THE PROSOCIAL EFFECTS OF DIGITAL GAMEPLAY

A Thesis

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Master of Science

by

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ABSTRACT

In 2019, approximately 2.5 billion people played digital games. With the popularity comes both concerns about possible negative consequences such as violence as well as the potential for positive outcomes such as improve social skills and prosocial behavior. This thesis proposes the real-game mesosystem to understand the important role of the physical environment which has rarely been examined in previous studies. We conducted a true experiment with 2x2 factorial design with two independent variables, Game Mode (collaborative v. competitive) and Game Setting (same room v. different rooms), using the game Overcooked 2. The dependent variables are Friendship, Social Closeness, and Prosocial Behavior. We found main effect of Game Setting on Friendship, and Game Setting by Game Mode interaction effects on Social Closeness and Prosocial Behavior, all effects are medium-small. Future game studies and designs should be more aware of the physical environments where the games were, or will be played.

BIOGRAPHICAL SKETCH

Tong Xu received his Bachelor of Literature in communication from School of Gifted Young, University of Science and Technology of China in 2014.

He then started his Ph.D. in Computer Science at Institute of Computing Technology, Chinese Academy of Sciences until eventually deciding to drop out in 2016 and starting to work for Infervision Technology Co., Ltd. on a visualized system for clinical doctors to define and train their own convolutional neural network with benchmark and activation feedback. He also worked for International Research Centre of Computational Design (IRCCD), Architectural Design and Research Institute of Tsinghua University (THAD) on several generative design, data-driven post-occupancy evaluation, and aerophotography-virtual-reality projects, while also participated Architectural Association (AA) Visiting School Beijing 2018 as teaching assistant.

Tong attended the M.S. program in Environmental Psychology and Ergonomics at Cornell University from 2018-2021, and also completed AA DLAB London in Digital Fabrication, Robotic Design & Technology in 2019.

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To all the games (and consoles) that have kept me company.

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Secondly, I want to thank my parents, especially my mother, Prof. Qiaoxia Tong, M.D., who fought on the front line during COVID-19 as the clinical director of department of infectious diseases at her hospital in Wuhan, China, and shared her experiences and expertise with doctors in USA, Canada, Brazil, Belarus, etc.

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LIST OF ABBREVIATIONS

ANOVA: Analysis of Variance

ADHD: Attention Deficit Hyperactivity Disorder

ANCOVA: Analysis of Covariance

ASD: Autism Spectrum Disorder

CBT: Cognitive Behavioral Therapy

DC: Different rooms, Cooperative mode

DV: Different rooms, Versus mode

MCI: Mild Cognitive Impairment

MMORPG: Massively Multiplayer Online Role-Playing Games

MUD: Multi-User Dungeon

PTSD: Post-Traumatic Stress Disorder

SC: Same room, Cooperative mode

SV: Same room, Versus mode

TTRPG: Tabletop Role-Playing Games

CHAPTER 1

INTRODUCTION

Digital Games

Digital games, also called video games, are games played with digital devices such as arcade machines, game consoles, and personal computers. They are an important element of popular culture and have become part of many people's daily life. Globally, it is estimated that there were about 2.5 billion digital game players ("gamers") who spent $152.1 billion on games in 2019 (Wijman, 2019). Gamers spend more than six hours playing games per week on average, and most of them have played games for more than four hours consecutively (Limelight Networks, 2020). One of the most popular online games, *World of Warcraft*, has about 4 million daily players (Advent Development, 2020).

While gaming is very popular, it is not without controversy, especially about excessive gaming, social isolation, and violence. Concerns about gaming, especially excessive gaming have led to the introduction of "Internet Gaming Disorder" (IGD) in the Diagnostic and Statistical Manual of Mental Disorders, 5th Edition (DSM) (Petry & O'Brien, 2013) and "Gaming Disorder," including both online and offline gaming in the 11th Revision of the International Classification of Diseases (ICD) (World Health Organization, 2020). While the ICD has more strict diagnosis criteria than the DSM (Jo et al., 2019), they share many common criteria, such as impaired control over gaming, and giving up other activities due to gaming.

There are debates in the fields of game study, neuroscience, and psychology regarding the necessity, reliability, and validity of Gaming Disorder as a mental

disorder. Efforts are being made to create a unified approach to assessment (Griffiths et al., 2014; Petry et al., 2014). In a debate paper, 24 authors from different fields expressed their concerns about the current operationalization of the disorder which is based on disorders related to substance abuse and gambling criteria, and the lack of consensus on symptomatology and assessment (Aarseth et al., 2016). Such issues potentially lead to improper and extreme treatments in some countries, such as China, where the disorder has been recognized without clear criteria even before the debate began (Stone, 2009).

Video game players also suffer from stereotyping, sometimes even stigmatization. One well-known stereotype is the so-called "Lonely Gamer", which links players to social isolation and addiction, while in fact, most players play with real-life friends and even make new real-life friends by playing games (Schiano et al., 2014). In fact, playing games online may increase both social capital and civic participation, promote social connectedness among elder players (Y.-H. Lee, 2019), while Nintendo Wii games may lead to lower reports of loneliness and greater positive mood (Kahlbaugh et al., 2011).

Some believe that violent games will result in physiological desensitization to violence which will lead to increased aggressive thought and behavior (Anderson et al., 2010; Anderson & Dill, 2000; Carnagey et al., 2007). However, many other studies have not found similar effects of violent games on increased aggression or decreased prosocial behaviors (Ferguson, 2015; Przybylski & Weinstein, 2019; Tear & Nielsen, 2013). One possible explanation of the conflicted results could be the heterogeneity of digital games. Digital games themselves can be very different from

each other. In fact, they are treated as "worlds" by many game designers (Bartle, 2004). Games may also be played on different devices, and in different physical settings. All these factors will affect the outcomes of games, making it extremely hard to draw conclusions about the "general" effect of games without research taking these variables into account.

Games with Specific Effects / Purposes

There are discussions about potential negative effects of gaming. However, gaming does have the potential to improve human functioning and well-being. Some people choose to design or modify games to utilize the positive effects of games on human.

Serious games are games designed for serious purposes that are mostly non-entertainment. Some scholars even suggested the term "computerized simulation" or "games for learning/training" instead of "serious games" (Crookall, 2010). Games designed for educational purposes are also called educational games and are sometimes considered to be "edutainment" (Charsky, 2010). Ideally, serious games should be both serious and fun, providing a combination of learning and entertainment and facilitating learning by in-game reward mechanics. However, in many cases, the relationship between design purpose and design of the game itself or its impact has not been clearly justified nor studied (Mitgutsch & Alvarado, 2012).

Another related term is *gamification*, which can even be traced back to "ludification" (from Latin *ludus* (game)/ *ludo* (play)) in the 18th century, such as lottery and playful furniture (Fuchs, 2016), and defined as "the use of game design elements in non-game contexts" (Deterding et al., 2011, p. 10). As a fundamental

difference from the above-mentioned serious game, a gamification design does not necessarily need to be a game – in fact, the definition even suggests that a gamification design should not be a game. Gamification can be applied to different media, for example, public media such as displays in urban places (Craven et al., 2014; Schieck et al., 2014). Some studies about location-based gamification design even suggested a gamification of "contemporary life" (Hjorth & Richardson, 2017). As one of the most important elements of game, rewards as feedback or reinforcement have been widely studied and commonly applied in gamification designs (Rapp, 2017).

A slightly different concept is the use of existing commercial games or modified games for a serious purpose. It is suggested that music games, such as *Guitar Hero,* in which the players use a controller to simulate guitar playing, can be used as a rhythmic training tool (Bégel et al., 2017). Other types of games, for example, the role-playing game *Neverwinter Nights*, in which the player control a group of characters to save the world and can also be modified for educational purposes (Loh & Byun, 2009). Similarly, *Second Life Teen*, a massively multiplayer online role-playing platform for teenagers, was modified for social skills training (van Dijk et al., 2008).

The Social Aspect of Digital Games

By the 1990s, players of Multi-User Dungeons (MUD) games were studied to explain how and why they play games, and to identify so-called "player types." One type or group of players who "empathise with other players" was identified and named "Socializers" (Bartle, 1996). These studies extended to modern Massively Multiplayer Online Role-Playing Games (MMORPG), as they are believed to be a successor of

MUD (Mortensen, 2006). The Socializer player type, or the Sociability aspect of digital gameplay is further confirmed and supported by follow-up studies about digital game players, where it remains as a player type, a dimension of players' motivation, or even as a type of fun (Hamari & Tuunanen, 2013).

Despite minor differences, similar constructs explaining the social aspect of digital gameplay were examined through both qualitative and quantitative methods. Socializers were described by Bartle (1996) to be more interested in people than in the game itself. Socializers use the game as a communicative tool, chatting with other players, getting to know people, and building relationships. They will talk with other players about their real-world life and are generally against killing other players. Following Bartle's work, four emotional experience types were summarized (Lazzaro, 2004): "hard fun", "easy fun", "altered states", and "people factor", also called "people fun." Being somehow different from Sociability, "people fun" focuses on social experiences, interpreting game as a social tool where players play with friends. Surveys and factor analysis were used as quantitative means to explore the underlying motivation of MMORPG players (Yee, 2006; Yee et al., 2012), through which scholars found a social component with three different aspects: socializing, relationship, and teamwork.

Social Interactions in Online Games

There are three types of digital games, categorized in terms of numbers of players playing together: MMORPGs where thousands of players play together on the same server, (non-massively) multi-player games where about ten players play in the same "room", and single-player games where players play alone. The interactions

between players have always been a main focus of design of online games. Usually, these interactions can be classified into cooperative and competitive.

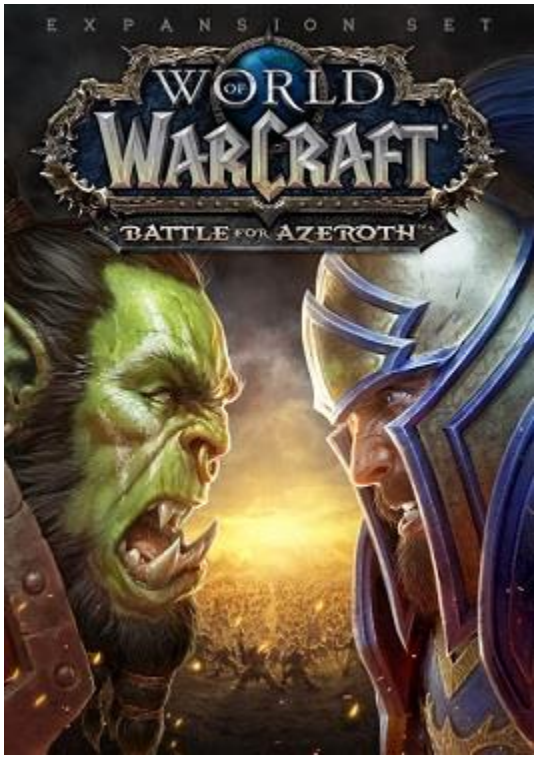


Figure 1: Cover art for *World of Warcraft: Battle for Azeroth*, illustrating the battle between the Horde (left) and the Alliance (right).

