

Player Matching using Personal Characteristics for Asynchronous Multiplayer Exergames

by

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Abstract

Participation in regular exercise can help with maintaining good health. However, exercise interventions, including those that are game based, while successful at capturing initial interest, usually suffer from retention as adherence declines overtime. To maintain continued interest, recent efforts are exploring the effects of gradual release of game features, tailoring gamified systems to personality, and matchmaking for multiplayer games. To encourage a better workout, asynchronous experiences, where the gameplay and exercise occur at separate times, are also being designed and investigated. The experience of fun and social affiliation are good predictors of long-term intention to play, yet current player matching algorithms are poor at facilitating and utilizing social connectedness and grouping based on compatible characteristics.

Grounded in psychological and sociological theories, we propose player matching based on personal characteristics as an attempt to create a more socially satisfying playing experience and address the retention problem. We start by exploring the effectiveness of pairing players based on personality types and simple game features such as competitive and cooperative team challenges. The results of our 60-day study show that grouping players based on similar personalities seems to increase the level of game engagement and retention compared to dissimilar ones. Using a storyboard approach, we further examined the effects of matching based on player types and various social features on increasing exergame retention. We found strong relationships between social game elements and player types. Correlational analyses demonstrated that the gamification element of “lottery”, unlockable content, and “update and encouragement” was strongly related to the “Achiever” player type, while “virtual character”, “custom goal” and “leaderboard” elements were most strongly related to both “Philanthropist” and “Socialiser” player types. We believe game designers can use these results and improve game and exercise adherence by offering more socially rewarding interactions between players through personalized features.

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List of Abbreviations

API	Application Programming Interface
AVG	Active Video Games
BCT	Behavioural Choice Theory
BFI	Big Five Inventory
BMI	Body Mass Index
CMS	Content Management System
CRS	Conscientious Responders Scale
COVID-19	COrona VIRus Disease 19
DDR	Dance Dance Revolution
DISC	Dominance, Inducement, Submission and Compliance
FFM	Five Factor Model
GEQ	Game Experience Questionnaire
GPC	Group Personality Composition
HCI	Human Computer Interaction
HIT	Human Intelligence Task
ICT	Information and Communication Technology
IMI	Intrinsic Motivation Inventory
IPIP	International Personality Item Pool
IT	Information Technology
LoL	League of Legends
MMOG	Massively Multiplayer Online Games
MOBA	Multiplayer Online Battle Arena
MUD	Multi-User Dungeon
NPC	Non-Player Character
PHP	PHP: Hypertext Preprocessor (recursive)
PMPC	Player Matching using Personal Characteristics
PT	Persuasive Technology
RO	Relationship Oriented

RQ	Research Question
SDT	Self Determination Theory
SG	Software Generated
SMTP	Simple Mail Transfer Protocol
TIPI	Ten Item Personality Inventory
TO	Task Oriented
TPD	Team Personality Diversity
TPE	Team Personality Elevation
UI	User-Interface
UK	United Kingdom
USA	United States of America

List of Statistical Notation

α	Cronbach's alpha
df	Degrees of freedom
H	Hypothesis
Kurt	Kurtosis
M	Mean
Mdn	Median
N	Number of scores in the data
n	Number of scores in each sample
p	Probability
SD	Standard Deviation
ρ	Rho – Spearman's rank correlation coefficient
r	Correlation coefficient
Skew	Skewness

1 Introduction

1.1 Background

Research suggests that sedentary lifestyle, one dominated by sedentary behaviours such as stationary screen time and desk-bound work, is associated with an increased risk of developing metabolic dysfunction, cardiovascular disease, osteoporosis, obesity, and lower levels of psychosocial health and well-being (Tremblay et al., 2010). In contrast, living an active lifestyle through engaging in regular exercise and physical activity is associated with many health benefits (Alpert, 2009). Keeping an active lifestyle can be challenging as it requires a great deal of commitment, effort, and motivation, and the proliferation of modern-day technology can potentially encourage people to be inactive rather than active (Dunstan et al., 2010). Designers and researchers are increasingly interested in how digital tools, particularly wearable technology, games, and mobile health applications, can be integrated into a user-centric healthcare model (Figure 1.1) and be redesigned to address the obesity problem (Lokshina & Bartolacci, 2014).

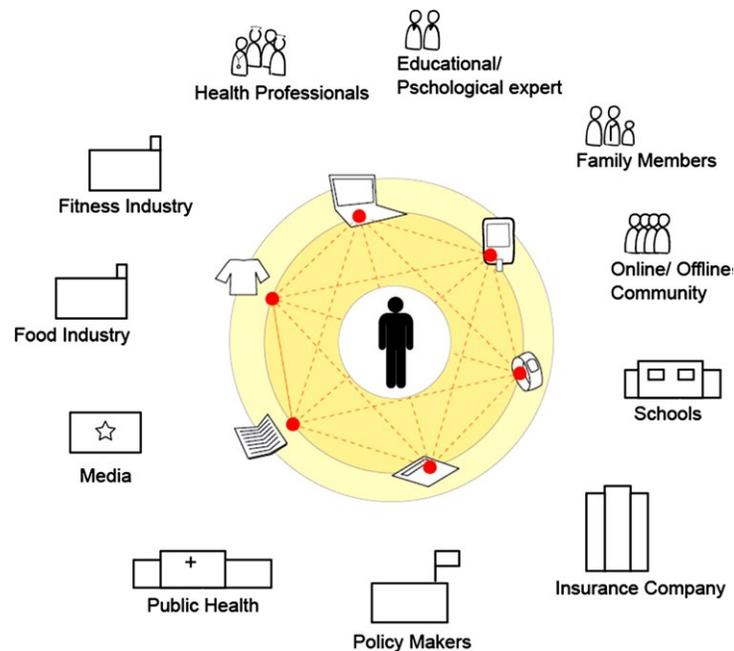


Figure 1.1: User-centered design of a new healthcare model (Lokshina & Bartolacci, 2014; Lokshina & Durkin, 2017).

According to Lokshina and Durkin (2017), a user-centered healthcare model is an integration of sophisticated game mechanics and social networks for motivating behavior changes toward adopting a healthy lifestyle. By applying an Information and Communication Technology (ICT) framework, wearable sensors, mobile phones, and multimedia diaries are used to collect information about the individual and the environment to offer personalized recommendations for a user on a wide range of subjects such as physical activities that are more suitable and interesting.

While video games are frequently considered as examples, and sometimes causes, of sedentary lifestyle, they are among technologies that have potential to promote active lifestyle by motivating people to be more physically active (Yim & Graham, 2007). Although there may be negative aspects associated with playing videogames such as sacrificing other things in life, feelings of guilt about time wasted, and social conflict (Wood et al., 2007), playing video games can be productive and active (McGonigal, 2012). Popularized with platforms such as Nintendo Wii (Kyoto, Japan), released in 2007, Microsoft Kinect for Xbox (2010), and more recently Ring Fit Adventure (2019), modern generations of video games frequently require players use a range of active body motions as an alternative to traditional non-active games (Pasch et al., 2009). These games encourage physical activity and reduce sedentary behaviours and are commonly referred to as “exergames”.

*Exergames*¹, which are a combination of exercise and video games (Yim & Graham, 2007), can make exercise more enjoyable, and offer an entertaining environment to motivate people to engage in physical activity (Altamimi & Skinner, 2012). A number of researchers have explored the value of exergames for encouraging participation in physical activity (Altamimi & Skinner, 2012; Staiano & Calvert, 2011; Trost et al., 2014; Whitehead et al., 2010) and have identified principles for designing successful

¹ Exergames are also commonly referred to as active video games, active gaming, movement-controlled video games, or exertion games, in which interaction with the game requires physical effort (Mueller, Gibbs, & Vetere, 2010; Yim & Graham, 2007).

exergames (Mandryk et al., 2014; Mueller & Isbister, 2014; Sinclair et al., 2007; Thin & Poole, 2010; Wiemeyer et al., 2014; Yim & Graham, 2007). While in most existing exergames such as the Wii Sports (Nintendo Inc., Kyoto, Japan), the player plays the game and performs the exercise at the same time, more recently, designers are developing an “asynchronous” experience where gameplay and exercise occur at separate times but are related through mechanisms such as collecting points through exercise to be used during the gameplay (Keeney et al., 2019; Moller et al., 2014; Tan et al., 2016) or using energy expenditure to gain assets for gameplay. An *asynchronous* experience offers players the flexibility and convenience of exercising at their own pace and in their own time.

Despite the growth of exergames, research shows that the problem of retention and continuous engagement is an issue for these and other games mainly because the level of interest declines over time (Baranowski et al., 2014; Caro et al., 2018; Graves et al., 2007; Kaos et al., 2019; Owen et al., 2011). While in commercial games this is primarily a matter of financial gain for developers and companies, in exergames, the health benefits of the promoted practice may be lost if the players lose motivation to play. In particular, the role of social interactions (Bekker et al., 2010) in the retention of multiplayer exergames has not been thoroughly investigated (Chan et al., 2019). Although there is some research comparing the adherence of single player vs. multiplayer exergames and show that multiplayer features do not augment extended play durations (Kaos et al., 2018), very little research has investigated the effects of cultivating social connectedness between players for increasing retention, particularly in the context of asynchronous exergames.

1.2 Problem Statement and Significance

As mentioned in the previous section, increasing exergame retention as a way of ensuring continuous physical activity is a challenge in exergame research and design. Even though a player who stops playing the game may continue to be active, continuous play can be considered a sign of continuous activity, and as such, is the goal of the research proposed in this thesis. While there are many approaches to

increase player retention (Choi & Kim, 2004; Debeauvais et al., 2010; Park et al., 2017; Schiller et al., 2019; Zhao et al., 2017a), to date, there are not many longitudinal studies examining the effects of social affiliation and the kinds of group interactions (both intergroup and intragroup) that can motivate continued exergame play (Chan et al., 2019).

Research shows that experience of fun, competition, and social affiliation are good predictors of long-term intention to playing exergames (Adam & Senner, 2016), whereas reasons for not playing exergames include factors such as not useful enough, lack of time, and preference for other forms of exercise (Kari et al., 2012). Social (multiplayer) exergames are becoming more popular among the research and game design community because of their potential for helping people achieve a range of positive physiological and psychosocial outcomes (Marker & Staiano, 2015). Some studies have shown that multiplayer exergames are more motivational and have better retention compared to single player exergames (Chin A Paw et al., 2008). Yet players report that current player matching services are poor for facilitating social connectedness (Horton et al., 2016). Thus, further research is needed to investigate more meaningful ways to connect players. If the interactions between players are more socially rewarding, exergame retention will be more probable.

The research reported in this thesis addresses the problem of game retention from the point of view of player matching in multiplayer exergames. We intend to understand how matching players in teams based on different personal characteristics can increase interaction, enjoyment, and engagement, and as the result, game retention. Our research focuses on asynchronous games where physical activities can be chosen by the player and not dictated by the game. We believe that this choice offers maximum flexibility in the type of physical activity and allow wider participation in our research studies. We expect the findings to be helpful for synchronous games too, but that discussion is out of scope for this thesis.

To comprehensively examine the effectiveness of player matching on exergame retention, this proposed study aims to gradually investigate the following research questions (Figure 1.2):

1. Can matching based on personal characteristics help with retention?
2. Which personal characteristics are more effective in helping with matchmaking to increase retention?
 - a. Is personality effective for player matching and retention?
 - b. Is player type effective for player matching and retention?
3. Which game features can take advantage of those personal characteristics more effectively?

While various personal characteristics such as friendship, culture, and lifestyle can be considered in such a research, for scoping reasons, we focused on personality and player type, presented by the Big-Five (Costa & McCrae, 1992) and Hexad (Marczewski, 2015) models as discussed later.

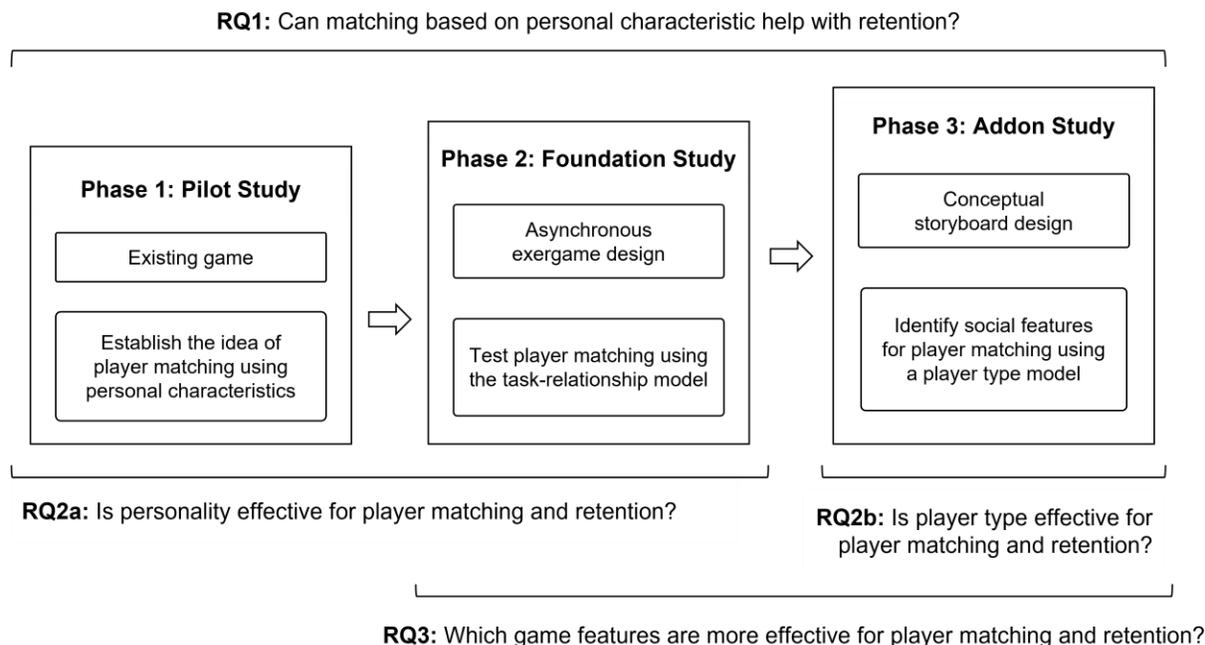


Figure 1.2: The goal of each study phase of the research and the research question we intended to answer.

1.3 Contributions

The major contribution of this research is the Player Matching using Personal Characteristics (PMPC) as a method for increasing retention in asynchronous exergames. As mentioned earlier, while the method can potentially be generalized for synchronous games, our proposed method and evaluation are focused on asynchronous games because this is a new trend in the field of exergames (Chan et al., 2019) and we wanted to explore what happens when players have the freedom to choose when and where they wish to perform the exercise activities. Also, based on our previous research on gamification and the gradual release of game features players wished for more opportunities to exercise outdoors (Zhao et al., 2017a), an asynchronous experience allows for both indoor and outdoor activities. As for personal characteristics, our primary choice was the use of personality types, but we also investigated player type, and intend to expand the research in future to other characteristics such as friendship, lifestyle, culture, and behavioural attitudes.

The main contributions of this thesis can be summarized as follows:

1. **Contribution from a Literature Review:** A literature review of the strategies, theories and practices that are considered when designing exergames to increase players' motivation which helps to motivate the research project and start answering the three research questions.

Insights gained:

- Social aspect of an activity and social experiences are important motivators for engaging in continued play.
- More research is needed to uncover optimal player tailoring and pairing mechanisms for facilitating group play.
- Lack of longer-term studies in the domain of exergames, particularly understanding the effects of competition, cooperation, and situational interest on exergame adherence over a longer period.
- Researchers are gradually moving away from designing and researching exergames that are confined to indoor play and require a game console

and are increasingly exploring the effectiveness of designs that are app-based for outdoor and asynchronous gameplay experiences.

- Metrics specialized for evaluating the exergame experience is needed.

Publication:

- Chan, G., Arya, A., Orji, R., & Zhao, Z. (2019). Motivational strategies and approaches for single and multi-player exergames: a social perspective. *PeerJ Computer Science*, 5, e230.
2. **Contribution from Pilot Study:** What personal characteristics (personality type) can be used for player matching to increase the level of enjoyment and social interactions for improving exergame retention, as well as a prototype to validate the methodology and show that it is viable to conduct it with a larger sample, which helped to answer RQs 1 and 2.

Publications:

- Chan, G., Arya, A., & Whitehead, A. (2018, April). Keeping players engaged in exergames: A personality matchmaking approach. In *Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems* (pp. 1-6).
 - Chan, G., Arya, A., & Whitehead, A. D. (2018). Personalizing the exergame experience: a personality tailoring approach. *Annual Review of CyberTherapy and Telemedicine*, 2018(16), 179-181.
3. **Contribution from the Foundation Study:** The results of a 60-day, long-term study to support the idea that increasing the level of social interactions between groups of players composed of different and similar personality types from a task-relationship perspective plays a role in motivating exergame retention, as well as the design and evaluation of an asynchronous exergame that allows players to be matched based on personality and other personal characteristics, which provided further evidence for answering RQs 1 and 2.

Publication:

- Chan, G., Arya, A., Orji, R., Zhao, Z., Stojmenovic, M., & Whitehead, A. (2020, November). Player Matching for Social Exergame Retention: A Group Personality Composition Approach. In *Extended Abstracts of the 2020 Annual Symposium on Computer-Human Interaction in Play* (pp. 198-203).

4. **Contribution from an Addon Study:** The design and evaluation of socially oriented gamification elements that can be used to personalize the game features and potentially match players accordingly, as well as the investigation of social features and design patterns that can be used to increase retention in game using personalization of social features with or without the resulting player matching, which helped to answer RQ3.

Publication:

- Chan, G., Arya, A., Orji, R., Zhao, Z., & Whitehead, A. (2021, August). Personalizing Gameful Elements in Social Exergames: An Exploratory Study. In *The 16th International Conference on the Foundations of Digital Games (FDG) 2021* (pp. 1-6).

5. **Reflection and Redesign:** A set of new game features for redesigning and implementation of an exercise game that is expected to increase retention, which can help to further elucidate RQs 1, 2, and 3 if such a game was to be developed and a study conducted.

Additionally, I have been a co-author on other publications which are indirectly related to this thesis. These include:

- Riyadh, M., Arya, A., Chan, G., & Imran, M. (2020, July). Enhancing Social Ties Through Manual Player Matchmaking in Online Multiplayer Games. In *International Conference on Human-Computer Interaction* (pp. 708-729). Springer, Cham.

- Zhao, Z., Arya, A., Orji, R., & Chan, G. (2020). Effects of a Personalized Fitness Recommender System Using Gamification and Continuous Player Modeling: System Design and Long-Term Validation Study. *JMIR Serious Games*, 8(4), e19968.
- Zhao, Z., Arya, A., Orji, R., & Chan, G. (2020, August). Physical Activity Recommendation for Exergame Player Modeling using Machine Learning Approach. In *2020 IEEE 8th International Conference on Serious Games and Applications for Health (SeGAH)* (pp. 1-9). IEEE.
- Zhao, Z., Arya, A., Whitehead, A., Chan, G., & Etemad, S. A. (2017, May). Keeping Users Engaged through Feature Updates: A Long-Term Study of Using Wearable-Based Exergames. In *CHI* (pp. 1053-1064).

1.4 Research Overview

In this research, we proposed and evaluated Player Matching using Personal Characteristics (PMPC) as a method for increasing retention in asynchronous exergames. Existing research on exergames has used a variety of methods including prototyping, as well as qualitative and quantitative data collection and analysis. To better understand the effect of different approaches of player matching on game retention, we use a quantitative data collection and analysis method combined with a game prototyping and experimentation. While our prototype implements various game features and matching approaches, our quantitative data includes both subjective (survey-based) and objective items (in-game observations) related to metrics required for our hypotheses. We also include qualitative data in the form of open-ended questions for extra information.

Our research is organized into the following three studies (Figure 1.2) each with their own related prototype design and development:

1. **Pilot Study:** A pilot study using an existing simple game was conducted to evaluate the idea of matching players together based on personal characteristics, particularly individual personality, and serves as a good prototype to validate the methodology.

2. **Foundation Study:** An exergame prototype with various features was designed and developed as a test bed to explore the relationship between game features, performance, and personality type. Players were purposefully matched based on similar and complementary personality types.
3. **Add-on Study:** Based on the results of the foundation study, we designed and tested social game features, presented them through online storyboards, and investigated the relationship between interest in these features and player type. The goal was to see if there are preferred features based on player type and if that can be used to influence the playing experience and ultimately retention.
4. **Redesign:** Based on the results of the add-on study, a list of features (gameful elements) for designing step-based multiplayer exergames were devised that are likely preferred by certain player types increasing the level of motivation for continued play.

1.5 Organization of Thesis

The first personal plural voice (*we*) is used in this thesis to reflect the fact that the work was conducted by me under the supervision of Dr. Ali Arya and Dr. Anthony Whitehead. The remainder of this thesis is organized as follows:

- Chapter 2 presents an overview of the state-of-the-art in the field highlighting some of the key theories and research that have been conducted to examine motivations underlying exercise behaviours, videogame play, exergame play, followed by an analysis of the drawbacks and limitations.
- Chapter 3 introduces a theoretical model that will be used as a guide for the present study along with our proposed solution.
- Chapter 4 describes the game that was designed to test our hypothesis.
- Chapter 5 describes our research approach which consists of a pilot study, a foundation study, and an add-on study.

- Chapter 6 describes the pilot study followed by an outline of the steps that were followed to conduct the foundation study including the measures, procedures, and early results.
- Chapter 7 describes and reports on the results of our add-on study.
- Chapter 8 outlines a set of new features based on the results of our add-on study.
- Chapter 9 offers some closing remarks and directions for future research to further understand the effects of player matching in exergames.

2 Related Work

2.1 Motivation to Engage in Health and Exercise Behaviours

A sedentary lifestyle is a growing health concern (Lynch & Owen, 2015; Tremblay et al., 2010). In recognition of this concern, various efforts have been put forth to encourage people to engage in an active lifestyle by participating in physical activity. Caspersen et al. (1985) defines “physical activity” as bodily movement produced by the contraction of skeletal muscle that requires energy expenditure in excess of resting energy expenditure whereas “exercise” refers to a subset of physical activity: planned, structured, and repetitive bodily movement performed to improve or maintain one or more components of physical fitness. Caspersen et al. (1985) explain that both *exercise* and *physical activity* share a number of common elements such as the involvement of bodily movement produced by skeletal muscles that expend energy and are positively correlated with physical fitness as the level of intensity, duration, and frequency of movement increase.

In addition to a sedentary lifestyle, research suggests that common complaints associated with physical activity include factors such as lack of social support, perceived feelings of exhaustion, and inconvenience of environmental conditions (Myers & Roth, 1997). From a psychological perspective, humans are intrinsically motivated to exercise both their mental and physical capacities (White, 1959) and reasons for adhering to exercise are associated with motives focused on enjoyment, competence, and social interaction rather than fitness or appearance (Ryan et al., 1997). One of the strongest predictors of exercise and physical activity adherence is feelings of intrinsic motivation (Ryan et al., 1997; Teixeira et al., 2012). Although extrinsic motives concerning body-related outcomes are highly rated as reasons for initiating physical activity programs, adherence is more reliably a function of differences in motives associated with intrinsic factors such as enjoyment and competence (Ryan et al., 1997). There are different reasons why one may be motivated to participate in exercise (Ingledeu et al., 2009; Li, 1999). Reeve (2014) describes a

variety of reasons and sources of motivation for participation in exercise as shown in Table 2.1.

Table 2.1: Different sources of motivation for exercise (Reeve, 2014).

Reasons for exercise	Source of motivation	Example
For fun	Intrinsic motivation	Children run and jump around the school playground because it is fun.
To please others	Extrinsic motivation	An athlete begins a new drill because he/she was instructed by his/her coach.
To accomplish a goal	Goal oriented	Runners see if they can run 5 kilometers in 30 minutes.
To meet a standard of excellence	Achievement strivings	A swimmer doing sprints to see if he/she can beat his/her previous time.
To spend time with friends	Positive affect	Treating exercise as a social event to spend time with friends.
Because it is beneficial	Value	People exercise to lose weight or strengthen the heart.

Modern technology affords sedentary behaviours and with the greater use of technology, there are not enough hours in the day for individuals to engage in physical activity. As a result, research is increasingly focused on how to harness the power of technology to support people to be physically active. Deci and Ryan (2009) argue that because humans are “active organisms” motivation to engage in exercise is for self-worth. They extended the meaning of intrinsic motivation and developed a broad model for understanding human motivation and personality called Self-Determination Theory (SDT) (Deci & Ryan, 2000) which can be represented along a continuum (Figure 2.1). The model consists of three interrelated components with respect to one’s primary psychological needs: competence, autonomy, and relatedness. “Competence” refers to the feeling of confidence both within the self and by receiving encouragement from others. “Autonomy” is an internal state which is regulated by the self. “Relatedness” refers to the sense of connectedness and acceptance by others. People engage in exercise to satisfy these needs. Multiplayer games have the

potential to satisfy these needs and participate in physical activity. Thus, SDT is a useful framework for our theoretical model because it can offer a theoretical foundation for understanding underlying motivations to engage in both individual and social play.

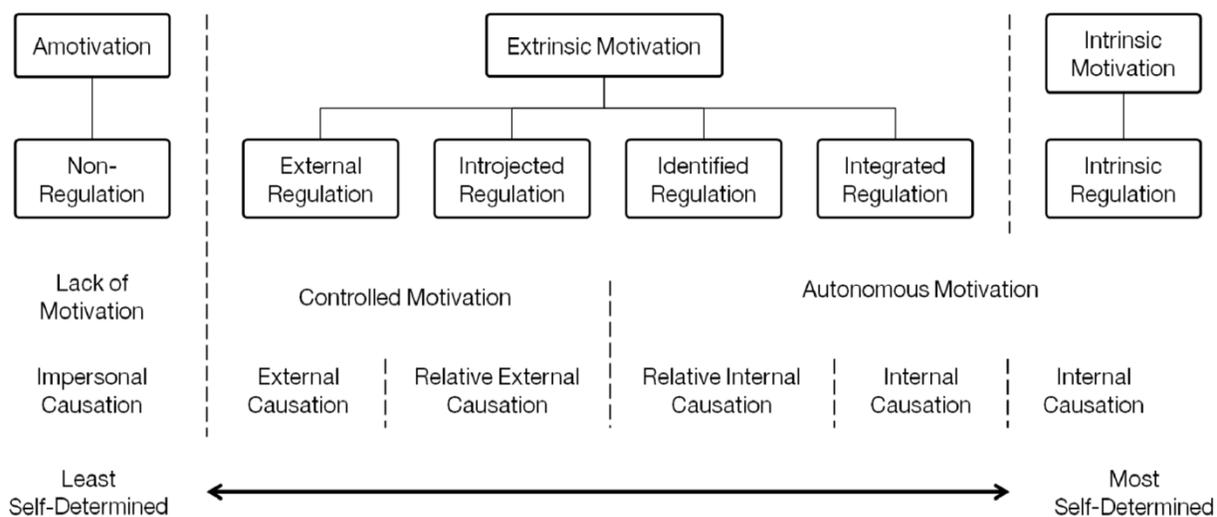


Figure 2.1: The Self-Determination Continuum adapted from Deci and Ryan (2000) SDT and the facilitation of intrinsic motivation, social development, and well-being.

2.2 Exergames

Exergames, can be defined as a combination of exercise and video games (Yim & Graham, 2007). The foundational premise of exergames is that many people do not find participation in exercise intrinsically motivating, but do find playing games compelling (Schneider & Graham, 2017). Exergames have gained much popularity because of their vast potential benefits, including everything from reducing childhood obesity (Koivisto et al., 2012) to improving cognitive abilities in older adults (Anderson-Hanley, Arciero, Brickman, Nimon, Okuma et al., 2012). Experience of fun and affiliation are good predictors of long-term intention to play exergames (Adam & Senner, 2016). Reviews of existing literature show that exergames offer moderate levels of exercise intensity (Biddiss & Irwin, 2010; Peng, Crouse, & Lin, 2013; Sween et al., 2014) and may be used to replace sedentary screen time with light levels of activity in healthy adults (Dutta & Pereira, 2014). In a physical education classroom context, research shows that exergames offer an effective way and are

socially acceptable interventions for inactive children to engage in more physical activity (Fogel et al., 2010). Children gravitate toward exergames because they not only provide a source of situational interest, but also elicit lasting feelings of challenge, exploration, and instant enjoyment (Sun, 2013a).

Based on principles of Behavioral Choice Theory (BCT) [a theoretical approach that attempts to understand the process of judgment and decision making, and how time and responses are allocated given the available options (Epstein, 1998)] on promoting physical activity, Biddiss and Irwin (2010) suggest four strategies for designing Active Video Game (AVG) systems and interventions to encourage long-term adherence particularly for children:

1. Provide positive feedback and be an accessible (e.g., low-cost and easy-to-use) alternative to sedentary activity;
2. Early exposure to active games rather than passive games to increase the chances of acceptance;
3. Perceived as personal choice instead of treatment/therapy, and;
4. Offer short-term (e.g., points system) and long-term (e.g., progress towards goals and skills development) reinforcement.

The researchers also pointed out that long-term studies and how group play can encourage participation in AVG are under-researched. Many researchers agree with Biddiss and Irwin (2010) that group play can encourage participation in AVG. Particularly the social interactions that occur in group play can be an important factor for increasing the level of engagement and enjoyment between multiple players. This is because opportunities for experiencing social interactions during a game can motivate intention to play (Sherry et al., 2006).

Many designers and researchers are investigating the possibility of personalizing the exergame experience in attempt to sustain motivation and keep players engaged. For example, Göbel, Hardy and Wendel (2010) introduced a set of personalized exergames which combine the concepts of serious games and sensor technologies. The

researchers added customized features which adapt gameplay to a player's stress levels, duration and intensity. Results showed that their approach enhances a player's level of motivation toward the gameplay. Shaw, Buckley, Corballis, Lutteroth and Wuensche (2016) tested a training system which adapts to the player's personality. They found that players were highly motivated when the system mimicked the competitiveness and cooperativeness of the player.

Although exergames can make the experience of engaging in physical activity more enjoyable (Thin & Poole, 2010; Yim & Graham, 2007), there is some research which suggests that exergames may not be able to maintain exercise motivation over the long-term (Sun, 2013b). Motives that do not predict long-term exergame adherence are doing sports, health and losing weight because players report that their expectations concerning physical activity, having health benefits, and weight loss were unfulfilled (Adam & Senner, 2016). There is also research evidence which suggests that some exergames are not intense enough to contribute toward the recommended daily amount of exercise for children because these games do not require as much energy expenditure as the actual sport (Graves et al., 2007). To encourage adequate energy expenditure, exergames must consist of two main features: (1) rewards for encouraging long-term motivation and, (2) better physical benefits which involves full body movements (Whitehead et al., 2010).

Researchers are investigating ways to increase the intensity of physical activity by applying existing team-based shooter game features (Hagen et al., 2016) and generating more situational interest (Pasco et al., 2017). To increase the level of engagement and enjoyment experienced in exergames, periodic and continuous feedback, physical and mental challenges, as well as rewards (both intrinsic and extrinsic) and punishment strategies need to be offered (Lyons, 2014).

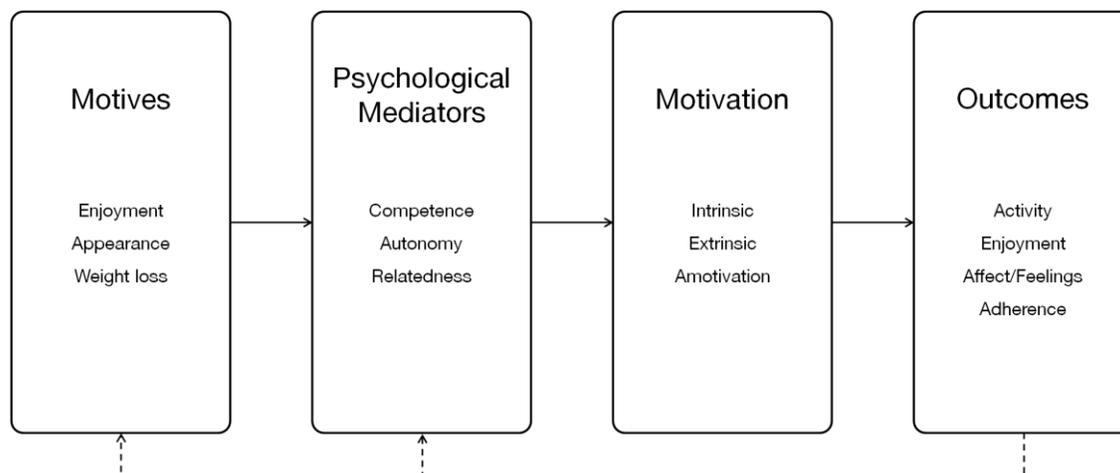


Figure 2.2: Relationship between SDT mediators, motivation, outcomes and motives adapted from Boulos and Yang, 2013.

Based on the SDT, researchers such as Boulos and Yang (2013) have proposed a framework (Figure 2.2) for conducting future research particularly on children's motives for participating in exergames. The researchers recommend that research should aim to understand the types of activities that children already find compelling and motivating, which may include enjoyment or physical appearance or weight loss. The researchers further posit that if players feel competent during play, they are more likely to continue playing because continued feeling of competence will likely lead to intrinsically motivated behaviours resulting in outcomes such as higher levels of physical activity, enjoyment, and adherence. Beyond Boulos and Yang (2013), Limperos and Schmierbach (2016) examined the relationship between exergame play experiences, enjoyment, and intentions for continued play, and found that player performance directly and indirectly predicts feelings of psychological responses, enjoyment of the experience, and the likelihood for future play. The researchers reported that players who achieved better performance experienced greater levels autonomy, presence, and enjoyment, and concluded that performance in exergames is related to the player's psychological experiences that motivate enjoyment and the intention for continued play.

2.3 Motivational Elements of Exergame Play

Among other theories and elements such as engagement (Wiebe et al., 2014), enjoyment (Mekler et al., 2014) and flow (Csikszentmihalyi & Csikszentmihalyi, 1975), research shows that *motivation* is the most important force for determining a player's desire for continued play (Stankevicius, Jady, Drachen, & Schoenau-Fog, 2015) and that consideration of self-efficacy is particularly important for maintaining motivation over time through setting achievable goals in exergames (Macvean & Robertson, 2013). Research in the field of psychology shows that self-initiation and choice are key factors for motivating physical activity (Wilson et al., 2008) and intrinsic motives such as challenge, affiliation and enjoyment are positively associated with exercise behaviours (Teixeira et al., 2012). Likewise, in the domain of videogames, satisfaction of intrinsic motivators such as enjoyment, mastery, and achievement are important for health-related behaviour change (Baranowski et al., 2008).

In the domain of behavioural economics, Thaler and Sunstein (2008) as cited in (Leonard, 2008) introduces the notion of “nudge” any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives which aims to motivate people to choose better and has been applied to promoting health-related behaviour change. With respect to technology, computer applications have been designed to motivate healthy behaviour change. For example, Fogg's (2003) notion of “Persuasive Technology” (PT) aims to bring desirable changes in attitudes and behaviours without using deception, coercion, or inducements. PT target emotional or cognitive changes through technology mediated transformation and have been applied to exergame-related activities (Adams et al., 2009). A review of existing empirical research suggests that persuasive technological interventions seem to be a promising approach for encouraging a wide range of health-related behaviours; yet, due to the lack of large-scale and longitudinal evaluations, the long-term effects of these technologies are unknown (Orji & Moffatt, 2018).

The following sections review some of the most common motivational theories and principles that have been studied in the exergame literature.

2.3.1 Gamification

Gamification refers to the application of game principles in non-game contexts (Deterding et al., 2011b) and is inherent in all exergames. An exergame without gamification would be only exercise. While gamification by itself is not necessarily a social strategy, some game features can consist of social mechanics, such as leaderboard where players are able to see and compare their own performance with other players. How to effectively use gamification features (particularly social features) as a motivator in exergames to sustain long-term play has been the research objective of many studies (e.g., Brauner, Calero Valdez, Schroeder, & Ziefle, 2013; Hamari & Koivisto, 2015). Gamification has been applied to a variety of health-related applications to promote a positive influence on health and wellness behaviors in recent years (Pereira et al., 2014) and can work by providing a source of motivation for one to engage in physical activity. Deterding (2012) argue that in order for gamification to be successful, proper “game design” elements (Schell, 2008) must be included, not simply game components.

Despite the growing interest in persuasive games and gamified systems for motivating health-related behaviours (Orji, Nacke, et al., 2017a; Orji & Moffatt, 2018; Torkamaan & Ziegler, 2021), the majority of persuasive games employ a non-tailored approach to their design (Busch et al., 2015a). Although some researchers are attempting to design better measure instruments to more accurately evaluate user preferences and motivations to use a gamified system (Tondello et al., 2016), very little research has been done to design better metrics to evaluate player preferences and motivations for personalizing the experience specifically in the context of exergames.

2.3.2 Psychological Components

Growing research evidence suggests that playing exergames are associated with many health benefits. For example, research shows that exergames that are enjoyable and engaging are more likely to encourage greater amounts of energy expenditure (Lyons et al., 2014) which is important for individuals and health practitioners who are interested in using exergames for weight management purposes. Another line of research shows that playing exergames once a week for 30 minutes may elicit positive mood states such as happiness (Huang, Wong, Yang, Chiu, & Teng, 2017).

In one survey paper, Lee, Kim, Park and Peng (2017) reviewed studies that explored the psychological effects of playing exergames, from the viewpoint of player engagement. Results showed that psychological effects of engagement included factors such as enjoyment, immersion, and flow, and that social interactions during play are important leading to positive psychological effects. Among the exergames that promoted positive psychological effects were games which allowed players to compete or collaborate with Software-Generated (SG) partners and real human players. However, one major limitation in exergaming research is that most studies to date rely on measures developed for either normal exercise or sedentary digital games. Thus, the researchers recommend that a unique evaluation for measuring the psychological effects of exergames is needed because exergames are different from sedentary video games and traditional kinds of exercise.

2.3.3 Social Interactions and Group Play

From the Human-Computer Interaction (HCI) perspective, Dourish (2002) argues that physical and embodied features of interactive systems are related to the features of social settings. However, Salen and Zimmerman (2013) suggest that design alone cannot warrant social play — designers can offer features that facilitate social play, but it is the players who create it. Park, Cha, Kwak and Chen (2017) argue that achievement features are essential for players at the initial phases of the game, whereas it is *social features* that become important as players reach the highest level

offered by the game. Yee (2007) developed an empirical model of player motivations in online games which identified “social interaction” as one overarching component which consists of three subcomponents:

1. *Socializing*: having an interest in helping and chatting with other players.
2. *Relationships*: the desire to form long-term meaningful relationships with others.
3. *Teamwork*: deriving satisfaction from being part of a group effort.

These sub-components provide a foundation for conducting quantitative research in online games to better understand usage patterns, in-game behaviours, and demographic variables such as age and gender, with respect to player motivations.

In a video game context, social interaction is important for experiencing enjoyment² (Anwar et al., 2017; Sweetser & Wyeth, 2005) and exertion games can facilitate social play in computer mediated environments (Mueller, Gibbs, & Vetere, 2009; Mueller, Gibbs, & Vetere, 2010). Research also shows that social presence (Ekman et al., 2012), social connections (Przybylski et al., 2010), social benefits (Granic et al., 2014), social context (Vella et al., 2016b) and the experience of social relatedness (Kooiman & Sheehan, 2015) are common motivations for videogame play. There is also research about the benefits of solitary play versus social play. For example, in one study, researchers found that children with a range of special needs such as mental health disorders and developmental disabilities, playing exergames alone can improve executive functioning skills more than playing with other children (Rachel & Nirmaliz, 2016). In a different study, researchers found that social exergames can help prevent loneliness and motivate physical activity for seniors (Brox et al., 2011). There is also some research suggesting that gamifying the group fitness exercise experience by customizing the game experience to enrich social interactions can

² Other components of flow include concentration, challenge, skill, control, goals, feedback, and immersion. Sweetser and Wyeth (2005) suggest that social interaction is not an element of flow, but is a strong element of enjoyment in games. The researchers further explain that social interaction is not a property of the task as are the other elements of flow, but the task is a means to allow social interaction.

motivate swimmers to follow a training routine and increase levels of physical exertion (Choi, Oh, Edge, Kim, & Lee, 2016).

2.3.4 Intrinsic Motivation and Continued Play

In addition to social interaction, many researchers are also interested in studying the effects of intrinsic motivation [doing an activity simply for the enjoyment of the activity itself, rather than for external rewards or pressures (Ryan & Deci, 2000)] and continued play (Schoenau-Fog, 2011). For example, Hsia, Katzmarzyk, Newton, Staiano and Beyl (2016) conducted a 12-week study to examine the potential transfer effects of exergaming on external behaviours such as physical activity levels, screen time and physiological constructs. Participants were given the freedom to choose the intensity and game play among a variety of dance games. Results showed the group that participated in the intervention reported high levels of intrinsic motivation to play exergames and high levels of self-efficacy towards physical activity. Results also showed that adolescents highly enjoyed the exergaming experience and continued intentions of future play. This is one of the first studies in this literature review so far that attempts to transform passive screen time to active screen time. Although evidence for transfer effects on physical activity was not significant, it still provides some support for the idea that video games can be used to as a physical activity promotional tool.

Other researchers have found that feelings of achievement predicts feelings of autonomy, competence, presence, enjoyment and motivation to play (Limperos & Schmierbach, 2016). A gamified approach can make doing exercise a more attractive activity (Mueller et al., 2011), and increase the level of engagement at the start of an intervention, yet wanes over time (Looyestyn et al., 2017). A review of existing literature on the effectiveness of including gamification in exergames shows both psychological, as well as, behavioural benefits (Matallaoui et al., 2017) and the gradual release of game features can persuade continued exercise interest (Zhao et al., 2017a). More recently, virtual reality-based exergame studies have shown that competing against a player's previously recorded performances (a history of

“multiple-ghosts”) provokes feelings of enjoyment, satisfaction, and competence which are all predictors of intrinsic motivation (Michael & Lutteroth, 2020).

2.3.5 Competition and Cooperation

Competition and cooperation are commonly conceptualized as contrasting goal structures (Deutsch, 2011). Both competition and cooperation are popular features in traditional videogames (often offered in multiplayer modes) and are important elements in game enjoyment and influences player’s choice of games (Vorderer et al., 2003). Competition and cooperation can both have an influence on exercise performance, motivation and enjoyment (Peng & Crouse, 2013; Staiano et al., 2013). Marker and Staiano (2015) conducted a review of existing literature on the effects of social exergaming, specifically how competitive and cooperative components of social play influence physical activity and motivation. The researchers found that cooperative exergaming promotes self-efficacy, intrinsic motivation, pro-social behaviours, and continued gameplay, whereas competitive exergaming may promote short-term physiological arousal, and acute bouts of aggression. Furthermore, Song et al. (2013a), investigated the role of competitive and cooperative play on intrinsic motivation in the context of exergames and found that players who were highly competitive enjoyed playing competitive games, whereas players who were not competitive exercised just as hard as competitive individuals, but did not enjoy their experience. The researchers concluded that further research is needed to study the effects of competition on motivation in exergames.

2.4 Player Modeling in Games

In the field of psychology, various models are proposed to describe personality types. Examples include the Five-Factor Model (Digman, 1990; Goldberg, 1999) and Wiggins’ two-dimensional affiliation/dominance model (Wiggins et al., 1988) (Figure 2.3). While these models (both circumplex and dimensional) have been shown to be effective for understanding general personality types (McCrae & Costa, 1989b), these models are not customized for game experiences.

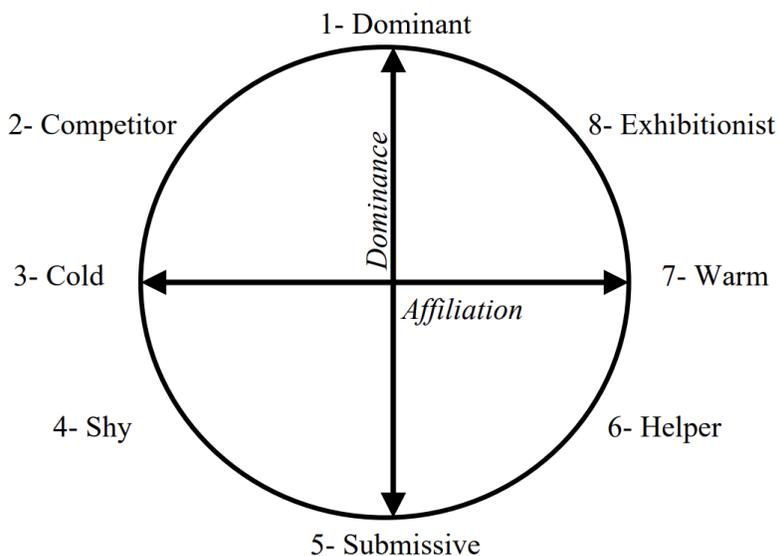


Figure 2.3: Circumplex structure of interpersonal adjective scales (Wiggins et al., 1988).

Player modeling is the study of computational means for modeling player cognitive, behavioural, and affective states based on data (or theories) derived from the interaction of a human player with a game (Yannakakis et al., 2013). It can help game designers create games that accommodate a wide range of playing styles by detecting the playing habits of players and adapting the game content generated in real-time. Busch et al. (2016) argues that the “one-size-fits-all” approach does not work for persuasive game design. Thus, player type models could be utilized when tailoring personalized persuasive systems.

One of the most recognized and widely used player type models for categorizing players is Bartle’s (1996) four player types: (1) killers, (2) achievers, (3) socializers, and (4) explorers. Bartle (1996) proposed that each player has some specific preference for one of the types makes those player types mutually exclusive. By organizing player types into four quadrants (Figure 2.4), Bartle (1996) identifies the sources of players’ interest: the x-axis goes from an emphasis on players (left) to an emphasis on the environment (right), whereas the y-axis goes from “acting with” (bottom) to “acting on” (top). Each of the four player types is placed in the quadrants associated with their playing preferences: killers “act on” players, socializes prefer to

interact with other players, achievers are interested in “acting on” the virtual world, and explorers enjoy having the game surprise them while interacting with the game environment. Every player has some overall preference for one of the types making them separate from each other. However, Bartle’s (1996) model has not been empirically validated nor intended to be applied beyond the context of Multi-User Dungeon (MUDs³).

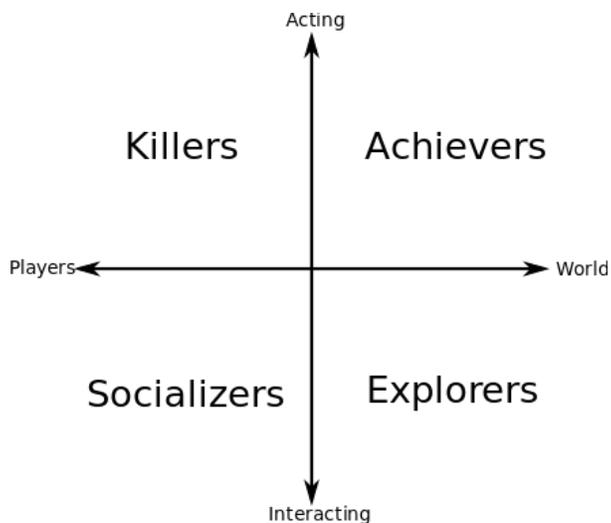


Figure 2.4: Model of four player types (Bartle, 1996).

Another model is the BrainHex model (Nacke et al., 2014), which consists of seven dimensions (Table 2.2) and can be grouped into three archetypes: 1) skill-oriented (*Conqueror*, *Daredevil*, and *Mastermind*), 2) aesthetic-oriented (*Survivor*, *Socializer*, and *Seeker*), and 3) goal-oriented (*Achiever*). The BrainHex model has been validated using a large pool of participants (Nacke et al., 2014). According to the BrainHex model, player types are not mutually exclusive. Scores under each category are presented to find the player’s primary type and subtypes. The model also connected player types to the game elements. Busch et al. (2016) have also used two dimensions of the *BrainHex* model (*Seeker* and *Mastermind*) to determine whether player type predicts player experience in the context of a personalized mobile location-based

³ MUDs: Multi-User Dungeon, with later variants Multi-User Dimension and Multi-User Domain (Bartle, 2003).

persuasive game. Researchers have examined whether personality dimensions are associated with gaming preferences using the *BrainHex* Model. Results showed that extraversion was positively associated with *Daredevil* and socialize preferences suggesting that players who score high on extraversion prefer to play exciting video games which includes the opportunity to interact others (Zeigler-Hill & Monica, 2015).

Table 2.2: Seven player typologies and associated characteristics (Nacke et al., 2011).

	Dimension	Characteristics
1	Seeker	Motivated by interest, curiosity about the world and moments of wonder.
2	Survivor	Enjoys fear and terror.
3	Daredevil	Enjoys the thrill of the chase, risk taking and playing on the edge.
4	Mastermind	Enjoys puzzles, problems that require strategy to overcome and making the most efficient decisions.
5	Conqueror	Challenge-oriented, enjoys struggling against adversity, defeating impossibly difficult opponents, and beating other players.
6	Socializer	Enjoys interacting with people they trust, talking to them and helping them.
7	Achiever	Goal-oriented, motivated by long-term achievements.

The Hexad model (Marczewski, 2015) has been developed particularly for mapping user personality onto gamified design elements and has been researched for understanding and explaining user preferences and behaviours in gameful systems (Orji et al., 2018a; Santos et al., 2021; Tondello et al., 2017) and shown to be reliable (Altmeyer, Tondello, et al., 2020a; Hallifax et al., 2019; Tondello et al., 2016). The model proposes six player types (Table 2.3), and the player types of individuals are correlated with their preferences for different game design elements. Design guidelines for tailoring persuasive gameful systems to each player type have also been studied (Orji et al., 2018a).

Table 2.3: Six player types and associated characteristics (Tondello et al., 2016).

	Type	Motivated by	Characteristics
1	Philanthropists	Purpose and meaning	Altruistic and willing to give without expected reward.
2	Socialisers	Relatedness	Create social connections and interact with others.
3	Free Spirits	Autonomy ¹ and self-expression.	Build new things and wish to explore the system.
4	Achievers	Competence and mastery	Seek to progress within a system by completing tasks or tackling hard challenges for self-improvement.
5	Players	Extrinsic rewards	Earn a reward within a system, independently of the type of the activity.
6	Disruptors	Change	Test the system's boundaries and try to push further to force positive or negative change.

¹ The freedom to express themselves and act without external control.

While there is significant research about player modeling, none of the existing studies have examined the idea of player matchmaking but have considered modeling players based on personal characteristics. For example, derived from educational and comparative psychology, Cowley and Charles (2016) devised a player model called *Behavlets* using psychology-based player traits, particularly a player's personal attitude and temperament to playing a game. *Behavlets* are features that help define what motivates a player to make gameplay choices and constructed based on the basis of dynamic game interactions, design patterns and grammar, information of alternative play styles in a specific domain, and an understanding of variations in player type (Cowley & Charles, 2016).

2.5 Matchmaking

Matchmaking is the process of connecting players online so that they can play together, and the most popular matching method is based on skill level (Horton et al., 2016). The video game industry has invested much effort to develop appropriate

matchmaking algorithms, accounting for variables such as game skills, levels, play time and style, as well as other quantitative data to create the best possible gaming experience (Francillette et al., 2013; Phillips et al., 2009; Riegelsberger et al., 2007) in an effort to increase player retention (Stroh-Maraun et al., 2018). Researchers such as Véron et al. (2014) have gathered and analyzed freely available game data such as avatar information and waiting times with the ultimate goal to improve the level of accuracy and effectiveness of matchmaking services. However, research shows that current matchmaking services for facilitating social connectedness among players are unsatisfactory because these services do not offer meaningful connections (Horton et al., 2016). There can be more meaningful ways to match and join players together to create a better game experience and enhance social connectedness. Good matchmaking mechanisms can help develop strong social connections and bonds between players. Once these close relationships are formed, it can serve as a motivator for encouraging players to remain in the game.

Horton et al. (2016) conducted a desktop review to identify matchmaking services for facilitating social connection between players in video games. Eight matchmaking services (e.g., Overdog and Leaping Tiger) were found based on inclusion criteria such as “connects players of any game type” and “connects players based on at least one factor other than skill”, and five matchmaking features: skill, interests, location, play style and game, were identified. Results showed that members of the gaming community were frustrated with these services and wished for more meaningful ways to connect with other players. The researchers conclude that players are interested in such services, but existing services lack meaningful ways to encourage the formulation of social connections and that further research is needed to find the source of the issue.

Riegelsberger et al. (2007) aimed to improve online gaming interactions by matching players based on “complementary” personality profiles. 267 responses to the question: “How much would you like to play MechAssault (an online action/shooter multiplayer videogame) with this player?” on a 7-point Likert scale (1 = “Not at all” to 7=

“Extremely so”) were gathered from gamers. Based on this information, a cluster analysis was conducted on the preference profiles and three meaningful player orientations emerged: 1) extreme, 2) social, and 3) skill. “Extreme” players are characterized by a strong preference for aggressive gaming partners and those who describe themselves as “trash-talkers” or “evil”. “Socially-oriented” players avoid *extreme* players and prefer to play with those who are friendly, likeable, and trustworthy. “Skill-oriented” players are interested in playing with highly skilled players and show less interest in other characteristics. The researchers concluded that their findings suggest that matchmaking based on *complementary* social and behavioural attributes and preferences can help to reduce undesired behaviours in game environments.

In addition to matching players based on personality, thinking style [the ways that individuals deal with problems and situations (Wang et al., 2015)] can also influence the dynamics in a videogame environment. Wang et al. (2015) investigated the effects of thinking style and team competition on performance and enjoyment in a massive multiplayer online game context. By focusing on two of Sternberg’s (1997) thinking style theory: (1) the local-global category – the tendency among individuals to deal with problems in a detailed manner, and (2) liberal-conservative category – liberal tendencies take more risks with the anticipation for greater rewards, whereas conservative tendencies prefer steady progress and predictability (Sternberg, 1997), the researchers formulated associations with features in League of Legends (LoL). This is because LoL gameplay strongly emphasizes cooperation, and more successful players are believed to be better at making decisions based on overall situations – a characteristic that the researchers believe makes *global-local* tendencies suitable for LoL player classification. Play data of 185,000 players were gathered from the LoLBase website. Enjoyment scores were calculated based on playing duration – matches lasting 28 minutes or less were identified as “low-enjoyment”. The researchers further confirmed this assumption by asking 26 players whether they felt that short games were enjoyable and why. Over 90% of players reported that short

games were less enjoyable due to reasons such as the imbalance of skills between teams, poor cooperation with other team members, and players suddenly leaving the game. The most important finding in this study is that the presence of *global-liberal* players is positively correlated with match enjoyment, and thus the researchers recommend that game designers may identify ways to evenly distribute *global-liberal* style players among competing teams to increase motivation to continue play.

Delalleau et al. (2012) developed an advanced matchmaking strategy to improve player enjoyment. First, the researchers demonstrated that adding “fun” information such as the player’s individual profile and the profile of the player’s teammates can result in more balanced matches. Next, players were asked to provide direct feedback on the quality of the match through an in-game survey. The results showed that collecting player skill information is not enough to offer a balanced match in a multiplayer game. Information such as player profile, particularly player statistics collected within the game. The researchers argue that *fun* is more important than balance, and the results of this study support the idea that it is possible to use *fun* as a main criterion in a matchmaking system.

Taken together, game researchers are developing and investigating a variety of methods for improving matchmaking services. While some researchers are proposing that players with certain playing styles can be included in a matchmaking algorithm to increase game enjoyment and team strength between players, other researchers are delving into the personality profile of players.

2.6 Retention Problem in Games and Exergames

While some games entice players to crave more playtime, other games dissuade players before they reach the next level or the end-goal of a game — this is the “**retention problem**”. Player retention has been an important and long-running investigation in the gaming industry (Debeauvais et al., 2010; Weber et al., 2011). Not all games are well-designed and thus, are unable to keep players motivated. Dias and Martinho (2011) suggest that all video games eventually “lose their charm and

the interest of the player” and by then, players should have already experienced all the key features, yet many games stop being fun before they have the chance to do that. This occurs because of two reasons: (1) players do not relate to the challenge they are assigned, and (2) players do not appreciate the rewards the game is giving them in return for their efforts (Chen, 2007). Research shows that factors such as lack of time, loss of interest, the novelty of a new game, (Tyack et al., 2016), as well as poor player-to-player matchmaking recommendations (Horton et al., 2016) and unsportsmanlike behaviours that are undesired by other players (Riegelsberger et al., 2007), can all result in players quitting a game.

Motivation is the most important force for determining a player’s desire for continued play (Stankevicius, Jady, Drachen, & Schoenau-Fog, 2015) and in an exergame context, consideration of self-efficacy is particularly important for maintaining motivation over time through setting achievable goals (Macvean & Robertson, 2013). Motivation can be defined as the driving force behind all the actions of an individual (Rabideau, 2005) and most researchers agree that most motivation theories attempt to explain three interrelated aspects of human behaviour: (1) the *choice* of a particular action, (2) the *persistence* of a particular action, and (3) the *effort* expended on a particular action (Dörnyei, 2000).

One theory that is commonly associated with motivation is the “flow” theory (Mihaly Csikszentmihalyi, 1977) which is characterized as a mental state marked by complete absorption and high concentration of an activity. Chen (2007) argues that a well-designed videogame will motivate repetitive play and “transports” its players to their personal “Flow Zones” – where a person’s abilities are matched by a challenge, delivering genuine feelings of pleasure and happiness. Moreover, games should adapt to the player’s skills to keep them in the *flow zone*. If the challenge exceeds the person’s abilities, “anxiety” will be experienced, whereas too little challenge leads to “boredom” (Figure 2.5). In the context of exergames, Huang et al. (2018) found that competitive individuals have an enhanced need for feelings of achievement and are focused on overcoming challenges, and thus, can easily experience flow. The

researchers also found that perceived challenge and exercise enjoyment were both positively related to the experience of flow.

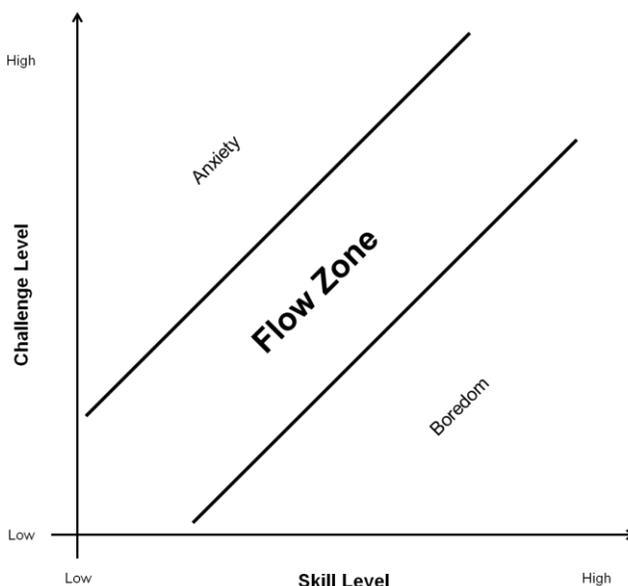


Figure 2.5: Model of the Flow zone in relation to challenge and skill level (Jackson & Csikszentmihalyi, 1999).

Furthermore, Crutzen, Riet and Short (2016) aimed to clarify the concept of *enjoyment* among other related constructs such as fun and engagement in the context of games for promoting health behaviours. The researchers reviewed empirical studies and found that concepts such as flow, engagement, and fun are associated with enjoyment. In quantitative studies measuring intrinsic motivation, the concept of game enjoyment is commonly associated with an individual’s experience of fun and their level of interest (Mekler et al., 2014). Engagement which refers to [the level of motivation that a player displays in gameplay reflecting a psychological process (Caroux et al., 2015)] is related to immersion⁴ which refers to [a state of high motivation to play the game, while retaining some awareness of one’s surroundings (Baños et al., 2004)] and presence which refers to [the experience of being personally and physically inside a virtual environment (Wirth et al., 2007)]. Both engagement

⁴ The terms “flow” and “immersion” can be conceptually similar as they share many common dimensions (Michailidis et al., 2018).

and enjoyment are important for keeping high levels of motivation and thus, are key factors for designing games that aim to promote health behaviours. Crutzen et al. (2016) concluded their review suggesting that other researchers use enjoyment, and enjoyment only, to refer to the action or state of deriving gratification from a game and identified three important factors for increasing the level of enjoyment while designing health games: (1) competence, (2) narrative transportation, and (3) relevance (Table 2.4).

Table 2.4: Factors for increasing enjoyment in health games (Crutzen et al., 2016).

Factor	Definition	Design recommendations
Competence*	The perception of increasing skills (Ryan, Rigby, & Przybylski, 2006).	Provide feedback, challenge and rewards (Lyons, 2014).
Narrative transportation	A process in which someone is mentally “transported” away from the physical world into the imaginary world presented in the form of a story (Green & Brock, 2000).	Characters provide the driving force or a narrative (Lu, Baranowski, et al., 2012) and the ethnic similarity between game characters and players enhances immersion (Lu, Thompson, et al., 2012).
Relevance	“Closely connected or appropriate to the matter at hand” (as cited in Crutzen et al., 2016). Both “game world” and “real world” relevance is important for facilitating enjoyment.	Self-identification with game characters. Games are most intrinsically motivating when players’ experience of themselves is congruent with their conceptions of their ideal selves during play (Lu, Thompson, et al., 2012).

* Crutzen et al. (2016) hypothesized that competence is more important for influencing enjoyment, even more so than autonomy and relatedness.

Despite the numerous benefits of exergames, they suffer from retention problems (Graves, Ridgers, Atkinson, & Stratton, 2016; Rhodes et al., 2019; Sun, 2012). Game retention has been studied extensively in the context of Massively Multiplayer Online Games (MMOG’s). For example, Debeauvais, Nardi, Schiano, Duncheneault and Yee (2010) examined retention mechanisms and the level of commitment in MMOG’s and

found that achievement-oriented players reported higher weekly playtime and a lower stop rate, whereas socially motivated players were attracted to engaging in the game activities (such as raids and quests) crafted by the game designer. The researchers also found that Asian players tend to be more dedicated, particularly if they were playing with a friend who they knew in real life, compared to Western players in terms of playtime. In a different study, Wang and Yu (2017) studied the relationship between a player's value system (behavioural attitudes in real life) and their actions in playing MMOG's. The researchers found that players who score high on self-expression and individualism (Graves, 2005) tend to commit a considerable amount of financial assets on the game, seek powerful items, and aim to level-up their character and skills as quickly as possible.

Other researchers such as Esakia, Harden, McCrickard and Horning (2017) are exploring how fitness monitoring tools such as smart watches can be used to encourage health outcomes in the context of small groups. Results from watch, phone, and web usage data provided examples of how groups use this tool based on four dimensions of group cohesion in an exercise setting — individual's attraction to task and social aspects of the group, and individual's perceptions that the group is integrated around the task and social other aspects (Carron & Spink, 1993).

In the context of exergames, there is research suggesting that some exergames may not be able to maintain long-term interest in exercise (Sun, 2013a) and reasons for not engaging with exergames over a long-term include factors such as games not being useful enough, lack of time, and preference for other forms of exercise (Kari et al., 2012). Sun (2013a) conducted a follow-up study to examine the effectiveness of exergames for motivating physical activity during physical education class over a two-semester period. Results revealed that the amount of physical activity increased over time, yet interest declined. The author concluded that although there is evidence that exergames may have strong motivational power at the initial stages of game play, they may not be able to maintain exercise interest over the long-term.

Macvean and Robertson (2013) conducted a seven-week long case study to examine how users' physical activity, motivation, and behaviour changes over-time. The concept of self-efficacy⁵ was applied within the context of a school based exergame intervention, including how players set goals and manage different levels of difficulty. Results showed that participants were motivated by different factors. While some participants were highly motivated by earning points, other players strived to improve performance and setting goals. Differences were found within individual preferences with respect to how points were treated – some were interested in earning points by competing with peers, some enjoyed keeping points hidden from others while some preferred to broadcast the achievements. The authors recommend that consideration of self-efficacy when designing an exergame intervention is important because it has a central role in maintaining high levels of motivation through effective goal setting.

Zhao et al. (2017) conducted a 70-day study on the effects of wearable-based exergames. In particular, the researchers were interested in whether the gradual release of game features can improve engagement over time. Participants were divided into three different groups: Group 1 received a game with basic features, Group 2 received full features (i.e., customization and multiplayer modes), and Group 3 gradually received new features that were unlocked every 10 days. The behavioural patterns of each group were tracked and at the end of the study, participants completed a post-study questionnaire to evaluate their experience during the study. Results showed that the level of engagement in exercise and gameplay were highly related, and that the gradual addition of new features increased the amount of application usage and overall physical activity. Results also showed that a gamified exercise experience was preferable compared to a regular exercise experience.

⁵ “How well one can execute courses of action required to deal with prospective situations” (Bandura, 1982).

Chan, Arya and Whitehead (2018) explored the effects of matching player pairs based on personality for increasing the level of enjoyment and social interaction in an exergame context. A match can be a combination of similar or different personalities. When both players agree and report high levels of enjoyment, they were identified as a potential match. A pilot study was conducted with 10 participants (5 pairs) and levels of enjoyment, social and motivational factors were evaluated. Results seem to show that when the personality of players matches, the level of enjoyment increases in both competitive and cooperative game scenarios. Yet, when the personalities of players clash, the level of enjoyment seems to decrease. This study serves as a good prototype to validate the methodology and show that it is viable to conduct it with a larger sample. Although this work offers some insight on matching players in exergames, further research is needed to examine the concept of personality-based pairings in games that require more physical effort and combinations of different personality pairing possibilities.

