Social Play in an Exergame: How the Need to Belong Predicts Adherence

Maximus D. Kaos
Queen's University
Kingston, Ontario, Canada
Aalto University
Espoo, Finland
maximus.kaos@aalto.fi

Ryan E. Rhodes
University of Victoria
Victoria, British Columbia, Canada
rhodes@uvic.ca

Perttu Hämäläinen
Aalto University
Espoo, Finland
perttu.hamalainen@aalto.fi

T.C. Nicholas Graham
Queen's University
Kingston, Ontario, Canada
nicholas.graham@queensu.ca

ABSTRACT

The general trend in exercise interventions, including those based on exergames, is to see high initial enthusiasm but significantly declining adherence. Social play is considered a core tenet of the design of exercise interventions help foster motivation to play. To determine whether social play aids in adherence to exergames, we analyzed data from a study involving five waves of six-week exergame trials between a single-player and multiplayer group. In this paper, we examine the multiplayer group to determine who might benefit from social play and why. We found that people who primarily engage in group play have superior adherence to people who primarily play alone. People who play alone in a multiplayer exergame have worse adherence than playing a single-player version, which can undo any potential benefit of social play. The primary construct distinguishing group versus alone players is their sense of program belonging. Program belonging is, thus, crucial to multiplayer exergame design.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in collaborative and social computing**; *Empirical studies in HCI*; User studies; • **Applied computing** → Computer games.

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1 INTRODUCTION

Adherence to exercise is considered a major public health concern [7, 21], and physical activity interventions aimed at improving adherence have generally been ineffective or inconclusive [60, 73]. Similarly, studies involving exergames elicit high initial enthusiasm, but adherence typically declines significantly over time [2, 6, 53, 59].

One of the primary factors of human motivation that influences the decision to adhere to an activity is the satisfaction of an individual's need to belong [4]. As described by Baumeister and Leary, the belongingness hypothesis proposes that humans almost universally have a fundamental need to feel a sense of relationship with others [4, 67]. Satisfying this need to belong generally involves frequent social interactions with other people who exhibit concern for one another's wellbeing [4, 8]. Belongingness has been shown to apply to all human activities [4], and evidence suggests that people show a preference toward exercising and playing games with others rather than participating in these activities alone [8, 38]. Social interactions also have a positive influence on adherence to exercise and future play of games [65, 66]. Thus, it stands to reason that offering the opportunity to play with others can potentially help to combat the issue of declining adherence over time in exergame play.

To test this hypothesis, we analyzed data from a study involving five waves of six-week trials with 70 participants

that played exergames on a recumbent bike; 30 participants played in a single-player condition and 40 in a multiplayer condition. A prior paper showed that there were no significant differences in adherence behaviours between the two conditions [34]. Thus, simply granting the ability to play with others in an exergame does not necessarily improve adherence.

Instead, as we will describe, it appears that some people benefit from social play through improved adherence, while others do not. In this paper, we examine who might benefit from social play in an exergame and why they might benefit from it, to better inform the design of future multiplayer exergames. To do so, we specifically analyze the multiplayer condition of the study to gain a greater understanding of the behaviours exhibited by participants who had the option of engaging in social play.

We discovered that participants who actively engaged in social play had significantly higher adherence than participants who did not. We termed these Group Players and Solo Players, respectively. To determine why Group Players benefitted from social play (e.g., by exhibiting significantly higher adherence than Solo Players), we compared several constructs between the two groups, including age, sex, game win rate, and prior engagement in physical activity. We found that the key defining predictor was that Group Players had significantly higher program belonging than Solo Players.

Our findings suggest that program belonging is an important factor in exergaming adherence. Moreover, preliminary evidence suggests that playing alone in a multiplayer exergame may be worse for adherence than playing a single-player version of the game. This may explain the prior finding that adherence was similar between the single and multiplayer arms of the study: Group Players benefited from social play, while Solo Players, through lack of establishment of program belonging, were less likely to continue play.

The remainder of the paper is structured as follows. We first review related work establishing the issue of diminishing adherence and the importance of social interaction to exercise and exergames. Then, we describe how social play is implemented in the games used in a six-week exergaming study. Next, we examine adherence behaviours between the multiplayer and single-player conditions in this study. We then outline the key takeaways of this paper and provide a detailed examination of social play in the multiplayer condition of the study. We conclude with implications for multiplayer exergame design.

2 RELATED WORK

In this section, we establish the issue with declining adherence in exercise and exergames. We then describe Baumeister and Leary's need to belong and compare it to other psychosocial theories of human needs. Finally, we establish the importance of social interactions to exercise and exergames.

Declining Exercise & Exergame Adherence

Most people know about the health benefits of exercise [10, 43, 52], and the vast majority of people report feeling better after exercising [46]. Despite this, half of individuals who begin an exercise program typically drop out within the first six months [19]. In general, adherence to exercise is considered a major public health concern [7, 21].

Some exergaming studies have shown positive adherence results. For example, Warburton et al. [75, 77] and Rhodes et al. [61, 62] have demonstrated that exergames can lead to greater enjoyment, increased exercise adherence, and improved health when compared with traditional cycle-based training [76]. More generally, however, participation in exergaming studies tends to decline over time [6, 26, 45, 53, 58], similar to other exercise interventions.