The design of digital games can greatly influence social interactions in the game, just as children's social play depends on their toys. As mentioned above, many social interactions happen inside MMORPGs. However, these interactions can differ a lot, and are affected by the dynamics and rules of the game which may promote cooperative or competitive relations between players, for example, fighting monsters together in the same team or killing other players in different factions. In the game *world of warcraft*, one of the most popular MMORPGs, wars between the two major in-game factions, the Alliance and the Horde, have always been a core element of both

the game design and the in-game story (Figure 1). Players have to choose a faction and will fight against NPCs (non-player characters) and other players in the opposite faction. The PVP (player versus player) practices are encouraged by in-game rewards, and promoted by quests that are given to players even if they choose to play in the PvE (player versus environment) server where all players play in PvE mode by default.

Competitive behaviors such as wars between factions and players are not always the main theme of MMORPGs. For example, *Guild War* has many mechanics and systems, such as PVP-only characters, battles between player guilds and alliances, and player "arenas", for PVP activities while keeping the experience in the "main world" of the game focused on PVE. In *Final Fantasy XIV*, teamwork is further encouraged by allowing players to give "recommendations" to their teammates after finishing in-game dungeons or boss fights. Players receive unique titles, badges, and equipment if they managed to get a certain number of recommendations.

The social structure of the player community becomes even more complicated in games like *EVE Online*. The game has a "standing" system representing the relationship between one's character and in-game non-player factions, "cooperation" (sub-factions), "agents" (NPC) that will be affected by your actions in the game helping or hindering them and other factions they like or dislike. In addition to the pre-designed in-game social structures, there are also regions governed by players, or more precisely, "warlords" who protect and collect taxes from "peasants", resembling medieval feudalism in many ways (Milik & Webber, 2020).

Multiplayer games that are not MMORPG usually have fewer players playing together at the same time. Many of them, especially multiplayer First-Person Shooter

(FPS) games such as *Counter-Strike*, and *Overwatch*, and Multiplayer Online Battle Arena (MOBA) games such as *Dota (2)* and *League of Legends*, are more focused on team fights where players will join a team, usually of around 5 or 6, and fight along with their teammates against another team, combining both cooperation and competition. Another example is *PlayerUnknown's Battlegrounds*, where players fight against each other as individuals to be the last one standing. Most of them usually have player-verses-robot, -zombies, etc., modes that are purely cooperative as well, but these modes are usually not as popular as the player-verses-player mode.

Other multiplayer games focus more on cooperation between players, usually to conquer great in-game challenges: In the game *Monster Hunter (Series)*, players fight together in a team of 4 or fewer against gigantic monsters that are threatening the ecological balance of the in-game environment. In another game *Death Stranding*, players have to deliver essential supplies to people in the in-game post-apocalyptic United States full of dangerous creatures, all the way from east to west coast. They will help each other by building infrastructures such as roads, bridges, power generators, and completing other players' failed deliveries. Players may also play the game in unintended ways: in the game *Dark Souls*, some players invade others' worlds only for giving them useful items and equipment, while some other players will leave seemingly friendly and helpful notes on the floor that can actually lead others to deadly traps.

While online games vary in terms of their cooperative and competitive mechanics, little research has explicitly examined how these variables might affect outcomes such as social connection and prosocial behaviors in the real world.

Addressing this gap in our understanding of online gaming and real-world social behaviors would contribute to a clearer appreciation of the benefits and potential risk of gaming.

Playing Together Physically

Another variable that has not been closely studied by online game researchers is the physical space in which a game is played. Before the age of digital games, people played most games, such as chess, card games, board games, and sports games face-to-face, and many of these games are played in the same way nowadays. A more "modern" example would be tabletop role-playing games (TTRPG), such as Dungeons & Dragons (D&D), Warhammer, and Cyberpunk. Players sit down around a table to play TTRPG as a small social gathering, usually with a "dungeon master" or "storyteller" controlling enemies and telling the story. Many popular modern games, such as Neverwinter Nights, Icewind Dale, Baldur's Gate, Warcraft, StarCraft, Cyberpunk 2077, are actually based on or directly inspired by traditional TTRPGs.

In fact, many digital games still provide means for players to play with their friends or family on the same device while in the same physical space. "Hotseat mode," usually available in turn-based games, allows multiple players to play on the same device by taking turns, while action games may provide split-screen mode, dividing the screen for multiple players, or simply place all the players on the same screen. Another similar example would be LAN parties where players bring their computers or other consoles to the same place and play games on the same Local Area Network (LAN). In fact, most professional video game ("eSport") tournaments are played in this way to ensure stable connection and minimal latency.

Despite the existence of options to play physically together or physically apart, gaming research has not examined the effects of this variable on behavioral or emotional outcomes. The effects of games on friendship and social behavior can be heavily influenced by how the games were played, whether in a cooperative mode, or in a competitive mode. In an experiment where students in 7th to 10th grade were randomly assigned to play *Mario Cart Double Dash!!* sitting together with their friends, in either solitary, competitive, or cooperative conditions, researchers found that mode of play changed players' in-game behavior, while competitive mode leads to lowered friendship quality, which might be caused by decreased positive and prosocial behavior during gaming sessions (Verheijen et al., 2019). In another experiment, undergraduate students showed more cooperative behaviors and trust in their partners after playing together in cooperative mode compared to competitive mode, either with their friends or strangers (Waddell & Peng, 2014).

Effects of Digital Games on Real-world Skills

Most serious games are intended to improve real-world skills such as cognitive function, social skills, as well as and mental health. Similar skill improvements are also found among players of commercial video games (Blum-Dimaya et al., 2010; Ceranoglu, 2010; Choi et al., 2020). This section will describe the concept of transfer effects and then provide background regarding the effects of both commercial and serious games on cognitive functions, social skills, and mental health.

The notion that gaming skills may apply to the real world is referred to as "transfer effects." Transfer effects, or the transfer of training/learning from one task or field to another, are important for learning and everyday functioning. There are two

kinds of transfer effects: *near transfer* refers to transfer to or between similar tasks or contexts, while *far transfer* refers to transfer to or between dissimilar tasks or contexts (Barnett & Ceci, 2002). For example, transfer from calculating 1+1 to 232+54 is near transfer; while transfer from hand drawing to using CAD (computer-aided design) software illustrates far transfer. Studies have shown that far transfers in general are less likely to occur than near transfers (Hattie et al., 1996), and effect sizes are smaller for far transfer than for near transfer (Karbach & Kray, 2009). Transfer effects are important for education and other forms of trainings since learned skills are expected to be useful outside the classes, schools, or other specific environment.

Cognitive Functions

It is believed that there is a relationship between digital game playing and cognitive functions. Action-video-game playing affects visual selective attention and other visual skills (Green & Bavelier, 2003) and may even have long-term effects on the motor system (Castel et al., 2005). Expert gamers have been found to have better basic cognitive performance when compared with non-gamers (Boot et al., 2008).

While suggested to explain the observed performance differences in attention, (working) memory, and planning tasks between game players and non-players, transfer effects were not found in other forms of non-game training such as "brain training" quests as the training-related improvements will not generalize (Owen et al., 2010). Some believe that video game playing may foster "learning how to learn," thus raising the general learning ability of players (Green & Bavelier, 2012), which might be related to the concept of general intelligence (Barnett & Ceci, 2002). However,

many studies only have limited sample sizes and the reported effects might be caused by publication bias: only publishing results that are significant (Hilgard et al., 2019).

Based on the effects of commercial digital games on cognitive functions, serious games were designed to improve cognitive functions for different populations, such as children with Attention Deficit Hyperactivity Disorder (Bul et al., 2016; Dovis et al., 2015; Kerns et al., 2016) and elders with mild cognitive impairment (MCI) (Anguera et al., 2013; Ballesteros et al., 2014). Despite controversy regarding the effectiveness of serious games, a review of 28 studies showed that serious games do have a positive effect on the acquisition of knowledge and cognitive skills (Wouters et al., 2009), though general video game playing may have similar effects. However, the review also found that serious games influence affective learning and more specifically, changes in attitude, which has not been mentioned by studies about general gameplay.

Mental Health

In addition to potentially affecting cognitive function and social skills, games are also designed and utilized as interventions to treat mental health disorders. Playing casual games like *Bejeweled 2* can lead to improved mood and decreased stress (Russoniello et al., 2009), even violent games such as *Hitman* and *Call of Duty* can result in decreased hostile feelings and decreased depression after frustration for young adults (Ferguson & Rueda, 2010). Playing augmented reality (AR) games such as Pokémon Go can have a positive effect on well-being (Bonus et al., 2018), which positively correlates with friendship maintenance and fun (Yang & Liu, 2017). A systematic review of game-based interventions for depression therapy found a

moderate effect size for the entertainment subgroup where commercial games were used as interventions for both adolescents and general adults (Li et al., 2014).

Aside from the use of entertainment commercial games to improve mental health, traditional evidence-based interventions such as cognitive behavioral therapy (CBT) have also been translated into games in many studies, these games are also called e-therapies (Fleming et al., 2017). Moderate effect sizes were also found in a similar meta-analysis of serious games designed for not only depression, but also other mental disorders including post-traumatic stress disorder (PTSD), autism spectrum disorder (ASD), and attention deficit hyperactivity disorder (ADHD). The results suggest that about one in three treated patients – ranging from children to older adults – receive benefit from such e-therapy interventions (Lau et al., 2017).

Social Skills, Prosocial Behavior, and Friendship

As mentioned above, there is often a social aspect of play. In fact, it is common for children to play socially. Social play happens when children's play involves social interactions, such as talking, smiling, and role-playing. Social play is closely related to the social development of children with or without autism spectrum disorder (ASD) (Jordan, 2003). Social play depends on the play material, e.g., toys designed for social or isolate play (Quilitch & Risley, 1973).

In addition to improving social skills and promoting prosocial behaviors, playing games together can also help establish and maintain friendship, even for those who are emotionally sensitive (Kowert et al., 2014). Playing online games can promote a sense of closeness, belonging, and security (Kowert & Oldmeadow, 2015). Playing games together frequently with family members can lead to better family

satisfaction and closeness (B. Wang et al., 2018). Interestingly, however, research found that while real-life friends are positively associated with only bonding social capital, which is considered to be exclusive and reinforce existing friendships, online-only friends are also associated with bridging social capital, which is more inclusive and open to others in the wider, diverse society (Leonard, 2004; Patulny & Lind, 2007; Perry et al., 2018).

Never the less, two recent papers studied *World of Warcraft*, an online digital game, and its effect on adolescents with ASD, examining friendships and other social relationships in games and in the real world (Gallup et al., 2016; Gallup & Serianni, 2017). They found that advancements in virtual environments hold the potential to support social skills, friendship development, and emotional awareness and expression that will ultimately increase successful face-to-face interactions. A transfer of social skills from the virtual environment to face-to-face settings was also suggested. People also play games to maintain relationships with friends and family, as suggested by another study about the same game (Williams et al., 2006).