More recently, Keeney et al. (2019) found that even asynchronous exergames integrating relatedness (such as social interactions with friends and strangers) and goal setting mechanisms based on the SDT into the design, exercise motivation drops after six weeks. The researchers suggest that future work can consider maximizing the satisfaction of the basic needs of the SDT (autonomy, competence, and relatedness) and concluded that more “formative and optimization” design approaches by offering opportunities for social support between players and regularly adjusting the group dynamics to sustain the level of intrinsic motivation are needed. By understanding the factors that attract players and the factors that do not, designers can tailor the design to keep motivation levels high, attract new players, while sustaining already existing ones.

2.7 Gap Analysis

2.7.1 Summary of Related Work

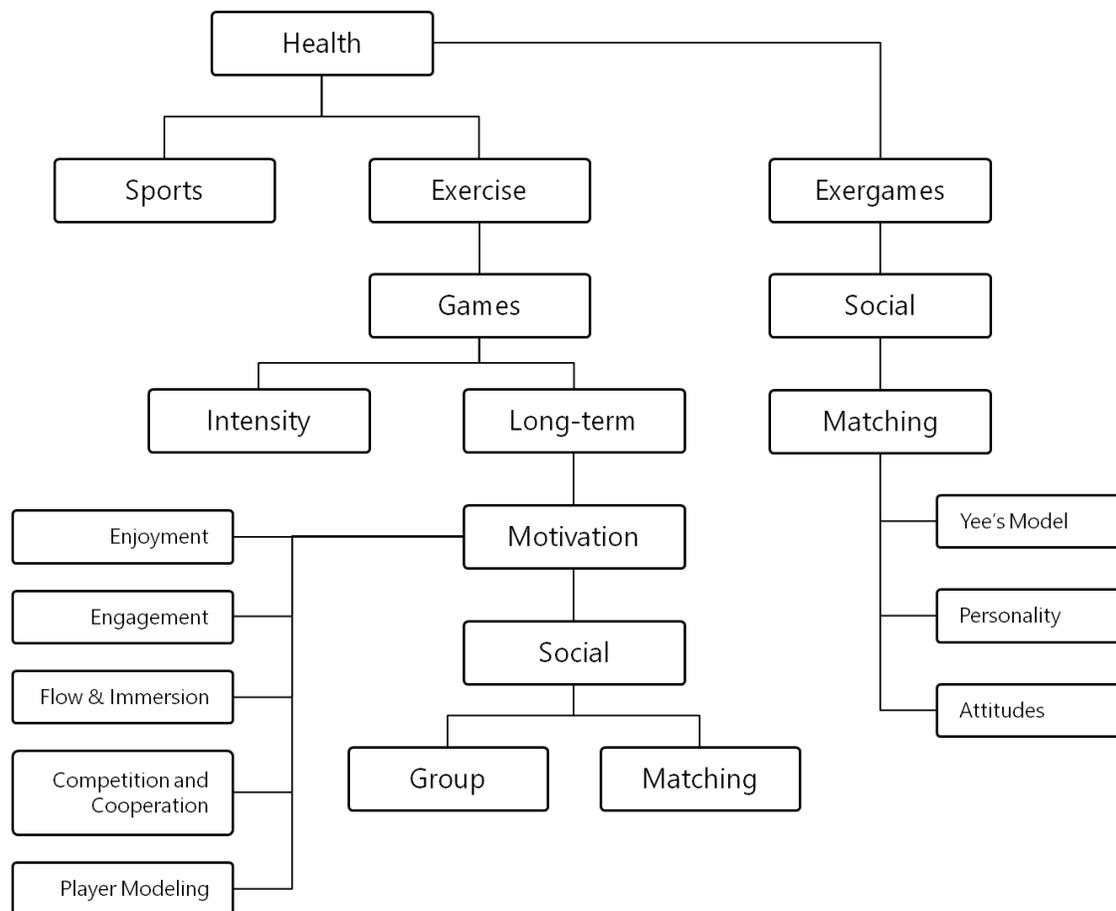


Figure 2.6: Summary of topics reviewed.

To summarize (Figure 2.6), much research has supported the idea that exergames can be a way of motivating people to perform physical activity. Exergames show some promise in encouraging people to exercise, but it is challenging to build them in a way that can keep players engaged offering both a good game and a good workout. To keep players engaged over the long-term, recent efforts are now exploring the effects of gradual release of game features, tailoring gamified systems to personality personality-based matchmaking, and to elicit a better workout, researchers are examining the effects of an asynchronous experience where the video game promotes exercise outside of play sessions. Although exergames can make participating in exercise more enjoyable there is some research suggesting that exergames may not

be able to maintain exercise interest over the long-term and some exergames are not intense enough to offer an effective workout because they do not require as much energy expenditure as the actual sport.

In the context of online games, achievement features are essential for players at the initial phases of the game, whereas it is *social features* that become important as players reach the highest level offered by the game. There is also some research suggesting that players prefer to play with other players who possess similar personality traits. Even for players who have an existing relationship, differences in personalities can clash, and result in conflicts due a mismatch with respect to skill or playstyle.

Moreover, current game player recommendation systems are unsatisfactory for facilitating social connectedness because they do not offer meaningful relationships between players. If current matchmaking recommendations are poor at facilitating social connectedness between players, it is likely that players will exit before even reaching the highest level of the game. To better understand player pairing mechanisms, future research is needed to find better ways for enhancing social experiences between players. However, the interaction between different personality types of players for motivating continued exergame play is still not well understood. To the best of our knowledge, no researchers have conducted a long-term study to evaluate the effectiveness of an asynchronous exercise game experience which examines the effectiveness of using personal characteristics such as personality information to group players.

2.7.2 Limitations of Existing Research

As online exergames become more popular (Navarro et al., 2017), there will be a wide range of possible player-pairings. This creates an opportunity for people to be brought together dynamically to play exergames in a way that might increase or decrease the level of motivation among multiple players. Thus, it is important to understand how these pairings can motivate interest and encourage long-term participation beyond

the novelty of a new game or technology. Three major gaps that we identified in this review are:

1. **Lack of long-term studies.** Chan, Arya and Whitehead (2018) found that matching players using personality type in competitive and cooperative scenarios can increase or decrease the level of enjoyment experienced between player pairs. However, the effects of personality-based matching in larger groups and the long-term effects of competitive and cooperative play are still unknown.
2. **Lack of design and research on multiplayer exergames.** Social exergames are popular because they offer competitive and cooperative experiences that are similar to group exercise (Marker & Staiano, 2015) and supportive peer relationships encourage exercise adherence (Murcia et al., 2008). However, current exergame research seems to focus mainly on designing for single player (e.g., Geelan et al., 2016; Shaw et al., 2016) rather than multiple players.
3. **Lack of research on social interactions and player matching in multiplayer exergames.** Although some researchers are investigating the potential of wearable devices for encouraging participation in physical activity and positive group cohesion (e.g., Choi et al., 2016; Esakia et al., 2017), there is not enough research examining the effects of social interaction and social connectedness in larger groups.

In this research project, we aim to further investigate the three major gaps listed above by exploring how to match players and tailor the playing experiences based on personal characteristics for facilitating group play.

3 Player Matching using Personal Characteristics

From reviewing existing literature on strategies, theories and approaches that motivate continued play, the major gaps were:

1. Lack of long-term studies to examine the long-term effects.
2. Lack of design and research on personalizing the experience for social (multiplayer) exergames.
3. Limited research on the topic of social elements and player matching in social exergames.

Based on these gaps, we inferred that (1) social interactions matter in creating an engaging and enjoyable playing experience, and (2) how to personalize the social interactions has not been adequately investigated in the context of player matching in exergames. Furthermore, these gaps suggested that personal characteristics can affect social interaction player matching based on various personal characteristics of players in a team can affect their social interaction, and so player matching may need to take into consideration these personal characteristics. Thus, we propose the idea of Player Matching using Personal Characteristics (PMPC). Personal characteristics can include an individual's personality type, age, gender, lifestyle, cultural groups to which they belong, their specific interests, and many other things. Personality is a popular and heavily studied personal characteristic (McCrae & Costa, 1997).

The topic of adherence to exergames has captured the interest of many researchers (Baranowski et al., 2014; Caro et al., 2018; Kaos et al., 2019; Kramer et al., 2014; Zhao et al., 2017a) and a variety of methods have been employed including survey methods (Kari, 2015), interviews and focus groups (Burges Watson et al., 2016), a mixture of both qualitative and quantitative methods (Caro et al., 2018), as well as formal experiments (Kaos et al., 2019). We believe that social elements can influence a player's decision to continue play or not include characteristics such as personality, group personality composition (Halfhill et al., 2005b), type of relationship (friends vs. non-friends), and how well players are matched. We also believe that elements such as competition, cooperation, choice, and reward structures can influence a player's

decision to leave or remain in the game. The results gathered in these studies can provide more insight into specific relationships that are developed between players in group play than one single study using one sample could yield. The main subject addressed in these studies is how to form groups that can extend play.

3.1 Research Approach

We conducted a series of three user studies to evaluate our hypothesis of player matching based on personal characteristics for increasing game retention. Figure 3.1 shows how the studies are connected and the progression of how we moved from first conducting a small Pilot Study to explore our idea of PMPC, followed by a Foundation Study to continue our investigation of personality-based matching using simple game features, and later on an Addon Study to further examine matching using player type for increasing exergame retention.

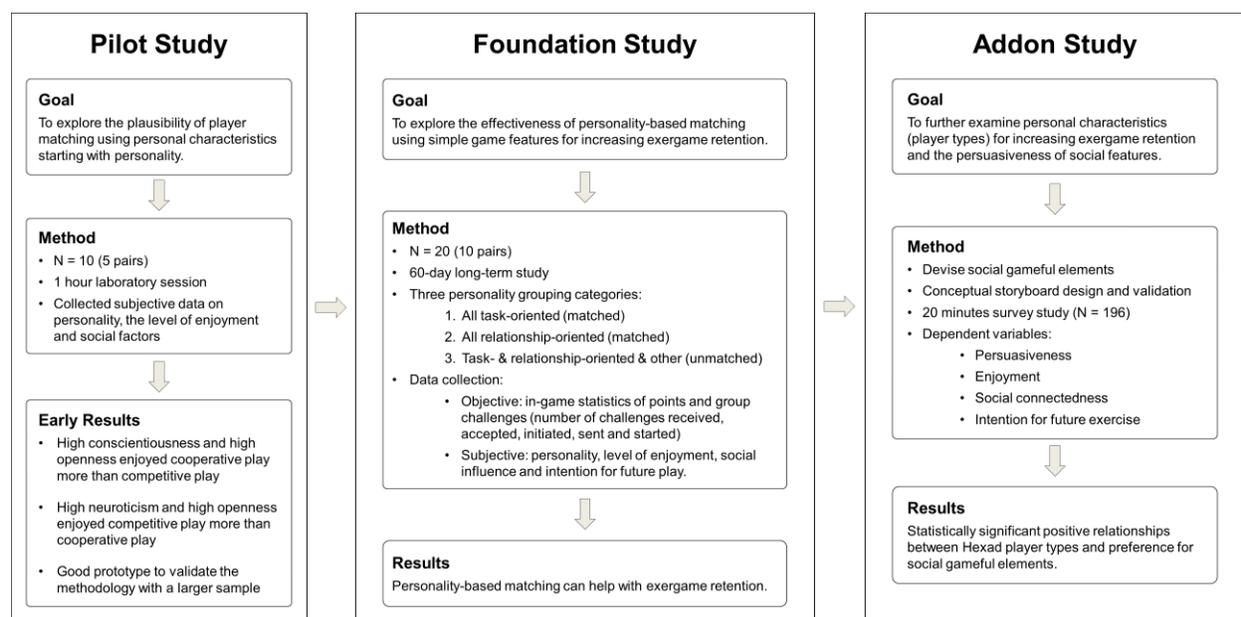


Figure 3.1: Study progression.

Jia, Xu, Karanam and Volda (2016) have examined the relationship between the Big-Five personality traits and perceived preferences for various motivational affordances used in gamification (Table 3.1) and we used these as a basis for developing the game features and testing its effectiveness for personalizing based on personal characteristics and motivating continued play.

Table 3.1: Types of motivational affordances and their corresponding motivational sources and design principles (Jia et al., 2016).

Motivational affordances	Motivational sources	Design principles
Points, badges, levels, clear goals, feedback, progress, challenge, rewards	Cognitive: competence and achievement	Systems provide various challenge levels or immediate performance feedback.
Leaderboard	Social and psychological: Leadership and followership	Systems facilitate one’s desire to influence others or influenced by others.
Story/theme	Emotional: affect and emotion Psychological: autonomy and self	Systems induce intended emotions via interaction with the system or promote creation and representation of self-identity.
Rewards	Extrinsic motivators	Systems provide incentives for certain actions.

3.1.1 Pilot Study

To test our idea of matching using personal characteristics, we first conducted a small pilot study to examine the prospect of matching players based on personality. In this pilot study, we aimed to identify a relationship between the personality type of players and mutual enjoyment between player pairs. A match could be a combination of similar (supplementary) or different (complementary) personalities. For example, in a player pair, if one scores high on openness to experience and the other player scores high on extraversion, but both rate high levels of enjoyment, then, they would be identified as a potential “match”. However, if one player provides a low enjoyment rating, and the other player provides a low enjoyment rating, this pair would be a potential “mismatch”. A low enjoyment rating can be an indication that players are not engaged and are likely not finding their interaction with the other player

rewarding. Both players must agree and report high levels of enjoyment to be identified as a *match*. A within-participant design was used to evaluate the plausibility of personality-based player pairings in two different game scenarios, competitive and cooperative. 10 participants (5 participant pairs; 7 males, 3 females), played virtual bocce for 1 hour and completed a post-game questionnaire to evaluate their personality, level of enjoyment and social perception of their teammate.

Early results showed that there was a strong agreement between player pairs who scored high on extraversion and openness, which seems to suggest that extraverts and explorers enjoy their game experience together. In contrast, results showed disagreement between player pairs who score high on conscientiousness and high on openness which seems to suggest that explorers and organizers may not enjoy their interactions in the game together. Furthermore, results also showed that player pairs who score high on conscientiousness and openness enjoyed playing a cooperative game more than a competitive game, whereas player pairs who score high on extraversion and openness and player pairs who score high on neuroticism and openness engaged in a competitive game more than a cooperative game. Results also seem to suggest player pairs who score high on extraversion and openness engaged in more positive social interactions in a competitive game compared to a cooperative game. Whereas player pairs who score high on neuroticism and openness to experience appear to have experienced more positive social interactions in a cooperative game than a competitive game.

This small pilot test found some evidence that matching based on similar and complementary personalities can influence game enjoyment and social interactions. However, there were some limitations associated with this study. First, the game used (virtual Bocce) was not a high physically demanding game and so the results may not hold true for more vigorous exergames such as “Shape Up” for the Xbox One. A future study can examine the effects of personality-based matching using a game that requires more physical exertion and different game genres (Anwar et al., 2017; Peever et al., 2012). Furthermore, results found in the context of one game are

potentially difficult to generalize to any other game, and so another avenue to future research can evaluate many different types of games. Although there is some research exploring the effects of situational interest using a variety of exergames from *XrBoards* and the Nintendo Wii (virtual tennis, boxing and bowling) to *Dance Dance Revolution (DDR)* and *Gamebikes* (Sun, 2013c), there is very little research examining the effects of personality-based matching using a variety of exergames.

Second, the measurement instrument used to evaluate personality (the TIPI (Samuel D. Gosling et al., 2003)) was brief. Research shows that these shorter measures are susceptible to Type 1 and Type 2 error rates (Credé et al., 2012). Other researchers such as Tondello et al. (2017) have examined the effects of gameful design and personality also recognizes that short scales are subject to acceptance issues and suggest that future research could verify specific claims in focused studies. Because of such limitations associated with brief measures, using a version that consists of more items rather than less can increase the validity of subsequent studies.

Third, the sample size was small ($N = 10$, 5 player pairs). Despite the limitations noted, these initial results seem to suggest that maintaining high levels of enjoyment and active social interactions is crucial because both can offer retention and continuation of gameplay and exercise involvement. This study also serves as a good prototype to validate the methodology and show that it is viable to conduct it with a larger sample.

3.1.2 Foundation Study using ExerQuest

Next, we conducted a Foundation Study to find evidence to further support the idea that matching players based on personality generates an enjoyable and satisfying experience and is effective for motivating continued play.

The Foundation study builds on the Pilot Study. An empirical evaluation of the game that we have designed (*ExerQuest*) was conducted. A combination of survey methods and content analysis on in-game data were used. The survey questions aimed to evaluate both the player experience and intention for future play and consist of both

validated items that other game researchers have used, as well as custom items. The study was initially planned for 30-days, and participants could decide to continue after the 30-day period or not. We selected our methodology because it allows us to triangulate our findings by first collecting objective data during the game followed by gathering subjective data at the end of one month using a post-game questionnaire to gain deeper insight on player's feelings and perceptions of the playing experience.

3.1.3 Add-on Study using Storyboards

Due to COVID-19⁶ pandemic restrictions and our goal to reach a wider audience, we continued our investigation of PMPC using conceptual storyboard and survey approach. Because we investigated the idea of matching using personality in the Pilot and Foundation studies, we thought we would explore a different characteristic – player types based on the Hexad Model (Marczewski, 2015) that can predict interest in social features and as such use it as a bases to suggest player matching. We selected the Hexad model because (1) the player types have been shown to be significantly correlated with the personality types in the FFM (Tondello et al., 2016), and (2) as we are interested in game design, the Hexad player types were modeled based on player motivations in the context of gameful applications (Marczewski, 2015). While there are many studies on the effectiveness of personalizing game elements for individual player type (e.g., Altmeyer et al., 2019; Orji et al., 2018; Zhao et al., 2020), very little research has examined the effectiveness of personalizing game elements for player groups particularly in the domain of social multiplayer exergames. Thus, we employed much of the same methods and measurement instruments as other researchers have studied personalizing gameful elements for individual players.

To investigate what social game features are effective and the role of player type on retention, we conducted two rounds of data collection with two different groups of

⁶ Severe acute respiratory syndrome Corona Virus Disease 19 was declared a pandemic by the World Health Organization on March 12, 2020 (Ciotti et al., 2020).

participants in an Addon study. Round 1 collected initial data to determine if there are any patterns between preference of social gamification elements and player type based on the Hexad model, whereas Round 2 aimed to reach a wider range of potential users.

3.1.4 Redesign of ExerQuest

Based on our findings from the Foundation and Add-on studies, we devised a list of features for redesigning ExerQuest. However, we did not create a new game (or modify the existing ExerQuest) to test these features. Based on the results of our Addon study and other related research on personalizing gameful elements using a player type approach (Altmeyer et al., 2021; Hallifax et al., 2019; Mora et al., 2019), we believe that the feature set devised can be useful for encouraging more socially satisfying interactions between player groups in multiplayer exergames and increase the level of motivation over the longer-term.

3.2 Theoretical Model

Our proposed solution is grounded in the SDT (Deci & Ryan, 2000) as described in Chapter 2, and Group Personality Composition (GPC) theory which discusses the composition, or mix, of individuals' characteristics to put into a group (Halfhill, Sundstrom, Lahner, Calderone, & Nielsen, 2005). Based on the Big-Five or Five-Factor Model (FFM) of personality (Robert R. McCrae & Oliver P. John, 1992), GPC theory categorizes task-oriented and relationship-oriented personality traits⁷. The task-relationship dichotomy allows us to examine our interest in the effect of matching players based on personality theory that is in line with FFM but combines the types into two categories that are easier to investigate: task-oriented personality traits (e.g., conscientiousness and achievement motivation) and relationship-oriented traits (e.g., agreeableness and cooperation). Our study offers a new application of the task-relationship dichotomy in general group functioning (Polley & McGrath, 1984),

⁷ GPC and FFM are further described in Sections 3.5 and 3.5.1, respectively.

and the Hexad user type model (Marczewski, 2015) with an aim to better understand how an asynchronous multiplayer exergame can motivate continued play and exercise adherence.

In the videogame literature, existing work has shown that experiencing high levels of flow (Anwar et al., 2017; Sweetser & Wyeth, 2005), enjoyment, engagement (Lyons et al., 2014; Lyons, 2014), and positive social interactions (Mueller, Gibbs, Vetere, & Edge, 2017; Yee, 2007) are all important elements for motivating play behaviours. The application of gamification features (gameful elements) such as points, levels and progress increases the level of motivation for engaging in physical activities (Matallaoui et al., 2017) and opportunities for social competition and cooperation (Caro et al., 2018; Chan et al., 2017) can increase the level of motivation experienced in exergames.

Designers and researchers are exploring the value of creating games that tailor to people's personality and gamer type profiles. For example, survey research shows that gamification elements work differently depending on one's personality (Codish & Ravid, 2014) and in the context of persuasive health games, tailoring the design to personality type can make the game more effective for promoting positive attitudes, behavioural change intentions, and self-efficacy (Orji, Nacke, et al., 2017a). There is also some research suggesting that personalizing gameful elements based on a player's behavioural change intentions and gamer type can augment the level of motivation and affective experiences (Altmeyer et al., 2019, 2021). As a theoretical argument, we believe that a combination of all these elements together with better personality- and gamer-based matching can enhance the level of social connectedness experienced between players and motivate intention for future play and exercise (Figure 3.2).

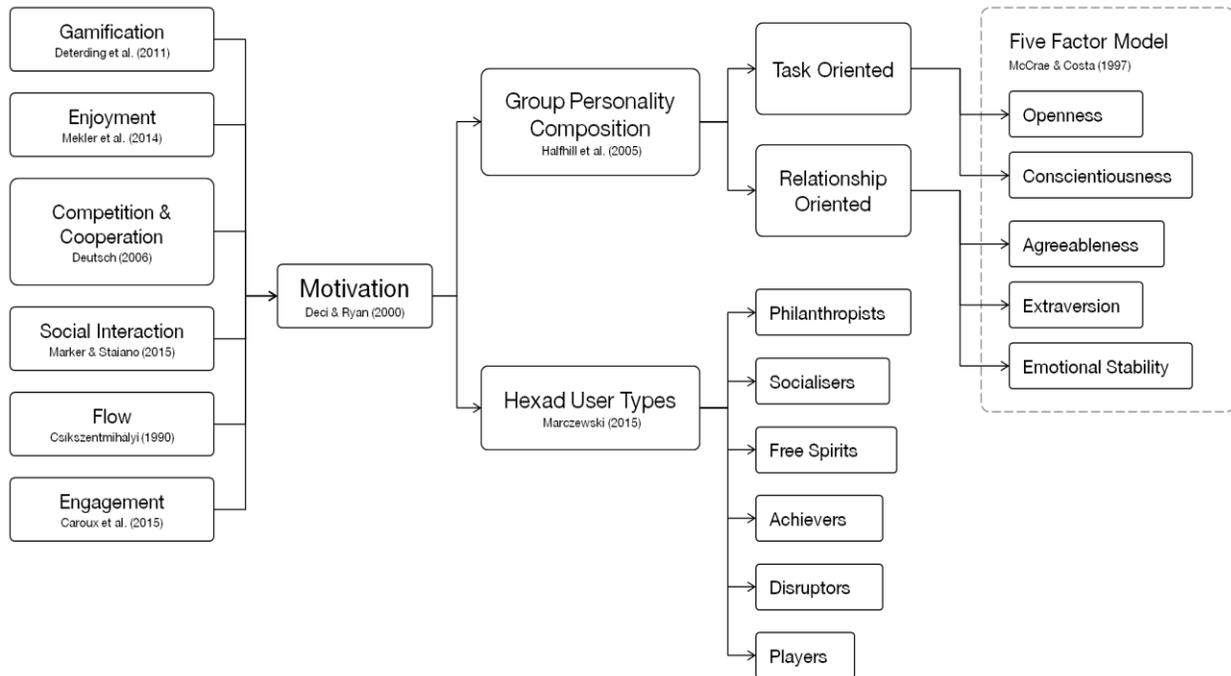


Figure 3.2: Diagrammatic representation of theoretical components that can have motivational effects on the group for continued play.

Among other personality models and theories such as the Interpersonal Circumplex Model (Gurtman, 1992, 2009; Wiggins, 1979) or the Myers-Briggs Type Indicator (MBTI) (McCrae & Costa, 1989a), we have decided to employ Halfhill et al.'s (2005) task-relationship dichotomy as a framework to aggregate individual trait scores captured by the Five-Factor Model (Digman, 1990; McCrae & Costa, 1987) into the group level – aggregated composition measures (i.e., mean score) can be a method of operationalizing trait characteristics of a group of individuals (Barrick et al., 1998). We decided to employ Halfhill et al.'s (2005) definition of GPC because (1) it allows us to examine all five personality types identified by Costa and McCrae (1988), (2) it uses only two aggregated measures, and (3) it enables us to examine the effect of personality types at the group level. Halfhill et al.'s (2005) conducted a review of empirical research on GPC theory and group effectiveness and devised two major thematic categories to broadly classify personality traits — task and relationship. The notion of a task-relationship dichotomy in general team process is well-established (Polley & McGrath, 1984) and has been adopted by meta-analytical reviews (Prewett et al., 2009). Researchers such as Zhou et al. (2015) have examined

the effects of shared leadership on group performance using the task-oriented and relationship-oriented model. This allows us to examine the effects of group effectiveness and performance at the team level. In particular, we are interested in how personality of the group influences the level of cohesion and social interactions can encourage continued play. Other researchers (e.g., Prewett et al., 2009; Zhou, Hu, & Zey, 2015) combined the Big-Five and we followed:

- **Task-Oriented** (TO) personality traits refer to traits that aid in the completion of work-related activities which two out of the Big-Five, include **conscientiousness** and **openness to experience** (Halfhill et al., 2005).
- **Relationship-Oriented**⁸ (RO) personality traits facilitate the interpersonal interactions necessary to works as a member of a team including **extraversion, agreeableness, and emotional stability** (Halfhill et al., 2005).

We paired players using the TO and RO model. For example, placing two TO players in the same group forms a supplementary pair. Likewise, placing two RO players together forms another supplementary pair. In contrast, placing one TO player and one RO player in the same group forms a complementary pair. In connection with our hypotheses, that player pairs who share similar personalities will experience higher levels of enjoyment compared to player pairs who have different personalities, we expect that supplementary player pairings (TO–TO and RO–RO) will engage more in the game as they agree on activities, whereas complementary player pairings (TO–RO) will be less engaged due to personality clashes.

Rather than a “one-size-fits-all” approach (Busch et al., 2015a; Mora et al., 2019), our aim is to personalize the social exergame experience. We believe that personalizing the exergame experience can increase retention as there is some research showing that not all players enjoy competitive games (Song et al., 2013b). As such, we posited

⁸ Also commonly referred to as “social orientation” in the group personality literature (Aeron & Pathak, 2012; Carron et al., 2002).

that player pairings (similar and complementary) can also be formulated using other personal characteristics such as player type. In particular, we used the Hexad player type model (Marczewski, 2015) that has been commonly used in games user research (Altmeyer et al., 2021; Hallifax et al., 2019; Krath & von Korfflesch, 2021; Orji et al., 2018a; Zhao et al., 2020a). For example, Philanthropists and Socialisers are both motivated to interact with others (Tondello et al., 2016) can be a similar pairing. In contrast, a Free Spirit, who is motivated by autonomy and self-expression, and a Player who is motivated by rewards, can be a complementary pairing as each are motivated by different sources of motivation. Among other player models such as the BrainHex (Nacke et al., 2014), we selected the Hexad model because it is one of the most suitable typology for personalizing gamified systems (Hallifax et al., 2019). This is likely because the Hexad model was specifically designed for gamification and most of its player types were developed based on the SDT (Richard & Edward, 2000).

Personality type based on GPC theory and player type based on the Hexad were the bases of our Foundation and Add-on studies, respectively.

Through our theoretical model, we aim to contribute to the game design literature and practices that matching player based on personal characteristics can be a viable solution for connecting players together provoking a more socially satisfying gaming experience. We also contribute to the game design literature and practices by offering some insight on designing for multiplayer experiences which could strengthen the relationship between player-to-player interactions by tailoring game features based on personality and player type.

In addition to the Hexad and the GPC theory, we also use Ryan and Deci's (2000) SDT for understanding motivation and personal characteristics in the context of social play (as represented by the Motivation block in Figure 3.2). Based on previous studies examining the conceptual overlap between the FFM and SDT (Olesen, 2011), we posit that the three interrelated components (Autonomy, Competence and Relatedness) can each be satisfied as players engage in exercise and gameplay. As

players interact with each other in the game, TO players will likely wish to achieve and if the level of motivation of both players aligns, then they are helping each other to satisfy their need for autonomy and competence, creating an experience that is enjoyable for both. The experience of autonomy and competence can be particularly satisfying for TO–TO groups because TO individuals are motivated by achievement, whereas feelings of relatedness can be rewarding for RO–RO groups as RO individuals desire social interactions and cooperation. We provide a review of GPC theory and the areas in which GPC has been researched in relation to group effectiveness, performance, and cohesion in subsequent sections.

3.3 Personal Characteristics

Besides personality, there are many other personal characteristics that can influence individual preferences and motivations. For example, depending on one's age, one can be motivated in different ways. In the context of exergames, research shows that children find them attractive because they provide a source of situational interest and elicit feelings of challenge, exploration and enjoyment (Sun, 2013) whereas older adults enjoy playing because exergames can remind them of previous experiences and elicit positive emotions (Zhang, 2019). Another characteristic that can influence a person's preferences and motivations can be relationship. For example, in one study, Caro et al. (2018) found that more gameplay actions offered in social motion-based games encourages higher levels of physical activity between friends compared to strangers.

There are many other ways in which other researchers have attempted to examine personal characteristics that could influence social exergame play. These include one's attitudes (Chan et al., 2017), age (Theng et al., 2018), and cultural background (de la Hera Conde-Pumpido et al., 2018). Among these characteristics we selected personality as our primary topic of interest because (1) it is widely accepted that the range of characteristics in the Five-Factor Model (FFM) suggest that personality trait structure is universal (McCrae & Costa, 1997) which in an online exergame context, players can be brought together from anywhere in the world to form groups, and (2)

although there is some research on the effects of player personality characteristics at the individual level in exergames (Dias & Martinho, 2011; Mattheiss et al., 2017; Snyder et al., 2016), there is very little research on player personality characteristics at the group level in the context of online multiplayer exergames (Chan et al., 2019).

Another avenue for enhancing the level of social connectedness of player matching could be taking on a player modeling approach (as described in Chapter 2, section 2.3.6) where we can leverage Cowley and Charles's (2016) model of *Behavlets* accounting for observable playing patterns (e.g., caution, planning, and optimization), as well as additional personal characteristics such as temperament and individual attitudes. In the domain of games user research, although the FFM has been investigated for providing design suggestions in gameful applications (Jia et al., 2016), research shows that the Hexad model (Marczewski, 2015) has more potential for personalizing gameful applications (e.g., Altmeyer et al., 2021; Mora et al., 2019; Orji et al., 2018a) because it was developed based on player motivations specifically for gameful applications. To date, much research has examined the effectiveness of these models for personalizing for individual players (Busch et al., 2015b; Orji et al., 2014; Zhao et al., 2020b), yet, there is very limited research on personalizing gameful elements for player groups.

3.4 Group Process / Group Dynamics

A **group** is [two or more individuals who are connected by and within social relationships (Forsyth, 2014)]. Groups differ from one another in various ways and can vary in size. For example, a graduate seminar of 10 to 12 students can be considered a small group, whereas a celebrity fan club consisting of thousands of members can be considered a large group. Some groups form unexpectedly and only exists for a short period of time (e.g., a group of volunteers come together for a certain event), while others are “deliberately created, sophisticatedly structured, and enduring” (Arrow et al., 2012). There are also groups that form for a specific purpose such as accomplishing tasks, whereas others seem to have no clear goals or purposes. Despite these wide variations, groups sustain and are sustained by relationships

among their members (Forsyth & Burnette, 2010). Forsyth (2014) defines “group dynamics” as [the influential actions, processes, and changes that occur within and between groups; also, the scientific study of those processes] (Forsyth, 2014, p. 2).

Forsyth (2014) identified the following five common characteristics of groups:

1. People in groups interact with one another. Bales’ Interaction Process Analysis (IPA) system distinguishes between task interaction and relationship interaction;
2. Groups seek a variety of goals (e.g., generating, choosing, negotiating and executing);
3. Groups create interdependence among the group members;
4. Interaction is patterned by group structure, including roles, norms, and interpersonal relations; and,
5. Group cohesion or cohesiveness is the unity of the group.

In an exercise context, research shows that group exercise results in more exercise adherence compared to solitary exercise (Dishman & Buckworth, 1996). In a video game context, research shows that social interaction is a component for experiencing enjoyment⁹ (Anwar et al., 2017; Sweetser & Wyeth, 2005) and exertion games can facilitate social play in computer mediated environments (Mueller et al., 2009; Mueller et al., 2010). Research also shows that social presence (Ekman et al., 2012), social connections (Przybylski et al., 2010) and social benefits (Granic et al., 2014) are common motivations for videogame play. Furthermore, research in video games, suggest that social presence is an important determinant of player enjoyment (Brian J. Gajadhar et al., 2008) and in the context of exergames, social support and communication inherent in exergame play are key mediators for subsequent behavior change, encouraging adherence to sustained play (Lieberman et al., 2011).

⁹ Other components of flow include concentration, challenge, skill, control, goals, feedback, and immersion. Sweetser and Wyeth (2005) suggest that social interaction is not an element of flow but is a strong element of enjoyment in games. Furthermore, social interaction is not a property of the task as are the other elements of flow, but the task is a means to allow social interaction.

In a related research, Osorio, Moffat and Sykes (2012) have also studied the SDT in exergames, particularly as it relates to a social context. Surveys were conducted to investigate the motivations that encourage participation in exergames and found that the need for both autonomy and relatedness were highly satisfied within a social context, yet the need for competence was lower compared to the other two needs. The researchers speculated that this was because exergaming was perceived as a social activity and that participation in exergames might be motivated by the enjoyment of social interactions rather than competition. More recently, Staiano et al. (2018) conducted a group-based exergames and reported that the

intervention group experienced higher levels of intrinsic motivation and improved self-efficacy towards physical activity compared to the control group. However, how to form groups that motivates meaningful social interactions and continued play remains unclear. Thus, our aim is to gain a better understanding of underlying motivations that encourage continued exergame play by employing existing methods that offer meaningful social interactions in a group context.

3.5 Personality

Personality is a complex and multidimensional construct and can be defined as a stable set of tendencies and characteristics that determine the commonalities and differences in people's psychological behaviour (thoughts, feelings, and actions) that have continuity in time (Maddi, 1996). Decades of psychological research into human personality has uncovered a theoretical framework, the Big Five or the Five Factor Model (FFM) of personality (Table 3.2) for assessing and classifying individuals into various dimensions (Digman, 1989; McCrae & Costa, 1997; McCrae & John, 1992). Longitudinal and cross-observer studies have shown that all five factors are stable dispositions found in patterns of behaviours and are universal among different age, sex, race, and language groups (Costa & McCrae, 1992; McCrae & Costa, 1987, 1997). Furthermore, correlational studies show that lower levels of Neuroticism and higher levels of Conscientiousness, Extraversion and Openness to Experience are associated with more physical activity and less inactivity (Sutin et al., 2016).

Table 3.2: Five-Factor model of personality and associated traits (Costa & McCrae, 1992; McCrae & Costa, 1997).

Factor	Personality dimension	Associated traits
1	Extraversion	Enthusiastic, energetic, quiet [®] , social, enjoys company of others.
2	Agreeableness	Affectionate, altruistic, modest, compassionate, cooperative, antagonistic [®] , suspicious [®] .
3	Conscientiousness	Punctual, self-disciplined, organized, high academic scores, careless [®] .
4	Neuroticism	Nervousness, poor coping capabilities, emotional instability, committed [®] , relaxed [®] .
5	Openness to experience	Original, creative, explorative, imaginative, conservative [®] .

[®] Reverse – common traits for low pole scores in each personality domain.

Among other personality models such as the 2-dimensional affiliation/dominance model (Wiggins, 1979; Wiggins et al., 1988) which has been shown to be a useful elaboration about aspects of extraversion and agreeableness proposed in the FFM (McCrae & Costa, 1989b), the Myers-Briggs Type Indicator (McCrae & Costa, 1989a) or the Big-3 (Eysenck, 1991), the FFM was selected for conducting this research because (1) the model has been used to examine the relationship between personality and group processes (Aeron & Pathak, 2012; Barrick et al., 1998; Barrick & Mount, 1991), and (2) the model has been applied in previous research on exergames (Mattheiss et al., 2017; Müller et al., 2015). The broad categories in the FFM allow us to capture a wide range of player preferences and fits well with the exploratory nature of the present study.

3.5.1 Group Personality Composition Theory

In psychological research, personality is generally considered an individual-level construct and most studies on personality have been conducted at the individual level of analysis. For many decades, research relating to personality with group effectiveness has had mixed success mainly due to the lack of agreement regarding how personality was to be defined and measured (Driskell, Hogan, & Salas, 1987)

and the absence of a guiding framework to organize the measures use in group studies has generated “a maze of inconsistent results” (Driskell et al., 1987, p. 94). It was not until the advent of the FFM has emerged to convincingly organize a multitude of personality traits (Digman, 1990; McCrae & Costa, 1987) in which is widely accepted by personality researchers bringing consistency to the conceptualization and measurement of personality. To examine the role that personality plays at the group level of analysis, researchers have identified a variety of ways of aggregating individual personality to higher levels of analysis (Halfhill et al., 2005b). One of the most commonly used methods to operationalize GPC is to calculate the mean score for the group (Barrick et al., 1998). This approach assumes that the amount of traits possessed by each individual member of the group increases the collective pool of that trait (Barrick et al., 1998).

To study the effects of personality within a group, researchers typically convert individual personality trait scores into a measure that represents group composition in terms of personality (Peeters et al., 2006; Prewett et al., 2009). Barrick et al. (1998) noted that researchers typically adopt one or more of several methods of operationalizing team composition. The most common method is to calculate the mean score for the group and works under the assumption that the amount of the characteristic possessed by each individual increases the collective pool of that characteristic. This collective increase is presumed to have positive or negative impacts on the group, regardless of how it is distributed within the group. A second method of operationalizing team composition is to assess the variability of individual personality traits. The variance and range of individual scores and proportion of team members possessing a particular trait are three ways to operationalize variance. A third approach focuses on the minimum and maximum scores in the group. There are two ways to conceptualize the effects of this operationalization. Barrick et al. (1998) noted that this method assumes that one individual can significantly affect the group outcome and is measured simply by taking the lowest or highest score within the

group. Examples of where this method is useful are in problem-solving groups (highest) and assembly-line work (lowest).

3.5.2 GPC and Group Effectiveness

GPC has been shown to influence group effectiveness (Driskell et al., 2006; Halfhill et al., 2005a). Barrick et al. (1998) found that higher average levels of conscientiousness, agreeableness, extraversion and emotional stability within a group predicted performance, and that higher average levels of extraversion and emotional stability within a group predicted team viability – the team’s capability to continue working together. Peeters et al. (2006) conducted a meta-analysis of existing literature and found that teams that score high on agreeableness and conscientiousness team performance were positively correlated, whereas teams composed of members who score high on extraversion, emotional stability, and openness to experience were not positively related to team performance.

3.5.3 Group Performance and Cohesiveness

Group performance can be influenced by the personality composition of the group (Gilley et al., 2010; Neuman & Wright, 1999) based on both internal and external factors. Internal factors can be the similarity or differences of group members’ personality traits. For example, Bradley, Klotz, Postlethwaite, and Brown (2013) found that task conflicts [disagreements among group members over the content of their decisions and differences in viewpoints, ideas, and opinions related to the task (Simons & Peterson, 2000)] can improve group performance, but only under the right conditions. In particular, Bradley et al. (2013) found that teams that score high on openness to experience or emotional stability is positively correlated with a positive impact of task conflict on performance, and teams with low levels of openness or emotional stability is associated with experience of negative impact on performance.

External factors such as task characteristics can also influence the effect of personality composition on group performance. For example, van Vianen and De Dreu (2002) describes that most teams perform tasks that are highly interdependent,

which involves additive, conjunctive, and disjunctive components. Group performance is “additive” when members work on similar tasks and the team’s performance is the summing of each team members’ individual input. Group performance is “conjunctive” when it is based on the input of the least productive member. For example, when the team climbs a mountain, the team that reaches the top is based on when the slowest member reaches the top. Group performance is “disjunctive” when performance is based on the input of the most productive member. For example, when the task requires the team to come up with a good solution, the best solution proposed by an individual member will then determine the team’s performance. For additive tasks, variability of personality traits will be related to group performance because different levels of personality traits can be associated with different skills (LePine et al., 2011).

Because of our interest in the experiences and interactions that occur between team members that encourage long-term play in a group context, it is important to introduce a variable that other researchers have used for examining the quality of group relationships over a long period of time. The construct of **cohesion** is a popular variable that other researchers have used to study processes within a group in the GPC domain (Barrick et al., 1998) and is typically described as an individual’s team member’s desire to stick together within a team. Group cohesion is defined as “a dynamic process which is reflected in the tendency of the group to stick together and remain united in the pursuit of its instrumental objectives and/or satisfaction of member affective needs” (Carron et al., 1998, p. 213). This tendency to stick together originates from the interpersonal attraction that members have toward the group or team. Interpersonal attraction to a group involves an individual’s level of identification with the group or the degree to which he/she identifies him or herself belonging to a particular group and not to others (Friedkin, 2004).

Researchers have examined the relationship between GPC and social cohesion on group performance. For example, both Barrick et al. (1998), and van Vianen and De Dreu (2002) have found that social cohesion is strong when groups have high mean

and minimum levels of extraversion and a high mean level of emotional stability. This suggests that group members experience more positive relationship with others within the group if the emotional stability of most team members is reasonably high and if there is no single member who is highly introverted. Both also found that the minimum level of conscientiousness positively contributes to group performance suggesting that the inclusion of a single member who scores relatively low on conscientiousness will likely reduce group performance. Furthermore, both studies also reported results that suggest that group members need to be quite similar in conscientiousness, because higher levels of variance in conscientiousness is related to lower performances. In contrast to Barrick et al. (1998), van Vianen and De Dreu (2002) found no relationship between social cohesion and the composition measures of agreeableness.

In summary, we reviewed research that examined personal characteristics, focusing on personality for understanding group processes (including performance, effectiveness and cohesion as they are related to GPC theory) and provided the reasoning behind for why we are using Halfhill et al.'s (2005) task-relationship dichotomy for our proposed solution. We also reviewed literature on personalizing gamified systems using the Hexad Model (Marczewski, 2015). Collecting concepts from the game design and psychology literature, we constructed a theoretical model (Figure 3.1) consisting of six related motivational elements (gamification, enjoyment, competition and cooperation, social interaction, flow, and engagement) that can be linked to GPC theory which includes all five dimensions of personality (openness, conscientiousness, agreeableness, extraversion, and emotional stability) and blended together using the task-relationship dichotomy, as well as the Hexad user types. Based on our theoretical model, we devised design guidelines for a social exergame experience that allows players to engage in the game based on their personality and player type through social interactions and collective decision making. In our design, performance is “additive” in that members work on similar tasks and the team’s performance is the summing of each team member’s contributions, while the game

activities and the matching of similar and complementary characteristics (stemming from interpersonal attraction theory) aim to foster team cohesion motivating members to stick together.

In the next chapter, we describe in detail our game design and how each motivational element was applied as a game feature justified by game design and psychological theories.

4 Game Design

4.1 Overview

Our research included three phases (discussed in Chapter 3). Phase 1 was a pilot study that used an existing commercial game. Phase 2 was our Foundation Study using a custom-design game. Phase 3 was an Addon Study using storyboards. For the

Phase 2 of this research, we needed a game experience that was (1) multiplayer, (2) allow players choices based on their personal characteristics, and (3) demands a light to moderate level of exercise intensity. Furthermore, based on our previous work (Zhao et al., 2017a) we found that players wished for an experience that was outdoors, more in-game interactions and more social interactions. As such, the following features were decided for our exergame design:

- Asynchronous exergame, to induce light to moderate-intensity exercise and not constrain to a game console or indoor play.
- Everyday exercise points (calories burnt) as the main score item in the game
- Group-based multiplayer design to allow competition and collaboration.
- Use of between-group challenges as the main gameplay mechanic. Each challenge is an attempt to collect exercise points within a certain time window.
- Allowing competitive and cooperative (non-friendly and friendly) challenges using the notion of guilds (collection of “friendly groups”). Non-friendly challenges offer extra “bonus” points for the winner.
- A voting system to decide on sending and accepting challenges within each group.
- A leaderboard as the main outcome and motivation of the game.

We hypothesized that a voting system also allows players to make choices based on personal characteristics resulting in the type of challenge they choose.

Based on the intended features defined above, we designed an asynchronous multiplayer exercise game, *ExerQuest* that was used in our Foundation study. Physical activity (steps and calories) is tracked using GoogleFit¹⁰ (Google, Mountain View, CA, USA) and displayed in the game interface. Some preliminary ideas and initial drafts of the game interface can be found in Appendix A. The game interface of *ExerQuest* was developed using an iterative design process, starting with a paper

¹⁰ <https://www.google.com/fit/>

prototype followed by digital wireframes sketched in Miro¹¹ (Miro, San Francisco, CA, USA). Essentially, the interface is an information dashboard which allows players to see game performance (both individual and group), as well as create challenges and communicate with other players in the same group. Figure 4.1 shows initial wireframes as we were designing the dashboard features and functions such as current quests (Figure 4.2), performance (Figures 4.3a and b), the discussion board (Figure 4.4), and leaderboard (Figure 4.5), as well as the process for creating and sending a challenge (Figure 4.6).

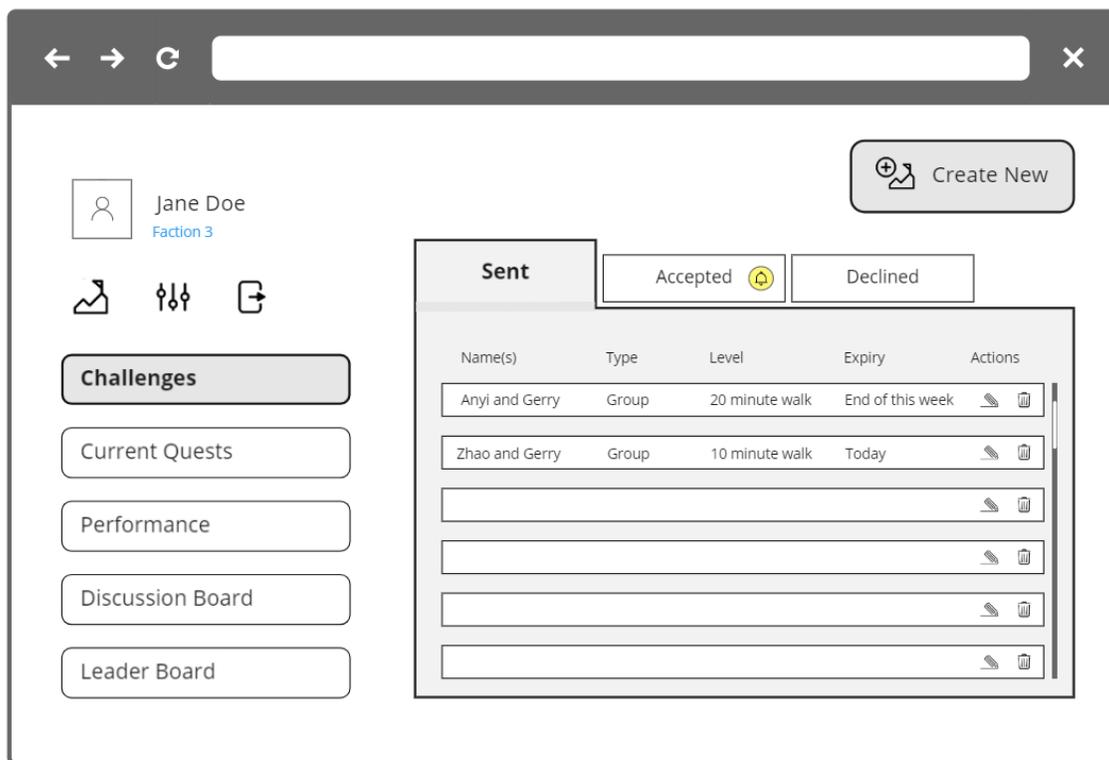


Figure 4.1: Initial wireframe showing challenges sent.

¹¹ <https://miro.com/>

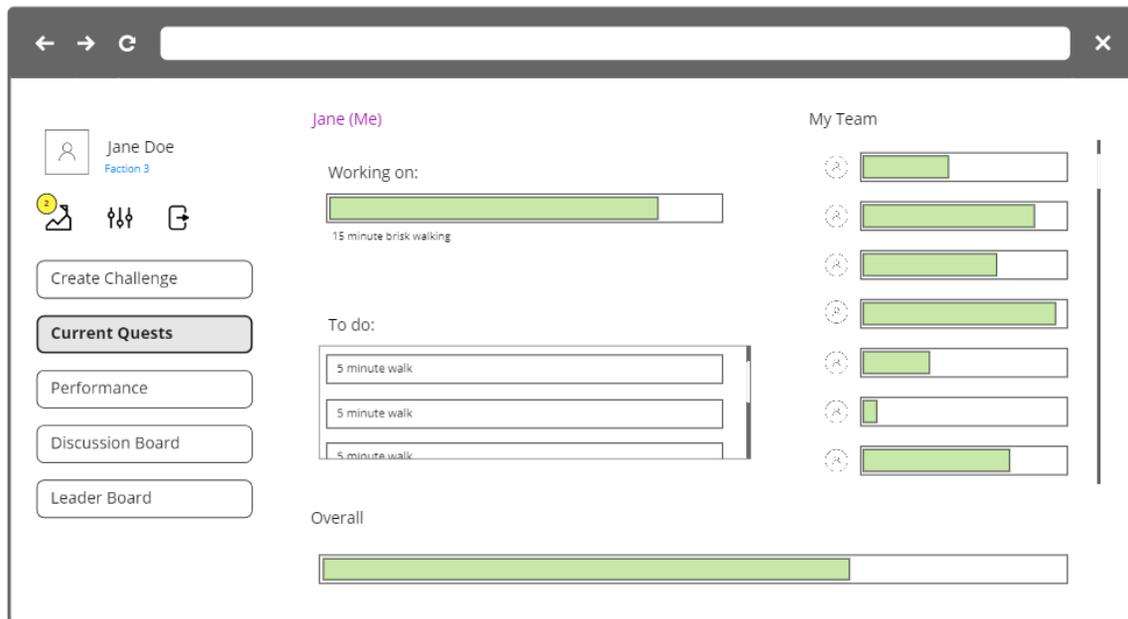
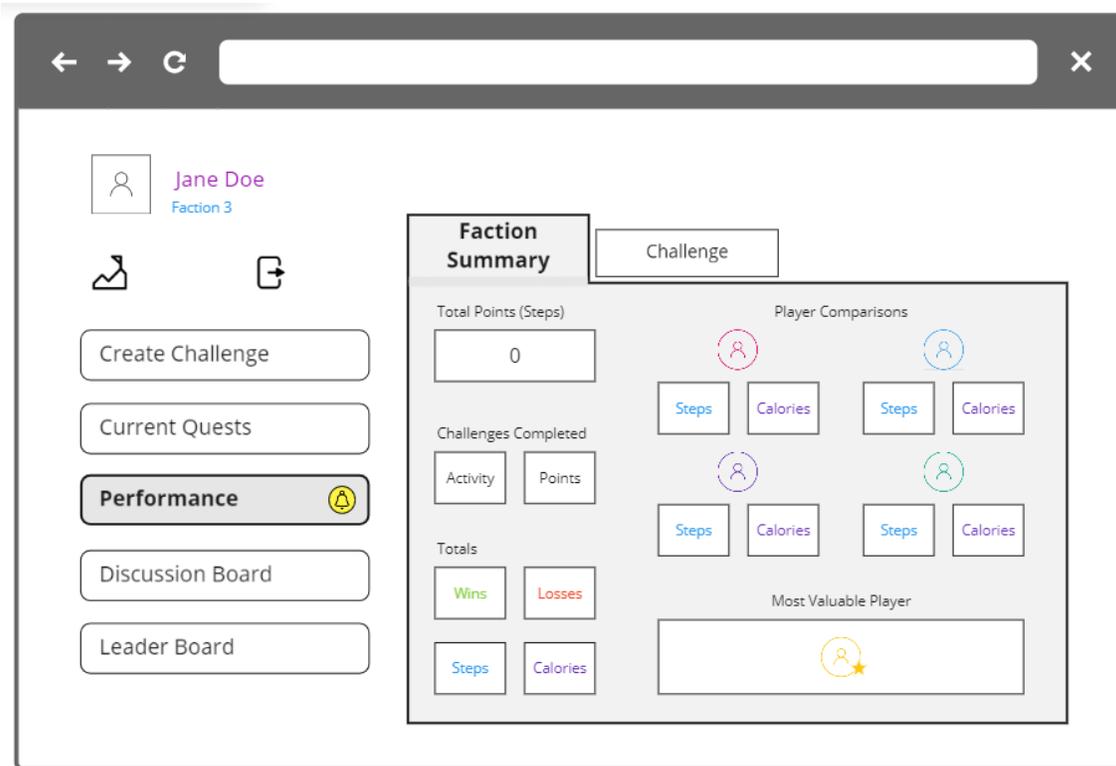
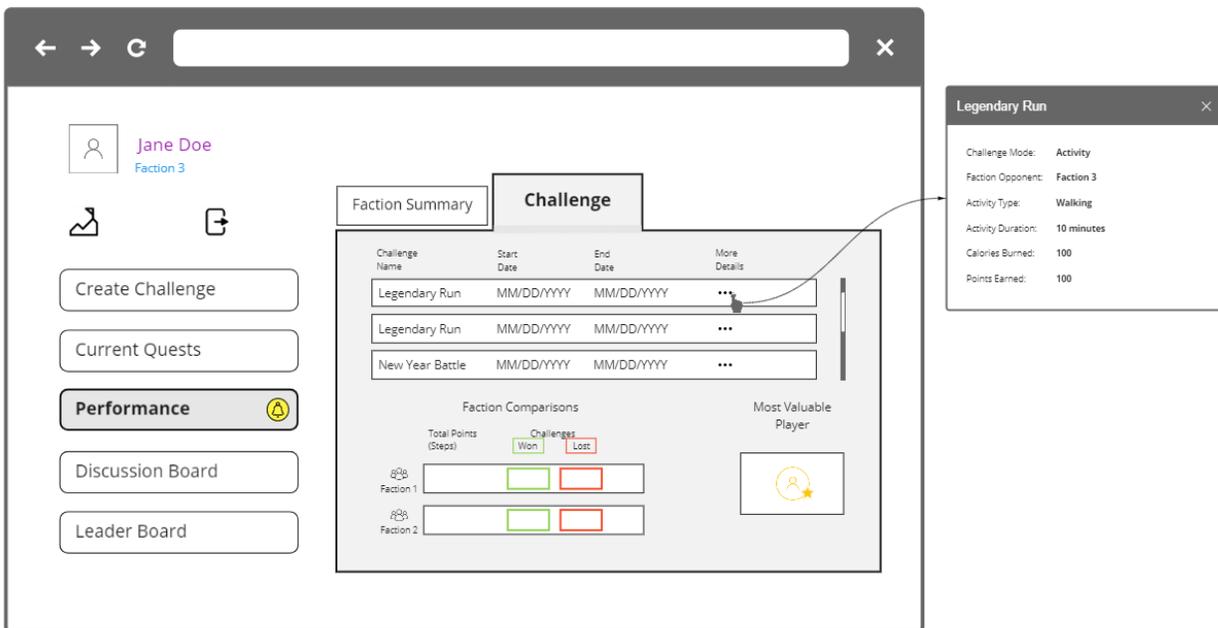


Figure 4.2: Initial wireframe of current quests.



a) Summary of performance challenges for player groups.



b) Summary of individual challenges.

Figure 4.3: Initial wireframe of game Performance.

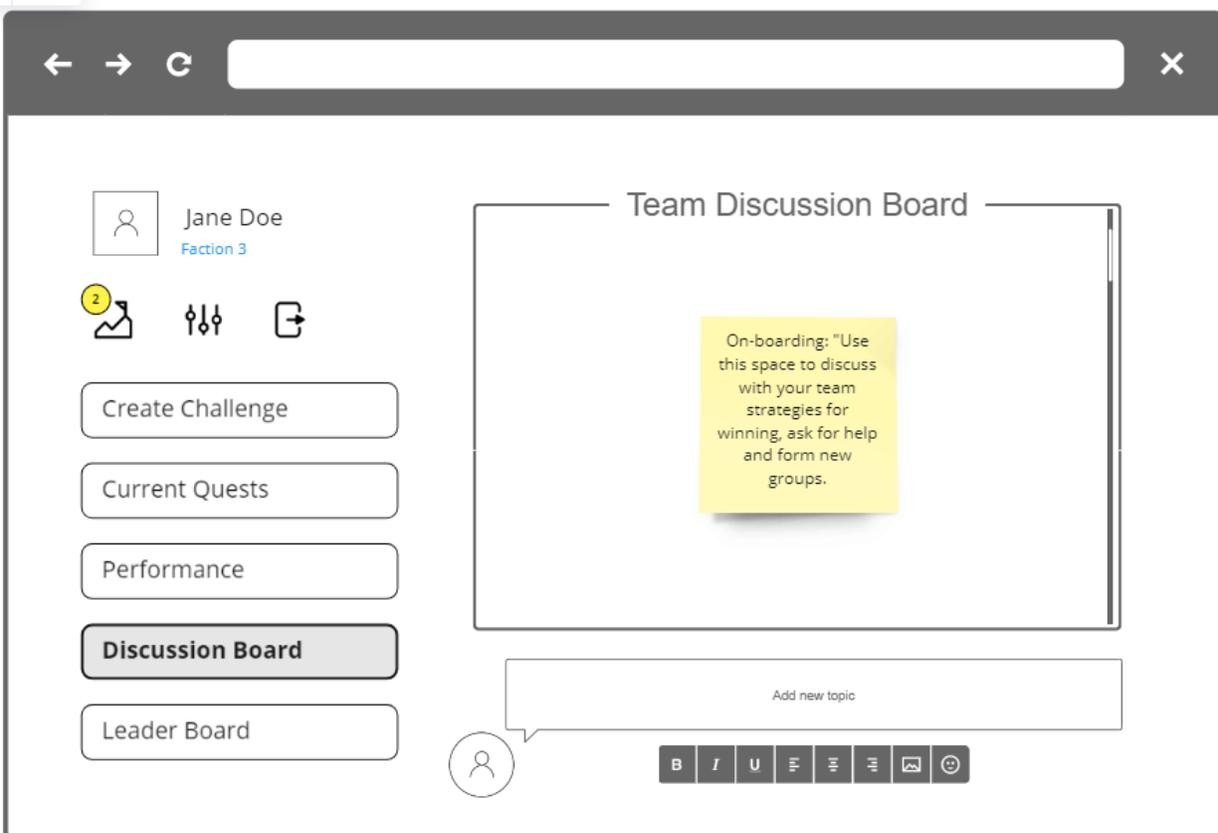


Figure 4.4: Initial wireframe of the discussion board.

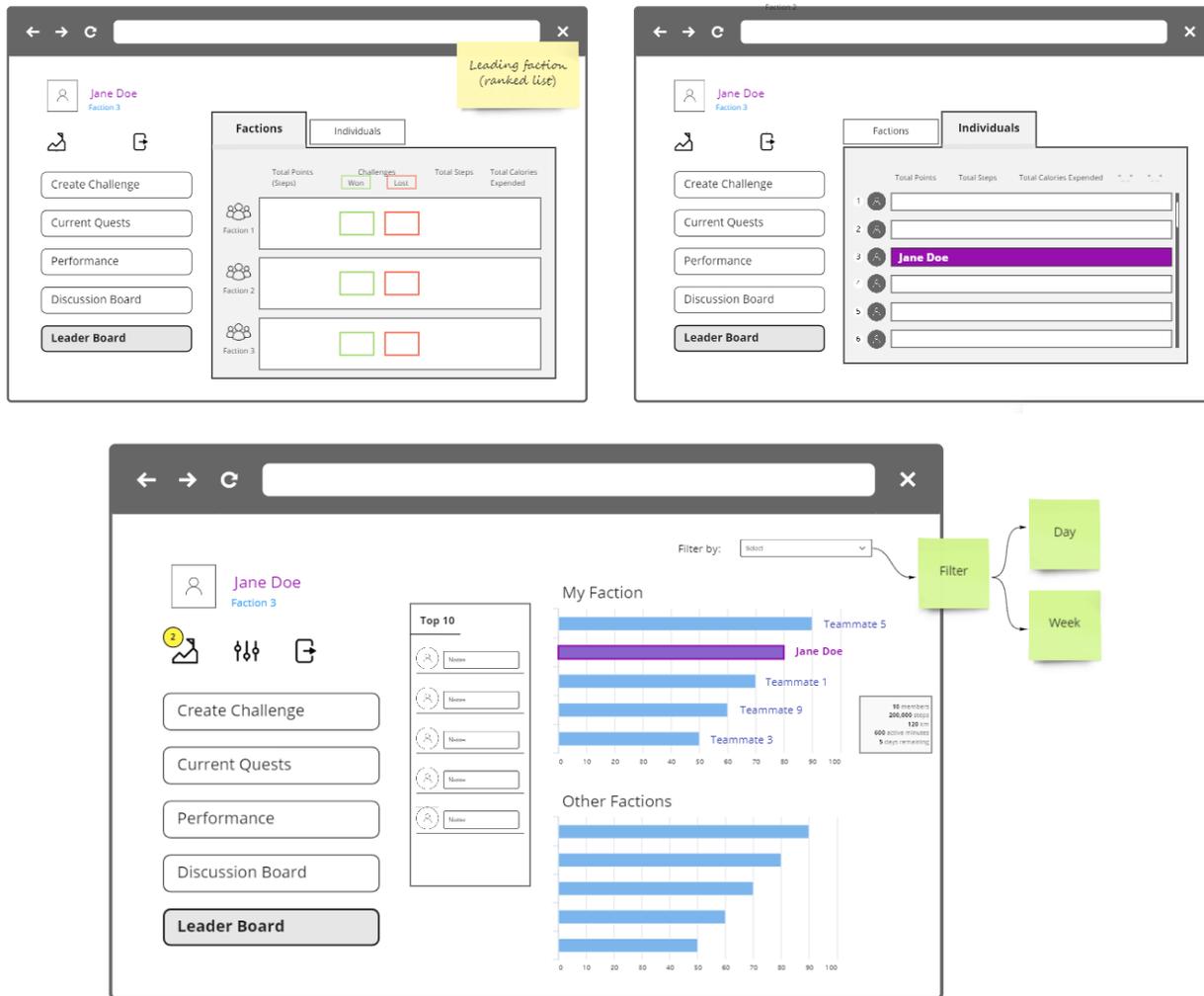


Figure 4.5: Initial wireframe of the leaderboard.

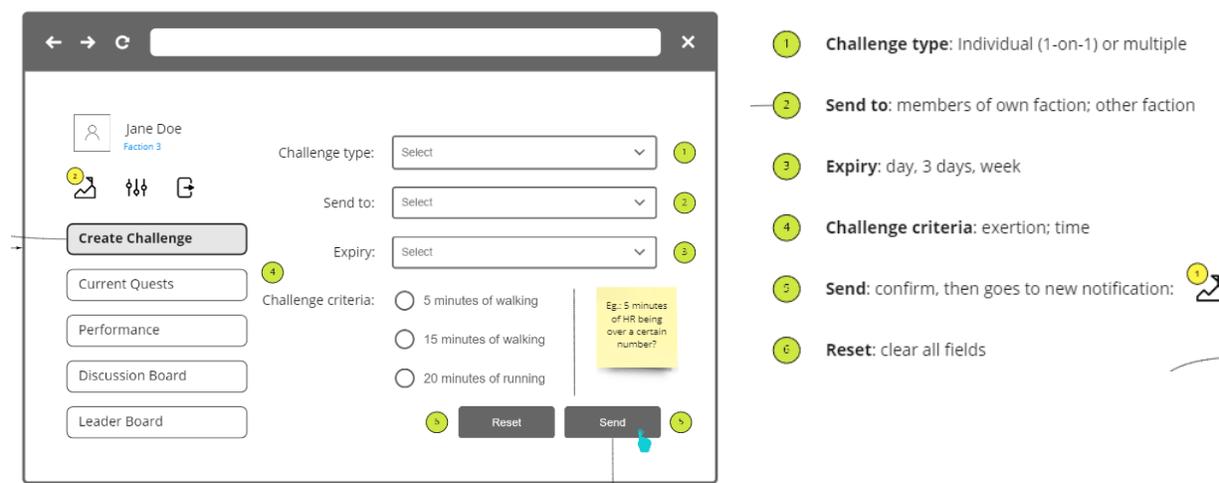


Figure 4.6: Initial wireframe of the process for creating and sending a challenge.

To participate in a challenge, the following sequence of actions happens:

- One player must initiate the challenge aimed at another group.
- The other group member(s) must agree to send this challenge.
- If all team members agree, then the challenge is sent to target group.
- All target group members must accept the challenge.
- Once everyone has accepted, the challenge starts.