Waning interest is also a problem more generally, outside the exercise adherence domain. Novelty of an experience has been found to be a key prerequisite for the feeling of curious interest [68]. In game-specific motivation and player type models, some form of exploration of novel things is likewise emphasized [27]. Thus, it is perhaps no surprise that people tend to lose interest in activities, be they exercise or a video game. In modern long-lived games such as *Fortnite* or *Clash Royale*, player engagement is refreshed using periodic content updates, which add novel things to try and explore. The same strategy has also been shown to reduce decline in adherence in an exergame [83].

Curiosity and the craving for novel experiences are only part of human intrinsic motivation and need satisfaction. In this paper, we focus on the need for belonging, emphasized by studies in games and experiences in general [66, 67, 69].

The Need to Belong

It is widely accepted that humans need to feel close with others [4, 57]. Baumeister and Leary proposed the belongingness hypothesis, that "human beings have a pervasive drive to form and maintain at least a minimum quantity of lasting, positive, and significant personal relationships [4]". This need has also been considered a major construct in other psychological theories of human motivation.

Deci and Ryan's self-determination theory describes relatedness as a core human need, the desire to feel a sense of closeness to others [18]. Maslow's theory of personality proposed that people need to feel a sense of love and affection with individuals who are important to them [44]. Epstein's cognitive-experiential self-theory specifies relatedness, akin to Deci and Ryan's self-determination theory, as a need that all individuals must satisfy [23]. Indeed, even

if the need to belong is not specified as a core component of the theory, many empirical theories of needs satisfaction assume that people have a desire for or tendency toward belongingness [18].

Multiplayer games have the potential to fulfill an individual's need to belong in several ways. When people play together, they are involved in a common social activity. This increases the number of social interactions between players, which contributes to their sense of belonging [4, 17]. Spending time together also encourages feelings of being a part of each other's social group, which generally elicits positive emotions [17]. A shared commonality of feelings (e.g., through being successful at a game together) also encourages a strong sense of belonging through confirmation and positive reinforcement [56]. To date, research has shown that some multiplayer games can be beneficial to initiating, enhancing, and maintaining relationships with others [28, 79]. In addition, the need to belong has been shown to be an essential motivator for game engagement and continued play [55]. However, not all multiplayer games exhibit these benefits, and people may choose to play alone even in massive multiplayer online games [22]. Therefore, further research is needed to help determine whether fulfilling the need to belong in multiplayer games is a primary factor important to adherence and, if so, how multiplayer games can successfully fulfill this need.

Social Interaction in Exercise & Exergames

Participating with others can increase adherence in exercise and exergames [24]. Evidence suggests that people are more likely to sustain physical activity if they participate in social, or group-based, activities rather than exercising on their own [5, 11, 20, 24, 82]. Numerous authors have advocated including social play in exergames to foster interaction and increase motivation [9, 41, 49, 50].

To date, though, there has been little research examining the role of social play on exergame adherence. In a six-week exergame study involving children with cerebral palsy, Knights et al. found that adherence held steady over the full duration, which was largely attributed to social interaction in the game [36]. In a more direct study of the role of social play on exergame adherence, Chin A Paw et al. performed a study comparing 27 children randomly assigned to a single-player or multiplayer group [13]. Participants in the single-player group played a dance game at home. Participants in the multiplayer group played the same dance game at home but also participated in a weekly multiplayer class. They found no statistically significant difference in adherence between the two groups, but over a 12-week period, the multiplayer group played over twice as many minutes as the single-player group, 901 min versus 376 min. Moreover, dropout rate was significantly lower in the multiplayer group (15%) compared to the single-player group (64%).

Beyond the Chin A Paw study, there is promising initial research that aims to aid in increasing exergaming adherence in social games by pairing players together according to their personality type [12]. For instance, in their pilot study, authors report that extroverts and explorers (players who desire to discover the unknown in games) enjoyed their game experience together. This highlights a particular group who may benefit most with social activities; specifically, there is evidence to suggest extroverts generally prefer group exercise over exercising alone [14]. Our study aims to add to the small body of research in this area by examining the association of social play with exergame adherence.

3 SOCIAL PLAY IN THE LIBERI EXERGAME

Liberi is a validated exergame originally designed for children with cerebral palsy developed using a participatory and iterative design approach [30, 31, 36, 80]. Liberi is not limited to this population; it has been used in this study and prior studies involving participants without disabilities [34, 35]. Liberi is a networked, cycling-based exergame that provides an opportunity for social play. Mini-games can be played together, and players can communicate using headsets.

Equipment

Liberi is played using a Windows tablet attached to a recumbent bike (see Figure 1). A cadence sensor is attached to the recumbent bike to detect pedaling movement which sends data to *Liberi* to make an in-game avatar move. Players use a

Figure 1: Equipment used to play the *Liberi* exergame.