In a more general sense, Bartle observed that most players of MMORPGs will eventually progress into one of the two types: “Friends” who play primarily with people they have known for a long time and developed deep bonds with; or “Hackers” who understand the games so well that they can play purely intuitively (Bartle, 2004, p. 171). Indeed, in-depth interviews examining 10-year friendships started from games showed that online acquaintances playing together will eventually develop into real-world friends, while also stressing the interconnection between digital world(s) and the real world (Lai & Fung, 2020).

Recent studies generally support the idea that playing games together, especially under the cooperative game mode, may increase prosocial behavior even after gameplay (Passmore & Holder, 2014). Prosocial behavior is influenced by altruism, reciprocity, and gender (C. C. Wang & Wang, 2008), can be promoted by gaining "superpower" in games (Rosenberg et al., 2013), but is not affected by co-player supportiveness nor game difficulty (Breuer et al., 2017).

Games were also designed to improve social skills. Most of them fall into these two above mentioned categories: serious game and gamification design. Existing games were utilized with additional rules to promote cooperation or other types of positive social interactions (Autcraft, 2013). Some games were designed to enhance social skills and help "make friendship amongst playing" (Uiphanit et al., 2020, p. 222). Other games took a step further, included mechanics that facilitate cooperation by allowing players to play within the same game, or to control the action of the same character together in classrooms (Boyd et al., 2015; Lyon et al., 2016). However, the carry-over effect of many of these games to social skills is still unclear, or at most vaguely positive, due to the lack of solid quantitative studies (Xu & Maxwell, 2019).

Summary of Effects of Digital Games on Real-world Skills

In sum, positive effects of digital games on cognitive function, social skills, and mental health have been found in different games, among different ages, under different conditions. People have also used games as interventions for treating mental disorders, such as ADHD, ASD, MCI, and depression. The differences in game design, and the physical environment where games are played may have a major impact on the outcomes of games.

Digital Games as Mesosystems

As we study games and their effects on real-world skills, it may be helpful to situate games within the context of human-environment relations theory. This section presents the bioecological theory and the social ecological model to understand digital game as part of a greater system containing both the game and the physical environment. A system model covering both the game and the real world will be proposed as a framework to understand the intertwined relationship between the digital game and the real world during and beyond game playing.

Games and play are often believed to have their own, separated time and space (Brown & Vaughan, 2010; Huizinga, 1949), but games also take place, and follow rules in the real world (Juul, 2011). The game genres, "couch co-op" and "couch versus," for example, are based on the idea of playing games while sitting on the couch together and playing either cooperatively or competitively. The importance of the physical environment, however, is rarely mentioned in most studies examining gaming. In fact, some of studies neglect to provide clear descriptions of the games they studied.

Recognition that the environment influences human behavior can be traced back to Kurt Lewin's formula for psychological events: "B = f(PE)", where B represents behavior, P represents the person, and E represents the person's environment (1936, pp. 11–12). Lewin's ideas were revolutionary in their time as the environment was not typically included in efforts to understand human behavior. Many formulas and models have been proposed since Lewin's formula based on or influenced by his idea to explain human behavior as well as development. One of the

most influential models is the (bio)ecological model developed by Urie Bronfenbrenner (Bronfenbrenner, 1979).

The environment variable in Lewin's formula has been expanded into systems in Bronfenbrenner's bioecological model for study of human development to better represent the complex, nested nature of the environment around us. The model defined "systems" to characterize physical, social and cultural influences on development and behavior. These systems are nested in the following order: microsystem, mesosystem, exosystem, macrosystem; and later on the time dimension or "chrono system" (Bronfenbrenner, 1979; Bronfenbrenner & Morris, 2007).

The **microsystem** is the immediate environment, such as a person's home and school environments. The **mesosystem** is a system of two or more interacting microsystems, representing "multiple forces (from multiple settings) and their interactions, … their combined effects (on development)" (Bronfenbrenner & Morris, 2007, p. 817). The **exosystem** includes systems that do not include the person, but can indirectly influence the person's immediate environment. An example of an exosystem is the influence of the policies at a mother's workplace on her child's experience in the home environment. The **macrosystem** is at the subculture or culture level, it includes belief systems and ideologies, such as the cultural differences between different countries or different ethnicity groups within the same country. The chronological system, or **chronosystem** takes into account time, another important dimension, including people's life courses and through historical periods at the macrolevel.

Similar understandings of the environment as a nested structure were also found in other studies. Brug et al. (2006) categorized environment into different sizes

including micro-environments (home, school, etc.) and macro-environments (town planning, healthcare systems, etc.) and of different types such as physical, economic, political, and sociocultural. Environmental factors of different sizes and types can affect people's behavior together. Similarly, in his model about development of children with ADHD, Sagvolden et al. (2005) included parent- and societal levels ("styles"), interactions and influences at these two different levels will lead to behavioral, emotional, and cognitive outcome on both short-term and long-term scales.

With the improvement of technology and particularly, prevalence of online social networks, the definition of microsystem has also been adapted to include digital spaces, or cyberspaces. Real-Virtual (R-V) mesosystems can include multiple bi-directionally linked real (physical) microsystem and virtual (digital) microsystem. While the relationship between physical and digital spaces can be complementary, neutral, or conflicted, determined by the effects of the virtual settings on the activities of the "host" (real) setting (Stokols, 2018, pp. 105–112). For example, (most) video games and social media may distract students from learning while they are in classrooms, while certain games such as *Civilization* and *Kerbal Space Program* can help them to learn more about history and rocket science respectively.

However, the digital microsystem has become more and more important, and sometimes even more important than the physical microsystem. One example would be working from home: the digital "workplace" should be considered more important than physical home environment during worktime, and an ideal home environment should complement the "host" setting which, in this case, would be the digital microsystem. This might become more common in the future as companies start to

have working from home as a permanent option for all the employees (SQUARE ENIX CO LTD, 2020).

Another related concept is environmental orientations, in this case, how much are people connected to physical and digital settings, similar to the "sentimental orientation" or attachment as defined by Cohen and colleagues (Cohen et al., 1976). People connected to the digital world, may treat the digital microsystem as a tool for their goals in the physical world, but may also have the digital environment as their primary source of meaning and self-identity (Misra & Stokols, 2012). Connected or not, the digital environment can affect our behaviors in the real world, even in some unexpected ways. The mere presence of a mobile device can lead to lower level of empathy during real-life in-person conversations, compared to a randomly assigned control group without a nearby mobile device (Misra et al., 2016).

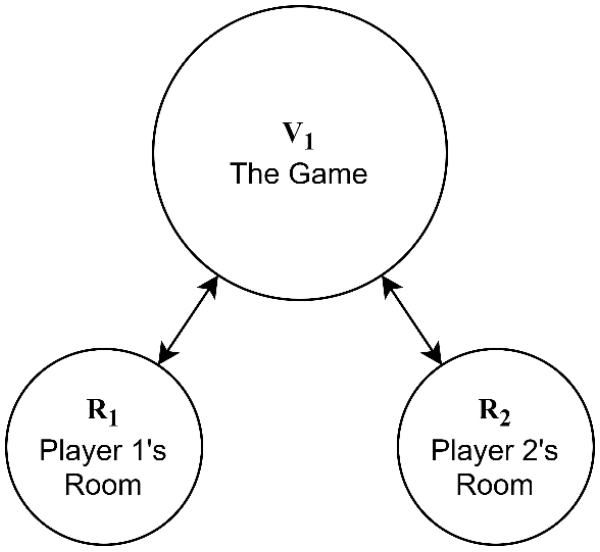


Figure 2: Real-Game Mesosystem.

Here we propose the real-game mesosystem, adapted from Stokols' (2018) Real-Virtual mesosystem, containing both the physical microsystem of each individual

player and the digital game as another microsystem where the players play together. The real-game mesosystem will serve as a framework to understand the complicated social interaction during gameplay with respect to interactions between players, physical environment, and digital game environment. While most previous studies focused on digital games themselves or functions and skills of players, this study will treat digital games as part of real-game mesosystems, examine digital games' (pro-)social effects as results of both rules of digital games and physical connectedness of players.

Summary and Hypotheses

As digital games, also called "video games," have grown in cultural and economic importance, they have drawn both concern and interest from various academic fields. Digital gameplay is believed to have the potential to improve certain cognitive functions, social skills, prosocial behavior, and mental health. This thesis proposes the real-game mesosystem to understand the complicated interactions during digital gameplay, especially the important role of the physical environment which was rarely examined in previous studies.

This thesis aims to examine the effects of digital games on social closeness, friendship, and prosocial behavior when played in different modes and in different physical settings. Four hypotheses about the social effects of game-playing will be examined, using the game "Overcooked 2."

H1. (a) Game Mode (iv1) (cooperative v. competitive/versus) will have a main effect on Social Closeness; (b) Game Setting (iv2) (same room v. different rooms) will

have a main effect on Social Closeness; (c) there will be Game Mode (iv1) by Game Setting (iv2) interaction effects on Social Closeness (dv1).

H2. (a) Game Mode will have a main effect on Friendship; (b) Game Setting will have a main effect on Friendship; (c) there will be Game Mode by Game Setting interaction effect on Friendship (dv2).

H3. (a) Game Mode will have a main effect on Prosocial Behavior; (b) Game Setting will have a main effect on Prosocial Behavior; (c) there will be Game Mode by Game Setting interaction effect on Prosocial Behavior (dv3).

H4. The main effects and interaction effects mentioned in H1-3 will be (partially) mediated by participants' in-game experience.

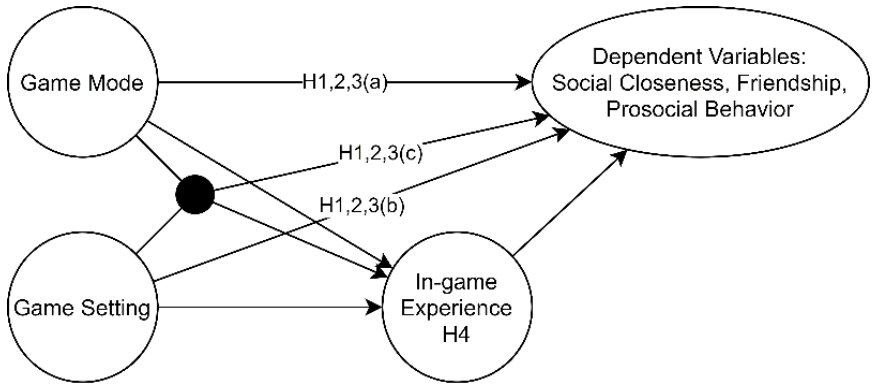


Figure 3. Diagram of the hypotheses. H123(a) and (b) represent main effects; H123 (c) is the interaction of game mode and game setting; H4 is the mediation hypothesis.