Previous studies have shown the positive aspects of incorporating social elements into exercise games, including increased physical activity (Barkley et al., 2017), higher levels of game engagement (Mueller, Gibbs, Vetere, & Edge, 2017), and both physical and mental health benefits for specific populations (Caro et al., 2017; Gerling et al., 2015). However, current research is limited to social exergames that offer relatively simple social interactions and game mechanics, as well as short-term evaluations (approximately 2-3 weeks). Thus, the game interface, features and user flow has been designed to offer a more interactive experience and awareness between player groups to show the effect of personality and increase both task and social interactions. Previous studies in group exergames have also shown that the level of motivation decreases when group members are inactive in the game (Caro et al., 2018), and thus, to foster richer social interactions, the game interface also aims to increase the situational awareness between group members by providing a discussion board for communication with each other allowing them to send updates regarding each other's activity progress to keep the level of motivation high.

4.2 Gameplay

4.2.1 Goal and Backstory

ExerQuest is an asynchronous exergame where players perform physical activities (step count) tracked by GoogleFit (Google, Mountain View, CA, USA) to collect points for gameplay. To determine the optimal number of members per team, we pilot tested with group sizes larger than two members and found that coordinating challenges were hard (each additional member would increase the waiting time to start a

challenge as the number of votes would also increase), and so we limited the size of the team to two members. Players form small teams of two members belonging to one of five major planetary guilds (Solatron, Michromers, Kannerites, Vuroflames, and Diablans) that have been travelling in space for millions of years. Their aim is to dominate the galaxy by taking over planets and make them part of their system. Each guild has a rich history and roles as their secret ingredient to success.

Originating from planet Solat, Solatrons have taken over 60 planets and five galaxies. Their bright orange colour is a symbol of bravery, determination, and trust. Members of this guild specialize in building resources and protecting the well-being of its members. Originating from planet Michrome, Michromers have taken over 37 planets and two galaxies. Their bright emerald green symbolizes, trust, resilience, and success. Members of this guild concentrate on the distribution of resources and ensures that everything around runs smoothly. Originating from planet Kanner, Kannerites have taken over 91 planets and five galaxies. Their bright aqua blue signifies growth, bravery, and wisdom. Members of this guild focus on keeping all the resources safe from predators and inventing new artilleries. Vuroflames originate from the planet Vuron have taken over 26 planets and three galaxies. Their bright golden yellow symbolizes courage, wisdom, and prosperity. Members of this guild are warriors and specialize in gathering new resources. Finally, Diablans originate from the planet Diablo have taken over 20 planets and two galaxies. Their bright metallic silver symbolizes strength, ambition, and honesty. Members of this guild are adventurers and specialize in exploring new spaces. Figure 4.7 shows three of the five planetary guilds traveling through space which is displayed as the welcome screen at the start of the game.

The inclusion of a backstory for ExerQuest was part of the design to elicit the experience of fun. Studies show that a story can make the game experience more meaningful and fun (Rogers et al., 2017). A “narrative” can also offer a plot to connect other gamification elements (Klock et al., 2020), and can be effective for personalizing the game experience that makes sense to players (Butler, 2014). The notion of guilds

was integrated into the design to promote a “team feeling” (i.e., being part of a group) and the caretaking between players (Klock et al., 2020) and was to facilitate cooperation (Busch et al., 2016; Orji, Nacke, et al., 2017b) and support (Butler, 2014) of the guildmates. Planetary guilds and the theme of outer space was selected as previous research using gameful applications encouraging physical activity demonstrates that this theme is well perceived in the physical activity context (Doyle et al., 2011; Finkelstein et al., 2010; Saksono et al., 2015).



Figure 4.7: Three planetary guilds traveling in space.

4.2.2 Rules and Challenges

The main purpose of the game is to take over other planets and gather the resources of that planet. To take over planets, the players must earn points by sending and accepting challenges within their own guild and other guilds. Challenging teams within their own guild will earn base points, and we call this a friendly challenge. To earn bonus points for the guild, groups must challenge a different guild, and we call this a non-friendly challenge. The more points the players/groups/guild earn, the

more resources they have. Larger planets have more resources, whereas smaller planets have less. Larger planets require more physical effort and duration, while smaller planets require less effort and time. The purpose of a challenge is to earn more points than the other team by burning more calories (by taking steps) within a specified timeframe. The rules of the game are as follows:

- Players/Groups can only be in one challenge at a time but can create a new challenge immediately after ending the current one.
- Players/Groups must be in a challenge to collect points.
- There are two types of challenges:
 - Friendly Challenge: challenges within the *same guild* earns base points (no bonus).
 - Non-Friendly Challenge: challenge between *different guilds* – winning will earn your guild bonus points (20%).
- The player/group/guild that performs the best remains at the top of the leaderboard.
- Players/groups can choose to participate in a 1-day, 2-day or 3-day challenge.
- Players/groups can choose to accept or reject challenges. This happens at both player and group level.
- Players can use the discussion forum to communicate with group members and keep them updated on activity progression.
- To view the performance results of completed challenges, players login once when the challenge ends and login again after 1 hour.
- Participation is mandatory for the player who creates the challenge.

4.2.3 Actions and User-Interface

Each Player can earn points based on the number of calories burned for the activity within the given time duration. The calories for all Players within the Guild are accumulated for the total. The most points win. For individual leaderboards, each Player from his/her group is awarded the individual points earned from the challenge. To create a challenge, the Player needs to select the duration (1-day, 2-day, or 3-day)

and choose the Opponent (same Guild or different Guild). After the Player creates the challenge, he/she must wait for others who have been challenged to vote accept or decline the challenge. Once everyone accepts, a timer will start counting and the challenge begins. If one Player declines, the challenge does not proceed. Then to earn points, Players must create a new challenge and the voting process repeats. During the challenge duration, Players perform as much physical activity (e.g., by walking, jogging, or running) as they wish. As soon as the challenge duration ends, Players can login to ExerQuest to view their performance. Figure 4.8 shows the list of challenges listed on the Challenges page in the game interface. Figure 4.9 shows the performance of the player in developed version of the game interface. Figure 4.10 shows a conversation between players on the same team using the Discussion Board. Figure 4.11a shows the fields that needs to be completed to create a challenge, while Figure 4.11b shows the status of a challenge that is still collecting votes from all the players who have been invited to participate in the challenge.

The screenshot shows the ExerQuest game interface. At the top, there's a header with the user's name 'John Doe' and 'Faction Name', and navigation links for 'Story' and 'Rules'. Below the header is a sidebar with navigation options: 'Challenges', 'Performance', 'Leaderboard', and 'Discussion Board'. The main content area is titled 'Challenges' and includes a 'Create New' button. Below this, there are filters for 'All (4)', 'Active (1)', 'Completed (2)', and 'Pending (1)'. A table lists the challenges with columns for 'Challenge Name', 'Creator', 'Faction', 'Date Created', 'Type', 'Status', and 'Action'.

Challenge Name	Creator	Faction	Date Created	Type	Status	Action
Legendary Run	John Doe	Faction Name	January 15, 2019	Activity	Pending	View Delete
Creed Dash	John Doe	Faction Name	January 05, 2019	Points	Completed	Results
New Year Battle	John Doe	Faction Name	December 31, 2018	Activity	Active	View

Figure 4.8: Summary of challenges in the developed game interface.

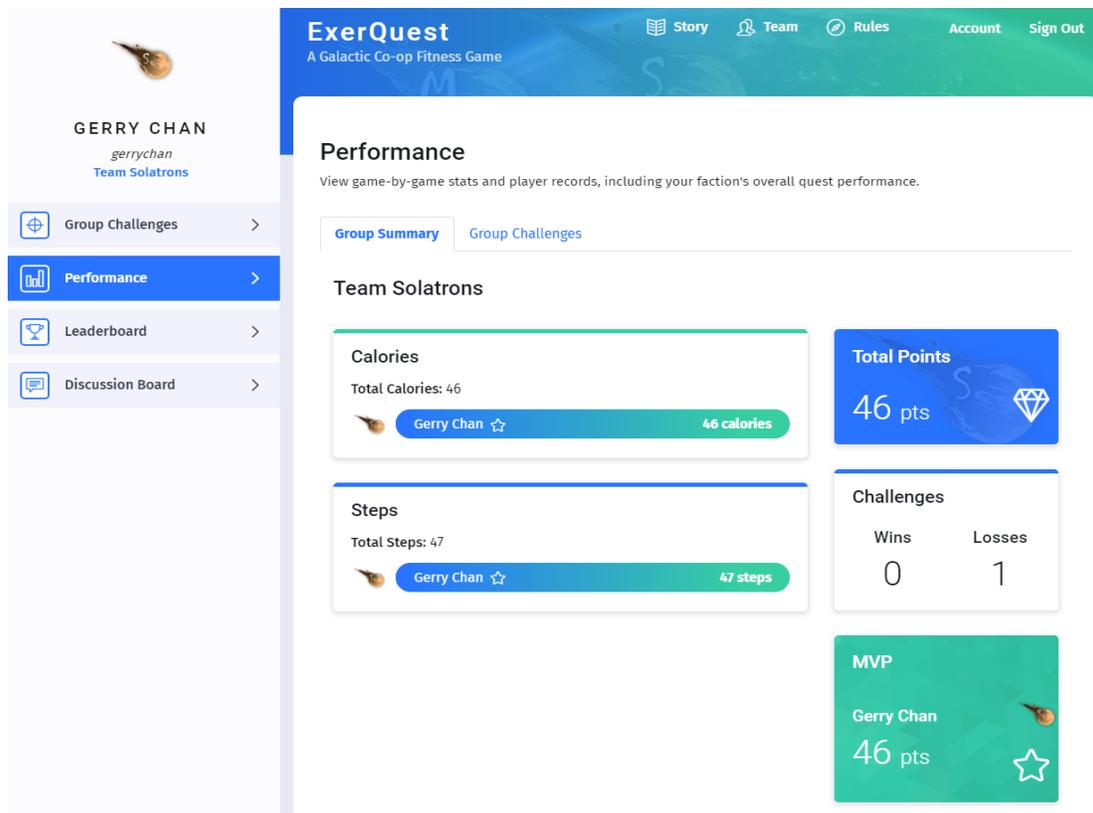


Figure 4.9: Screen shot the developed game interface showing overall player performance.

Discussion Board

Get a chance to have quick chat and device strategies with your team members.

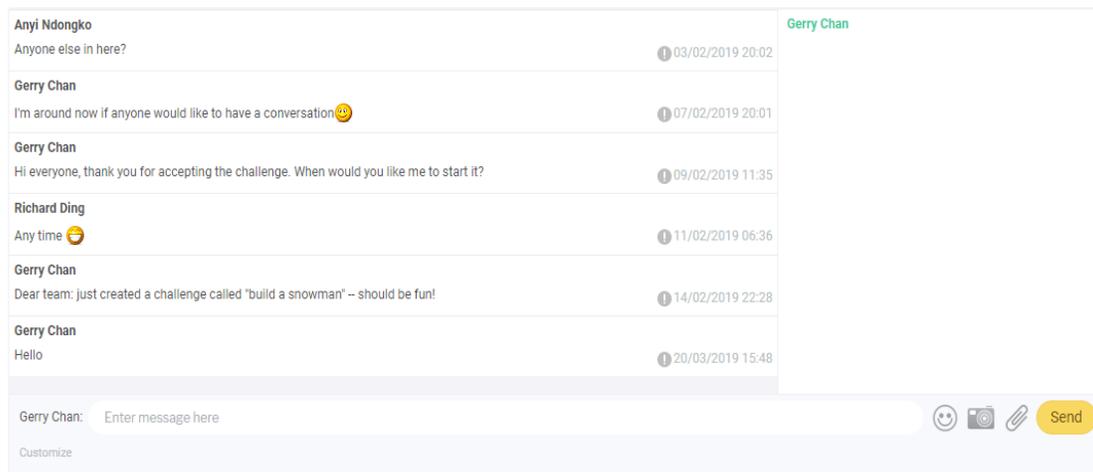


Figure 4.10: Developed game interface discussion board.

Create New Challenge ✕

Create a new challenge for both your team and an opposing faction. As creator of this challenge, participation is mandatory.

Game Rules

Each Player can earn points based on the number of calories burned for the activity within the given time duration. The calories for all Players within the Faction are accumulated for the Total. The most points wins. For individual leaderboards, each Player from his/her Faction is awarded the individual points earned from the challenge.

Duration

10 mins

Choose your Opponent

Tellemars

⚠ Team Tellemars has 3 members. Therefore, only 3 members, including you, can participate in this challenge. There are 2 spots available.

Name of Challenge *

Let's build a snowman together

Description of Challenge

Collect as much snow as you can between today and tomorrow to build a snowman.

Create

(a) Create a new challenge

Challenge name ✕

Created by Gerry Chan on March 20, 2019

Description

The hardest challenge

Details

Challenge Mode: Time

Faction Opponent: Tellemars

Duration of Challenge: 15 mins

Team Opponent

You have accepted the challenge

has accepted the challenge

s not yet responded

⚠ There is 1 spot available on Team Solatrons

(b) Voting on a challenge

Figure 4.11: Procedures for creating and voting on a challenge.

4.3 Game Features

Game features (Table 4.1) have been purposefully offered in the game interface to motivate participation in the exercise activity as suggested by Reeve (2014) (Table 2.1) and to examine the role of personality. To date, very few social exergames incorporate collaborative decision making (in our case, a voting system) where players have the option to choose to accept or reject both short (1-day) and long-term (3-day) challenges. Our research explores the social interactions, particularly decision making, between multiple player groups and the effects of personality matching on exergame adherence.

Table 4.1: Game features that show the effect of personality and exercise motivations.

Game features	Goal	Personality & motivations
Points system	Tie physical activity to online activities	Gamification works differently for different personality types (Codish & Ravid, 2014). Extroverts found rewards that can be demonstrated more playful which makes sense given their extroverted personality. Introverts perceived badges to be a competitive environment which they feel more comfortable competing in. High conscientiousness players were discouraged by leader boards but were motivated by rewards related to progress and playfulness. Highly agreeable personalities found badges to be more playful than those with lower levels of agreeableness.
Challenge types (friendly and non-friendly)	Earn points	Show group competitiveness and cooperativeness – cooperativeness falls into the facet of <i>agreeableness</i> (Costa & McCrae, 1992). Individuals who score high on agreeableness prefer cooperation, whereas individuals who score low on agreeableness prefer competition. Motivated by achievement strivings and provides a source of extrinsic motivation (Reeve, 2014).
Goals (short and long-term)	Encourage the formation of groups and game retention	Conscientiousness personalities are intrinsically motivated to achieve and seek organization and goal setting (Costa & McCrae, 1992). To motivate goal-oriented players (Reeve, 2014).
Voting system	Decision making	Choice and decision making are common tasks that other researchers have evaluated in the GPC literature and show the effect of personality within a group (Halfhill et al., 2005b).
Most valuable player	To create an awareness of the level of contribution within the group	Researchers (e.g., Curșeu, Ilies, Vîrgă, Maricuțoiu, & Sava, 2019) have examined the relationships between personality traits and contributions to teamwork. For players who are motivated by positive affect (Reeve, 2014).

Game features	Goal	Personality & motivations
Discussion board	To socialize and keep the group updated on activity progress	People who score high on extraversion show high levels of emotional expressiveness and talkativeness (Lewis Goldberg, 1999). For players who are motivated by positive affect (Reeve, 2014). The level of motivation decreases when group members are inactive in the game (Caro et al., 2018).

4.3.1 Feedback for Version 1

We tested the functionality and clarity (particularly the user flow) of ExerQuest with six evaluators. These six evaluators are all experts in the field of game and interaction design. The evaluators were asked to explore the user interface and comment on the look and feel, review the rules, and whether the buttons and icons made sense or not. The testing took approximately two weeks and below is a summary of the feedback we received:

- The views between group summary and group challenges were inconsistent.
- Terminology (e.g., groups, teams, factions; game and quest) was confusing.
- Game rules need more explanation about game itself and how points are calculated.
- Players would like more information about what other players are doing.
- Waiting time to begin a short challenge was too long.
- The performance page does not show individual summary (for a person).

4.3.2 Features for Version 2

Based on the feedback we received, we defined a set of new requirements for a second iteration of the game interface (Table 4.2).

Table 4.2: Features to change for version 2 of game interface.

	Feature	Version 1	Version 2
1	Challenge duration	Minimum = 10minutes Maximum = 60minutes	1-, 2-, and 3-day challenges
2	Hierarchy	No concept of umbrella including many groups	Build hierarchy (“guilds”) to offer players choice between friendly and non-friendly challenges.

	Feature	Version 1	Version 2
3	Challenge type	Competitive only	Friendly challenges – no bonus points Non-friendly challenges – 20% bonus
4	Notifications	Does not notify players outside of the game	Notify players outside of the game to check back into the game to allow system to collect/calculate data
5	Terminology	Faction/group/team Game/quest	“Group” only “Game” only
6	Performance summary	Only group summary and challenges	Add individual summary
7	Number of players per group	Maximum of 3	Maximum of 2
8	Timer	Active challenges keep on going forever when players do not start challenge	Set timer to end active challenges
9	Storyline	Destroy earth	Save earth
10	Rules	Limited	Add/clarify details about how to earn points and winning vs. losing conditions

4.4 Implementation

Once the wireframes and game features were designed by the main researcher, a web-developer was employed for the implementation. The implementation described in the section is the work of the developer, not the main researcher. ExerQuest was built using WordPress’s CMS platform / PHP framework and the Google API. Two major components are required to successfully run the game:

1. Themes (wp-content/themes)
 - ExerQuest: Hosts templates (login.php and dashboard.php) including script and styling files for the game.
2. Plugins (wp-content/plugins)
 - ExerQuest: Runs and manages the game and dashboard

- Gmail SMTP: Enables the sending of emails from the WordPress site via Gmail's SMTP server
- Wise Chat: Fully featured chat plugin used in the "Discussion Board" module of the dashboard
- WP User Avatar: Supports the uploading and personalization of user profile photos

Both jQuery and Bootstrap libraries are utilized by the ExerQuest plugin and theme in the development of the interface. The source code is available at www.exerquest.ca/wp-login.

4.4.1 Theme Files and Functions

ExerQuest consists of three theme files: (1) template files, (2) styling files, and (3) script files. Template files include `dashboard.php` and `login.php`. The `exerquest_view_dashboard` shortcode is inserted from the ExerQuest plugin ("Shortcode" class) to display the game dashboard and to display the Google login page for the game, the `exerquest_role_message` shortcode is inserted from the ExerQuest plugin ("Shortcode" class) to display user account status messages when logged out of the dashboard. The `exerquest_google_signin` shortcode is inserted from the ExerQuest plugin ("Shortcode" class) to display the Google sign in button. Styling files include `components.css` and `colors.css`. `Components.css` is for the structural styling of the dashboard interface and theme templates, whereas `colors.css` is for the colour styling of game and dashboard elements. Finally, there is one Script file, "custom.js", and it is managing the front-end of the user interface interactions and displays. It accesses query data from the ExerQuest plugin ("Dashboard class") to manage the different dashboard views. In addition to theme files, there are also functions. Table 4.3 summarizes all the functions used in ExerQuest.

Table 4.3: Function used in ExerQuest.

Functions	Description
mobileMenuSiteNav	Customizes the look and feel of mobile menu elements with the use of styling classes.
mobileMenu	Toggles the display of the mobile menu when clicking the menu button.
toggleContentByQuery	Toggles the display of content (e.g., tabs, navigation) passed by queries. Query variables and values (e.g., Query.view_group) are accessed from the ExerQuest plugin (“Dashboard” class).
toggleContent	Toggles the display of content when clicking tabs or navigation links/buttons.
modalChallenges	Handles the display of modal views passed via a query.
forms	Toggles the display of form fields from “select” options.
getQueryVars	Parses queries from the browser.
bootstrapComponents	Enables Bootstrap tools and functionalities.
responsiveScreen	Detects changes in window screen size.

4.4.2 Plugins

The structure consists of components and vendors. The components contain all dashboard user-interface (UI) components, game setup functions, and child classes to the “ExerQuest” parent class.

- The Dashboard contains all dashboard views, screen modals, and data classes for the dashboard.
- Google access contains classes for accessing fitness data from Google Fit services and functions supporting Google user account creations on WordPress.
- Images are assets used in the dashboard.
- The menu page contains components that help setup an “admin menu” for the game on WordPress, allowing the administrator to manage Google OAuth settings, groups, challenge data, and account notifications.
- The user profile contains custom fields that are added to a user’s profile allowing the administrator to manage user roles and group assignments.

Vendor – installed Google API Client library for PHP using composer and ExerQuest.php which is the parent class (ExerQuest).

4.4.2 Classes

The hierarchy is as follows:

- ExerQuest
 - Menu Page
 - User Account
 - User Profile
 - Mail
 - Factions
 - Tables
 - Posts
 - Google Access
 - Fitness Data
 - Shortcodes
 - Dashboard
 - Player Data
 - Game Data
 - Challenge Data
 - Faction Data
 - Introduction
 - Main

4.4.3 Variable and Value Definitions

All **Tables** for ExerQuest are initialized in the Tables classes. Specific table columns from the database require defined values in for the game and dashboard to operate properly. **Sessions** are used to store information based on a user's actions on the site. Sessions in ExerQuest are equivalent to global variables that can be accessible in all classes. Sessions are initiated in the ExerQuest class by the `__construct` function. When a user is logged out of the dashboard, all the sessions are cleared (unset). This

action is carried out by the `auto_logout_redirect` function from the `ExerQuest` class. All **Query** variables and values are initialized and standardized in the `Dashboard` class by the `get_query_vars` function. Queries are used to access different views and information from the dashboard, as well as manage all form requests. These queries are generated from submitted forms and clicked links/buttons. All set queries can be combined to form query strings. All query strings must start with the view variable and its set value when accessing different views and information from the dashboard. This, however, does not apply to form requests. Form requests use queries that are applied to the `action` attribute of the `<form>` tag.

5 Foundation Study

5.1 Overview

5.1.1 Theoretical Rationale

To encourage game retention, we studied and utilized players' personal characteristics and as such, we propose Player Matching using Personal Characteristics (PMPC). In this foundation study, we focused on and started with personality types. In the field of social and organizational psychology, many researchers have studied the effects of Group Personality Composition (GPC) [the combination of group members' individual traits, as represented in group-level indexes such as average, minimum, maximum, or variance on traits such as individual agreeableness or conscientiousness (Barrick et al., 1998)] on group effectiveness and performance (Halfhill et al., 2005a; Peeters et al., 2006; Prewett et al., 2018; Taberner et al., 2010). Within the workplace, the terms "team" or "workgroup" typically refer to two or more individuals working together to achieve a common work goal or set of goals (Allen & Woodley, 2016).

In past research, researchers typically examine the relationship between the role of GPC and have operationalized personality in terms of *elevation* and *diversity* (Neuman et al., 1999), and in the GPC literature, usually referred to as Team Personality Elevation (TPE) or Team Personality Diversity (TPD). TPE is used to represent a team's mean level on a particular personal trait or a set of personality traits. For example, characterizing a team as high in TPE on extraversion would mean that the team, members are sociable, talkative, and assertive. In contrast, TPD is used to describe the differences among team members for a particular personality trait or set of traits. Teams that are high in terms of TPD are typically referred to as heterogeneous or complementary, whereas teams that are low on TPD are described as homogenous or supplementary. Many personality researchers have used the complementary vs. supplementary model of "person-environment fit" (Muchinsky &

Monahan, 1987) to examine the role of GPC on group effectiveness and group performance.

We believe that by matching player groups that possess traits that are complementary [diversity in a trait for contributing to the effectiveness of the group (Halfhill et al., 2005b)] and/or supplementary [team members have similar levels of the same trait to optimize performance (Halfhill et al., 2005b)] will not only improve the quality of the playing experience, but also exercise adherence. This is because if players are well-matched (when personalities do not clash and complement each other to increase group performance and effectiveness), they are more likely to enjoy the playing experience and continuation in exercise is also more probable. Furthermore, we expect that groups will enjoy their interaction together because their personalities will complement or supplement each other rather than clash. For example, based on GPC theory (Halfhill et al., 2005b), a group of players composed of relationship-oriented personality traits (traits that facilitate the interpersonal interactions necessary to work as a member of a team) such as agreeableness, cooperation, emotional stability, and helpfulness would enjoy their interaction during the game, while groups composed of traits that differ (“heterogeneous”) around certain personality variables where personalities between players clash (Vaccaro, 1988, as cited in Halfhill et al., 2005) would likely experience conflicts and not enjoy their interactions during the game.

The foundation study aimed at establishing the general idea of the research with personality type as the main characteristics for matching and group-based challenges as the main game feature. This study was approved by the Carleton University Research Ethics Board – B, protocol #11034, and was conducted in winter, 2020. In this study, a pair of players forms a group and is composed of supplementary (matched) or complementary (unmatched) combinations. A pair is *matched* when both players possess the same personality type (e.g., two TO players, two RO players), whereas a pair is *unmatched* when both players’ personality types are not the same which includes the groups we intentionally set (e.g., one TO player + one RO player)

and those with players who were neither TO or RO (identified as X (other)) so their results cannot be “personality-driven” (game actions/decisions were not made based on the player’s personality) as defined in our experiment.

5.1.2 Research Question and Hypotheses

The purpose of this study is to assess how personal characteristics of players, particularly personality, relate to game retention, and our main research question is “Can matching based on personal characteristics help with exergame retention?” Participation in challenges was the primary means of exercising in our test exergame. We hypothesized that personality composition of groups in our exergame can influence the number of challenges they send and accept, and as the result, the duration and level of exercise activity (which are the end goals). The reason behind this hypothesis was that if players are well-matched, they will agree on similar challenges (the only way to collect points) and are more likely to enjoy their interaction together which increases both play and exercise time.

Stemming from research conducted on the similarity-attraction perspective in the domain of interpersonal relations and group processes (Baskett et al., 1971; Condon & Crano, 1988; Montoya et al., 2008; Van Hoye & Turban, 2015), we hypothesized that TO groups would be attracted to other TO groups, RO groups would be attracted to other RO groups, yet TO–RO groups would experience tension. We also hypothesized that RO groups would thrive in the longer term because they would support each other and would not just be invested in winning in the short-term. Our main hypothesis is further broken down into eleven sub-hypotheses as follows:

- H1: Matched groups (TO player pairs or RO player pairs) will agree to engage in more challenges compared to unmatched groups (TO–RO player pairs and X player pairs).
- H2: Matched groups will gain more points (more activity level) than unmatched groups.
- H3: Matched groups will remain active for more days (overall retention) than unmatched groups.

- H4: TO groups will agree to and engage in more short duration (1-day) challenges.
- H5: RO groups will agree to and engage in a greater number of longer duration (3-day) challenges.
- H6: TO groups will be motivated to engage in non-friendly (competitive) challenges.
- H7: RO groups will be motivated to engage in friendly (cooperative) challenges.
- H8: Matched groups will experience higher levels of enjoyment than unmatched groups.
- H9: Matched groups will experience a stronger sense of social relatedness than unmatched groups.
- H10: Matched groups will experience a sense of social presence than unmatched groups.
- H11: Matched groups will have stronger intentions for future exergame play than unmatched groups.

5.2 Participants and Recruitment

Participants were recruited from the Carleton University community by posters (Appendix B) posted around the Carleton campus, email notices consisting of an invitation letter (Appendix C) sent to the students at Carleton School of Information Technology and advertised on the Carleton Research Participants Facebook group page. The inclusion criteria were that the participants must be over 18 years old, must own a Smartphone (Android or iPhone) with GoogleFit (www.google.com/fit/) app installed, have a Google account, and be in good health.

Twenty participants (12 *males*, 8 *females*; 10 pairs) ranging in age from 20 to 46 years old ($M = 31$ years, $SD = 7$ years) volunteered to participate in the study. Seven participants identified themselves as gamers and the remainder identified themselves as non-gamers. Gamers reported that they spend an average of 4 hours per week ($SD = 2.5$ hours) playing and engage in a variety of game genres ranging

from puzzles, racing and adventure games to first-person shooters, flight simulation and role-playing games. Sixteen participants reported that they participate in regular exercise at intensities ranging from light ($n = 5$), moderate ($n = 8$), and vigorous ($n = 3$). Participants who engaged in regular exercise spend an average of 5 hours per week ($SD = 3$ hours) exercising and participate in a variety of exercises such as swimming, yoga, cycling and weight training.

5.3 Materials

The primary tool used for this research was the ExerQuest game described in Chapter 4. To help with the measurement of various variables, we also used a combination of well-established and custom items into a series of questionnaire statements as described below and shown in Appendix G.

5.3.1 Variables and Measures

The independent variables for this study were the personality types (TO, RO, X) and the resulted groups (T, R, M, and X).

- T = all task-oriented player groups
- R = all relationship-oriented player groups
- M = (Mixed) a mixture of task- and relationship-oriented player groups
- X = (Other) neither task- nor relationship-oriented player groups

The dependent variables were determined based on our evaluation criteria and hypotheses and were primarily enjoyment and activity level. Both subjective and objective measures related to these variables were gathered for analysis. Subjective measures included: the level of enjoyment, social influence, and future intention to play. Objective measures included: the number of challenges created, accepted, declined, the number of challenge types (1-day, 2-day, and 3-day), and exercise points (calories burned). Personality (evaluated using the 50-items IPIP) was used as an independent variable (to formulate personality matching categories), while enjoyment, social presence, social influence, and intention for future play were dependent variable measures. The level of activity (collect exercise points) over the

longer term is an objective measure of retention, whereas the level of enjoyment as evaluated by the Intrinsic Motivation Inventory (Ryan & Deci, 1994) and intention for future play (Limperos & Schmierbach, 2016) is a subjective measure of retention.

Potential confounding variables can be exercise and fitness levels. Out of all participants who completed the demographics questionnaire (Appendix F, Part 1) and provided their height and weight, the Body Mass Index (BMI) breakdown was: overweight ($n = 8$), healthy ($n = 15$), and underweight ($n = 1$)¹². As for exercise, out of all 20 participants, 16 participants participate in exercise and 4 do not participate in exercise. The breakdown for exercise intensity was light ($n = 5$), moderate ($n = 8$), and vigorous ($n = 3$), and when paired, the resulting groups are as follows:

- One group consisted of two members who do not participate in exercise.
- One group consisted of two members who participate in light intensity exercise.
- One group consisted of two members who both participate in moderate intensity exercise.
- One group consisted of one member who participates in light intensity exercise, and the other member does not participate in exercise.
- One group consisted of two members who both participate in moderate intensity exercise.
- Two groups were composed of one member who participates in light intensity exercise, while the other member participates in moderate intensity exercise.
- Three groups were composed of one member who participates in moderate intensity exercise, and the other member participates in vigorous intensity exercise.

This breakdown is too small to treat exercise level as an independent variable and conduct a meaningful analysis.

¹² The total N of 24 for BMI is different from the N used for conducting the analysis for personality (N = 16 after the 30-day period; N = 17 after the 60-day period) because not all who completed the demographics questionnaire (Appendix F, Part 1) participated in the study.

5.3.2 Subjective Measures

5.3.2.1 *Personality*

Individual personality was measured by the 50-items International Personality Item Pool (IPIP) (Appendix F, Part 2) which is a representation of the Goldberg (1992) markers for the Big-Five factor structure and was used as an independent variable (to determine groups) for the study. It is frequently used and is publicly available to researchers on the IPIP website at no cost¹³ (Goldberg et al., 2006). The 50-item IPIP-FFM inventory is psychometrically strong because it yields good internal consistency and relate strongly to major dimensions of personality (Gow et al., 2005). Other researchers have attempted to reduce the number of items (e.g., 10-item measure (S D Gosling et al., 2003) 20-item measure (Donnellan et al., 2006)) primarily to shorten the amount of time, particularly in studies where participants will be completing a number of items. However, research shows that these shorter measures are susceptible to Type 1 and Type 2 error rates (Credé et al., 2012). Other researchers (e.g., Tondello, Mora, & Nacke, 2017) who have examined the effects of gameful design and personality also recognizes that short scales is subject to acquiescence issues and suggest that future research could verify specific claims in focused studies. Because of such limitations associated with brief measures and because of our primary interest in personality, we have decided to use a version of the IPIP consisting of more items rather than less.

To interpret individual scores, the IPIP website¹⁴ suggests that one might calculate the mean and standard deviations (SD) for a sample of persons and interpret score within one-half SD of the mean as “average.” Scores beyond that range can be interpreted as “low” or “high.” It is recommended to compute means and SD in one’s

¹³ <http://ipip.ori.org/newQform50b5.htm>

¹⁴ <https://ipip.ori.org/InterpretingIndividualIPIPScaleScores.htm>

own sample rather than norms¹⁵ because is not “obvious” that one could ever find a population of which one’s present sample is a representative subset.

5.3.2.2 Enjoyment

Enjoyment was measured by the Intrinsic Motivation Inventory (IMI) developed by Deci and Ryan (2000) (Appendix G). The IMI is a multidimensional instrument designed to evaluate participant subjective experience related to a target activity in laboratory settings using a 7-point Likert scale (1 = not at all true to 7 = very true) and has been used in studies related to intrinsic motivation and self-regulation (Ryan et al., 1991; Ryan & Plant, 1985; Ryan et al., 1983). It consists of six subscales: (1) interest/enjoyment, (2) perceived competence, (3) effort, (4) value/usefulness, (5) felt pressure and tension, and (6) perceived choice. The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation; thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, it is only the one subscale that assesses intrinsic motivation. The IMI items can be modified slightly to fit specific activities. Because we are interested in game enjoyment, the items were adjusted as they relate to the gaming experience (e.g., “I enjoyed doing this activity very much” to “I enjoyed playing this game very much”). To score the IMI, which is available on the Center for Self-Determination Theory website¹⁶, the reverse score items need to be subtracted from 8 and use the resulting number as the item score followed by calculating the subscale scores by taking the average across all the items on that subscale.

5.3.2.3 Social Presence/Influence

Social presence was measured using a module of the Game Experience Questionnaire (GEQ) developed by Kort, IJsselsteijn and Poels (2007). The module was designed to assess psychological and behavioural involvement of the player with other social entities, be they virtual (e.g., in-game characters), mediated (e.g., others playing

¹⁵ <https://ipip.ori.org/newNorms.htm>

¹⁶ <https://selfdeterminationtheory.org/intrinsic-motivation-inventory/>

online), or co-located. Research shows that positive relationships between feelings of social presence and continued intentions for playing online games (Tseng et al., 2015). The GEQ is widely applied in games research (Law et al., 2018) and fits with the purpose of the present study as we are interested in the effects of social and continued play. While the original uses a 5-point scale (0 = not at all to 4 = extremely) we have decided to use a 7-point scale to maintain consistency with other items presented in the post-game questionnaire (Appendix G). Social influence will be measured using custom items used in our previous work that evaluated the effects of competitive/cooperative play between player pairs (Chan et al., 2017). Participants indicated their level of agreement on a 7-point Likert scale from 1 = strongly disagree to 7 = strongly agree.

5.3.2.4 Future Intention to Play

Future intention for exergame play was evaluated using a 5-item measure which was developed based on studies involving technology adoption (Venkatesh & Davis, 2000) and was purposefully selected to evaluate intended future exergame play. This instrument has been used in other studies (e.g., Limperos & Schmierbach, 2016) examining the likelihood for future intention for continued exergame play. Participants indicated their level of agreement on a 7-point (1 = strongly disagree to 7 = strongly agree) Likert scale. Due to the repetitiveness of the items, we decided to reduce the number of statements to three which were included in the post-game questionnaire (Appendix G).

5.3.3 Objective Measures

5.3.3.1 Number of Challenges

An objective measure of enjoyment is the number of times that friendly and non-friendly challenges are accepted and rejected by player pairs. The more accepted a challenge type, indicates that certain personality pairings enjoyed a certain type of challenge more. We expect that player pairs will engage in challenges that are congruent with their personality type. For example, RO-RO pairings will likely

engage in more friendly challenges than non-friendly challenges, whereas TO–TO pairings will likely engage in non-friendly challenges than friendly challenges. Relatedly, we expect that RO–RO pairings are more likely to accept a greater number of friendly challenges than non-friendly challenges, whereas task-oriented pairings are more likely to accept a greater number of non-friendly challenges than friendly challenges. RO–RO pairings will more likely reject non-friendly challenges, while TO–TO pairings will more likely reject friendly challenges. The number of accepted and rejected challenges in all groups was tracked by the backend system and displayed on the frontend of the game interface (Figure 5.1).

Kannerites		
Challenges Created: 2		
Challengee	Accepted	Declined
Solatrons	2	0
Challenges Accepted: 2		
Accepted Challenge From	#	
Administrator	1	
Solatrons	1	
Challenges Declined: 0		
Solatrons		
Challenges Created: 6		
Challengee	Accepted	Declined
Kannerites	1	0
Michromers	2	0
Tellemars	0	0

Michromers		
Challenges Created: 0		
Challenges Accepted: 3		
Accepted Challenge From	#	
Administrator	1	
Solatrons	2	
Challenges Declined: 0		
Tellemars		
Challenges Created: 1		
Challengee	Accepted	Declined
Michromers	0	0
Challenges Accepted: 1		
Accepted Challenge From	#	
Administrator	1	
Challenges Declined: 0		

Figure 5.1: Summary of accepted vs. declined challenges for all three categories of personality-based groupings.

5.3.3.2 Exercise Points

Exercise points are also an objective measure of the level commitment and retention. The more points gained demonstrates that players are more committed to the group and motivated to perform exercise. Week-by-week trends can show the level of commitment and retention. We expected that matched groups (TO–TO and RO–RO) will motivate each other to earn exercise points, yet unmatched groups (TO–RO and

X) will earn less points due to personality clashes between player pairs. Groups that are persistent in earning points show that they are motivated by achievement which aligns with TO personality traits, while if there is a pattern that points decline overtime and shows that groups are not motivated by achievement.

5.3.3.3 Active Duration

Active duration is an objective measure of overall retention. The number of challenges that each group participates in per week and the groups that are not in the game can be an indication of overall retention. As the weeks go by, we expect that the retention of matched groups (TO–TO and RO–RO) will be longer than unmatched groups (TO–RO and X). Again, this is based on our assumption that matched groups are more likely to get along well, whereas unmatched groups are more likely to clash.

5.4 Procedures

After receiving clearance from the university ethics committee, the recruitment for participants commenced.

Individuals who respond to the recruitment notice expressing interest were offered an opportunity to participate. Prior to participation, participants were emailed a consent form (Appendix E) and were reminded that their level of physical activity will be tracked. The researcher introduced the purpose of the study and explained the nature of their participation in the welcome email (Appendix D). Once the participant replied to the researcher with a signed copy of the consent form, the participant was asked to complete a demographics questionnaire (Appendix F, Part 1) followed by a personality questionnaire (Appendix F, Part 2). To start tracking activity, participants were asked to install GoogleFit (<https://www.google.com/fit/>) on their smart phone and allow ExerQuest permission to access the collected data.

As soon as the personality type of the participant was calculated, the researcher placed the participant into one of four personality grouping categories: (1) RO–RO (two relationship-oriented players), (2) TO–TO (two task-oriented players), (3)

TO–RO (one task-oriented and one relationship-oriented player), and (4) X (two players who were neither task, nor relationship-oriented – identified as “other”).

Prior to analyzing any data, the personality type of each participant needs to be determined. To categorize participants, the data collected from the pre-game questionnaire that evaluated personality were scored for each participant. Halfhill et al. (2005) found that conscientiousness and openness are frequent predictors of TO traits, whereas extroversion, agreeableness, and emotional stability seem to be predictors of RO traits. Researchers such as Zhou et al. (2015) have examined the effects of shared leadership on group performance using the TO and RO model.

To compute TPD, Zhou et al. (2015) followed Barrick et al. (1998) method of calculating means and Standard Deviations (SD) on each Big-Five personality trait at the team level and then SD on Openness and Conscientiousness were combined to obtain the TO personality diversity score, whereas SD on Agreeableness, Extraversion and Emotional Stability were combined to obtain the RO personality diversity score. Rather than at the team level (a group of individuals), we computed TO and RO scores for individuals by combining scores on different personality traits and comparing their relative magnitudes. We defined TO by combining Conscientiousness and Openness and RO by combining Extraversion, Agreeableness and Emotional Stability scores. This is similar to what other researchers (e.g., Zhou et al., 2015; Barrick et al., 1998) did, but at the level of individuals rather than groups. To compute TO and RO scores for individuals, we first transformed all scores (O, C, E, A and ES) to standardized scores (T-scores) using the formula $50 + [10 \times (x - \text{mean}) \div \text{SD}]$ using separate means and Standard Deviations (SD) for each personality trait score: O, C, E, A and ES. The new means for the five transformed Big-5 scores were 50 and the *SD* was all 10. Finally, a TO score for an individual was computed by averaging the T-transformed C and O scores, whereas RO scores for an individual was computed by averaging the T-transformed E, A and ES scores. A $\frac{1}{2}$ *SD* was interpreted as an appreciable difference — translated to T-scores, TO and RO would have to differ by at least 5 to say that one is higher than the other.

Normalization using T-scores is popular in hypothesis testing and converts individual scores into a standard form and has been used by other researchers including Schmitt et al. (2007). We believe that personality traits are social constructs and relative in nature. In our case, it is important to compare the relative effect of TO and RO (i.e., show “the more” an individual is TO, the more they may be interest in a particular game feature). As such, we believe that the normalized numbers should be used, but we compare the effect of this normalization. However, we recognize that there can be different ways to compute TO and RO scores (e.g., using data from large sample personality studies to estimate the mean and SD for the T-scores), and thus, any explanation of the study’s data from here on should be interpreted cautiously. The results of computing non-normalized scores showed that most of the participants in our dataset scored high on TO which makes the analysis meaningless because the majority will be groups composed of TO individuals. The reality is that they have relative differences in the level of being TO, and thus, we continued with the use of normalized scores to create player groups.

Using the normalized method (computation of T-scores¹⁷), out of 20 participants, six were identified as TO, six were identified as RO, and the remainder as unknown (less than ½ SD difference). 10 player pairings were balanced as much as possible forming 4 player pairing categories:

- (1) Two pairs of TO–TO (matched),
- (2) Two pairs of RO–RO (matched),
- (3) Two pairs of TO–RO (unmatched), and,
- (4) Four pairs of others (unmatched).

TO–TO and RO–RO groups are supplementary (matched) in that both players share the same personality type, whereas TO–RO and X are complementary (unmatched)

¹⁷ Example calculation for TO score: the average of [normalized Conscientiousness score $(50 + (10 \times (47 - 34.96) \div 5.17) = 73.32)$ and the normalized Openness score $(50 + (10 \times (38 - 39.26) \div 4.14 = 46.95))$] = 60.13.

in that both players have different personality types. Teams were assigned to each guild as follows: Guild 1 (2 TO teams), Guild 2 (2 RO teams), Guild 3 (2 Mixed teams), and finally, Guilds 4 and 5 (all others).

An email notification was sent to the participant consisting of a link to the game interface to begin playing sessions. Over the next 30-days, participants engaged in challenges and the number of challenges created, accepted, and declined between and within each group was recorded. At the end of the 30-day period, participants were asked to complete a post-game questionnaire (Appendix G) to evaluate their playing experience. If participants wished to continue for 30-days more, then they were asked to complete the post-game questionnaire (Appendix G) again to evaluate their playing experience. The game lasted for a total of 60-days. Finally, participants received an email enclosed with a debriefing form (Appendix H) and a \$20.00 Tim Horton's gift card in appreciation of their participation in this study. Participants who are outside of Canada were offered a Starbucks e-card in the currency of the country in which they reside equivalent to \$20.00 Canadian dollars.

5.5 Results

We present our results along with our eleven hypotheses. We also present some qualitative results as evaluated by the open-ended questions in the post-game questionnaire (Appendix G). Data were computed using IBM SPSS for Windows Version 27.0 (SPSS, Chicago, Illinois, USA) and prior to computation of statistics, the dataset was screened for missing values, outliers, and out-of-range values. Non-parametric tests were selected because the use of an ordinal scale in the post-game questionnaire (Appendix G) and the distribution of the data were not normally distributed (most p-values are less than or equal to 0.05) as verified by a Shapiro-Wilk test of normality¹⁸ (Table 5.1) and frequency histogram plots (Appendix I). Table

¹⁸ The Shapiro-Wilk test rejects the hypothesis of normality when the p-value is less than or equal to 0.05.

5.2¹⁹ further summarizes the descriptive statistics for both subjective and objective data between the two personality grouping categories (matched vs. unmatched) for the 30-day period (N = 16), followed by the 60-day period (N = 17).

Table 5.1: Descriptive statistics and Shapiro-Wilk test for normality for subjective and objective measures.

(30-day, N = 16)		Descriptive Statistics				Shapiro-Wilk			
Subjective Measures		Mean	SD	Median	Skewness	Kurtosis	W	df	p
Enjoyment		4.59	1.44	5.00	-0.15	-0.94	.89	16	.05
Value		5.30	1.36	6.00	-0.90	0.25	.89	16	.06
Choice		5.81	1.17	6.00	-1.03	0.83	.86	16	.02
Relatedness		4.52	1.52	4.00	-0.22	-0.30	.95	16	.50
Pressure		2.44	1.25	2.00	1.02	0.30	.83	16	.01
Effort		4.01	1.28	4.00	0.05	-1.11	.87	16	.03
Competence		4.39	1.33	4.00	-0.39	-0.17	.92	16	.18
Social Presence		4.23	1.53	4.00	-0.32	-0.48	.94	16	.41
Future Intention		4.35	1.59	5.00	-0.62	-0.57	.88	16	.04
Subjective Measures									
(60-day, N = 17)		Mean	SD	Median	Skewness	Kurtosis	W	df	p
Enjoyment		4.64	1.68	5.00	-0.66	-0.37	.86	17	.02
Value		4.89	1.89	5.00	-0.76	-0.52	.86	17	.02
Choice		5.24	1.71	6.00	-1.43	1.48	.81	17	.00
Relatedness		4.29	1.28	4.00	-0.50	-0.50	.96	17	.55
Pressure		2.22	1.35	2.00	1.37	1.28	.69	17	.00
Effort		3.60	1.47	4.00	-0.09	-0.99	.90	17	.06
Competence		4.25	1.56	4.50	-0.29	-0.54	.92	17	.13
Social Presence		4.17	1.71	4.00	-0.08	-0.83	.91	17	.09
Future Intention		4.24	2.03	5.00	-0.39	-1.42	.88	17	.04
Objective Measures									
(60-days, N = 20)		Mean	SD	Median	Skewness	Kurtosis	W	df	p
Number of challenges	Received	1.94	1.57	1.50	1.01	1.09	0.92	8	.42
	0-Accepted	0.00	0.00	0.00	—	—	—	8	—
	1-Accepted	0.56	0.90	0.00	1.30	-0.26	0.65	8	.00
	2-Accepted	1.63	1.06	1.50	0.04	-0.94	0.91	8	.34
	Initiated	2.13	1.89	1.50	1.30	1.94	0.88	8	.18
	Sent	2.00	2.00	1.50	1.14	1.36	0.89	8	.22
	Started	3.00	2.56	2.00	1.09	0.99	0.91	8	.33
Points (calories burned)		3496.27	1973.53	2953.50	0.57	-0.82	0.88	8	.18
Active days		1.76	0.85	1.50	0.36	-1.12	0.74	8	.01

¹⁹ The N = 17 is odd because not all 20 participants completed the post-game questionnaire. Only 17 individual participants completed the post-game questionnaire after the 60-day period and thus, 17 data points were used for analysis.

Table 5.2: Descriptive statistics for objective and subjective data with respect to matched and unmatched personality groupings.

(30-day period, N = 16)		Personality grouping categories									
		Matched (n = 5)					Unmatched (n = 11)				
Subjective measures		M	SD	Mdn	Skew	Kurt	M	SD	Mdn	Skew	Kurt
IMI	Enjoyment	5.06	1.85	6.00	-0.67	-1.04	5.06	1.85	6.00	-0.62	-1.11
	Relatedness	5.25	1.46	5.50	-0.30	-0.86	4.19	1.44	4.00	-0.30	-0.10
	Value	5.37	1.70	6.00	-1.04	-0.10	5.27	1.19	5.00	-0.74	0.29
	Choice	6.40	0.89	7.00	-1.26	0.31	5.55	1.21	6.00	-0.95	0.65
	Pressure	2.04	1.24	2.00	1.20	0.75	2.62	1.22	2.00	1.10	0.33
	Effort	4.36	1.32	5.00	-0.50	-0.86	3.85	1.24	4.00	0.29	-0.91
	Competence	4.93	1.23	5.00	-0.34	-0.40	4.14	1.31	4.00	-0.43	-0.19
GEQ	Presence	4.83	1.68	5.00	-0.88	0.24	3.95	1.37	4.00	-0.28	-0.46
Future intention		4.67	2.02	6.00	-1.26	-0.03	4.21	1.36	4.00	-0.17	-0.73

(60-day period, N = 17)		Personality grouping categories									
		Matched (n = 7)					Unmatched (n = 10)				
Subjective measures		M	SD	Mdn	Skew	Kurt	M	SD	Mdn	Skew	Kurt
IMI	Enjoyment	4.10	2.06	5.00	-0.29	-1.42	5.01	1.23	5.00	-0.27	-0.36
	Relatedness	4.36	1.21	4.00	-0.54	0.79	4.25	1.33	4.00	-0.48	-0.43
	Value	4.10	2.18	5.00	-0.21	-1.46	5.44	1.43	6.00	-0.89	0.33
	Choice	5.43	2.07	6.00	-2.07	4.69	5.10	1.52	5.50	-1.15	0.82
	Pressure	2.00	1.43	2.00	1.84	2.56	2.38	1.28	2.00	1.14	1.02
	Effort	3.57	1.58	3.00	0.19	-1.02	3.62	1.40	4.00	-0.35	-0.96
	Competence	3.62	1.55	4.00	0.14	-0.79	4.70	1.42	5.00	-0.59	0.43
GEQ	Presence	3.52	1.89	4.00	0.33	-1.01	4.62	1.43	4.50	-0.01	-0.68
Future Intention		3.71	2.35	3.00	-0.06	-1.89	4.60	1.71	5.00	-0.47	-1.33

(60-day period, N = 20)		Personality grouping categories									
		Matched					Unmatched				
Objective measures		M	SD	Mdn	Skew	Kurt	M	SD	Mdn	Skew	Kurt
Number of challenges	Received	2.50	2.75	1.71	0.75	0.34	1.00	1.13	1.03	0.71	1.79
	0-Accepted	0.00	0.00	0.00	—	—	0.00	0.00	0.00	—	—
	1-Accepted	1.00	1.00	1.15	0.00	-6.00	0.00	0.13	0.25	2.00	4.00
	2-Accepted	2.50	2.25	0.96	-0.85	-1.29	1.00	1.00	0.82	0.00	1.50
	Initiated	2.50	3.00	2.16	1.19	1.50	1.00	1.25	1.26	1.13	2.23
	Sent	2.50	3.00	2.16	1.19	1.50	0.50	1.00	1.41	1.41	1.50
	Started	3.50	4.25	2.87	0.85	-1.29	1.50	1.75	1.71	0.75	0.34
Points (calories burned)		4081	2124	3675	0.33	-1.44	3145	1862	2802	0.77	-0.18
Active days		2.00	0.89	2.00	0.00	-1.82	1.52	0.75	1.50	0.70	0.51

Note: **M** = Mean, **SD** = Standard Deviation, **Mdn** = Median, **Skew** = Skewness, **Kurt** = Kurtosis.

The sample size was reduced because out of 20 participants, 16 participants completed the questionnaire (Appendix G) after the 30-day study period, while 17 participants completed the post-game questionnaire (Appendix G) after the 60-day study period. This created an imbalance in the subjective data analysis. In total, there were 16 data points for the 30-day period, and 17 data points for the 60-day period, per individual. Table 5.3 summarizes the number of participants who completed the post-game questionnaire (Appendix G) after both the 30- and 60- day study periods with respect to the 4 different personality grouping categories (T, R, M and X). The alpha level was set at 0.05 for all statistical tests.

Table 5.3: Breakdown of personality grouping categories who completed the post-game questionnaire (Appendix G) after the 30- and 60-day study periods.

Study Period	N	Personality grouping categories			
		Matched		Unmatched	
		T	R	M	X
30-day	16	4	1	3	7
60-day	17	4	2	4	7

5.5.1 Objective Results

H1: Matched groups will agree to engage in more challenges compared to unmatched groups.

To determine which personality combinations (TO–TO (T), RO–RO (R), TO–RO (M for Mixed), and other (X)) preferred friendly vs. non-friendly challenges, we counted the number of challenges that were initiated (a challenge that was created by a player), sent (both players agreed, and the challenge was sent to the opponent), received (the challenge was received by the opponent), accepted (the opponent accepted the challenge) and started (both teams started the challenge).

Table 5.4 summarizes the number of friendly, non-friendly, and total challenges that were initiated, sent, received, accepted, and started with respect to each personality combination category. These results (Table 6.4) seem to suggest that matched groups (R and T) started more challenges compared to unmatched groups (M and X). Results

also show that R have disagreed more on non-friendly challenges and T disagreed on friendly challenges which supports our hypothesis that task-oriented groups prefer competition, whereas relationship-oriented groups prefer cooperation.

Table 5.4: The total number of friendly, non-friendly and total challenges that were received, accepted, initiated, sent, and started for each personality grouping category (matched and unmatched) over the 60-day study period.

Total sample size N = 20 participants (10 pairs)		Personality grouping categories					
		Matched			Unmatched		
		R	T	R+T	X	M	X+M
Friendly challenges	Received	2	1	3	0	1	1
	0-Accept	0	0	0	0	0	0
	1-Accept	0	0	0	0	0	0
	2-Accept	2	1	3	0	1	1
	Initiated	2	1	3	0	1	1
	Sent	2	1	3	0	1	1
	Started	2	2	4	0	2	2
Non-friendly challenges	Received	5	3	8	5	1	6
	0-Accept	0	0	0	0	0	0
	1-Accept	2	0	2	1	0	1
	2-Accept	3	3	6	4	1	5
	Initiated	3	6	9	6	1	7
	Sent	3	6	9	6	0	6
	Started	5	8	13	8	1	9
Total challenges	Received	7	4	11	5	2	7
	0-Accept	0	0	0	0	0	0
	1-Accept	2	0	2	1	0	1
	2-Accept	5	4	9	4	2	4
	Initiated	5	7	12	6	2	8
	Sent	5	7	12	6	1	7
	Started	7	10	17	8	3	11

Note: **R** = all relationship-oriented players, **T** = all task-oriented players, **M** = mixture of 1 relationship-oriented player and 1 task-oriented player, **X** = not TO nor RO (other), **0-Accept** = no player on the opposing group voted to accept the challenge, **1-Accept** = only one player on the opposing group voted to accept the challenge, **2-Accept** = both player on the opposing group voted to accept the challenge.

To examine the level of agreement between challenges, a Mann-Whitney U Test²⁰ (Nachar, 2008) was conducted on the number of challenges that were received, accepted, initiated, sent, and started for matched and unmatched groups. A Mann-Whitney U Test (also known as the Wilcoxon Rank Sum Test) is the non-parametric

²⁰ Assumptions: Independence of observations, continuous or ordinal measures.

version of the t-test and was selected because the kurtosis values generally deviated quite a bit from three²¹ (Table 5.1) suggesting that the shapes of the distributions were not normal. Although there were no statistically significant differences between matched vs. unmatched groups, mean rank results (Table 5.5), showed that matched groups received, accepted, (except for “0-accepted” where no players on the opposing group voted to accept the challenge), initiated, sent, and started slightly more challenges than unmatched groups, which somewhat supports **H1**.

Table 5.5: Mean rank results of Mann-Whitney U tests on the number of challenges there were received, accepted, initiated, sent, and started for matched and unmatched groups over the 60-day period.

Challenges	Personality grouping categories		Statistics	
	Matched (<i>Mdn</i>)	Unmatched (<i>Mdn</i>)	<i>Z</i>	<i>p</i>
Received	5.75 (2.50)	3.25 (1.00)	-1.48	0.14
0-Accepted	4.50 (0.00)	4.50 (0.00)	0.00	1.00
1-Accepted	5.25 (1.00)	3.75 (0.00)	-1.00	0.32
2-Accepted	5.88 (2.50)	3.13 (1.00)	-1.65	0.10
Initiated	5.63 (2.50)	3.38 (1.00)	-1.34	0.18
Sent	5.75 (2.50)	3.25 (5.00)	-1.47	0.14
Started	5.75 (3.50)	3.25 (1.50)	-1.48	0.14

H2: Matched groups will gain more points (more activity level) than unmatched groups.

Figure 5.2 shows the total exercise points over the course of the study (from January 15th to March 15th) that task-oriented groups collected the most points while from Figure 5.3 it seems that the level of commitment and retention for matched groups remained relatively consistent from one week to the next, whereas for unmatched groups, the level of retention was high at the beginning, but seemed to have drastically dropped near the end of the study. Figure 5.4 seems to show that unmatched groups started off being more active than matched groups. But, as the

²¹ A standard normal distribution as mesokurtic.

weeks went by, retention dropped. The level of retention for matched groups seemed to reach a peak after the third week and remained relatively consistent for the remainder of the study duration.

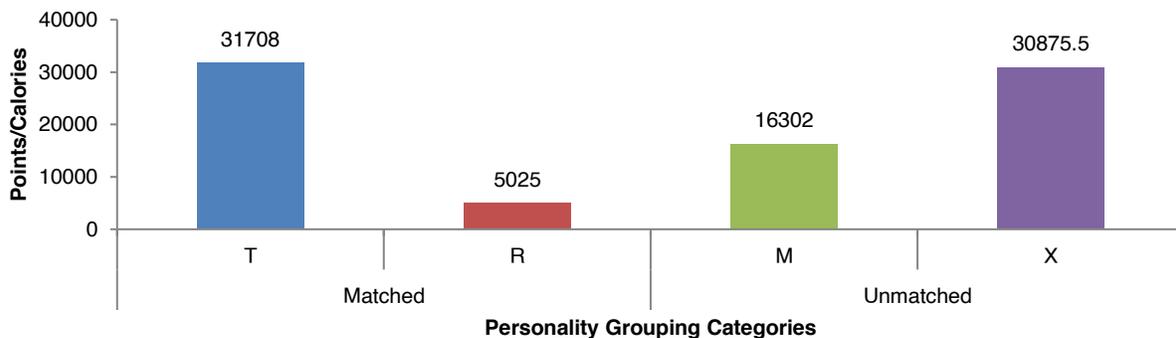


Figure 5.2: Total exercise points earned by each personality grouping category from January 15 to March 16, 2020.

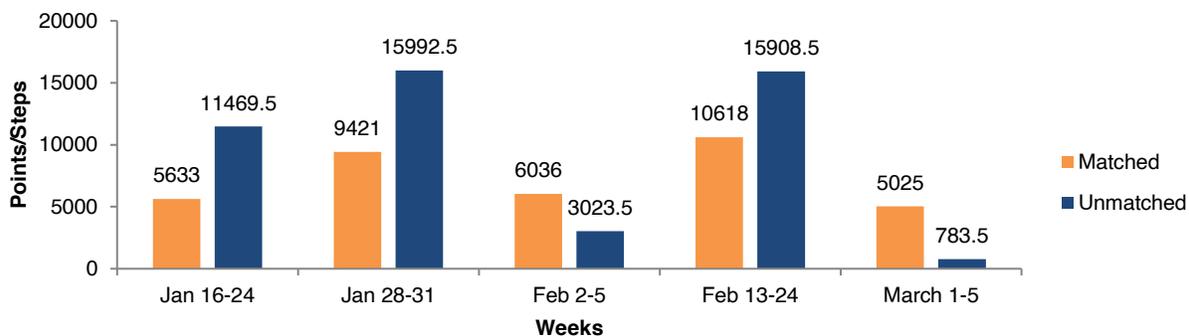


Figure 5.3: Exercise points collected by two personality groupings (matched and unmatched) for the duration of the study (from January 15 to March 16, 2020). Points for group X were divided in 1/2 to balance the number of player groups.

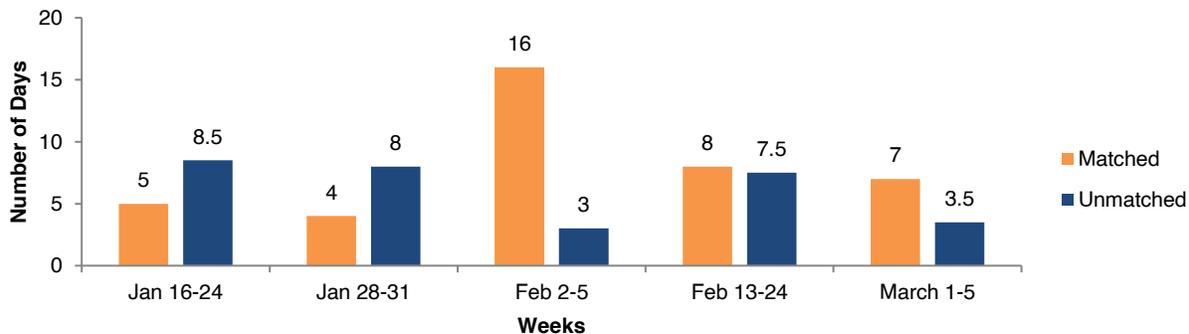


Figure 5.4: Active exercise durations by two personality groupings (matched and unmatched) for the duration of the study (from January 15 to March 16, 2020). Days for group X were divided in 1/2 to balance the number of player groups.

A Mann-Whitney U test was performed to compare the differences between personality groupings (matched vs. unmatched) on the number of calories burned (points earned) over the 60-day period. Results showed that there were no significant differences between matched ($Mdn = 3675$ calories/points) and unmatched ($Mdn = 2802.35$ calories/points) personality groups ($Z = -0.87$, $p = 0.39$), and thus, it is unclear whether matched vs. unmatched groups made a difference. However, mean rank results (Figure 5.5) showed slightly more calories burned for matched groups than unmatched groups, which somewhat supports **H2**.

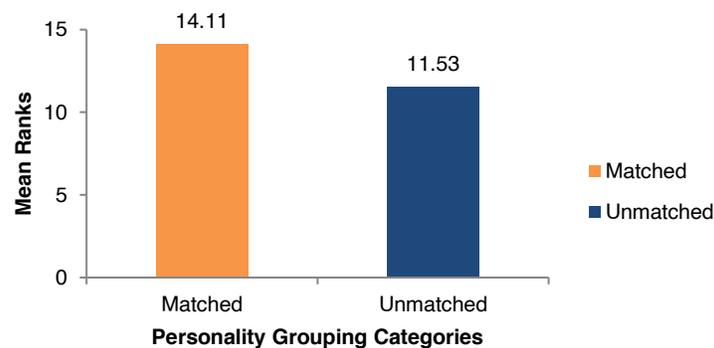


Figure 5.5: Mean rank results of a Mann-Whitney U test on the number of calories burned (points earned) for matched and unmatched personality groups over the 60-day study period.

H3: Matched groups will stay active for more days (overall retention) than unmatched groups.

A Mann-Whitney U test was performed to compare the difference for the number of days in each challenge that player groups were active between matched and unmatched personality groups over the 60-day period. Results showed that there were no statistically significant differences between matched ($Mdn = 2$ days) and unmatched ($Mdn = 1.5$ days) personality groups ($Z = -1.39$, $p = 0.16$) and thus, it is unclear whether matched vs. unmatched groups made a difference. However, mean rank results (Figure 5.6) showed slightly more days active for matched groups than unmatched groups. **H3** was somewhat supported.

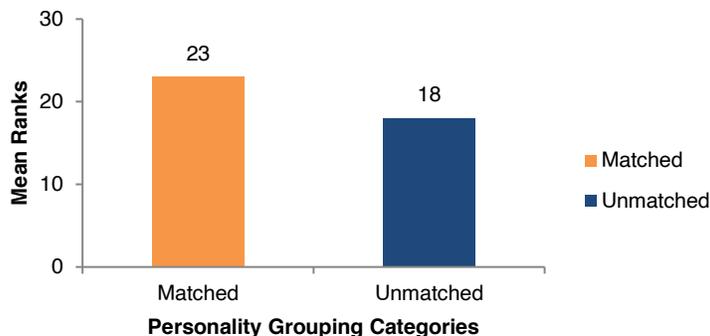


Figure 5.6: Mean rank results of a Mann-Whitney U test on active exercise days by matched and unmatched personality groups over the 60-day study period. Days for group X were divided in half to balance the number of player groups.

H4: TO groups will agree and engage in more short duration (1-day) challenges, and H5: RO groups will agree and engage in a greater number of longer duration (3-day) challenges.

Results in Figure 5.7 show the number of challenges that each personality grouping category participated in with respect to challenge duration. From a total of 26 challenges, task-oriented groups seem to prefer 1-day challenges, whereas X groups prefer 3-day challenges. **H4** was supported, however, **H5** was not.

