touch points were made on the opposite side of the display during cooperation. We demonstrate this statistically by comparing the percentage of all touch points on the opposite of the display  $\bar{x}_{coop} = 63.0$  or 59.06%  $> \bar{x}_{comp} 53.1$  or 40.94% via a comparison of means  $t(23) = 1.714, p = 0.0599$  (one-tailed) and  $2.069, p = 0.120$  (two-tailed).

We explored the count of 'enemy kills' for the floating condition with direct touch on the opposite side:  $t(13) = -1.799$  (one tailed) or  $1.771$  (two tailed),  $p = 0.0476$  (one-tailed t-test) and  $p = 0.0952$  (two-tailed t-test) for  $\bar{x}_{coop} 60.6$  and  $\bar{x}_{comp} = 32.3$ . We also can observe this effect qualitatively:

*"I guess, when we were doing cooperative play, I'd say it was very- I felt like I had more access to the other person's side of the screen, cause we were working together. When we were doing competitive play, I definitely felt more of an invasion of space. "* [P204B]

*"I felt like being more gracious to letting him being there in the cooperative mode, and more like" ;\*exasperated sigh; " 'he's there' in the competitive mode."* [P107A]

Finally, although boundaries are more flexible in the cooperative condition, participants still report that they felt more comfortable when they were being asked for help than offering unsolicited help. P108 explains that despite shared goals in the game (e.g., keeping the earth alive, gaining and maintaining score) participants would only warn the other person of dire conditions on their own half of the screen. This leads naturally into an analysis of the negotiation that leads to acceptable territorial violation.

### 5.5.5 Good Table Manners

Our results demonstrate that perception of good intention impacts perceptions of encroachment. Understanding one's intention was important to players. Consider that even in the cooperative condition, participants telegraphed their intent during action. For example, P102B states when speculating on a non-game task—file passing—said they would try and communicate with that person. *"If I need to interrupt their side, I would verbalise what I was trying to do."* This does not imply asking for permission, but instead ensuring that to the other user their intent is televised and recognized as altruistic. Participant 207A explains this need for clarity in intention well:

*"During competitive, I felt like a worse person for going to their side and stealing all their points.[...] Whereas [cooperative] the reason i did it was to help them out sort of thing.[...]it depends in terms of what my intent it was, one of them was to steal points, the other was to be useful."*

In the competitive interaction, it was a matter of: 'how aggressive can I be?' versus the cooperative version: 'how polite do I need to be?'. For example, when describing obtaining items, P102A explains this in terms of *table manners while eating*:

*"Common etiquette! [...] if we are having a meal, and I just reach over your food to grab something without saying anything."*

A possible explanation for sharing intention is to convince other players that the action is within the permissible space negotiated by players in advance of gameplay. In other words, we are witnessing the negotiation of a social contract [266] that dictates which actions are acceptable.

### 5.5.6 Equality and Diplomacy in Games

Extending this point on acceptable action, while participants commented on the need for common etiquette or *good table manners*, and, while we see a respect for sides in gameplay, gameplay was designed to encourage encroachment and – in the competitive condition – create conflicts regarding territory. We observed that some dyadic pairs engaged in physical altercations (e.g., pushing, holding, shoving, and hip-checking) due to this conflict. However, there were also pairs that engaged in pre-game negotiation, metaphorically similar to an establishment of *jus in bello* or ‘rules of war’ to guide interactions. Three pairs made verbal contracts not to compete at all. Reasons for this included feeling that skill and aggression levels were unequal. Of these pairs, only one violated the verbal contract. Further, although some participants felt that competitive gameplay did afford some permission for aggressive play (i.e. crossing spaces), participants still needed to feel that the other person was reciprocating this action for them to have unspoken permission. When participants violated agreements or were significantly more aggressive than the other player, they often apologized or encouraged more aggression from the other player.

*“Even with the competitive[...] it was still like: ‘OK, if I don’t want to steal his stuff or get in his way, I don’t have to.’ But I can when I really want to annoy him.”* [P107A]

It was made clear by some that they violated a social contract that they normally would not have in non-competitive/non-gameplay interactions. P202A explains that there was an established contract “*because we are friends, and ’cause at the beginning I said I was not gonna steal the tools from you’ and stuff, but then I totally did. You kinda feel like a Shithead for like doing that, but its like the point of the game*”. When behaviours were not reciprocated, it placed strain on the interaction and player relationship. 207B explains that due to 207A’s overly competitive behaviour, 207B was upset with his actions and yelled “*get out of here!*”. They explain:

*“I felt that he had an advantage, and I felt like he was already winning, and I was starting to get a little tired of that.”*

P207B also explains that due to this, she was less willing to collaborate afterwards (for this pair, the collaborative condition followed the competitive condition). Extending this point, regardless of the overall cooperative goal of saving the Earth, if a single player was very overbearing or overly helpful it can pose a social problem. For example, in the case of pair 207, one person greatly surpassed the other in skill; the more skilled player attempted to hold back until the situation was critical.

*“I used the magnet less during cooperative. She isn’t an experience player and I could see that she was frustrated with some of the the mechanics so further exasperating that, did*

*nothing for anyone, sort of thing. Except for the times when it was mission critical to save earth. ”* [P207A].

It is also clear – within the analysis of rules-of-war vs good table manners, that the feeling of being invasive went beyond that of the competitive condition. For instance, participant 205B explains that it is similar to the workplace:

*“If we are working on two independent [cooperative] tasks, then yeah no, I wouldn’t feel compelled to touch his side of the screen, that would be a breach cause I have nothing to do with a task, right?”*

Simply, players needed to balance their social and competitive priorities to be good opponents. P108A notes *“In the trade-off between, yes, optimising a high score and not being offensive to somebody, I would choose not being offensive to somebody.”* The participant P108A went on to continue to explain that this choice was a consequence of their personality.

Similarly, participants felt that their level of disruption was consideration they made before taking an action:

*“it’s different if you steal a tool and the person doesn’t really need it any more[...] vs. if you steal it when they are right in the middle of using it then that’s more of a jerk move.”* [P202A].

Prevalent in these conversations there is the constant thread of manners and social politeness.

*“To that end, in competitive, I made effort not to it too often because it would be seen as antagonistic and combative[...] like the polite thing to do”* [P207A].

### 5.5.7 Physical Meta-Game

As expected in competitive games, researchers observed aggressive behaviours and strategies in the digital space. In the game players could use the magnet tool to steal another player’s tool. Additionally, strategies may be introduced in the game to the detriment of their opponent. Participant 201A is an example of how strategies in the digital space can be used to maintain control of the game.

*“It was that I want him to be half way doing it, so he was committed something, Because if he was most way around a lasso or maybe even half way, he doesn’t realize it was happening, he is going to continue his motion, and that gives me more time ”* [P201A]

The physical presence of a player also affords physical actions such that the physical space also became a playspace. Physically imposing players could choose to leverage their

physical presence in this extended gamespace to their advantage. A subset of players who choose to play aggressively demonstrated behaviours akin to *griefing* in digital games. For example, experimenters observed players steal the workspace of their opponent and shove it in a corner out of reach. This is particularly interesting since it is somewhat akin to stealing the other player's controller. Some players also engaged in physical altercations such as blocking the other player from the display or using their body to force players away from their own side. Players discussed how physical confrontations may be a possible part of gameplay, despite rules and ethical considerations being against physical altercations. For example one couple commented:

*[The competitive mode] felt this could be the first physical e-sports ... without rules how far can we go? Can I wrestle him?* [102A]

Players also leveraged their physical bodies to make threats of reciprocation to gameplay actions. For example: 107B explains that although they did not physically engage with the other player *"it was more like fun, I didn't really wanted to. It was like 'hey I could block you if I want"*. In the 107 pair, the threat of physical engagement was answered:

*I didn't really perceive him as physically blocking... I think of myself as stronger, I could ram him out of the way if I have to ... it was more like a challenge not like an obstacle that I had to overcome.* [P107A]

Other players also took advantage of the physical playspace in a less overtly aggressive strategies such as using distractions or occluding parts of the screen with their bodies.

*I mean, if it was a game, just a friendly competition, then I might intentionally try to do something that would distract them in order to maximize my own score relative to everyone else.* [104B]

The physical scale of the display enabled aspects of this physical meta-game. As one example, while engaging with the multi-touch display, it was physically harder to see the whole screen and often players interrupted their gameplay to take a step back and survey the game area. At this point in time, another player could move over and physically block their access to their workspace. As another example, they could also take advantage of this difficulty seeing the entire display to engage in opportunistic griefing; by noting when their opponent was attending to a specific part of the display, 204A was able to use the information provided by physical co-presence to time digital actions in game. In the following quote, 204B describes being on the receiving end:

*Argh! Frustrated. I'm going to go kick him, no. Yeah, no, frustrated. Cause I was trying to do something, say like, over on the far end of my screen and suddenly because of this little thing he did closer to the middle, sorta out of my line of sight [...] has it just glitched on me? Or has [204A] just gone and taken my controller?* 204B.

Finally, in the same way gameplay needed to be negotiated to determine appropriateness of action, the physical meta-game was also subject to negotiation and accommodation of perspectives of both players:

*“I mean, depending on the individuals in question, my assessment of whether they would be OK with that. Whether they would see that as just part of the game. Or whether they’d be personally offended by it, maybe I wouldn’t.”* [104B]

## 5.6 Discussion

Our contributions can be summarized as follows: First, territoriality is evident in gameplay, and—despite the playful nature—players perceive ownership of their territory. Second, the perception of distant reaching is less disruptive than physical reaching. Third, boundaries of physical and digital space are more permeable during cooperative play. Fourth, diplomacy, reciprocity, and important aspects of appropriate practice in gameplay, are negotiated either explicitly or implicitly, including aspects of “good table manners” (i.e., common courtesy) and “*jus in bello*” (i.e., the humanitarian rules of war). Finally, in large display gaming, acknowledging territoriality means a real-world physical meta-game exists alongside the digital game.

Negotiation is an important component for fostering both the physical game and respect for digital boundaries. Our participant actions and comments point to a social contract [266] that moderates the expectation and unspoken permission surrounding shared resources. The rule set guides participants in maintaining a positive social environment and indulging in enjoyment of the shared experience.

This social contract enables the physical meta-game. It allows for personal characteristics to permeate the gamespace and accounts for player personality. However, there are also drawbacks to the emergent physical meta-game that we also observed. The nature of having physical space may encourage more aggression and overt aggression may detract from some players’ experiences. Intimidation tactics become more real because of the participants actual physical presence in the game world. This may become a particular concern when deploying games in public or semi-public spaces. Further probing of the players’ pre-game social behaviours reveals that players may counteract the imposed presence of a physical body in the playspace with verbal agreements (e.g., some players refused or agreed to compete).

The importance of considering both physical and digital gamespace clearly emerges from our results. This leads us to the question: how do we design ‘behind the screen’ for

behaviour carried out in front of the screen? We conclude this section by exploring how two factors, the physical gamespace and digital territory boundaries, may be manipulated by game design.

### Leverage Display Properties to Manage Physical Gamespace

Spatial design is important to games. In our large display game, physical space became game space, and the size of our display allowed us to extend the game world to the physical world in varied ways. For example, because players struggled to clearly see both extremities while completing touch interactions, players would step back from the display, providing opportunities for three-dimensional movement and griefing.

There are many additional ways that game designers can leverage display attributes to encourage further physical movement within the physical gamespace. As one simple example, presentation of information can be located at one extremity, encouraging players to move positions or increase frequency of communication between collaborating players. Players can also be attracted into each others territories through rewarding game mechanics to enhance competition (e.g. through resource distribution, as is currently done digitally in games such as Overcooked 2). Digital games already leverage resource distribution to encourage varied use of the digital gamespace, and work on exergames has also begun to exploit ways to encourage physical movement through digital means [163].

