Towards Extending Social Exergame Engagement with Agents

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CSCW'18 Companion, Nov. 2–7, 2018, Jersey City, NJ, USA.

ACM ISBN 978-1-4503-6018-0/18/11.
https://doi.org/10.1145/3272973.3274094

Abstract
Social interactions motivate engagement with physical activities. This paper extends existing work on software generated partners for exercising from single-user settings to a multi-player social exergame. Initial results suggest that our Wizard of Oz agents in our game *StepQuest* may prolong player engagement with the game, increase their participation in moderate physical activities, and are preferable to idle human players.

Author Keywords
Game for Health;Exergame;Social Interaction;Agent

Introduction and Background
Approximately two thirds of the U.S. adult population is affected by overweight and obesity. Social exergames use players' social interactions and gameplay to increase players' motivation for physical activities (PA) and potentially lead to a more active lifestyle [1, 7].

However, how to sustain players' engagement with social exergames for an extended period of time is an open problem. Most existing empirical findings on social exergames are from short-term studies, typically 2-3 weeks [2]. A promising direction is to use computer agents to provide extra support and guidance. Although a widely used approach in multi-player games for entertainment

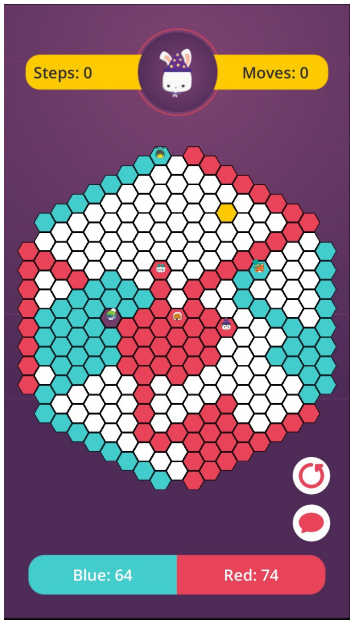

Figure 1: Screenshot of *StepQuest*

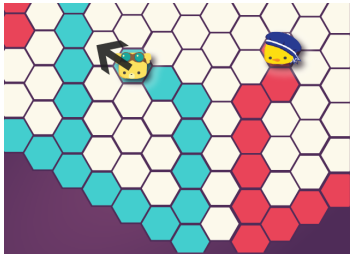

Figure 2: Area Capture through Enclosing an area

(e.g., non-player characters), the use of agents in social exergames and multi-player serious games in general is limited.

Our prior work [2], extending the typical 2-3 week studies in literature to 6 weeks, showed significantly decreased player engagement and PA performance after 3-4 weeks. To further explore how to sustain player engagement, this paper reports our new agent-based approach and our preliminary results.

Research in software generated partners [5, 6, 8] has shown positive impact when the user exercises with a computer agent as partners. Specifically, existing work indicates that a superior agent (one that performs better than its human counterpart) can improve exercise motivation in exergames [5, 8]. Our on-going work extends this insight from single-user settings to a multi-player game called *StepQuest* (4 human players plus 2 agents). In addition, we expand the original work's setting from single lab sessions to extended play (6 weeks) in the wild. Our initial 6-week user study (n=10) uses a Wizard of Oz protocol to test agent behavior. Our preliminary results indicate that agents may prolong player engagement, increase participation in moderate PA, and are preferable to idle human players.

StepQuest and Agent Design

StepQuest is a multi-player, social exergame for mobile devices where two teams of three players compete to capture spaces on a board (Figure 1). The team with more captured spaces at the end of two weeks wins the game. Players earn in-game moves based on their steps tracked via Fitbit.

Designed for extended play, *StepQuest* supports asynchronous play (to accommodate players' different schedules), increase the gameplay complexity and replayability, and create a sense of temporal progression. Details of our design is in our prior work [2]. *StepQuest* supports two main types of social interaction: competition between teams and collaboration within teams. Competition takes place as the two teams race to capture more space. Its main collaborative mechanic is *area capture*. Players of a team can create an encirclement, enclosing an area and capturing all spaces within (Fig. 2). Any enemy players inside the encircled area will be sent to the starting position. With this design, the game rewards the team that collaborates more effectively toward larger area captures to win the game.

In our new agent design, we replace two of the six players (one from each team) with agents controlled by an algorithm. Existing research on software generated partners suggests that superior computer agents can increase users' PA performance [5, 8]. We extended this insight from single-user settings to a multi-player social exergame and from lab settings to a extended period of gameplay in the wild. Each agent is given 1.2 times the average daily steps of its two human teammates from the previous day, adjusted by a random factor between 0.8 and 1.2 to increase variability. Using actions allowed based on its daily steps, the agent will act in the following order: 1) comply if a teammate requests an action; 2) notify a teammate who is at risk of being captured; 3) complete or facilitate an area capture if it is closest player to make that capture. Note that this protocol focuses primarily on facilitating human players instead of initiating new gameplay strategies.