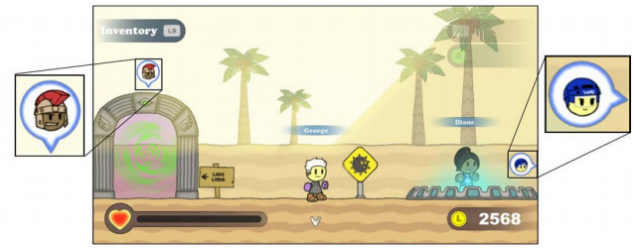

Figure 2: A player stands on the launch pad to *Dozo Quest*. Players' stickers are enlarged and displayed on each side.

wireless gamepad to control the direction of characters and perform in-game actions. Headsets are worn during play to hear in-game audio and talk to other players. A heart-rate monitor is worn during play, and games grant powerups for reaching and maintaining a target heart rate [35].

Designing Liberi for Social Play

Liberi has features that enable multiple players to play the game simultaneously and was designed using principles that foster social interaction [30]. *Liberi* was developed to support frictionless group formation, balancing for player ability, and a variety of play styles.

Frictionless Group Formation. Liberi makes it easy for participants to join others in the game. Players can join and leave games at any time, thus allowing for automatic forming of groups. *Liberi* also features voice chat so players can talk with one another. And, as shown in Figure 2, Liberi has onscreen avatar "stickers" that help players locate each other in the game world.

Balancing for Player Ability. Liberi is played on a recumbent bike, and pedaling the bike makes an onscreen avatar move. The version of *Liberi* used balanced for players of different fitness levels by having all avatars move at the same speed, no matter how fast the bike was pedaled [32]. In addition, *Liberi* often provides group goals instead of individual goals. This enables players with lower skill levels to feel a sense of accomplishment while preventing players with higher skill levels from becoming frustrated. In *Bobo Ranch*, for instance, players are rewarded for working as a team to herd sheep into a barn.

Supporting a Variety of Play Styles. Liberi is designed to attract players who like different types of games by supporting a variety of play styles. *Liberi* contains six different mini-games, each with a different style of play and different goals. The games are detailed next.

Social Play in the Liberi Mini-Games

Liberi contains a central plaza, in which players can shop for costumes for avatars and weapon upgrades and socialize. The plaza also provides access to the six mini-games.

In *Bobo Ranch* (Figure 3A), players lasso floating sheep (Bobos) with the goal of pulling sheep into a barn. *Bobo Ranch* is a cooperative game.

In *Dozo Quest* (Figure 3B), the goal is to traverse a maze and defeat or avoid opponents along the way, ultimately facing a boss at the end of the maze. *Dozo Quest* encourages cooperative play. As new players join, they are placed at key checkpoints in the game to quickly catch up to the other players and defeat obstacles and enemies together.

Players compete against each other or against artificial intelligence opponents in the *Gekku Race* racing game (Figure 3C). *Gekku Race* is a competitive game; players can shoot cashews and breathe fire to slow down their opponents.

In *Wiskin Defense* (Figure 3D), players attempt to defend rabbit-like creatures (Wiskins) while defeating wave after wave of increasingly tougher enemies. Besides fighting enemies together, cooperative play is encouraged: when players are overwhelmed, they can ask for help.

Biri Brawl pits players against each other or against artificial intelligence opponents in a fast-paced fighting game, and *Pogi Pong* is a space hockey game, in which players attempt to knock a star past the opponent's goal.

4 STUDY DESIGN

Our data was collected in a study that compared exergaming adherence behaviours of children playing a multiplayer suite of six mini-games, *Liberi*, to play of single-player versions

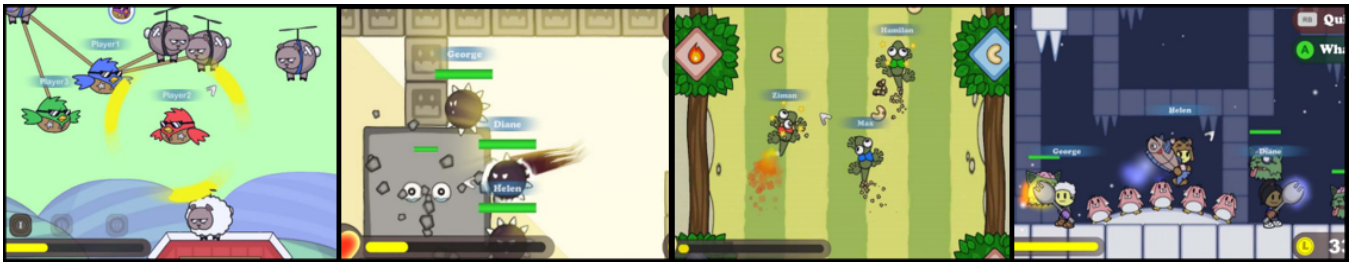

Figure 3: A-D (Left to Right). A. *Bobo Ranch*. B. *Dozo Quest*. C. *Gekku Race*. D. *Wiskin Defense*.