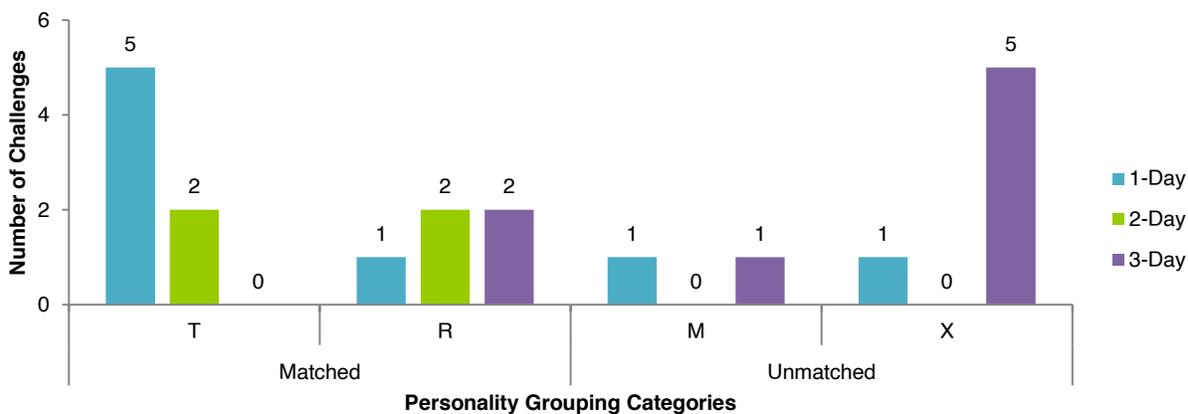


Figure 5.7: Number of active challenges by matched and unmatched player groups over the 60-day study period. The number of challenges for group X was divided in half to balance the number of player groups.

5.5.2 Subjective Results

The post-game questionnaire (Appendix G) asked participants to indicate their level of agreement or disagreement using a 7-point Likert scale (ranging from 1 = strongly disagree to 7 = strongly agree) on intrinsic motivation (which included the level of enjoyment, value/usefulness, perceived competence, effort/importance, pressure/tension, perceived choice, and relatedness), social influence, and intention for future play. Out of 20 participants, only 16 of them completed the post-game questionnaire (Appendix G). Descriptive statistics for each of the statements in the questionnaire after the 30-day period, and descriptive statistics for each of the statements in the questionnaire after the 60-day period are available in Appendix I.

5.5.2.1 Intrinsic Motivation (Enjoyment)

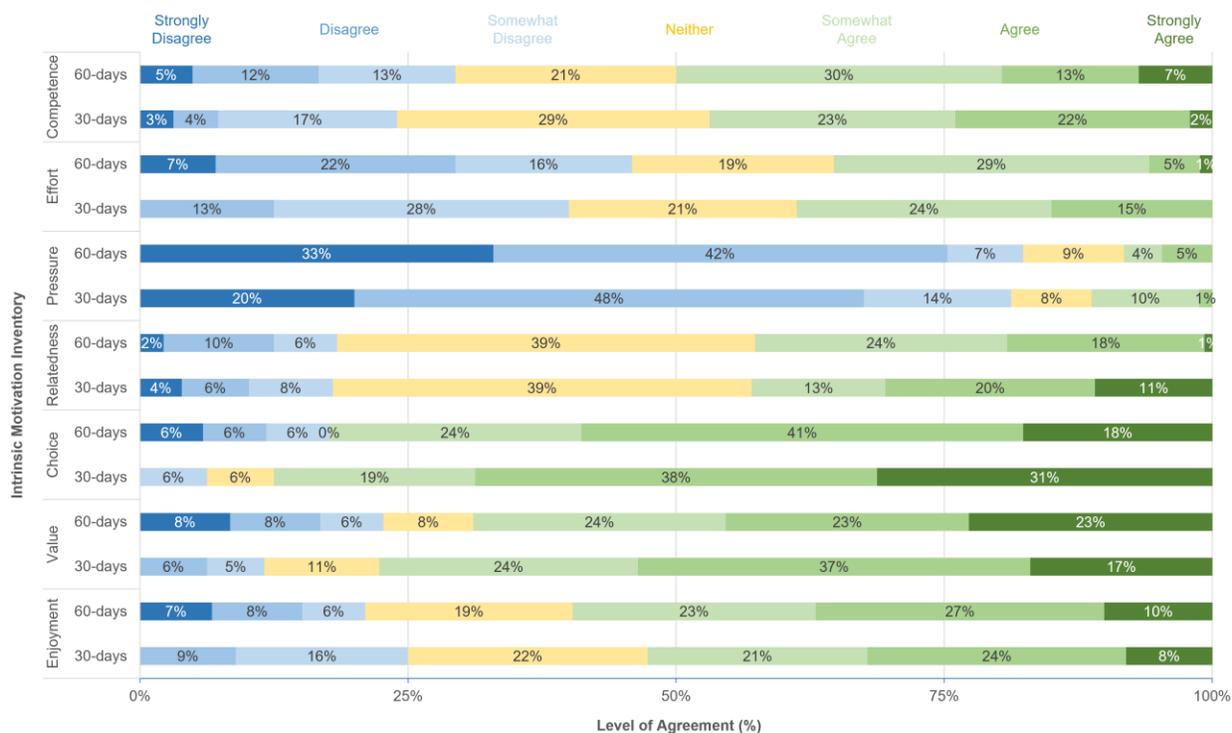


Figure 5.8: Intrinsic motivation inventory subscale score results summary over the 30-day (N = 16) and 60-day study period (N = 17).

The 100% stacked bar charts (Figure 5.8) summarize the 7 sub-scale dimensions of the IMI results of both the 30- and 60-day study periods. Overall, it seems that participants felt that the level of choice was high in the game and experienced a

relatively low amount of pressure while playing the game. As for the other measures (enjoyment, value, relatedness, effort, and perceived competence), were rated rather neutral.

H6: TO groups will enjoy non-friendly (competitive) challenges, and H7: RO groups will enjoy friendly (cooperative) challenges.

It was hypothesized that players would enjoy challenge scenarios that are congruent with their personality. For example, task-oriented teams would enjoy non-friendly challenges, whereas relationship-oriented teams would enjoy friendly challenges. Figures 5.9 and 5.10 seem to show that task-oriented groups enjoyed friendly challenges more than non-friendly challenges, relationship-oriented groups enjoyed equally both friendly and non-friendly challenges, mixed groups (1 task-oriented player, 1 relationship-oriented player), and other groups enjoyed friendly challenges slightly more than non-friendly challenges.

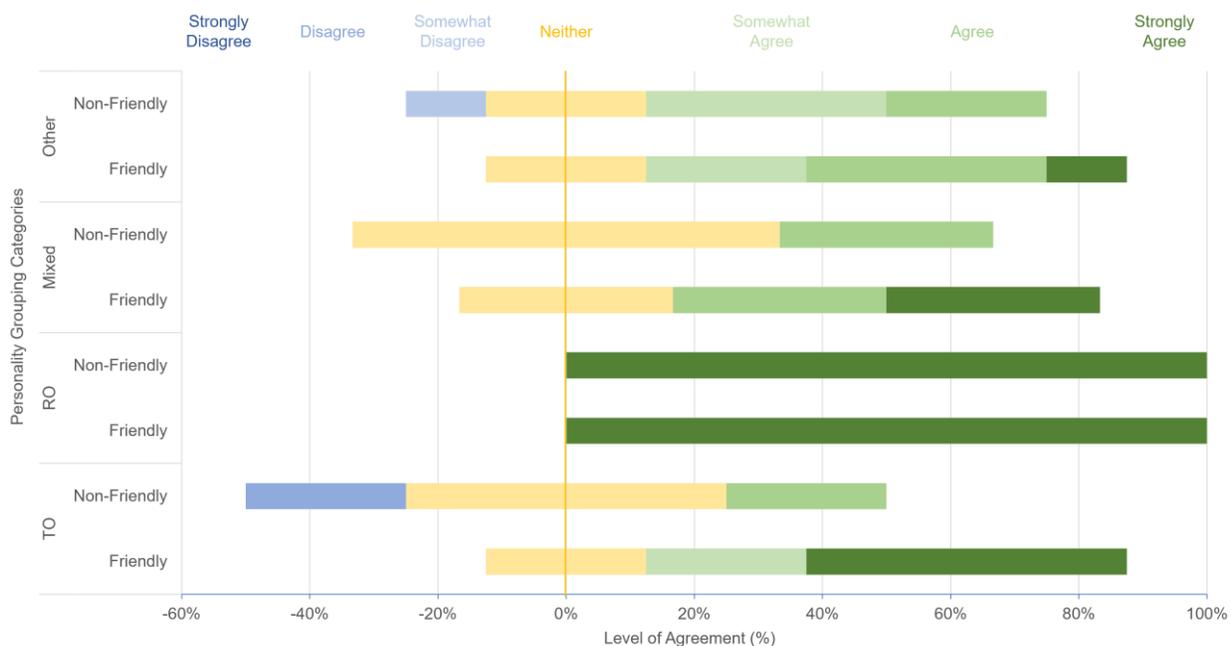


Figure 5.9: The level of enjoyment for both friendly and non-friendly challenges with respect to 4 personality grouping categories after the 30-day study period (N = 16).

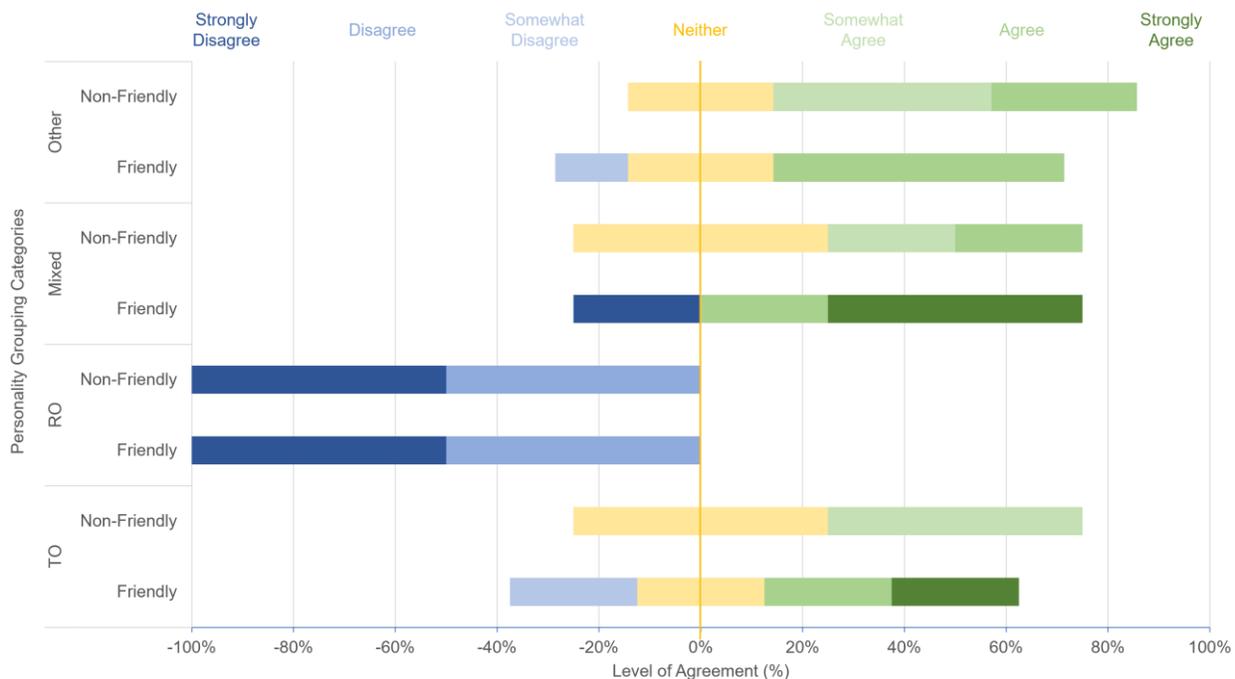


Figure 5.10: The level of enjoyment for both friendly and non-friendly challenges with respect to 4 personality grouping categories after the 60-day study period (N = 17).

To further examine the effect of personality matching, particularly T and R groups, on enjoyment between friendly and non-friendly challenges, a Wilcoxon matched-pairs test²² (also known as Wilcoxon signed-rank test) was conducted on 2 statements in the post-game questionnaire that evaluated the level of enjoyment for friendly (“I enjoyed playing friendly challenges.”) and non-friendly (“I enjoyed playing non-friendly challenges.”) challenges. A Wilcoxon matched-pairs test was selected for the analysis because the same participants completed the same questionnaire twice (once after the 30-day period, and again after the 60-day period) and the distributions of frequency histograms were skewed (Appendix J), which is further supported by the skewness and kurtosis values (Appendix I, Tables A1 and A2). Results (Table 5.6) showed no statistically significant differences for the level of enjoyment of friendly vs. non-friendly challenges with respect to any personality grouping categories after

²² Assumptions: The dependent variable is measured at the continuous or ordinal level; the independent variable consist of related groups.

the 30-day or 60-day study period. While subjective results showed no differences, the objective results presented in Table 5.4 shows that T groups engaged in more non-friendly challenges (8 started) than friendly challenged (2 started) which may suggest that they were motivated for the opportunity to earn bonus points. Likewise, R groups also engaged in more non-friendly challenges (5 started) than friendly challenges (2 started) which may suggest that R groups could have enjoyed engaging in non-friendly challenges more than friendly challenged. Based on the objective results, **H6** seems to be supported, but **H7** was not.

Table 5.6: Mean rank results of a Wilcoxon paired-samples test on the level of enjoyment for friendly and non-friendly challenges with respect to matched and unmatched personality grouping categories after the 30-days and 60-days study period.

30-Days. Total sample size N = 16 participants (8 pairs).					
Personality grouping categories		Challenge type		Statistics	
		Friendly (Mdn)	Non-Friendly (Mdn)	Z	p
Matched	T	0.00 (6.00)	2.00 (5.50)	-1.60	0.11
	R	0.00 (7.00)	0.00 (6.25)	0.00	1.00
Unmatched	M	0.00 (7.00)	1.50 (6.00)	-1.34	0.18
	X	0.00 (6.00)	2.00 (5.75)	-1.60	0.11
60-Days. Total sample size N = 17 participants (8.5 pairs).					
Matched	T	2.00 (5.00)	2.00 (4.50)	-0.58	0.56
	R	0.00 (1.50)	0.00 (1.50)	0.00	1.00
Unmatched	M	3.00 (6.50)	2.33 (4.50)	-0.76	0.45
	X	3.00 (6.00)	1.50 (5.00)	0.00	1.00

Note. **T** = TO player groups (2 TO players), **R** = RO player groups (2 RO players), **M** = Mixed player groups (1 TO player + 1 RO player), **X** = other player groups (2 X players). Not all 20 participants completed the post-game questionnaire and thus, the unbalanced participant pairs.

H8: Matched groups will experience higher levels of enjoyment than unmatched groups.

To determine whether the level of enjoyment persisted over the duration for matched and unmatched groups, a Wilcoxon paired-samples test was conducted on the enjoyment ratings evaluated by the interest/enjoyment subscale in the IMI. Results

(Figure 5.11) showed that after the 30-day period ($N = 16$), there were no significant differences between matched ($Mdn = 6.00$) vs. unmatched ($Mdn = 4.00$) groups ($Z = -1.43$, $p = 0.15$), but after the 60-day period ($N = 17$), matched ($Mdn = 5.00$) groups reported higher levels of enjoyment than unmatched ($Mdn = 5.00$) groups ($Z = -2.61$, $p = 0.00^{**}$). Furthermore, from the objective results in Table 6.4 that matched groups engaged in more challenges (17 started) than unmatched groups (11 started) suggesting that matched groups could have enjoyed their interactions more and so engaged in more challenges, which somewhat supports **H8**.

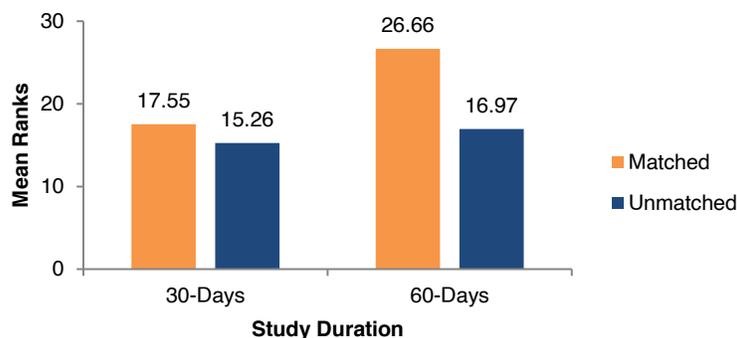


Figure 5.11: Mean rank results of a Wilcoxon paired-samples test for the level of enjoyment between matched and unmatched groups over the study duration.

5.5.2.2 Social Relatedness and Presence

H9: Matched groups will experience a stronger sense of social relatedness than unmatched groups.

To determine which player groups experienced a greater sense of social relatedness over the study duration, a Wilcoxon paired-samples test was conducted on the relatedness ratings evaluated by the relatedness subscale in the IMI. Results (Figure 5.12) showed that after the 30-day period ($N = 16$), unmatched ($Mdn = 4.00$) groups experienced stronger feelings of relatedness compared to matched ($Mdn = 5.50$) groups ($Z = -3.22$, $p = 0.00$), whereas after the 60-day period ($N = 17$), there were no statistically significant differences for feelings of relatedness between matched ($Mdn = 4.00$) vs. unmatched ($Mdn = 4.00$) groups ($Z = -0.14$, $p = 0.89$), which does not support **H9**.

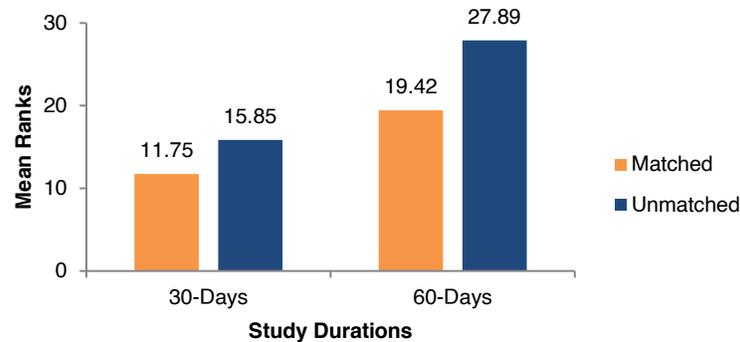


Figure 5.12: Mean rank results of a Wilcoxon paired-samples test for feelings of social relatedness between matched and unmatched groups over the study duration.

H10: Matched groups will experience a stronger sense of social presence than unmatched groups.

To determine which player groups experienced a stronger sense of social presence over the study duration, a Wilcoxon paired-samples test was conducted on the social presence ratings evaluated by the social presence module of the GEQ. Results (Figure 5.13) showed that after the 30-day period, there were no statistically significant differences between matched ($Mdn = 5.00$) and unmatched ($Mdn = 4.00$) groups ($Z = -1.51, p = 0.13$). However, after the 60-day period, matched ($Mdn = 4.00$) groups reported higher levels of social presence compared to unmatched ($Mdn = 4.50$) groups ($Z = -3.58, p = 0.00^{**}$), which supports **H10**.

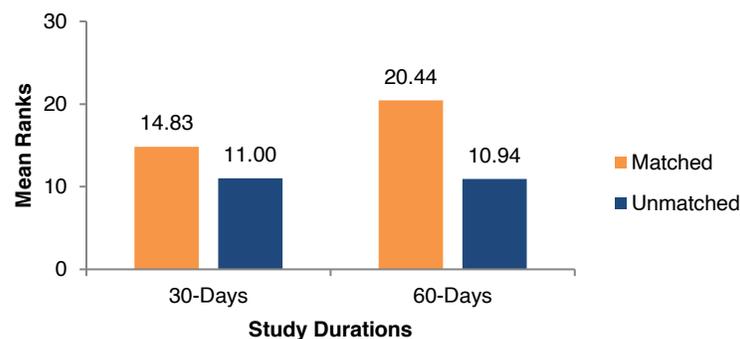


Figure 5.13: Mean rank results of a Wilcoxon paired-samples test for feelings of social presence between matched and unmatched groups over the study duration.

5.5.2.3 Intention for Future Play

H11: Matched groups will have stronger intentions for future exergame play than unmatched groups.

A Wilcoxon paired-samples test was conducted on the three items in the post-game questionnaire that assessed future intention for continued exergame play to determine which player groups have stronger intentions for future play. Results (Figure 5.14) did not show a statistically significant intentions for continued play after the 30-day period for matched ($Mdn = 6.00$) and unmatched ($Mdn = 4.00$) groups ($Z = -0.47, p = 0.64$), nor after the 60-day period for matched ($Mdn = 3.00$) and unmatched ($Mdn = 5.00$) groups ($Z = -1.22, p = 0.22$), which does not support **H11**.

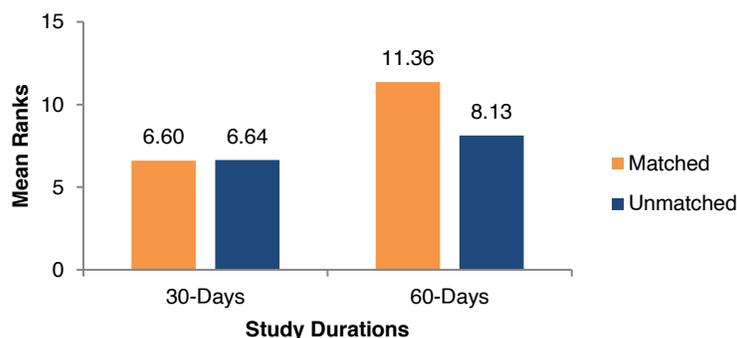


Figure 5.14: Mean rank results of a Wilcoxon paired-samples test for future intention for exergame play between matched and unmatched groups over the study duration.

5.5.3 Qualitative Results

Results presented in this section are comments that were gathered from the open-ended questions in the post-game questionnaire (Appendix G). Comments were organized into a spreadsheet, and all likes and dislikes regarding the game experience were scanned for patterns and commonalities as they relate to enjoyment and social interaction. Any indications related to personal characteristics (based on the task- and relationship model) were also noted that links personality to playing preferences.

In general, participants reported that they enjoyed the social aspect and were motivated by seeing their performance relative to other players. For example, one TO

participant said that “it’s exciting to check the results” [P2]. Similarly, another TO participant explained that “I liked being able to see where my team ranked and taking steps to improve our ranking” [P8] suggesting that TO participants seem to enjoy leaderboard elements and are motivated by achievement and performance. Furthermore, one more TO participant said that “it’s great to play in a group rather than individually” [P5] while a different TO participant thought that the game “has the ability to create a community of fun seekers who are also health enthusiasts” [P10]. These comments seem to suggest that TO players are interested in group play and motivated by earning points as they check their performance and see the game results. RO participants seemed to have also enjoyed the social aspects of the game experience. For example, one RO participant wrote that they liked “being part of a group challenge with many players” and “leaderboards to see other people participating in the game” [P7]. Another RO participant thought that “this game will be helpful to people in encouraging them to do exercises, especially when the social features are involved, people might wanna compete with their friends and gain more points” [P6]. In addition, one X participant felt that “I was more motivated to get steps in when I saw how well my partner was doing because I didn’t want to let them down” [P19] suggesting that the exergame experience could have created some degree of social influence/attachment to motivate exercise performance.

There were aspects of the game that participants did not like. Primarily, participants absolutely disliked the waiting time; out of the 16 who responded, 12 participants expressed how frustrating it was for them to have to wait for all players (particularly “uncommitted” members) to respond and agree before the challenge can start. Participants also complained about technical issues such as points not updating properly, the need to log out and back in to see the results, as well as the inconsistency between points earned and actual exercise activity.

Furthermore, participants had some recommendations for improving the game experience. One participant recommended the idea of system generated challenge templates which he can choose from. Another participant commented that “it would

be nice to see other teams' challenges to each other or receive updates about the game as a whole as it was easy to forget about participating with no updates, requirements for making challenges, or overarching reason to keep playing" [P1]. Several participants also wished for more social opportunities to play with their friends ("I loved the concept and wish more of my friends had this type of game" [P17]), more creative ways to play the game ("It would be nice to apply more creativity into the games" [P19]), as well as additional challenges ("I like to have more challenging tasks to keep me moving on" [P3]) and make use of the points earned ("I think it could be developed more so maybe you can use the points you acquire" [P10]).

5.6 Discussion

To summarize, results seem to show that grouping based on personality can have an effect of exergame retention. Based on the objective results there seemed to have been more consensuses between supplementary groups than complementary groups. More specifically, based on exercise points, T and X groups seemed to have been more engaged in the game compared to R and M groups. From the subjective results, R groups equally enjoyed both friendly and non-friendly challenges, whereas T groups seemed to have enjoyed friendly challenges more than non-friendly challenges even though the objective data showed that they engaged in more non-friendly challenges than friendly challenges. Furthermore, the R groups rated slightly being more socially influenced during the game and higher intention to continue play compared to the other three personality grouping categories.

Keeping players engaged over the long-term has been the subject of many studies (Caro et al., 2018; Kaos et al., 2019; Staiano et al., 2018). In this Foundation study, we aimed to increase game retention and exercise motivation by matching players using personality type. We designed an asynchronous exergame prototype (ExerQuest) and used it as a testbed to evaluate the possibility of matching players based on personality for motivating continued play. After 60-days, we have some preliminary evidence showing that matching players who possess similar personalities can increase retention. We offer our interpretations of the results and

some initial insights for game design in two propositions: (1) personality-based tailoring, and (2) personality-based matching.

5.6.1 Personality-Based Tailoring

Our results showed that TO groups engaged in more non-friendly (competitive) challenges to earn bonus points than friendly (cooperative) challenges, as well as short-term (1-day) challenges rather than long-term (3-day) challenges (**H6 and H4**). This preference was also reflected in the qualitative findings when a task-oriented participant reported that they were motivated by seeing their score and is consistent with the literature on GPC that individuals who score high on TO traits are motivated by achievement (Halfhill et al., 2005b). For game design, if a player scores high on TO traits, a game can offer the player short-term, competitive challenges.

However, our expectation that R groups would engage in long-term (3-day) friendly (cooperative) challenges (**H5**) was not supported. This could be due to the nature of the game design as R groups were challenged with short-term challenges more. Moreover, because individuals who score high on relationship-oriented traits tend to be agreeable and collaborative (Halfhill et al., 2005b), to maintain positive relationships, R groups were perhaps more hesitant to decline challenges even though the challenge type does not align with their personality as other researchers have found that players will participate in a game scenario that is incongruent with their motivational orientation even when they do not enjoy their playing experience (Song et al., 2013b). For game design, allow players who score high on RO traits to decline a challenge without penalty, but immediately recommend a different challenge scenario that is congruent with their personality to keep their motivation levels high.

5.6.2 Personality-Based Matching

According to the SDT (Richard & Edward, 2000) and psychological research on why people with similar personality patterns are especially inclined to like each other (Tenney et al., 2009), the matching of players who possess similar personalities was expected to strengthen the level of social connectedness (van Vianen & De Dreu, 2002)

and motivate continued play. However, we observed that after the 30-day period, unmatched groups experienced stronger feelings of relatedness compared to matched groups. This is inconsistent with the literature on personality and social cohesion (van Vianen & De Dreu, 2002) and can be attributed to the theory of desirable vs. undesirable traits (Tenney et al., 2009) that although studies have shown that similarity of personality patterns predicts relationship satisfaction (Cottrell et al., 2007; Hutto et al., 2011; Lykourentzou et al., 2016) the same results may not generalize to groups of acquaintances (Eastwick et al., 2007). In the context of this game, players recognize that they are only brought together temporarily to achieve a common goal, and thus, the level of motivation to establish stronger relationships were not as relevant compared to other contexts that do.

In addition to relatedness, social presence ratings were also collected. Results showed that after the 30-day period, there were no differences between matched and unmatched groups. However, after the 60-day period, matched groups reported higher levels of social presence compared to unmatched groups. This suggests that social relationships take time to develop (Hays, 1985). For game design, social activities/interactions can be offered early on to help players quickly build feelings of relatedness and development of friendships.

Finally, there were no significant differences between matched and unmatched groups for intention for continued play (**H11**). However, after the 60-day period, mean rank results (Figure 5.14) showed that matched groups rated their intention for future play slightly higher than unmatched groups. This seems to suggest that matched groups are more likely to continue, but more research is needed to confirm this observation.

As presented in the qualitative results, there were quite a few participants who were unsatisfied with “uncommitted” members who were unresponsive to the voting system. If players are left alone, the level of motivation drops. One possible solution can be to add more social features that can increase the level of participation and

ownership into the game. For example, one participant suggested displaying group challenges to other groups or receiving updates about the game. Being aware that other groups are involved could provide an additional source of social motivation.

5.6.3 Limitations and Future Work

Although these results show some interesting patterns, one drawback is that so far, we have only explored personality type as the personal characteristic and no other personal characteristics. Because we are interested in designing games and the effects of gamification on player matching and retention, it is pertinent to use another personal characteristic that is game-related, in addition to more generic personality. As such, we explored matching based on game-specific user models, aka gamer types, as discussed in the next Chapter 6 – the Addon Study.

Another weakness was the limited number of social features, and the voting system was cumbersome as the waiting time to start a challenge took too long resulting in declining interest. More features (particularly ones that allow for players to make choices and behave in a way that is congruent with their personality) could have made the game more interesting. Research shows that games can be highly motivating when players are provided the opportunity to make choices (Ryan et al., 2006) and persuasive technologies such as health-promoting applications are more effective when they are catered to individual personality (Halko & Kientz, 2010). There were also not enough activities to encourage interactions between players and ways for players to develop social relationships. Features that allow players to build stronger relationships and harness team effort could have increased the level of connectedness and engagement experienced between players as research shows that feelings of belongingness can increase exercise adherence (Kaos et al., 2019). As such, in the Addon Study (described in the next Chapter 6) we aimed to explore the kinds of social interactions and game features that would increase the level of participation and engagement.

Finally, one more limitation of the analysis is the small sample size which undermines the generalizability of the results. The very small sample size of the study also makes it difficult to detect significant effects as there were only 2 pairs in the R matched group category (with player with relationship-oriented personality traits), and other 2 pairs in the T matched group category (with players with task-oriented personality traits) which is hard to make comparisons that have a high statistical power. Furthermore, not all participants completed the post-game questionnaire. This is a common limitation in many other exergame-related research (Consolvo et al., 2006; Gao & Mandryk, 2011; Geelan et al., 2016; T. Park et al., 2012; Shaw et al., 2016) and calls for a future study to further examine the effects of matching players using task- and relationship-oriented traits using a larger sample. In attempt to reach a wider audience and increase the sample size, we employed a crowdsourcing platform as our recruitment method in the Addon Study (Chapter 6).

The groups were balanced at the beginning of the study, yet only 16 participants (3 RO, 5 TO, and 8 X) completed the post-game questionnaire which also led to an imbalance in the analysis of personality grouping categories (1 R, 2 T, 2 M, and 4 X). The low number of challenges between TO-RO groups (only 3 challenges) compared to other personality groups also diminishes the statistical validity of these results. Furthermore, X groups could potentially be identified as matched groups in that their personalities were similar.

One avenue for future research is that some researchers have examined the effects of existing positive relationships on asynchronous exergame retention and found that physical activity levels decline after 4 weeks of play (Caro et al., 2018), while other researchers have found that social support was reported as a key motivating factor for increasing physical activity, yet motivation is unsustainable beyond 6 weeks (Keeney et al., 2019). It would be interesting to further explore the long-term effects of player matching, the effect of friendship, along with other factors such as group cohesion (Carron et al., 2002) and other personal characteristics (such as gamer type or lifestyle) together with personality matching on motivating continued play.

The results are influenced by the particular game design. For example, the voting system proved to be cumbersome and delayed and as such reduced the motivation to engage. Future research may also focus on more user-friendly ways to incorporate group work.

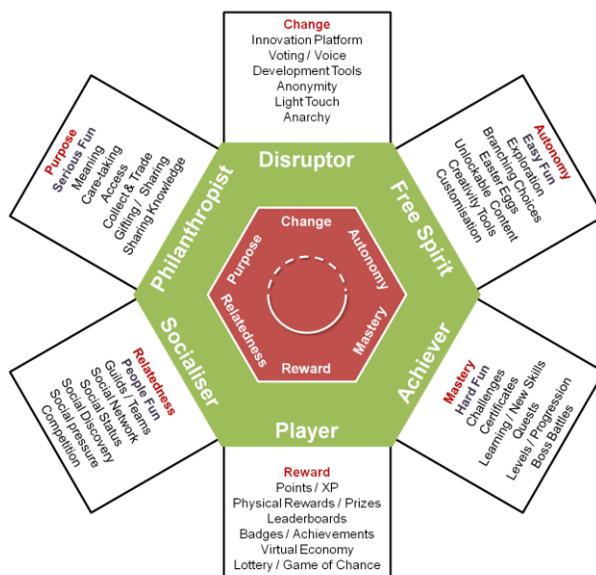
This research investigated the concept of matching players based on personality type and a method for testing its effectiveness for adherence to an asynchronous exergame. We grouped players based on matched and unmatched personality types and used a variety of game features such as points, groups and guilds, challenges, and a voting system to allow player's personality type to influence their gameplay experience. Matched personalities and agreement on performing were expected to increase player retention by players motivating each other to continue both exercise and play. While the results did not verify all our hypotheses, they were promising and showed some potential that can be explored further through better game design and incorporation of other personal characteristics and game features.

6 Add-on Study using Storyboards

6.1 Overview

6.1.1 Theoretical Rationale

In this add on study, we continued our investigation of matching using personal characteristics for exergame retention. We particularly focused on the effect of matching player types using the commonly used Hexad model (Marczewski, 2015) and investigated the relationship between their user type and various attitudes towards game elements. While not a rigorous psychological model, the Hexad has been used frequently as a common tool for understanding player preferences and perceptions of gameful design elements in different contexts and domains (Altmeyer et al., 2019; Mora et al., 2018; Orji et al., 2018b) and has been shown to be reliable (Tondello et al., 2016). Figure 6.1 illustrates the six user types from the Hexad model and game elements suggested by Marczewski (2015) to address the motivations of each type. Appendix K describes each element in the Hexad model in more detail as identified by Klock et al. (2020) from reviewing literature on tailored gamification.



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Figure 6.1: Gamification user types from the Hexad model and game elements suggested by (Marczewski, 2015) to address the motivations of each type.

Such a study will allow us to see if there are patterns of compatible interest between a team of players that can be used to (1) match the players, and (2) offer personalized features for a team of players. Due to COVID-19 pandemic restrictions and our goal to reach a wider audience, we utilized storyboards as our main design and a survey approach as our method.

Personalization, a method where the content is tailored by the system to individual preferences (Sundar & Marathe, 2010), is essential for gameful systems because it has been shown to be more effective at persuading attitude/behavior change than the “one-size-fits-all” approach (Busch et al., 2015b). While there are many studies on the effectiveness of personalizing game elements for individual player type (Altmeyer et al., 2019; Hirsh et al., 2012; Mattheiss et al., 2017; Orji et al., 2013; Zhao et al., 2020a), very little research has examined the effectiveness of personalizing game elements for player groups particularly in the domain of social multiplayer exercise games. In two latest reviews on existing gamified fitness tracker apps, the authors reported that social features were paramount in nearly every app they reviewed, particularly plot-based collaborative games, and proposed that a potential direction for future research is to perform a qualitative examination of collaborative games (Neupane et al., 2020, 2021).

As a theoretical argument, we believe that personalizing the playing experience and better player type-based pairings can enhance the level of social connectedness experienced between players and motivate intention for future play. This is based on psychological research conducted in the domain of interpersonal relations on the similarity-attraction perspective (Tenney et al., 2009; Van Hove & Turban, 2015) and past studies in multiplayer online game (Riegelsberger et al., 2007) and exergames (Chan et al., 2020) have shown the potential of matching players for increasing retention. Our Add-on study aims to add to the small body of research in the area by offering some insight into the association between the compositions of group player types on exergame adherence.

As mentioned in Chapter 2, many researchers are beginning to explore the value of personalized gamification systems on motivation (Busch et al., 2016; Klock et al., 2020; Passalacqua et al., 2020; Rodrigues et al., 2021; Passalacqua et al., 2021) and one of the most promising approaches to personalize gamified systems is using the Hexad user type model (Tondello et al., 2016). The model has been developed particularly for mapping user personality onto gamified design elements and has been researched for understanding and explaining user preferences and behaviours in gameful systems (Orji et al., 2018a; Tondello et al., 2017). The model proposes six player types (Table 2.3), and the player types of individuals are correlated with their preferences for different game design elements.

The Hexad is a trait-oriented scale which is similar to personality, not a type-oriented scale (Tondello, Arrambide, et al., 2019). That means that no individual is perfect on one specific type, rather, they have a dominant type but have attributes of other types. Some motivations underlying these user types are related and the user types themselves overlap slightly (Marczewski, 2015). For example, Achievers and Players are both motivated by achievement but differ in their focus. Players focus on extrinsic rewards, while Achievers focus on competence. Philanthropists and Socialisers are both motivated to interact with other players. However, they differ because a Socialiser's interest is in the interaction itself while a Philanthropist is motivated by interaction to help others. Although earlier works have attempt to classify players using a type-based approach (Busch et al., 2016) more recently, researchers are exploring the effectiveness of a traits-based approach for understanding player choices in games. Trait-oriented models are preferred in recent studies (e.g., Fortes Tondello et al., 2018; Tondello, Arrambide, et al., 2019; Tondello & Nacke, 2019) because an individual is rarely motivated by a single factor and because of their applicability to game user research in that they aim to characterize players using a set of scores rather than categorizing players into a single type.

In this add-on study, we take on a type-based approach as some studies show that considering the dominant personality dimension is more effective for personalizing

persuasive content (Hirsh et al., 2012). The contributions of this add-on study to the field of game design and human computer interaction are the following:

1. The design and evaluation of socially oriented game elements that can be used to match players using a player trait modeling approach.
2. A preliminary investigation of social features and design patterns that can be used to increase retention in games using the player matching based on personal characteristics.

6.1.2 Research Questions and Hypotheses

The purpose of this study is to examine the effectiveness of specific social game elements from increasing exergame retention in groups. Based on existing evidence from the literature on exergames and games user research, we formulated the following two research questions to explore if there are any relationships between player type and attitudes towards game features:

1. Based on the positive results of previous empirical studies on correlations among player types and game elements for effectively personalizing to individual preferences (Altmeyer et al., 2019; Hallifax et al., 2019; Orji et al., 2018b; Santos et al., 2021; Tondello et al., 2017), can the same results can be found in a group of individuals with similar or complementary characteristics? For example, we predict the following correlations:
 - a. Incentive elements such as bonus points will be positively correlated with groups composed of Player and Achiever dominant traits.
 - b. Altruism elements such as sharing of goods (donating points to other users) and collaboration with others will be positively correlated with groups composed of Philanthropist dominant traits.
2. Based on research showing the success of a gamified approach for designing mobile fitness applications for increasing retention (Altmeyer et al., 2018; Tu et al., 2019; Zhao et al., 2017a), the integration of social features can increase social closeness (Depping & Mandryk, 2017), and social patterns that improve

player retention in social exergames (Villareale et al., 2019), would a game design applying such patterns, as illustrated in the storyboards (Figure 6.4), elicit feelings of social connectedness between groups of players and the same long-term effects?

6.2 Participants and Recruitment

We conducted two rounds of data collection using a different recruitment strategy for each round and with two different groups of participants. We conducted two rounds of data collection because we employed an iterative sampling approach where we started recruiting a small number of responses (Round 1: $N = 60$) and engage in a preliminary analysis to verify if there are any emerging patterns (relationship between the features and player type) before moving forward with a larger sample (Round 2: $N = 136$, combined with Round 1, the total number of responses analyzed was 196).

6.2.1 Round 1

In the first round, we recruited participants by email (in both academic and non-academic contexts) and posting a notice on social networking sites such as an HCI Slack channel and Facebook. Participants had to be over 18 years old, understand English, own a computer or a mobile phone with a web browser installed, and internet connection to complete the survey. Participants who completed the survey providing meaningful response to all required questions received a \$10.00 Tim Hortons e-gift card in appreciation for their time. Our aim is to continue data collection until the results show a stable state (Schönbrodt & Perugini, 2013), not varying significantly by new data. Participants' average scores in the Hexad user types followed a similar distribution as reported in previous studies (Altmeyer, Tondello, et al., 2020b; Santos et al., 2021; Tondello et al., 2016, 2017; Tondello, Mora, et al., 2019). Philanthropists showed the highest average scores ($M = 23.55$, $SD = 3.18$), followed by Free Spirits ($M = 22.35$, $SD = 3.75$) and Achievers ($M = 22.20$, $SD = 3.96$) and Players ($M = 21.78$, $SD = 4.05$) and Socialisers ($M = 21.58$, $SD = 4.64$), while Disruptors ($M = 15.65$, $SD = 5.04$) followed with the lowest average scores.

Considering the Hexad model's theoretical background (Richard & Edward, 2000), similar to Tondello et al. (2016), we conducted bivariate correlation coefficients of each user type with all others using Spearman's rho. Results (Figure 6.2 and Table 6.1) shows that there were overlapping in the Philanthropist, Free Spirit, and Achiever types, which are similar patterns to the results reported in other studies (Tondello et al., 2016; Tondello, Mora, et al., 2019).

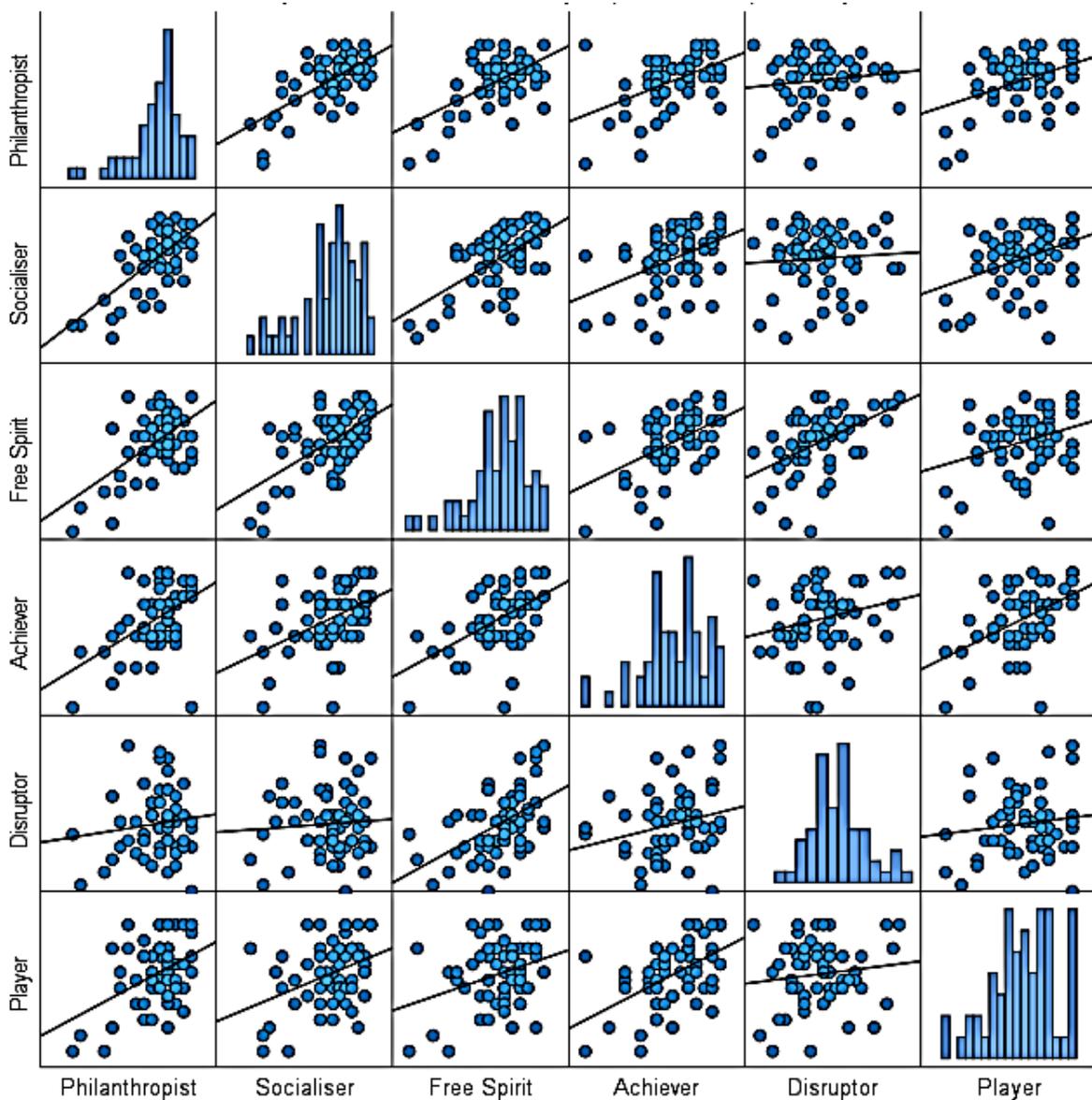


Figure 6.2: Scatterplot matrix of bivariate relationships between each Hexad user type and all others (N = 60).

Table 6.1: Bivariate correlation coefficients (Spearman’s rho) and significance between each Hexad user type and all others (N = 60).

User Type	Philanthropist	Socialiser	Free Spirit	Achiever	Player
Socialiser	0.499**				
Free Spirit	0.340**	0.466**			
Achiever	0.433**	0.459**	0.446**		
Player	0.203	0.313*	0.208	0.481**	
Disruptor	0.048	0.007	0.505**	0.265*	0.052

* $p < .05$, ** $p < .01$.

6.2.2 Round 2

In the second round of data collection, to increase our sample size and our aim to reach a wider variety of audience, we employed a crowd sourcing [the act of taking a job traditionally performed by a design agent (usually and employee) and outsourcing it to an undefined, generally large group of people in the form of an open call (Howe, 2006)], platform for recruitment. We completed the Change to Protocol form for ethics and it was cleared by the ethics board before the study commenced.

6.2.2.1 Using Amazon MTurk

Amazon Mechanical Turk²³ (MTurk) is an online crowd sourcing tool that allows “workers” to complete small tasks for monetary compensation. Participants can register on Amazon’s site to become “workers” who can participate in simple tasks at their convenience. Researchers such as Buhrmester et al. (2015) found that most “workers” participate out of interest or to pass time, rather than for the sake of the compensation, making these participants a good source for data. Amazon MTurk is a common method of gathering responses and has been used in many game and HCI studies (Hirsh et al., 2012; Jia et al., 2016; Orji et al., 2018a). Mason and Suri (2012)

²³ <https://www.mturk.com/>

discusses the advantages of conducting experiments on MTurk, such as easy access to a large, stable, and diverse participant pool, the low cost and faster iteration between developing theory and executing experiments, but also some of the problems that a researcher might encounter including techniques for conducting synchronous experiments, methods for ensuring high-quality work, how to keep data private, and how to maintain security. One way to detect whether workers are consciously reading the questions and providing meaningful answers is to inject attention questions sporadically into the survey. One commonly used scale is called the Conscientious Responders Scale (CRS) (Marjanovic et al., 2014). It consists of 5-items and has been shown to correctly classify responders as either conscientious or random with greater than 93% accuracy. The items are:

1. To answer this question, please choose option number four, “neither agree nor disagree.”
2. Choose the first option, “strongly disagree”, in answering this question.
3. To respond to this question, please choose option number five, “slightly agree.”
4. Please answer this question by choosing option number two, “disagree.”
5. In response to this question, please choose option number three, “slightly disagree.”

6.2.2.2 Participants and Recruitment

A notice was posted on the Amazon MTurk for recruitment. The description of the study was written based on recommendations suggested by (Hauser et al., 2018), participants should not be able to see the eligibility criteria on the recruitment page as they are then able to respond to the survey eligibility items in a way that confirms these requirements (even if they do not fit the criteria). Thus, information was provided that was relevant to the criteria, without revealing the specifics. Participants were encouraged to only sign-up if they were willing to provide meaningful responses. The systems basic qualifications were used and a HIT (Human Intelligence Task) rate of 95% and an approval rate of 500 (ensures experienced workers) were selected to guarantee better data quality. To better ensure that

participants can read and understand English, English-speaking countries, Canada, USA, and the UK were selected. Participants were asked to enter a completion code and their MTurk worker ID which is considered anonymous. The researcher released small batches (30 at a time) and if the completion code matched, the HIT was approved. Participants were paid \$2.00 (USD) which is the typical remuneration for social psychology studies for similar duration (Buhrmester et al., 2015) while still ensuring good quality data.

When combined with the data we gathered from Round 1, a total of 271 participants completed the survey. However, 75 responses were discarded from the MTurk dataset because the descriptions did not properly describe the scenarios, answers were too brief, or attention questions were missed. The final dataset contained 196 responses (90 men, 104 women, and 2 did not indicate their gender) ranging in age from 18 to 72 years old ($M = 37.95$ years, $SD = 12.16$ years). Participants who reported that they played videogames ($n = 175$) played an average of 11.10 hours a week ($SD = 11.69$ hours) and the types of games they played ranged from cards and puzzle games such as Solitaire and Blockudoc to online role-playing games such as StarCraft II and League of Legends. Participants who reported that they exercise ($n = 152$), spend an average of 6.45 hours exercising a week ($SD = 5.43$) and engage in a variety of sports and exercises of different intensities ranging from running, dancing, and weightlifting to biking, yoga, and boxing.

Participants' average scores in the Hexad user types followed a similar distribution as reported in previous studies (Altmeyer, Tondello, et al., 2020b; Tondello et al., 2016, 2017; Tondello, Mora, et al., 2019). Philanthropists showed the highest average scores ($M = 23.15$, $SD = 3.80$), followed by Players ($M = 22.56$, $SD = 3.74$), Free Spirits ($M = 22.34$, $SD = 3.29$), Achievers ($M = 22.04$, $SD = 3.47$) and Socialisers ($M = 21.03$, $SD = 4.79$), while Disruptors ($M = 14.54$, $SD = 5.22$) followed with the lowest average scores. In addition to the means and standard deviations of the calculated scores for each of the six user types from the 24-items scale (Appendix O, Part 2), like Round 1, we conducted correlation coefficients (Spearman's rho) between each user type and

all others. Results (Figure 6.3 and Table 6.2) showed similar patterns as in Round 1 and other studies (Tondello et al., 2016; Tondello, Mora, et al., 2019), positive correlations were found between the pairs suggested by the theoretical background (Richard & Edward, 2000): Philanthropist with Socialiser, Free Spirit with Disruptor, and Achiever with Player. Furthermore, similar magnitude correlations were also found between Philanthropist and Free Spirit, Achiever and Free Spirit, as well as Player and Free Spirit.

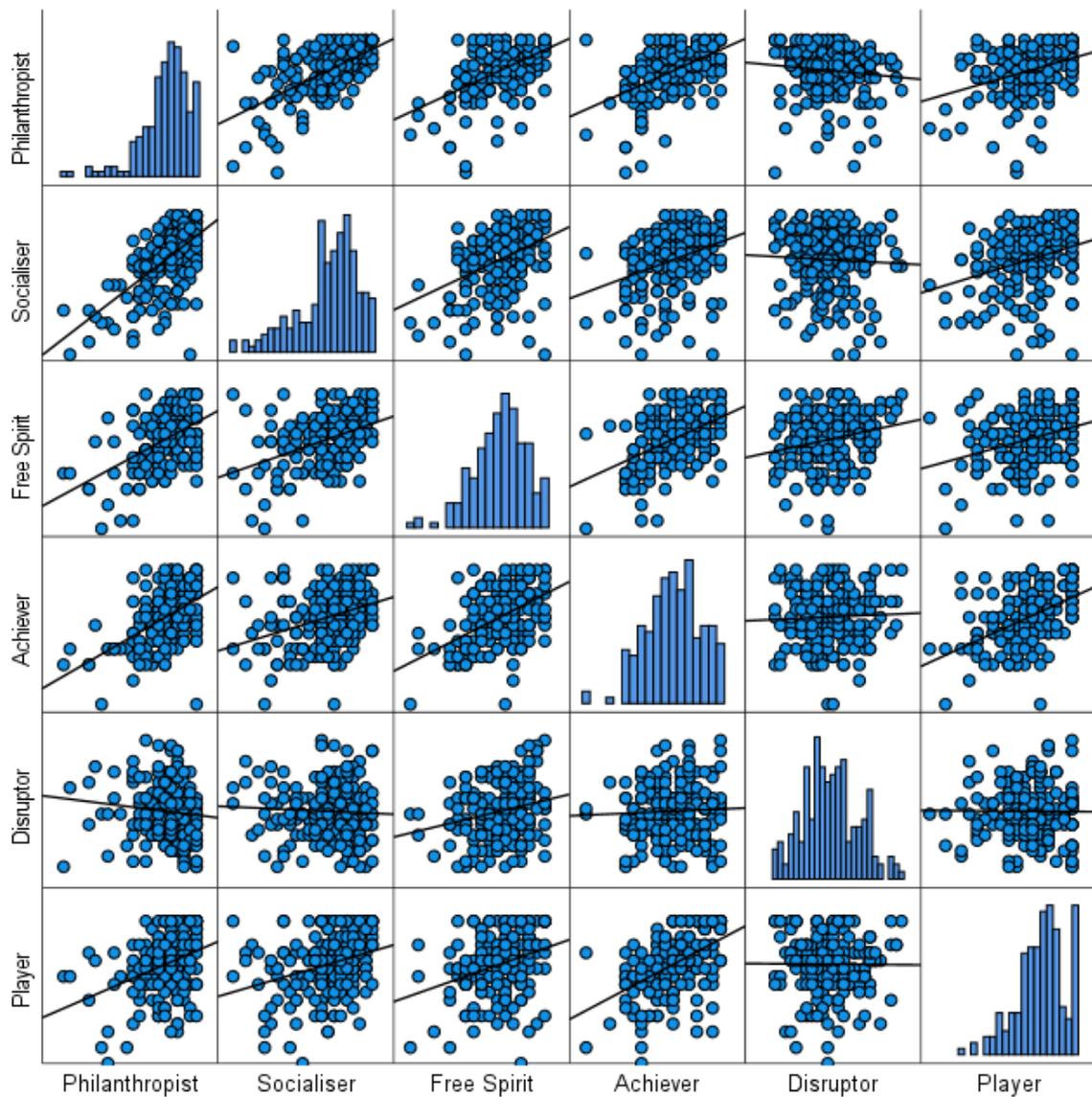


Figure 6.3: Scatterplot matrix of bivariate relationships between each Hexad user type and all others (N = 196).

Table 6.2: Bivariate correlation coefficients (Spearman’s rho) and significance between each Hexad user type and all others (N = 196).

User Type	Philanthropist	Socialiser	Free Spirit	Achiever	Player
Socialiser	0.563**				
Free Spirit	0.426**	0.376**			
Achiever	0.489**	0.355**	0.452**		
Player	0.339**	0.327**	0.307**	0.505**	
Disruptor	-0.150*	-0.059	0.205**	0.032	-0.034

* $p < .05$, ** $p < .01$.

6.3 Materials

6.3.1 Using Storyboards

For this research, we needed social situations where players interact and engage in decision-making. This is because of our interest in the kinds of social game elements that appeal to certain player groups composed of similar or complementary characteristics. Thus, we devised scenarios depicted using storyboards (Figure 6.4) that require social interactions to find potential compatibilities between two people that can be used for matching and increasing retention.

Storyboards were ideal because (1) we wanted to explore what specific social elements and game features are effective in a multiplayer context, and (2) storyboards provide a common visual language that is easy to understand and do not involve game- or technology-specific knowledge (Orji et al., 2014). Because this is a relatively novel approach, storyboards also allow us to gather some insight into the possible features and scenarios that a group of users can interact with in the context of step-based, asynchronous experience before moving forward with implementation of an actual game. It is important to note that pre-deployment storyboard studies do not replace the need for more objective analysis of actual game use, but are considered suitable ways to gather self-reported preferences of player attitudes and select game features

(Altmeyer et al., 2019, 2021; Halko & Kientz, 2010; Jia et al., 2017; Orji et al., 2018a; Oyibo & Vassileva, 2021, 2019; Santos et al., 2021) because it offers a visual presentation that is understandable by diverse audience.

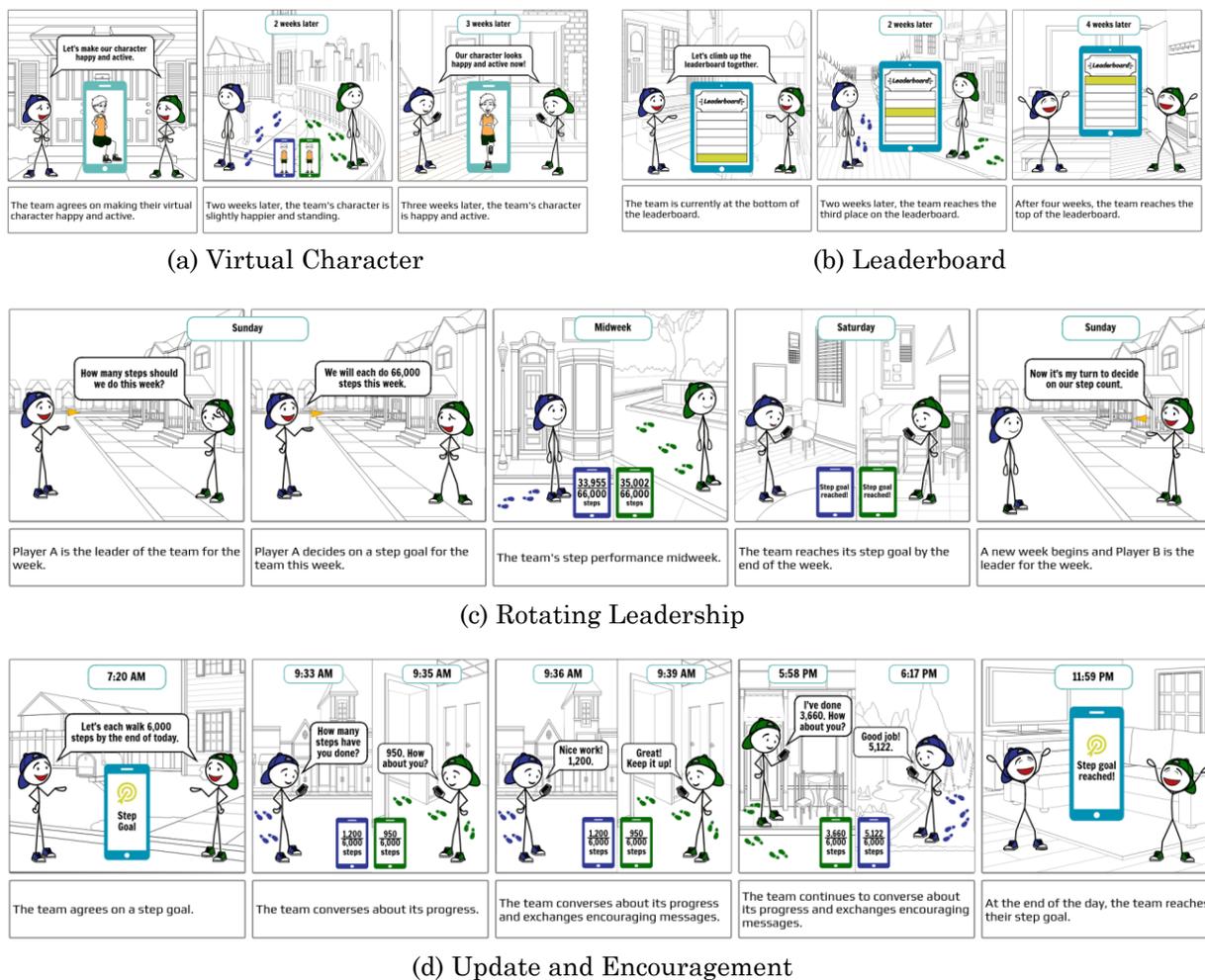


Figure 6.4: Example storyboards²⁴ that were designed and evaluated.

The exergame we designed and used in our previous studies (the Foundation Study) was an asynchronous step-based game (Chan et al., 2020). Players can collect points based on everyday exercise activities performed separately and at different times. These points are collected through mobile phones and used in an online game. The storyboards in this study depict such a game. In the storyboards, Player A wears a blue baseball cap and Player B wears a green baseball cap. At the start of each

²⁴ Designed using Storyboardthat (<https://storyboardthat.com>)

scenario, players engage in decision making where they can agree or disagree on a specific goal (e.g., grow a virtual character (Figure 6.4a) or climb the leaderboard (Figure 6.4b)). Joint effort is required in the game to succeed and reach the end goal (e.g., unlock a new feature). We made sure to include common gamification elements such as leaderboards (Figure 6.4b) to offer social competition and social cooperation, but also other elements that involve conversations between players such as opportunities to exchange updates and encouragement (Figure 6.4d).

Additionally, we included elements that are preferred by certain user types based on the Hexad framework (Tondello et al., 2016) such as philanthropist who are described as “altruistic and willing to give without expected reward”, are likely to use a feature such as donating exercise points to a charity. Game scenarios were particularly designed to span across a long period of time (ranging from 1-day to an entire month) to show that this is a long-term game and thus, a certain amount of effort and commitment between players and the formation of an exercise routine are essential for success. Storyboards were created using Storyboardthat (Needham, MA, USA) and all storyboard scenarios are available in Appendix L.

6.3.2 Storyboard Design

We ensured to have at least one gamification element²⁵ that appeals to each user type based on a framework developed by Marczewski (2015). The storyboards (Figure 6.4) were specifically designed to present scenarios that represent some form of social interaction with others (same team). To inform the design of each scenario and game features (Table 6.3), in addition to reviewing empirical studies on correlations among player types and game elements (Altmeyer et al., 2019; Orji, Nacke, et al., 2017b; Tondello et al., 2017), we also integrated ideas from the psychology and gaming literature on the motivational aspects of social play (Caro et al., 2018; Mueller et al., 2017; Sailer et al., 2014, 2017; Xi & Hamari, 2019).

²⁵ In the game design literature, “gamification elements” is also commonly referred to as “gameful elements” (Altmeyer et al., 2021; Altmeyer, Tondello, et al., 2020b; Tondello et al., 2017).

Table 6.3: Gamification elements that were evaluated in the main study, followed by a short textual description of the element that was depicted in each storyboard (Figure 7.4) and the user types that we expected would be positively related based on the Hexad user type model (Marczewski, 2015).

	Gamification element	Description	Expected to appeal to
1	Lottery	Each team member takes turns to spin the challenge wheel.	Achiever and Player
2	Custom Goal	A team agrees on a custom step goal.	Achiever and Free Spirit
3	Knowledge Sharing	The team helps each other by exchanging advice.	Philanthropist
4	Unlockable Content	A new feature is unlocked after the team reaches its weekly step goal by the third week.	Free Spirit
5	Encouraging Updates	A team exchanges step updates and sends encouraging messages to each other during a challenge.	Socialiser and Philanthropist
6	Virtual Character	A team engages in a step goal to improve the appearance of a virtual character.	Achiever and Player
7	Cheating	Each player in the team thinks of a way to cut corners to reach their step goal.	Disruptor
8	Donate Points	Players on the same team help each other by donating points to each other to pass a level.	Philanthropist
9	Earn a Trophy	Two players on the same team earn a trophy by reaching their weekly step goal 3 weeks in a row.	Achievers and Player
10	Support a Charity	A team earns points by reaching their step goal and donates their earnings to a charity.	Philanthropist
11	Rotating Leadership	Each member on the team takes turns to decide on a weekly step challenge.	Socialiser and Disruptor
12	Leaderboard	A team collaborates to climb up the leaderboard.	Socialiser and Player

Past research shows that the need for social relatedness can be induced by emphasizing the importance of the players' actions for the group's performance, particularly when the player is given a meaningful role and is situated with teammates (Groh, 2012; Rigby & Ryan, 2011). A shared goal, can promote feelings of social relatedness (Sailer et al., 2014), and turn-taking can be enjoyable and increase the level of communication and team interaction between players (Rooksby et al., 2015). Shared goals and cooperation, particularly maximizing interdependence, can increase the level of social closeness experienced between players (Depping & Mandryk, 2017). Depping and Mandryk (2017) suggest that designs can maximize group saliency by emphasizing group identity. In-group identification can be enhanced by opposing the in-group against an outside force, such as challenging a system or another group. To maximize interdependence, games can offer different means of interaction such as text chat or low bandwidth signals that signify simple messages like, for example, 'help', 'danger', or 'missing enemy' (as is implemented in *League of Legends*). As such, many of the scenarios were designed to include shared goals (e.g., "virtual character" and "leaderboard" as shown in Figures 6.4a and 6.4b), meaningful roles and turn-taking (e.g., "rotating leadership" as shown in Figure 6.4c), as well as communication (e.g., "update and encouragement" as shown in Figure 6.4d), to induce feelings of enjoyment, interdependence, and social relatedness between players.

6.3.3 Storyboard Development and Validation

To ensure the clarity of storyboards, we underwent two iterations of the design process. Earlier versions of the storyboards are available in Appendix M. For the first iteration, we conducted semi-structured interviews and a questionnaire session with four participants (three males, one female) ranging in age from 25 to 46 years old ($M = 31.25$ years, $SD = 9.91$ years) to check the understandability of the drawings and descriptions. All participants had a Master's degree in HCI and IT-related fields. Both interview and questionnaire sessions were conducted virtually, and the entire session took approximately 35 minutes. During interviews, participants were asked to look

at the drawings and describe what they think was going on. Participants were also asked to articulate anything they thought was unclear and if they had any suggestions for improving the clarity of the scenarios. In the questionnaire session, participants were given the same drawings as in the interview session along with a brief textual description of each of the scenarios (e.g., for the game element “virtual character”, the textual description was “two players on the same team trying to make their virtual character fit and happy”) and were asked to rate the level of clarity (1 = unclear to 5 = very clear) on how well the text described the drawing. At the end of the entire session, participants were invited to provide any general comments they had. To summarize, below were the changes that we made based on the comments we received:

- Different coloured baseball caps were added to help further distinguish that there are two players (blue for one player, and green for the second player).
- A points system was added to show game progress.
- Footprints/trails were added to emphasize that players were moving.
- Colours denoting players were changed from red and green to blue and green to account for individuals who are red-green colourblind.
- Symbols (e.g., a flag instead of a crown for denoting leadership) were replaced with more common representations.