Display properties can also be used to better calibrate player interactions and preserve the social experience. For example, the greater impact of physical versus digital intrusion validates the assumption that physical space ownership can be constrained via on-screen territories, and designers may consider using the digital space to constrain use of physical space, rather than promote its use. As one example, to manage issues of physical intimidation during interaction, fixed physical workspaces and distant reaching tools can control physical overlap between players, helping us leverage or overcome inherit ideas of ‘Equity and Diplomacy in Games’ for better collaboration or competition.

### Leverage Variable Boundary Enforcement

While boundaries may be necessary to control competition, the first finding ‘*My starting side is My side*’ demonstrates that borders and barriers are not always needed for collaborative environments because participants will consider their space their starting location. Our ‘Equity and Diplomacy in Games’ results illustrate that there are expectations that these inherit territories will be respected. Moreover, our results demonstrate that ‘Cooperation

makes Boundaries more Permeable' and we can see this during cooperation encroachments, which are more often viewed as benign.

Participant arm span and physical body helps implicitly define the boundaries of their space, so giving participants different starting locations also appears to induce feelings of territory. With the creation of these territorial feelings, users will move to defend and share their own space based on the information gleaned during social interaction because it is 'Good Table Manners'.

Our study also shows that in collaborative environments, boundaries are more permeable. This is helpful for designers trying to make more cooperative environments. Our game was explicitly designed to limit direct competition by preserving the common goal, and, even with our limited competitive gaming aspects, we noted a marked difference in participant perspectives. Other factors can also be used to encourage better collaboration and sharing of resources. For example, starting participants in the same area may help to convince participants that the full gamespace is shared. Additionally—because good manners are expected when skill levels are unequal—we can design asymmetric games to support collaboration where territoriality may be less of a concern because player tasks are different.

## 5.7 Limitations and Future Work

The game context, a tightly coupled, single-view, common-goal gaming experience, may limit the generalizability of this work. Extensions of this work might explore anywhere along the spectrum of workplace non-gaming situations to more directly competitive gameplay goals. However, given the scale of the display we used, we considered carefully the intersection of game design (a common primary goal, save the planet) against the likely placement of large displays (public or semi-public spaces). We believed that territorial violations and physicality within the gamespace were, perhaps, more acceptable in these public or semi-public contexts than purely competitive goals. If the primary goal (saving the planet) were replaced by a more directly competing goal (defeating/destroying another player) then our observations might be impacted by this change, e.g. it might be either less or more acceptable to invade territories; asymmetries of skill may be perceived differently; physicality might need to be more rigidly controlled to avoid injury.

In the future, we wish to explore different display environments (e.g. AR/VR [13]) and gaming configurations (e.g., competing goals, asymmetrical tasks, lower coupling) to observe the impact on physical space and digital territory. Alongside this, public deployments to measure the spectator experience of large display gaming and to explore the impact of more than pairs of players are fruitful avenues of future work.

Understanding the territorial cues continues to be an ongoing area of research. Work citing this paper discusses how the context in which cues are received brings us to an understanding of mediated interactions and information sharing behaviours [119]. The nuances of the results in both these works indicates that there is space to further explore how mediated social interaction affect participants' and points to further areas of research.

## 5.8 Conclusion

The study explored the relationship between physical and digital boundaries for large-display multi-touch gaming. We discussed how participants view their own boundaries, how it affects their behaviours, and highlighted the need for negotiation. Overall, our study demonstrates the importance of the physical space in front of the display as a part of the gamespace and provides insight on how physical space affects and is affected by the digital display. In Part II, I investigate the effect another social entity can have on reported player experience. In Chapter 4, I ask if players can differentiate between human and AI-controlled Non-Player Character Teammate (NPC-T)s. In addition, Chapter 5.1 explores how the affect of another player co-located changes the player experience. Both research materials presented (4 and 5.1, contribute to the overall research question II:

### RQ2 How do players perceive other social entities in game?

From the research in Chapter 4, it is clear that the presence of another character (human or AI) has a notable effect on the player. Despite players being generally unable to differentiate between human and non-human AI, players felt less alone during the game's challenges. Player's feel a need to reciprocate friendly actions (e.g. healing, protecting, collaborative problem solving) regardless of the nature of their collaborators. The reciprocation of actions and pro-social behaviours indicate there is a formation of a social contract between players and their teammates. Players assign different levels of value to these social contracts based on the true nature of whom they played with (humans vs. NPC-T characters). Although players value their human collaborators more, there is still meaning and obligation to NPC relationships. Therefore, we can simulate the social contract between human and their NPC-Ts to manipulate the player's actions within the game; which is a form of persuasive design.

In Chapter 5.1, I explored how the co-presence of another player within a shared physical and digital space affects the primary player's behaviours. Player's report the need to respect spatial boundaries, and avoid highly disruptive physical encroachment in favour of more

acceptable digital long-distance reaching. The workspace condition (floating or fixed) further manipulated the players' understanding of boundaries and acceptable behaviour by changing how they viewed their starting position as 'theirs'.

The results exemplify there is always a need to consider social ramifications. We see that players enact rules of good social conduct and friendly collaboration in both cooperative and competitive conditions. Even in the competitive condition, player still report the need to think diplomatically because players consider the long-term relationship and social consequences of playing aggressively. In contrast to the competitive environment, the cooperative condition was especially important for changing the permeability of boundaries. When cooperating, players considered the intent behind their actions as helpful and therefore felt encroachments were more permissible.

The result further indicate that social, cultural expectations are consistently present despite the increase in permissible actions afforded because the activity is a game. Players will not play aggressively unless they felt that the aggressive play was appreciated and reciprocated by the other player. Moreover, players assessed the 'fairness' of the competition and acted aggressively when their competitor were considered an equal opponent.

Rules of social conduct, competitive engagement, and collaboration were all affected by a variety of territorial and social factors. To navigate the interaction, participants discussed looking for cues from the interface layout, permissible in-game actions, instructions (rules), or affordances within the application. In combination, players depended on their existing knowledge of social and cultural interactions to pickup cues from the other player to determine the acceptability of their actions and predict reactions to these actions.

Due to the dependency of the player on these cues, we can engineer the interface to direct player behaviour. As an example, consider how the affects of a floating vs fixed workspace changed the player's willingness to cross physical or digital boundaries. Similarly, the competitive vs. cooperative condition changed the player's view of acceptable in-game behaviour. Therefore, designers of this applications can harness the power of design to direct player actions, indicate acceptable choices, and discourage certain in-game decisions. In other words, according to the results of this research, we can compel player behaviour as a form of persuasive design.

Together the results of Chapters 4 and 5.1 indicate that designers can manipulate player actions via supplemented **NPC** behaviours, interface design, and social-cultural cues to leverage the presence of other social entities for persuasive design.

## **Part III**

### **Part 3: Thesis Research Question**

At this point in my thesis, I have presented the research materials that comprise the body of my doctoral work.

In [I](#), I focus on quantitative aspects of calibration, i.e.:

**RQ1 How can quantitative game systems calibration enhance player satisfaction?**

I discuss games as quantitative systems and I explore how these systems affect individuals who play via the presentation of two research projects in Chapters [2](#) and [3](#).

In Part[II](#), I explore how social, cultural factors can guide players to make decisions, examining player perceptions of other entities, i.e.:

**RQ2 How do players perceive other social entities in game?**

I explore design of games with social entities, both human and [NPC-T](#) in [4](#). In chapter [5.1](#), I explore the emergent territoriality of multiplayer games in a shared co-located space with a loosely coupled task.

Finally, in Part [III](#), I present a discussion of the overall research question, within the context of the literature. I will also explore limitations of the work. Finally, I will end this dissertation by discussing my future ambitions and research directions as I explore the application of persuasive playful spaces to create Games4Change or games whose purpose is beyond that of entertainment.

# Chapter 6

## Thesis Discussion

As I noted in my introduction, this thesis began with the goal of contributing to the design of games, specifically trying to create compelling and immersive experiences based on design approaches within gameful environments. I focused, initially, on how game systems calibration can enhance player satisfaction and, through increased satisfaction, a more immersive, compelling experience.

As I explored, aspects of creating believable movement for NPCs, new research directions presented themselves, specifically around how we perceive NPCs vs how we perceive human players, and whether or not game design can influence our interactions with co-players. This lead to a second, related research question on how we perceive other social entities in gameful environments and how this impacts aspects of our immersive experiences.

As noted in Figure 6.1, the above, layered, research questions correspond to the research questions presented in each study of the two parts of this thesis. In Part I, I presented two chapters that explored the calibration of game elements. Chapter 2 explored difficulty in games based on parameter tuning within platformers (jumping, target size, movement speed). Chapter 3 explored the calibration of NPC movement.

In Part II, we investigate the behaviours of players when playing with others. In Chapter 4, we investigate the differences in player behaviour and expectations when playing with in-game teammates that they believed were AI or human-controlled. In Chapter 5, we further probe the boundaries of acceptable behaviour during gameplay that is co-located on a shared large display.

	Thesis RQs	Study RQs	Research Materials	Study Contributions	Thesis Contributions
P1: Single player	<b>RQ1:</b> How can quantitative game systems calibration enhance player satisfaction?  <i>Can we calibrate the difficulty to make more challenging gameplay?</i>	<i>Can we calibrate Non-Player Characters (NPC) movement algorithms to increase user-reported realism?</i>	<b>Incremental Difficulty</b>  <b>NPC Movement</b>	Yes! Study demonstrates that designers can influence player experience (PX/UX) through incremental changes to game design mechanics which determine difficulty  Not really, differences are just noticeable; however, results indicate other factors will be better suited to persuasive design.	<b>Game mechanics and entities manipulate player experience but seem to have limited impact on player engagement</b>
P2: Multiplayer	<b>RQ2:</b> How do players perceive other social entities in game?  <i>What are characteristics of a human player? How do we differentiate humans and NPC-Teammates (NPC-TJs)? Can we use this persuasively?</i>	<i>What determines the actions that are acceptable when playing with other humans? Can we use this persuasively?</i>	<b>LT4D</b>  <b>Playing with Personal Space</b>	In our deception, players could be misled on the identity of their opponent. Yes! Players respond differently to entities perceived as human  Yes! Perceptions of 'Acceptable' social boundaries weigh heavily on players. Win conditions change the social environment, influences player beliefs, and subsequently, actions.	<b>Social contracts are created between valued collaborators &amp; we can make design decisions to influence behaviours and attitudes towards others</b>

Figure 6.1: Thesis and Chapter Contributions, replicated from Figure 1.1

## 6.1 Answering the Research Questions

As noted above, Part I concentrates on exploring the quantitative factors behind the design of games as stated in research question 1:

### RQ1 How can quantitative game systems calibration enhance player satisfaction?

The results of the work presented in Part I indicate that quantitative game balancing is important for playability of a game (a concept similar to usability of an application). As a second part of our exploration of quantitative game factors, we also look at NPC movement algorithms. In this second study, we note that there are differences, but preferences between different algorithms were not well articulated by participants. In response to the lack of convergence within results, we followup the first study of the paper with a JND study design. The JND study indicated that there were differences in perception of the algorithms' underlying calibration on the users'; however, the effect size is small. Since, the effects of the quantitative work were not robust and instead, just-noticeable, we returned to our data to identify factors that might create more persuasive, compelling experiences in games.

One factor that we did identify in Part I of the thesis was the perception of emotion and intentional behaviour resulting from different algorithms that control NPC movement. Participants described NPCs as angry, dangerous, or friendly. Participants' tendency to

anthropomorphize the **NPC** characters lead us to consider investigating design of characters as social entities instead of as realistic game world occupants. By considering the **NPC**'s effect as a social entity, we move to design descriptions which evoked more emotion.