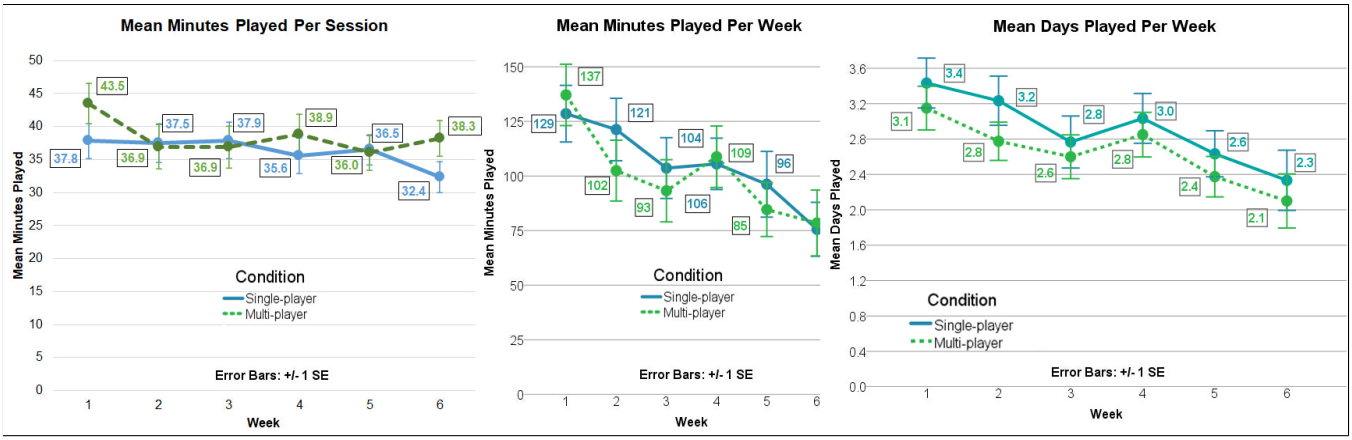

Figure 4: A-C (Left to Right). Weekly mean: A. Play session duration. B. Play duration. C. Play frequency.

of the same games. This paper extends these earlier results through an exploratory analysis of what factors predict who benefits from social play.

In the study, 70 children between 9 and 12 years old, who were not meeting physical activity guidelines at baseline [72], played exergames on recumbent bikes for 6 weeks in a home environment; 40 participants played in a multiplayer condition and 30 in a single-player condition. Exergaming sessions were available 5 days per week for 90 min in the early evening with online supervision. Players were channelled to fixed blocks of time to increase the chance of finding other people to play within the multiplayer condition. Participants were free to attend as few or as many sessions as they wished.

Experimental Conditions

The experiment consisted of a multiplayer and single-player condition. In the multiplayer condition, participants could play games with each other and artificial intelligence opponents. Players in the multiplayer condition were connected by a network from home, could see other player's avatars in the game, and could speak to one another using headsets. Single-player participants could play only with artificial opponents.

Primary Outcome Measures

The study had three primary outcome measures: play session duration, play duration, and play frequency. Outcomes were objectively measured through gameplay logs that recorded activity for every second *Liberi* was loaded. Consistent with prior research, it was hypothesized that play session duration and weekly play duration would wane significantly over time [13, 16, 26]. It was also hypothesized that multiplayer participants would play longer and more frequently.

Statistical Analyses

Analyses were performed using SPSS version 24.0 [33]. All statistical tests were two-tailed and maintained a 5% confidence level. Welch's unequal variances t-test was performed on mean play session duration. Repeated measures ANOVAs using a six-level within-subjects factor of week and a between-subjects factor of condition were performed on play duration and play frequency.

5 PRIOR RESULTS

There was no significant difference between conditions in any of the primary outcome measures. Weekly mean play session duration is shown in Figure 4A. Overall mean play session duration was 37.6 (SD=15.4) min/day. Mean play session duration was M=41.0 (SD=15.5) min/day in Week 1 and M=35.6 (SD=13.6) min/day in Week 6. The decrease was significant across time; $t(135)=2.20$, $p=.03$, $\eta_p^2=.03$. Weekly mean play duration is shown in Figure 4B. Overall mean play duration was 103 (SD=68.6) min/week. Mean play duration was 133 (SD=81.3) min in Week 1. In Week 6, mean play duration was 77.2 (SD=84.1) min. Mean weekly play duration declined significantly across time [$F(4.52, 307)=9.61$, $p<.01$, η_p^2]=.12. Weekly mean play frequency is shown in Figure 4C. Overall mean play frequency was 2.77 (SD=1.21) day/week. Mean play frequency was 3.27 days in Week 1 and 2.20 days in Week 6. Mean weekly play frequency declined significantly across time [$F(4.52, 312)=7.83$, $p<.01$, $\eta_p^2=.10$].

Overall, *Liberi* was successful in encouraging physical activity. Even in the sixth week of the study, participants performed, on average, 77 minutes of new activity. This is significantly better than what has been seen in earlier exergaming interventions [13, 16, 39, 40].

However, there were no significant differences between the multiplayer and single-player conditions in play session

duration, play duration, and play frequency. This might lead one to believe that developers should forgo the complexity of multiplayer exergames and simply design single-player games.

6 NEW FINDING: GROUP & SOLO PLAYERS

Deeper analysis of the data reveals a subtler story. Among participants in the multiplayer condition, there appear to be two types: those that primarily engage in group play (*Group Players*), and those that primarily engage in solo play (*Solo Players*). We defined Group Players as participants who, for a majority of weeks, chose to play games with others for longer durations than they chose to play alone. Conversely, Solo Players were participants who chose to play alone for longer durations than they chose to play with others. In characterizing Group Players and Solo Players, we looked at data only when at least two people were logged into Liberi, that is, where there was an opportunity to play with another participant. We removed participants who played an equal number of weeks in both settings (5 participants) from further analyses.