Chapter 2

METHOD

Design

The true experiment with 2x2 factorial design has two independent variables: Game Mode and Game Setting, which are both active, have two levels and are between-groups (Table 1). Game Mode was manipulated by randomly assigning participants to play the game in either cooperative mode or competitive ("versus") mode. Game Setting was manipulated by randomly assigning participants to play the game with the other participant either in the same room or in different rooms. In all cases, participants played the game with another person, in pairs.

Table 1. Two by Two Factorial Design

Game Setting \ Game Mode	Cooperative	Competitive (Versus)
Same Room	SC, n = 32	SV, n = 32
Different Rooms	DC, n = 32	DV, n = 32

Note. SC: Same room, Cooperative mode; SV: Same room, Versus mode; DC: Different rooms, Cooperative mode. DV: Different rooms, Versus mode.

We performed a power analysis before the experiment to determine the sample size. The suggested total sample is 128 (32 in each of the four conditions) to reach a power of 0.80 with an alpha level of 0.05, assuming medium effect size (f = 0.25), for the ANOVA test to examine differences between experimental groups (main and interaction effects) in dependent measures (H1,2,3).

The three dependent variables are: Social Closeness, Friendship, and Prosocial Behavior. The potential mediator, in-game experience, was calculated based on

recorded gameplay (experiment) sessions. Age, biological gender, gaming experience, personality, and player types was measured as part of the survey before the experiment and recorded for further analysis.

Participants

Participants (n=128) were recruited from a university human subjects pool of undergraduate students, and in pairs by asking them to recruit a friend, partner, or family member who lived in the same house, apartment, or residence hall to participate in study with them.

Table 2. Participant Characteristics, 2x2 Factorial Design (n = 128)

	DC n = 32	DV n = 32	SC n = 32	SV n = 32	Total n = 128	Difference (df)
Age	25.75 (9.21)	23.41 (3.45)	22.72 (4.30)	22.03 (3.13)	23.48 (5.70)	2.68 (3,124)[a]
Gender	n (%)	n (%)	n (%)	n (%)	N (%)	4.34 (6)[b]
Female	23 (71.9)	20 (62.5)	22 (68.8)	24 (75.0)	89 (69.5)	
Male	9 (28.1)	12 (37.5)	9 (28.1)	8 (25.0)	38 (29.7)	
N-B	0 (0.0)	0 (0.0)	1 (3.1)	0 (0.0)	1 (0.8)	
Gaming Experience	n (%)	n (%)	n (%)	n (%)	n (%)	0.83 (3)[c]
< 1 y	9 (28.1)	10 (31.3)	7 (21.9)	4 (12.5)	30 (23.4)	
1-2 y	1 (3.1)	3 (9.4)	2 (6.3)	5 (15.6)	11 (8.6)	
3-5 y	7 (21.9)	3 (9.4)	5 (15.6)	6 (18.8)	21 (16.4)	
6-10 y	5 (15.6)	3 (9.4)	6 (18.8)	5 (15.6)	19 (14.8)	
> 10 y	10 (31.3)	13 (40.6)	12 (37.5)	12 (37.5)	47 (36.7)	
Gaming: Days /wk	1.75 (2.02)	2.63 (2.69)	2.19 (2.04)	1.69 (1.75)	2.06 (2.16)	1.32 (3,124)[a]
Gaming: Hours/ wk	n (%)	n (%)	n (%)	n (%)	n (%)	3.43 (3)[c]
< 5 h	22 (68.8)	19 (59.4)	25 (78.1)	22 (68.8)	88 (68.7)	
5-10 h	7 (21.9)	6 (18.8)	4 (12.5)	9 (28.1)	26 (20.3)	
11-20 h	3 (9.4)	4 (12.5)	3 (9.4)	1 (3.1)	11 (8.6)	
20-50 h	0 (0.0)	2 (6.3)	0 (0.0)	0 (0.0)	2 (1.6)	
> 50 h	0 (0.0)	1 (3.1)	0 (0.0)	0 (0.0)	1 (0.8)	

a. F-tests (3, 124) were used to compare the difference between conditions.
b. Chi-square (6) test was used to compare the difference between conditions.
c. Kruskal-Wallis tests (3) were used to compare the difference between conditions.
Note. All test results are not significant at 0.05 level.

The mean age of participants was 23.5 (18-55, SD=5.7) years; 69.5% of participants are female (n=89), 29.7% are male (n=38), one participant (0.8%) is non-binary/third gender. Age, gender, and gaming experience distribution can be found in Table 2 for the overall sample as well as for all the conditions: Different rooms, Cooperative mode (DC); Different rooms, Versus mode (DV); Same room, Cooperative mode (SC); Same room, Versus mode (SV).

Apparatus

The experiment was conducted using a video game named "Overcooked 2" running on laptop computers. Participants used their own laptops to play the game in keyboard and mouse mode on the Steam online game platform with accounts provided by the researcher.

Constructs & Measures

The three dependent variable measures, which are provided in Appendix A, are described below.

Social Closeness. The Inclusion of Other in the Self Scale (Aron, Aron, & Smollan, 1992) is a single-item measure of interpersonal closeness. Participants selected one of seven pictures to describe their relationship with others, in this case, with the other player they just played with. The test is rather reliable (test-retest r=.83 overall, r=.86 for friendship) and has good convergent and predictive validity (r = .46, p=.001) for predicting if couples are still together after 3 months.

Friendship. Two 5-point scale questions about friendship ("How much are you friends with this person?") and play ("How much do you like to play with this person?") (Leff et al., 2016, p. 599) were adapted to measure friendship. Response

options were from “not at all” to “very much.” Though originally developed for elementary school students, it is suitable for this study since participants were asked to play together. No reliability or validity information is available for this measure.

Prosocial Behavior. To assess prosocial behavior, or prosocial behavior tendency, participants were asked if they want to make a donation (“Do you want to donate part of your compensation ($5) to a COVID relief fund?”). Donation has been commonly used in prior research to measure prosocial behavior, in the form of whether or not the participants donated a fixed amount of money (Erlandsson et al., 2018; Frey & Meier, 2004), how much the participants donated (Nook et al., 2016), or sometimes the donation intention (Wallace et al., 2020). In this study, we measured prosocial behavior both by whether or not they decided to make the donation and by the amount of money they donated.

The following are control variables. They are provided in Appendix B.

Personality. Ten-Item Personality Inventory is a brief measure of the Big-Five personality traits (Gosling et al., 2003). The inventory is rather reliable (mean test-retest r=. 72) and has good convergent correlations with the original Big-Five Inventory (mean r = .77) compared to discriminant correlations (mean r = .20).

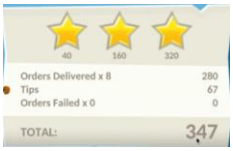
Player Types. Though they were named “types”, player types were treated as dimensions in this study, similar to the Big-Five personality traits. We calculated scores for each of the four “player type” dimensions. The Bartle test of gamer psychology (Andreasen & Downey, 2001) was developed based on Bartle’s (1996) player types model in his paper about players of MUD (Multi-User Dungeons). Scores of each of the four player types (Killers, Achievers, Explorers, and Socializers) were

calculated based on participants' responses to 39 binary choice questions. For example, two choices for question "Are you more comfortable, as a player on a MUD…" are "Talking with friends in a tavern?" and "Out hunting orcs by yourself for experience?", picking the first choice will add one point to the Sociliser type while picking the second one will add one point to the Achiever type. There are 20 response options that count toward Killer, 19 options count toward Achiever, 19 count toward Explorer, and 20 options count toward Socializer. While there is little study regarding the reliability and validity of the measure, the player types/taxonomy is well-known within the field of digital game study, the gamer community, and the industry. The following instruction was added before the original inventory to clarify the context: "For the following items, imagine that you are playing a multiplayer online game, for each of the items, please indicate which of the two options suits you best:". The player types were calculated by adding points together and rescaling them to a theoretical range from 0 to 1.

In addition to the Bartle test, we also added a 4-item 7-point Likert scale to measure self-rated player type scores based on the updated definitions of four player types based on his new studies of modern MMORPG (Massively Multiplayer Online Role-Playing Game) players (Bartle, 2004), with the following instruction: "Please choose a number next to each description to indicate the extent to which you agree or disagree with that statement 'I see myself as…'.". We used both the test-measured and self-rated player types as control variables in our analysis since the Bartle test was not developed by Bartle himself, and was based on his paper published 25 years ago.

In-Game Experience. One observer observed recorded videos of participants' game session and coded them as described below to characterize in-game experience.

Table 3. Coding of In-Game Experience Values per Participant per Round

Variable	Description	Coding	Screenshot
Proficiency	= Dash + Throw		
Dash	Briefly run faster than usual by pressing LCTRL (default).	1=occurred 0=did not occur	
Throw	Throw an ingredient by pressing LALT (default)	1=occurred 0=did not occur	
Accident	Set stove on fire if leave food on the stove for too long.	1=occurred 0=did not occur	
Score	= Delivered + Failed + Tips		
Delivered Failed Tips	Values generated in the game, at the end of each round based on players' performance.	Continuous	

Note. In cooperative mode, both players will share the same Score values.

First, we coded in-game experience values *per participant per round*. Three in-game rounds were observed for each participant: the rounds covering the 10th min, 20th min of the video, and the last round. The following behaviors or events were coded dichotomously as 1 if the event happened at least once during the round and 0 if not: **Dash**, briefly run faster than usual by pressing a key; **Throw**, throw an ingredient

to save time; and **Accident**, an undesirable outcome, getting food overcooked and setting the stove on fire. The scores for the 3 rounds were then summed. The numbers generated automatically by the game at the end of each round, were also recorded as **Delivered**, **Failed**, and **Tips**. Note that **Failed** values are always negative. Detailed descriptions and examples can be found in Table 3.

Proficiency. The 3-round sums of **Dash** and **Throw** are added together to operationalize Proficiency one player's skill. The pair's proficiency is then calculated by summing the values for the two players. This value can range from 0-12.

Proficiency Difference. To calculate proficiency difference, we use the absolute value after subtracting one player's score from his/her partner's score. The theoretical range of this variable is 0-6.

Accident. The 3-round sums of **Accident** are added together to operationalize the undesirable experience. The pair's accident is then calculated by summing the values for the two players. This value can range from 0-6.

Score. The 3-round sums of **Delivered**, **Failed**, and **Tips** are added together to operationalize player's final scores in the game. The pair's score is then calculated by summing the values for the two players. This value usually ranges from a few hundred below zero to around five thousand.

Similarly, we calculated pair's Friendship by summing the friendship values for the two players, pair's Social Closeness by summing the social closeness score, and pair's Prosocial Behavior by summing the prosocial behavior score.

Procedure

Participants were told that the experiment is about "gaming experience during COVID-19" to hide the true intention. Participants took a survey about demographic information, gaming experience, personality, and player types, followed by a training session for them to get used to the game rules and control. After the experiment in which participants played the game in pairs under their randomly assigned conditions, participants answered another survey about social connectedness, friendship, and prosocial behavior. They were asked to record their screens while playing the game.