By pivoting design goals from a realistic to social **NPC**, we discovered a new direction towards the design of persuasive content. Therefore, we conclude Part **I** provided insight into the importance of simulated social interactions via the automatic anthropomorphism of the **NPC-T**; as a result, Part **II** focuses on the presence of social entities. This motivates my second research question:

## RQ2 How do players perceive other social entities in games?

I had already begun to investigate the importance of (simulated) social interactions to games with a dissection of ‘believable’ **NPCs** movement characteristics. The work in Chapter **4** further delves into the this line of questioning by continuing the investigation by switching the focus from **NPCs** to **NPC-T** by comparing **NPC-T** to human-controlled teammates. Using deception, I explore player ability to differentiate between human and **AI**-controlled characters when playing directly with them as **NPC-Ts**, and I also explore similarities and differences in the way we treat **NPC-T** vs human-controlled teammates. I find that there exists different social contracts between **NPC-T** and human-controlled teammates. Essentially, while we want to protect our **NPC-T**, **NPC-T** are more viewed as a resource in a quasi-feudal relationship with the player. In contrast, human-controlled teammates merit a different level of respect and consideration; we need to balance our own needs for success and enjoyment in the game with the need to provide other human players represented by human-controlled teammates with an enjoyable experience as well.

In accompaniment, in Part **II**, I also explore social interactions surrounding the gameplay input area; specifically, I explore the interactions during gameplay as they apply to both the physical and digital environment. In Chapter **5.1**: Playing with Personal Space, I require that players interact in the same physical space using a large multi-touch display. I seek to understand how the game’s social setting as either collaborative or cooperative, and interface design as either containing fixed territories enforcing physical separation versus floating territories that allow players to invade their co-player’s physical space can contribute to different social expectations.

In Part **II** of the thesis, I find factors that can be used persuasively. Players’ carry with them social expectations of how the game should be played; in particular, players have a set of schema[273, 274] or beliefs on how to behave appropriately during competition. For example, during gameplay players keep limits on their own competitive behaviours

and actively compete with players that are considered equal opponents. Moreover, players avoid being a 'poor loser' by self-policing negative behaviour after the game at following the declaration of the winner. In addition, players are also shown to maintain rules of engagement that dictate how to cross into others territories or spaces, e.g. players in the cooperative condition of 5.1 felt that more comfortable crossing into another players territory because their intent was to help.

The adhesion to these social rules of engagement or schema [273] is part of maintaining a social contract discussed in the findings of Chapter 4. Players keep track of their social obligations to ensure they are not ruining the experience for others. For example, reciprocating helpful behaviours in a collaborative condition is a fulfillment and maintenance of a positive social contract.

Overall, from the results of II, indicate that players look for signals from both the environment, situational circumstances, and reference the behaviours of others to determine the expectations and understand the terms of the social contract. Therefore, manipulating the environment can change player behaviour; this effect is demonstrated when comparing the expectations players reported for themselves and others in the cooperative vs. competitive conditions in Chapter 5.1.

Based on the results of the research materials presented in Part II, I determine that manipulation of social entities, cultural expectations, and the weight applied to being a good collaborator, allow us to design persuasively. For example, we might manipulate the player's feelings of guilt and need for reciprocation to encourage investment into an NPC storyline. Alternatively, we can design the space in which individual players interact to moderate the pro-social collaborative behaviours or antagonistic competitive behaviour using cues within the design of the interface.

Finally, the totality of the work presented in my dissertation contributes to a better understand of the overall thesis research question 1.1:

RQ-T How can we design persuasively using playful approaches within gameful environments?

Within the findings of my work in both Parts I and II, I contribute to the discussion on persuasive design using playful elements in gameful environments.

I talk about games as a playful, low stakes platform for exploration and the emergent factors that guide players attitudes toward others, including looking at whether other players are perceived as human and how game design factors can modulate the perceived intent of actions. As such, I discern the potential of games and playful applications to

provide small cues that can begin to hint to players a direction of thought or behaviour under the guise of game-specific intentions.

From the results of my work, I conclude that the social elements of interaction with the characters present more effective, impactful opportunities to design persuasively. Through interaction with human-controlled characters, establishment of cooperative trade, and reciprocating helpful actions - social exchange creates an environment where people consider others' enjoyment. This effect is not limited to human collaborators, as demonstrated within the results of my thesis. Ascribing human-like characteristics to **NPC-T** encouraged a different form of reciprocity in the interaction.

## 6.2 Beyond the Research Questions

Research in this dissertation only explored some of the aspects of gaming that are important for designing compelling, immersive experiences. Literature indicates that there are other aspects which provides an opportunity to explore and leverage game design factors for persuasive design. For example, story telling is an important aspect of any gaming environment. Furthermore, even in the absence of stories, game design methods, and gamification[53] techniques can be used to create compelling, engaging experiences. As an example, consider the popularity of absent play or optimization games e.g. Cookie Clicker (Julien Thiennot, Dashnet, 2013). The actions taken in game like Cookie Clicker affect the games progress (score), and requires the user revisit the game to manage the progress of the game. Creating an environment that requires players to revisit the game, e.g. monitor or observe ongoing processes within the game have been used to maintain a player base.

Moreover, combinations of strategies can be further leveraged to design compelling games. As another example, consider a similar game 'Cow Clicker' by Ian Bogost, a games scholar [15]. Bogost released 'Cow Clicker' which leveraged the social properties of Facebook to involve a community of socially connected players. The game collected player data to build a database. The success of the game's goal (to build a database from player data) was completed by leveraging social factors of the Facebook platform. In many ways, cow-clicking is an example that proves the point of the compelling, persuasive nature of social interactions – cow-clicking was only compelling because of the social environment on Facebook and the ability to brag about how long you had spent on a meaningless activity. To add insult to injury, in return for the social rewards of playing, players were persuaded to allow personal information to be collected[15].

## 6.3 Synthesis With Related Work

This section delves more deeply into the intersection of my research with the current literature in Human-Computer Interaction (HCI) and GUR. In particular, I review work on games as learning environments to contextualize Csikszentmihalyi's optimal flow work [48]. It is this work that can serve to contextualize much of my initial work on difficulty adjustment and challenge through character movement. Next, I review relevant work on games as social devices and as a gathering space for community to contextualize the work in Part II of my thesis. Finally I touch on broader issues of persuasion through games, to ground some of my future work.

### 6.3.1 Games are Reward-Fuelled Long-term Learning Environments

Games are powerful learning environments. Games place players in a system of rewards and heavily rely on re-enforcement of ideas to teach the system of the game in which the player must abide by to enter the 'magic circle' [156]. Games are built on a pattern of action and reward[116]. The correct actions encourage additional repetitions similarly to classic and operand conditioning protocols[206]. Research has shown this relationship, consider work Huang *et al.* which follows the development of skill in games as a function of repeated correction, progress, and reward [90]. Moreover, since games can inspire players to keep playing researchers have also used games to explore motivation [157]. In addition, more pragmatic approaches have used games to motivate desired behaviours [186], and healthier lifestyles[75].

Skills, information, and learning acquired in games is portable[202] Researchers continue to use games as a method for exploration of concepts (e.g. a study which explores how the conditioning of stimuli propagates anxiety in VR [74]). Evidence for the use of games as an educational tool continues to have great breadth demonstrating usefulness across different disciplines[134, 88], age groups[11], and special populations[19].

With all reward structures[254], it is important to develop a balanced system of reward and challenge, which is part of the underlying premise of Chapter 2. In chapter 2, I focus on developing methods for calibrating this balance or optimised experience often reference to as the 'flow state' [48]. The flow state keeps players attention, maintaining their interest, and ultimately distorting their perceptions of time.

After a user becomes entranced in the game's world, we can see hours of gameplay recorded. In a study of World of Warcraft (W.O.W.) players, researchers studied over 34000

accounts surveyed over a two years period and state that 50% of players who revisited after their initial play period maintained a paid subscription to the game for over 500 days[227]. **What would you do with over 500 days of a person's attention?** After the game's initial base game mechanics have created player interest, the slowly unfolding narrative can use curiosity as fuel to maintain the ongoing subscription [55, 151]. Perfection of completion-ist tendencies can drive up game hours [68? ]. The game can even drive player attachment to digital objects [233], creating value in the intangible models or objects in the game world which have the potential to be meaningless when removed.

Classic psychology of persuasion theories of Petty and Cacciopo's 1986 work[181] discusses the gradual process needed to shift ideas. Building on this work, current literature identifies a persuasive strategy involving silent, slow long-term persuasive arguments, which allow slow buildup of ideas through placements and subtle information presentation [110]. A player's enraptured attention in the game maintains the environment needed; therefore, my work on 2 is part of increasing play time. In a sense, games can be thought of as analogous to a Skinner box[206], where game designers control every aspect of the artificial environment.

### 6.3.2 Games are Social Devices

Stenros *et al.* [216] investigate the sociability of single-player, two-player, multi-player, and massively online multi-player (MMO) games. The paper argues that the nature of games are inherently social and highlights how even single-player games are non-individualistic, since they still allow for the awareness of other players and their progress.

*What if there are no human players to socialize with?* Incidentally, single-player games can also be thought of as being played simultaneously or as part of a performance. The current popularity of gamers entertaining audiences on platforms like Playstation Live, Twitch, and YouTube is evidence of how video-games can also become streamed media content. Furthermore, the awareness of others in the surrounding game context may encourage a competitive scenario which they describe with the terms 'gaming capital and status'. This idea can be exemplified as two players playing the same single player game and comparing progress markers.

The profitability of fan following or **fandom** is a known technique to continue profitability and has been used by entertainment companies to maintain audiences that will consume media, create content, and support brand recognition. For example, companies such as Disney extend past simply creating content to creating a community to belong to. The feelings of belonging can be so strong that continued dedication of the **fandom** can pass

from caregiver to children. Disney has a fan club, store fronts, amusement parks, Disney TV Channel, radio stations, and now a Disney Content Distribution Platform Disney Plus. *Don't believe me? Talk to the parents of today's children - who have all the words of Disney's Frozen Feature Track 'Let it Go' memorized (or better yet, ask my thesis supervisor Edward Lank to play a piano rendition).*

The social environment of games is increasingly beginning to include **AI**, as shown by my work in [3](#) and [4](#), the **NPC-T** are part of this emergent sociality. The literature on attachment to these artificially controlled agents, is complementary to the work I discuss in Chapter [4](#). The chapter presents gained insight into participant thoughts and beliefs about **AI** capabilities and typically human behaviour and attributes through a blind deception experimental protocol. The salience of this experimental design, which at times required participants to be only partially informed, revealed insights into the fundamental beliefs of player's biases towards **AI NPC-T** that many not have been consciously apparent or easily articulated by players. In Chapter [4](#) participants had difficulty identifying the true nature of their opponents (as **AI** or human-controlled entities. Participants of the study expressed solid preferences for the desired nature of their teammates as either human or **NPC-T**. Interestingly, despite biases towards **NPCs**, the study revealed that participants had difficulty identifying the true nature of their teammates. Therefore participant comments provided insight into the factors players use to define or identify '*human-ness*'. For example, participants explained their expectations for human players were tied to more competent actions, and perceived leadership. Player emphasized communication as also being 'more human'. Of interest, when participant identified 'more human communication factors' during post-game interviews, participants mentioned game content that was not controlled by human-players, i.e. the audio phrases and reactions of characters to in-game events as being a determinant of '*human-ness*'.

Regardless of who controlled the character (**AI** or human-player), when healed characters are heard thanking the other **NPC-Ts**, player, or expressing a sigh of relief. Comparison of the game's story characters' Coach<sup>[38]</sup> and Rochelle<sup>[39]</sup>'s dialogue demonstrate intentionally written differences in personality between the two protagonists, for example, when Rochelle - the only female character on the team - is generally incapacitated she will yell phrases like: "Damsel... in distress over here!" or "Boys! I'm down!"<sup>[39]</sup>; to differentiate, Coach who is characterized as being a large-set, overweight, and oldest survivor will yell phrases like: "God dammit, I knew I shoulda lost some weight", when incapacitated by a fall and hanging-off a ledge in the game <sup>[38]</sup>. Work in which I was a supporting author <sup>[232]</sup>, also demonstrates that people also become attached to digital game objects.