Surprisingly, multiplayer participants were split evenly between these two player types; in total, there were 35 participants for analysis, 17 Group Players and 18 Solo Players.

We found that Group Players benefit from the group play in terms of increased adherence, while Solo Players do not. As we shall see, this divergence of player types may be enough to explain why no difference was seen between the single and multiplayer conditions. In the remainder of the paper, we analyze the properties of these two groups, which will lead us to the following observations around participants in multiplayer exergames:

(1) In a multiplayer exergame, people who primarily engage in group play have significantly higher adherence than people who primarily play alone.
(2) The key differentiator between these two groups is a sense of program belonging.
(3) For people who primarily engage in solo play, the effect of not participating in group play in a multiplayer exergame may lead to worse adherence than simply engaging in a single-player version of the game. That is, Group Players' adherence is better than adherence seen in single player games, while Solo Players' adherence is worse. The poor adherence of Solo Players can undo the positive effects of multiplayer gaming.
(4) A critical aspect of designing multiplayer exergames is, thus, enhancing a sense of program belonging for all players.

Table 1: Comparison of Solo Player and Group Player adherence behaviours. Holm-corrected p-values and effect sizes are reported.

Mean (SD)	Solo Player	Group Player	*df*	*t*	*p*	*d*
Min	388 (199)	822 (491)	20.9	3.40	.01	.89
Min / Week	64.5 (33.2)	137 (81.8)	20.9	3.40	.01	.89
Days	12.9 (5.64)	18.3 (7.24)	33.0	2.45	.02	.82
Days / Week	2.16 (.940)	3.05 (1.21)	33.0	2.45	.02	.82
Min / Day	29.3 (8.05)	42.1 (15.1)	24.1	3.12	.01	1.06

Why Social Play May Augment Adherence

Before determining who benefits from social play and why, it is beneficial to address why social play is thought to augment adherence. Social interaction is theorized to be a core human need. Self-determination theory (SDT) and the belongingness hypothesis posit that people have a universal need to connect to others [4, 37, 64]. Social interaction has also played a large role in the success of exergames [13, 30, 36] and games in general [70, 74, 81]. Finally, social interaction in exergames has also been thought to enhance motivation to play [9, 41, 49, 50]. Still, players may actively choose to play alone even when playing a multiplayer game [22]. This is a potential explanation for why social play did not augment adherence; social play might only positively influence adherence in some participants.

7 GROUP PLAYERS HAVE HIGH ADHERENCE

Since Group Players engaged in more social play, and since social play is expected to influence a person's decision to adhere to an activity, social play might be expected to elicit high adherence in Group Players. To determine whether this was the case, we analyzed the results of independent-samples t-tests on three primary outcomes: play duration, play session duration, and play frequency. We hypothesized that Group Players would play longer overall, participate in longer sessions, and participate in more sessions than Solo Players. Holm-corrected p-values and effect sizes for comparisons between Solo Players and Group Players are reported in Table 1.

8 GROUP PLAYERS HAVE HIGH BELONGING

Our first key takeaway is that some people appear to benefit from social play; namely, Group Players had significantly

Table 2: Comparison of *Gekku Race* win rate.

Gekku Race Win Rate	Mean Solo Player (*SD*)	Mean Group Player (*SD*)	*p*
Week 1 (%)	31.1 (19.5)	32.2 (10.7)	.86
Week 2 (%)	36.8 (32.8)	38.5 (25.5)	.88
Week 3 (%)	46.3 (17.7)	30.9 (20.4)	.07
Week 4 (%)	52.6 (23.7)	40.1 (23.1)	.21
Week 5 (%)	20.4 (23.0)	44.7 (34.5)	.14
Week 6 (%)	68.3 (55.0)	31.4 (30.2)	.15
Overall (%)	43.1 (18.3)	34.3 (13.5)	.12

higher adherence than Solo Players. To better inform future multiplayer exergame design, though, it is important to determine whether Group Players indeed benefitted from social play, or whether other factors predicted adherence.

Demographics

First, we wished to ensure that Group Players were actively choosing to play with others more than Solo Players did and not simply encountering more people to play with. We performed an independent-samples t-test comparing the mean number of people Group Players and Solo Players encountered during the study when there was an opportunity to play with others. Results revealed no significant difference between the mean number of players Group Players encountered (M=3.09, SD=.293) and the mean number of players Solo Players encountered (M=2.84, SD=.560) during the study; $t(26.0)$=1.66, p=.11. This lends evidence to the hypothesis that Group Players did not engage in more group play than Solo Players simply due to encountering more players during the study; this indicates that Group Players were, thus, actively choosing to play more with others.

Next, we determined whether there were demographic differences between Group Players and Solo Players that might account for the differences seen in playtime. Specifically, a participant's gender or age might have played a role in whether they were a Group Player. Results of a Pearson Chi-Square test on gender and an independent-samples t-test on age found no significant differences in gender (p=.88) or age (p=.32) between Group Players and Solo Players. The mean age for Group Players was 10.5 (SD=1.28) yr, and the mean age for Solo Players was 10.2 (SD=.786) yr. Nine males and eight females were Group Players. Ten males and eight females were Solo Players.