Analytic Strategy

The data were analyzed using the R language and JASP, an R-based graphic interface. We used library BayesFactor for Bayesian analysis, the calculation of Bayes Factors for AN(C)OVA designs, implemented in JASP, are based on Rouder (2012). We used multivariate Cauchy prior distributions for fixed effects and covariates, with r-scale values of 0.5 and 0.354 respectively. We also used Lavaan for path analysis.

Hypotheses 1, 2, and 3 (main and interaction effects of Game Mode and Game Setting on dependent measures) will be examined using both classical ANOVA and Bayesian ANOVA. We also performed ANCOVA tests for these effects, controlling for age, Agreeableness, Conscientiousness, and Socializer player "type" from both the Bartle test and the self-rating question. These five variables can have influence on our dependent measures, and even with randomization, chance imbalances could arise, and conditioning on these variables can improve precision of our estimate.

In addition to the AN(C)OVA tests, to analyze the dichotomous donate variable, a logistic regression was conducted to estimate the influences of Game

Setting and Game Mode, including the interaction term on the recoded binary donation variable.

To examine the Hypotheses 4, the main and interaction effects of Game Mode and Game Setting on dependent measures will be mediated by in-game experience, we will consider all the main and interaction effects in H1,2,and 3, regardless of their significance, as suggested by Zhao et al. (2010). First, we will examine if there is any relation of independent variables and the interaction term to mediators by regression. Second, for mediators with relation(s) from independent variables, we will examine if there is any significant relation of these mediators on dependent variables adjusted for: a) Game Mode; b) Game Setting; c) Game mode, Game Setting, and the interaction term for the mediation of interaction effect, or mediated moderation (Morgan-Lopez & Mackinnon, 2006). Lastly, for mediators that are associated with the independent and dependent variables, mediation will be examined using path analysis.

Chapter 3

RESULTS

The study examined the following hypotheses, organized by the three dependent variables: social closeness, friendship and prosocial behavior.

H1. (a) Game Mode (iv1, cooperative v. versus) will have a main effect on Social Closeness; (b) Game Setting (iv2) (same room v. different rooms) will have a main effect on Social Closeness; (c) there will be Game Mode (iv1) by Game Setting (iv2) interaction effects on Social Closeness.

H2. (a) Game Mode will have a main effect on Friendship; (b) Game Setting will have a main effect on Friendship; (c) there will be Game Mode by Game Setting interaction effect on Friendship.

H3. (a) Game Mode will have a main effect on Prosocial Behavior; (b) Game Setting will have a main effect on Prosocial Behavior; (c) there will be Game Mode by Game Setting interaction effect on Prosocial Behavior.

H4. The main effects and interaction effects mentioned in H1-3 will be (partially) mediated by participants' in-game experience operationalized by Proficiency, Proficiency Difference, Accident, and Score.

Descriptive Statistics

Overall, participants reported to be close to their partners, with a mean level of 5.430 on a 7-point scale; they also reported to have a high level of friendship, scoring 4.688 on a 5-point scale; and were willing to donate $2.32 on average from their $5 compensations to a COVID relief fund. Mean and SD of social closeness, friendship, and prosocial behavior can be found in Table 4.

Table 4. Mean and SD of closeness, friendship, and prosocial behavior per group

Game Setting	Game Mode	Closeness	Friendship	Prosocial Behav.
different rooms	cooperative	5.16 (1.25)	4.41 (1.16)	2.50 (2.31)
	versus	5.94 (1.22)	4.63 (0.83)	2.72 (2.39)
same room	cooperative	5.53 (1.08)	4.88 (0.34)	2.44 (2.37)
	versus	5.09 (1.65)	4.84 (0.37)	1.63 (2.34)
All	All	5.43 (1.34)	4.69 (0.77)	2.32 (2.36)

Note. Mean (SD). Prosocial Behav.: Prosocial behavior.

Note that while we have two questions to operationalize friendship, only the second question was used as the friendship variable, since there is little variance in the responses to the first question (range: 4-5, variance: 0.03).

Hypothesis 1: Social Closeness (H1abc)

There is no significant main effect of Game Setting on Social Closeness ($F(1, 124) = 1.02$, $p = 0.316$), and no significant main effect of Game Mode on Social Closeness ($F(1, 124) = 0.55$, $p = 0.461$).

A Game Mode by Game Setting interaction effect on social closeness was found. As illustrated in Figure 4, the effect of Game Mode on social closeness depends on Game Setting. Specifically, when in the same room, those who played the game in the cooperative mode reported to have higher levels of social closeness, compared with those who played the mode in competitive (versus) mode. For the different rooms condition, those who played the game in the cooperative mode reported to have lower levels of social closeness, compared with those who played the mode in competitive

mode. The cross-over interaction effect is significant, $F(1,124) = 11.88$, $p = 0.010$, with medium-small effect size, partial $\eta^2 = 0.052$, $\omega^2 = 0.044$. Detailed results can be found in Table 5. Social Closeness did not homoscedasticity assumption (Levene's p=0.088).

We found similar result for the Bayesian ANOVA test with a Bayes Factor of 4.62 to include the interaction effect, when comparing the model with interaction term (full model) to the equivalent model without the interaction term (model room + mode, Table 6).

ANCOVA results, adjusted for age, Agreeableness, Conscientiousness, Socializer, and self-rated Socializer, are similar and can be found in Appendix C.

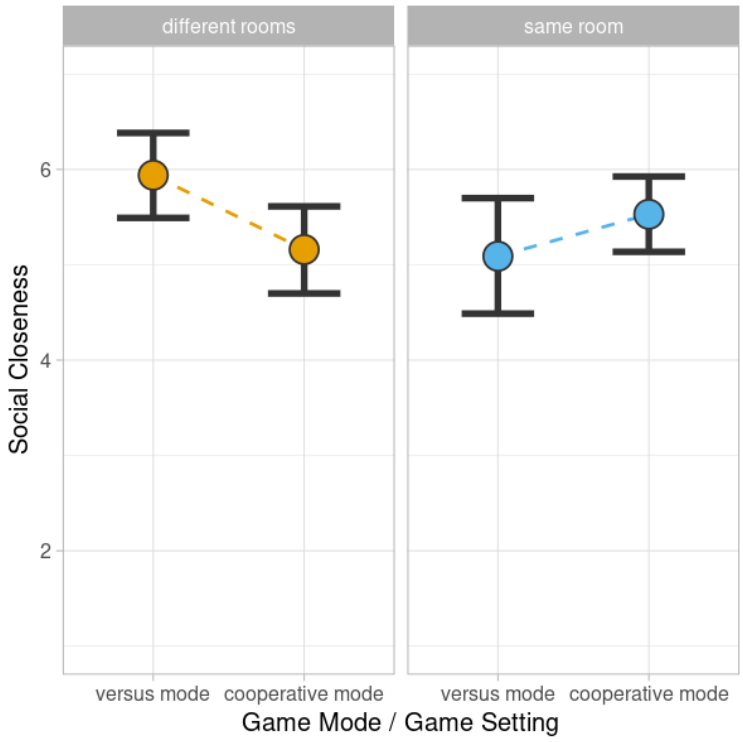


Figure 4. Social Closeness levels in each condition. Bars: 95% CI.

Table 5. ANOVA result for Social Closeness

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p	ω^2
room	1.76	1	1.76	1.02	0.316	0.008	0.008	0.000
mode	0.95	1	0.95	0.55	0.461	0.004	0.004	0.000
room ✻ mode	11.88	1	11.88	6.86	0.010	0.052	0.052	0.044
Residuals	214.78	124	1.73					

Note. Room: Game Setting, Mode: Game Mode.

Table 6. Bayesian ANOVA result for Social Closeness

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model	0.200	0.519	4.32	1.00	
room + mode + room ✻ mode	0.200	0.168	0.81	0.32	2.08
room	0.200	0.152	0.72	0.29	0.03
mode	0.200	0.124	0.57	0.24	0.04
room + mode	0.200	0.036	0.15	0.07	1.07

Note. Room: Game Setting, Mode: Game Mode.

Hypothesis 2: Friendship (H2abc)

A main effect of Game Setting (room) on friendship was found. In same room condition, reported friendship level was higher than in different rooms condition (fig. 5) The main effect is significant, $F(1,124) = 6.61$, $p = 0.011$, with medium-small effect

size, partial $\eta^2 = 0.050$, $\omega^2 = 0.042$. Detailed results can be found in Table 7. Note that Friendship violated homoscedasticity assumption (Levene's $p < 0.001$). Follow-up Kruskal-Wallis test showed a marginal effect of Game Setting on Friendship ($\chi^2(1) = 3.83$, $p = 0.050$).

There is no significant main effect of Game Mode on friendship ($F(1, 124) = 0.49$, $p = 0.485$), and no significant Game Mode by Game Setting interaction effect on friendship ($F(1, 124) = 0.87$, $p = 0.352$).

We found similar result for the Bayesian ANOVA test with a Bayes Factor of 3.69 to include the room effect, compared to the null model (Table 8).

ANCOVA results, adjusted for age, Agreeableness, Conscientiousness, Socializer, and self-rated Socializer, are similar and can be found in Appendix C.

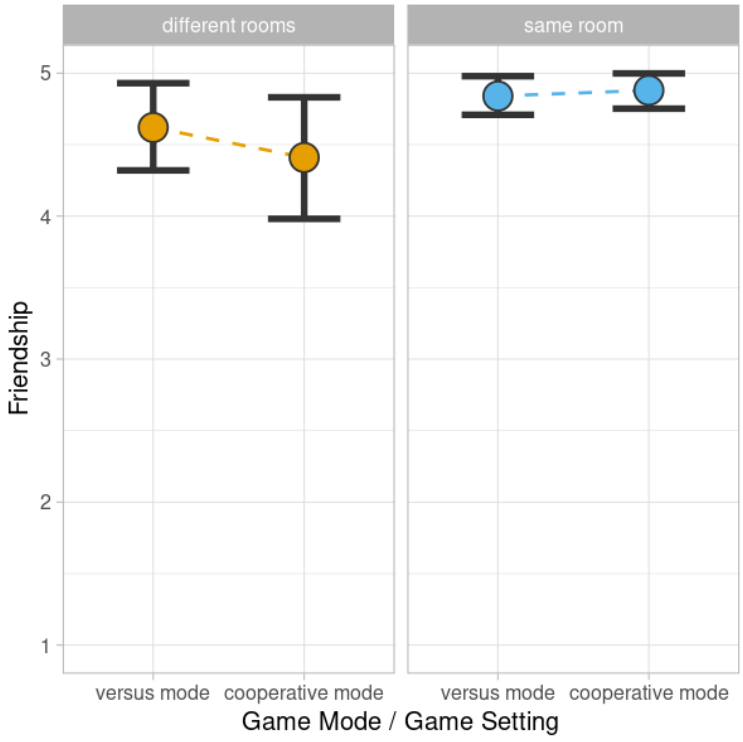


Figure 5. Friendship levels in each condition. Bars: 95% CI.