Literature in **HCI** and psychology explore the relations that we develop with digital characters <sup>[106, 46, 18, 97]</sup> and demonstrate that humans show true attachment to these

virtual people. With the results of Chapter 4, research indicates that generally players feel the need to reciprocate actions, especially for other human characters. Similar to literature [158], human-controlled characters are the dominate motivating factor; however, my work demonstrates that, albeit weaker, there is still feelings of social obligation towards NPC-T. The obligation to reciprocate and feelings of value assigned to these digital characters and objects allow an opportunity for persuasive design [180, 179]. The humanization and anthropomorphism of the AI-controlled NPC-Ts characters also evoke the feelings obligation and social contract that causes participants to invest in the well-being of these simulated people i.e. NPC-Ts. Participants revealed that the simulation of social obligations or social contracts create feelings of sociality between players and AI-controlled NPC-Ts. In support of this finding, literature demonstrates that character customization, relationship with NPC-T or NPC, and collection of digital objects [233], contributes to the player's feeling of involvement in game [180, 179].

### 6.3.3 Games Create a Gathering Space and Community

Games allow us to think new thoughts and explore new information. The world of the game asks players to suspend their feelings of disbelief and engage in a space where players can chose to abide by a new rule set and narrative. The phenomena of entering this game world is often related back to the concept of a magic circle [107, 156] where we enter the game world. Therefore, the game world becomes a space in which to explore. Classifying the game as a space, allows us to consider the outcomes of approaches for Games as a point where it then allows errors, exploration, and sandboxes consequences within the parameters of the game. Games and playful applications provide a unique environment in which people may explore actions, personality traits, ideas, etc. - without the consequences imposed on interaction 'in real life'. As such, games and playful environments are an ideal place for education because it inspires exploration of these new concepts. Due to the compartmentalization offered by the division of the game world or magic circle, can encourage players to accept a different persona or play a character with imbued beliefs that are counter to what one believes core to their own self.

Taking on these multiple roles becomes a lesson in empathy [79, 141]. From the literature, we have evidence that prosociality can be cultivated using a game environment to allow for increased prosocial behaviour [80] and increase prosocial thoughts [81]. Research has demonstrated that prosocial behaviours are not affected by violent or ultra-violent game content, as demonstrated by a study of altruistic behaviour following gameplay [229]. In contrast, research in social psychology has shown that playing a game with pro-social

behaviours can increase both pro-social thoughts and behaviours, such as the likelihood that an individual will offer help following their gameplay experience [80, 82, 81, 79].

In-game social interaction can create communities, where there is discussion, collaboration and sharing of media. Large online multiplayer games can be thought to create a micro-culture within them. The formation and interaction of online communities of different games are a largely studied area by GUR [226, 177, 215]. Players of the game interact with this smaller self-selected group of players. As individual players in the real world interact as digital representations of themselves, they begin to find a need for governance. For example, a homophobic interaction within Fallout76 prompted a conversation with producers Bethesda on social media [194]. It stands to say, that games can also affect the beliefs, thoughts, and ultimately influence the behaviour of people. As I have demonstrated in Part I understanding how to balance game difficulty (i.e. in Chapter 2) and calibration of NPC (i.e. Chapter 3) is only the beginning of what is needed to understand how to make games truly convincing. In Part II, I explore the social aspects of games with both NPC-T in Chapter 4 and in an in-person large display computing space, i.e. Chapter 5. The work presented in this thesis embarks on a greater exploration of persuasive media and games for change.

### 6.3.4 Games as Vehicles for Changes in Messaging

There is evidence that games can shift a community to adapt a more positive opinion. For example, consider the popular game series Fallout produced by Bethesda. Fallout 4 (Bethesda, 2015) turned a huge profit according to Statistica [3], the game sold 13.51 million units worldwide. The large profits surrounding this game series is one indicator of the game's international reach. Its predecessor Fallout76 (Bethesda, 2018) was studied[22] and the results of the work prompted an interview featured on Virginia's local news [146]. The researcher reported that the featuring of Virginia as the setting in Fallout76 played a role in residual feelings about the state and had a role introducing people to the area, geography and culture via digital tourism. The game was shown to increase emotional attachment and positive affect towards West Virginia in real life. Moreover, the effect last beyond the gameplay and creates longer-term positive affect towards the state [22, 146]. This is one example of how digital games can affect real life communities, cultures, and attitudes.

Influencing behaviour and attitude through passive media (TV Show or movie) or active media (video game) is a common practice[94]. Literature from psychology has confirmed that individuals construct ideas based on consumed media, and as explained by Mar *et al.*, in [140] the results demonstrate that the introduction of these ideas shape our thoughts and our personalities [139, 141].

Racism and fantasy and popular media examples are classically defined by long drawn out analogies known to both fans of Tolkien and those less found of high fantasy. However there is less acknowledgement to the simulated racism featured in popular media today. As astoundingly simple example is found in the troupe films with recycled plots. Tell me if this sounds familiar:

*A young half-human and half-mythical creature observes a lonely existence growing up in a remote part of the world. Our main character is cared for by an old wizened caretaker who is strict but obviously fond of our protagonist. Due to their close relationship, they develop a mentor-mentee relationship resulting in above average skills and talent in combat and other superhuman talents. Unknown to our protagonist war is coming. To save the world our would-be hero heads to the mythical kingdom which donated half of the genetics. During the quest to save the world, they also battle the scorn of the non-humans, reclaim ownership of the throne, and find true love, all while saving the world.*

The above passage summarizes an unthinkably common plot regurgitated in movies, games, and entertainment media such as Legend of Zelda Series (Nintendo), Action Hero films like Aquaman (Warner Brothers, 2018) and Tolkien's Lord of the Rings (Tolkien, 1954). The concepts illustrated in the above passage are one of the oldest forms of persuasive messaging hidden in plain sight and consumed by mass culture; in this example persuasion is built on multiple repetition of this messaging [27] which enhances our recall cues making it easier to remember the content. Over time, the simple repetition may lead to belief because the human brain uses repetitive patterns to form memory [213]. As adults, we may express that we have out grown these messages but the repetition that has dogged us our lives is has now shaped our fundamental beliefs.

The strategy of using media and movies to battle stigma against marginalized groups is present in the literature [94] for passive media (movies). interactive media and games becomes more complex because players can exercise freewill in unpredictable ways and thereby create emergent design [25]. With planning, designers can leverage games to promote messaging and enforce learning skills.

In addition, there remains questions regarding ethics and efficacy. Future work can explore and challenge researchers to question the governance of persuasive media; for example:

- Who should be responsible for messaging?
- Do game designers and media production companies bear the social responsibility of the message?

- How can measure the long term retention of ideals and social cohesion?
- How do we study game mechanics more precisely to understand which mechanisms in game design can be used strategically to create the best learning environment, and inspire the longest retention?
- Can we ensure that the impact of the in-game messaging is being comprehended through the narrative of the story?

### 6.3.5 Synthesis with Non-Gaming Research

Part I of this thesis was motivated by the prevalence and popularity of Csikszentmihalyi's theories of optimal experience [48]; where the goal is to create an experience that mediates difficulty to avoid creating insurmountable frustration, while continuing to present non-trivial challenges. Additionally, Fogg's *Behaviour Model* [65] highlights two primary dimensions of persuasion, motivation and ability. Together these two theories present a theoretical basis of this work. Thus managing both the ability and motivation through a system of rewards (c.f. a *spark* in Fogg's model and optimal experience in Csikszentmihalyi's work [48, 47]).

Part II of my dissertation was mainly motivated by work concentrating on computer supported collaborative systems including topics like group behaviour in shared computing spaces[246], division of resources (e.g. shared real estate [34] , tools[250], file access[135], etc.) and territoriality[204, 6, 250].

In Chapter 4, we referenced literature discussing digital meeting places [34] to begin to understand the importance of the digital world as a meeting space. Communication and ability to communicate on platform discussed in the HCI literature [117, 214, 240, 241] illustrated the need to control for voice and chat communication to allow for better understanding of the expectations, thought, and perceived cues participants used to determine the 'human-ness' of their collaborators. The results of the empirical study performed in chapter 4 provided an understanding of the social contract developed between collaborators.

Chapter 5.1 leverages the understanding of territoriality while using shared large display workspaces to design the game's setup. Work by Scott et al. [204] provided insight into the shared spaces of participants while working around the large display and motivated the exploration of shared tool use. Hence in Chapter 5.1 we explore the shared tool space as a neutral method for passing tools between players; in contrast, the magnet tool allowed for the abrupt stealing of tools. This lead to the contributions regarding 'Good Table Manners' which describes how participants transferred of one set of cultural expectations (i.e. dinner table manners) to this unknown situation (i.e. our large display task).

The literature also provides insight into the gathering of individuals approaching the display in reference to the display itself, and the position of other potential users. Azad et al. [6] provided grounding for understand how positions of individual participants and groups of users position themselves in front of the display. Azad et al.'s work motivated the placement of a floor grid in chapter 5.1. The floor grid allowed for the collections of users position in response to the independent variables of the study (workplace anchoring, and the addition of competitive elements). After triangulation with the qualitative interview results, the results demonstrate attachment to one's starting position. In future work, I would hypothesize that the standing position may even correspond to a physical expression of intent to cross boundaries.

The exploration of screen real estate including use of the space, crossing boundaries, and otherwise were informed by literature discussing how standing position as a function of the placement of a large display can indicate intent to interact with the display [85, 246, 247]. Use of the display is shared between multiple users co-located by design; so, we can explore boundaries between users as they are affected by the content on the display. From the results of the study, we understand hesitations to approach based on the position of an individual user and the their starting space on the display. Exploring this and the aforementioned factors lead to the chapters overall contributions on managing space physically and digitally including screen real estate and the surrounding physical areas surrounding the display

## 6.4 Limitations

Like any piece of research, the research presented in this thesis has limitations. Perhaps the most significant limitation is generalizability, primarily because each research context is different, and, particularly in Part I, much of the research relies on bespoke games. Bespoke games are controlled research stimuli. With any controlled environment, researchers trade aspects of *experimental validity*, the ability to control for factors and context, against *ecological validity*, real world impacts of this work. Stated more succinctly, In this section I explain how the results of this thesis generalize to real world situations, off-the-shelf games, and/or to other contexts [7]. Beginning with Chapter 2, this section discusses generalizability of the findings for each of the research materials within the scope of the research questions.

First, in Chapter 2, we have some evidence that aspects of this research do, in part, generalize. Consider: While our study on difficulty adjustment was novel at the time it was executed and published, since publication others have explored difficulty adjustment. For example, as we discuss near the end of Chapter 2, Tsujina et al. [234] explore calibration,

and researchers have also continued to explore error modelling as measures of difficulty [49, 147].

Next, I consider the generalizability of the work presented in Chapter 3. As noted in the discussion of the chapter, the work does contribute to the field as shown by the references to other papers continuing work on movement and AI Algorithms. However, the work in Chapter 3 may not directly generalize, primarily because the results of differences in immersion due to algorithms was not observed.

The value of the work is that it demonstrated a need to pivot directions by indicating that the quantitative calibration I was exploring was not high-impact contributing factor to persuasive design. Moreover, the paper provided direction and acts as a bridge between the first and the second research question. This chapter does highlight that there are perceived differences in the social interactions between the player the NPC. This, then leads to my exploration of in-game social entities (both human and NPC) which followed.

In Chapter 4, one aspect of the game design that was important was the common role of teammates for both human and AI-controlled characters when evaluating differences in attitude and perception depending on whether one was playing with human or AI collaborators/teammates. In this study, we used an off-the-shelf game which contributes to the ecological validity. Moreover, the double blind study design ensured effective deception and as a research method removes potential sources of bias[283]. Another point of caution is the study was a lab-based study; in-lab based studies, the lab environment has been shown to influence participant behaviour[283]. As a precaution, we protect against some bias and add ecological validity by simulating a home living space in lab (details further explained in Chapter 4).