We integrated all the comments and improved the design of the storyboards. We then evaluated the second iteration following the same procedures as iteration one. In addition to inviting the same participants who evaluated the storyboards as in iteration one, we also asked three new participants (two males, one female) ranging in age from 26 to 52 years old ($M = 36.67$, $SD = 13.61$) to provide feedback. The new participants had Master’s and PhD degrees in HCI and IT-related fields. Based on the comments we received, the storyboards were fine-tuned to include:

- More textual description under each drawing.
- More visual details to convey that play sessions are asynchronous.
- Additional background context to explain the gameplay.

6.3.4 Variables and Measures

The independent variables are the six player types: (1) Philanthropist, (2) Socialiser, (3) Free Spirit, (4) Achiever, (5) Disruptor, and (6) Player, defined by the Hexad model (Marczewski, 2015; Tondello et al., 2016). The dependent variables are the attitudes towards the game features in scenarios. We expected these attitudes to give insight into designing a more personalized experience based on player type for increasing retention. They were perceived persuasiveness [an estimation of its ability to motivate behaviour change (Orji et al., 2019)], level of enjoyment (Mekler et al., 2014), engagement (B. J. Gajadhar et al., 2009) and intention for future exercise. Perceived persuasiveness, enjoyment, and social engagement are more immediate motivational factors as player groups are participating in the game, whereas intention for future exercise is an evaluation of the possibility of long-term engagement.

6.3.4.1 Player Type

We used the Hexad scale (Tondello et al., 2016) to evaluate gaming preferences (Appendix O, Part 2). While the Hexad model is not a rigorous psychological model, it has been used effectively for game design and game user studies (Altmeyer et al., 2019, 2021; Hallifax et al., 2019; Orji et al., 2018a; Zhao et al., 2020a). The Hexad framework is a 24-item questionnaire for evaluating motivations for game elements in gamified applications. The questionnaire evaluates peoples' player type in six dimensions and has been shown to have high internal reliability: (1) achiever ($\alpha = 0.759$), (2) philanthropist ($\alpha = 0.893$), (3) disruptors ($\alpha = 0.738$), (4) socialisers ($\alpha = 0.838$), (5) free spirits ($\alpha = 0.723$) and (6) players ($\alpha = 0.698$), using a 7-point (1 = strongly disagree to 7 = strongly agree) Likert scale. The scores in each of the Hexad user type has also been cross-validated with items in the BFI-10 (Rammstedt & John, 2007) resulting positive correlations suggesting that the Hexad framework and the new scale is theoretically supported. As suggested by Tondello et al. (2016) statements were presented in random order to reduce any possible order-effects.

6.3.4.2 Player Attitudes towards the Features

The persuasiveness of each gamification element was measured using a modified version the perceived persuasiveness scale developed by Drozd et al. (2012) and has been validated and used in a number of studies including Orji et al. (2017b). The dataset yielded acceptable internal consistency ($\alpha = 0.88$). The level of enjoyment was measured using 1-item (“I would enjoy this feature.”), while the level of engagement was measured using a modified version of the behavioural engagement subscale (3-items) evaluating specifically social connection (Abbasi et al., 2017, 2019). For example, the item “I would love playing this videogame with my friends” was changed to “I would love playing this feature with my friends”. Finally, intention for future exercise was assessed using one custom item (“This feature would motivate me to exercise more in the future.”). A single-item measure has been shown to be predictive of exercise intention in research on physical activity (Greenockle et al., 1990). For all statement items, participants were asked to indicate their level of agreement or disagreement on a 7-point Likert scale. The full questionnaire is available in Appendix O, Parts 1, 2 and 3.

6.4 Procedures

After receiving clearance from our institutional ethics review committee, the recruitment for participants commenced. Individuals who responded to the recruitment notice indicating interest were provided a link to the survey hosted online (Qualtrics, Provo, UT)²⁶. Following informed consent (Appendix N), participants were presented with the survey questions as described below. The survey takes approximately 25 minutes to complete and consists of 3 parts.

Part 1 collected general demographical information about the participant’s age, level of education, gaming, and exercise habits. Part 2 asked questions related to the participant’s preferences from gamification elements as evaluated by the Hexad user

²⁶ <https://www.qualtrics.com>

type scale (Tondello et al., 2016). Part 3 presented some background context to explain the game, followed by the 12 scenarios (randomly) where participants were asked to look at the drawings and indicate the level of agreement and disagreement on a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree) to questionnaire statements evaluating the dependent variables: perceived persuasiveness, enjoyment, social connection, and future exercise intention. To ensure the understanding of each scenario depicted in the storyboard, in addition to providing a brief textual description underneath each scenario, participants were asked to briefly describe in their own words what they think is going on in the pictures before the provided the rating. At the end of each scenario, participants were asked to provide any further comments they had. Upon completion of the survey, the researcher screened the responses for completeness and meaningfulness. Participants who provided valid and meaningful answers were emailed a \$10.00 (CAD) digital gift card to Tim Hortons.

6.5 Round 1 Results

In this survey, we collected both quantitative and qualitative data. Quantitative data were from subjective Likert scale ratings of the 4 dependent variables evaluating player attitudes towards the gamification features (perceived persuasiveness, enjoyment, social connectedness, and future exercise intention), while qualitative data were from open-ended questions (Appendix O, Part 3). Data were computed using IBM SPSS²⁷ for Windows Version 27.0 (SPSS, Chicago, Illinois, USA) and prior to computation of statistics, a number of validity checks were performed to ensure quality of data. These included the time to complete the survey and that responses on attention check questions were removed. The significance level was set at $\alpha = .05$ for all statistical tests.

²⁷ <https://www.ibm.com/analytics/spss-statistics-software>

6.5.1 Participant Characteristics

A total of 63 participants completed the survey. However, three were discarded because they did not complete all the questions. Therefore, the final dataset contained sixty responses (28 males, 32 females) ranging in age from 20 to 57 years old ($M = 31.40$ years, $SD = 8.27$ years). Forty-nine participants identified themselves as gamers and the remainder identified themselves as non-gamers. Gamers reported that they spend an average of 9.66 hours per week ($SD = 9.89$ hours) playing and engaging in a wide variety of game genres ranging from puzzles, fighting and adventure games to first-person shooters, sports, and social deduction games. Forty participants reported that they participate in regular exercise at intensities ranging from light ($n = 3$), moderate ($n = 14$), and vigorous ($n = 23$). Participants who engaged in regular exercise spend an average of 4.21 hours per week ($SD = 2.70$ hours) exercising and participate in different kinds of sports and exercises such as badminton, jogging, walking, weightlifting, circuit training and boxing.

6.5.2 Subjective Results

First, descriptive statistics (Tables 6.4–6.7) and histograms (Appendix P) of each gamification element for each of the 4 dependent variables that evaluated player attitudes, as well as Shapiro-Wilk tests were conducted to explore the shape of the distributions. 100% stacked bar charts (Figure 6.5a–d) were also generated to compare the agreement levels on questionnaire statements that evaluated the 4 dependent variables (perceived persuasiveness, enjoyment, behavioural engagement (social connectedness), and intention for future exercise) with respect to each of the 12 gamification features.

Table 6.4: Descriptive statistics and Shapiro-Wilk test of Normality for perceived persuasiveness with respect to all gamification elements.

N = 60 Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	<i>W</i>	<i>df</i>	<i>p</i>
Lottery	17.23	6.02	19.00	-0.57	-0.43	0.94	60	.01
Custom Goal	17.65	6.04	18.00	-0.59	-0.25	0.95	60	.02
Knowledge Sharing	15.50	6.43	16.00	-0.24	-1.16	0.93	60	.00
Unlockable Content	18.80	5.53	20.00	-1.34	1.76	0.86	60	.00
Encouraging Updates	16.93	6.52	17.50	-0.36	-0.64	0.96	60	.06
Virtual Character	16.07	7.49	16.50	-0.16	-1.15	0.94	60	.00
Cheating	11.57	6.82	11.00	0.45	-0.84	0.90	60	.00
Donate Points	14.82	6.99	16.00	-0.08	-0.87	0.95	60	.01
Earn Trophy	17.13	6.29	18.00	-0.53	-0.24	.095	60	.02
Support Charity	22.43	5.18	24.00	-1.74	3.95	0.83	60	.00
Rotating Leadership	15.08	6.35	16.00	-0.26	-0.97	0.95	60	.01
Leaderboard	18.00	7.16	20.00	-0.67	-0.65	0.91	60	.00

Table 6.5: Descriptive statistics and Shapiro-Wilk test of Normality for enjoyment with respect to all gamification elements.

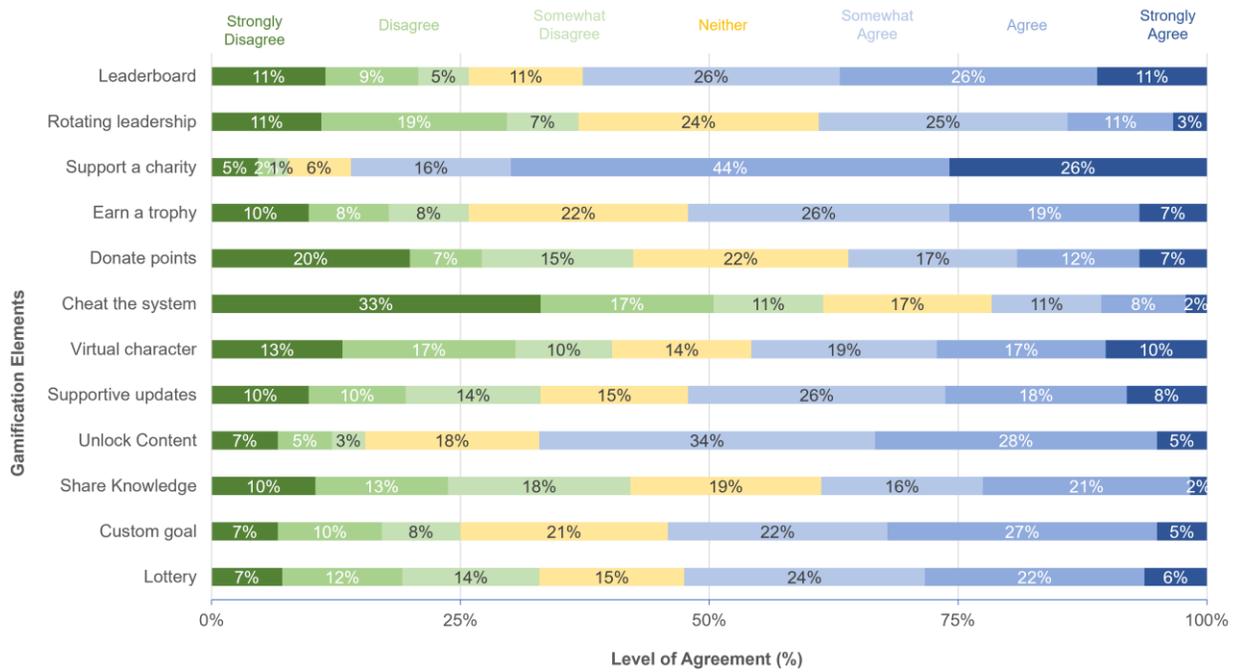
N = 60 Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	<i>W</i>	<i>df</i>	<i>p</i>
Lottery	4.57	1.68	5.00	-0.61	-0.47	0.91	60	.00
Custom Goal	4.43	1.67	5.00	-0.59	-0.63	0.91	60	.00
Knowledge Sharing	4.02	1.63	4.00	-0.37	-0.82	0.93	60	.00
Unlockable Content	4.90	1.67	5.00	-1.16	0.38	0.82	60	.00
Supportive Updates	4.40	1.70	5.00	-0.44	-0.79	0.92	60	.00
Virtual Character	4.35	1.94	5.00	-0.31	-1.11	0.91	60	.00
Cheating	2.92	1.82	3.00	0.39	-1.12	0.87	60	.00
Donate Points	4.00	1.95	4.00	-0.30	-1.23	0.90	60	.00
Earn Trophy	4.83	1.68	5.00	-0.63	-0.43	0.91	60	.00
Support Charity	5.83	1.34	6.00	-1.95	4.79	0.75	60	.00
Rotating Leadership	3.62	1.67	4.00	0.10	-0.91	0.94	60	.01
Leaderboard	4.50	1.96	5.00	-0.45	-1.02	0.90	60	.00

Table 6.6: Descriptive statistics and Shapiro-Wilk test of Normality for behavioral engagement (social connectedness) with respect to all gamification elements.

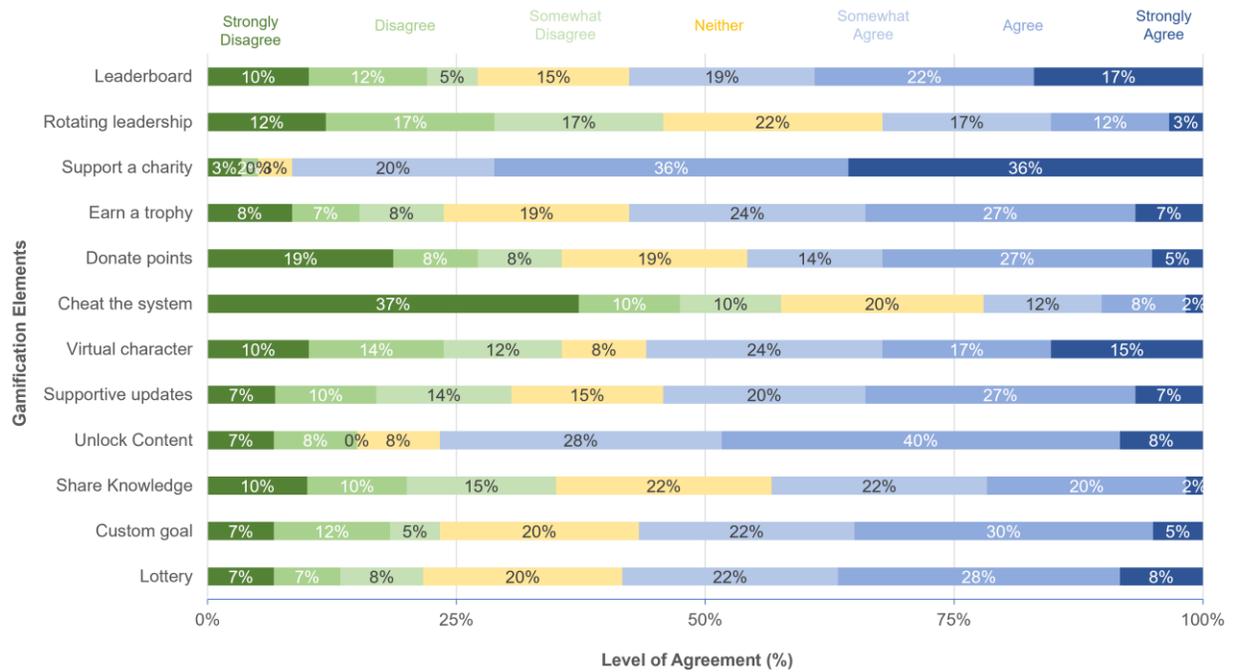
N = 60 Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	<i>W</i>	<i>df</i>	<i>p</i>
Lottery	17.95	6.64	20.00	-0.59	-0.58	0.93	60	.00
Custom Goal	19.15	6.31	20.50	-0.89	0.08	0.92	60	.00
Knowledge Sharing	17.17	5.99	17.00	-0.49	-0.18	0.95	60	.02
Unlockable Content	19.45	5.81	20.00	-1.09	1.00	0.91	60	.00
Supportive Updates	18.42	6.41	20.00	-0.65	-0.34	0.94	60	.01
Virtual Character	16.23	7.52	17.00	-0.09	-1.17	0.94	60	.01
Cheating	12.45	7.80	12.50	0.49	-0.96	0.88	60	.00
Donate Points	16.50	7.18	18.00	-0.34	-0.88	0.94	60	.01
Earn Trophy	18.63	6.45	20.00	-0.89	0.15	0.91	60	.00
Support Charity	22.13	4.80	23.00	-1.24	2.55	0.90	60	.00
Rotating Leadership	16.35	4.60	17.50	-0.42	-0.83	0.94	60	.01
Leaderboard	18.80	7.06	20.00	-0.86	-0.33	0.88	60	.00

Table 6.7: Descriptive statistics and Shapiro-Wilk test of Normality for future exercise intention with respect to all gamification elements.

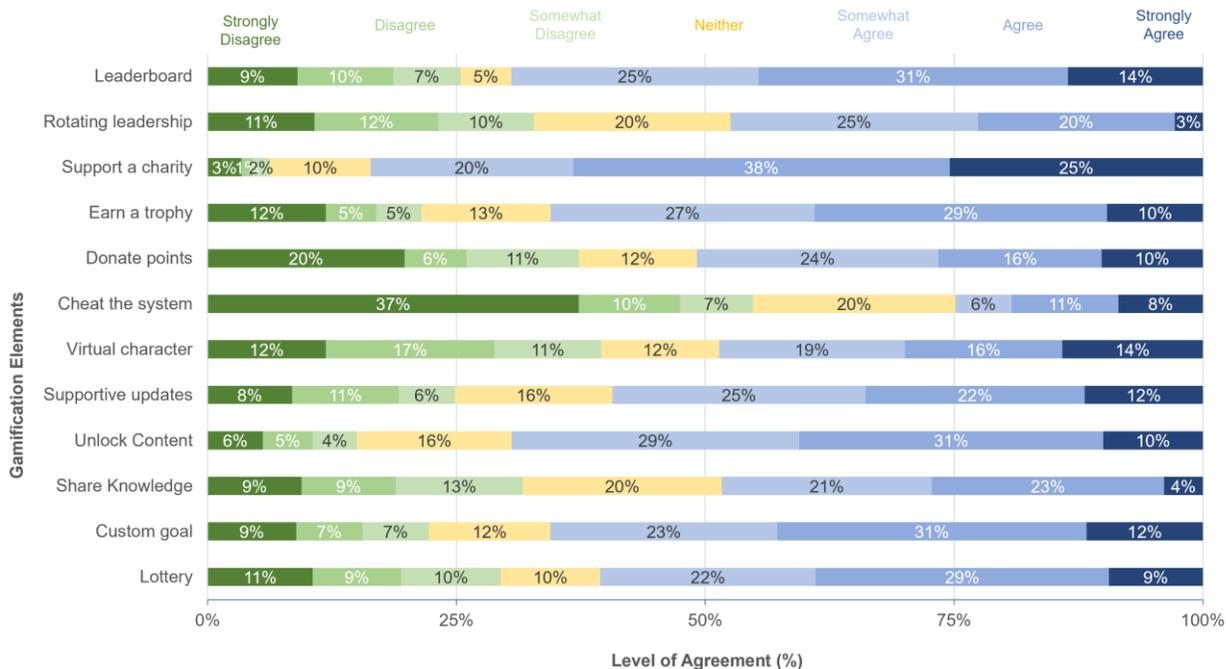
N = 60 Gamification element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	<i>W</i>	<i>df</i>	<i>p</i>
Lottery	4.23	1.81	5.00	-0.36	-1.08	0.91	60	.00
Custom goal	4.25	1.71	5.00	-0.40	-0.78	0.93	60	.00
Knowledge sharing	3.67	1.71	4.00	0.08	-0.81	0.94	60	.01
Unlockable content	4.65	1.69	5.00	-0.70	-0.43	0.90	60	.00
Supportive updates	4.25	1.87	4.00	-0.20	-0.96	0.93	60	.00
Virtual character	4.05	2.01	4.00	-0.08	-1.19	0.92	60	.00
Cheating	2.62	1.87	2.00	0.83	-0.52	0.81	60	.00
Donate points	3.40	1.88	3.00	0.31	-0.96	0.92	60	.00
Earn trophy	4.17	1.80	4.00	-0.46	-0.85	0.91	60	.00
Support charity	5.42	1.64	6.00	-1.23	1.05	0.84	60	.00
Rotating leadership	3.80	1.65	4.00	-0.20	-0.88	0.93	60	.00
Leaderboard	4.43	1.95	5.00	-0.58	-0.92	0.88	60	.00



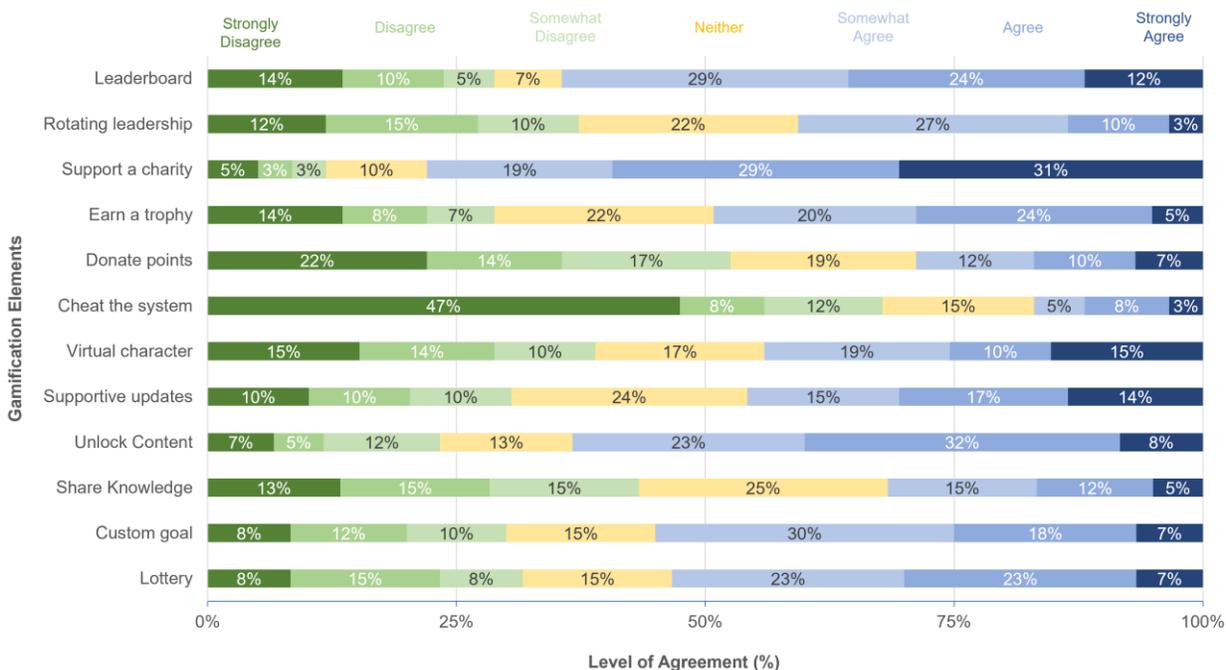
(a) Perceived Persuasiveness



(b) Enjoyment



(c) Behavioural Engagement (Social Connectedness)



(d) Intention for Future Exercise

Figure 6.5: 100% stacked bar charts for 4 dependent measures with respect to 12 gamification elements (N = 60).

Based on the shape of the distributions, skewness, and kurtosis values, as well as the p-value of the Shapiro-Wilk test, a Spearman's rank order correlation (Hauke & Kossowski, 2011) was selected for the analysis. A Spearman's rank order correlation was selected because the shape of the distributions (Appendix P) was skewed (not normally distributed as verified by a Shapiro Wilk's test) which is further supported by the skewness and kurtosis statistics (Tables 6.4–6.7) and the use of an ordinal scale for evaluating the 4 dependent measures of individual attitudes toward game features. For comparison, in addition to computing Spearman coefficients, we also conducted the more popular Pearson's product-moment which is for normal distributions and has been used in previous game user studies examining preferences for gameful elements and the Hexad user types (Tondello et al., 2017). Results of the Pearson's correlation (Appendix R) were comparable to results of the Spearman's correlation. The purpose of the statistical method is to compute a correlation coefficient which is a value that summarizes a large dataset representing the degree of linear association or relationship between two measured variables (Taylor, 1990). Common interpretation of the value (for both Pearson's and Spearman's correlation coefficients) is the following (Akoglu, 2018):

- +1 or -1, Perfect
- Between +0.9 to +0.7 or -0.9 to -0.7, Strong
- Between +0.6 to +0.4 or -0.6 to -0.4, Moderate
- Between +0.3 to +0.1 or -0.3 to -0.1, Weak
- 0, Zero

Due to multiple comparisons, threshold levels of significance for correlation coefficients were adjusted using the Bonferroni correction, 0.004 per test (0.05/12), to reduce the chance of making a type 1 error (Curtin & Schulz, 1998).

Table 6.8: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and perceived persuasiveness of gamification elements.

N = 60 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.171 (.192)	-.094 (.476)	-.011 (.932)	.140 (.286)	.018 (.892)	.033 (.800)
Custom Goal	.325 (.011)	.116 (.376)	-.056 (.672)	.038 (.771)	-.108 (.411)	-.145 (.270)
Knowledge Sharing	.370* (.004)	.302 (.019)	-.070 (.596)	.128 (.328)	-.075 (.570)	-.112 (.394)
Unlockable Content	.227 (.081)	.050 (.702)	-.090 (.492)	.046 (.726)	-.005 (.967)	-.007 (.961)
Encouraging Updates	.406* (.001)	.170 (.194)	-.135 (.305)	.117 (.373)	-.038 (.773)	-.086 (.513)
Virtual Character	.208 (.111)	.104 (.428)	-.148 (.206)	-.054 (.680)	-.217 (.096)	-.189 (.148)
Cutting Corners	-.032 (.809)	-.068 (.608)	-.194 (.137)	-.116 (.377)	-.111 (.400)	-.006 (.963)
Donate Points	.167 (.202)	-.140 (.285)	-.431* (.001)	-.263 (.042)	-.34 (.007)	-.294 (.023)
Earn Trophy	.282 (.029)	.168 (.199)	-.078 (.555)	.083 (.527)	-.195 (.135)	.058 (.662)
Support Charity	.151 (.251)	-.015 (.912)	-.153 (.242)	.000 (.999)	-.216 (.097)	-.028 (.832)
Rotating Leadership	.453* (.000)	.287 (.026)	.010 (.941)	.187 (.153)	-.051 (.698)	.004 (.978)
Leaderboard	.336 (.009)	.126 (.336)	-.131 (.318)	.091 (.489)	-.180 (.168)	.059 (.655)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table 6.9: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and enjoyment of gamification elements.

N = 60 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.282 (.029)	.149 (.257)	.104 (.430)	.287 (.026)	-.056 (.671)	.123 (.347)
Custom Goal	.271 (.036)	.170 (.193)	.011 (.932)	-.012 (.925)	-.074 (.575)	-.158 (.229)
Knowledge Sharing	.359 (.005)	.249 (.055)	-.123 (.348)	.109 (.408)	-.097 (.461)	-.070 (.594)
Unlockable Content	.341 (.008)	.277 (.032)	.077 (.557)	.155 (.236)	-.091 (.492)	.112 (.393)
Encouraging Updates	.460* (.000)	.229 (.078)	-.099 (.451)	.111 (.400)	-.037 (.780)	-.010 (.942)
Virtual Character	.160 (.221)	.077 (.560)	-.142 (.278)	-.115 (.383)	-.186 (.156)	-.074 (.574)
Cutting Corners	-.029 (.828)	-.067 (.611)	-.210 (.107)	-.120 (.361)	-.117 (.371)	-.023 (.863)
Donate Points	.093 (.479)	-.202 (.122)	-.476* (.000)	-.301 (.019)	-.392* (.002)	-.188 (.150)
Earn Trophy	.285 (.027)	.247 (.057)	-.012 (.927)	.129 (.325)	-.179 (.172)	.117 (.371)
Support Charity	.164 (.210)	-.107 (.416)	-.216 (.098)	-.031 (.812)	-.290 (.025)	-.027 (.838)
Rotating Leadership	.423* (.001)	.230 (.077)	.013 (.921)	.095 (.472)	.013 (.924)	-.077 (.558)
Leaderboard	.355 (.005)	.163 (.214)	-.014 (.918)	.086 (.515)	-.119 (.366)	.078 (.555)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table 6.10: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and social connectedness of gamification elements.

N = 60 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.179 (.172)	.189 (.148)	.106 (.422)	.150 (.254)	-.064 (.625)	-.050 (.704)
Custom Goal	.313 (.015)	.287 (.026)	.075 (.569)	.007 (.956)	-.123 (.349)	-.031 (.813)
Knowledge Sharing	.351 (.006)	.225 (.084)	-.122 (.352)	.032 (.808)	-.147 (.261)	-.029 (.823)
Unlockable Content	.184 (.159)	.248 (.057)	.140 (.288)	.115 (.381)	-.061 (.646)	-.034 (.795)
Supportive Updates	.339 (.008)	.244 (.061)	-.043 (.742)	.004 (.978)	-.076 (.564)	-.063 (.631)
Virtual Character	.235 (.071)	.205 (.116)	-.111 (.399)	-.026 (.842)	-.264 (.042)	-.170 (.195)
Cutting Corners	-.022 (.865)	-.048 (.718)	-.208 (.111)	-.172 (.190)	-.212 (.104)	-.039 (.767)
Donate Points	.112 (.393)	-.091 (.491)	-.46* (.000)	-.271 (.036)	-.419* (.001)	-.285 (.027)
Earn Trophy	.278 (.032)	.218 (.095)	.015 (.909)	.111 (.399)	-.123 (.347)	-.046 (.725)
Support Charity	.021 (.873)	-.020 (.877)	-.229 (.078)	-.005 (.970)	-.175 (.182)	-.008 (.952)
Rotating Leadership	.422** (.001)	.293 (.023)	-.036 (.785)	.031 (.815)	-.073 (.581)	-.025 (.847)
Leaderboard	.364** (.004)	.283 (.029)	-.005 (.972)	.194 (.138)	-.116 (.379)	.088 (.504)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table 6.11: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and future exercise intention of gamification elements.

N = 60 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.232 (.075)	.135 (.304)	.106 (.421)	.097 (.460)	-.092 (.485)	.002 (.991)
Custom Goal	.211 (.105)	.109 (.408)	-.068 (.608)	-.044 (.737)	-.138 (.294)	-.117 (.374)
Knowledge Sharing	.288 (.026)	.181 (.168)	-.156 (.234)	.135 (.304)	-.022 (.868)	-.048 (.715)
Unlockable Content	.219 (.093)	.271 (.036)	.102 (.438)	.071 (.589)	-.062 (.639)	-.007 (.957)
Supportive Updates	.381* (.003)	.201 (.124)	-.151 (.248)	.049 (.708)	-.085 (.518)	-.021 (.875)
Virtual Character	.114 (.386)	.073 (.581)	-.165 (.207)	-.100 (.449)	-.179 (.171)	-.185 (.158)
Cutting Corners	.015 (.907)	.036 (.783)	-.162 (.217)	-.067 (.611)	-.089 (.497)	-.058 (.662)
Donate Points	.195 (.136)	-.126 (.337)	-.400* (.002)	-.237 (.068)	-.352 (.006)	-.294 (.023)
Earn Trophy	.200 (.125)	.105 (.425)	-.050 (.702)	.010 (.941)	-.105 (.424)	-.008 (.954)
Support Charity	-.020 (.881)	-.078 (.552)	-.212 (.104)	-.059 (.652)	-.197 (.132)	-.054 (.681)
Rotating Leadership	.541* (.000)	.343 (.007)	.058 (.662)	.183 (.161)	-.080 (.543)	.009 (.944)
Leaderboard	.380* (.003)	.228 (.080)	-.017 (.897)	.078 (.552)	-.137 (.297)	.065 (.624)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Philanthropists seem to strongly prefer sharing knowledge and the exchange of encouraging updates. This finding is consistent with previous research on personalizing gamification elements for persuasive fitness systems (Altmeyer et al., 2019). Moreover, Philanthropists seem to find setting custom goals, sharing knowledge, exchanging updates, earning trophies, taking turns to be the leader, and climbing up the leaderboard to be socially satisfying. Elements of knowledge sharing, encouraging updates, rotating leadership, and leaderboard seem to be particularly effective for motivating future intention for exercise. These findings can be explained by the social nature of the scenarios. Players could have enjoyed the game and perceived a sense of relatedness (Deci & Ryan, 2000) simply because the elements portrayed offered opportunities to engage in social interactions.

Socializers seem to strongly prefer elements of knowledge sharing and rotating leaderboard and enjoy unlockable content. Socialisers seem to find opportunities to create custom goals, switch leadership roles, and climb up the leaderboard socially rewarding. Elements of unlockable content and rotating leadership seem to be effective for motivating future exercise intention. As expected, Achievers seem to enjoy lottery elements which is consistent with Player related traits and opportunities to gain rewards (Marczewski, 2015).

Finally, there seems to be a general pattern that Free Spirits, Achievers, Disruptors and Players find the game element donating points unfavourable. One reason for finding this effect can be attributed to Achiever related traits – one who is motivated by self-enrichment and prefers to collect everything they find (Marczewski, 2015), might not be willing to donate the points they earned even in a team context.

6.5.3 Qualitative Results

Results presented in this section are comments that were gathered from the open-ended questions inviting participants to provide additional comments in part 3 of the survey (Appendix O, Part 3). Comments were organized using a spreadsheet. A thematic analysis (Braun & Clarke, 2006) was used to identify indications of likes

and dislikes regarding the overall experience of each scenario were scanned for patterns and commonalities as they relate to the enjoyment, motivation, social interactions, and intention for future play for the game element. The process of a thematic analysis involves a methodical examination of the data to develop codes and applying these codes across the dataset line-by-line. These codes are then used to develop broader themes that sufficiently represent the meanings of multiple codes which is similar to the variability in statistics.

In general, participants reported that they found certain aspects of the game compelling and believe that it would be effective if players had a common goal. Some participants really liked the virtual character in the app while others would enjoy the leaderboard most, particularly when they reach to the top experiencing a sense of accomplishment. Participants found unlocking a new feature to be rewarding as they enjoy elements of surprise and like the idea of teamwork but would depend on who their teammate is. A feature that was very well liked is the support a charity feature. Many participants liked it because it was a way for them to “*give back to the community*” [P55] and that exercising had some “*external meaning*” [P9], but one participant said that it is something he would only use once a year at most because “*asking people for money to donate to a cause can be difficult and people will stop donating if you ask too frequently*” [P20].

There were features participants disliked for certain reasons. For example, a few participants disliked the leaderboard because they do not enjoy being situated in a competitive environment while another participant explained that it is their least favourite feature because it is “*not good for beginners*” [P31]. Quite a few participants commented that the leaderboard would lead them to “*burnout and not use it for a long period of time*” [P29] and might also lead to cheating to reach the top. Another feature that was not well liked was the rotating leadership. One participant explained that they would not want “*the responsibility of telling people what to do*” [P35] while another participant would simply not have their step goal be given to them by a friend “*even when they can switch roles*” [P1].

Some other interesting comments related to how certain game elements might work better for them depending on their relationship with the other person. For example, one participant commented that certain features they would “*enjoy more with my family members like my mom, while other features I would prefer to engage with my friends*” [P6]. Several participants also wished for more opportunities to try different features and if the exercise buddy were unhelpful, they would want the option to change their teammate. Collectively, these comments are related to the kinds of social interactions, both positive (e.g., trying different features with friends vs. family members) and negative (e.g., the option to change a teammate if he/she was unhelpful), that can influence the level of motivation, enjoyment, and intention for future play. For example, offering a specific set of features for friends, and a different set of features for family members can increase enjoyment, yet not being able to change a teammate if he/she was unsupportive, can hinder gameplay and reduce enjoyment and intention for future play.

6.6 Implications for Design

Based on these initial findings, we suggest the following guidelines for designing social multiplayer exergames that can increase enjoyment, social connectedness, and intention for future exercise behaviours. At the start of the game, players can be matched based on similar (e.g., a group of players who score high on philanthropist-oriented traits) and complementary (e.g., a group of players composed of player and achiever-oriented traits) player traits and specific game elements can be offered to increase motivation as the game progresses.

- **Philanthropist only:**
 - Offer opportunities to share knowledge, exchange supportive messages and updates, switch leadership roles, and leaderboard elements.
 - Offer the opportunity to earn trophies at the beginning of the game, but as the game progresses, additional elements will need to be offered to keep motivation levels high.

- **Socialiser and Philanthropist:**
 - Offer custom goal at the start of the game, but then offer additional features such as the opportunity to share knowledge and exchange encouraging and supportive messages as the game progresses.
- **Socialiser only:**
 - Offer opportunities to share knowledge at the beginning of the game, but as the game progresses, offer opportunities to change leadership roles, and unlock new features/content.
- **Free Spirit, Achiever, Disruptor, and Player:**
 - Avoid game elements that allow players to donate points.

6.7 Round 2 Results

6.7.1 Quantitative Results

All the storyboards, variables, and instruments were the same as described in Section 6.5. To examine the pattern of the collected data, frequency histograms (Appendix Q) and descriptive statistics, as well as the Shapiro-Wilk test²⁸ was computed for all dependent measures (perceived persuasiveness, level of enjoyment, behavioural engagement, and future exercise intention) with respect to the gamification elements (Table 6.12–6.15). 100% stacked bar charts (Figures 6.6a–d) were also generated to compare the agreement levels on questionnaire statements that evaluated the 4 dependent variables with respect to each of the 12 gamification features. The alpha level of 0.05 was set for all statistical tests. Consistent with previous studies using the perceived persuasiveness scale (Altmeyer et al., 2021; Orji et al., 2014), the dataset showed high internal consistency ($\alpha = .93$).

²⁸ If the p-value is less than 0.05, reject the null hypothesis – there is a difference between the ratings for the elements and the normal distribution and presume that the scores for the elements are not normally distributed.

Table 6.12: Descriptive statistics and Shapiro-Wilk test of Normality for perceived persuasiveness with respect to all gamification elements (N = 196).

N = 196 Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	W	df	p
Lottery	19.85	5.89	21.00	-1.02	0.50	0.91	196	.00
Custom Goal	19.43	6.19	20.00	-0.84	0.10	0.93	196	.00
Knowledge Sharing	16.95	6.99	19.00	-0.40	-1.01	0.94	196	.00
Unlockable Content	20.06	5.98	21.00	-1.11	0.76	0.89	196	.00
Supportive Updates	19.30	6.61	21.00	-0.84	-0.11	0.91	196	.00
Virtual Character	16.82	7.34	18.00	-0.32	-1.06	0.93	196	.00
Cheating	13.77	7.56	12.50	0.17	-1.32	0.91	196	.00
Donate Points	16.43	7.48	17.00	-0.24	-1.11	0.94	196	.00
Earn Trophy	19.08	6.38	20.00	-0.79	-.06	0.92	196	.00
Support Charity	21.49	6.01	23.00	-1.34	1.36	0.85	196	.00
Rotating Leadership	17.41	7.01	19.00	-0.50	-0.84	0.93	196	.00
Leaderboard	19.66	6.87	21.50	-0.94	-0.09	0.88	196	.00

Table 6.13: Descriptive statistics and Shapiro-Wilk test of Normality for level of enjoyment with respect to all gamification elements (N = 196).

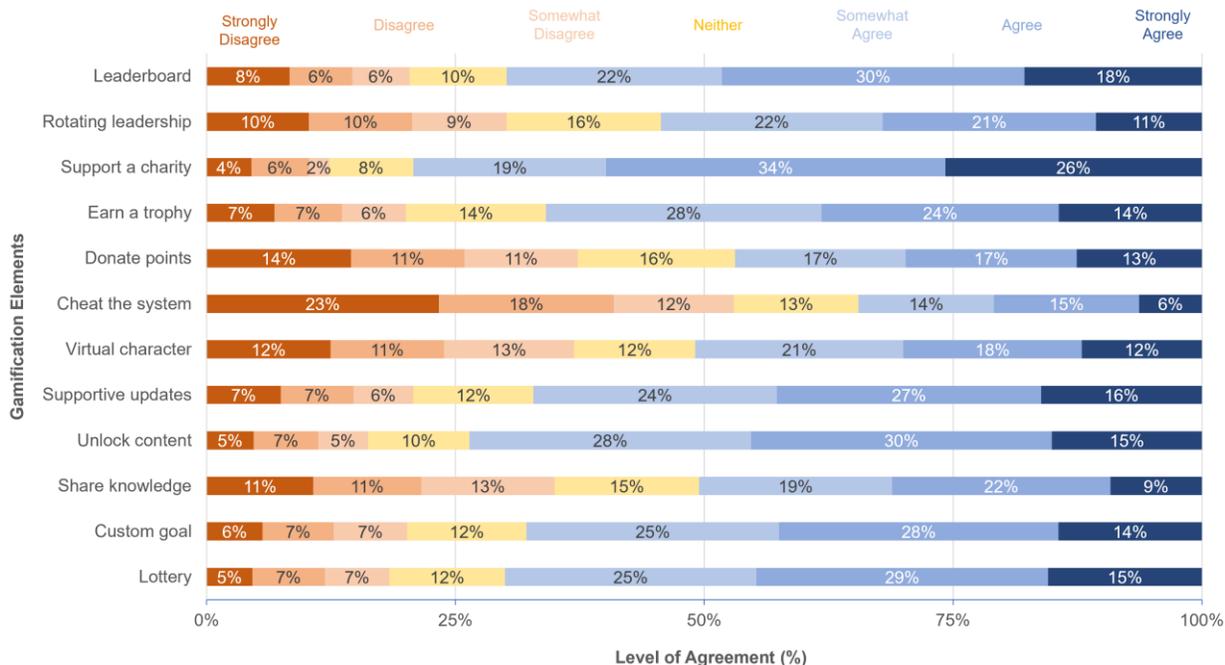
N = 196 Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	W	df	p
Lottery	5.18	1.66	6.00	-0.96	0.26	0.87	196	.00
Custom Goal	4.92	1.70	5.00	-0.85	-0.06	0.88	196	.00
Knowledge Sharing	4.39	1.75	5.00	-0.48	-0.73	0.92	196	.00
Unlockable Content	5.18	1.63	6.00	-1.14	0.57	0.84	196	.00
Supportive Updates	4.91	1.76	5.00	-0.77	-0.27	0.89	196	.00
Virtual Character	4.41	1.88	5.00	-0.41	-0.94	0.91	196	.00
Cheating	3.45	1.95	3.50	0.18	-1.25	0.90	196	.00
Donate Points	4.32	1.94	4.00	-0.38	-1.05	0.90	196	.00
Earn Trophy	4.86	1.70	5.00	-0.72	-0.30	0.90	196	.00
Support Charity	5.54	1.62	6.00	-1.47	1.57	0.79	196	.00
Rotating Leadership	4.33	1.85	5.00	-0.38	-0.96	0.92	196	.00
Leaderboard	4.96	1.89	6.00	-0.85	-.044	0.86	196	.00

Table 6.14: Descriptive statistics and Shapiro-Wilk test of Normality for behavioral engagement (social connectedness) with respect to all gamification elements.

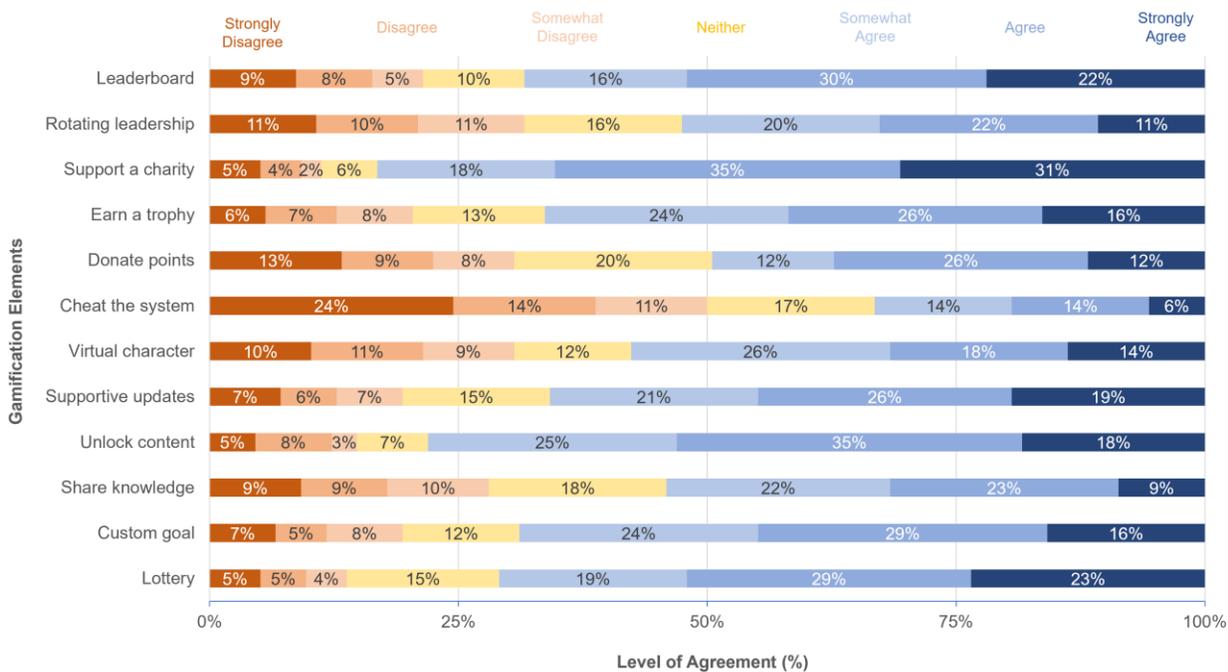
Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	<i>W</i>	<i>df</i>	<i>p</i>
Lottery	20.71	6.13	22.00	-1.21	0.85	0.87	196	.00
Custom Goal	20.16	6.30	22.00	-1.04	0.42	0.89	196	.00
Knowledge Sharing	18.16	6.41	20.00	-0.68	-0.38	0.93	196	.00
Unlockable Content	20.86	5.83	22.00	-1.16	1.04	0.89	196	.00
Supportive Updates	19.98	6.38	21.00	-0.98	0.31	0.90	196	.00
Virtual Character	17.46	7.36	19.00	-0.40	-1.03	0.93	196	.00
Cheating	14.45	7.87	14.50	0.10	-1.35	0.92	196	.00
Donate Points	17.89	7.26	20.00	-0.52	-0.82	0.93	196	.00
Earn Trophy	19.94	6.23	21.00	-1.03	0.40	0.89	196	.00
Support Charity	21.50	5.89	23.00	-1.27	1.27	0.87	196	.00
Rotating Leadership	18.52	7.01	20.00	-0.67	-0.57	0.92	196	.00
Leaderboard	19.94	6.76	22.00	-1.01	0.11	0.88	196	.00

Table 6.15: Descriptive statistics and Shapiro-Wilk test of Normality for future exercise intention with respect to all gamification elements.

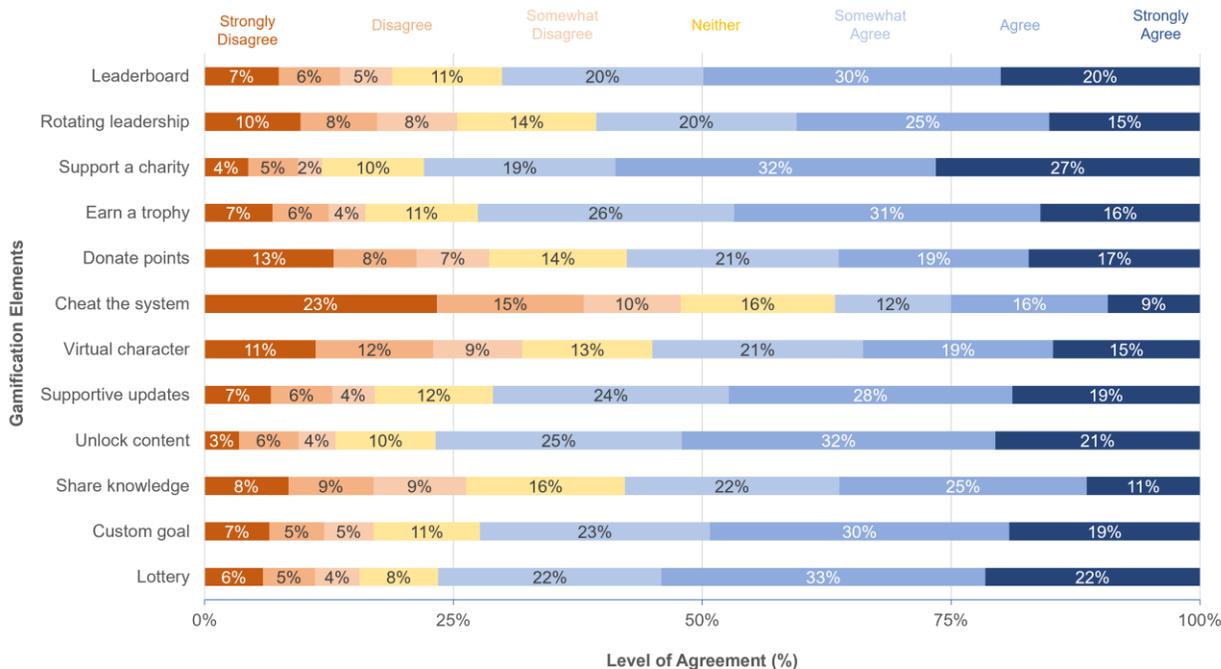
Gamification Element	Descriptive Statistics					Shapiro-Wilk		
	Mean	SD	Median	Skewness	Kurtosis	<i>W</i>	<i>df</i>	<i>p</i>
Lottery	5.07	1.71	5.00	-0.90	-0.03	0.87	196	.00
Custom Goal	4.81	1.72	5.00	-0.67	-.043	0.90	196	.00
Knowledge Sharing	4.14	1.86	4.00	-0.19	-1.07	0.93	196	.00
Unlockable Content	5.13	1.71	6.00	-0.92	-0.01	0.87	196	.00
Supportive Updates	4.83	1.82	5.00	-0.71	-0.48	0.89	196	.00
Virtual Character	4.23	1.98	5.00	-0.20	-1.17	0.92	196	.00
Cheating	3.39	2.04	3.00	0.26	-1.30	0.89	196	.00
Donate Points	3.99	2.04	4.00	-0.11	-1.32	0.91	196	.00
Earn Trophy	4.74	1.73	5.00	-.070	-0.63	0.90	196	.00
Support Charity	5.28	1.71	6.00	-1.12	0.40	0.84	196	.00
Rotating Leadership	4.40	1.87	5.00	-0.42	-0.95	0.91	196	.00
Leaderboard	4.89	1.87	5.50	-0.87	-0.42	0.85	196	.00



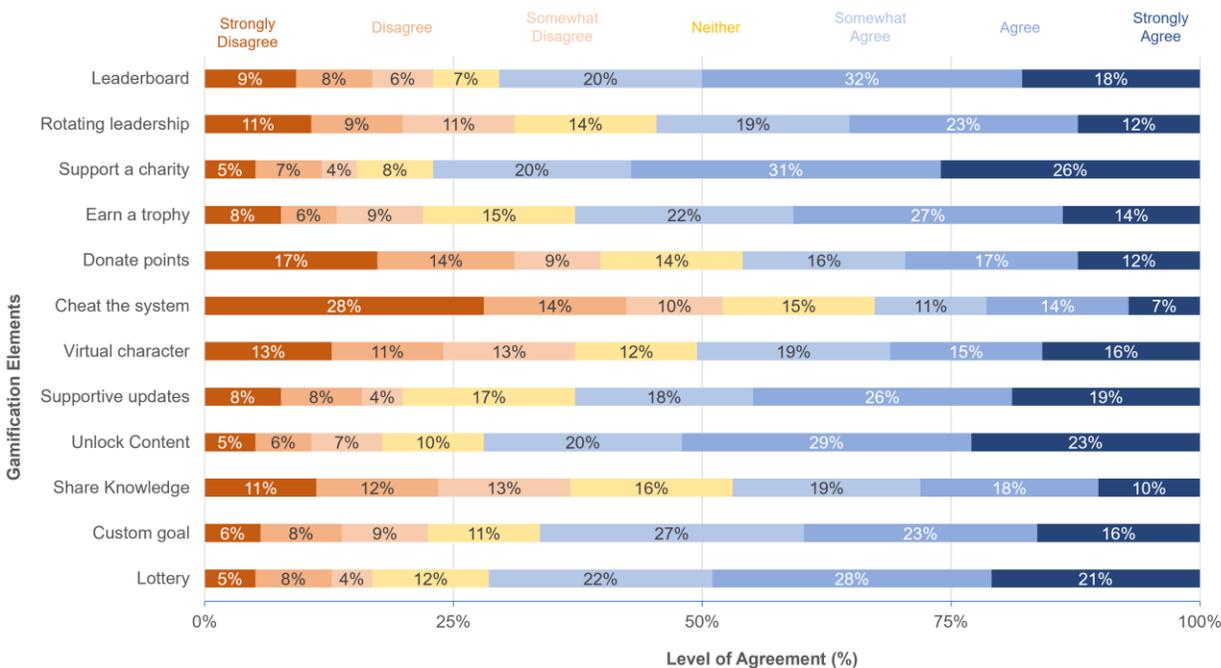
(a) Perceived Persuasiveness



(b) Enjoyment



(c) Behavioural Engagement (Social Connectedness)



(d) Future Exercise Intention

Figure 6.6: 100% stacked bar charts for 4 dependent measures with respect to 12 gamification elements (N = 196).

Based on the skewness, and kurtosis values, as well as the p-values as calculated using a Shapiro-Wilk test ($\alpha = 0.05$), the distribution of the dependent variables for each of the gamification elements were not normal. As such, we conducted Spearman's rank correlation (Field, 2013) coefficients to evaluate the strength of the relationship between each of the twelve game elements and participant's player type scores on the dependent variables: perceived persuasiveness (Table 6.16), level of enjoyment (Table 6.17), behavioural engagement (social connectedness) (Table 6.18) and intention for future exercise (Table 6.19).

Similar to Round 1, in addition to computing Spearman coefficients, we also conducted the more popular Pearson's product-moment which is for normal distributions. Results of the Pearson's correlation (Appendix S) were comparable to results of the Spearman's correlation. It is also worth mentioning that a Kendall's tau could have been used when there is a small data set with a large number of tied ranks (Gudgeon & Howell, 1994). However, a Spearman's correlation is more appropriate as a sample size of 196 should have yielded stable estimates (Schönbrodt & Perugini, 2013). In general, all correlations supported our hypotheses, the game elements we expected to appeal to certain player types (as presented in Table 6.3), as well as some new ones.

The correlational results showed that all game elements, except for the element *Cutting Corners* seem to be strongly preferred by individuals who score high on **Philanthropist** related traits. This result is consistent with previous research on personalizing gamification elements for persuasive fitness systems (Altmeyer et al., 2019). All game elements were strongly preferred by individuals who score high on **Socialiser** related traits. This finding can be explained by the social and interactive nature of the scenarios offering situations where players can engage in conversations and build social connections (Altmeyer et al., 2018; Kaos et al., 2019) with each other.

Table 6.16: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and perceived persuasiveness of gamification elements.

N = 196 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.333* (.000)	.205* (.004)	.197 (.006)	.234* (.001)	-.086 (.228)	.313* (.000)
Custom Goal	.333* (.000)	.380* (.000)	.146 (.041)	.208 (.003)	-.108 (.131)	.155 (.030)
Knowledge Sharing	.225* (.002)	.349* (.000)	.166 (.020)	.141 (.049)	.109 (.128)	.110 (.125)
Unlockable Content	.430* (.000)	.301* (.000)	.120 (.093)	.281* (.000)	-.079 (.271)	.300* (.000)
Supportive Updates	.412* (.000)	.363* (.000)	.122 (.088)	.262* (.000)	-.161 (.024)	.284* (.000)
Virtual Character	.259* (.000)	.289* (.000)	.061 (.393)	.123 (.087)	.006 (.937)	.097 (.175)
Cutting Corners	.012 (.865)	.150 (.035)	.035 (.629)	-.026 (.720)	.184 (.010)	.070 (.331)
Donate Points	.262* (.000)	.232* (.001)	-.011 (.876)	.071 (.325)	.041 (.567)	.138 (.053)
Earn Trophy	.385* (.000)	.401* (.000)	.171 (.017)	.222* (.002)	-.078 (.277)	.304* (.000)
Support Charity	.391* (.000)	.300* (.000)	.095 (.185)	.255* (.000)	-.130 (.069)	.235* (.001)
Rotating Leadership	.338* (.000)	.336* (.000)	.143 (.046)	.215* (.002)	.000 (1.000)	.234* (.001)
Leaderboard	.397* (.000)	.322* (.000)	.133 (.063)	.293* (.000)	-.130 (.070)	.283* (.000)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table 6.17: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and the enjoyment of gamification elements.

N = 196 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.371* (.00)	.285* (.000)	.240* (.001)	.298* (.000)	-.151 (.034)	.303* (.000)
Custom Goal	.367* (.000)	.383* (.000)	.160 (.025)	.192 (.007)	-.150 (.036)	.130 (.070)
Knowledge Sharing	.261* (.000)	.368* (.000)	.192 (.007)	.148 (.038)	.030 (.676)	.151 (.035)
Unlockable Content	.421* (.000)	.345* (.000)	.121 (.092)	.243 (.001)	-.148 (.038)	.242* (.001)
Supportive Updates	.399* (.000)	.405* (.000)	.128 (.074)	.269* (.000)	-.114 (.111)	.308* (.000)
Virtual Character	.213* (.003)	.262* (.000)	.037 (.611)	.100 (.164)	.029 (.688)	.116 (.106)
Cutting Corners	.007 (.923)	.141 (.049)	.001 (.991)	-.017 (.812)	.198 (.005)	.055 (.446)
Donate Points	.250* (.000)	.158 (.027)	-.031 (.662)	.001 (.988)	.009 (.900)	.151 (.035)
Earn Trophy	.376* (.000)	.424* (.000)	.125 (.080)	.223* (.002)	-.075 (.297)	.273* (.000)
Support Charity	.395* (.000)	.248* (.000)	.000 (.996)	.249* (.000)	-.121 (.091)	.170 (.017)
Rotating Leadership	.329* (.000)	.274* (.000)	.099 (.167)	.175 (.014)	.028 (.698)	.167 (.019)
Leaderboard	.387* (.000)	.326* (.000)	.158 (.027)	.261* (.000)	-.110 (.126)	.231* (.001)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table 6.18: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and social connectedness of gamification elements.

N = 196 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.416* (.000)	.319* (.000)	.240* (.001)	.253* (.000)	-.128 (.073)	.230* (.001)
Custom Goal	.365* (.000)	.445* (.000)	.181 (.011)	.191 (.007)	-.155 (.030)	.147 (.040)
Knowledge Sharing	.276* (.000)	.362* (.000)	.152 (.033)	.120 (.093)	.023 (.748)	.135 (.059)
Unlockable Content	.421* (.000)	.371* (.000)	.154 (.031)	.266* (.000)	-.106 (.138)	.224* (.002)
Supportive Updates	.440* (.000)	.425* (.000)	.157 (.028)	.270* (.000)	-.172 (.016)	.261* (.000)
Virtual Character	.275* (.000)	.330* (.000)	.084 (.242)	.132 (.065)	-.002 (.981)	.105 (.142)
Cutting Corners	-.004 (.956)	.149 (.037)	.005 (.948)	-.053 (.464)	.178 (.012)	.032 (.660)
Donate Points	.283* (.000)	.228* (.001)	-.008 (.912)	.071 (.325)	-.064 (.374)	.133 (.063)
Earn Trophy	.393* (.000)	.409* (.000)	.178 (.012)	.240* (.001)	-.084 (.244)	.180 (.011)
Support Charity	.353* (.000)	.356* (.000)	.067 (.349)	.257* (.000)	-.106 (.138)	.265* (.000)
Rotating Leadership	.373* (.000)	.361* (.000)	.131 (.068)	.217* (.002)	-.061 (.398)	.200 (.005)
Leaderboard	.431* (.000)	.409* (.000)	.179 (.012)	.326* (.000)	-.131 (.067)	.277* (.000)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table 6.19: Bivariate correlation coefficients (Spearman's ρ) and associated p-values between the Hexad user types and future exercise intention of gamification elements.

N = 196 Gamification Element	User Types					
	Philanthropist (<i>p</i>)	Socializer (<i>p</i>)	Free Spirit (<i>p</i>)	Achiever (<i>p</i>)	Disruptor (<i>p</i>)	Player (<i>p</i>)
Lottery	.376* (.000)	.273* (.000)	.245* (.001)	.259* (.000)	-.231* (.001)	.252* (.000)
Custom Goal	.380* (.000)	.382* (.000)	.129 (.072)	.197 (.006)	-.208* (.003)	.179 (.012)
Knowledge Sharing	.216* (.002)	.339* (.000)	.129 (.072)	.155 (.030)	.049 (.495)	.129 (.071)
Unlockable Content	.412* (.000)	.358* (.000)	.175* (.014)	.273* (.000)	-.126 (.078)	.246* (.001)
Supportive Updates	.365* (.000)	.317* (.000)	.089 (.213)	.253* (.000)	-.131 (.067)	.273* (.000)
Virtual Character	.232* (.001)	.262* (.000)	.023 (.754)	.081 (.259)	-.005 (.941)	.086 (.229)
Cutting Corners	.016 (.822)	.168 (.018)	-.008 (.907)	-.012 (.864)	.149 (.037)	.035 (.628)
Donate Points	.219* (.002)	.159 (.026)	-.078 (.277)	-.025 (.723)	.062 (.385)	.089 (.217)
Earn Trophy	.312* (.000)	.331* (.000)	.166 (.020)	.176 (.014)	-.093 (.197)	.227* (.001)
Support Charity	.274* (.000)	.222* (.002)	.052 (.473)	.242* (.001)	-.132 (.064)	.208* (.003)
Rotating Leadership	.351* (.000)	.339* (.000)	.115 (.110)	.192 (.007)	-.030 (.681)	.197 (.006)
Leaderboard	.399* (.000)	.323* (.000)	.145 (.042)	.220* (.002)	-.132 (.064)	.219* (.002)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

As expected, individuals who score high on **Free Spirit** related traits seem to enjoy elements of *Unlockable Content*, and surprisingly, also seem to enjoy elements of Lottery. This finding can be explained by the interactive nature of the scenarios in that players can take turns (Rooksby et al., 2015) to explore the system. While a similar pattern for *Unlockable Content* was observed for future intention, the same was not observed for social connectedness suggesting that these elements might be less preferred in a social context. **Achievers** seem to be strongly motivated by elements of *Lottery*, *Leaderboards*, *Rotating Leadership*, *Encouraging Updates*, and *Earning Trophies*. Although *Earning Trophies* seem to be moderately persuasive and enjoyable, trophies might be inadequate to sustain motivation over the long-term as the same pattern was not observed for future intention for exercise. This finding can be explained by the notion of competition decreases intrinsic motivation when an activity (such as winning a trophy) is perceived as an instrument to gain external reward (Deci et al., 1981). A similar pattern was observed for individuals who score high on **Player** related traits. As expected, **Disruptors** seem to strongly prefer the game element *Cutting Corners*.

6.7.2 Qualitative Results

Similar to the procedures for analyzing the dataset in Round 1, one reoccurring theme was that participants found that earning exercise points to support a charity feature motivating as quite a few participants commented “the charity donation seemed like the best motivation for me” [P122], while another participant said “working on a goal that supports charity is super motivating to me” [P100], one more participant thought “I would do it if I am definitely sure it will really go to that charity chosen” [P79]. Considering that the majority of the sample score high on Philanthropist related traits, this finding aligns with characteristics possessed by Philanthropists who are described as selfless, wanting to give to other people and enrich the lives of others in some way without expectation of something in return (Marczewski, 2015), and the feature of supporting a charity through gameplay offers a way for players to give to other people which satisfies the need for purpose and meaning.

Other features that were liked by many participants was the ability to set goals and engaging in competitive challenges. For example, one participant commented “A lot of these would be highly motivating, some of them not as motivating, but it is always fun to chase after something in a competition. It makes me more motivated” [P119], while another participant wrote “I love a challenge, but doing so virtually bores me to tears” [P67] suggesting that it is important to extend exercise and gameplay challenges to the real-world. Furthermore, a participant reported that “These are all great ideas to have in an app”, and further explained “However I do like the individual's step progress showing alongside seeing the team's progress, instead of only showing the team's progress” [P105] suggesting that displaying “progress” of both individual and team performance can be useful for motivating individuals who score high on Player and Achiever related traits satisfying the need for mastery and rewards.

One more interesting comment that also overlaps with results collected in Round 1 is the idea of social features tailored to a player’s social circle. For example, one participant mentioned “I am not a person who likes to exercise with others, but it seems like a cool program to exercise when I am with some family members or friends” [P189]. This comment further supports the idea that a specific feature set can be designed for play with friends, while a different feature set can be designed for play with family members. A feature set can also be designed for play with strangers.

Additionally, many participants also commented on that such a game would require both members of the team to be equally invested in the task or activity. For example, one participant wrote “The main reward would be completing the steps and goals. Receiving the virtual trophy may be an added bonus, but I would be interested only if my teammate is interested in receiving the trophy” [P70]. Another participant remarked “I would be very happy to accomplish my goals in a team setting that was dependent on a challenge wheel. My only concern is what would happen if my teammate didn't pull their weight” [P191]. One more participant believes that “it's

motivational to have a team aspect in a challenge because you don't want to let your teammates down" [P136]. Furthermore, a participant said "The feature described looks like too much work to stay motivated, but if I have a teammate that stays motivated with me and there's a competitive reward, I'd feel encouraged to reach the goal" [P99]. Collectively, these comments suggest the importance of a committed teammate who needs to be equally invested (in effort, interest, and motivation) in the game as the other player is.