Table 7. ANOVA result for Friendship

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p	ω^2
room	3.78	1	3.78	6.61	0.011	0.050	0.051	0.042
mode	0.28	1	0.28	0.49	0.485	0.004	0.004	0.000
room ✻ mode	0.50	1	0.50	0.87	0.352	0.007	0.007	0.000
Residuals	70.94	124	0.57					

Note. Room: Game Setting, Mode: Game Mode.

Table 8. Bayesian ANOVA result for Friendship

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
room	0.200	0.604	6.11	1.00	
Null model	0.200	0.164	0.78	0.27	0.00
room + mode	0.200	0.143	0.67	0.24	0.94
room + mode + room ✻ mode	0.200	0.051	0.22	0.08	2.10
mode	0.200	0.038	0.16	0.06	0.04

Note. Room: Game Setting, Mode: Game Mode.

Hypothesis 3: Prosocial Behavior (H3abc)

There is no significant main effect of Game Mode on Prosocial Behavior ($F(1, 124) = 0.51$, $p = 0.477$), and no significant main effect of Game Setting on Prosocial Behavior ($F(1, 124) = 1.93$, $p = 0.167$). The Game Mode by Game Setting interaction

effect on Prosocial Behavior is not significant without adjustment ($F(1, 124) = 1.54$, $p = 0.217$). Prosocial Behavior did not homoscedasticity assumption (Levene's $p=0.784$). Detailed results can be found in Table 9.

However, when adjusted for age, Agreeableness, Conscientiousness, Socializer, and self-rated Socializer, the interaction effect became marginally significant, $F(1,119) = 3.66$, $p = 0.058$, with small-medium effect size, partial $\eta^2 = 0.030$, $\omega^2 = 0.019$. As illustrated in Figure 6, the effect of Game Mode on prosocial behavior depends on Game Setting. Specifically, when in the same room, those who played the game in the cooperative mode showed higher level of prosocial behavior than those who played the game in competitive (versus) mode. For the different rooms condition, those who played the game in the cooperative mode showed slightly lower level of prosocial behavior, compared with those who played the game in competitive mode.

We found similar result for the Bayesian AN(C)OVA tests with a Bayes Factor of 0.48 to include the interaction effect without adjustment, and 1.03 after adjustment, by comparing the full model with the equivalent model without the interaction term (Table 10)

Other ANCOVA results, adjusted for age, Agreeableness, Conscientiousness, Socializer, and self-rated Socializer, are similar, they can all be found in Appendix C.

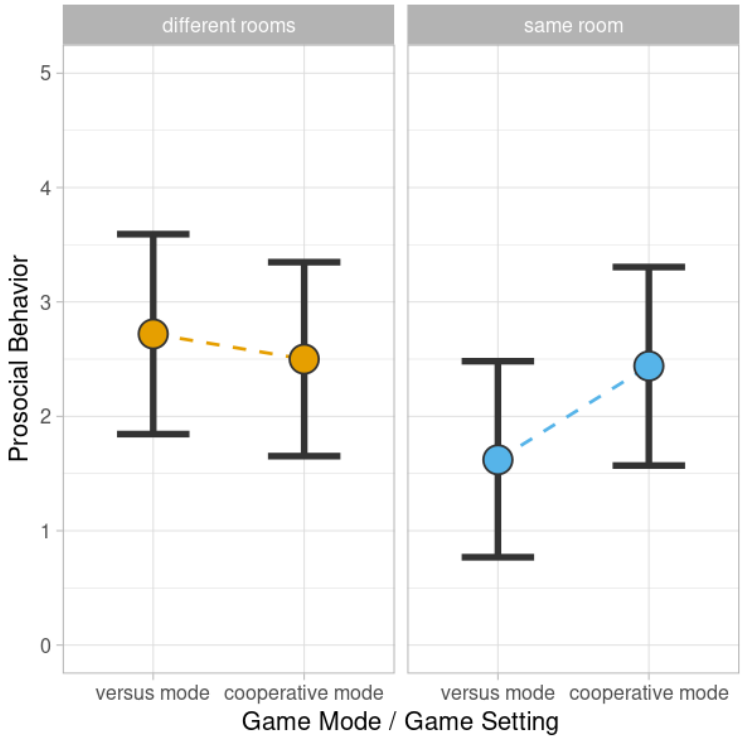


Figure 6. Prosocial Behavior levels in each condition. Bars: 95% CI.

Table 9. ANOVA result for Prosocial Behavior

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p	ω^2
room	10.70	1	10.70	1.93	0.167	0.015	0.015	0.007
mode	2.82	1	2.82	0.51	0.477	0.004	0.004	0.000
room ✻ mode	8.51	1	8.51	1.54	0.217	0.012	0.012	0.004
Residuals	685.84	124	5.53					

Note. Room: Game Setting, Mode: Game Mode.

Table 10. Bayesian ANOVA result for Prosocial Behavior

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model	0.200	0.541	4.71	1.00	
room	0.200	0.245	1.30	0.45	0.01
mode	0.200	0.128	0.59	0.24	0.04
room + mode	0.200	0.058	0.25	0.11	1.04
room + mode + room ✻ mode	0.200	0.028	0.11	0.05	2.12

Note. Room: Game Setting, Mode: Game Mode.

The logistic regression model is significant ($X^2(3) = 9.56$, $p = 0.023$), predicts 64.8% of the responses correctly, with a McFadden R^2 of 0.055. The coefficient on room variable is significant with Wald Statistic of 6.04 (df = 1), $p = 0.014$. The odds ratio for room is 1.91 (95% CI: 1.14 to 3.20), suggesting that those who played the game with their peer in different rooms are nearly 2 times more likely to make donations than those who played the game with their peer in the same room.

Table 11. Coefficients of Logistic Regression on Recoded Donation (Binary)

	Estimate	SE	OR	95% CI	z	W	df	p
(Intercept)	0.51	0.26	1.67	1.01-2.77	1.98	3.93	1	0.048
room	0.65	0.26	1.91	1.14-3.20	2.46	6.04	1	0.014
mode	0.07	0.27	1.07	0.64-1.81	0.27	0.07	1	0.790
room_x_mode	-0.44	0.37	0.64	0.31-1.33	-1.19	1.42	1	0.234

Note. Room: Game Setting, Mode: Game Mode. SE: Standard Error. OR: Odds Ratio. CI: Confidence interval.

Summary: Main and Interaction Effects (H1, H2, H3)

We found significant effect of Game Setting on Friendship, and significant Game Setting by Game Mode interaction effects on Social Closeness and Prosocial Behavior, as summarized in Figures 7 and 8. The interaction effect on Prosocial Behavior is only marginally significant when adjusted for age, Agreeableness, Conscientiousness, Socializer, and self-rated Socializer.

Further analysis revealed a significant correlation between age and prosocial behavior ($r = 0.293$, $p < 0.001$). Age levels are also different between Game Setting groups, Welch's $t(96.328) = 2.221$, $p = 0.029$. This may explain why controlling for age improved the significance of interaction effect.

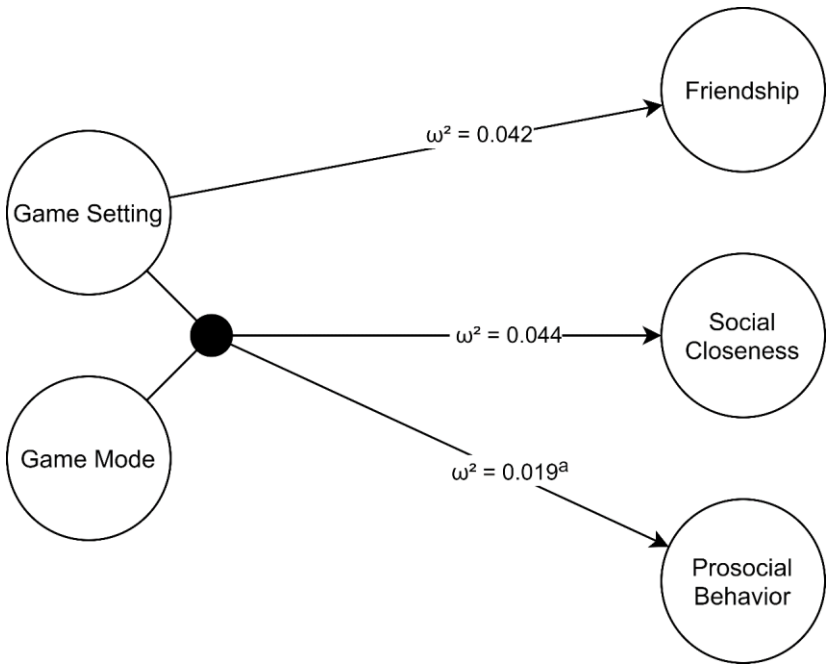


Figure 7. Effect sizes of (marginally) significant main and interaction effects. a: adjusted for covariates.

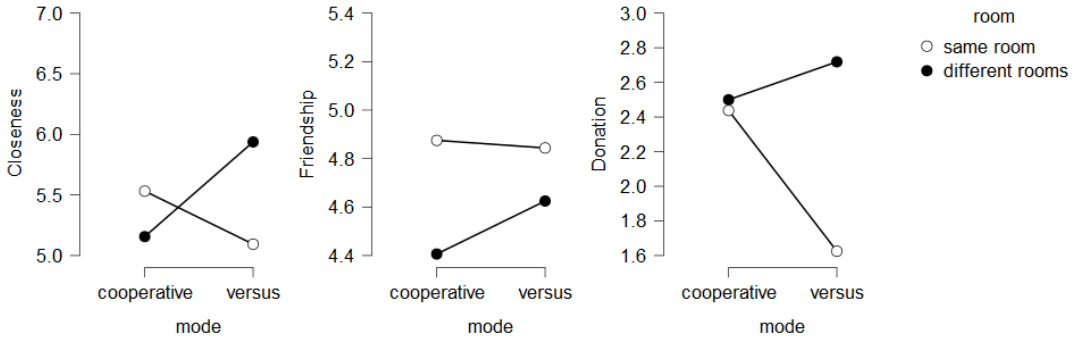


Figure 8: Interaction effects of game mode by room on closeness and donation. Closeness: Social Closeness. Donation: Prosocial Behavior. Mode: Game Mode. Room: Game Setting. Note: Interaction effect on friendship is not significant, figure included just for reference.

Hypothesis 4: Mediation Effect (H4)

We hypothesized that in-game experience (i.e., Proficiency, Proficiency Difference, Accident, Score) would mediate the main effects and interaction effects examined in H1-3, for a total of nine possible mediated effects. As explained in previous section, all the main and interaction effects in H1,2, and 3 are candidates for mediation, regardless of their significance.

As showed in Table 12, we found a significant relation of Game Mode to Score ($t = -4.424$, $p < .001$), and marginally significant relation of Game Mode to Accident ($t = -1.772$, $p = .082$). However, when adjusted for Game Mode, both Score and Accident are not a significant predictor of our dependent variables (Table 13).

Given the above fact, in-game experience variables cannot mediate the main effects or interaction effects.