Chapter 5.1 explores a very specific context,a tightly coupled, single-view, common-goal gaming experience on large displays. Due the projects specificity, the generalization of the results are not a direct translation applicable to other situations; however, general findings of the study do. Specifically, the results of my work in Chapter 5.1 provide information on how individuals approach sharing aspects and collaborative design features on large displays. The results of the work are also congruent with literature of territoriality [178, 204] and expand on current knowledge of the space.

## 6.5 Future Work

The ability of game dynamics to engage users is well-established [236, 186, 102]. However, how to leverage game dynamics for persuading users remains an area for research. This



Figure 6.2: Concept for the *Pet Project* game.

topic underlies all aspects the research presented in this thesis.

Given the complexity of persuasive game design [113], in this section I present my on-going work in designing persuasively through games. In particular, my thesis intersects aspects of persuasive design and the gaming literature as follows:

- **Learning Environments for Long Term Engagement** Through difficulty calibration, we prevent frustration and encourage longer engagement with the game, as in Chapter 2. Moreover, as studied in Chapter 3 with improved NPC movement algorithms, we can maintain challenge in games by encouraging the suspense of disbelief to create anxiety and excitement response to artificial danger. Users spend longer in the game to learn and improve.
- **Social Opportunities** Through believable character movement and behaviour, we control how people perceive and approach other entities within the gaming environment, as studied in chapter 4. Through control of competitive versus collaborative

behaviours, we encourage users to develop more positive inter-player communication and coordination [5](#).

- **Creating Space** By creating a physical gamespace in Chapter [5](#), we leverage the physical space to explore how interface factors can be used to create social environments that encourage more coupled-play. From the results of the study, we contribute to an understanding of how a playful environment can traverse both physical and digital spaces. The results of the study also demonstrate the influence designers can exert on these space to change the collaborative and competitive behaviour of those occupying the gamespace.

Demonstratively, from the results of these chapters, one can understand how we can design games to manipulate players; by doing so we can then begin to change behaviours and, potentially, attitudes. Although further exploration of these principles are needed to understand the calibrations and specific actions to be taken by game designers, the conclusions presented can inform further work and encourage refinement of these ideas.

### 6.5.1 Short-Term Research Plan

In the immediate term, aspects of my research were interrupted. Currently, I am actively working toward publishing an evaluation of the efficacy of a game to battle stigma surrounding mental health, called *Above Water*. The design of the game[\[271\]](#) and a demonstration of the multi-modal, digital and physically distributed game design[\[270\]](#) are published as works-in-progress and as entries in a game design competition. Currently, I am working on a submission which features evaluations of the game with experts from health care and game design. Evaluation with experts preceded evaluation with players due to ethical concerns regarding the safety of the game because of the mental health content. While the COVID19 pandemic, which overlapped the end of my Ph.D., has limited researchers' ability to perform user studies, expert evaluation represents a significant research contribution which we aim to share with the community. As restrictions lift, this mixed media game will be evaluated through play-testing. Given the sensitive nature of the topic, we believe that play-testing is something that must be done in-person and under supervision. Figure [6.3](#) depicts the materials used in the Above Water game and the interested reader is referred to early work-in-progress publications for additional details [\[271, 270\]](#).

The next step in my work on [Games for Change \(G4C\)](#) is to deploy a larger game featuring content on [Mental Health and Wellness \(MHW\)](#). The game '*Pet Project*' (Figure [6.2](#)) is designed as a Snowball fight, with mini games which allow the player to form

snowballs, build their snow fort, and visit a large display to participate in the snowball fight. Each mini-game targets different aspects of mental health stigma including: mental health literacy, inclusive language, and general MHW guidelines for use in emergency situations. The game plans to allow players to play with others in shared computing spaces with large displays. In March 2020, I had planned to deploy the game in public spaces internationally in the region of Waterloo, across Waterloo University campus, and our collaborators' campus at Carnegie Mellon University (CMU); however, the study is on-hold due to the ongoing global COVID19 pandemic.

Additionally, I also plan to further my work on the role of territoriality to foster in game collaboration and competition. The project: 'Crushedit!' was presented as an interactivity demonstration at CHI2019[263] and is shown in Figure 6.4. Continuation of this study is planned when it is once again safe to gather. The game *Crushedit!* will be used to explore designing an [exergames](#) to encourage physical health. The game provides an opportunity for further exploration of territoriality as a continuation to the Playing with Personal Space project presented in chapter 5. *Crushedit!* is, like our game in Chapter 5, a tightly coupled, single-view, common-goal gaming experience, and . Ideally, the game will be deployed in re-opened public spaces to create a shared social computing environment.

### 6.5.2 Long-term Research Goals

Beyond these near-term goals, I aim to continue to explore aspects of G4C. I will be applying the findings from my work to continue to develop games which are both entertaining and educational. Topics of future games will continue to include physical and mental health. Current literature points to a need for additional mental health resources and support following the current pandemic[59]. Due to the emergency protocols, it is predicted that additional support will be needed to help the public cope with fallout following the lift of the state-of-emergency due to extended social isolation[130]. Experts predict that the physical[238, 237], mental[245], and social[130] health concerns that have arisen due to the social isolation of the pandemic's continued shelter-in-place orders will need to be addressed, especially for younger members of society[130, 62] who have faced disruptions in their developmental milestones[284].

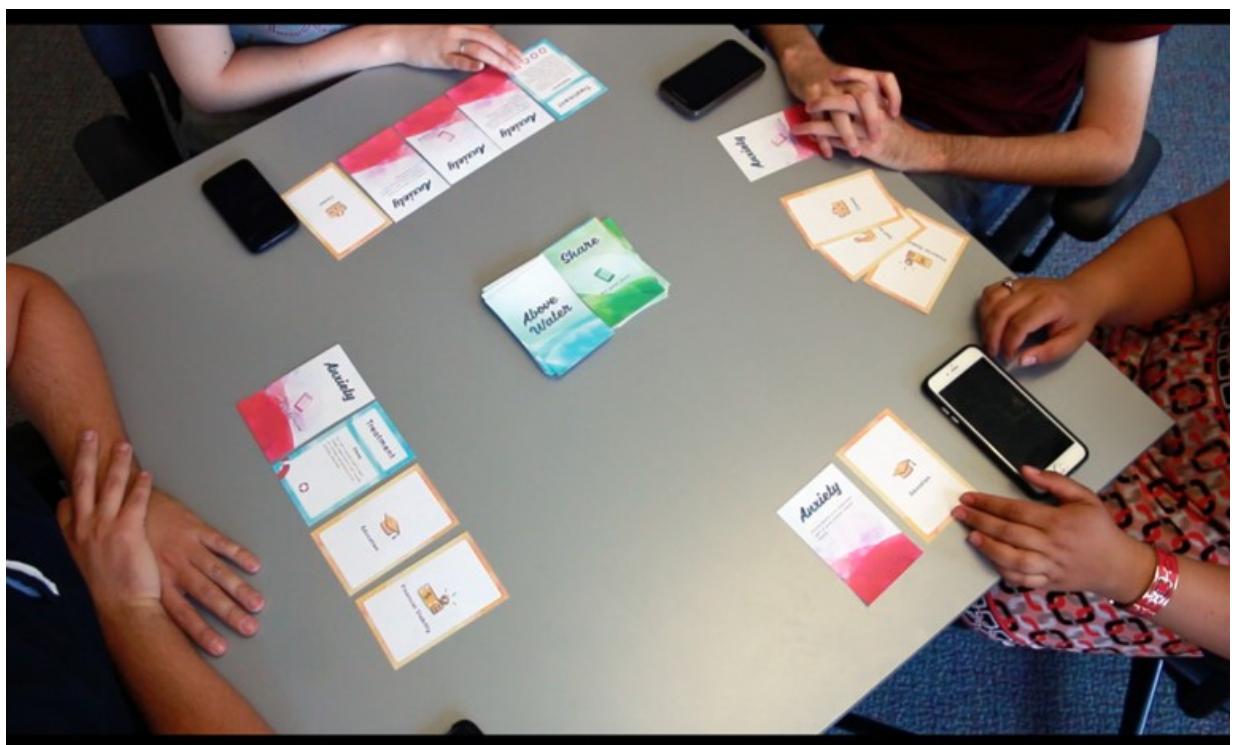


Figure 6.3: Players co-located each with their own device to play the game *Above Water*.



Figure 6.4: The *Crushedit!* game, a tightly coupled, single-view, common-goal exergame.

## 6.6 Conclusion

My work capitalizes on the many positive aspects of games and playful environments to bring together work on understanding and creating spaces for sociality and change. In my work, I began by researching games as an environment to be optimized for a user, beginning with the calibration of difficulty in chapter 2 and satisfactory world occupants in chapter 3.

Following this, I identified and explored the definition of ‘human-ness’, as participants attempted to distill what factors they used to judge the nature of a collaborator and reflected on their actions based on assumptions made during play. Subsequently, the exploration of social protocol and shared space in chapter 5 further allows insight into the social structure of collaboration, addressing the ideal collaborator and territoriality in shared spaces and supplementing the need for social contracts as initially identified in chapter 4.

Overall, the work described in this thesis probes how the compelling nature of games can be leveraged to provide a positive environment in which people can play, socialise, and collaborate.

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# APPENDICES

Chapter 2 Appended Materials presented in the next page includes the ethics documents processed by the Office of Research Ethics at University of Waterloo and a Sample of the micro-questionnaire given between levels.

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ORE # \_\_\_\_\_

**APPLICATION FOR ETHICS REVIEW OF RESEARCH INVOLVING HUMAN PARTICIPANTS**

Please remember to **PRINT AND SIGN** the form and **forward with all attachments** to the Office of Research Ethics, EC5, 3rd floor.

**A. GENERAL INFORMATION**

**1. Title of Project:** Incremental Difficulty in Video Games

**2. a) Principal and Co-Investigator(s)**

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigation must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPSS2\)](#) prior to submitting an ethics application. The tutorial takes at least three hours; it has start and stop features.

Name	Department	Ext:	e-mail:
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**2. b) Collaborator(s)**

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigation must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPSS2\)](#) prior to submitting an ethics application. The tutorial takes at least three hours; it has start and stop features.

Name	Department	Ext:	e-mail:
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**3. Faculty Supervisor(s)**

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigation must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPSS2\)](#) prior to submitting an ethics application. The tutorial takes at least three hours; it has start and stop features.

Name	Department	Ext:	e-mail:
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Edward Lank	Computer Science, School of	lank@uwaterloo.ca
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**4. Student Investigator(s)**

Name	Department	Ext:	e-mail:	Local Phone #:
Rina Wehbe	Computer Science, School of		rina.wehbe@uwaterloo.ca	6474027462

**5. Level of Project:** PhD      **Specify Course:**

Research Project/Course Status: New Project\Course

**6. Funding Status** (If Industry funded and a clinical trial involving a drug or natural product or is medical device testing, then [Appendix B](#) is to be completed):

Is this project currently funded? No

- If No, is funding being sought OR if Yes, is additional funding being sought? No
- Period of Funding:

**7. Does this research involve another institution or site?** Yes  
If Yes, what other institutions or sites are involved:  
University of Ontario Institute of Technology

**8. Has this proposal, or a version of it, been submitted to any other Research Ethics Board/Institutional Review Board?** Yes  
If Yes, provide the name of the REB/IRB, date of ethics review, and the decision or date of submission. Attach a copy of the ethics clearance certificate, if applicable:

*University of Ontario Institute of Technology, REB# 13-029, Sept, 2013, Approved*

**9. For Undergraduate and Graduate Research:**

Has this proposal received approval of a Department Committee? Not Dept. Req.