Then, we performed independent-samples t-tests on four primary measures to determine the contrasts between Group Players and Solo Players that may predict why Group Players had higher adherence: game win rate, differences in the games played, total physical activity, and program belonging.

Game Win Rate

Group Players could have performed better in games, leading them to want to play more. We compared the win rate in *Gekku Race* using independent-samples t-tests, as summarized in Table 2. The win rate is broken up in weeks, and the final row shows the overall proportion of wins. Results of the t-tests showed no significant differences between Group Players and Solo Players in win rate in *Gekku Race* on any of the weeks. Thus, we did not find evidence that game win rate was a predictor of greater adherence in Group Players.

Games Played

Differences in adherence could also stem from participants' playing different games. There were six mini-games available to play. If some were more engaging, this might have predicted adherence. We performed independent-samples t-tests on the proportion of time spent playing each of the six mini-games. Results of the t-tests showed no significant differences in the proportion of time spent playing any of the games between Group Players and Solo Players.

Total Physical Activity

Activity level prior to the start of the study was a potential predictor of adherence because the people who were engaging in social play might have already been active in general. Previous physical activity is generally a predictor of continued activity during an intervention [3]. Total physical activity was measured at baseline and at six weeks using the Physical Activity Questionnaire for Children (PAQ-C), a validated, self-report physical activity measure [15, 63]. Results of independent-samples t-tests on total physical activity, however, showed that the PAQ-C did not differ significantly between groups at baseline (p=.98) or at six weeks (p=.74).

Program Belonging

Fostering a sense of program belonging was also a potential predictor of adherence. Relatedness, or the need to belong, is a primary component of Self-Determination Theory (SDT) [37]. Similarly, the belongingness hypothesis proposed by Baumeister and Leary suggests that human beings have an almost universal need to form and maintain relationships with others [4]. This hypothesis might explain adherence differences between Group Players and Solo Players. If Solo Players were not fulfilling this innate need by readily forming groups, their adherence would potentially be lower than Group Players.

To assess belonging, participants were asked questions measured on a four-point Likert scale ("NO!", "no", "yes", and "YES!") [1]. These questions stemmed from a measure of belonging designed for use in youth development programs [1]. The questions were modified to be positively worded, as

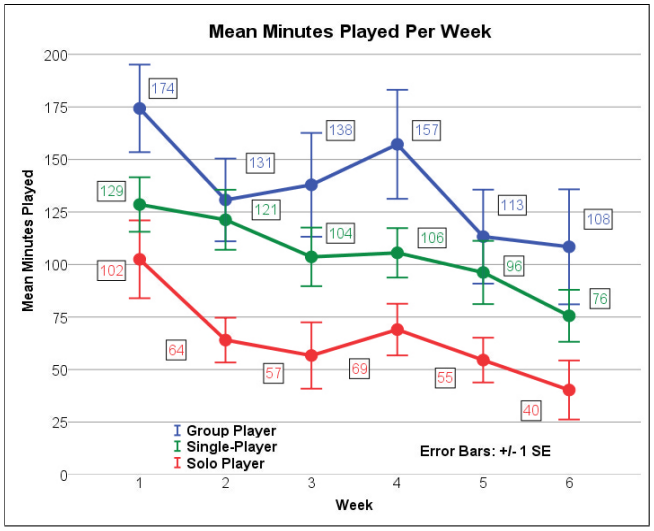

Figure 5: Weekly mean minutes played.

negative wording can introduce extraneous variance in analysis [1, 42, 47, 71]. The following were asked:

(1) …I feel comfortable with the other players.
(2) …I feel like I am part of the community.
(3) …I am committed to the other players.
(4) …I am supported by the other players.
(5) …I am accepted by the other players.

Program belonging was measured three times during each six-week wave of the study, once after two weeks (T0), four weeks (T1), and six weeks (T2). A reliability analysis was carried out on the program belonging subscale comprising five items (the five questions we asked). Cronbach's alpha was α = .81 for T0, α = .88 for T1, and α = .93 for T2, which showed acceptable reliability for each time period.

The most important of these three measurements is the two-week measure because at this point, enough time had passed for social groups to form, and not so much time had passed that players had dropped out. After two weeks, program belonging differed significantly between Group Players and Solo Players. Group Players had a mean program belonging of 3.31 (*SD*=.44), and Solo Players had a mean of 2.70 (*SD*=.90); $t(33.0)=2.51$, $p=.02$, $d=.86$. Therefore, program belonging was a factor in predicting greater adherence in Group Players. Belongingness appears to be especially important to foster early in a study, as Group Players had significantly higher program belonging compared to Solo Players after two weeks. It is possible that if the need to belong is not fulfilled, participants may reduce or even stop play.