There were aspects that participants did not find appealing about the design. For example, in the case of sharing supportive updates, there were some comments that related to how participants would feel aggravated if they had to keep track of their steps as one participant wrote "It annoys me to count my steps. It would annoy me even more to have to pay attention to how many steps my friend is walking [P205]" while another participant thought that it is "Way too invasive, this totally infringes on my privacy and would be very annoying [P207]". For game design, these comments suggest that it is important to carefully consider when it is best to send and display notifications to players, as well as designing to protect the privacy of users when a system collects and shares personal information.

For player matching, one participant wrote "If this were a real idea, I would be interested in doing this with a friend, neighbor or even a virtual partner" [P82], while a different participant likes the idea of "having friends to reach out to, and get advice in areas I struggle in [P88]". Other participants thought that unlocking new content would be appealing "If it's for an app me and my friends are interested in, this feature would be amazing [P137]". Another participant thought that the donating points feature "would be fun with a large group of friends that have a common goal and interest [P90]", while one more participant said that "I would love this feature and if my friends got involved, it would motivate me enough to work out every day [P83]" when they are exercising to donate to a charity. For game design, these comments seem to suggest that matching using friendships can increase the level of engagement.

6.8 Discussion

6.8.1 Design Recommendations

Taking all the results of this study into consideration, we suggest some recommendations for designing multiplayer step-based exergames that can be enjoyable, socially rewarding, and motivate continued exercise (Table 6.20). At the start of the game, players can be matched based on similar and complementary (e.g., a Philanthropist can be matched with a Socialiser, or a player can be matched with an Achiever) player traits and specific game elements can be offered to increase the level of motivation.

Table 6.20: Design recommendations for designing multiplayer step-based exergames.

Groups composed of	Offer the following gamification elements	Will likely increase
Philanthropists only, Philanthropists and Socialisers	Lottery, custom goal, knowledge sharing, unlockable content, supportive updates, virtual character, donate points, earn trophy, support a charity, rotating leadership, and leaderboard.	Persuasiveness
		Enjoyment
		Engagement
		Future exercise intention
Socialisers only	Lottery, custom goal, knowledge sharing, unlockable content, supportive updates, virtual character, cutting corners, donate points, earn trophy, support a charity, rotating leadership, and leaderboard.	Persuasiveness
		Enjoyment
		Engagement
		Future exercise intention
Free Spirits only	Lottery, custom goal, knowledge sharing, earn a trophy and rotating leadership. Lottery, custom goal, knowledge sharing, and leaderboard. Lottery, custom goal, knowledge sharing, unlockable content, supportive updates, earn a trophy and leaderboard. Lottery, unlockable content, earn a trophy, and leaderboard	Persuasiveness
		Enjoyment
		Engagement
		Future exercise intention

Groups composed of	Offer the following gamification elements	Will likely increase
Disruptors only	Cutting corners	Persuasiveness Enjoyment Engagement Future exercise intention
Achievers only	Lottery, custom goal, knowledge sharing, unlockable content, supportive updates, earn a trophy, support a charity, rotating leadership, and leaderboard.	Persuasiveness Enjoyment Future exercise intention
	Lottery, custom goal, unlockable content, supportive updates, earn a trophy, support a charity, rotating leadership, and leaderboard.	Engagement
Players only	Lottery, custom goal, unlockable content, supportive updates, earn a trophy, support a charity, rotating leadership, and leaderboard.	Persuasiveness Engagement Future exercise intention
	Lottery, knowledge sharing, unlockable content, supportive updates, donate points, earn a trophy, support a charity, rotating leadership, and leaderboard.	Enjoyment
Achievers and Players	Lottery, knowledge sharing, unlockable content, supportive updates, support a charity, rotating leadership, and leaderboard.	Persuasiveness Enjoyment Engagement Future exercise intention
Philanthropists, Socialisers, Free Spirits, Achievers, and Players	Lottery, custom goal, earn trophy, and rotating leadership	Persuasiveness

We also extracted from our results and offer some general guidelines based on individual player preferences that can increase the level of motivation:

- **Philanthropist:** Offer a variety of game elements but avoid offering elements that can disrupt the system.

- **Socialiser:** Offer a variety of game elements, particularly ones that involve social interactions.
- **Free Spirit:** At the start of the game, offer opportunities of chance, knowledge sharing and turn-taking, but, as the game progresses, offer unlockable content and leaderboard elements.
- **Disruptor:** Offer elements of change but avoid offering elements of lottery.
- **Player and Achiever:** Offer elements of chance, unlockable content, prize, leaderboard, turn-taking, and opportunities for players to exchange updates and signs of support.

6.8.2 Limitations and Directions for Future Work

Although these results show some interesting patterns, one limitation of this research is the use of static storyboards, and so the next step will be to implement a game that can be tested in a real-world context to further validate the elements and the idea of matching based on player traits. Future work can explore combining gamification elements and dynamically changing the mechanics (teammates and elements) as the game progresses. Future work can also explore personalizing based on other personal characteristics such as personalizing social game elements specifically for between friends and elements specifically for family members, as well as elements specifically for between strangers. Researchers have examined the effects of existing positive relationships on exergame retention and found the physical activity levels declined after 4-weeks of play (Caro et al., 2018), and it would be interesting to further explore the effect of friendship and other personal characteristics (such as personality) together with player type matching on motivating continued play and exercise.

To personalize the social experience even more, different features can be offered for different types of groups. For example, a feature set for friends, a feature set for family members and a feature set for strangers. Research has already investigated personalizing exercise coach that matches the players level of competitiveness and cooperativeness (Shaw et al., 2016), and recent studies shows that personalized gamification is more effective and motivational than non-personalized gamification

(Rodrigues et al., 2021; Passalacqua et al., 2021). It would be interesting to combine socially competitive and cooperative features and see how players prefer different among the player's social network of friends, family, and strangers. For player matching, based on the qualitative comments, matching using friendships seem to be favorable as many participants expressed that many of the features would be enjoyable to engage with their friends, but possibly even neighbours and virtual partners.

Different personality and player type models can also be explored. For example, in the domain of personality, in addition to the Five-Factor Model (Digman, 1990) and the Task- and Relationship model (Halfhill et al., 2005a), there is the 28-item DISC (Dominance, Inducement, Submission and Compliance) personality test (Marston, 2013) which explicitly describes how individual personalities interact at the group level and has been shown to be effective personality matching for forming more effective teams in crowdsourcing contexts (Lykourentzou et al., 2016). As for player types, in addition to the Hexad model (Marczewski, 2015) the BrainHex model (Nacke et al., 2014), is another popular for personalizing game towards individual player preferences (Busch et al., 2016), and has been tested to show that the consideration of multiple factors (e.g., traits, gender, and attitudes towards stories in games) are important when predicting player preferences for different game genres. It would be interesting to compare both the effectiveness of the Hexad and the BrainHex preferences for social features in the context of social exergames.

This Addon study investigated the potential of personalizing multiplayer exergames using social elements and player type matching as the motivators. We employed a storyboard approach to test our hypothesis that applying patterns based on the literature that increase social connectedness can improve player retention. We found that certain game elements are strongly preferred by players who possess certain traits. While some of these results were expected and are consistent with findings in previous studies (e.g., positive correlation between philanthropist and knowledge sharing), there were also some new ones (e.g., positive correlations between

philanthropist and rotating leadership). Finally, we suggested guidelines for developing step-based asynchronous multiplayer exergames based on player types and the kinds of game elements that can be offered for increasing retention. These findings broaden our understanding of player preferences in gamification and can enable researchers and practitioners to develop more personalized exergames that include more socially enriching game mechanics in the future.

7 ExerQuest Redesign

The actual effects of personalizing social elements for motivating exergame retention and the compatibility between similar and complementary player matching cannot be investigated without allowing users to interact and experience the gameful design elements in a real system. Thus, based on results of the foundation and add-on study, we attempted to reflect on our findings and the current design of our exergame, ExerQuest, to see how we can improve it. While the evaluation of a new design beyond the scope of this thesis, we are hoping to demonstrate how the research findings can be used in the design of exergames, and to evaluate this new design in the future.

7.1 Design and Concept

The main theme of planetary guilds and outer space can be kept the same as previous research using gameful applications encouraging physical activity demonstrates that this theme is well perceived in the physical activity context (Doyle et al., 2011; Finkelstein et al., 2010; Saksono et al., 2015). Having unlimited number of groups belonging to a limited number of guilds allowed us to have flexibility, scalability, and friendly and non-friendly challenges. The asynchronous aspect (where exercise and gameplay occur at separate times) can also be preserved as this experience can offer better flexibility and is a new trend in both exergame research and design (Chan et al., 2019). However, the process for starting a challenge (the voting system) needs to be improved, especially if groups are to be larger (in our foundation study, we tested groups of two members only). The durations of challenges can be extended, and additional features can be introduced to keep players engaged and committed while no other game related activities are happening. Social interactions also need to be encouraged and frequent, so players are reminded that they are in a challenge and their teammate depends on them.

7.2 Gamification Elements

Based on the findings of the conceptual storyboard-based online study and that player pairings can be formulated using the Hexad framework for personalizing social elements presented in Chapter 6, we decided to use the following gameful design

elements for redesigning ExerQuest, which we call “ExerQuest II”. Table 7.1 summarizes how these new features were inspired by our findings in the Foundation and Addon studies. In addition to our own results, we also reviewed existing literature on psychology and game design to develop a basis and describe how these features can be integrated in the following five sub-sections below.

Table 7.1: New social features (gameful elements) that were inspired by our findings in the Foundation and Addon studies.

New Feature (Gameful Element)	Foundation Study	Addon Study
Social Competition and Collaboration	Task-oriented groups engaged in more non-friendly (competitive) challenges than friendly (collaborative) challenges. Players desired to see the challenges of other teams.	Leaderboards, which belong to a broader category of socialization elements (Tondello et al., 2017), were strongly preferred by all Hexad player types except for Disruptors.
Supportive Updates	Players reported that “it was easy to forget about the game with no updates” and “I was more motivated to get steps in when I saw how well my partner was doing because I didn’t want to let them down”.	Sending and receive supportive updates were strongly preferred by all Hexad player types except for Disruptors.
Earning Rewards and Prizes	Task-oriented groups engaged in more non-friendly challenges suggesting that they were motivated for the opportunity to earn bonus points.	Rewards and prizes (e.g., lottery, and earning a trophy) were strongly preferred by all Hexad player types except for Disruptors.
Support a Charity	Players wished for more creative ways to play the game and make use of the points acquired.	Support a charity was highly rated by players who score high on Philanthropist, Socialiser, Achiever, and Player related traits.
Alternating Roles	Players wished for more social opportunities and activities to engage with other players and their friends.	Spin the lottery wheel and being the leader were particularly appealing for players who score high on Philanthropist, Player, Free Spirit, Achiever related traits.

7.2.1 Social Competition and Collaboration

Competition has been shown to be enjoyable in digital games (Staiano et al., 2012; Vorderer et al., 2003), and particularly, social competition can offer competence-enhancing experiences by engaging in social interactions with others (Vella et al., 2016a). Leaderboards have been shown to increase competence need satisfaction and perceived meaningfulness whereas teammates can affect feelings of social relatedness (Sailer et al., 2017). In our storyboard-based study, results showed that leaderboards, which belong to a broader category of socialization elements (Tondello et al., 2017), were strongly preferred by all Hexad player types except for Disruptors. Including leaderboard elements to show both team (e.g., all groups) and individual (e.g., most valuable player or top 5 players) performance should be particularly appealing for players who score high on Philanthropist, Socialiser, Player and Achiever related traits.

7.2.2 Supportive Updates

To maintain social interactions occurring within the game, players can receive prompts to update and send encouraging messages to earn additional points. Research in the domain personality and social psychology, shows that communicating positive events with others is associated with increased daily positive affect and when others responded actively and constructively, the benefits flourished even more (Gable et al., 2004). In the context of exergames, there is some research suggesting that highly supportive feedback messages is linked to higher levels of enjoyment, and feelings of social presence can facilitate feedback and playing experiences (Kim & Timmerman, 2018). In ExerQuest II, prompts can be sent once a day for players to exchange positive events, but players can decide to send more if they wish. This allows freedom while not adding too much pressure/annoyance to update. This would depend on the progress of the game as well. For example, more messages to encourage exercise might be more relevant at the beginning of a challenge as players might need more motivation to start. At the end of a challenge, teammates can congratulate each other if they succeed or support each other if they did not as they plan on the next

challenge. This gameful design element should be perceived particularly well for individuals who score high on relationship-oriented traits, and likely appeal to individuals who possess Player, Achiever, Philanthropist, and Socialiser type traits.

7.2.3 Earning Rewards and Prizes

Research shows that reward elements such as lotteries and challenges are preferred by Achievers and Players (Tondello et al., 2017). Gamification elements such as unlocking content, customizations, which have been shown to be preferable for individuals who score high on Free Spirit related traits (Orji et al., 2018b; Tondello et al., 2016), and earning rewards or prizes (such as a trophy) can be integrated with other elements to help motivate continued engagement. While the existing challenges in ExerQuest are only at the group level, these rewards and prizes can be earned and distributed both at the group and individual level. For example, for unlocking new content, a new challenge can be displayed on the challenge wheel or a new virtual character or accessory for a virtual character. Earning prizes can also unlock a new feature of the game or more difficult challenges. This gameplay experience is likely to appeal to groups composed of task-oriented players, and players who score high on Philanthropist, Socialiser, Achiever and Player related traits and can generate interest in other related features. For example, group who enjoys collecting points to support a charity, might be motivated to collect points to unlock more difficult challenges. As the team engage in more difficult challenges, they can earn more to support the charity even more.

7.2.4 Support a Charity

Based on the results of our Addon storyboard-based study, a feature that was particularly well liked was when a team was able to donate the points earned to support a charity. Perhaps ExerQuest II can be paired with an existing application such as Sweatcoin For Good²⁹ (London, UK) or Charity Miles³⁰ (New York, NY, USA)

²⁹ <https://sweatco.in/forgood>

³⁰ <https://charitymiles.org/>

along with other social features presented in this section. Such a feature will likely be well perceived by players who score high on Philanthropist, Socialiser, Achiever, and Player related traits.

7.2.5 Alternating Roles

Taking turns has been shown to increase the level of social interaction between players (Rooksby et al., 2015) and feelings of belongingness, group cohesion, empathy, and social connectedness (Dobbins et al., 2018). In our storyboard-based study, there were two gameful elements that offered opportunities for players to take turns: (1) spin the lottery wheel, and (2) being the leader. While spinning a lottery wheel may be a simple role with casual effect, a leader can be defined as someone with specific capabilities such as extra vote or veto power. For the lottery wheel, a set of predefined challenges can be offered where players can take turns to spin the wheel to determine a daily, weekly, or monthly challenge. For taking turns to be the leader (social status), this can be determined by the player who won the last challenge (or other conditions such as completed the challenge early). Both gameful elements can be integrated into the game to increase social interactions and is likely to attract player groups that score high on Philanthropist, Player, Free Spirit, Achiever related traits.

7.2.6 Additional Design Considerations

In addition to the gameful elements mentioned above, it would also be important to carefully match the skill level (a balanced exertion experience) of teammates. For example, a person who is not physically active to begin with, may prefer a person who is also the same so they can work together on the same goals. Another possibility is that a person who is not physically active, may like to be in a group with someone who is so that he/she can be motivated by the person who exercises. This idea is supported by research on virtual trainers and the personality of players that cooperative mode can be designed to cooperate with the player, helping the player in achieving exercise goals, whereas competitive mode, the trainer can be designed to encourage the player to compete and keep ahead (Shaw et al., 2016). It would be interesting to offer teammates who are at the same skill level (e.g., all teammates are

beginners) and different (e.g., intermediate and beginner), and examine the level of motivation together with personality matching. Other factors can include age matching (e.g., approximately the same age category), gender matching (e.g., males only vs. females only, vs. males and females), as well as physical fitness matching (similar Body Mass Index (BMI)).

Another consideration is connecting the accumulated exercise points with an existing game. This idea has been researched (Moller et al., 2014; Tan et al., 2016) and in addition to offering gameful elements for teams to motivate exercise, it would be interesting to also offer a way to use the points in a real game. For example, the points earned can be used as virtual tokens in a real game to purchase resource, earn power-ups, or to advance to the next level. A more concrete example is that rather than simple button presses to increase a character's strength in the game, players can choose to perform exercise to increase the character's strength.

7.3 Beyond Designing Exercise Games

Beyond exergames, some thoughts on designing for MMOGs or other domains are:

- In MMOGs, typically player matching is done using similar skills (Horton et al., 2016; Wang et al., 2015), but it can be matching player profiles and playing preferences (Delalleau et al., 2012).
 - Player profiles can be displayed, and players can be asked to rate the degree to which they would like to be part of the same team.
 - The Q-sort method (Ozer, 2004) has been used in the domain of personality psychology to assess social desirability (Fluckinger, 2014).
- We can consider creating a positive working environment by matching team members based on personal characteristics. For example, in the domain of organizational and social psychology, much research has examined the effects of personality in work environments for formulating teams and team effectiveness (Neuman et al., 1999).

- In the education domain, researchers have examined the effects of grouping students based on personality for group projects (Hutto et al., 2011). Our findings can potentially help with such grouping.
- The results can also be useful for designing persuasive apps for health and wellbeing. For example, many researchers are investigating the Hexad model (Marczewski, 2015) and tailoring gamification elements for persuading healthy eating behaviours in app based technologies for individuals (Altmeyer, Schubhan, et al., 2020; Hamari & Koivisto, 2015; Orji et al., 2013, 2014; Orji, Mandryk, et al., 2017). Our findings can be extended to designing personalized apps for groups.

8 Conclusions

8.1 Thesis Summary

The goal of this thesis was to address the retention problem in exergames. Accordingly, we conducted three user studies to investigate player preferences (based on personality and player type) for gameful design elements frequently employed in gamification. The first was a Pilot study, which served as a precursor to explore the idea of matching using personal characteristics. The second was a Foundation study to examine the effects of personality groupings offering simple game features that can increase the level of social interactions and in turn, increase retention. The third was an Add-on study to further investigate player matching based on player types and the kinds of gameful elements and interactions that can be offered to enhance social connectedness between player groups, and in turn increase exercise motivation.

In this work, we explored a variety of personal characteristics and game features that can be used for designing more socially satisfying exergame interventions. Stemming from the SDT (Deci & Ryan, 2000), GPC theory (Halfhill et al., 2005a), and the Hexad framework for gamification design (Marczewski, 2015), this research introduced the concept of matching players based on personal characteristics (personality and player type) in different ways (similar and complementary) and a method for testing its effectiveness for adherence to an asynchronous exercise game. Through our game design and examination of player matching, we sought to harness the power of positive social interactions and offer player groups experience a stronger sense of connectedness. These feelings of connectedness developed during gameplay is expected to increase player retention by players motivating each other to continue both exercise and play.

With respect to our three research questions:

1. Can matching based on personal characteristics help with retention?
2. Which personal characteristics are more effective in helping with matchmaking to increase retention?

- a. Is personality effective for player matching and retention?
 - b. Is player type effective for player matching and retention?
3. Which game features can take advantage of those personal characteristics more effectively?

For our first question, all three studies (the Pilot, Foundation, and Addon) seem to suggest that matching players using personal characteristics (personality and player type) can increase retention provided two main conditions: (1) the persuasiveness of the features offered to engage player groups, and (2) the commitment between players. For our second question, the results of our Pilot and Foundation studies, seem to show that personality-based matching can be effective for increasing retention, while the results of our Add-on study can predict interest in player matching and retention when socially satisfying features offered and compatible players are grouped together. And finally, for our third question, the Addon study shows that tailoring gameful elements to player type can provoke a more socially satisfying experience, and in turn increase exercise motivation.

8.2 Contributions

This thesis contributes to the literature on games user research in the following ways:

- Offering a review of existing literature on the motivational strategies and approaches for single and multiplayer exergames identifying the following main research gaps:
 - The long-term effectiveness of exergame interventions is unclear mainly because of the limited number of long-term studies.
 - The need for more domain specific metrics (questionnaires) for evaluating the exergaming experience.
 - A key area for future research is social factors and group dynamics, such as multiplayer exergames and more effective player matchmaking strategies for increasing social connectedness.
- Proposing and verifying that player matching using personal characteristics can increase game retention.

- Designing player pairing mechanisms (similar or complementary) using personal characteristics can be used to match players in exergames.
- Exploring how to offer more socially satisfying interactions between players to increase the level of social connectedness.
- Extending and applying personality theories and player type models to the design of exergames to personalize (rather than a “one-size-fits-all” approach) playing preferences and the user experience (in both individual and groups) and motivate continued play.

8.3 Limitations and Directions for Future Research

Our work has several limitations. First, most measures were self-reported. Although in the foundation study, we collected some objective data (e.g., number of challenges, duration of challenges) in all three studies we relied mostly on the analysis of subjective, and qualitative data. Particularly in the Addon study where respondents were asked to rate their level of agreement or disagreement with survey statements on hypothetical scenario. Thus, future research can collect more objective data. Relatedly, some of the scales we used were for measuring general experiences, such as the IMI, and while the IMI has been used in other exergame research (Kooiman & Sheehan, 2015; Song et al., 2013a; Zhao et al., 2017b), specific measures for evaluating the exergaming experience and the perceived gamefulness of the features could have been more appropriate. For example, recent instruments have been developed to measure the motivation for exergame play (Staiano et al., 2019), exergame enjoyment (Fitzgerald et al., 2020), and an individual user’s gameful experience of a system and service (Högberg et al., 2019).

A second limitation is the group size. While some insight for designing exergames for paired play can be derived from the results presented in this thesis, whether these results are valid beyond teams of two players is unknown. Thus, the findings from the three studies should represent an invitation for future research that could further verify the effectiveness of player matching and persuasiveness of gameful elements in larger groups. Future research can explore the effects of personality or player type

matching similar to Hutto et al. (2011) where student groups were formed in a classroom context for doing a class project or Zhou et al. (2015) where existing teams in a technology incubator were recruited for a survey study. However, recruitment of existing teams might not allow the balance of personality or gamers to represent each category type. For example, a team can be composed of members possessing the same type. Thus, many groups will need to be recruited to better ensure that there are groups composed of similar and groups composed of complementary characteristics. People with different characteristics and interests can also be brought together to play by inviting different levels of participation, focusing on value, combining familiarity and excitement, as well as creating a sense of “rhythm” for the group (Wenger et al., 2002). Another method to balance the characteristics of participants is to conduct a mass testing study to screen for certain personal characteristics (e.g., introduction to psychology class) and manually formulate player groups based on the screening results.

A third limitation of this work is associated with the balance of player groups and the relationships between the players. In the pilot study, player pairs were acquaintances. In the foundation study, player pairs were composed of strangers and friends. While in the add-on study, respondents were asked to rate hypothetical scenarios that can represent groups of strangers, friends, or family members. Previous research have investigated the effects of pairing strangers vs. friends (Caro et al., 2018; Chan et al., 2017), as well as groups of students in the same class (Sun, 2012, 2013a) on exergame enjoyment. Research also shows that gamers prefer to play MMOGs with their real-life friends and family members (Uz & Cagiltay, 2015). Depending on the social relationships (e.g., groups of friends, family members, co-workers, classmates, strangers) the dynamics can be different, and features may be more preferable than others. For example, a group of friends may enjoy competitive elements, whereas a group of strangers who are getting acquainted with each other, cooperative elements can facilitate the development of positive relationships.

An individual's cultural preferences (Hofstede & Milosevic, 2018) can be another type of personal characteristic where players can be matched. For example, individualistic cultures may prefer competitive game features that focus on independence, whereas collectivistic cultures may prefer cooperative game features that focus on support and group loyalty. Researchers are investigating the role of cultural values on gamification preferences (Salimon et al., 2021; Usunobun et al., 2019) and it would be interesting to form groups based on similar (e.g., a group of individualistic members) and different (e.g., a group composed of both individualistic and collectivistic members) cultural preferences together with gender and personality (Costa et al., 2001), and examine the effect on game enjoyment, social engagement, and exercise adherence.

Furthermore, future work can investigate player matching where player preferences are detected by the system which then recommend a player partner based on in-game choices and actions. Recently, researchers are investigating the plausibility of gamifying the Hexad questionnaire making the experience of taking the survey as if it was part of the game (Altmeyer, Tondello, et al., 2020b). In both the Foundation and Add-on studies, we employed and tested a model-based (top-down) approach (Yannakakis et al., 2013; Yannakakis & Togelius, 2011), where players take a survey based on a theoretical framework (e.g., the FFM, task-relationship personality model, Hexad) to measure their playing preferences, followed by devising similar/complementary groupings and offering game content that would likely appeal to players. As it might be cumbersome to do the modeling before the game, it would be interesting to explore the effects of player matching using a model-free (bottom-up) approach where there are no preconceived assumptions about the player and allow relationships to develop organically. The game can start with offering basic features and continuously adapt based on player preferences and choices.

Another avenue for future research is how to invite players who leave to return to the game. Perhaps some kind of incentive can be offered, such as bonus points, as a reward for players who return to the game. Researchers are examining the

effectiveness of idle game patterns for improving player retention in social exergames (Villareale et al., 2019). In addition to rewarding a player for returning to the game, other patterns such as timed actions was proposed to increase long-term engagement, while player-driven auto-play, and system automation was proposed to mitigate the *snowball effect* (when player become inactive and deter the other players' experience) (Villareale et al., 2019). It would be interesting to offer software-generated (SG) (Samendinger et al., 2021) or non-player characters (NPCs) (Ochs et al., 2008; Tomlinson & Blumberg, 2003) that perform in-game actions that are similar or complementary to the player's personality or player type and explore whether that might influence exergame retention.

At a more general level, the results of this study can be fruitful for designing all kinds of exergames. For example, game developers and designers can choose from a variety of game features, and offer different modes (e.g., competitive, or cooperative) and playing options (e.g., single-player, multiplayer, NPC). Moreover, certain aspects of the game can even be customized by the player. For example, a list of individual features in which the player can choose from (e.g., participate in leaderboard, unlocking new content, and lottery, but not participate in donating points), the user-interface (e.g., colours, themes and virtual characters), and the level of motivation (e.g., exercise intensity or setting an achievable goal) can all be customized by the player to his/her playing preferences.

Glossary

Affective learning	The <i>emotional</i> area of learning reflected by the beliefs, values, interests, and behaviours of learners (Krathwohl & Bloom, 1956).
Attitudes	The predisposition to respond evaluatively, favourably or unfavourably, to aspects of one's environment or self (Deutsch, 2011).
Behaviour change	A long-term process characterized by initiation of a new health-promoting behavior, and maintenance (i.e., repetition) of this behaviour over time (Lally & Gardner, 2013).
Behavioural Choice Theory (BCT)	A theoretical approach that attempts to understand the process of judgment and decision making, and how time and responses are allocated given the available options (Epstein, 1998).
Big Five Inventory (BFI)	44-item inventory (5-point Likert scale: 1 = disagree strongly to 5 = agree strongly) that measures an individual on the Big Five Factors (openness, conscientiousness, extraversion, agreeableness, neuroticism) of personality (Goldberg, 1992).
Competition	A negative attitude that people are against each other (Deutsch, 2011).
Complementary fit (opposites attract)	Attributes where heterogeneity among team members is desired (Prewett et al., 2018).
Cooperation	A positive attitude that people benefit one another (Deutsch, 2011).
Engagement	The level of motivation that a player shows during gameplay which reflects a psychological process (Caroux et al., 2015).
Enjoyment	In the videogame literature, <i>enjoyment</i> is a positive affective state during and as a result of gameplay (Caroux

et al., 2015) and is commonly associated with a player's experience of fun and level of interest (Mekler et al., 2014).

Exercise	A subset of physical activity: planned, structured, and repetitive bodily movement performed to improve or maintain one or more components of physical fitness (Caspersen et al., 1985).
Exergame	A combination of video games and exercises (Yim & Graham, 2007).
Extrinsic motivation	Doing an activity to attain some separable outcome or value (Ryan & Deci, 2000).
Flow	The optimal level of experience during work or play (Csikszentmihalyi, 1977).
Game design	The act of deciding what a game should be (Schell, 2008).
Gamification	Application of game elements in non-game contexts (Deterding et al., 2011a).
Group	Two or more individuals who are connected by and within social relationships (Forsyth, 2014).
Group cohesion	A dynamic process reflected by the tendency of a group to stick together and remain united in the pursuit of its instrumental objectives and/or for the satisfaction of member affective needs (Carron et al., 1998).
Group Personality Composition (GPC)	The mix of group members' individual traits, as reflected in group-level indexes such as average, minimum, maximum, or variance on such traits as individual agreeableness or conscientiousness (Barrick et al., 1998).
Interest	A psychological state that emerges from a person's interaction with an activity or their environment (Renninger et al., 2014).
Intrinsic motivation	Doing an activity simply for the enjoyment of the activity itself, rather than for external rewards or pressures (Ryan and Deci, 2000).

Intrinsic Motivation Inventory (IMI)	Multidimensional self-report instrument consisting of 45-items (7-point Likert scale) for assessing motivational structures for a wide variety of activities (Ryan & Deci, 1994). Dimensions include interest/enjoyment, perceived competence, effort/importance, pressure/tension, perceived choice, value/usefulness, and relatedness.
Matchmaking	The process of connecting players online so that they can play together (Horton et al., 2016).
Motivation	The driving force behind all the actions of an individual (Rabideau, 2005).
Nudge	Any aspect of the choice architecture that alters people's behavior in a predictable way without forbidding any options or significantly changing their economic incentives (Thaler & Sustein, 2017).
Personality	A stable set of tendencies and characteristics that determine the commonalities and differences in people's psychological behavior (thoughts, feelings, and action) that have continuity in time (Maddi, 1996).
Perceived Persuasiveness	An estimation of its ability to motivate behaviour change (Orji et al., 2019).
Persuasive Technology (PT)	Interactive systems designed to change a person's attitudes or behaviours (Fogg, 1998).
Physical activity	Bodily movement produced by the contraction of skeletal muscle that requires energy expenditure in excess of resting energy expenditure (Caspersen et al., 1985).
Relationship-oriented	Relationship-Oriented personality traits facilitate the interpersonal interactions necessary to works as a member of a team including extraversion, agreeableness and emotional stability (Halfhill et al., 2005b).
Self Determination Theory (SDT)	A broad framework for the study of human motivation and personality. It consists of three conditions (autonomy, competence and relatedness) supporting the individual's

experience for fostering the most “volitional and high quality” forms of motivation and engagement for activities (Deci & Ryan, 2000).

Self-efficacy	How well one can execute courses of action required to deal with prospective situations (Bandura, 1982).
Situational interest	An interactive psychological state that occurs at the moment there is a match between a person and an activity (Chen et al., 1999).
Supplementary fit (like-attracts-like)	Attributes where homogeneity is desired among team members – typically, it is preferred that each team member has a high level of a job-relevant attribute, leading to the term “elevation” (Prewett et al., 2018)
Task-oriented	Task-Oriented personality traits refer to traits that aid in the completion of work-related activities which 2 out of the Big-Five, include conscientiousness and openness to experience (Halfhill et al., 2005a).
Team Personality Diversity (TPD)	The variance or differences among team members for a particular personality construct or set of constructs (Neuman et al., 1999).
Team Personality Elevation (TPE)	A team’s mean level on a particular personality trait or set of personality traits (Neuman et al., 1999).

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Appendices

Appendix A: Preliminary Game Design Document

The game consists of the 3 following features:

1. Multiplayer (group of 5 players)
2. Induces a moderate level of exercise intensity
3. Shows the effect of personality

High Concept

ExerQuest is a web-based, social exergame designed to form groups where players can participate in challenges both inside and outside the group with the ultimate goal to save the world before it's too late. Group members can compete against each other within the same group, but groups can also engage in competitions. Gameplay and exercise occur at separate times and players can play when they wish. The more physical activity the player does the more points they will have to use in the game. It is all self-driven in real-life, and a social experience in the virtual world.

There are 5 regions in the world (mountains, water, glacier, forest, and desert) and players get one week to clear the region of its problems (obstacles) before they can move onto the next region. Each region consists of different problems. The group that gathers the most resources to clear the land of its problems can move onto to the next region before the other teams! However, it is possible for other teams to get a chance to collect more resources by accepting daily bonus offerings. This is to give other groups the opportunity to advance creating a competitive game experience. Groups will not know who will win until they reach the final level/stage of the game.

Genre

ExerQuest is a multiplayer exergame. It provides both entertainment and exercise at the same time. It offers both competitive and cooperative playing scenarios. Groups can compete against each other, whereas players within the same group can cooperate with each other. Players can choose playing scenarios as desired. ExerQuest is asynchronous meaning that exercise occurs outside of play sessions – a

virtual experience that encourages players to participate in exercise in real-life. Physical activity is tracked and turned into virtual rewards. Virtual rewards (points) can be used to power a game character, purchase resources, and help others (individual and groups) who are in need, as well as, banked for future use.

Target Audience

People (minimum 18 years old) who are interested in starting an exercise program or keeping an active lifestyle.

Goals

The main goal of the game is to save the world before it ends. The first group that can move through the regions and conquer all the obstacles covering the landscape wins. All 3 factions strive to keep the fog out or make the world brighter. If the world remains dark or if fog sticks around for too long, the percentages decrease.

Rules

Players need to keep exercising and earning points. If a player would like to play more, they can add more challenges to the “game-board” schedule (Figure 2). There are 5 regions of different landscapes that compose the whole world. Groups will have a piece of the landscape to work on each week. For example, in the forest region, all players must work together to clear the fog, put out the fires and save the animals. By the end of the week, players should have cleared the entire landscape of a region in-order to move onto to a different region. If all the fog is not cleared, all the fires are out and all animals saved by the end of the week, the players remain in the forest for another week until everything is cleared. At the end of 5 weeks, players will have reached the goal to save the entire world. Region types (levels):

1. Mountains
2. Forests
3. Water
4. Desert
5. Glacier

Actions

- To clear fog, players need to earn points
- To save animals, free them from a cage.

Points and Rewards

Region	Exercise Time		Reward
Forest	5 minutes	=	1 bucket of water to put out 1 fire
	10 minutes	=	2 buckets of water to put out 3 fires
	15 minutes	=	5 buckets of water to put out 8 fires
	30 minutes	=	10 buckets of water to put out 12 fires

Obstacles

The goal of each level is to restore the ecosystem making it livable.

Week	Regions (levels)	Obstacles
1	Mountains	Restore fallen trees, prevent mud slides
2	Forests	Clear fog, fight fires, save animals
3	Water	Reduce pollution
4	Desert	Collect water, grow plants
5	Glacier	Reduce carbon

Hardware

- The amount of exercise will be recorded by Fitbit activity trackers:
 - Walking
 - Running
 - Aerobic
 - Elliptical
 - Outdoor bike
 - Sports
 - Swimming
- A desktop computer capable of running a browser to go online and form groups and accept challenges.

- A mobile phone to show the player his/her amount of activity and level, as well as progress/status of other players for comparison purposes.

Software

Web-based (internet browser) and mobile – Android.

Back Story

One day the player receives that the world is about to end, but they can save it by accepting this mission. Ways to save the world include building a better economy, creating more energy efficient products, and conserving resources.

Progression and Levels

There are a total of 5 regions = 5 levels. To unlock a new region, players must overcome all the obstacles presented in the previous region within the allotted time which is 1 week. Each level consists of different obstacles, but similar mechanics in that players will gather resources to remove barriers. For example, players must gather enough water to put out fires in the forest or remove enough pesticides from the water to clear the pollution in the sea.

Mission/Challenge Structure

The main mission is to save to world. Challenges include short- and long-term challenges. Short term challenges are short exercises ranging from 5, 10 and 15 minutes, whereas long term challenges are longer exercise durations ranging from 30, 45 to 60 minutes. All count: strength, steps, cardio, and so on.

Objectives

The objective to complete the greatest number of challenges in the least amount of time in the most efficient way. After creating a player personality profile (Figure A1), the game begins by a player selecting a method he/she would like to save the world (see back story for more details).

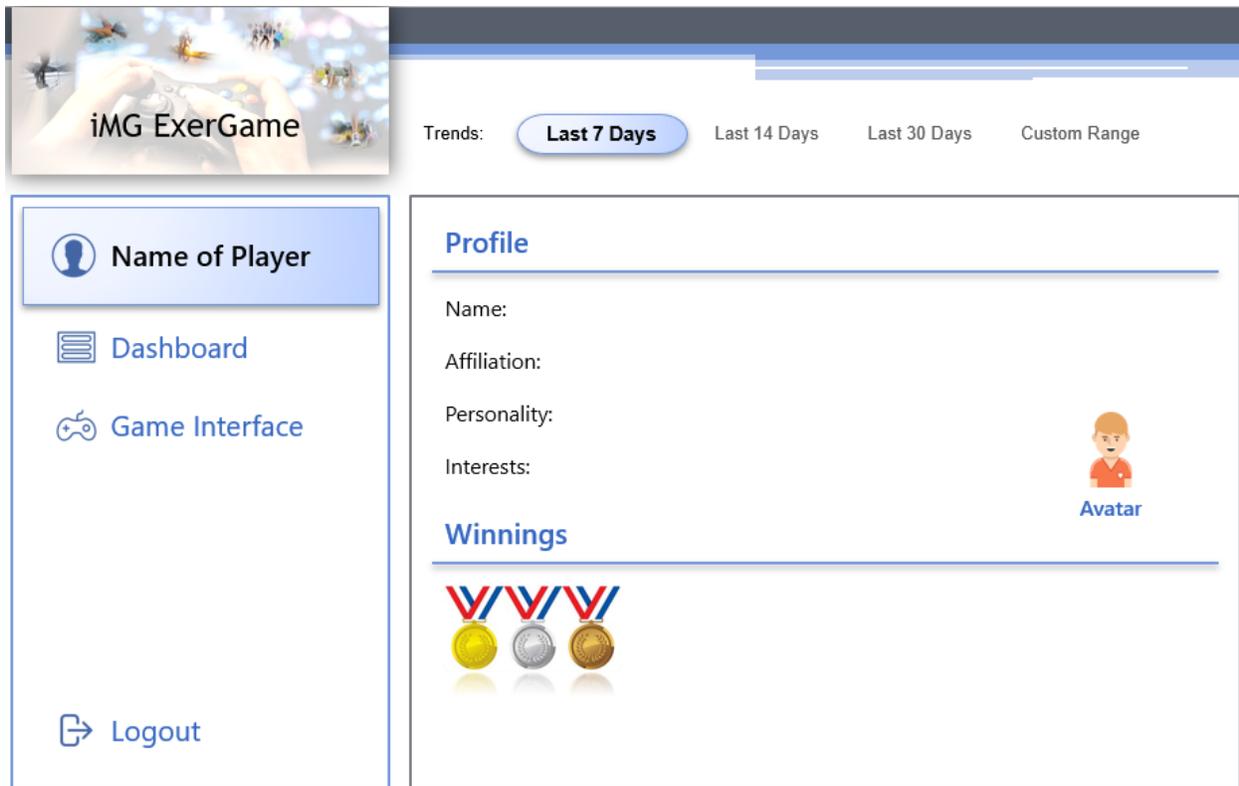


Figure A.1: Wireframes of player profile.

To better understand the effects of a personality based tailoring approach and create an intrinsically motivated experience, players are offered choices for how they would like to use their points in the game. Players can decide on 1 of 3 ways:

1. Bank: keep points and not use until the right moment
2. Keep to self and not share (agency)
3. Use to help others and join a group (communion)
 - a. May decide to help 1 group only
 - b. May decide to help multiple groups

Player may also decide to allocate points to a combination of these 3 ways – bank 50%, use 50% to help others. The player is always in control. From a psychological perspective, a player can choose at their own will the need (autonomy, competence and relatedness) they wish to satisfy. For example, if relatedness is low, a player can earn some points to engage with others by offering help to others.

Group Formation & Dynamics

- Fixed size: all groups will consist of 5 members
- Creation: Groups form organically (free choice) versus assign groups (forced situation)
- Group members may join or leave at any time.
- To join a group & leave a group
- Select to join based on player profile (initial point), but choose to leave based on negative experience
- Equality of each member (flat) Vs. group leader (same vs. rotating)

Play Flow/Timeline

Game resets every week. The group meets once a week to plan the challenges they wish to take on (Figure A2).

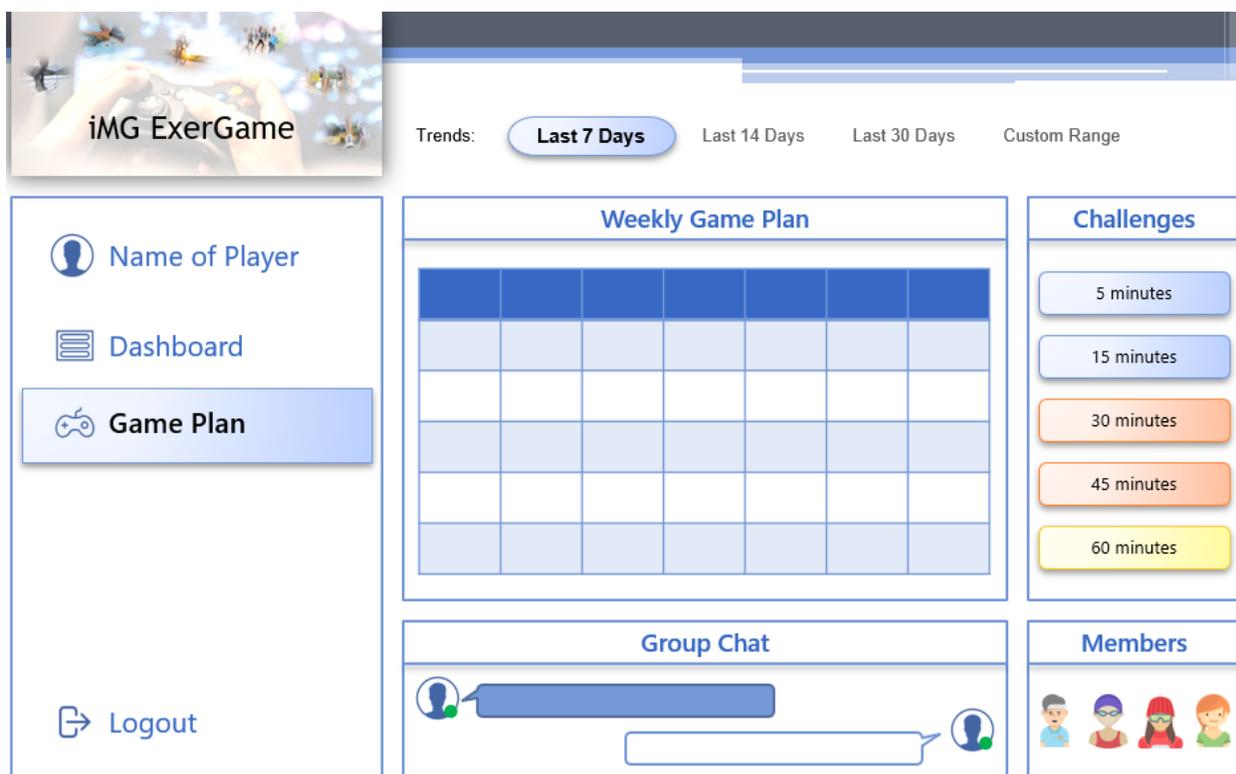


Figure A.2: Wireframe of weekly game plan UI.

Objects and Actions

Players drag and drop objects into the Weekly Game Plan table to plan their actions. Everyone will be aware of the roles and responsibilities of each of their teammates. The plan can change as they go along – if one player cannot do a particular challenge, he/she can ask for help from one of their team members who might have some extra exercise points. That player might help back when others are in need.

Modes/Scenarios

Offers friendly competition and collaboration game experience between groups where they can compete against each other.

Rewards

Ranking, first second and third place.

- Intrinsic: the actual activity – competition/cooperation
- Extrinsic: tangible reward – earn a key to unlock a piece that will contribute to the end goal, which is saving the world.

Dashboard (dynamic monitoring)

Highlighting significant changes in the data and visual story telling (Figure A3).

- Players need to know performance of self and of others and the system needs to show changes in game performance clearly
- Players can view a reply of game history in an interactive way.
- Dashboard shows:
 - Online/offline status
 - Sedentary/active status
 - Group membership – the team that is taking the lead
 - Which of the 3 themes players are invested – can be single or multiple
 - Trends on a daily and weekly basis. *Hourly?*

Alternative Concept

Inspiration:

Reddit's r/place canvas – first 24 hours full recap (2:15)³¹

- A game where players do exercise to earn colour pixels to draw on a canvas
- The canvas serves as a dynamic dashboard for showing player performance
- Canvas resets every week – continuous game where there is no ending to test how many times players would keep doing this

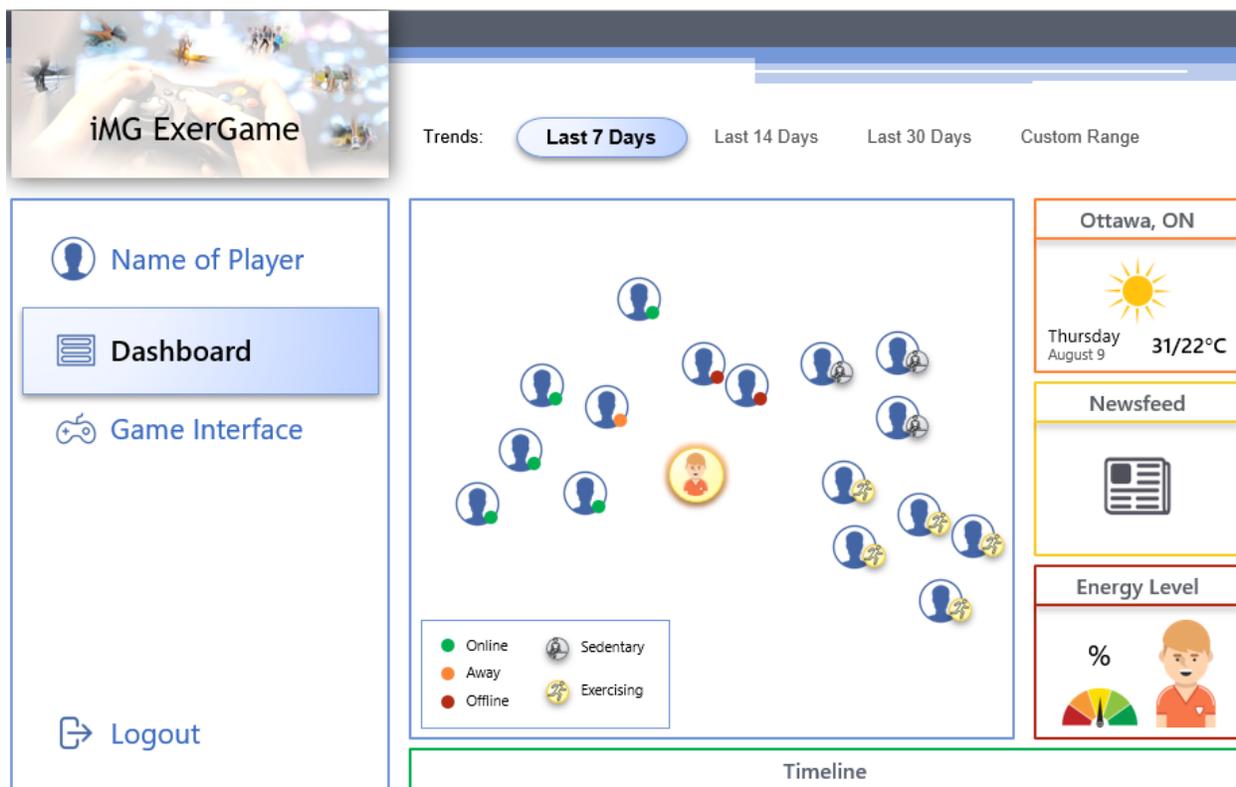


Figure A.3: Wireframe of information dashboard.

³¹ <https://www.youtube.com/watch?v=o-nH7U-WvbE>

Appendix B: Recruitment Poster



Social Exercise Game Study

CUREB-B Clearance # 110034
 Clearance Date: until January 31, 2020

Description: This is a 30-day study. But you may continue for another 30 days if you wish. You will be earning points while exercising to play a multiplayer online game. Exercises can be done anywhere such as the gym, park or at home. The activity you do will be logged by Google Fit and turned into virtual points for use online to compete and collaborate with other players. You will be asked to complete a questionnaire about your personality before playing (~12 minutes) and complete another questionnaire about how much you enjoyed the playing experience at the end (~15 minutes). If you choose to continue for another 30 days, you will be asked to complete the same questionnaire about how much you enjoyed the playing experience again after the 30-day period.

Eligibility Requirements: We are looking for anyone who is interested in playing a multiplayer online exercise game.

- Must be at least 18 years old
- Own an Android phone or iPhone
- Have a Google account

Compensation: \$ 20.00 Tim Horton's gift card.

Contact: For more information or if interested, please contact Gerry Chan at gerrychan@cmail.carleton.ca. Faculty supervisor Professor Ali Arya (ali.arya@carleton.ca).



Social Exergame Study
 Gerry Chan (gerrychan@cmail.carleton.ca)

Appendix C: Recruitment Email Notice

Dear Professor (Replace with name of Professor),

It's Gerry from the Digital Media division. I am currently conducting an experiment for a component of my thesis work supervised by Professor Ali Arya (ali.arya@carleton.ca) and was wondering if you can please kindly broadcast the study description provided below to students in your class?

Thank you,

Gerry.

—

Social Exercise Game Study

CUREB-B Clearance # 110034; Clearance Date: until 01/31/2020.

I am currently conducting a study to evaluate the effectiveness a new online game for increasing exercise motivation. No prior game experience is necessary, and your participation is completely voluntary. This is a 30-day study, but you may continue for another 30 days if you wish. You will be earning points while exercising to play a multiplayer online game. Exercises can be done anywhere such as the gym, park or at home. The activity you do will be logged and turned into virtual points for use online to compete and collaborate with other players. You will be asked to complete a questionnaire about your personality before playing and complete another questionnaire about how much you enjoyed the playing experience at the end.

To participate in this study, you must be at least 18 years old and own a Smartphone (iPhone or Android). You will receive a \$20.00 Tim Horton's gift card in appreciation of your participation.

If you have any questions about the study or interested in participating, please do not hesitate to contact me at: gerrychan@cmail.carleton.ca.

Thank you,

Gerry.

Faculty Supervisor: Professor Ali Arya (ali.arya@carleton.ca)

Appendix D: Welcome Email

Dear Participant:

I am the researcher for this study and would like to thank you for contacting me and for your interest. In general, this is a 30-day long study, but you may continue for 30 more days if you wish. Google Fit (<https://www.google.com/fit/>) needs to be installed on your smartphone (iPhone or Android) for the game to work. In appreciation of your participation, I would like to offer you a \$20.00 gift card to Tim Hortons or Starbucks. Please find enclosed a consent form which consists of more information about the study and the nature of your participation for review. After reading through, if you agree to participate, please sign page 4, and return to me at your earliest convenience.

Please feel free to contact me if you have any further questions.

Thank you and I look forward to hearing from you.

Kindest regards,

Gerry.

Appendix E: Informed Consent Form

Research Consent Form

Research Personnel

The following people are involved in this study and may be contacted at any time if you have any questions.

Gerry Chan
Principal Investigator
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Carleton University
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Dr. Ali Arya
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arya@carleton.ca

Project Title Social Exercise Game Study

Project Sponsor and Funder

National Sciences and Engineering Research Council of Canada (NSERC) through Engage grant (in-progress).

Carleton University Project Clearance

Clearance Number: CUREB-B Clearance #110034

Date of Clearance: 01 / 31 / 2020.

Invitation

You are invited to take part in this research project. The information on this form is intended to help you understand what we are asking of you so that you can decide whether you agree to participate in this study, or not. Your participation in this study is voluntary, and a decision not to participate will not be used against you in any way. As you read this form, and decide whether to participate, please ask any questions you might have, take all the time you need, and consult with others as you wish.

Purpose

Participation in exercise can improve health and well-being. However, it can be hard for some people to meet the recommended amount due to lack of motivation. Exergames, which is a combination of videogames and exercise, aim to increase the level of motivation by presenting exercise as a fun activity. Yet, some exergames may not be able to maintain exercise interest over the long-term. The purpose of this study is to explore the effects of personality matching for increasing exercise motivation in the context of an exergame.

Eligibility Criteria

To participate in this study, you must be at least 18 years old, own a Smartphone (Android or iPhone), have a Google account and be in good health.

Task Requirements, Duration and Locale

You will be asked to play a multiplayer online game by using points you've earned while doing exercise in the real world. You will also be asked to complete a personality profile before the game (pre-game questionnaire) which will take approximately 12 minutes. The experiment will last for 30 days and if you wish, you may continue for another 30 days. After 30 days, you will be asked to complete a questionnaire about your playing experience (post-game questionnaire) which will take approximately 15 minutes. If you decide to continue, you will be asked to complete the same post-game questionnaire again after the 30-day period.

The study will take place where you decide to perform physical activity such as a gymnasium, parks, or at home, as well as, where you decide to go online to play the game such as a shopping mall, in school or at home. The game interface is accessed through a web browser (desktop or mobile). The amount of time it will take to play the game and perform the exercise sessions over the 30-day or if you wish, 60-day period depends on you – how many challenges you and your group decide to accept. For example, if you and your group decide on accepting a 5-minute challenge one day,

then it will take approximately 3 to 5 minutes to interact with the web interface (which includes task such as login, check challenges, create challenges and accept challenges) and 5 minutes to for performing the exercise. You may create, send, and accept as many challenges as you wish. All daily physical activities will be tracked and turned into virtual exercise points. Google Fit (<https://www.google.com/fit/>) must be installed on your mobile phone to track your level of activity. If you do not have it, please install it.

Potential Risks and Inconveniences

There are no known physical/psychological risks, beyond any risk normally involved with using a mobile phone and performing physical activity.

Possible Benefits

You might gain some health benefits that are commonly associated with doing exercise such as better cardio-vascular health and sleep quality.

Compensation/Incentives

As a token of our appreciation, you will receive a \$20.00 E-Gift Card to Tim Horton's upon completion of this study.

Waiver of Rights

By signing this form, you are not waiving any rights or releasing the researchers from any liability.

Right to Withdraw

Your participation is entirely voluntary. You can refuse to answer any individual question and you have the right to withdraw from this experiment at any time without penalty. If you withdraw during the experiment, you have the right to request that your data be deleted 2 weeks after the exercise session begins. You will receive compensation even if you choose to withdraw from the study.

Anonymity/Confidentiality

We will treat your personal information as confidential, although absolute privacy cannot be guaranteed. No information that discloses your identity will be released or published without your specific consent. Research records may be accessed by the Carleton University Research Ethics Board to ensure continuing ethics compliance.

The results of this study may be published or presented at an academic conference or meeting, but the data will be presented in a way such that it will not be possible to identify any participants. You will be assigned a code so that your identity will not be directly associated with the data you have provided. A digital copy of research consent forms will be stored on Carleton Servers (Ottawa, ON, Canada) with password protection for 5 years, before being deleted.

The data will be coded (participant ID number – e.g., 101) such that your identity is not associated with your data. Only the researchers directly involved with this experiment will have access to the data. Your questionnaire data will be stored and protected by SurveyMonkey, on servers located in San Mateo, California, but may be disclosed via a court order or data breach.

Data Retention

Once the project is completed, all research data will be kept for five years and potentially used for other research projects on this same topic. At the end of five years, any digital copies of raw data files will be securely destroyed.

New information during the study

In the event that any changes could affect your decision to continue participating in this study, you will be promptly informed.

Ethics Review

This study has received clearance by the Carleton University Research Ethics Board-B.

Should you have any ethical concerns with the study, please contact the REB Chair, Carleton University Research Ethics Board-B (by phone: 613-520-2600 ext. 4085 or by email: ethics@carleton.ca). For all other questions about the study, please contact the researcher.

Statement of Consent

I have read the above form and understand the conditions of my participation. My participation in this study is voluntary, and I understand that if at any time I wish to leave the experiment, I may do so without having to give an explanation and with no penalty whatsoever. Furthermore, I am aware that the data gathered in this study are confidential and anonymous with respect to my personal identity.

I voluntarily agree to participate in this study. Yes No

Name of Participant (Please print)	Signature of Participant	Date
---------------------------------------	--------------------------	------

Research team member who interacted with the participant

I have explained the study to the participant and answered any and all of their questions. The participant appeared to understand and agree. I provided a copy of the consent form to the participant for their reference.

Gerry Chan		
Name of Researcher	Signature of Researcher	Date

Appendix F: Pre-Game Questionnaire

Part 1: Demographics Questionnaire

1. Age: _____ years old.
2. Gender: Male Female Prefer not to say
3. Height: _____ feet, and _____ inches.
4. Weight: _____ pounds.
5. Do you play video/computer games? Yes No

(If yes, please answer a., b., c., & d. below. If no, please proceed to question 6.)

- a. Do you typically play alone, with friends, or both?

 - b. What type of video games do you play?
(E.g., action, adventure, role-playing, puzzles, simulations, strategy)

 - c. Please list a few of your favourite video games:
· _____
· _____
· _____
 - d. On average, how much time do you spend playing video games?
_____ hours/week.
6. Do you participate in regular exercise? Yes No
(If yes, please answer a., b., c., & d. below. If no, please proceed to Part 2.)
- a. Do you typically exercise alone, with friends, or both?

 - b. What kinds of exercises do you do?

 - c. How much time do you typically spend exercising?
_____ minutes/day
 - d. What is the intensity level at which you typically exercise?
 Light Moderate Vigorous

Part 2: Personality Questionnaire

50-Item sample questionnaire of the International Personality Item Pool³² (Goldberg, 1992).

Please describe yourself as you generally are now, not as you wish to be in the future. Describe yourself as you honestly see yourself, in relation to other people you know of the same sex as you are, and roughly your same age. So that you can describe yourself in an honest manner, your responses are anonymous and shall be kept in absolute confidence. Indicate for each statement whether it is (1) Very Inaccurate, (2) Moderately Inaccurate, (3) Neither Accurate nor Inaccurate, (4) Moderately Accurate, or (5) Very Accurate as a description of you.

	Very Inaccurate	Moderately Accurate	Neither	Moderately Accurate	Very Accurate
1. Am the life of the party.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
2. Feel little concern for others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
3. Am always prepared.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
4. Get stressed out easily.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
5. Have a rich vocabulary.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
6. Don't talk a lot.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
7. Am interested in people.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
8. Leave my belongings around.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
9. Am relaxed most of the time.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
10. Have difficulty understanding abstract ideas.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
11. Feel comfortable around people.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
12. Insult people.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
13. Pay attention to details.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
14. Worry about things.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
15. Have a vivid imagination.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

³² https://ipip.ori.org/New_IPIP-50-item-scale.html

	Very Inaccurate	Moderately Accurate	Neither	Moderately Accurate	Very Accurate
16. Keep in the background.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
17. Sympathize with others' feelings.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
18. Make a mess of things.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
19. Seldom feel blue.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
20. Am not interested in abstract ideas.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
21. Start conversations.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
22. Am not interested in other people's problems.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
23. Get chores done right away.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
24. Am easily disturbed.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
25. Have excellent ideas.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
26. Have little to say.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
27. Have a soft heart.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
28. Often forget to put things back in their proper place.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
29. Get upset easily.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
30. Do not have a good imagination.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
31. Talk to a lot of different people at parties.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
32. Am not really interested in others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
33. Like order.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
34. Change my mood a lot.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
35. Am quick to understand things.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
36. Don't like to draw attention to myself.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
37. Take time out for others.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
38. Shirk my duties.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
39. Have frequent mood swings.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

	Very Inaccurate	Moderately Accurate	Neither	Moderately Accurate	Very Accurate
40. Use difficult words.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
41. Don't mind being the center of attention.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
42. Feel others' emotions.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
43. Follow a schedule.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
44. Get irritated easily.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
45. Spend time reflecting on things.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
46. Am quiet around strangers.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
47. Make people feel at ease.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
48. Am exacting in my work.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
49. Often feel blue.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
50. Am full of ideas.	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Appendix G: Post-Game Questionnaire

Please indicate your level of agreement or disagreement with each of the following statements.		Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	I enjoyed playing this game very much.	<input type="radio"/>						
2.	This game was fun to play.	<input type="radio"/>						
3.	I thought this was a boring game.	<input type="radio"/>						
4.	This game did not hold my attention at all.	<input type="radio"/>						
5.	I would describe this game as very interesting.	<input type="radio"/>						
6.	I thought this game was quite enjoyable.	<input type="radio"/>						
7.	While I was playing this game, I was thinking about how much I enjoyed it.	<input type="radio"/>						
8.	I enjoyed engaging in friendly challenges.	<input type="radio"/>						
9.	I enjoyed engaging in non-friendly challenges.	<input type="radio"/>						
10.	I enjoyed being part of this team.	<input type="radio"/>						

Next >

Please indicate your level of agreement or disagreement with each of the following statements.		Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	I believe this game could be of some value to me.	<input type="radio"/>						
2.	I think that playing this game is useful for keeping me active.	<input type="radio"/>						
3.	I think this game is important to play because it can motivate me to engage in exercise.	<input type="radio"/>						
4.	I would be willing to play it again because it has some value to me.	<input type="radio"/>						
5.	I think playing this game could help me stay active.	<input type="radio"/>						
6.	I believe playing this game could be beneficial to me.	<input type="radio"/>						
7.	I think this is an important game.	<input type="radio"/>						
8.	I would use this game to exercise in the future.	<input type="radio"/>						
9.	Based on the experience I had for the past 2 months, I would consider playing this game regularly in the future.	<input type="radio"/>						
10.	If I owned this game, I would play it regularly.	<input type="radio"/>						

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Please indicate your level of agreement or disagreement with each of the following statements.		Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	I played this game because I wanted to.	<input type="radio"/>						
2.	I felt really distant to this person.	<input type="radio"/>						
3.	I really doubt that this person and I would ever be friends.	<input type="radio"/>						
4.	I felt like I could really trust this person.	<input type="radio"/>						
5.	I would like a chance to interact with this person more often.	<input type="radio"/>						
6.	I would really prefer not to interact with this person in the future.	<input type="radio"/>						
7.	I don't feel like I could really trust this person.	<input type="radio"/>						
8.	It is likely that this person and I could become friends if we interacted a lot.	<input type="radio"/>						
9.	I feel close to this person.	<input type="radio"/>						
10.	I would have rather played alone.	<input type="radio"/>						

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Please indicate your level of agreement or disagreement with each of the following statements.		Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	I did not feel nervous at all while playing this game.	<input type="radio"/>						
2.	I felt very tense while playing this game.	<input type="radio"/>						
3.	I was very relaxed in playing this game.	<input type="radio"/>						
4.	I was anxious while playing this game.	<input type="radio"/>						
5.	I felt pressured while playing this game.	<input type="radio"/>						
6.	I put a lot of effort into this game.	<input type="radio"/>						
7.	I did not try very hard to do well in this game.	<input type="radio"/>						
8.	I tried very hard on this game.	<input type="radio"/>						
9.	It was important to me to do well at this game.	<input type="radio"/>						
10.	I did not put much energy into this game.	<input type="radio"/>						

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Please indicate your level of agreement or disagreement with each of the following statements.		Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	I think I am pretty good at this game.	<input type="radio"/>						
2.	I think I did pretty well at this game, compared to other players.	<input type="radio"/>						
3.	After playing this game for a while, I felt pretty competent.	<input type="radio"/>						
4.	I am satisfied with my performance at this game.	<input type="radio"/>						
5.	I was pretty stilled at this game.	<input type="radio"/>						
6.	This was a game that I could not do very well.	<input type="radio"/>						
7.	I found it enjoyable to play with another player.	<input type="radio"/>						
8.	What my partner did influenced what I did.	<input type="radio"/>						
9.	What I did influenced what my partner did.	<input type="radio"/>						
10.	When my partner was performing well it motivated me to perform well.	<input type="radio"/>						

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Please indicate your level of agreement or disagreement with each of the following statements.		Strongly Disagree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	My actions/decisions depended on my partner's actions.	<input type="radio"/>						
2.	My partner's actions/decisions were dependent on my actions/decisions.	<input type="radio"/>						
3.	I would play with the same partner again.	<input type="radio"/>						
4.	I felt my partner was a burden to me in the game.	<input type="radio"/>						
5.	I felt that my partner was helpful.	<input type="radio"/>						
6.	I felt my partner was a good player.	<input type="radio"/>						
7.	I felt playing with my partner was pleasant.	<input type="radio"/>						

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1. Please share anything that you liked about this game.

2. Please share anything that you disliked about this game.

3. Finally, please provide any additional thoughts/comments you might have.

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✓ Thank you. Your responses have been submitted.

Appendix H: Debriefing Form

Debriefing Form

Study Title: Social Exercise Game Study
Clearance Date: until 01 / 31 / 2021.
Project Number: CUREB-B Clearance # 110034.

What we are trying to learn in this research and why is it important?

A sedentary lifestyle is a growing health concern. The purpose of this experiment is to study the usefulness of videogames for motivating people to engage in physical activity and encouraging a more active lifestyle. By comparing different ways of grouping players by personality, we are evaluating which personality combinations work best to encourage continued play. We hypothesize that groups composed of supplementary personalities will enjoy their interaction together more than groups composed of complementary personalities. Groups that enjoy their interaction together will more likely continue to play and exercise over the long-term keeping an active lifestyle.