**10. a) Indicate the anticipated commencement date for this project:** 4/10/2017

**b) Indicate the anticipated completion date for this project:** 4/10/2018

**11. Conflict of interest:** [Appendix B](#) is attached to the application if there are any potential, perceived, or actual financial or non-financial conflicts of interest by members of the research team in undertaking the proposed research.

**B. SUMMARY OF PROPOSED RESEARCH**

**1. Purpose and Rationale for Proposed Research**

a. Describe the purpose (objectives) and rationale of the proposed project and include any hypothesis(es)/research questions to be investigated. For a non-clinical study summarize the proposed research using the headings: Purpose, Aim or Hypothesis, and Justification for the Study. For a clinical trial/medical device testing summarize the research proposal using the following headings: Purpose, Hypothesis, Justification, and Objectives.  
Where available, provide a copy of a research proposal. For a clinical trial/medical device testing a research proposal is required.

We would like to reanalyze the game performance data. Data was collected with participants being informed that their game information (score, errors, and time) would be analyzed. We would particularly like to look at factors that were difficult and cause participants to lose the game (required speed). The game is about a cat that jumps on trampolines. It is a platform game. The goal is to jump from platform to platform. The data is anonymous.

b. In lay language, provide a one paragraph (approximately 100 words) summary of the project including purpose, the anticipated potential benefits, and basic procedures used.  
We will look at the anonymous game score of participants playing a video game. The game has a cat that jumps on trampolines.

**C. DETAILS OF STUDY**

**1. Methodology/Procedures**

a. Indicate all of the procedures that will be used. Append to form 101 a copy of all materials to be used in this study.

Analysis of secondary data set or secondary use of information

b. Provide a detailed, sequential description of the procedures to be used in this study. For studies involving multiple procedures or sessions, provide a flow chart. Where applicable, this section also should give the research design (e.g., cross-over design, repeated measures design).

The data will be analyzed with statistical software. No human involvement.

c. Will this study involve the administration/use of any drug, medical device, biologic, or natural health product? No

d. Will you be using, processing and/or storing any biological materials of human origin such as blood, tissue, cells or bodily fluids?

No

## 2. Participants Involved in the Study

a. Indicate who will be recruited as potential participants in this study.

Non-UW Participants:

No participants needed, its an anonymous data set.

b. Describe the potential participants in this study including group affiliation, gender, age range and any other special characteristics. Describe distinct or common characteristics of the potential participants or a group (e.g., a group with a particular health condition) that are relevant to recruitment and/or procedures. Provide justification for exclusion based on culture, language, gender, race, ethnicity, age or disability. For example, if a gender or sub-group (i.e., pregnant and/or breastfeeding women) is to be excluded, provide a justification for the exclusion.

No participants needed, its an anonymous data set from a video game.

c. How many participants are expected to be involved in this study? For a clinical trial, medical device testing, or study with procedures that pose greater than minimal risk, sample size determination information is to be provided.

No participants needed, its an anonymous data set.

## 3. Recruitment Process and Study Location

a. From what source(s) will the potential participants be recruited?  
anonymous data set.

b. Describe how and by whom the potential participants will be recruited. Provide a copy of any materials to be used for recruitment (e.g. poster(s), flyers, cards, advertisement(s), letter(s), telephone, email, and other verbal scripts).

No participants needed, its an anonymous data set.

c. Where will the study take place? On campus: DC HCI Lab

## 4. Remuneration for Participants

Will participants receive remuneration (financial, in-kind, or otherwise) for participation? No

## 5. Feedback to Participants

Describe the plans for provision of study feedback and attach a copy of the feedback letter to be used. Wherever possible, written feedback should be provided to study participants including a statement of appreciation, details about the purpose and predictions of the study, restatement of the provisions for confidentiality and security of data, an indication of when a study report will be available and how to obtain a copy, contact information for the researchers, and the ethics review and clearance statement.

None

## D. POTENTIAL BENEFITS FROM THE STUDY

1. Identify and describe any known or anticipated direct benefits to the participants from their involvement in the project.

None

2. Identify and describe any known or anticipated benefits to the scientific community/society from the

conduct of this study.

None

## E. POTENTIAL RISKS TO PARTICIPANTS FROM THE STUDY

1. For each procedure used in this study, describe any known or anticipated risks/stressors to the participants. Consider physiological, psychological, emotional, social, economic risks/stressors. A study-specific current health status form must be included when physiological assessments are used and the associated risk(s) to participants is minimal or greater.

No known or anticipated risks  
Data is anonymous

2. Describe the procedures or safeguards in place to protect the physical and psychological health of the participants in light of the risks/stressors identified in E1.

Data is anonymous. It is a table of scores of game players who previously consented to their data being analyzed for research. We are reanalyzing.

## F. INFORMED CONSENT PROCESS

1. What process will be used to inform the potential participants about the study details and to obtain their consent for participation?

None

2. If written consent cannot be obtained from the potential participants, provide a justification for this. The data is already anonymous without identifiers. We can not identify participants for consent. Previous consent for data collection in the original study was already received. Participants knew they would play a game and their game metric (time, scores, errors) would be recorded.

3. Does this study involve persons who cannot give their own consent (e.g. minors)? No

## G. ANONYMITY OF PARTICIPANTS AND CONFIDENTIALITY OF DATA

1. Provide a detailed explanation of the procedures to be used to ensure anonymity of participants and confidentiality of data both during the research and in the release of the findings.

Already anonymous data set.

2. Describe the procedures for securing written records, video/audio tapes, questionnaires and recordings. Identify (i) whether the data collected will be linked with any other dataset and identify the linking dataset and (ii) whether the data will be sent outside of the institution where it is collected or if data will be received from other sites. For the latter, are the data de-identified, anonymized, or anonymous?

Anonymous data set.

3. Indicate how long the data will be securely stored and the method to be used for final disposition of the data.

Electronic Data

Erasing of electronic data after NA year(s).

Would like to retain data indefinitely without identifiers, data is already anonymous.

Location: Data set is on dropbox.

4. Are there conditions under which anonymity of participants or confidentiality of data cannot be guaranteed?

No

## H. PARTIAL DISCLOSURE AND DECEPTION

**1. Will this study involve the use of partial disclosure or deception?** Partial disclosure involves withholding or omitting information about the specific purpose or objectives of the research study or other aspects of the research. Deception occurs when an investigator gives false information or intentionally misleads participants about one or more aspects of the research study. No

Researchers must ensure that all supporting materials/documentation for their applications are submitted with the signed, hard copies of the ORE form 101/101A. Note, materials shown below in bold are normally required as part of the ORE application package. The inclusion of other materials depends on the specific type of projects.

**Protocol Involves a Drug, Medical Device, Biologic, or Natural Health Product**

If the study procedures include administering or using a drug, medical device, biologic, or natural health product that has been or has not been approved for marketing in Canada then the researcher is to complete [Appendix A](#). Appendix A is to be attached to each of the one copy of the application that are submitted to the ORE. Information concerning studies involving a drug, biologic, natural health product, or medical devices can be found on the ORE website.

Please check below all appendices that are attached as part of your application package:

- Other - None

\* Refer to [sample letters](#).

**NOTE:** The submission of incomplete application packages will increase the duration of the ethics review process.

To avoid common errors/omissions, and to minimize the potential for required revisions, applicants should ensure that their application and attachments are consistent with the [Checklist For Ethics Review of Human Research Application](#)

Please note the submission of incomplete packages may result in delays in receiving full ethics clearance. We suggest reviewing your application with the Checklist For Ethics Review of Human Research Applications to minimize any required revisions and avoid common errors/omissions.

**INVESTIGATORS' AGREEMENT**

I have read the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, 2nd Edition (TCPS2) and agree to comply with the principles and articles outlined in the TCPS2. In the case of student research, as Faculty Supervisor, my signature indicates that I have read and approved this application and the thesis proposal, deem the project to be valid and worthwhile, and agree to provide the necessary supervision of the student.

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigators must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPS2\)](#) prior to submitting an ethics application. Each investigator is to indicate they have completed the TCPS2 tutorial. If there are more than two investigators, please attach a page with the names of each additional investigator along with their TCPS2 tutorial completion information.

\_\_\_\_\_  
Print and Signature of Principal  
Investigator/Supervisor

\_\_\_\_\_  
Date

Completed TCPS2 tutorial:  
 YES  NO  In progress

\_\_\_\_\_  
Print and Signature of Principal  
Investigator/Supervisor

\_\_\_\_\_  
Date

Completed TCPS2 tutorial:  
 YES  NO  In progress

Each student investigator is to indicate if they have completed the Tri-Council Policy Statement, 2nd Edition Tutorial (<http://pre.ethics.gc.ca/eng/education/tutorial-didactice>). If there are more than two student investigators, please attach a page with the names of each additional student investigator along with their TCPS2 tutorial completion information.

\_\_\_\_\_  
Signature of Student Investigator

\_\_\_\_\_  
Date

Completed TCPS2 tutorial:  
 YES  NO  In progress

\_\_\_\_\_  
Signature of Student Investigator

\_\_\_\_\_  
Date

Completed TCPS2 tutorial:  
 YES  NO  In progress

**FOR OFFICE OF RESEARCH ETHICS USE ONLY:**

Julie Joza, MPH  
Acting Chief Ethics Officer  
OR  
Sacha Geer, PhD  
Manager, Research Ethics  
OR  
Nick Caric, MDiv  
Research Ethics Advisor  
OR  
Karen Pieters, MPH  
Research Ethics Advisor

\_\_\_\_\_  
Date

ORE 101  
Revised September 2016

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Please rate the following on a scale of 1 to 7, where 1 is strongly disagree and 7 is strongly agree.

	7 Strongly agree	6 agree	5 Somewh at agree	4 Neither agree nor disagree	3 Somewhat disagree	2 disagree	1 Strongly disagree
The level was fun							
The level was difficult							
The level was easy							
The enemies acted "tricky" or "strategic".							
The enemies were predictable							

Chapter 3 appended materials includes the research ethics form filed with Office of Research Ethics at University of Waterloo.

## APPLICATION FOR ETHICS REVIEW OF RESEARCH INVOLVING HUMAN PARTICIPANTS

Please remember to **PRINT AND SIGN** the form and forward with all attachments to the Office of Research Ethics, EC5, 3rd floor.

### A. GENERAL INFORMATION

**1. Title of Project:** Exploring the Effects of Algorithm Characteristics on Player Experience

**2. a) Principal and Co-Investigator(s)**

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigation must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPS2\)](#) prior to submitting an ethics application. The tutorial takes at least three hours; it has start and stop features.

Name Department Ext: e-mail:

**2. b) Collaborator(s)**

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigation must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPS2\)](#) prior to submitting an ethics application. The tutorial takes at least three hours; it has start and stop features.

Name Department Ext: e-mail:

**3. Faculty Supervisor(s)**

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigation must complete the [Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. \(TCPS2\)](#) prior to submitting an ethics application. The tutorial takes at least three hours; it has start and stop features.

Name Department Ext: e-mail:

**4. Student Investigator(s)**

Name Department Ext: e-mail: Local Phone #:

Rina R. Wehbe Computer Science, School of mwehbe@uwaterloo.ca

Giovanni Ribeiro Computer Science, School of ggsribei@uwaterloo.ca

Kin Pong Computer Science, School of kennyy\_81@hotmail.com

**5. Level of Project:** PhD      **Specify Course:**

Research Project/Course Status: New Project/Course

**6. Funding Status (If Industry funded and a clinical trial involving a drug or natural product or is medical device testing, then Appendix B is to be completed):**

Is this project currently funded? No

- If No, is funding being sought OR if Yes, is additional funding being sought? No
- Period of Funding:

**7. Does this research involve another institution or site?** No

If Yes, what other institutions or sites are involved:

**8. Has this proposal, or a version of it, been submitted to any other Research Ethics Board/Institutional Review Board?** No

**9. For Undergraduate and Graduate Research:**

Has this proposal received approval of a Department Committee? Not Dept. Req.