Preliminary User Study

To explore the potential of using agents in social exergames, we conducted a new 6-week user study. We designed a two-group, between-subject experiment with 10 college students (2 males, 7 female, 1 non-binary, average age 19.4) recruited from a university in a large U.S. city. We randomly assigned 4 participants, controlled for gender

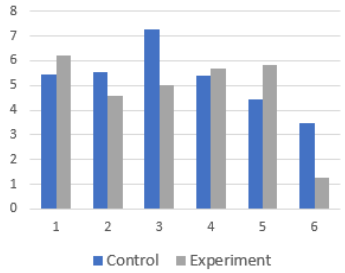

Figure 3: Average daily participant steps by week as reported by Fitbit trackers between control and experimental conditions (x-axis: study week, y-axis: step counts in thousands)

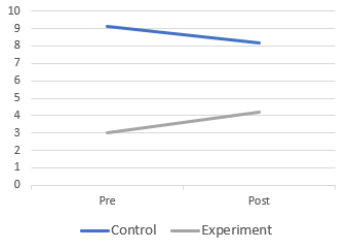

Figure 4: Change in average participant moderate activity as reported in pre- and post-test IPAQ surveys between control and experimental conditions (x-axis: pre or post test survey, y-axis: MET-Min/Wk in hundreds)

and self-reported activity level, to the experimental condition where they played *StepQuest* with two agents controlled by researchers using the Wizard of Oz method[4]. The researchers strictly followed the protocol described above. 6 participants were assigned to the control condition where they played *StepQuest* without agents. Each condition played three 2-week-long games. We did not reveal the use of agents until the end of the study in a focus group with all participants. We collected PA data through pre-test and post-test International Physical Activity Questionnaire (IPAQ) [3] surveys immediately before and after the study as well as step data tracked via Fibit.

Results

Though weekly Fitbit step counts for both groups ultimately decreased by the end of the study, we found the decline started earlier for the control group (week 4, consistent with our prior work [2]), whereas the experimental group showed a gradual increase in step counts until week 6 (Figure 3). A possible explanation is that the WoZ agents' superior performance motivated players to remain engaged with the game and sustained their PA. Given the sample size, statistical significance was not tested. Pre-test IPAQ surveys assessing participant PA levels showed a mean of 3,297 MET-Min/Wk in the control condition, considered to be a "High" level of PA by the IPAQ [3]. The experimental condition presented a mean of 2,955 MET-Min/Wk, considered a "Moderate" level [3], and there was a 48% larger variance among the experimental group. This suggests that, based on this single self-report measure, participants in the control group may be more active.

The IPAQ classifies three levels of activities, from mild to strenuous: "walking," "moderate," and "vigorous." Through comparison of pre- and post-test IPAQ surveys, both groups showed an increase of overall IPAQ activity. However, the control group has a greater average increase (2,264 MET-Min/Wk) than the experimental group (82 MET-Min/Wk). Among the 3 sub-categories, the largest contributor to the increase in control participant overall PA was due to an increase of 3,128 MET-Min/Wk in walking. In terms of moderate activities, we observed an increase of 120 MET-Min/Wk per experimental participant verses a decrease of -96 MET-Min/Wk per control participant (Figure 4).

Discussion

Overall, our preliminary results suggest that our WoZ agents may potentially help to prolong player engagement and increase their participation in moderate PA. The drop in steps in the last week for both groups may be related to its coincidence with the university's final exams week. In the exit focus group, one participant reported, *"...I would say the last week I struggled the most just because I found that my school schedule was a lot busier with finals and I found myself interacting a lot less with [the game]."*

Players in both groups were motivated by teammates' superior and/or consistent performance. A participant in the control group stated, *"I found that my team was doing really well and they had a lot of steps so I would try to keep up with that sometimes, and that kind of motivated me."* Another participant in the experimental group mentioned, *"It definitely felt good to see everyone moving and taking part."*

Participants in the experimental group responded positively to the agents. No participants figured out that they were playing with agent teammates, indicating that our WoZ protocol was sufficiently human-like. When we revealed the experiment, one player commented, *"I think [the agent] helped, I was under the impression that it was just a teammate... But I think it definitely was beneficial."* However, we do not know if our participants would behave the same way if they were informed about the game's use of agents.

In contrast, idle human players in the control group had a negative impact. Participants from the losing team expressed that they would not feel as demotivated if they were paired with an agent to compensate for idle players. Players stated, *"We probably would've covered more space [if we had an agent teammate instead of an idle human player]," and "I wouldn't feel as hopeless about catching up."*

Conclusion and Future Work

We presented our approach to extending player engagement to social exergames using agents. Extending existing software generated partner literature, we developed a Wizard of OZ protocol for superior agents to motivate and engage human players in *StepQuest*. The results of this 6-week study suggest that agents may potentially increase player engagement with the game and are preferable to idle human players. Despite the limitation of the sample size, our initial results show that an agent-based approach is a promising direction worthy of further investigation. For future work, we plan to implement agent behavior and evaluate its effect with a larger sample.

Acknowledgement

This work is partially supported by the National Science Foundation under Grant Number IIS-1816470.

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