9 NEGATING BENEFITS OF SOCIAL PLAY

Our third key takeaway is that for Solo Players, the effect of not participating in group play in a multiplayer exergame may lead to worse adherence than simply engaging in a single-player version of the game. Furthermore, this can negate the positive effects of multiplayer gaming. We observed this when comparing Group Player, Solo Player, and single-player adherence behaviours. Note, however, that as an exploratory study, the analysis between these conditions is purely observational, and we cannot draw definitive conclusions from these results alone. Thus, this comparison might be best used to generate hypotheses for future studies.

Table 3: Comparison of Solo Player, Single-Player and Group Player adherence behaviours. Holm-corrected p-values and effect sizes are reported for Single-Players compared to Solo Players. Comparisons between Group Players and Single-Players showed no statistically significant differences.

Mean (*SD*)	Solo Player (*SD*)	Single-Player (*SD*)	Group Player (*SD*)	*p*	*d*
Min	388 (199)	631 (375)	822 (491)	.03	1.22
Min / Week	64.5 (33.2)	105 (62.4)	137 (81.8)	.03	1.22
Days	12.9 (5.64)	17.4 (7.58)	18.3 (7.24)	.03	.67
Days / Week	2.16 (.940)	2.91 (1.26)	3.05 (1.21)	.03	.67
Min / Day	29.3 (8.05)	35.7 (8.22)	42.1 (15.1)	.04	.78

According to theories of human motivation and the success of multiplayer games in general, multiplayer engagement was expected to augment adherence. However, we began this examination into who might benefit from social play because no differences were found in adherence between the multiplayer and single-player conditions of the study. This suggests that in a multiplayer exergame, being a Group Player might enhance adherence while being a Solo Player might diminish it. It was worthwhile, then, to compare Group Player and Solo Player adherence to the single-player group in the study. We performed independent-samples t-tests to determine whether there were significant differences between conditions. The differences in play duration across time between Group Players, Solo Players, and single-player participants are shown in Figure 5. The differences in adherence between Group Players and single-player participants were not statistically significant. However, the differences in adherence were significant between Solo Players and single-player participants; Holm-corrected p-values and effect sizes for comparisons between Solo Players and single-player participants are reported in Table 3.

There were no significant differences found in adherence behaviours between the multiplayer and single-player conditions. However, we did find significant adherence differences between Group Players and Solo Players. Group Players had significantly higher adherence than Solo Players. Thus, in the multiplayer condition, some people responded positively, and others did not. This potentially negated any between-group effects of the multiplayer versus single-player condition.

One explanation for the lack of a between-group effect is a possible flattening effect in the single-player condition: i.e., people who would naturally be Solo Players have higher adherence than in the multiplayer condition, and people who would naturally be Group Players have lower adherence in the single-player condition. While we do not have enough data to draw definitive conclusions, analysis of adherence differences between the multiplayer and single-player conditions supports that this flattening was taking place. The single-player condition had lower standard deviations than the multiplayer condition across multiple measures—*SD*=13.5 versus *SD*=16.7 minutes played per day, *SD*=58.8 versus *SD*=78.4 minutes played overall, and *SD*=1.04 versus *SD*=1.39 days played during the study.

It should be noted that playing alone in the multiplayer condition is different from playing alone in the single-player condition. In the multiplayer condition, you can see and hear the other players in the game. If someone has a low sense of program belonging, this could be exacerbated by observing and hearing others engaging in social play.

This is also in alignment with attribution theory [25, 29]. Group Players, knowing they are in a multiplayer condition, might have liked being in this condition and attributed their fulfillment of program belonging to the intervention. Solo Players might have disliked being in a social setting and attributed their discontent to the intervention.

Such a flattening effect could explain why Solo Players might have higher adherence in the single-player condition than in the multiplayer condition. Conversely, players in the single-player condition who were naturally Group Players would fail to get the motivation from playing in a group, potentially leading to lower adherence.

10 IMPLICATIONS FOR DESIGN

Analysis of the multiplayer condition of the study showed that there was an evenly split dichotomy of players. Group Players engaged primarily in social play, while Solo Players engaged primarily in solo play. Group Players played for significantly longer durations and participated in more and significantly longer sessions than Solo Players. Group Players did not have significantly higher adherence than single-player participants. Solo Players played for significantly shorter durations and participated in fewer and shorter sessions than both Group Players and single-player participants.

The only significant difference found between Solo Players and Group Players was in program belonging. This fits with the belongingness hypothesis and relatedness in SDT, which propose that humans generally need to form social bonds [4]. If Solo Players were not fulfilling this innate need by readily forming groups, it could be the reason they dropped out. One potential explanation for this is attribution bias [25, 29]. Since Solo Players knew they were in a social setting, they could have attributed their lack of belonging to *Liberi*.

Results from our analyses demonstrate the final takeaway of this paper, that it is crucial in the design of multiplayer exergames to focus on enhancing a sense of program belonging for all players. This leads straightforwardly to implications for design: one should foster a sense of program belonging.

Foster a Sense of Program Belonging

Social play in *Liberi* worked well only for some participants. The people who engaged in social play the most, Group Players, had significantly higher play durations, play session durations, and play frequency than Solo Players. Future study is warranted to determine whether being a Group Player or Solo Player is an individual difference variable, such as a personality difference, or a learnable behaviour that can be fostered through an intervention. We do not know, for instance, whether a lack of belonging influenced people to become Solo Players, or whether people were naturally Solo Players to begin with, which, in turn, caused them to become to not easily form bonds.