**10. a) Indicate the anticipated commencement date for this project:** 2/22/2016

**b) Indicate the anticipated completion date for this project:** 12/30/2017

**11. Conflict of interest:** [Appendix B](#) is attached to the application if there are any potential, perceived, or actual financial or non-financial conflicts of interest by members of the research team in undertaking the proposed research.

### B. SUMMARY OF PROPOSED RESEARCH

**1. Purpose and Rationale for Proposed Research**

a. Describe the purpose (objectives) and rationale of the proposed project and include any hypothesis(es)/research questions to be investigated. For a non-clinical study summarize the proposed research using the headings: Purpose, Aim or Hypothesis, and Justification for the Study. For a clinical trial/medical device testing summarize the research proposal using the following headings: Purpose, Hypothesis, Justification, and Objectives.

Where available, provide a copy of a research proposal. For a clinical trial/medical device testing a research proposal is required: Purpose

The purpose of this study is to assess whether changing the algorithms of a non-player enemy character in a video game will change the level or excitement or emotional response of the player.

Methodology

Players will be asked to play a game with four different types of enemies. The enemies will be controlled by different biologically inspired algorithms (Control, Firefly, Swarm, and Flocking algorithm). The algorithm will change how quickly the enemy characters move towards the players and whether or not they make a detour.

Game

The game will be a simple game played on the computer with an arrow or on a touch device (tablet, phone, or tabletop). Art will be simple, cartoonish, and colourful. The game will play like 'school-yard tag' where the player's finger will be running away from the enemies characters.

Measures

The players will be asked about their experience with the game. The enemies will be colour or shape coded. For example, did you think the blue enemies were harder to evade than the red enemies? To understand players underlying physiology we will also use heart rate and EEG, research grade or consumer grade models. We will also collect in game metrics (e.g. number of collisions, changes in direction, etc.).

Justification for the Study

The study seeks to make a contribution to game design by testing how we can change the movement of the enemy characters to make the game more emotionally exciting, scary, or fun. The game is meant to be played like an iPhone game and will be family friendly. All participants will be over 18.

b. In lay language, provide a one paragraph (approximately 100 words) summary of the project including purpose, the anticipated potential benefits, and basic procedures used.

Players will play a game with different types of enemies. Enemy characters will move according to inspired biological algorithms. Players will be wearing heart rate or EEG monitors to understand emotional response. Additionally players will be asked to fill out questionnaires.

## C. DETAILS OF STUDY

### 1. Methodology/Procedures

a. Indicate all of the procedures that will be used. Append to form 101 a copy of all materials to be used in this study.

Survey(s) or questionnaire(s) (in person) Some are standardized.  
Computer-administered task(s) or survey(s) None are standardized.

Interview(s) (in person)  
Non-invasive physiological measurement(s)

- Heart Rate  
- Electroencephalogram  
Unobtrusive observations

b. Provide a detailed, sequential description of the procedures to be used in this study. For studies involving multiple procedures or sessions, provide a flow chart. Where applicable, this section also should give the research design (e.g., cross-over design, repeated measures design).

The study will take approximately 60 minutes. Upon arriving you will be shown the study room, been shown the equipment, and game.

Equipment Description:

Electroencephalogram (EEG) An EEG sensors are made up of electrodes

Cardiovascular Measures Commonly referred to as heart rate

Before asking if the participant would like to participate, we will also show the game and gaming environment.

c. Will this study involve the administration/use of any drug, medical device, biologic, or natural health product? No

d. Will you be using, processing and/or storing any biological materials of human origin such as blood, tissue, cells or bodily fluids? No

### 2. Participants Involved in the Study

a. Indicate who will be recruited as potential participants in this study.

**UW Participants:**  
Undergraduate students  
Graduate students  
Faculty and/or Staff

**Non-UW Participants:**  
Adults

b. Describe the potential participants in this study including group affiliation, gender, age range and any other special characteristics. Describe distinct or common characteristics of the potential participants or a group (e.g., a group with a particular health condition) that are relevant to recruitment and/or procedures. Provide justification for exclusion based on culture, language, gender, race, ethnicity, age or disability. For example, if a gender or sub-group (i.e., pregnant and/or breastfeeding women) is to be excluded, provide a justification for the exclusion.

Anyone above 18+.

c. How many participants are expected to be involved in this study? For a clinical trial, medical device testing, or study with procedures that pose greater than minimal risk, sample size determination information is to be provided.

30

### 3. Recruitment Process and Study Location

a. From what source(s) will the potential participants be recruited?

UW undergraduate or graduate classes  
UW Psychology Research Experiences Group  
KW residential community  
Games Institute Mailing List, Game Club mailing list, posters around campus

b. Describe how and by whom the potential participants will be recruited. Provide a copy of any materials to be used for recruitment (e.g. posters(s), flyers, cards, advertisement(s), letter(s), telephone, email, and other verbal scripts).  
Posters, Mailing list, Verbal Scripts, SONA

c. Where will the study take place? On campus: Games Institute

### 4. Remuneration for Participants

Will participants receive remuneration (financial, in-kind, or otherwise) for participation? No

### 5. Feedback to Participants

Describe the plans for provision of study feedback and attach a copy of the feedback letter to be used. Wherever possible, written feedback should be provided to study participants including a statement of appreciation, details about the purpose and predictions of the study, restatement of the provisions for confidentiality and security of data, an indication of when a study report will be available and how to obtain a copy, contact information for the researchers, and the ethics review and clearance statement.

A verbal thank you will be given along with a period to ask questions and rest as long as the participant needs before leaving the lab.

## D. POTENTIAL BENEFITS FROM THE STUDY

1. Identify and describe any known or anticipated direct benefits to the participants from their involvement in the project.

The game might be fun for them. They will also get to give feedback that will be used to improve the game.

2. Identify and describe any known or anticipated benefits to the scientific community/society from the conduct of this study.

The study will help game designers, the game design community, and contribute to games user research a branch of human computer interaction to inform how the design of a computer application can change the experience of the user.

## E. POTENTIAL RISKS TO PARTICIPANTS FROM THE STUDY

1. For each procedure used in this study, describe any known or anticipated risks/stressors to the participants. Consider physiological, psychological, emotional, social, economic risks/stressors. A study-specific current health status form must be included when physiological assessments are used and the associated risk(s) to participants is minimal or greater.

Minimal risks anticipated.

The study is using a game which may be frustrating or the participant might lose the game.

The study uses sensors (heart rate and EEG). The sensors are gel based and saline solution respectively. As a result, they may cause irritation (although this is rare).

2. Describe the procedures or safeguards in place to protect the physical and psychological health of the participants in light of the risks/stressors identified in E1.

Players will be told that performance is not graded or posted. Instead performance data and all other data will be statistically analyzed not individually, but instead as a group and used to improve the game and inform future game design.

Sensors will be shown before consent is gained. Participants will be optionally able to try on the sensors or put solution on their inner wrist as a test. If there is a reaction to the sensors or discomfort, we will stop the study and the participant will rinse with cool water.

The participant will be reminded that they can stop at any time, participation is optional, and all they need to do is inform the researcher.

## F. INFORMED CONSENT PROCESS

1. What process will be used to inform the potential participants about the study details and to obtain their consent for participation?

Information letter with written consent form

2. If written consent cannot be obtained from the potential participants, provide a justification for this.

3. Does this study involve persons who cannot give their own consent (e.g. minors)? No

## G. ANONYMITY OF PARTICIPANTS AND CONFIDENTIALITY OF DATA

1. Provide a detailed explanation of the procedures to be used to ensure anonymity of participants and confidentiality of data both during the research and in the release of the findings.

Identifying information will not be collected or linked to study data. Consent forms and scheduling of appointments will be done separately from the study. Once the consent form is signed participants will participate under an unlinked ID number (which links collected measures).

2. Describe the procedures for securing written records, video/audio tapes, questionnaires and recordings. Identify (i) whether the data collected will be linked with any other dataset and identify the linking dataset and (ii) whether the data will be sent outside of the institution where it is collected or if data will be received from other sites. For the latter, are the data de-identified, anonymized, or anonymous?

Data will not be linked to any identifiers. Aggregated data will be submitted as supporting supplementary material for replicability.

3. Indicate how long the data will be securely stored and the method to be used for final disposition of the data.  
Aggregated data will be kept without identifiers and submitted as supplementary supporting material. Raw data without identifiers will be kept on a private hard disk.  
Location: Locked cabinet in the Games Institute

4. Are there conditions under which anonymity of participants or confidentiality of data cannot be guaranteed? No

## H. PARTIAL DISCLOSURE AND DECEPTION

1. Will this study involve the use of partial disclosure or deception? Partial disclosure involves withholding or omitting information about the specific purpose or objectives of the research study or other aspects of the research. Deception occurs when an investigator gives false information or intentionally misleads participants about one or more aspects of the research study. No

Researchers must ensure that all supporting materials/documentation for their applications are submitted with the signed, hard copies of the ORE form 101/101A. Note, materials shown below in bold are normally required as part of the ORE application package. The inclusion of other materials depends on the specific type of projects.

### Protocol Involves a Drug, Medical Device, Biologic, or Natural Health Product

If the study procedures include administering or using a drug, medical device, biologic, or natural health product that has been or has not been approved for marketing in Canada then the researcher is to complete Appendix A. Appendix A is to be attached to each of the one copy of the application that are submitted to the ORE. Information concerning studies involving a drug, biologic, natural health product, or medical devices can be found on the ORE website.

Please check below all appendices that are attached as part of your application package:

- Recruitment Materials: A copy of any poster(s), flyer(s), advertisement(s), letter(s), telephone or other verbal script(s) used to recruit/gain access to participants.
- Information Letter and Consent Form(s)\*. Used in studies involving interaction with participants (e.g. interviews, testing, etc.)
- Data Collection Materials: A copy of all survey(s), questionnaire(s), interview questions, interview themes/sample questions for open-ended interviews, focus group questions, or any standardized tests.
- Debriefing Letter: Required for all studies involving deception.
- Ethics Approval Certificate from other institution's Research Ethics Board. A copy is required for multi-centered research\*

\* Refer to sample letters.

**NOTE:** The submission of incomplete application packages will increase the duration of the ethics review process.

To avoid common errors/omissions, and to minimize the potential for required revisions, applicants should ensure that their application and attachments are consistent with the *Checklist For Ethics Review of Human Research Application*

Please note the submission of incomplete packages may result in delays in receiving full ethics clearance.

We suggest reviewing your application with the Checklist For Ethics Review of Human Research Applications to minimize any required revisions and avoid common errors/omissions.

## INVESTIGATORS' AGREEMENT

I have read the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans, 2nd Edition (TCPS2) and agree to comply with the principles and articles outlined in the TCPS2. In the case of student research, as Faculty Supervisor, my signature indicates that I have read and approved this application and the thesis proposal, deem the project to be valid and worthwhile, and agree to provide the necessary supervision of the student.

**NEW** As of May 1, 2013, all UW faculty and staff listed as investigators must complete the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans Tutorial, 2nd Ed. (TCPS2)* prior to submitting an ethics application. Each investigator is to indicate they have completed the TCPS2 tutorial. If there are more than two investigators, please attach a page with the names of each additional investigator along with their TCPS2 tutorial completion information.

Print and Signature of Principal Investigator/Supervisor \_\_\_\_\_ Date \_\_\_\_\_

Completed TCPS2 tutorial:  
 YES  NO  In progress

Print and Signature of Principal Investigator/Supervisor \_\_\_\_\_ Date \_\_\_\_\_

Completed TCPS2 tutorial:  
 YES  NO  In progress

Each student investigator is to indicate if they have completed the Tri-Council Policy Statement, 2nd Edition Tutorial (<http://pre.ethics.gc.ca/eng/education/tutorial-didacticiel/>). If there are more than two student investigators, please attach a page with the names of each additional student investigator along with their TCPS2 tutorial completion information.