Table 12. Compiled Regression Results, IVs to Mediators

Predictors	on Proficiency	on Prof. Diff.	on Accident	on Score
Game Mode	-0.017	0.001	-0.229	-0.506
	(-0.127, .899)	(0.01, .992)	(-1.772, .082)	(-4.424, < .001)
Game Setting	0.086	0.176	-0.054	-0.046
	(0.650, .518)	(1.352, .182)	(-0.411, .683)	(-0.349, .728)
Game Mode *	-0.216	-0.278	0.364	0.133
Game Setting	(-0.909, .368)	(-1.188, .240)	(1.591, .117)	(0.645, .522)

Note. Prof. Diff.: Proficiency Difference. Standardized coefficient (t, p).

Table 13. Compiled Regression Results, Mediators to DVs, adjusted for IVs

Predictor	Social Closeness	Friendship	Prosocial Behavior
Score	-0.127 (-0.831, .410)	-0.123 (-0.801, .426)	0.092 (0.598, .552)
Accident	0.028 (0.207, .837)	-0.151 (-1.115, .270)	0.125 (0.920, .362)

Note. Adjusted for Game Mode. Standardized coefficient (t, p).

Chapter 4

DISCUSSION

In this study, we examined the effects of playing digital games under different Game Modes and Game Settings on Social Closeness, Friendship, and Prosocial Behavior. We found a Game Mode by Game Setting interaction effect on Social Closeness, a main effect of Game Setting on Friendship, and a Game Mode by Game Setting interaction effect on Prosocial Behavior. All effects have medium-small effect sizes. The hypothesized mediators, in-game experience, are not mediating any main effects or interaction effects.

Our finding of higher prosocial behavior levels after playing games cooperatively with other people in the same room, were similar to those of prior research (Greitemeyer et al., 2012; Bloch & Wehrle, 2013). However, neither of the prior studies included competitive mode. Interestingly, we did not find any main effect of Game Mode on any of the other dependent variables. In other words, whether people were playing cooperatively or competitively had no effect on their ratings of social closeness or friendship nor on their tendency to give a donation (pro-social behavior). Studies with similar dependent variables often found positive effects of game mode on prosocial behavior, and negative effects on aggressive behavior with small to moderate effect size (Verheijen et al., 2019; Whitaker & Bushman, 2012).

Design Implications

As we can see from the results, Game Setting can change the outcomes of playing games, whether alone or together with Game Mode. To achieve the optimal outcome, game designers will need to think about the ideal game setting for their

games: is the game more suitable for people to play alone, play with others together in the same place, or play with others together online? Even games that lead to aggression when played alone or online may have the potential to promote friendship when playing with friends together in the same place.

Another interesting finding is that lower differences in proficiency may lead to higher friendship and closeness after playing the game together. In other words, playing with a partner who has a similar skill level may yield more connection between players. Many competitive multiplayer games, for example, *overwatch*, are already matching players by their proficiency levels. Cooperative multiplayer games should also implement similar measures to improve players' overall gaming experience.

The Physical-Digital Mesosystem

What happens in the digital microsystems can influence our behaviors in the physical world, or physical systems. Regarding the social aspect, the online communities of digital games are almost identical to other communities that only exist in the real world. In fact, many people play games online together with their friends and/or family members in the real world. While the players are not able to have face-to-face communication with their teammates, they often have powers or abilities that they do not have in real life which enable them to help their teammates by, for example, healing, protecting, or crafting useful equipment and potions. These "super powers" may promote prosocial behaviors even after playing the game (Rosenberg et al., 2013), in addition to the prosocial behaviors in the digital microsystem.

Similarly, physical microsystems can influence our experience in digital microsystems as well. As we discussed above, many people play online games together with their friends or family members in the physical world, and maintain or reinforce their relationships with them in digital games. Another good example would be internet or gaming "addition/disorder." They share the same "symptom": spending too much time in the digital world instead of the physical world. Risk factors for people who are addicted to gaming include TV or video game consoles in bedroom (Gentile et al., 2017), poor family functioning (J. Lee et al., 2021), and insecure peer attachment (Reiner et al., 2017), while protective factors include parents' awareness of children's experiences (Liang et al., 2021), and attachment to parents (Jeong et al., 2021). Most of these risk factors are originated from or related to home or school environments for children or adolescent.

Instead of real and virtual microsystems, in this paper we used the terms physical and digital microsystems to avoid implying one of them to be more important than the other one. Experiences in digital microsystems can influence behaviors in physical microsystems, and vice versa. The concept of "host" microsystem may not be necessary, or should at least be situational, depending on what task the person of interest is focusing on at the moment.

A "host" digital microsystem has the potential to connect physical microsystems that are fundamentally different, or far away from each other and result in a heterogeneous mesosystem, compared to most of the purely physical mesosystems, since it is much easier to transport information digitally than to transport people physically in this age. The heterogenous mesosystems may even go beyond

what used to be believed to be at the macrosystem level such as differences between cultures and countries by simply connecting people with different backgrounds together and promoting social interactions between them. This would allow people to reflect on existing stereotypes and bias of other groups and communities. Thus, one potential benefit of digital games may be to bridge cultural differences, foster friendship, potentially reduce bias and discord, and ultimately, making the world a better place.

Strengths and Limitations

The most significant contribution of this study is the inclusion of Game Setting. While most studies focus on Game Mode, only a few of them have mentioned the physical setting where games were played. Even among these studies, Game Setting was usually combined with Game Mode. For example, people will compare playing together with another player in the same room with playing the game alone in solo mode. The Game Setting by Game Mode interaction effects might be an explanation for conflicting results found in some previous studies, such as those about games and violence. While playing violent games alone may lead to increased aggression in real life, playing the same violent games with friends together may decrease aggression instead. We also chose a commercial game instead of some simple free games or games designed specifically for lab experiments, making the experience as close to gaming in daily life as possible, potentially increased the external validity of the study.

However, the study also has the following limitations. Even with a true experimental design with randomization, there may be some threats to internal

validity. For example, selection by history: in the first half of the experiment, we had 18 participants assigned to the SC condition, 14 participants to the SV condition, 14 participants assigned to DC condition, and 18 participants to the DV condition. Since the experiment took place before and during the semester, responses might be influenced by the stressful events such as start of the semester, or the mid-term exams. These stressful events may make participants feel less close or friendly toward each other, and less likely to make a donation. Since we have a slight difference in numbers of participants assigned to each condition over time, such stressful events or absence of them could potentially be an alternative explanation to the differences in dependent measures we found between groups, instead of our independent variables.

Threats to external validity also exist. First of all, the findings may not be generalizable to other situations, in our case, other games. While we asked participants to play commercial games in their houses or apartments to mimic gaming in real life, the game (*overcooked 2)* that we selected can be very different from other popular games, such as *call of duty*. This is inevitable given the diverse nature of games, including experimental narrative games focusing strongly on emotions such as *Journey*, realistic simulation games such as *The Sims*, action-focused games such as *Monster Hunter*, and relaxing puzzle games such as *Mini Metro*. The difference in games should be considered when examining any study of digital games.

We also have a sampling bias and may not be able to generalize our findings to other populations. The participants were mainly recruited from a university human subjects pool of undergraduate students, and only included a few non-student young

adults, who contribute a large proportion of gamers. We were also not able to include any participants below 18, who are also part of the gamer population.

There are also threats to construct validity. We only used one item for each of the three dependent variables, and one observer to code the hypothesized mediators, this can lead to mono-operation bias. While the item for Social Closeness has been shown to have good reliability and validity, and the item for Prosocial Behavior has been commonly used in similar studies, the item used for Friendship focused only on the play aspect and may not be representative. Adults can have friends that they do not want to play with. The item might be more about enjoyment rather than friendship.

Another threat to construct validity is that we may have restricted range for our independent variables, and dependent variables. The competitive (versus) mode in the game *Overcooked 2* may not be intensive enough compared to some serious competitive games such as *Mortal Kombat*. More competitive game mode may lead to different outcomes. Similarly, a lot of participants (99 out of 128) chose to donate either $5 or nothing. Only 29 participants chose to donate an amount between 0 and $5. We might see more donation amounts in between if we could give them, for example, $50 to donate. Given a limited budget, this would dramatically decrease our sample size and was not implemented.

Time can be another concern for construct validity. We were not able to test the long-term effects of playing the game under different conditions due to the limitation of time and limited copies of the game. In a different but relevant study, male participants were found to have better visuospatial abilities compared to female participants before and after training in a digital game only in the short term, but not in

long term (Harwell et al., 2018). We might also be able to find long-term effects of our independent variables that are different from the short-term effects.

There are some threats to the statistical validity of the study. As mentioned in the results section, the homoscedasticity assumption was violated when testing for main and interaction effects on Friendship. For the main effect of Game Setting on Friendship, the result was validated using a non-parametric Kruskal-Wallis test.

Even though we have performed a power analysis before the experiment, it turns out the analysis could still be underpowered since the effect sizes which were estimated to be medium are in fact medium-small. Based on the observed effect size of the interaction effect on Prosocial Behavior (partial $\eta^2 = 0.012$, adjusted) which is the smallest of the three, we estimated that a minimal sample size of 649 for future study to achieve a power of 0.80 with an alpha level of 0.05 for the ANOVA test, assuming no difference in covariates with randomization.

Future Studies

In addition to a larger sample size, future studies should also include different populations, especially children to provide more insights for developing digital games suitable for classrooms, to help children learn knowledge and skills, or better handle developmental disorders such as ASD. Another idea would be pairing participants with people in distant areas or even different countries, to examine how games may help people feel more connected to strangers they may never meet in real life.

We could add more levels to our independent variables, since the effects may not be linear: it is possible that both highly cooperative mode and highly competitive mode can lead to higher closeness while a relatively neutral mode will lead to lower

closeness. For example, use a more "intense" game, such as *Battlefield*, to introduce a more significant and fundamental difference between cooperative and competitive mode. As for Game Setting, one level between the same room and different rooms might be different rooms with voice chatting. This level would allow communication between participants with not face-to-face interactions.

We may extend the length of the experiment to better understand the long-term effects of playing different games by asking participants to play games under assigned condition for weeks or months. In addition to the length, we can also include different "dosage" of gaming, comparing gaming three hours per day to gaming one hour per day, to find the optimal gaming "dosage" for the best outcome.

The outcome of playing different games may depend on the digital devices on which games are played. Variables such as size and resolution of display or TV, distance to them, sound quality, input device (keyboard + mouse or controller), immersiveness (virtual reality headset or ordinary display) should be examined as independent variables or moderators.

We could also add mood, especially positive affect as a potential mediator, as found in a similar study (Whitaker & Bushman, 2012). However, more attention should be paid to mediators that are unique to digital games, such as the powers players gained, roles they played, or friendly and unfriendly interactions between them during the game.

Conclusion

In sum, we found a main effect of Game Setting on Friendship, and Game Setting by Game Mode interaction effects on Social Closeness and Prosocial

Behavior, all with medium-small effect sizes. The results supported some of our hypotheses, with mediators of these effects left unclear. This study provides a novel perspective to examine digital games as part of real-game mesosystems. Future studies and designs of game should be more aware of the physical environments where the games were, or will be played.