Of all of the demographic and behavioural measures considered, the two player types differed significantly only in program belonging. This suggests that fostering a sense of belonging is important in exergaming studies. If being a Group Player or Solo Player is an individual difference, it might be more difficult to foster belonging in Solo Players and conversely, easier in Group Players. For instance, shyness can play a role in the difficulty of forming social bonds due to a fear of rejection [4]. But, evidence suggests that people who are shy still have a desire to form social bonds [4]. Thus, it is still important to foster a sense of belonging in exergames, but future studies should consider that it might be difficult for some people to form groups.

Liberi uses group goals to foster belonging [30]. In *Bobo Ranch*, for instance, players receive bonus rewards for rescuing sheep together. Indeed, this is a practice seen in games in general. Some multiplayer games feature guilds, groups of players who join together to accomplish a common goal [78]. It is typical for these games to hold guild events, which foster group engagement through in-guild cooperation and competition with other guilds. Providing group play in this way has been shown to enhance and support social relationships among players [54].

It should be noted, though, that even if a multiplayer game supports guilds, people may choose not to join them, may have difficulty finding a guild that fits them, or may choose to play alone even in massively multiplayer online games [22]. Also, in general, guilds are only practical to implement in games that have at least hundreds of concurrent players. But, group goals are still possible, as exhibited by *Liberi*.

Program belonging can also be fostered outside an exergame during an intervention [48]. For example, social interaction has been promoted to some success by using social media, such as Facebook or forums, so that participants in a study can communicate with one another outside the game [34, 51]. Thus, to foster a sense of program belonging, future studies might benefit from employing group goals in exergames and outside the game during interventions. Guilds may also be cautiously used to foster a sense of belonging.

11 LIMITATIONS

Limitations of this study include the use of post-hoc analysis and the lack of a personality assessment; the study design limits generalization beyond the age groups tested and the games studied.

Post-Hoc Analysis: This was an exploratory study based on post-hoc analysis of data gathered in an earlier study. The earlier study found no significant difference in adherence between single-player and multiplayer conditions despite significant literature and intuition suggesting social play would augment adherence [9, 41, 49, 50].

The obvious and burning question is, thus, *why* no effect was seen in the single-player versus multiplayer condition. This was followed up by using theories of belongingness to explore why the multiplayer condition did not augment adherence as expected [4, 18, 23, 44]. Thus, while the analysis does not provide the same quality of evidence as a test of the initial hypothesis, the hypotheses tested follow intuitively from the earlier study's null result.

Personality Assessment: As noted in Implications for Design, future study is warranted to determine whether being a Group Player or Solo Player is an individual difference variable or a learnable behaviour that can be fostered. In this study, participant personalities were not analyzed, and doing so in future studies could help answer this question.

Generalization: Limitations preventing generalization include the age group and the set of games tested. Specifically, the results of this study have been obtained with children ages 9 to 12. Thus, generalizing beyond this age group is not possible. Regarding the games studied, each has properties designed to promote social play, such as easy group formation. As such, these games have properties that would seem to be desirable in general for study of social play. However, since these were the only games tested, the results cannot be generalized beyond this set of games.

12 CONCLUSION

Physical activity [60, 73] and exergame interventions [2, 59] generally see high initial enthusiasm, but adherence significantly declines over time. Social play is thought to have a positive influence on exergame adherence, but little research has been conducted to compare multiplayer to single-player exergame adherence [13]. To add to this area of research, we conducted an exploratory analysis of the data from a six-week study comparing a multiplayer suite of exergames to the same games in a single-player condition. The original study found no statistically significant differences between conditions, but adherence was high relative to past studies for both conditions [13, 16, 39, 40]. Exploratory research was warranted to determine who might benefit from social play (and why) to better inform future multiplayer exergame interventions and help shed light on why social play did not augment adherence.

Further examination of the multiplayer condition led to four key takeaways. First, we found that two player types predict overall adherence. Group Players primarily engaged in group play, while Solo Players primarily engaged in solo play. Group Players had greater adherence than Solo Players: they played longer overall, played more often, and played longer per session than Solo Players.

Second, in nearly all the factors we tested, including age, gender, total physical activity, and win rate in the games, there were no significant differences between Group Players and Solo Players. However, after two weeks of play, Group Players rated program belonging significantly greater than Solo Players. Of numerous measures considered, Group Players and Solo Players differed only in program belonging.

Third, there was evidence to suggest that one possible reason why social play did not augment adherence is a flattening effect in the single-player condition, in which people who would naturally be Solo Players have higher adherence than in the multiplayer condition, and people who would naturally be Group Players have lower adherence in the single-player condition. Thus, Group Players might have lower adherence in a single-player condition, and Solo Players might have higher adherence.

Finally, our work underscores the importance of program belonging in exergaming adherence behaviours. Solo Players experienced a significantly lower sense of program belonging than Group Players, and had significantly lower adherence than Group Players or players in the single-player condition. Thus being a Solo Player was a predictor of generally lower adherence. It is important, then, for exergaming systems to focus on fostering a sense of program belonging for all players.

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