Where can I learn more?

Online Resources

- Bergland, C. (2015). Sitting all day increases your risk of anxiety: A sedentary lifestyle – that includes excessive sitting – increases risk of anxiety. *Psychology Today*. Available at: <https://www.psychologytoday.com/intl/blog/the-athletes-way/201506/sitting-all-day-increases-your-risk-anxiety>
- Gray, P. (2018). Benefits of play revealed in research on video gaming: Video gaming leads to improved cognition, creativity sociability, and more. *Psychology Today*. Available at: <https://www.psychologytoday.com/ca/blog/freedom-learn/201803/benefits-play-revealed-in-research-video-gaming>
- Hogan, M. (2016). Exergaming: Playing video games while you exercise – Exergaming produces greater cognitive benefits than exercise alone. *Psychology Today*. Available at: <https://www.psychologytoday.com/ca/blog/in-one-lifespan/201601/exergaming-playing-video-games-while-you-exercise>

Academic Papers

If you would like access to any of these articles, please kindly send an email to the principle investigator.

- Adam, C., & Senner, V. (2016). Which motives are predictors for long-term use of exergames? *Procedia Engineering: 11th Conference of the International Sports Engineering Association, ISEA 2016*, 147, 806–811.

- Chan, G., Arya, A., & Whitehead, A. (2018). Keeping players engaged in active video games: A personality matchmaking approach. *CHI'18, Extended Abstracts*, April 21–26, 2018, Montréal, QC, Canada.
- Lyons, E. J. (2015). Cultivating Engagement and enjoyment in exergames using feedback, challenge, and rewards. *Games for Health Journal: Research, Development, and Clinical Application*, 4(1), 12–18.

What can I do if I feel distressed?

We do not anticipate any stress resulting from this study. But, should you experience any distress or anxiety, please feel free to contact the Carleton University Health and Counseling Services at: 613-520-6674, or the Distress Centre of Ottawa at 613-238-3311 (<http://www.dcottawa.on.ca>).

What if I have questions later?

If you have any remaining concerns, questions, or comments about your participation, please do not hesitate to contact any of the researchers listed below:

Gerry Chan
Principal Investigator
Carleton School of Information Technology
Carleton University
1125 Colonel By Drive
Ottawa, ON K1S 5B6
gerrychan@cmail.carleton.ca

Dr. Ali Arya
Faculty Advisor
Carleton School of Information Technology
Carleton University
1125 Colonel By Drive
Ottawa, ON K1S 5B6
arya@carleton.ca
(613) 520-2600, ext.: 4184

Ethical Concerns

This study has received clearance by the Carleton University Research Ethics Board (15-239). If you have any ethical concerns about this study, you may contact:

Dr. Bernadette Campbell, Chair
Carleton University Research Ethics Board-B
613-520-2600, ext.: 4085
Bernadette.Campbell@carleton.ca

The Carleton University Office of Research Ethics
Carleton University
Ottawa, Ontario K1S 5B6
Email: ethics@carleton.ca
Phone: 613-520-2600, ext.: (4085)

Thank you for your participation in this study.

Your time and effort are much appreciated.

Appendix I: Descriptive statistics for all postgame questionnaire statements after the 30- and 60-day study period

Table A.1: Descriptive statistics for the level of agreement (7-point Likert scale: 1 = strongly disagree to 7 = strongly agree) with respect to post-game questionnaire statements after the 30-day study period (N = 16, 8 pairs).

Measure	Total sample size (N = 16, 8 pairs)	Descriptive statistics				
		Post-game questionnaire statements	Mean	SD	Median	Skewness
IMI subscale: enjoyment	I enjoyed playing this game very much.	4.63	1.59	5.00	-0.55	-0.68
	This game was fun to play.	4.50	1.51	5.00	-0.07	-1.30
	I thought this was a boring game.	3.13	1.63	3.00	0.20	-1.23
	This game did not hold my attention at all.	3.25	1.34	3.00	-0.14	-0.81
	I would describe this game as very interesting.	4.88	1.41	5.00	-0.90	0.52
	I thought this game was quite enjoyable.	4.69	1.40	4.50	-0.19	-0.79
	While I was playing this game, I was thinking about how much I enjoyed it.	3.81	1.17	4.00	0.41	0.11
Enjoyment	I enjoyed engaging in friendly challenges.	5.63	1.20	6.00	-0.20	-1.51
	I enjoyed engaging in non-friendly challenges.	4.56	1.55	4.50	-0.75	0.76
	I enjoyed being part of this team.	5.06	1.77	5.00	-0.93	0.59
IMI subscale: value/usefulness	I believe this game could be of some value to me.	5.31	1.40	5.50	-0.97	0.88
	I think that playing this game is useful for keeping me active.	5.06	1.73	5.50	-0.90	-0.25
	I think this is important to do because it can motivate me to engage in exercise.	5.25	1.48	5.50	-0.91	0.26
	I would be willing to play it again because it has some value to me.	5.88	0.96	6.00	-0.77	0.12
	I think playing this game could help me stay active.	5.25	1.44	5.50	-0.81	0.30

	I believe playing this game could be beneficial to me.	5.56	1.31	6.00	-1.46	2.50
	I think this is an important game.	4.81	1.05	5.00	-0.38	-0.95
IMI subscale: perceived competence	I think I am pretty good at this game.	4.38	1.20	4.50	-0.32	-0.66
	I think I did pretty well at this game, compared to other players.	4.56	1.26	4.50	-1.29	3.29
	After playing this game for a while, I felt pretty competent.	4.38	1.54	4.50	-0.73	-0.13
	I am satisfied with my performance at this game.	4.00	1.32	4.00	-0.40	0.34
	I was pretty stilled at this game.	3.94	1.12	4.00	0.46	-0.16
	This was a game that I could not do very well.	2.94	1.39	3.00	0.64	0.09
IMI subscale: effort/importance	I put a lot of effort into this game.	3.69	1.35	4.00	-0.09	-1.29
	I did not try very hard to do well in this game.	3.75	1.29	4.00	-0.32	-1.72
	I tried very hard on this game.	3.56	1.36	3.00	0.57	-0.73
	It was important to me to do well at this game.	4.44	0.96	4.50	-0.05	-0.76
	I did not put much energy into this game.	3.88	1.31	4.00	-0.15	-1.36
IMI subscale: pressure/tension	I did not feel nervous at all while playing this game.	5.69	1.35	6.00	-1.01	0.10
	I felt very tense while playing this game.	2.06	1.06	2.00	1.39	2.79
	I was very relaxed in playing this game.	5.13	1.41	5.50	-0.74	0.06
	I was anxious while playing this game.	2.31	1.01	2.00	1.46	2.57
	I felt pressured while playing this game.	2.36	1.36	2.00	0.97	-0.38
IMI subscale: perceived choice	I played this game because I wanted to.	5.81	1.17	6.00	-1.03	0.83
	I felt really distant to this person.	4.06	1.69	4.00	-0.21	-0.68

IMI subscale: relatedness	I really doubt that this person and I would ever be friends.	3.38	1.63	4.00	0.36	0.06
	I felt like I could really trust this person.	4.56	1.26	4.50	-1.29	3.29
	I would like a chance to interact with this person more often.	4.88	1.20	4.50	0.53	-0.77
	I would really prefer not to interact with this person in the future.	2.81	1.33	2.50	0.00	-1.48
	I don't feel like I could really trust this person.	3.06	1.65	3.00	0.70	0.54
	It is likely that this person and I could become friends if we interacted a lot.	4.56	1.36	4.00	0.39	0.00
	I feel close to this person.	3.50	1.55	4.00	0.37	0.18
	Social presence/ influence	My actions/decisions depended on my partner's actions.	3.31	1.45	3.50	-0.02
	My partner's actions/decisions were dependent on my actions/decisions.	3.38	1.45	4.00	-0.16	-0.67
	I found it enjoyable to play with another player.	4.49	1.39	5.00	-0.39	-0.15
	What my partner did influenced what I did.	4.69	1.49	5.00	-0.48	-0.56
	What I did influenced what my partner did.	4.38	1.31	4.00	0.01	0.54
	When my partner was performing well it motivated me to perform well.	4.69	1.40	5.00	-1.19	1.77
Perception of the other player	I would play with the same partner again.	4.81	1.68	5.50	-0.43	-1.15
	I felt my partner was a burden to me in the game.	2.56	1.41	2.00	0.91	0.72
	I felt my partner was helpful.	4.81	1.64	5.00	-0.48	-0.92
	I felt my partner was a good player.	4.69	1.62	5.00	-0.28	-0.97
	I felt playing with my partner was pleasant.	4.88	1.31	5.00	-0.55	0.06
		I would use this game to exercise in the future.	4.56	1.82	5.00	-0.68

Intention for future play	Based on the experience I had for the past 2 months, I would consider playing this game regularly in the future.	4.25	1.48	4.00	-0.63	0.01
	If I owned this game, I would play it regularly.	4.25	1.53	5.00	-0.87	-0.13

Table A.2: Descriptive statistics for the level of agreement (7-point Likert scale: 1 = strongly disagree to 7 = strongly agree) with respect to post-game questionnaire statements after the 60-day study period (N = 17, 8.5 pairs).

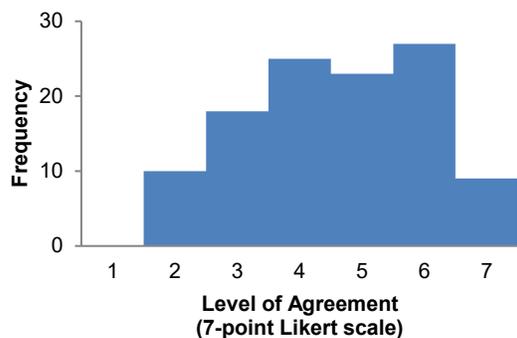
Measure	Total sample size (N = 17, 8.5 pairs)	Descriptive statistics				
		Post-game questionnaire statements	Mean	SD	Median	Skewness
IMI subscale: enjoyment	I enjoyed playing this game very much.	5.00	1.66	6.00	-1.12	0.92
	This game was fun to play.	4.82	1.70	5.00	-0.89	0.17
	I thought this was a boring game.	3.12	1.54	3.00	0.83	1.10
	This game did not hold my attention at all.	3.76	1.92	3.00	0.20	-1.26
	I would describe this game as very interesting.	4.53	1.74	5.00	-0.54	-0.33
	I thought this game was quite enjoyable.	5.00	1.62	5.00	-1.20	1.34
	While I was playing this game, I was thinking about how much I enjoyed it.	4.00	1.58	4.00	-0.65	-0.28
Enjoyment	I enjoyed engaging in friendly challenges.	4.71	1.96	6.00	-0.49	-1.11
	I enjoyed engaging in non- friendly challenges.	4.41	1.33	5.00	-1.24	1.93
	I enjoyed being part of this team.	5.18	1.29	5.00	-0.17	-0.81
IMI subscale: value/ usefulness	I believe this game could be of some value to me.	4.88	2.00	5.00	-0.78	-0.67
	I think that playing this game is useful for keeping me active.	4.88	1.76	5.00	-0.81	0.00
	I think this is important to do because it can motivate me to engage in exercise.	4.76	2.05	5.00	-0.73	-0.62

	I would be willing to play it again because it has some value to me.	5.29	1.72	6.00	-1.35	1.49
	I think playing this game could help me stay active.	4.88	2.09	5.00	-0.76	-0.58
	I believe playing this game could be beneficial to me.	5.12	1.96	6.00	-1.08	0.40
	I think this is an important game.	4.41	1.84	5.00	-0.42	-0.87
IMI subscale:	I think I am pretty good at this game.	4.06	1.52	4.00	0.13	-0.60
perceived competence	I think I did pretty well at this game, compared to other players.	4.00	1.80	5.00	-0.29	-0.93
	After playing this game for a while, I felt pretty competent.	4.59	1.50	5.00	-0.94	1.05
	I am satisfied with my performance at this game.	4.12	1.58	4.00	-0.11	-0.42
	I was pretty stilled at this game.	3.94	1.52	4.00	-0.01	-0.04
	This was a game that I could not do very well.	3.18	1.42	3.00	0.53	0.31
IMI subscale:	I put a lot of effort into this game.	3.35	1.28	4.00	-0.38	-0.91
effort/ importance	I did not try very hard to do well in this game.	4.65	1.41	5.00	-0.04	-1.55
	I tried very hard on this game.	3.18	1.24	3.00	0.07	-1.05
	It was important to me to do well at this game.	4.06	1.60	5.00	-0.73	-0.96
	I did not put much energy into this game.	4.12	1.73	4.00	0.13	-0.55
IMI subscale:	I did not feel nervous at all while playing this game.	6.12	1.36	7.00	-2.08	4.62
pressure/ tension	I felt very tense while playing this game.	2.06	1.20	2.00	1.36	1.25
	I was very relaxed in playing this game.	5.41	1.66	6.00	-1.03	0.12
	I was anxious while playing this game.	2.12	1.05	2.00	1.56	2.88
	I felt pressured while playing this game.	2.47	1.42	2.00	1.26	1.30
IMI subscale:	I played this game because I wanted to.	5.24	1.17	6.00	-1.42	1.48

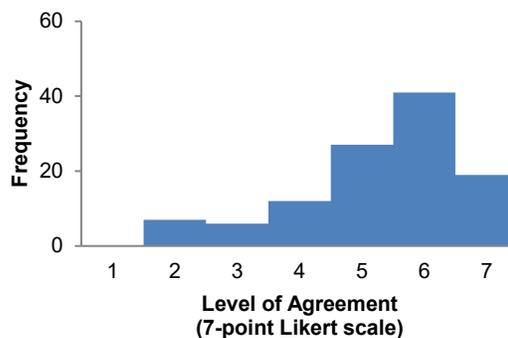
perceived choice						
IMI subscale: relatedness	I felt really distant to this person.	3.88	1.62	4.00	0.11	-0.37
	I really doubt that this person and I would ever be friends.	3.88	1.17	4.00	0.25	-0.17
	I felt like I could really trust this person.	4.24	1.25	4.00	-0.72	-0.08
	I would like a chance to interact with this person more often.	4.41	1.23	4.00	-1.15	2.73
	I would really prefer not to interact with this person in the future.	3.24	1.15	3.00	0.61	0.28
	I don't feel like I could really trust this person.	3.29	0.99	4.00	-0.23	-1.29
	It is likely that this person and I could become friends if we interacted a lot.	4.41	1.23	5.00	-0.69	0.01
	I feel close to this person.	3.59	1.37	4.00	-0.29	-0.67
Social presence/ influence	My actions/decisions depended on my partner's actions.	4.71	1.61	5.00	-0.47	-0.57
	My partner's actions/decisions were dependent on my actions/decisions.	4.29	1.76	4.00	-0.12	-0.69
	I found it enjoyable to play with another player.	3.88	1.83	4.00	0.33	-0.82
	What my partner did influenced what I did.	4.53	1.46	4.00	0.00	-0.24
	What I did influenced what my partner did.	3.94	1.98	5.00	-0.07	-1.26
	When my partner was performing well it motivated me to perform well.	3.65	1.58	4.00	0.02	0.06
	Perception of the other player	I would play with the same partner again.	4.29	1.76	4.00	-0.59
I felt my partner was a burden to me in the game.		3.00	1.17	3.00	0.26	-0.86
I felt my partner was helpful.		4.82	1.24	5.00	-0.52	0.49

	I felt my partner was a good player.	4.65	1.50	5.00	-0.20	-0.44
	I felt playing with my partner was pleasant.	4.76	1.39	5.00	-0.15	-0.37
Intention for future play	I would use this game to exercise in the future.	4.12	2.00	4.00	-0.18	-1.48
	Based on the experience I had for the past 2 months, I would consider playing this game regularly in the future.	4.24	2.02	5.00	-0.52	-1.58
	If I owned this game, I would play it regularly.	4.35	2.18	5.00	-0.56	-1.31

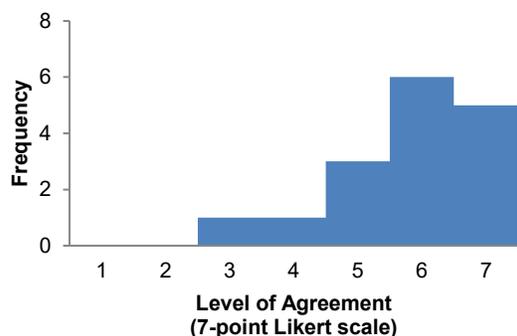
Appendix J: Frequency histograms for subjective measures as evaluated by the post-game questionnaire



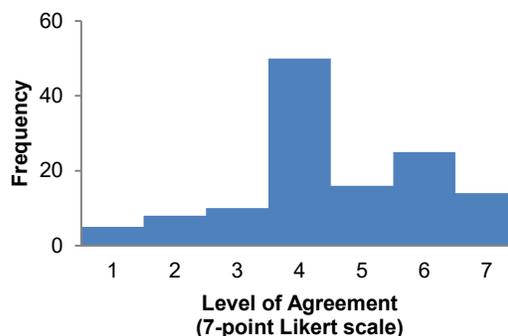
(a) Enjoyment



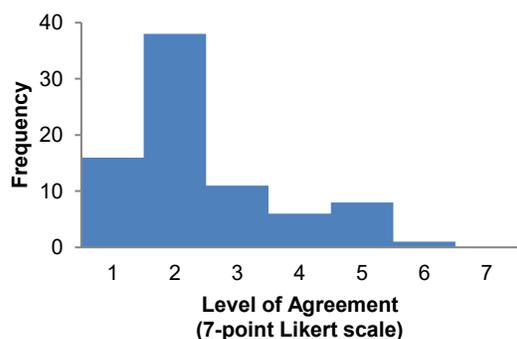
(b) Value



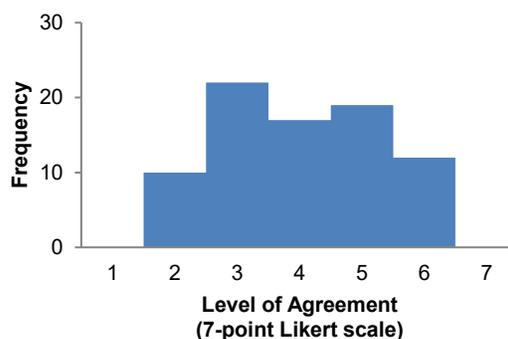
(c) Choice



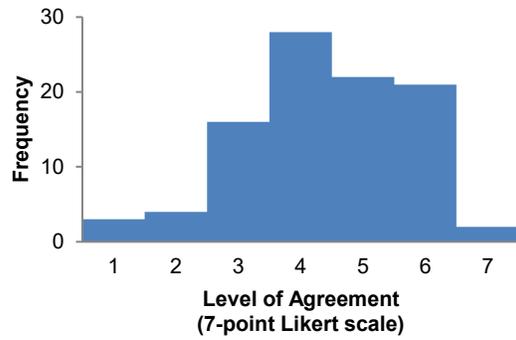
(d) Relatedness



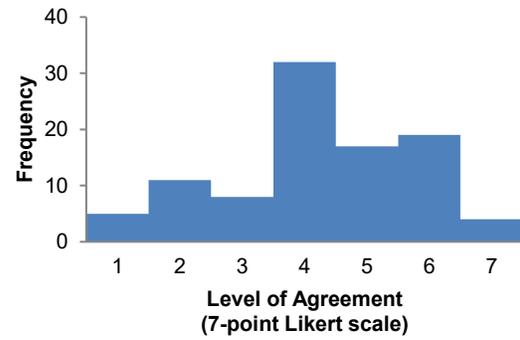
(e) Pressure



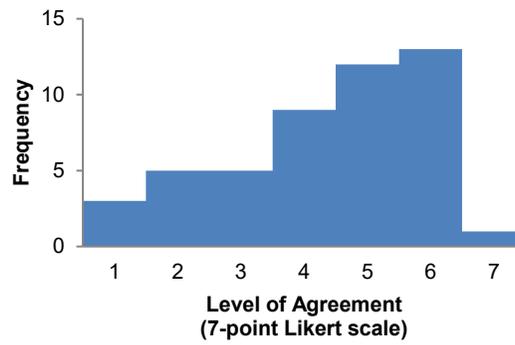
(f) Effort



(g) Competence

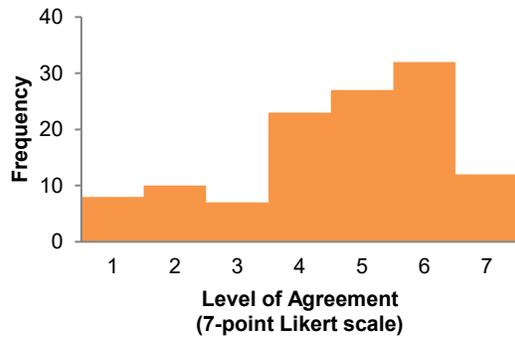


(h) Social Presence

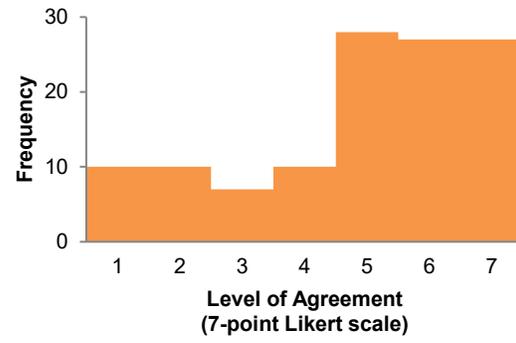


(i) Intention for Future Play

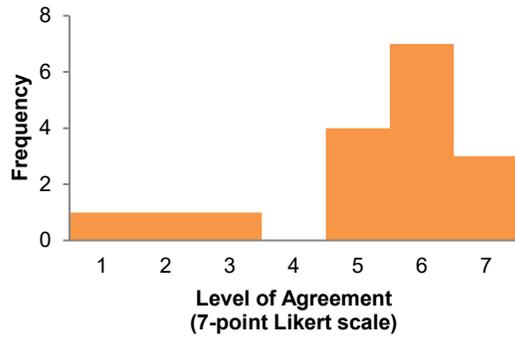
Figure A.4: Frequency histograms for subjective measures (IMI, GEQ, and intention for future play) as evaluated by the post-game questionnaire after the 30-day period ($N = 16$).



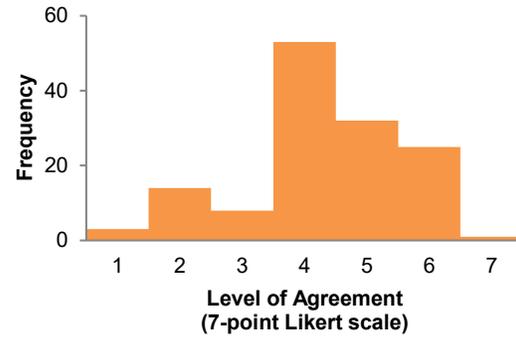
(a) Enjoyment



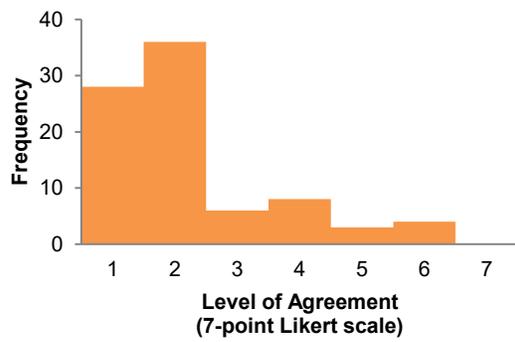
(b) Value



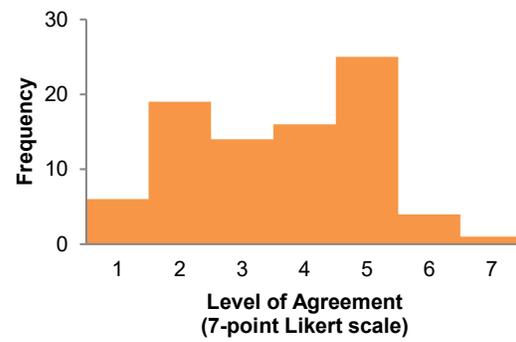
(c) Choice



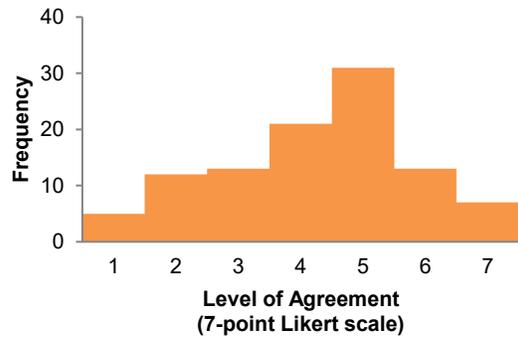
(d) Relatedness



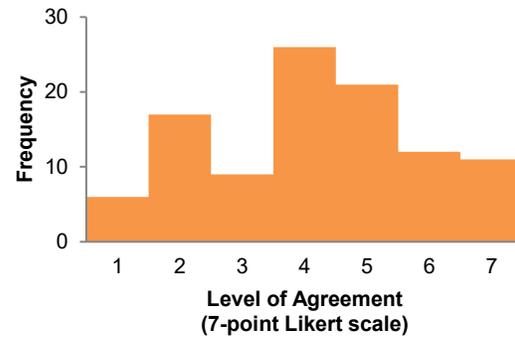
(e) Pressure



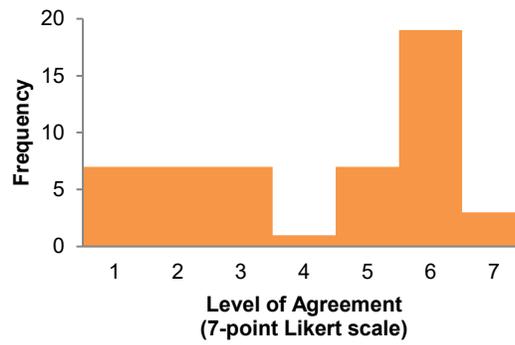
(f) Effort



(g) Competence



(h) Social Presence



(i) Intention for Future Play

Figure A.5: Frequency histograms for subjective measures (IMI, GEQ, and intention for future play) as evaluated by the post-game questionnaire after the 60-day period ($N = 17$).

Appendix K: Game elements in the Hexad model

The descriptions/definitions of game elements were adapted from Klock et al. (2020) based on a review of research on tailored gamification.

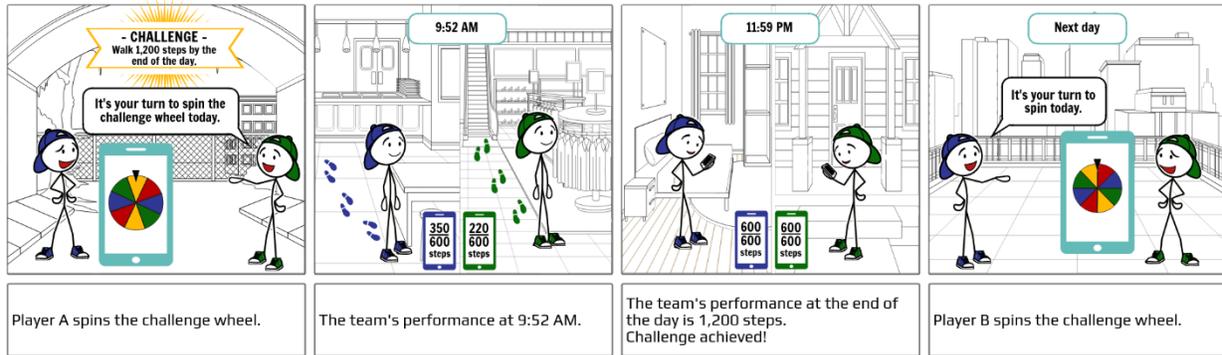
Table A.3: Game element descriptions in the Hexad Model (Marczewski, 2015).

Player type	Game element	Description
Philanthropist	Collection	Creates a sense of ownership in the system through picking up, trading and management collectables and resources within an inventory.
	Gifting	Allows the user to give or share resources with others, encouraging altruism and satisfaction.
	Meaning	Allows the user to auto-identify with the system through a common purpose.
Socialiser	Guild	Includes the team feeling (i.e., being part of a group) and the caretaking between users.
	Social network	Enables the connection between users through communication channels that support the human-human interaction (e.g., likes, chat, voice and face-to-face).
	Social status	Allows the user to brag about himself/herself through the system.
	Social discovery	Supports the user to find or be found by other people with the same interests or status by checking the public profile.
	Social pressure	Permits users to influence or be influenced by others, through public comments or creating fear of becoming “the loser” in the team (e.g., allowing others to know the number of times one spent on a specific level).
	Competition	Allows social comparison between users and promotes a possibility to prove themselves better than others.
Free Spirit	Exploration	Gives the user the possibility to investigate and discover areas and features of the system, through exploratory tasks, imperfect information, and mystery boxes.
	Choice	Allows the user to have the autonomy to determine his/her verdict among many possibilities.

	Easter eggs	A surprising response of the system to a specific action of the user.
	Unlockable content	An exclusive content conditioned to an action of the user to be available, such as new contents and features.
	Customization	Enables the self-expression of the users through the creation and decoration of their virtual space, their avatar or their character, and the personalization of some aspects of the system's interface.
Achiever	Challenge	Can be a variety of situations to deal with or figure them out, boss battles, or any other kind of action that requires effort from the user to be completed.
	Learning	Allows the user to gain and master a new skill by imitating other users (i.e., social learning) or through visual representation (i.e., knowledge maps, skill trees).
	Level	Supports users to track their progression through the system's purpose over time, aiding the visualization (e.g., progress bar or flags along a path of a continuously and gradually growing towards a specific goal).
Disruptor	Voting	Allows the user to give his/her opinion within a subject, including any rating and voting mechanism.
	Anonymity	The opportunity to share the data (e.g., performance, opinions) in the system without naming the user.
	Anarchy	Creates an environment without any restrictions or penalties, allowing anarchic gameplay.
Player	Points	Numerical feedback provided when the user performs a specific action.
	Prize	Any reward that the user wins for his/her action (e.g., bonuses, combos, win states, and boosters).
	Leaderboard	Ranks the users according to some criteria (e.g., points, levels, badges) contextualizing the other game elements to enable user comparison.
	Badges	A visual representation of the user's achievements.
	Virtual economy	Creates a currency to allow users to purchase features and virtual goods.

Lottery An element of randomness (i.e., a chance) within the system.

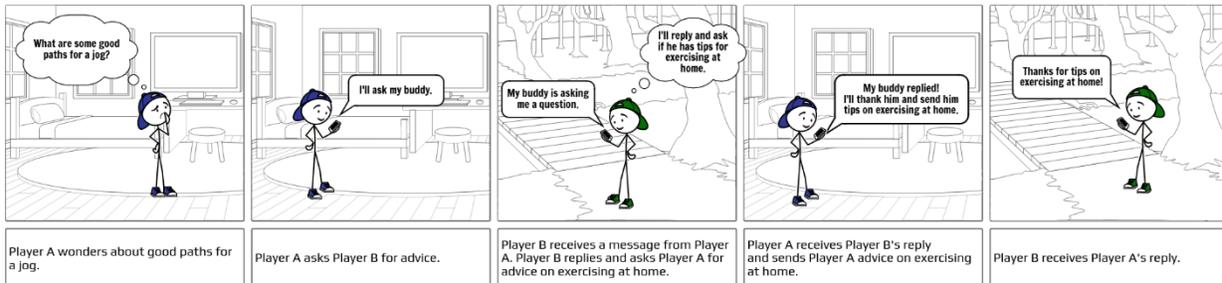
Appendix L: Final version of storyboards for testing



(a). Spin the lottery wheel.



(b). Set a custom goal.



(c). Knowledge sharing.

<p>Let's unlock a new feature together.</p>	<p>End of week 1</p> <p>Step goal reached!</p>	<p>End of week 2</p> <p>Step goal reached!</p>	<p>End of week 3</p> <p>New Feature</p> <p>Step goal reached!</p>
<p>The team agrees to unlock a new feature together.</p>	<p>The team reaches its weekly step goal by the end of the first week.</p>	<p>The team reaches its weekly step goal by the end of the second week.</p>	<p>The team reaches its weekly step goal by the end of the third week. A new feature is unlocked.</p>

(d). Unlockable content.

<p>7:20 AM</p> <p>Let's each walk 6,000 steps by the end of today.</p>	<p>9:33 AM 9:35 AM</p> <p>How many steps have you done?</p> <p>950. How about you?</p> <p>1,200 6,000 steps</p> <p>950 6,000 steps</p>	<p>9:36 AM 9:39 AM</p> <p>Nice work! 1,200.</p> <p>Great! Keep it up!</p> <p>1,200 6,000 steps</p> <p>950 6,000 steps</p>	<p>5:58 PM 6:17 PM</p> <p>I've done 3,660. How about you?</p> <p>Good job! 5,122.</p> <p>3,660 6,000 steps</p> <p>5,122 6,000 steps</p>	<p>11:59 PM</p> <p>Step goal reached!</p>
<p>The team agrees on a step goal.</p>	<p>The team converses about its progress.</p>	<p>The team converses about its progress and exchanges encouraging messages.</p>	<p>The team continues to converse about its progress and exchanges encouraging messages.</p>	<p>At the end of the day, the team reaches their step goal.</p>

(e). Exchange supportive and encouraging updates.

<p>Let's make our character happy and active.</p>	<p>2 weeks later</p>	<p>3 weeks later</p> <p>Our character looks happy and active now!</p>
<p>The team agrees on making their virtual character happy and active.</p>	<p>Two weeks later, the team's character is slightly happier and standing.</p>	<p>Three weeks later, the team's character is happy and active.</p>

(f). Virtual character.

<p>The team is deciding on its step goal for the month.</p>	<p>It's the last day of the month, but the team is still far away from the goal.</p>	<p>Each player thinks of a way to cut corners.</p>	<p>The team reaches its step goal by the end of the month.</p>

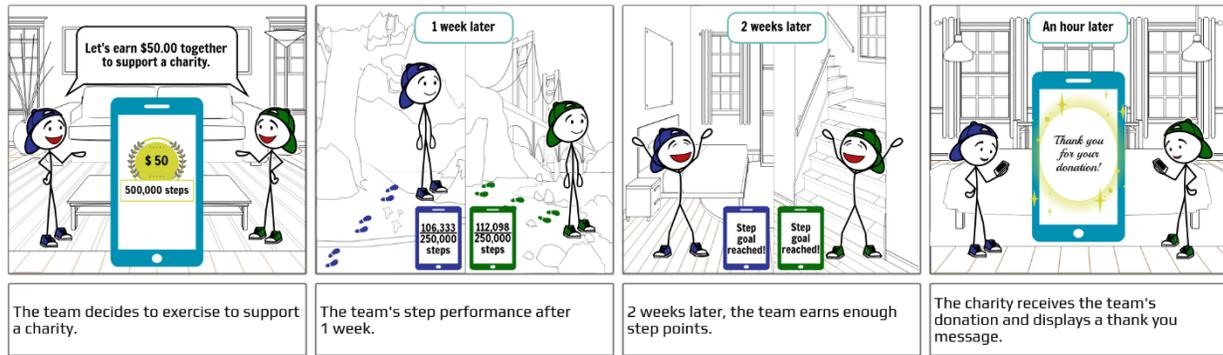
(g). Cutting corners.

<p>One day, Player A sees that Player B needs help to pass a level and decides to donate some points to help.</p>	<p>Player B receives points and sends a thank you note to Player A.</p>	<p>On a different day, Player B sees that Player A needs help and decides to help him back.</p>	<p>Player A receives points and sends a thank you note to Player B.</p>

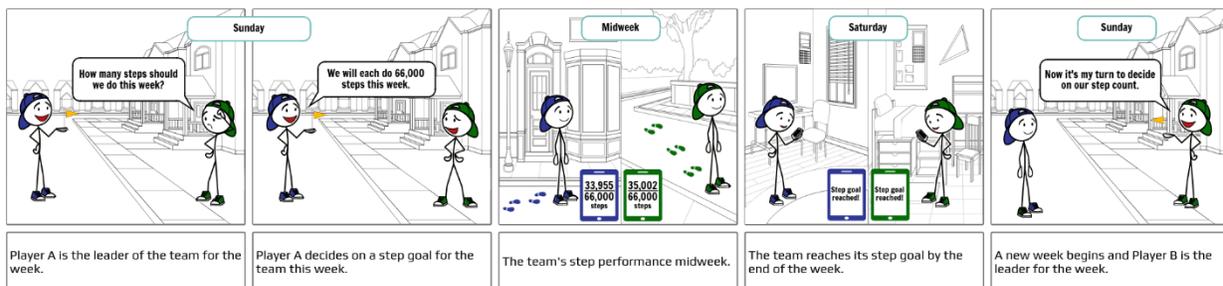
(h). Donate points.

<p>The team agrees to earn a trophy.</p>	<p>The team reaches their 1-week step goal.</p>	<p>The team reaches their 2-week step goal.</p>	<p>The team reaches its weekly step goal 3 weeks in a row and earns a trophy.</p>

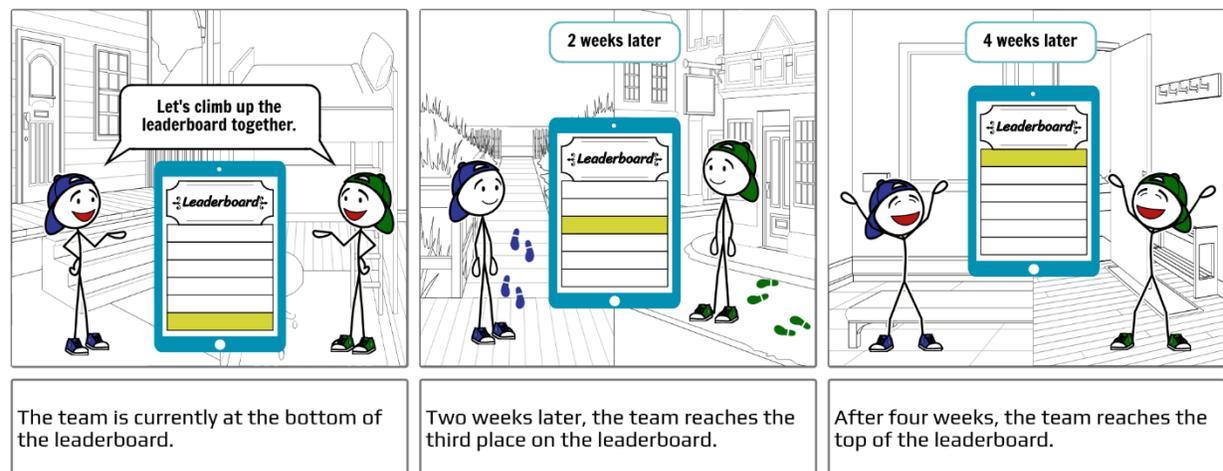
(i). Earn a trophy.



(j). Support a charity.



(k). Rotating leadership.



(l). Climb the leaderboard.

Figure A.6: Final versions of conceptual storyboards used for testing.

Appendix M: Earlier versions and iterations of storyboards

Based on user interviews, the following issues were detected:

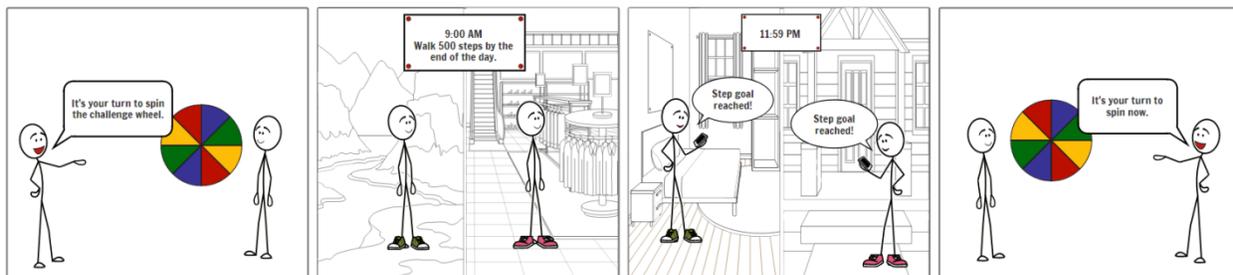
Iteration 1:

1. There are 2 different characters is unclear. Looks like the same person but just changed shoes. Need to emphasize more differentiation between the 2.
2. Characters don't seem to be moving at all. Need to make them look like they are exercising (e.g., add foot-trails/prints).
3. Points system is confusing and recommend showing totals (e.g., Day 1: 20/80, Day 2: 50/80)
4. Earning points for what is unclear except for donating to charity. Why are they exercising? Need to tie each one to a goal of some sort.
5. Need more background information/context (e.g., explain that it is an exercise game, and 2 players are in a team together striving for a goal).
6. Earning a team badge does not make sense, but a team trophy or medal does.
7. In some text is too heavy (e.g., the "sharing knowledge" storyboard).
8. Some symbols are confusing (e.g., the crown).

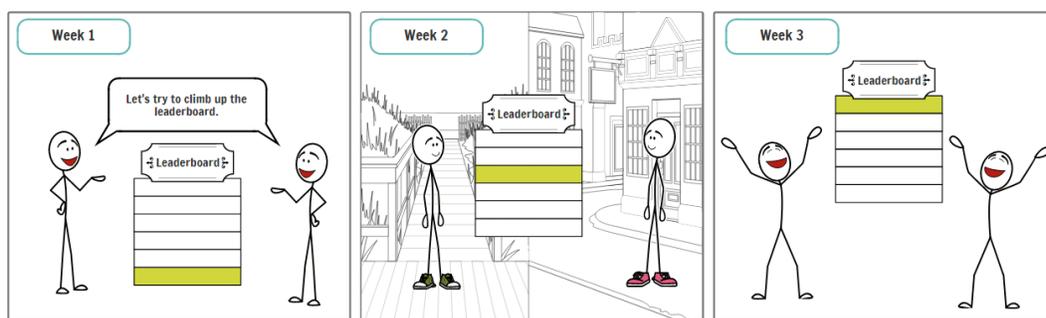
Iteration 2:

1. Still few grammatical errors and typos.
2. Some text in pictures and description below feels redundant.
3. The text is too small.
4. Red and green are poor colour choices considering the potential of colorblindness
5. The points system is unclear (shared vs. individual goal).
6. No competitive scenarios/features. The participant suggested a few:
 - a. Win streak: When a team wins consecutive games, award bonus points. The longer the streak, the more bonus.
 - b. Overcome failure: If team A lost to team B in week 1, but Team A manages to defeat team B in week 2, Team A is awarded bonus points.
 - c. Defeat the leading team: When a team beats the leading team on the leaderboard, bonus points are awarded.

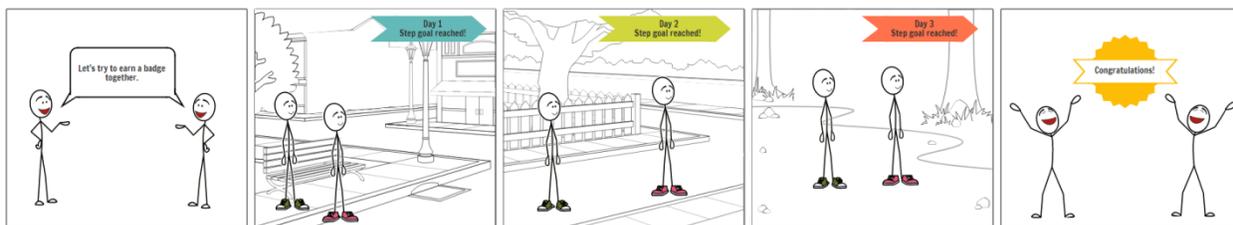
Lottery/game of chance system where both players on the same team are taking turns to spin a challenge wheel.



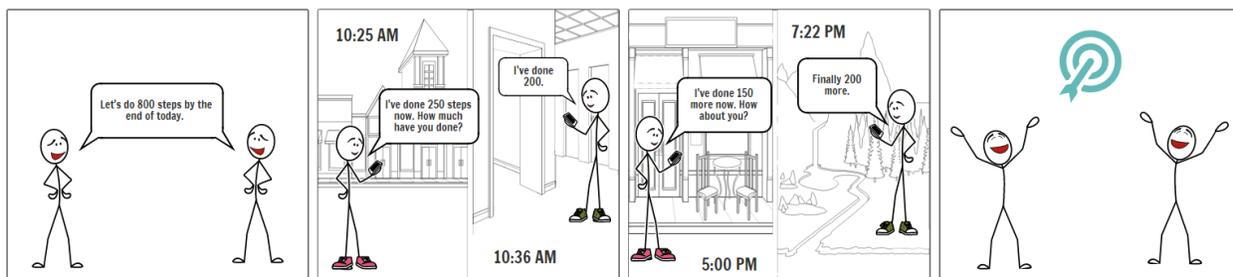
A pair of players aiming to climb up the **leaderboard**.



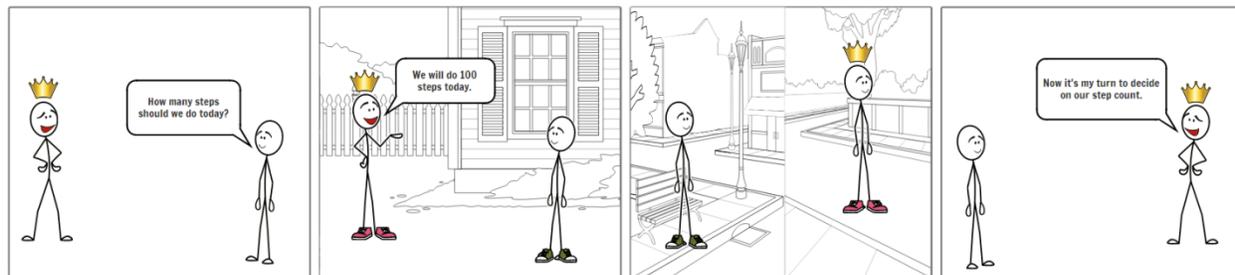
Player pairs reach their step goals each day to earn a **reward**, in this case a **badge**.



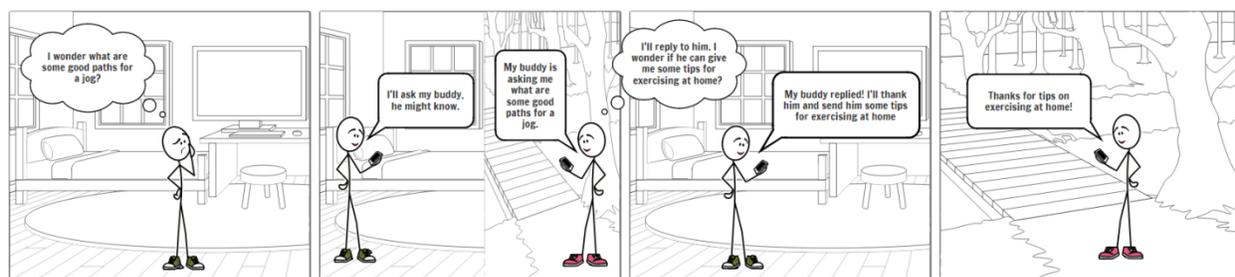
Player pairs collaborating (**social collaboration**) to reach a step target by updating each other of their progress/performance using a messaging system.



Rotating leadership roles (**social status**) where players take turns to lead the team (or maybe even the guild) to achieve a goal.



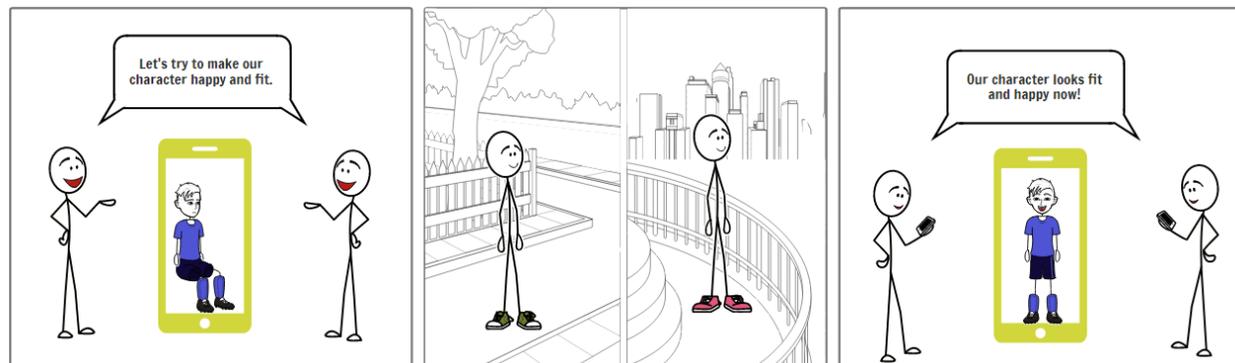
Player pairs help each other by **sharing knowledge**.



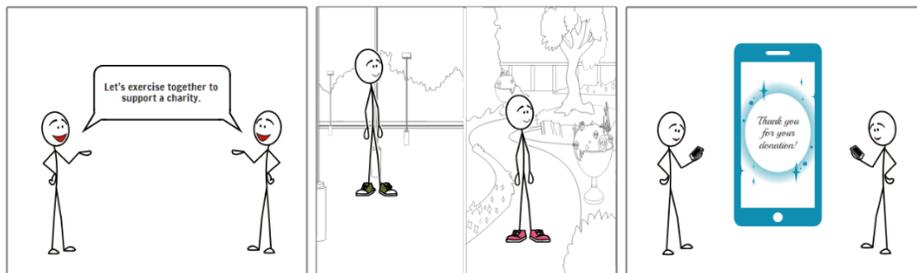
Caretaking/gifting/sharing where players donate points to help a teammate.



Caretaking of a virtual character where each player take on a responsibility.



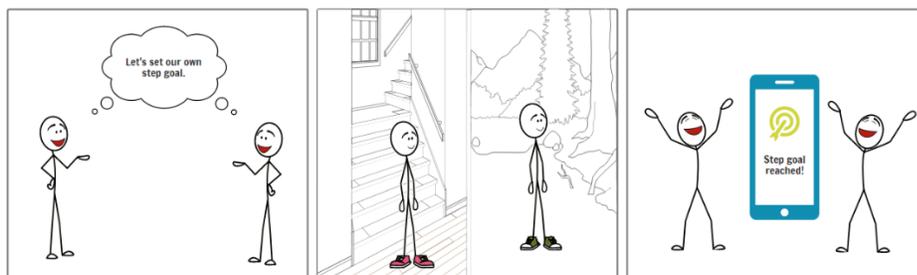
Meaning and Gifting (purpose) where the steps accumulated are to raise money for charity.



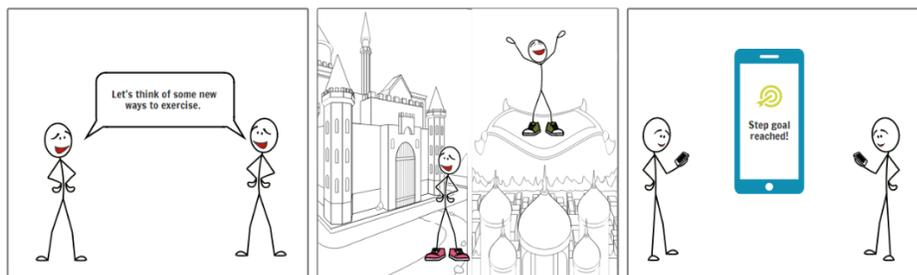
Unlockable content – Player pairs decide to aim for more difficult challenges and commits to a goal and the app unlocks a new feature.



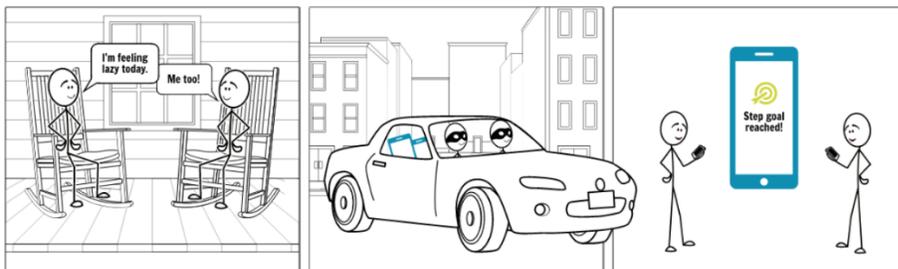
Custom Goal – Player pairs setting and working together to reach a custom goal.



Innovation platform (positive change) where players can change the system and develop new ways to exercise.



Player pairs deciding to **cheat (negative change)** the system by taking shortcuts to reach a step goal or earn exercise points.



Competitive Scenarios

Defeat the champion – If a team defeated the leading team on the leaderboard, the team is awarded bonus points.



Win/Maintain a streak – If a team wins consecutive games, bonus points are awarded. The longer the streak, the more bonus points.



Appendix N: Storyboard Study Consent Form

Consent Form

Project Title

Social Scenarios for Exercise Games Study

Research Personnel

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Purpose

Participation in exercise can improve health and well-being. However, it can be hard for some people to meet the daily recommended amount due to lack of motivation. Exergames, which is a combination of videogames and exercise, can make exercising seem more enjoyable and increase the level of motivation. Yet, some exergames may not be able to maintain exercise interest over the long-term. The purpose of this study is to explore the effectiveness of social features for designing multiplayer exergames and player matching to encourage more sustainable exercise habits.

Eligibility Criteria

To participate in this study, you must be at least 18 years old and have internet access through a computer or phone.

Task Requirements, Duration and Locale

You will be asked to complete 3 separate questionnaires. The first is a demographics questionnaire which will ask you questions such as your age, gender, and gaming habits. The second questionnaire which will ask you questions about your user type. Finally, the third questionnaire will ask you to look at 12 individual storyboards portraying various game scenarios and rate the level of perceived persuasiveness of each. The entire questionnaire takes approximately 25 minutes to complete and can be accessed online (the researcher will provide you with a link) through a web browser on a computer or mobile phone. The study will take place where you decide to complete the survey at your convenience.

Potential Risks and Inconveniences

There are no known physical/psychological risks, beyond any risk normally involved with using a computer or mobile devices.

Possible Benefits

You can gain some new ideas about social exercise games.

Compensation/Incentives

As a token of our appreciation, you can receive a \$10.00 electronic gift card to Tim Horton's upon completion of the survey. To receive this, you need to provide meaningful answers to all questions and an email address. If you do not want your email address to be stored with your data, please first contact us (gerrychan@cmail.carleton.ca) to receive a code that you can enter instead of your email address. You will be asked to enter your email address or code below.

Right to Withdraw

Your participation is entirely voluntary, and you can refuse to answer any individual question. You have the right to withdraw from the study at any time without penalty, but without full and legitimate answers to the required questions, we cannot provide any compensation. Some questions will be marked as required and some as optional. The required ones are those that are essential to the survey objectives. You can withdraw at any time but without full and legitimate answers to the required questions, we cannot provide any compensation. If you submit and later decide to withdraw your data, you need to have provided an email address and contact through that address within a week. You can keep the compensation even if you choose to withdraw after receiving it.

Anonymity and Confidentiality

No personally identifiable information will be collected except for the email address required for compensation. We will not share your email address with anyone or use it for any other purpose. The results of this study may be published or presented at an academic conference or meeting, but the data will be presented in a way such that it will not be possible to identify any participants. Your questionnaire data will be stored and protected by Qualtrics (<https://www.qualtrics.com/>) on US-based servers but may be disclosed via a court order or data breach.

Data Retention

Once the project is completed, all research data will be kept indefinitely and potentially used for other research projects on this same topic. We will download all the data and delete the survey on the server after data collection is finished. The email addresses will be deleted from the local data once all compensations are paid.

Ethics Review

This research has been cleared by Carleton University Research Ethics Board-B (CUREB-B Clearance #114921). Should you have any ethical concerns with the study, please contact the REB Chair, Carleton University, Ethics Research Board, by email: ethics@carleton.ca. For all other questions about the study, please contact the principal investigator (gerrychan@cmail.carleton.ca).

Please enter the 5-digit code you received from the research or an email address below:

5-digit code: _____

Email address: _____

Statement of Consent

I have read the above form and understand the conditions of my participation. My participation in this study is voluntary, and I understand that if at any time I wish to leave the experiment, I may do so without having to give an explanation and with no penalty whatsoever. I am aware that the data gathered in this study are confidential and anonymous with respect to my personal identity.

I voluntarily agree to participate in this study.

- Yes
- No

Next >

Appendix O: Storyboard Study Survey

Part 1: Demographical Information

Personal Information

1. Age: ____ years old.
2. Gender: Male Female Prefer not to say
3. Level of Education: _____.

Game and Exercise Habits

1. Do you play computer/video games? Yes No
(If yes, please answer a, b, c, and d below. If not, please proceed to question 2.)
 - a) Do you typically play alone, with friends, or both?
_____.
 - b) What type of videogames do you play? (E.g., action, adventure, puzzles, role-playing, strategy, simulations).
_____.
 - c) Please list a few of your favourite videogames:
 - _____
 - _____
 - _____
 - d) On average, how much time do you spend playing videogames?
_____ hours/week.
2. Do you participate in regular exercise? Yes No
(If yes, please answer e, f, g, and h below. If no, please proceed to the next page.)
 - e) Do you typically exercise alone, with friends, or both?
_____.
 - f) What kinds of exercises do you do?
_____.
 - g) On average, how much time do you spend exercising?
_____ minutes/day.
 - h) What is the intensity level at which you typically exercise?
 Light Moderate Vigorous

Next >

Part 2: Personal Preferences Questionnaire

Please rate your level of agreement or disagreement with how well each of the following statement describes you.

	Strongly Agree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1. It makes me happy if I am able to help others.	<input type="radio"/>						
2. I like helping others to orient themselves in new situations.	<input type="radio"/>						
3. I like sharing my knowledge.	<input type="radio"/>						
4. The wellbeing of others is important to me.	<input type="radio"/>						
6. Interacting with others is important to me.	<input type="radio"/>						
7. I like being part of a team.	<input type="radio"/>						
8. It is important to me to feel like I am part of a community.	<input type="radio"/>						
9. I enjoy group activities.	<input type="radio"/>						
10. It is important to me to follow my own path.	<input type="radio"/>						
11. I often let my curiosity guide me.	<input type="radio"/>						
12. I like to try new things.	<input type="radio"/>						
13. Being independent is important to me.	<input type="radio"/>						
14. I like defeating obstacles.	<input type="radio"/>						
15. It is important to me to always carry out my own tasks completely.	<input type="radio"/>						
16. It is difficult for me to let go of a problem before I have found a solution.	<input type="radio"/>						
17. I like mastering difficult tasks.	<input type="radio"/>						
18. I like to provoke.	<input type="radio"/>						
19. I like to question the status quo.	<input type="radio"/>						
20. I see myself as a rebel.	<input type="radio"/>						
21. I dislike following rules.	<input type="radio"/>						
22. I like competitions where a prize can be won.	<input type="radio"/>						
23. Rewards are a great way to motivate me.	<input type="radio"/>						
24. Return of investment is important to me.	<input type="radio"/>						
25. If the reward is sufficient, I will put effort into it.	<input type="radio"/>						

Next >

Part 3: Social Exergame Scenarios Questionnaire

Background Context

In each of the 12 scenarios, there are two players on the same team together using a feature. Player A wears a blue baseball cap, and Player B wears a green baseball cap. Both are playing an exergame where their step counts are tracked by their phone and are converted into virtual points/rewards. The team does not have to be co-located in the same physical space and they can be walking at different times.

Instructions

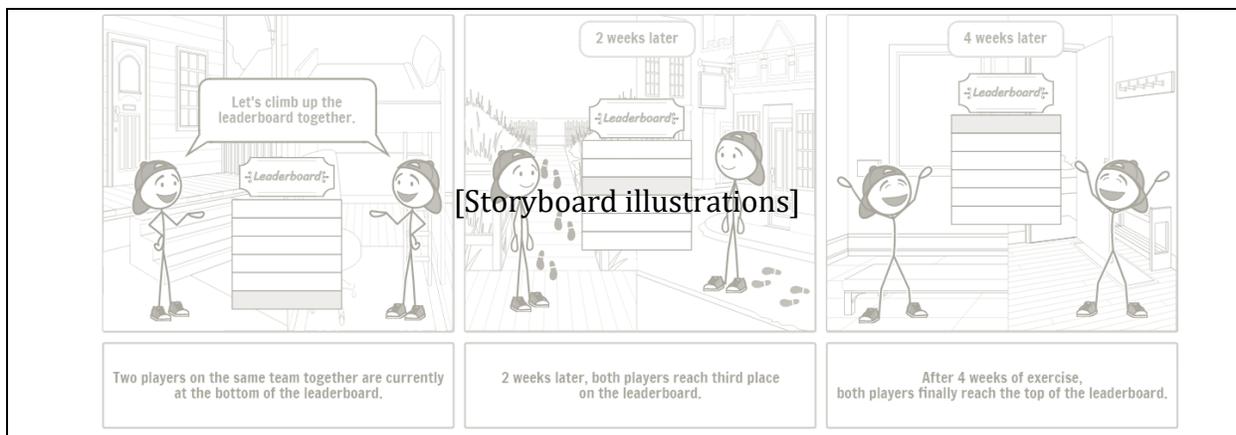
For each scenario, please first look at the drawings (can be enlarged by clicking on the thumbnail image below) and briefly describe what you think is going on. Then, please rate your level of agreement or disagreement (1 = strongly disagree to 7 = strongly agree) with the statements below and provide any additional thoughts that you might have to further explain your rating.

Please remember to read and respond to each question carefully. Thank you.