APPENDIX A – DEPENDENT VARIABLE MEASURES

Friendship

Regarding the person you just played the game with:

1. How much are you friends with this person?

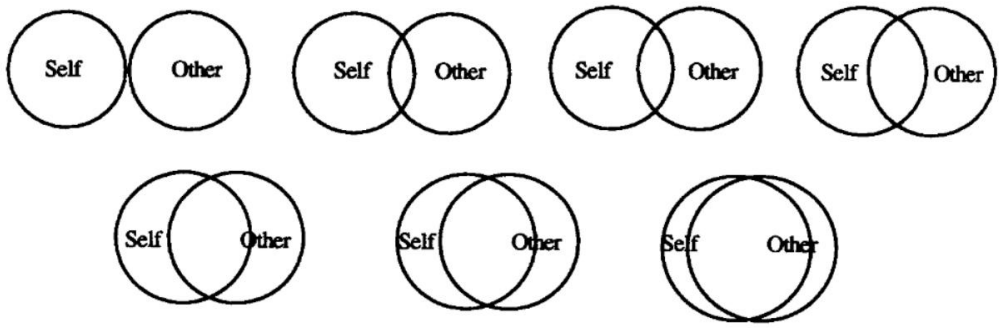
Not at all; Not really; Undecided; Somewhat; Very Much

2. How much do you like to play with this person?

Not at all; Not really; Undecided; Somewhat; Very Much

Social Closeness

Please circle the picture below which best describes your relationship with the person you just played with:



Prosocial Behavior

Do you want to donate part of your compensation ($5) to a COVID relief fund (more details will be provided later)?

0 1 2 3 4 5

APPENDIX B – CONTROL VARIABLE MEASURES

Personality

Here are a number of personality traits that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement "I see myself as…". You should rate the extent to which the pair of traits applies to you, even if one characteristic applies more strongly than the other.

Disagree strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	2	3	4	5	6	7

I *see myself as*:

1. _____ Extraverted, enthusiastic.
2. _____ Critical, quarrelsome.
3. _____ Dependable, self-disciplined.
4. _____ Anxious, easily upset.
5. _____ Open to new experiences, complex.
6. _____ Reserved, quiet.
7. _____ Sympathetic, warm.
8. _____ Disorganized, careless.
9. _____ Calm, emotionally stable.
10. _____ Conventional, uncreative.

Player Type

For the following items, imagine that you are playing a multiplayer online game, for each of the items, please indicate which of the two options suits you best:

Are you more comfortable, as a player:

Talking with friends in a tavern?

Out hunting orcs by yourself for experience?

Which is more enjoyable to you?

Killing a big monster

Bragging about it to your friends?

Which do you enjoy more in quests:

Getting involved in the storyline

Getting the rewards at the end?

Which would you rather be noticed for?:

Your equipment

Your personality

Would you rather be:

Popular

Wealthy

Which do you enjoy more?

Getting the latest gossip

Getting a new item

Which would you rather have, as a player?

A private channel, over which you and your friends can communicate

Your own house, worth millions of gold coins

Which would you enjoy more as a player?

Running your own tavern?

Making your own maps of the world, then selling them?

What's more important in a game to you?

The number of people

The number of areas to explore

What's more important to you:

The quality of roleplaying

The uniqueness of the features, and game mechanic

You are being chased by a monster. Do you:

Ask a friend for help in killing it

Hide somewhere you know the monster won't follow

You're a player, and you want to fight a really tough dragon. How would you approach this problem?

Get a big group of players to kill it.

Try a variety of weapons and magic against it, until you find its weakness.

You're a player, and about to go into an unknown dungeon. You have your choice of one more person for your party. Do you bring:

A bard, who's a good friend of yours and who's great for entertaining you and your friends

A wizard, to identify the items that you find there

Is it better to be:

Feared

Loved

Someone has PK'ed you. Do you want to:

Find out why, and try to convince them not to do it again

Plot your revenge

Which is more exciting?

A well-roleplayed scenario

A deadly battle

Which would you enjoy more?

Winning a duel with another player

Getting accepted by a clan

Would you rather

Vanquish your enemies

Convince your enemies to work for you, not against you

What's worse:

To be without power

To be without friends

Would you rather:

Hear what someone has to say

Show them the sharp blade of your axe

A new area opens up. Which do you look forward to more?

Exploring the new area, and finding out its history

Being the first to get the new equipment from the area

Would you rather be known as:

Someone who can run from any two points in the world, and really knows their way around.

The person with the best, most unique equipment in the game

Would you rather:

Become a hero faster than your friends

Know more secrets than your friends?

Would you rather:

Know where to find things

Know how to get things?

Which would you rather do:

Solve a riddle no one else has gotten

Getting to a certain experience level faster than anyone else

Do you tend to:

Know things no one else does

Have items no one else does

Would rather join a clan of:

Scholars

Assassins

Would you rather win:

A trivia contest

An arena battle

If you're alone in an area, do you think:

It's safe to explore

You'll have to look elsewhere for prey

Would rather be known for

Knowledge

Power

Would you rather:

Defeat an enemy

Explore a new area

You learn that another player is planning your demise. Do you:

Go to an area your opponent is unfamiliar with and prepare there

Attack him before he attacks you

You meet a new player. Do you think of him as:

Someone who can appreciate your knowledge of the game

As potential prey

Would you rather:

Have a sword twice as powerful as any other in the game

Be the most feared person in the game

Would you be more prone to brag about:

How may other players you've killed

Your equipment

Would you rather have:

A spell to damage other players

A spell that increases the rate at which you gain experience points?

Would you rather have:

Two levels of experience

An amulet that increases the damage you do against other players by 10%.

Would you rather receive as a quest reward:

Experience points

A wand with 3 charges of a spell that lets you control other players, against their will.

(charm person)

When playing a video game, is it more fun to:

Have the highest score on the list?

Beat your best friend one-on-one?

Note: The MUD Personality Test was retrieved from

http://www.andreasen.org/bartle/questions-en.dat

Player Type (Self-Rated)

Please choose a number next to each description to indicate the extent to which you agree or disagree with that statement "I see myself as…".

These people put the game-like aspect of the virtual world to the fore. They like doing things that achieve defined goals, thereby progressing their character through the world's built-in ranking system.

Disagree Strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	2	3	4	5	6	7

People for whom the greatest reward is interacting with other people, through the medium of the virtual world. Some do it as themselves; others role-play behind a mask.

Disagree strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	2	3	4	5	6	7

The ultimate delight for these people is increasing their knowledge about the way the virtual world works. Their joy is in discovery. They seek out the new.

Disagree strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	2	3	4	5	6	7

People who want to dominate others. The classic way is through attacking them or otherwise making life difficult for them, but it also can manifest in less overt fashion, such as politicking, rumor-mongering, pedanticism, or guilt-trip maternalism ("No, it's okay, you go and enjoy yourself. I'll just sit here by myself, waiting for someone to come along, I'll think of something to do…")

Disagree strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	2	3	4	5	6	7

APPENDIX C – ANCOVA RESULTS

Room: Game Setting. Mode: Game Mode. Socializer_Self: Self-rated Socializer.

ANCOVA - Social Closeness

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p	ω^2
room	0.71	1	0.71	0.41	0.523	0.003	0.003	0.000
mode	1.87	1	1.87	1.07	0.303	0.008	0.009	0.001
room ✻ mode	13.11	1	13.11	7.52	0.007	0.057	0.059	0.049
Agreeableness	0.62	1	0.62	0.36	0.552	0.003	0.003	0.000
Conscientiousness	0.07	1	0.07	0.04	0.842	0.000	0.000	0.000
Socializer	0.36	1	0.36	0.20	0.652	0.002	0.002	0.000
Socializer_Self	0.07	1	0.07	0.04	0.843	0.000	0.000	0.000
age	6.76	1	6.76	3.88	0.051	0.029	0.032	0.022
Residuals	207.33	119	1.74					

Bayesian ANCOVA - Social Closeness

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. all covariates)	0.200	0.482	3.72	1.00	
room + mode + room ✻ mode	0.200	0.228	1.19	0.47	4.01
mode	0.200	0.139	0.65	0.29	3.03
room	0.200	0.116	0.53	0.24	3.25
room + mode	0.200	0.034	0.14	0.07	3.86

Note. All models include age, Agreeableness, Conscientiousness, Socializer, Socializer_Self.

ANCOVA - Friendship

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p	ω^2
room	3.16	1	3.16	5.50	0.021	0.043	0.044	0.035
mode	0.31	1	0.31	0.54	0.466	0.004	0.004	0.000
Socializer_Self	0.18	1	0.18	0.32	0.576	0.002	0.003	0.000
room ✻ mode	0.51	1	0.51	0.89	0.349	0.007	0.007	0.000
age	0.09	1	0.09	0.16	0.689	0.001	0.001	0.000
Agreeableness	1.04	1	1.04	1.81	0.181	0.014	0.015	0.006
Conscientiousness	0.22	1	0.22	0.38	0.538	0.003	0.003	0.000
Socializer	0.27	1	0.27	0.47	0.497	0.004	0.004	0.000
Residuals	68.39	119	0.58					

Bayesian ANCOVA - Friendship

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
room	0.200	0.546	4.82	1.00	
Null model (incl. all covariates)	0.200	0.215	1.09	0.39	2.80
room + mode	0.200	0.136	0.63	0.25	4.38
room + mode + room ✻ mode	0.200	0.052	0.22	0.10	4.85
mode	0.200	0.051	0.22	0.09	4.08

Note. All models include age, Agreeableness, Conscientiousness, Socializer, Socializer_Self.

ANCOVA - Prosocial Behavior

Cases	Sum of Squares	df	Mean Square	F	p	η^2	η^2_p	ω^2
room	1.09	1	1.09	0.22	0.643	0.002	0.002	0.000
mode	0.54	1	0.54	0.11	0.745	0.001	0.001	0.000
Socializer_Self	17.41	1	17.41	3.45	0.066	0.025	0.028	0.018
room ✻ mode	18.47	1	18.47	3.66	0.058	0.026	0.030	0.019
age	43.18	1	43.18	8.56	0.004	0.062	0.067	0.054
Agreeableness	0.13	1	0.13	0.03	0.872	0.000	0.000	0.000
Conscientiousness	7.91	1	7.91	1.57	0.213	0.011	0.013	0.004
Socializer	12.69	1	12.69	2.52	0.115	0.018	0.021	0.011
Residuals	600.26	119	5.04					

Bayesian ANCOVA - Prosocial Behavior

Models	P(M)	P(M|data)	BF_M	BF_{10}	error %
Null model (incl. all covariates)	0.200	0.649	7.38	1.00	
room	0.200	0.147	0.69	0.23	2.10
mode	0.200	0.138	0.64	0.21	2.02
room + mode + room ✻ mode	0.200	0.033	0.14	0.05	2.82
room + mode	0.200	0.032	0.13	0.05	2.69

Note. All models include age, Agreeableness, Conscientiousness, Socializer, Socializer_Self.

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