Signature of Student Investigator \_\_\_\_\_ Date \_\_\_\_\_

Completed TCPS2 tutorial:  
 YES  NO  In progress

Signature of Student Investigator \_\_\_\_\_ Date \_\_\_\_\_

Completed TCPS2 tutorial:  
 YES  NO  In progress

## FOR OFFICE OF RESEARCH ETHICS USE ONLY:

Julie Jozza, MPH  
Acting Chief Ethics Officer  
OR  
Nick Caric, MDiv  
Research Ethics Advisor  
OR  
Karen Pieters, MPH  
Research Ethics Advisor

ORE 101  
Revised September 2016

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Chapter 5.1 appended materials includes research ethics documents processed by the Office of Research Ethics at University of Waterloo. The consent form and information letter are included in full. Additional materials include scripted introduction of instructions participants were given including instructions on how to effectively use the large-display. Moreover, I include the Poster Advertising the Study. Finally, attached are Pre and Post Collected Questionnaires and Interview Materials.

**Title of Project:** HybridTouch  
**Student Investigator:** Terence Dickson  
**Faculty Supervisor:** Dr. Daniel Vogel

**Dear Potential Participant:**

You are being asked to volunteer in a study at the University of Waterloo as part of a graduate-level thesis. The intent of the study is to evaluate the performance of a new kind of touch-screen input on large screens. The researcher involved in this study is Terence Dickson, Computer Science graduate student with the University of Waterloo.

This study is a replication of previous research by Dr. Daniel Vogel from the Cheriton School of Computer Science at the University of Waterloo studying pen input on large screens, where participants were able to switch between using a pen to tap directly on targets and using the pen to move a cursor in broad movements to click on distant targets. We will be evaluating a similar input method for touch input, and seeing how it affects the time required to click a target, as well as participants' error rates, compared to the regular use of a touchscreen.

To evaluate this, we will ask you and another participant to stand in front of a large touchscreen and select targets using either normal touch input, or our input-switching method. Upon successfully clicking on the target, it will vanish and a new target will appear. The computer will keep track of how long it takes you to click each target after it appears, as well as how many times you miss the target before clicking on it. You will be asked to fill out a short demographic questionnaire before the trial begins, and to fill out a short questionnaire about your experience with the interaction technique after the experiment, as well as to participate in a semi-structured interview about your experience during the trial. The entire session will take 60 minutes, of which no more than 40 will be spent selecting targets on the touch screen. During the experiment, your performance will at times be tracked separately from the other participant's performance, and be visible to both of you. There is no reward or penalty for performing better or worse than the other participant, and this condition is intended to be non-stressful. You will each receive \$10 remuneration for your time. The amount received is taxable. It is your responsibility to report this amount for income tax purposes.

**Confidentiality and Data Retention**

All data collected is considered confidential. However, with your permission, we would like to make available de-identified data on time taken to click targets and error rates in our study to the research community to support replication, and to make this data set available on-line. No identifying information will be recorded, only the time taken to click targets and error rates, yielding a completely de-identified data set. This data set will be available for at least the next seven years, and may be available and shared indefinitely. Paper records (e.g. consent forms) will be stored in the secure office of Dr. Daniel Vogel at the University of Waterloo until the end of initial data analysis, and then securely shredded. Your name will not appear in any publication resulting from this study; however, with your permission anonymous quotations may be used. In these cases participants will be referred to using generic labels (P1, P2, ...) or collectively as a group (Group A, Group B, ...). Data collected during this study will be retained on encrypted removable media in locked cabinets. Electronic data will not include personal identifying information such as names.

You will be explicitly asked for consent for the use of any photo/video/audio data for the purpose of reporting the study's findings. If consent is granted, these data will be used only for the purposes associated with teaching, scientific presentations, publications, and/or sharing with other researchers. You will not be identified by name. Your video footage will be anonymized by altering the tone and pitch of your voice, and/or by obscuring your identity in the video. If consent is not granted, then information provided by you in the pre-experiment and post-experiment questionnaires and the semi-structured interview will still be recorded and stored securely, but will not be disseminated with the de-identified data on your interactions with the touch screen. No personally identifying information will be asked of you in the pre-experiment and post-experiment questionnaires, and in the semi-structured interview.

To disseminate results, aggregate agreement between data collected and the result of Dr. Daniel Vogel's previous research will be presented both in research papers and in conference presentations. As well, other researchers may make use of the data set and publish aggregate or individual analyses of the data.

Participation in the study is voluntary. You may decline to answer particular questions, if you wish, and may withdraw participation at any time. You

will receive a prorated amount of remuneration of \$2.50 per fifteen minutes if you withdraw.

#### Risks

There are no known or anticipated risks to you as a participant in this study other than those associated with the normal use of a large touchscreen.

#### Benefits

There are no direct benefits to you for participating in the study. However, the results of this research may contribute to the knowledge base of Human-Computer Interaction research and lead to the development of better computer devices and interfaces.

#### Questions

If you have any questions about participation in this study, or would like additional information to assist you in reaching a decision about participation, please contact Terence Dickson at (226)-789-0098 or via email at tpdickso@uwaterloo.ca, or contact Dr. Daniel Vogel at (519)-888-4567 x33561 or via email at dvogel@uwaterloo.ca.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 21119). If you have questions for the Committee contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca. However, the final decision about participation is yours.

Thank you for your assistance in this project.

Terence Dickson  
Cheriton School of Computer Science  
University of Waterloo  
200 University Ave. West, Waterloo, Ontario N2L 3G1 Canada  
Tel: +1 (226) 789-0098  
Email: tpdickso@uwaterloo.ca

#### Consent Form

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

**Project:** HybridTouch: fluid switching between absolute and relative pointing with touch

I have read the information presented in the information letter about a study being conducted by Terence Dickson, under the supervision of Dr. Daniel Vogel, for the Cheriton School of Computer Science at the University of Waterloo. I have had the opportunity to ask any questions related to this study, to receive satisfactory answers to my questions, and any additional details I wanted.

Sometimes a certain image and/or segment of videotape clearly shows a particular feature or detail that would be helpful in teaching or when presenting the study results at a scientific presentation or in a publication.

I am aware that I may allow video and/or digital images in which I appear to be used in teaching, scientific presentations, publications, and/or sharing with other researchers with the understanding that I will not be identified by name. I am aware that I may allow excerpts from the conversational data collected for this study to be included in teaching, scientific presentations and/or publications, with the understanding that any quotations will be anonymous. I am aware that I may allow my anonymous touch data to be stored and shared with other researchers for the purpose of further inquiry.

I am aware that I may withdraw my consent for any of the above statements or withdraw my study participation at any time without penalty by advising the researcher.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 21119). I was informed that if I have questions for the Committee I may contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or ore-ceo@uwaterloo.ca.

**Please circle and initial**

With full knowledge of all foregoing, I agree,  
of my own free will to participate in this study.

YES NO \_\_\_\_\_

I agree to be videotaped with audio.

YES NO \_\_\_\_\_

I agree to let my conversation during the study  
be directly quoted, anonymously, in presenta-  
tions of research results.

YES NO \_\_\_\_\_

I agree to let clips, audio, and/or digital im-  
ages from the video be used for presentations  
of the research results.

YES NO \_\_\_\_\_

I agree to let my anonymous touch data be  
stored and shared with other researchers for  
the purpose of further inquiry.

YES NO \_\_\_\_\_

\_\_\_\_\_  
Name of participant (Please print)

\_\_\_\_\_  
Signature of participant

\_\_\_\_\_  
Name of witness (Please print)

\_\_\_\_\_  
Signature of witness

\_\_\_\_\_  
Date

**Introduction:**

This is the PowerWall, a touchscreen we assembled here at Waterloo. It's made up of eight computer screens, as well as an optical frame that can detect where your fingers are, to allow for touch input. Because the frame uses cameras to detect where your fingers are, it will sometimes see your fingers if you allow them to rest near the screen. (Demonstrate). Because of this, try to keep your fingers straight and pulled back from the screen while interacting with it. Likewise, you may find it more reliable if you try to work with your hands closer to the centre of a screen, instead of overtop of a seam between two screens. (Demonstrate.) Note: the bottom screens are less sensitive and you will need to press a bit harder.

The screen can be a bit sticky, so feel free to apply some hand powder if you feel it improves your interaction with the screen.

You will be given breaks to rest at several points during the experiment to make sure you aren't tired out.

**Game**

The object of the game is to save planet earth from the alien invasion. As you can see here, there is a health bar surrounding earth (point).

Enemies will spawn from the corners. You will need to use the tool whose colour matches the enemy alien to kill it. For example, green enemies need to be killed with the green tool.

**Tools:**

(show the direct and indirect movement)

Red Cannon	Tap to explode red enemies
Green Shield	Green enemies need to be hit with the shield
Blue Blackhole	Circle to kill blue enemies. The circle needs to cross over each other. The circle can be imperfect
Purple Magnet	Used to steal tools from the other player

**Activating tools:**

To activate a tool you must drag it over to your side and drop it (demonstrate). Note the change in border colour and the tool name at the top. You cannot use a tool unless it is active, and your workspace shows the tool's name.

**Rules of the Game:**

- You must stay within your boundary area
- Return tools to the neutral zone (one at a time)
- Score points by killing enemies
- Loss points by letting them hit the earth
- Coop (same score) / Comp (diff scores)

**Pre-experiment Questionnaire**

1. Gender: *Male Female Other/Prefer not to specify*
2. Age: \_\_\_\_\_
3. Which hand do you write with? *Left Right*
4. How many hours per week on average do you use a computer?  
\_\_\_\_\_ Hours
5. How many hours per week on average do you use device with a touch-screen?  
\_\_\_\_\_ Hours
6. What is your height?  
\_\_\_\_\_ cm
7. What is your arm-span?  
\_\_\_\_\_ cm
8. Did you know the other participant before arriving? *Yes No*

### Post- Experiment Questionnaire

Please rate the following from 1 - 7 with 7 representing the worst possible score.

		Fatigue	Speed	Accuracy	Comments:
Red Cannon	Direct				
	Hybrid				
Green Shield	Direct				
	Hybrid				
Blue Blackhole	Direct				
	Hybrid				
Purple Magnet	Direct				
	Hybrid				

Any other Comments? Write below.

## A novel input method for multiple users



We are conducting a study observing performance with pointing methods on large touchscreens. We're looking for participants to play a game where you select targets on a large touchscreen, and answer pre- and post-experiment questionnaires as well as participate in a semi-structured interview about your experience. The study will be no longer than 60 minutes, no more than 40 minutes in the game. You will receive \$10 remuneration for your time participating in this study.

We are running the experiment with two participants using the touchscreen simultaneously. If you and a friend would like to participate, send an email to [tpdicks@uwaterloo.ca](mailto:tpdicks@uwaterloo.ca) to set up a mutually-satisfactory time to run the experiment. Alternatively, if you'd like to sign up alone, visit [waterloohci.sona-systems.com](http://waterloohci.sona-systems.com) to sign up for a **HybridTouch** time slot, where you can be matched with someone else.

This study has been reviewed and received ethics clearance through a University of Waterloo Research Ethics Committee (ORE# 21119). If you have any comments or concerns, please contact the researchers associated with this study at [tpdicks@uwaterloo.ca](mailto:tpdicks@uwaterloo.ca) or [dvogel@uwaterloo.ca](mailto:dvogel@uwaterloo.ca), or contact the Chief Ethics Officer, Office of Research Ethics, at 1-519-888-4567 ext. 36005 or [ore-ceo@uwaterloo.ca](mailto:ore-ceo@uwaterloo.ca).

HybridTouch <a href="mailto:tpdicks@uwaterloo.ca">tpdicks@uwaterloo.ca</a> <a href="http://waterloohci.sona-systems.com">waterloohci.sona-systems.com</a>								
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**Fin**