Next >

Scenario No.: Name of feature

Please briefly describe what you think is going on in the illustrations below:



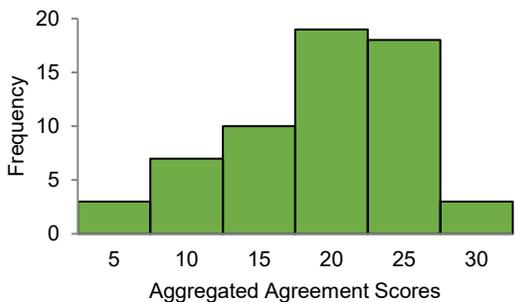
No.	Statement	Strongly Agree	Disagree	Somewhat Disagree	Neither	Somewhat Agree	Agree	Strongly Agree
1.	The system would influence me.	<input type="radio"/>						
2.	The system would be convincing.	<input type="radio"/>						
3.	The system would be personally relevant for me.	<input type="radio"/>						
4.	The system would make me reconsider my exercise habits.	<input type="radio"/>						
5.	I would enjoy this feature.	<input type="radio"/>						
6.	I would use this feature.	<input type="radio"/>						
7.	I would exercise more.	<input type="radio"/>						
8.	This feature would make me feel more socially connected to my teammate.	<input type="radio"/>						
9.	This feature would motivate me to do more exercise in the future.	<input type="radio"/>						
10.	I would love to play this feature with my friends.	<input type="radio"/>						
11.	I would enjoy this feature more when I am with others.	<input type="radio"/>						
12.	This feature would be more fun when other people around me use it too.	<input type="radio"/>						

Please provide any additional thoughts:

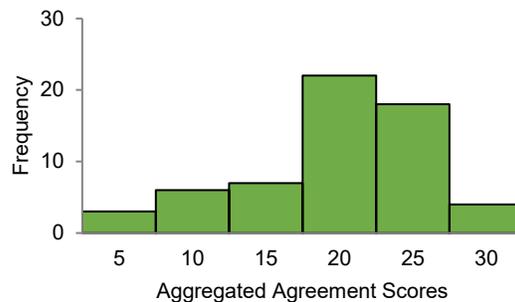
Finally, please provide any general comments you might have in the space below:

Submit >

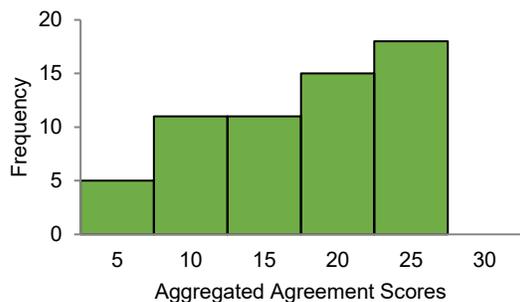
Appendix P: Frequency histograms for the 4 dependent variables with respect to each gamification element in Round 1 (N = 60) of Addon Study



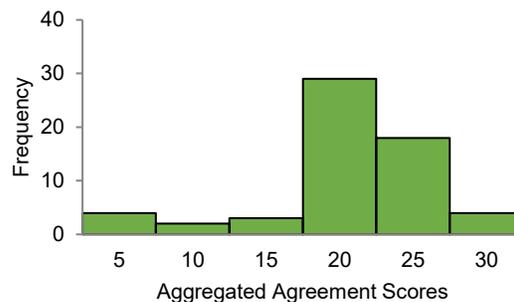
(a) Lottery



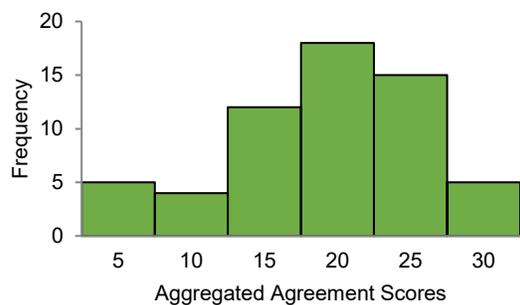
(b) Custom Goal



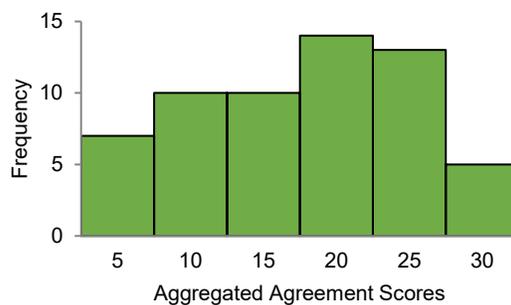
(c) Knowledge Sharing



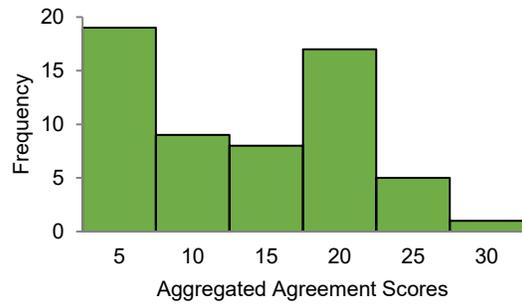
(d) Unlockable Content



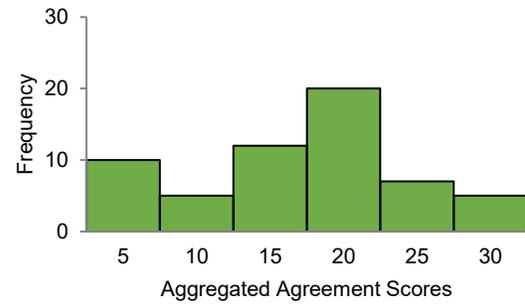
(e) Encouraging Updates



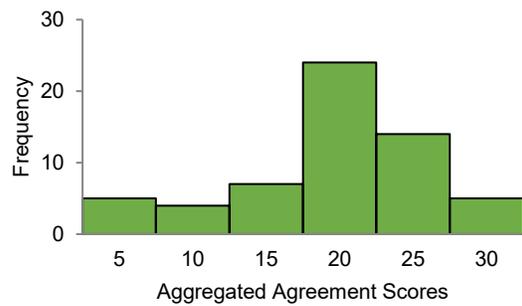
(f) Virtual Character



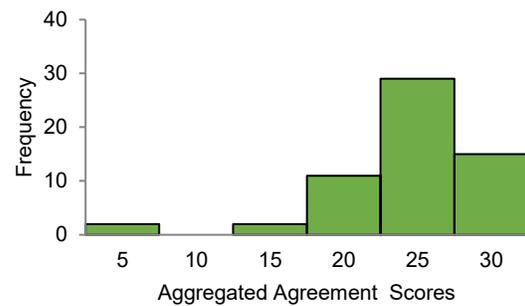
(g) Cheating



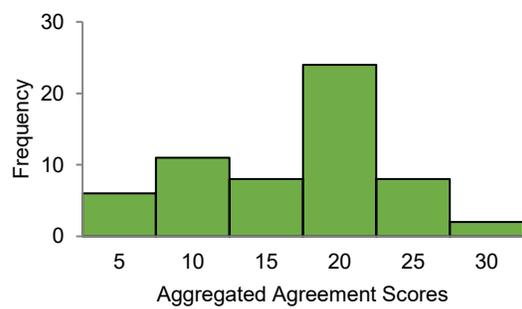
(h) Donate Points



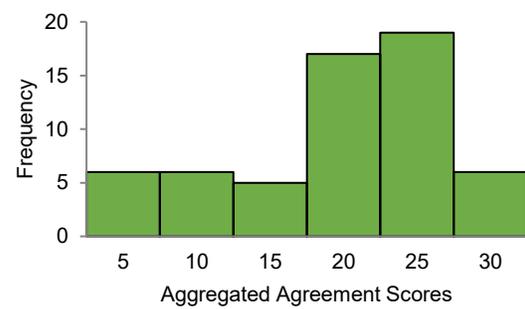
(i) Earn Trophy



(j) Support Charity

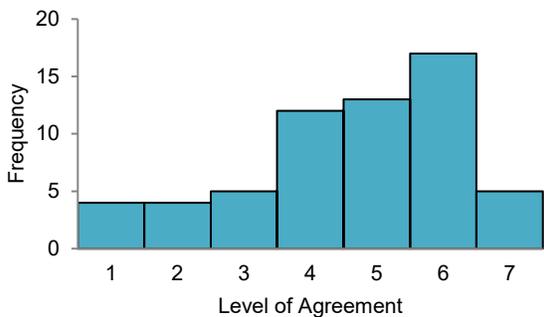


(k) Rotating Leadership

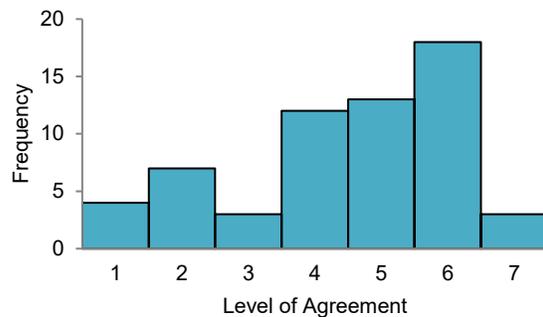


(l) Leaderboard

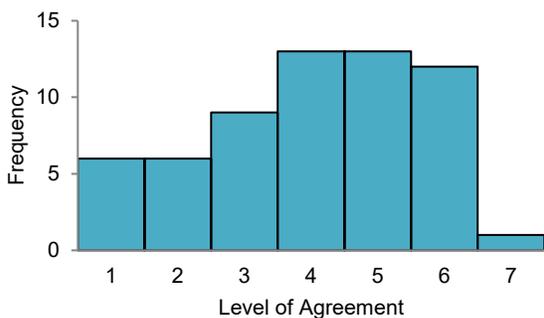
Figure A.7: Frequency histograms showing the distribution of perceived persuasiveness for each gamification element ($N = 60$).



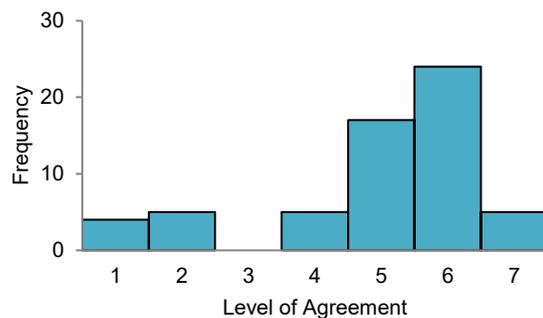
(a) Lottery



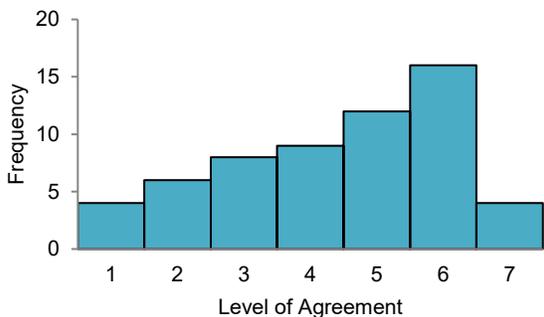
(b) Custom Goal



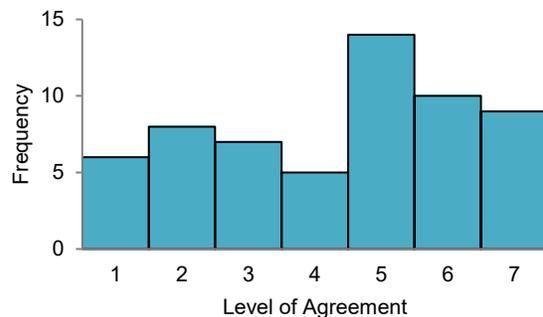
(c) Knowledge Sharing



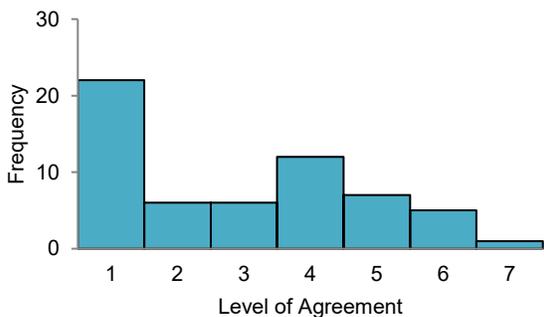
(d) Unlockable Content



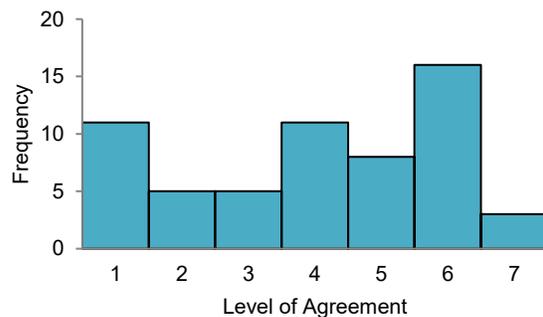
(e) Supportive Updates



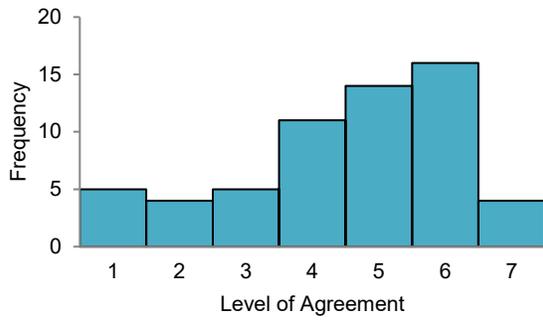
(f) Virtual Character



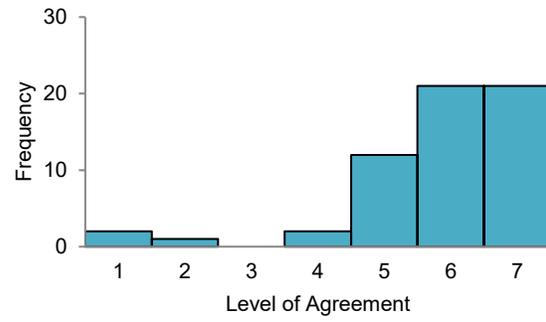
(g) Cheating



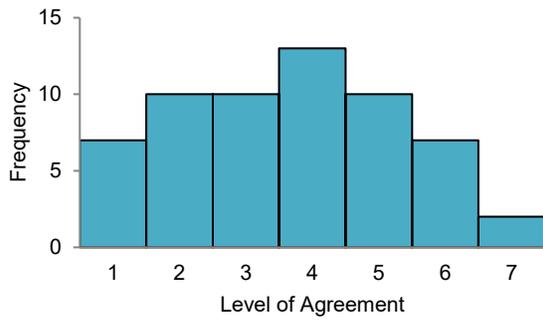
(h) Donate Points



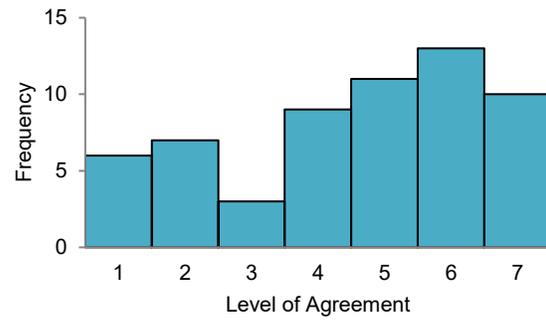
(i) Earn Trophy



(j) Support Charity

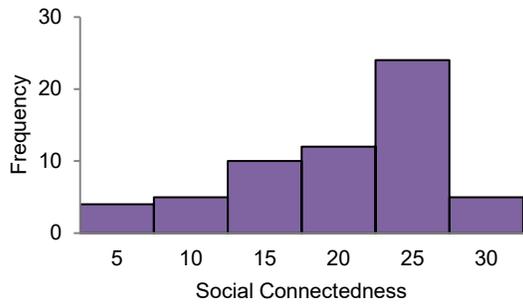


(k) Rotating Leadership

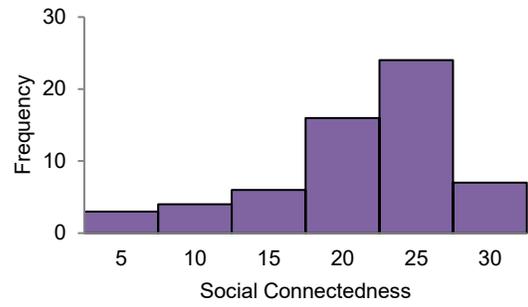


(l) Leaderboard

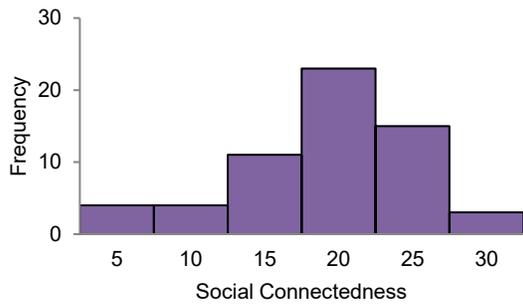
Figure A.8: Frequency histograms showing the distribution of enjoyment for each gamification element (N = 60).



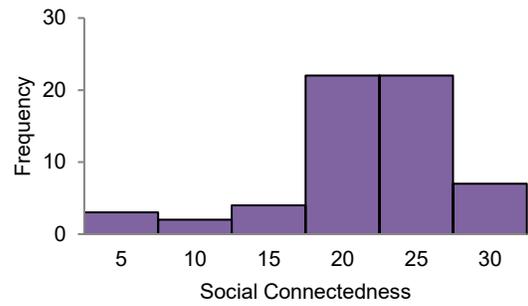
(a) Lottery



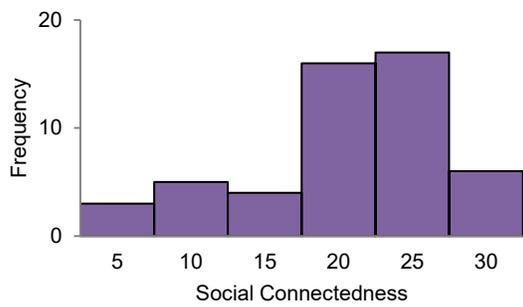
(b) Custom Goal



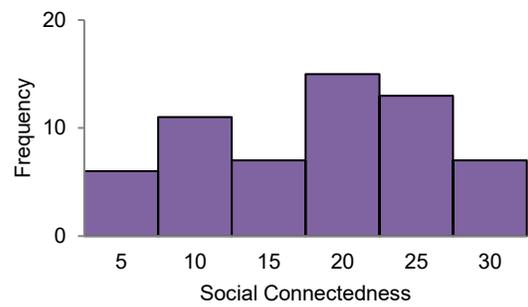
(c) Knowledge Sharing



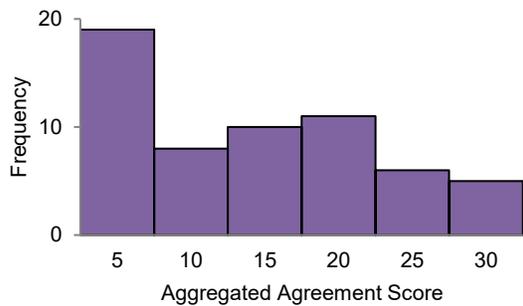
(d) Unlockable Content



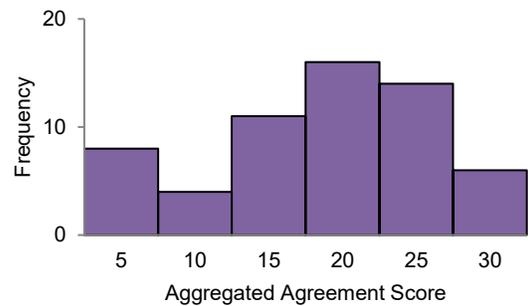
(e) Encouraging Updates



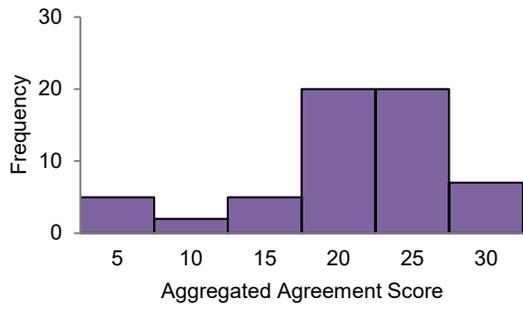
(f) Virtual Character



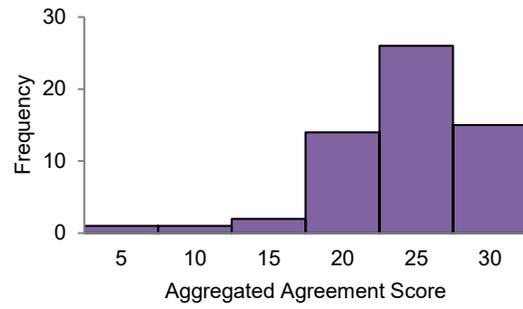
(g) Cheating



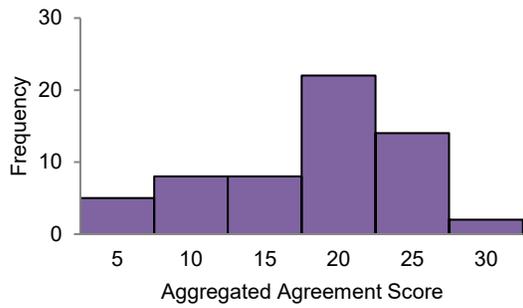
(h) Donate Points



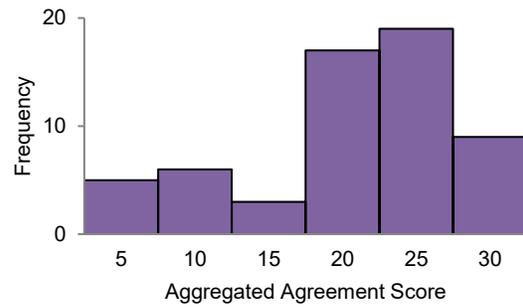
(i) Earn Trophy



(j) Support Charity

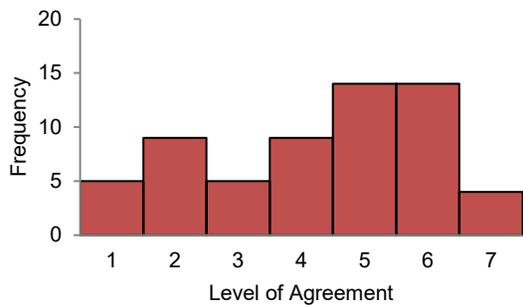


(k) Rotating Leadership

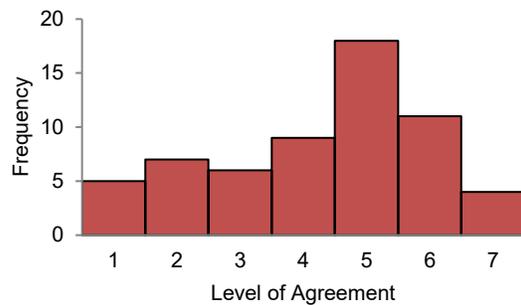


(l) Leaderboard

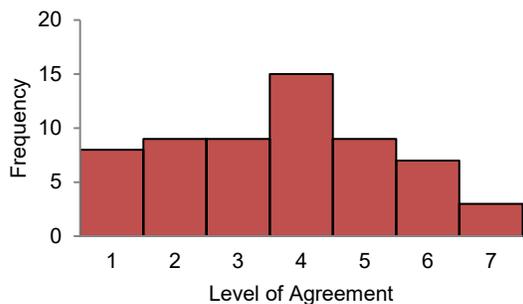
Figure A.9: Frequency histograms showing the distribution of social connectedness for each gamification element (N = 60).



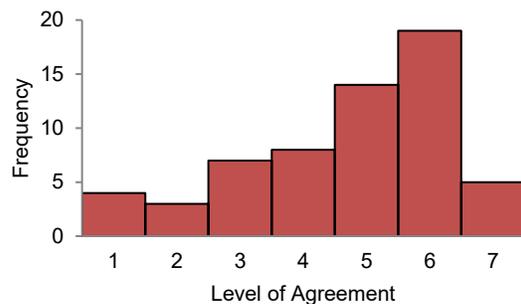
(a) Lottery



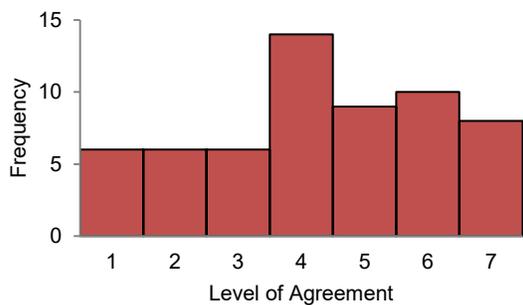
(b) Custom Goal



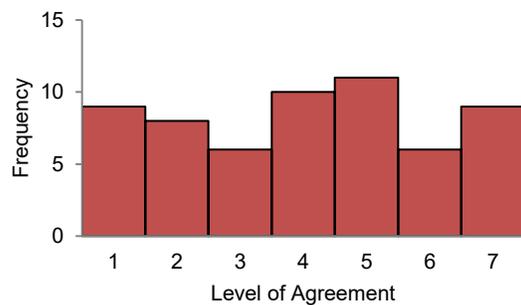
(c) Knowledge Sharing



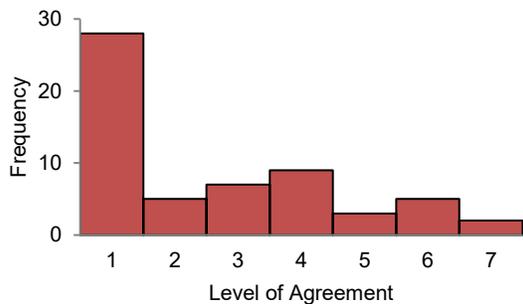
(d) Unlockable Content



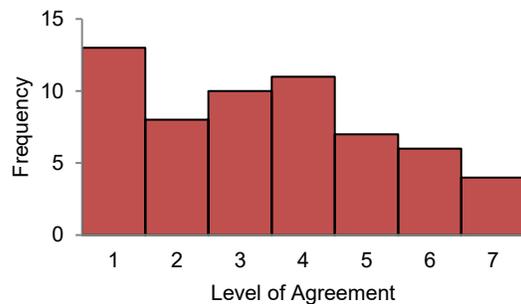
(e) Supportive Updates



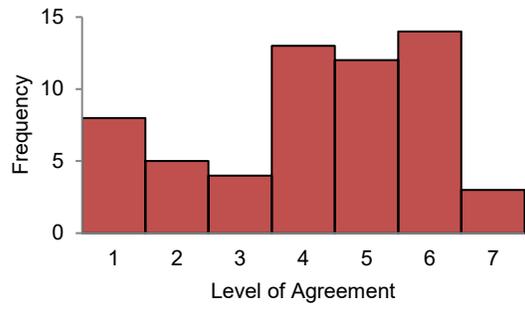
(f) Virtual Character



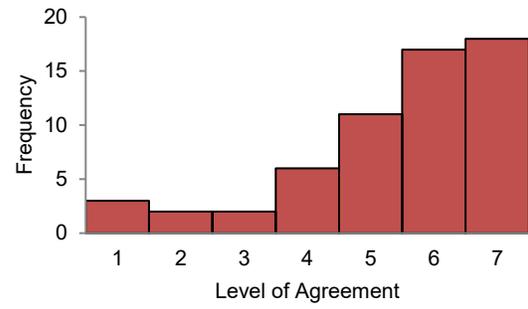
(g) Cheating



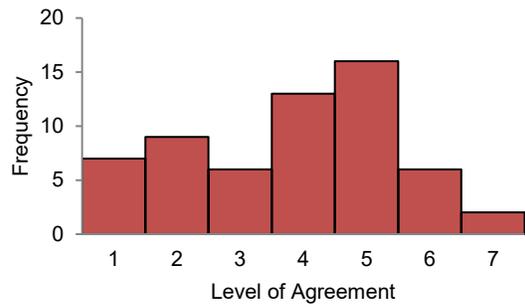
(h) Donate Points



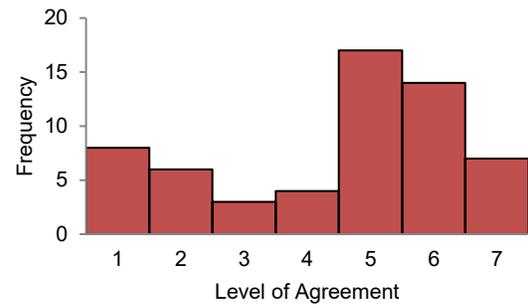
(i) Earn Trophy



(j) Support Charity



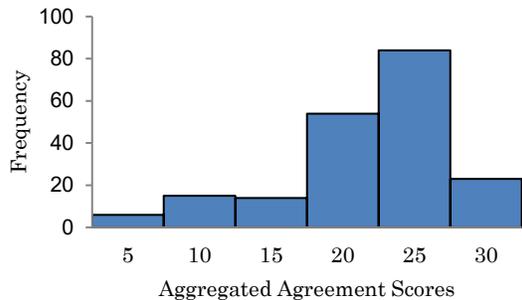
(k) Rotating Leadership



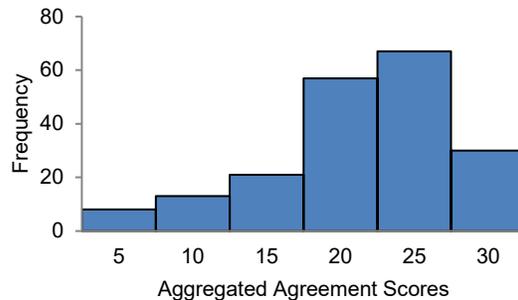
(l) Leaderboard

Figure A.10: Frequency histograms showing the distribution of future exercise intention for each gamification element (N = 60).

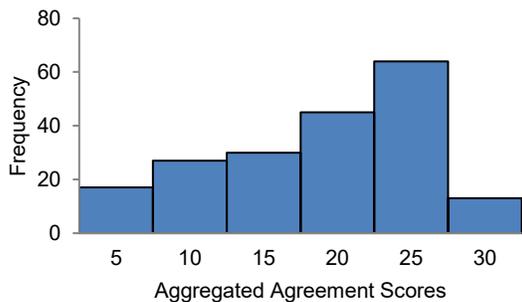
Appendix Q: Frequency histograms for the 4 dependent variables with respect to each gamification element in Round 2 (N = 192) of Addon Study



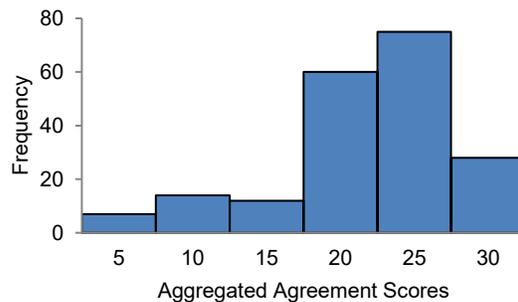
(a) Lottery



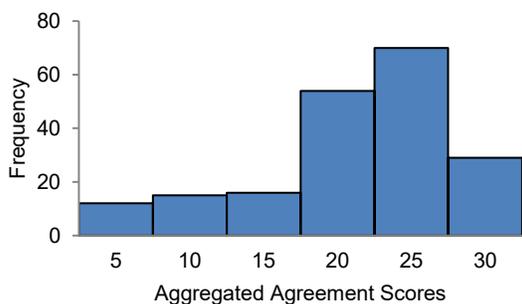
(b) Custom Goal



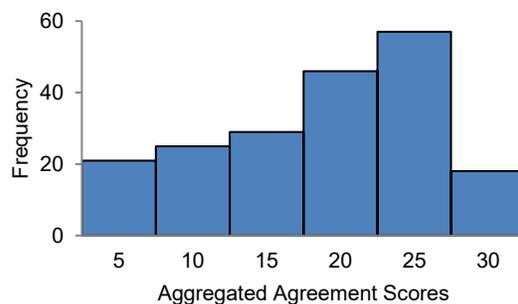
(c) Knowledge Sharing



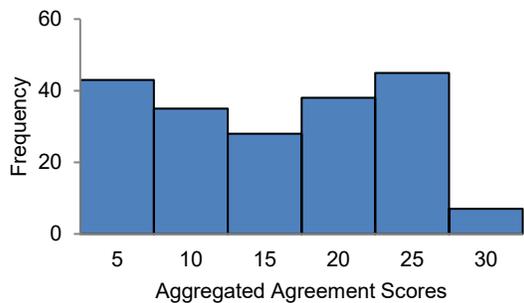
(d) Unlockable Content



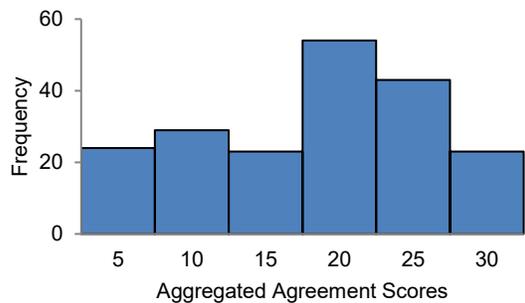
(e) Supportive Updates



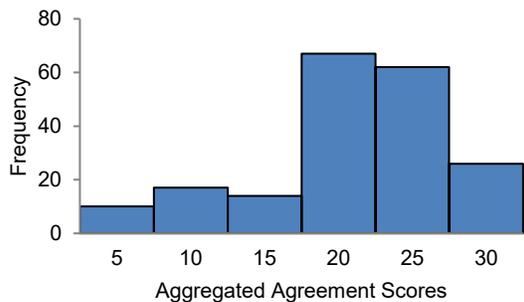
(f) Virtual Character



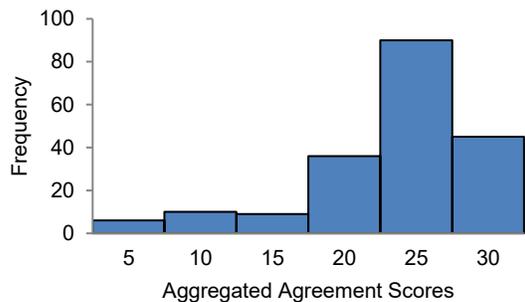
(g) Cheating



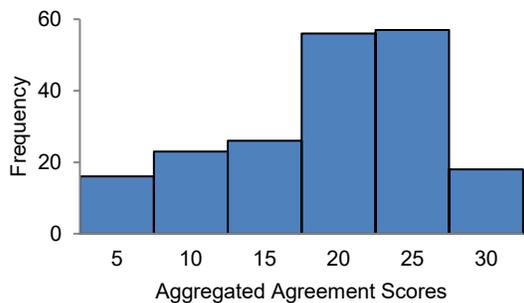
(h) Donate Points



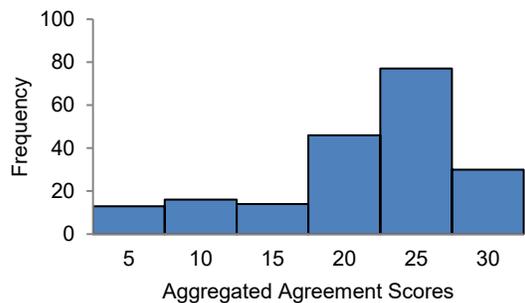
(i) Earn Trophy



(j) Support Charity

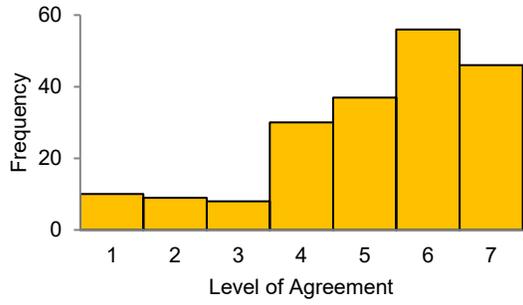


(k) Rotating Leadership

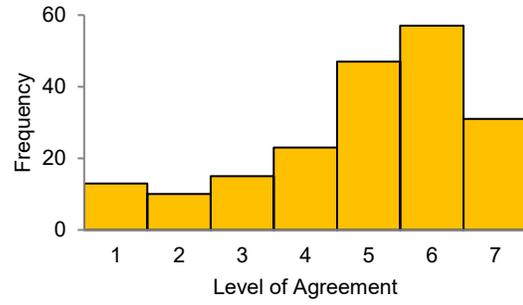


(l) Leaderboard

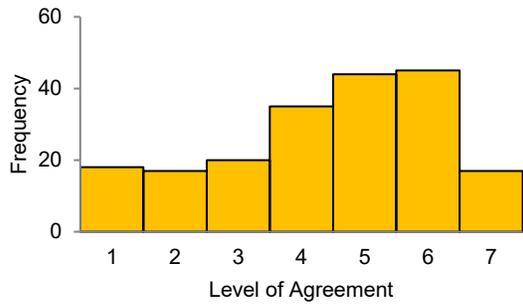
Figure A.11: Frequency histograms showing the distribution of perceived persuasiveness for each gamification element (N = 196).



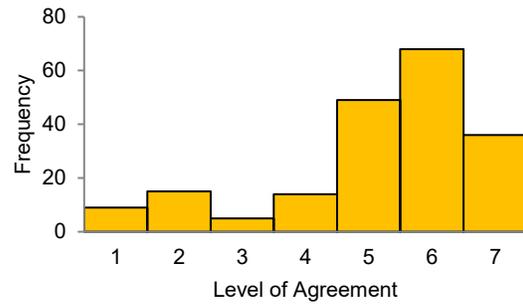
(a) Lottery



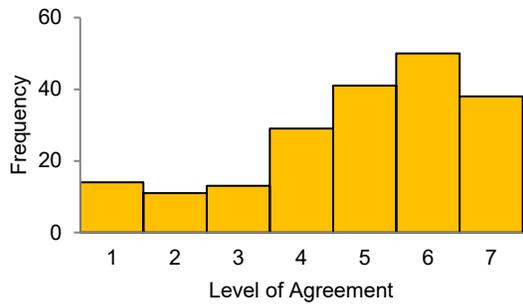
(b) Custom Goal



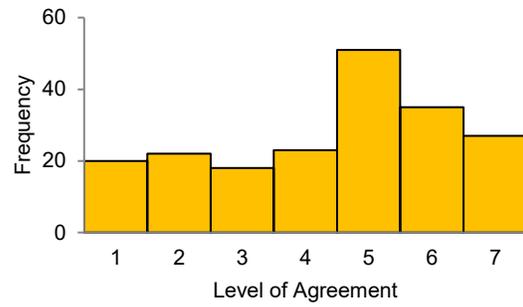
(c) Knowledge Sharing



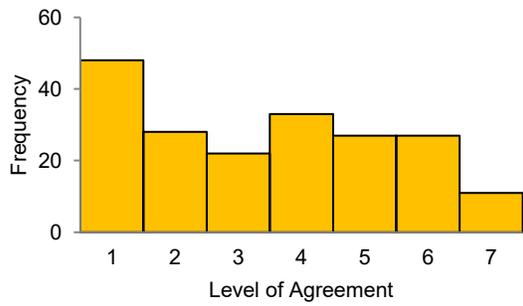
(d) Unlockable Content



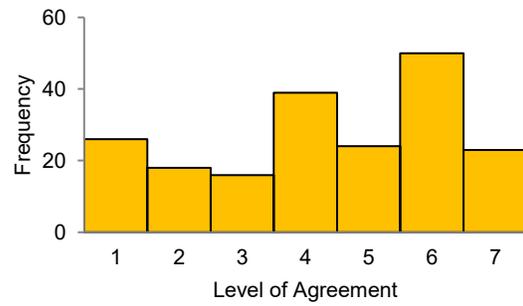
(e) Encouraging Updates



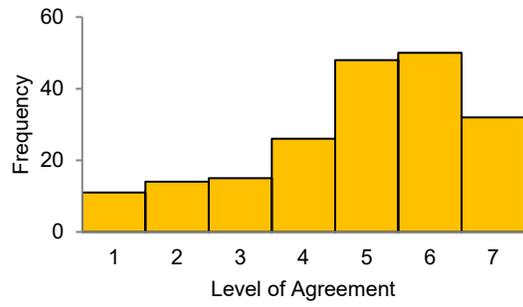
(f) Virtual Character



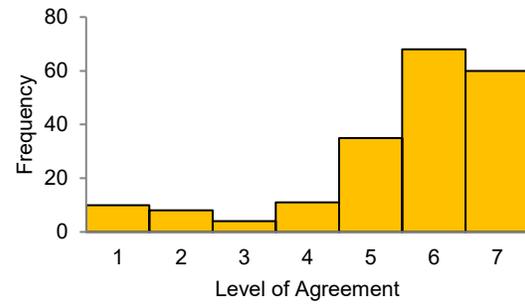
(g) Cheating



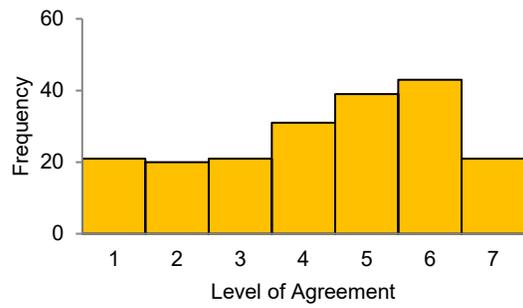
(h) Donate Points



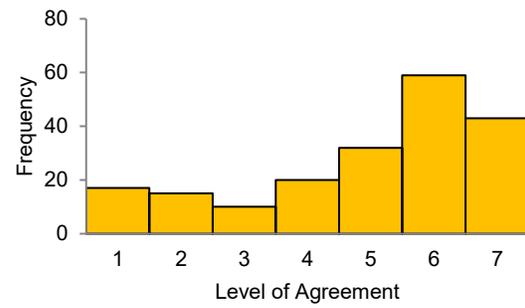
(i) Earn Trophy



(j) Support Charity

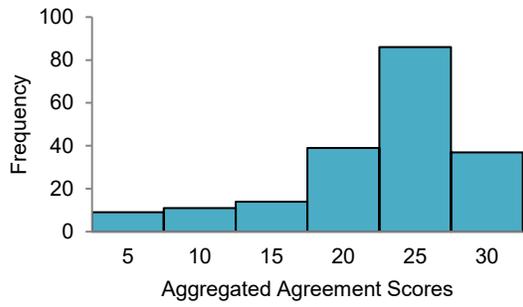


(k) Rotating Leadership

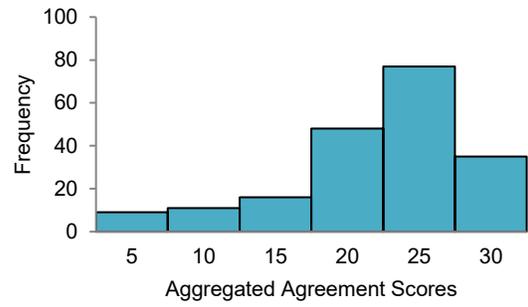


(l) Leaderboard

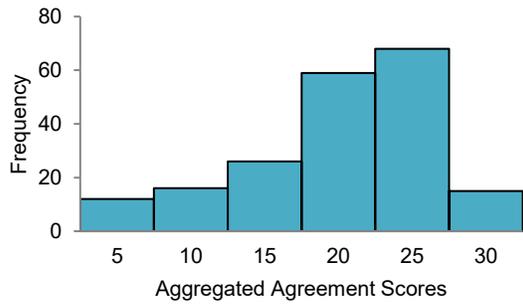
Figure A.12: Frequency histograms showing the distribution of enjoyment for each gamification element (N = 196).



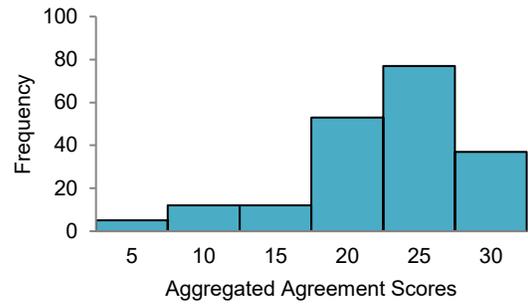
(a) Lottery



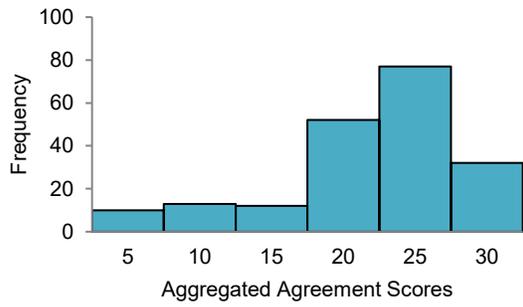
(b) Custom Goal



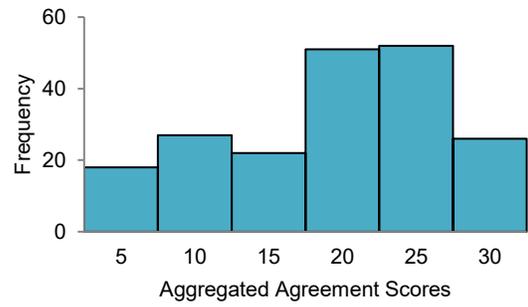
(c) Knowledge Sharing



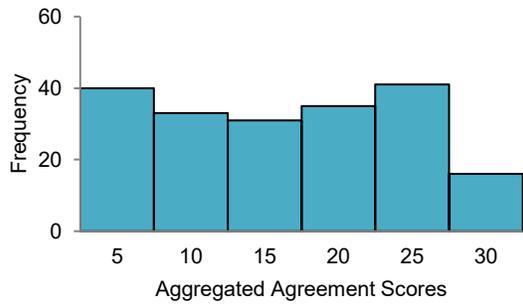
(d) Unlockable Content



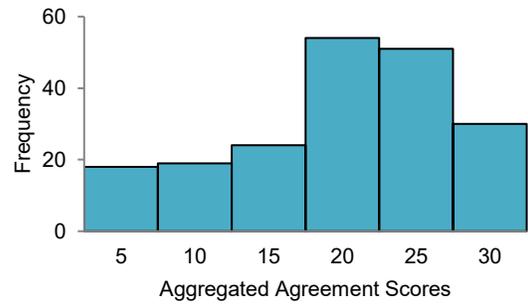
(e) Supportive Updates



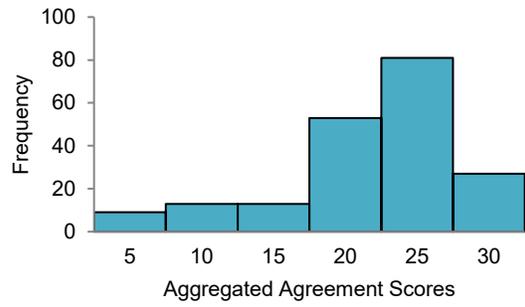
(f) Virtual Character



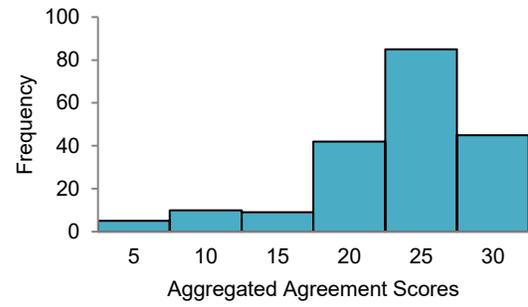
(g) Cheating



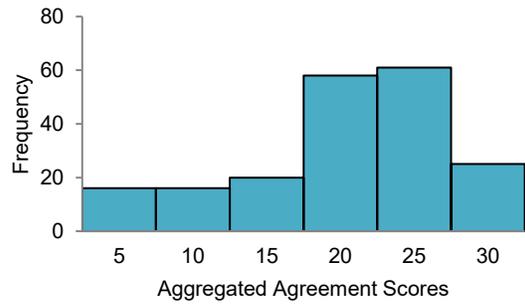
(h) Donate Points



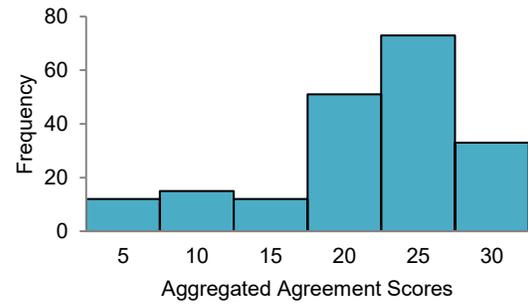
(i) Earn Trophy



(j) Support Charity

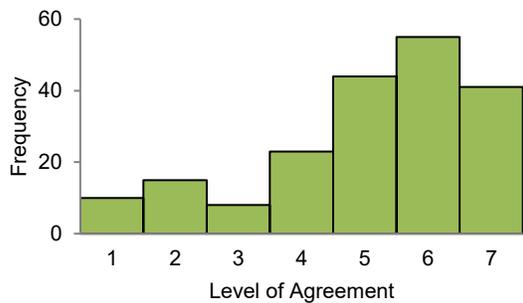


(k) Rotating Leadership

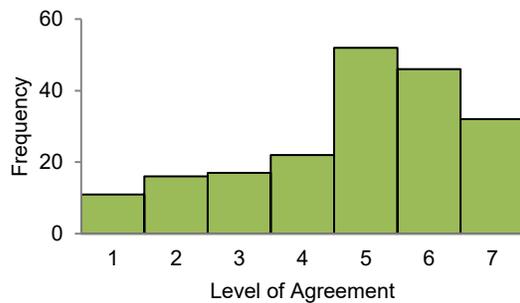


(l) Leaderboard

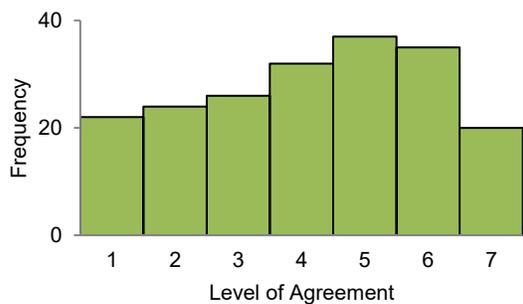
Figure A.13: Frequency histograms showing the distribution of engagement (social connectedness) for each gamification element (N = 196).



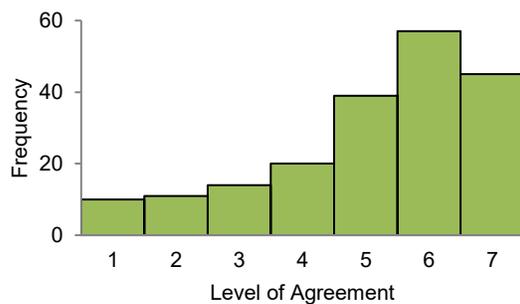
(a) Lottery



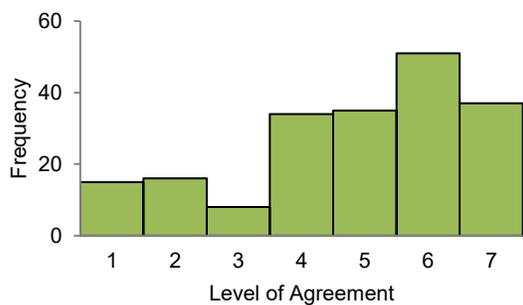
(b) Custom Goal



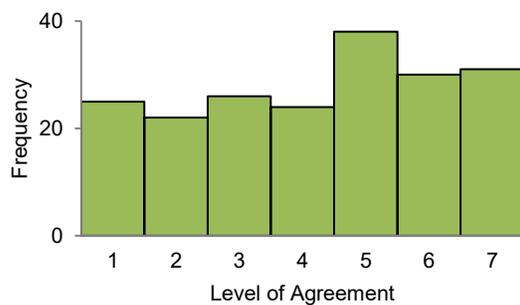
(c) Knowledge Sharing



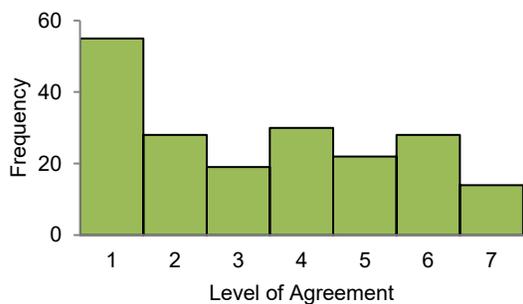
(d) Unlockable Content



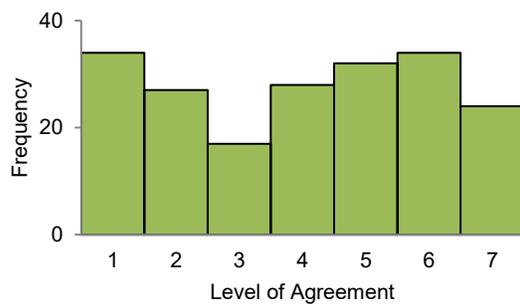
(e) Supportive Updates



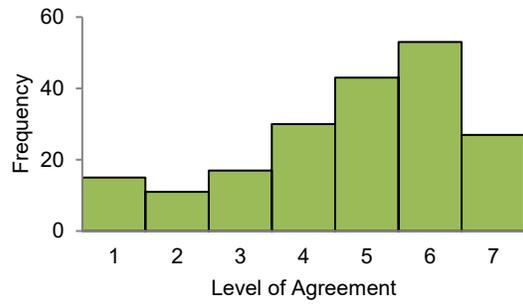
(f) Virtual Character



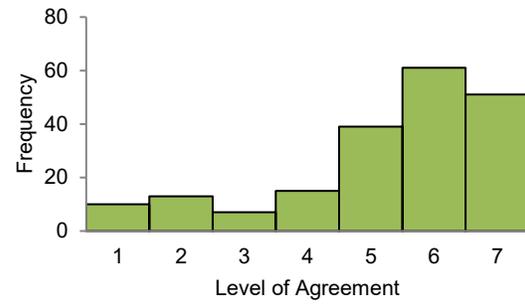
(g) Cheating



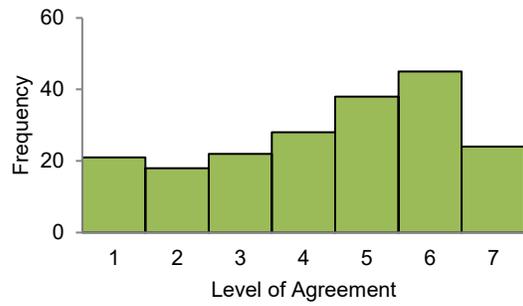
(h) Donate Points



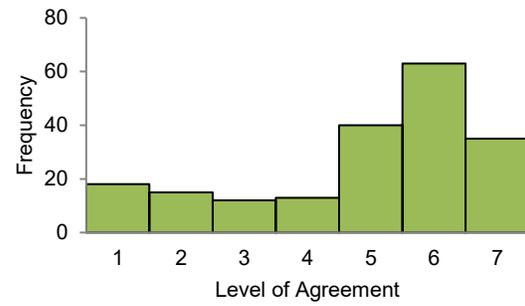
(i) Earn Trophy



(j) Support Charity



(k) Rotating Leadership



(l) Leaderboard

Figure A.14: Frequency histograms showing the distribution of future exercise intention for each gamification element (N = 196).

Appendix R: Pearson Correlation Coefficients for Addon Study – Round 1 (N = 60)

Table A.4: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and perceived persuasiveness of gamification elements.

N = 60 Gamification Element	User Types					
	Philanthropist (p)	Socializer (p)	Free Spirit (p)	Achiever (p)	Disruptor (p)	Player (p)
Lottery	.158 (.228)	-.058 (.662)	-.013 (.919)	.117 (.372)	-.002 (.990)	.072 (.583)
Custom Goal	.267 (.040)	.134 (.308)	-.019 (.884)	-.098 (.455)	-.191 (.144)	-.144 (.273)
Knowledge Sharing	.330 (.010)	.292 (.024)	.014 (.917)	.125 (.341)	-.080 (.542)	-.099 (.450)
Unlockable Content	.267 (.039)	.155 (.236)	.022 (.866)	.027 (.840)	-.088 (.505)	-.022 (.870)
Supportive Updates	.416* (.001)	.237 (.068)	.038 (.775)	.072 (.585)	-.066 (.618)	-.049 (.712)
Virtual Character	.143 (.276)	.057 (.664)	-.104 (.428)	-.099 (.453)	-.271 (.037)	-.168 (.199)
Cutting Corners	-.010 (.940)	-.053 (.688)	-.148 (.259)	-.131 (.318)	-.187 (.152)	.024 (.855)
Donate Points	.036 (.785)	-.110 (.403)	-.364* (.004)	-.317 (.014)	-.367* (.004)	-.283 (.028)
Earn Trophy	.270 (.037)	.133 (.313)	-.073 (.578)	-.043 (.747)	-.279 (.031)	.028 (.829)
Support Charity	.135 (.305)	-.115 (.382)	-.175 (.182)	-.103 (.435)	-.244 (.060)	-.138 (.294)
Rotating Leadership	.446* (.000)	.270 (.037)	.093 (.481)	.148 (.258)	-.089 (.498)	.059 (.652)
Leaderboard	.335 (.009)	.165 (.207)	-.019 (.886)	-.044 (.737)	-.188 (.150)	.033 (.804)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table A.5: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and level of enjoyment of gamification elements.

Gamification Element	User Types					
	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor	Player
Lottery	.245 (.059)	.183 (.162)	.103 (.436)	.202 (.122)	-.086 (.512)	.123 (.350)
Custom Goal	.210 (.108)	.177 (.177)	.035 (.791)	-.111 (.400)	-.107 (.418)	-.151 (.249)
Knowledge Sharing	.299 (.020)	.236 (.070)	-.054 (.684)	.102 (.439)	-.131 (.317)	-.064 (.629)
Unlockable Content	.266 (.040)	.265 (.041)	.119 (.364)	.059 (.653)	-.089 (.501)	.012 (.929)
Supportive Updates	.414* (.001)	.268 (.038)	.026 (.846)	.028 (.831)	-.061 (.646)	.015 (.908)
Virtual Character	.073 (.580)	-.004 (.974)	-.146 (.267)	-.151 (.251)	-.256 (.048)	-.083 (.528)
Cutting Corners	-.033 (.802)	-.083 (.531)	-.180 (.169)	-.148 (.258)	-.174 (.185)	.002 (.987)
Donate Points	-.014 (.917)	-.170 (.193)	-.404* (.001)	-.345 (.007)	-.442* (.000)	-.223 (.086)
Earn Trophy	.305* (.018)	.211 (.106)	.002 (.986)	.013 (.920)	-.266 (.040)	.078 (.555)
Support Charity	.133 (.310)	-.166 (.204)	-.214 (.101)	-.089 (.498)	-.307 (.017)	-.106 (.418)
Rotating Leadership	.348 (.006)	.211 (.106)	.033 (.804)	.043 (.747)	-.034 (.794)	-.030 (.820)
Leaderboard	.347 (.007)	.222 (.088)	.063 (.630)	-.017 (.895)	-.129 (.324)	.080 (.543)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table A.6: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and behavioural engagement of gamification elements.

N = 60	User Types					
	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor	Player
Lottery	.155 (.237)	.227 (.081)	.100 (.446)	.098 (.455)	-.097 (.462)	-.037 (.779)
Custom Goal	.193 (.140)	.224 (.086)	.053 (.688)	-.101 (.443)	-.193 (.139)	-.082 (.536)
Knowledge Sharing	.317 (.014)	.269 (.037)	-.024 (.857)	.018 (.892)	-.183 (.162)	-.054 (.680)
Unlockable Content	.186 (.156)	.259 (.046)	.145 (.268)	.076 (.562)	-.146 (.267)	-.045 (.730)
Supportive Updates	.314 (.014)	.251 (.053)	.071 (.591)	-.018 (.891)	-.093 (.482)	-.013 (.923)
Virtual Character	.128 (.330)	.129 (.326)	-.071 (.590)	-.062 (.638)	-.335 (.009)	-.161 (.220)
Cutting Corners	-.020 (.877)	-.017 (.899)	-.123 (.350)	-.228 (.080)	-.254 (.050)	-.029 (.826)
Donate Points	-.012 (.930)	-.089 (.501)	-.406* (.001)	-.302 (.019)	-.440* (.000)	-.304 (.018)
Earn Trophy	.214 (.101)	.162 (.217)	-.002 (.986)	.020 (.878)	-.242 (.062)	-.074 (.572)
Support Charity	.034 (.796)	-.143 (.276)	-.257 (.047)	-.041 (.758)	-.235 (.071)	-.080 (.541)
Rotating Leadership	.358 (.005)	.270 (.037)	.026 (.844)	.035 (.793)	-.144 (.271)	.030 (.817)
Leaderboard	.329 (.010)	.254 (.050)	.067 (.612)	.057 (.664)	-.182 (.165)	.062 (.639)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table A.7: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and future exercise intention of gamification elements.

N = 60	User Types					
	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor	Player
Lottery	.225 (.083)	.187 (.152)	.113 (.390)	.048 (.717)	-.125 (.342)	.014 (.916)
Custom Goal	.186 (.154)	.122 (.353)	-.011 (.932)	-.132 (.313)	-.210 (.108)	-.131 (.318)
Knowledge Sharing	.258 (.046)	.202 (.123)	-.066 (.616)	.135 (.304)	-.090 (.493)	-.011 (.936)
Unlockable Content	.217 (.096)	.278 (.032)	.138 (.294)	.021 (.875)	-.100 (.445)	-.034 (.799)
Supportive Updates	.391* (.002)	.251 (.053)	.012 (.930)	.011 (.931)	-.124 (.345)	.030 (.822)
Virtual Character	.062 (.683)	-.005 (.970)	-.135 (.304)	-.129 (.326)	-.251 (.053)	-.169 (.196)
Cutting Corners	.048 (.718)	.050 (.707)	-.065 (.620)	-.079 (.550)	-.176 (.177)	-.016 (.906)
Donate Points	.079 (.549)	-.085 (.516)	-.333 (.009)	-.261 (.044)	-.397* (.002)	-.260 (.045)
Earn Trophy	.212 (.103)	.069 (.598)	-.037 (.782)	-.081 (.538)	-.164 (.211)	-.051 (.700)
Support Charity	.011 (.936)	-.170 (.193)	-.209 (.109)	-.110 (.404)	-.232 (.074)	-.114 (.387)
Rotating Leadership	.495* (.000)	.344 (.007)	.140 (.286)	.164 (.211)	-.106 (.420)	.079 (.547)
Leaderboard	.388* (.002)	.232 (.075)	.079 (.551)	-.022 (.865)	-.127 (.332)	.042 (.749)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Appendix S: Pearson Correlation Coefficients for Addon Study – Round 2 (N = 196)

Table A.8: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and perceived persuasiveness of gamification elements.

N = 196	User Types					
	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor	Player
Lottery	.283*	.179	.152	.199	-.083	.225*
	(.000)	(.012)	(.033)	(.005)	(.245)	(.002)
Custom Goal	.304*	.345*	.125	.124	-.102	.102
	(.000)	(.000)	(.081)	(.082)	(.155)	(.156)
Knowledge Sharing	.252*	.355*	.147	.117	.109	.091
	(.000)	(.000)	(.040)	(.103)	(.128)	(.206)
Unlockable Content	.414*	.313*	.101	.223*	-.081	.214*
	(.000)	(.000)	(.158)	(.002)	(.258)	(.003)
Supportive Updates	.403*	.369*	.139	.212*	-.127	.221*
	(.000)	(.000)	(.052)	(.003)	(.076)	(.002)
Virtual Character	.261*	.264*	.039	.092	-.006	.071
	(.000)	(.000)	(.583)	(.199)	(.931)	(.323)
Cutting Corners	.071	.170	.049	-.020	.171	.092
	(.322)	(.017)	(.493)	(.781)	(.017)	(.200)
Donate Points	.243*	.204*	-.028	.042	.024	.111
	(.001)	(.004)	(.693)	(.557)	(.744)	(.120)
Earn Trophy	.368*	.359*	.109	.143	-.105	.227*
	(.000)	(.000)	(.129)	(.046)	(.143)	(.001)
Support Charity	.368*	.252*	.017	.182	-.075	.103
	(.000)	(.000)	(.813)	(.011)	(.297)	(.150)
Rotating Leadership	.385*	.325*	.152	.175	.002	.194
	(.000)	(.000)	(.034)	(.014)	(.973)	(.006)
Leaderboard	.372*	.314*	.120	.183	-.107	.177
	(.000)	(.000)	(.093)	(.010)	(.136)	(.013)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table A.9: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and level of enjoyment of gamification elements.

Gamification Element	User Types					
	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor	Player
Lottery	.359*	.290*	.197	.256*	-.141*	.262*
	(.000)	(.000)	(.006)	(.000)	(.048)	(.000)
Custom Goal	.327*	.351*	.171	.125	-.127	.091
	(.000)	(.000)	(.016)	(.080)	(.077)	(.203)
Knowledge Sharing	.262*	.351*	.172	.118	.037	.105
	(.000)	(.000)	(.016)	(.099)	(.607)	(.142)
Unlockable Content	.366*	.323*	.116	.196	-.112	.149
	(.000)	(.000)	(.106)	(.006)	(.117)	(.037)
Supportive Updates	.380*	.405*	.157	.211*	-.103	.232*
	(.000)	(.000)	(.028)	(.003)	(.149)	(.001)
Virtual Character	.211*	.222*	-.004	.068	.006	.079
	(.003)	(.002)	(.955)	(.341)	(.930)	(.274)
Cutting Corners	.075	.164	.021	-.008	.187	.080
	(.298)	(.022)	(.769)	(.911)	(.009)	(.263)
Donate Points	.220*	.136	-.041	-.022	-.027	.108
	(.002)	(.057)	(.567)	(.762)	(.710)	(.134)
Earn Trophy	.363*	.386*	.092	.166	-.108	.233*
	(.000)	(.000)	(.199)	(.020)	(.133)	(.001)
Support Charity	.360*	.232*	-.054	.197	-.076	.095
	(.000)	(.001)	(.450)	(.006)	(.290)	(.183)
Rotating Leadership	.317*	.279*	.102	.146	.027	.151
	(.000)	(.000)	(.155)	(.042)	(.708)	(.034)
Leaderboard	.373*	.321*	.139	.194	-.075	.206*
	(.000)	(.000)	(.052)	(.006)	(.295)	(.004)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table A.10: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and behavioural engagement of gamification elements.

Gamification Element	User Types					
	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor	Player
Lottery	.308*	.293*	.177	.180	-.130	.139
	(.000)	(.000)	(.013)	(.012)	(.069)	(.052)
Custom Goal	.306*	.381*	.116	.088	-.131	.075
	(.000)	(.000)	(.105)	(.220)	(.068)	(.294)
Knowledge Sharing	.267*	.339*	.144	.082	.034	.073
	(.000)	(.000)	(.044)	(.256)	(.637)	(.312)
Unlockable Content	.395*	.364*	.140	.237*	-.124	.163
	(.000)	(.000)	(.051)	(.001)	(.082)	(.022)
Supportive Updates	.404*	.388*	.166	.222*	-.126	.205*
	(.000)	(.000)	(.020)	(.002)	(.079)	(.004)
Virtual Character	.239*	.279*	.062	.099	-.016	.069
	(.001)	(.000)	(.388)	(.168)	(.825)	(.335)
Cutting Corners	.019	.160	.016	-.067	.170	.036
	(.795)	(.025)	(.821)	(.352)	(.017)	(.621)
Donate Points	.221*	.175	-.045	.032	-.062	.070
	(.002)	(.014)	(.529)	(.635)	(.391)	(.329)
Earn Trophy	.339*	.349*	.115	.177	-.111	.111
	(.000)	(.000)	(.108)	(.013)	(.120)	(.121)
Support Charity	.346*	.292*	-.009	.237*	-.051	.177
	(.000)	(.000)	(.901)	(.001)	(.476)	(.013)
Rotating Leadership	.328*	.341*	.129	.190	-.061	.163
	(.000)	(.000)	(.072)	(.008)	(.393)	(.022)
Leaderboard	.385*	.382*	.136	.248*	-.120	.212*
	(.000)	(.000)	(.058)	(.000)	(.094)	(.003)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.

Table A.11: Bivariate correlation coefficients (Pearson's r) between the Hexad user types and future exercise intention of gamification elements.

N = 196	User Types					
	Gamification Element	Philanthropist	Socializer	Free Spirit	Achiever	Disruptor
Lottery	.320*	.270*	.188	.199	-.207*	.174
	(.000)	(.000)	(.008)	(.005)	(.004)	(.015)
Custom Goal	.339*	.344*	.122	.117	-.180	.140
	(.000)	(.000)	(.088)	(.101)	(.011)	(.051)
Knowledge Sharing	.242*	.344*	.131	.146	.055	.140
	(.001)	(.000)	(.068)	(.042)	(.442)	(.050)
Unlockable Content	.382*	.356*	.173	.225*	-.110	.171
	(.000)	(.000)	(.016)	(.002)	(.125)	(.017)
Supportive Updates	.365*	.338*	.122	.213*	-.110	.259*
	(.000)	(.000)	(.089)	(.003)	(.125)	(.000)
Virtual Character	.219*	.232*	.013	.055	-.019	.067
	(.002)	(.001)	(.857)	(.441)	(.795)	(.348)
Cutting Corners	.066	.196	.031	.001	.142	.056
	(.358)	(.006)	(.668)	(.993)	(.047)	(.434)
Donate Points	.184	.165	-.076	-.022	.036	.075
	(.010)	(.021)	(.290)	(.755)	(.618)	(.297)
Earn Trophy	.285*	.290*	.136	.121	-.094	.150
	(.000)	(.000)	(.058)	(.091)	(.189)	(.036)
Support Charity	.298*	.189	-.019	.190	-.087	.154
	(.000)	(.008)	(.795)	(.008)	(.225)	(.032)
Rotating Leadership	.334*	.340*	.142	.177	-.021	.174
	(.000)	(.000)	(.048)	(.013)	(.774)	(.015)
Leaderboard	.389*	.312*	.147	.161	-.089	.149
	(.000)	(.000)	(.040)	(.024)	(.212)	(.037)

* = Bonferroni adjusted 2-sided significance level of $\alpha \leq 0.05/12 = p \leq 0.004$.