Augmenting Traditional Playground Games to Enhance Game Experience

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***Abstract*—Technology can provide engaging game experiences. However, it can also decrease the exhibition of essential play behavior such as social interaction and physical activity. In this paper, we discuss how the Interactive Tag Playground (ITP) can enhance the traditional tag game experience by making it more enjoyable and immersive without sacrificing social and physically active behavior. Additionally, we also show it can double as a research tool to analyze player behavior using data obtained in-game. These conclusions are derived from a user study and behavior analysis of participants playing traditional and interactive tag game sessions. The findings lead us to believe that the ITP can provide an engaging tag experience while facilitating the analysis of player behavior and promoting key aspects of play.**

Keywords—Interactive playgrounds, Interactive tag, Ambient entertainment.

I. Introduction

Play is regarded as an essential activity not only because of its entertaining value, but because of the social, physical and cognitive benefits that it provides [1]. Traditional playground games have existed for decades, providing children with a space where they could refine their motor skills while creating and maintaining positive social bonds with their peers [2], [3]. On the other hand, digital games, which have become the mainstream method of playing for children, have introduced several important issues with their adoption. There is an alarming trend of children playing "together and apart", playing games with others but not interacting with them [4]. This is especially true for most video games. In addition, studies have shown increasing sedentary behavior of children in western cultures, which is associated to digital games [5]. This shift of play from traditional playgrounds towards living rooms can prevent children from developing the necessary social skills needed later in life, and can be a potential precursor for future health issues.

The last decade has seen an increase of games that employ interactive technology to address the issues introduced by digital gaming, for example by promoting physical activity [6], encouraging social interactions [7] or by steering behavior in positive directions [8]. The way technology is used varies greatly, ranging from interactive toys [9] to full-blown interactive installations [10] where players' body movements become a core part of the game experience. Designing, with interactive technology, embodied games that sustain all the physical and social engagement of traditional games is not a trivial process. Several guidelines for designing interactive games and engaging game experiences have been introduced [11], [12]. One issue that needs special consideration is how technology can affect key aspects of play [7].

There are several possible approaches to introduce technology into games without taking away the physical and social aspects of play. Tetteroo et al. in [13] present a method to design interactive playground games based on key elements derived from traditional children's play. In contrast, we propose to start with an existing traditional playground game which inherently promotes exertion and social behavior. We then augment it using technology to make it more fun and engaging for players. Tag is one of such well-known traditional playground games. In tag, children adopt one of two roles: tagger or runner. When players are taggers, their goal is to chase runners and tag (touch) them. When they are runners, their goal is to avoid being tagged by the taggers. If a player is tagged, the roles of both players switch. These simple rules allow players to understand the game quickly and join others almost immediately. However, since the rules are so simple, prolonged play can easily lead to boredom. By introducing technology into the playground, we envision a plethora of opportunities to enhance the game which would otherwise not be feasible. For instance, we could make the game less susceptible to a breakdown of play, dynamically adapt the level of game difficulty to maintain engagement during extended play sessions, or add elements that would introduce a strategic layer to the game.

To this end, we developed the Interactive Tag Playground (ITP), an interactive tag game installation that enhances the game experience of traditional tag games in a way that does not detract it from eliciting playful, physically active, and social behavior. The ITP is capable of sensing and tracking players inside the playing area, display visualizations on the floor, and guide interactions by processing the game logic. By being in charge of the game logic, it becomes *de facto* a referee, enforcing rules for the players in situations where disagreements exists. It also allows us to explore with experimental gameplay elements. Additionally, researchers benefit from the ITP since it provides logs with role and position data of the players. This information significantly reduces the time involved in data analysis.

In the present study, we evaluate three different aspects of the ITP. First, we evaluate whether the ITP enhances the game experience of traditional tag games. Second, we check whether the augmented tag game allows players to demonstrate physically active and social behavior. Third, we analyze specific behavioral cues important to tag games to showcase the potential of the ITP as a research platform. To this end, we recorded people playing both normal tag and interactive tag. The participants were asked to evaluate their experience by filling in a questionnaire. Behavior analysis was carried out using the data that was automatically measured during the interactive tag game sessions by the ITP.

In the following section, we present an overview of how technology is used to enhance games, and point out important design considerations. Next, we present the ITP and describe its components. In Section IV we present the user study, and detail the observations and discussions we had with the players. We also present the results of the subjective experience evaluation and analyze its significance. In Section V, we discuss the analysis of player behavior in the ITP based on objectively measured data. Finally, we summarize our findings and discuss avenues for future work.

II. Using Technology to Augment Games

Technology can be used to create novel games and experiences, but also to improve the user experience of existing traditional games. For instance, Mueller et al. try to put a spin on normal table tennis [14]. Instead of playing against one opponent, a technical enhancement allows people to play table tennis with two other players in different locations. The setup is similar to the one used to practice alone, however instead of hitting the ball against a wall, a screen where the video feedback of the other two players is shown. The BuzzTag installation of Avontuur et al. allows players to enjoy games reminiscent of traditional tag [15]. In “BuzzThief”, one player possesses the “buzz” and all other players have to stand close to him for a short period of time to steal it away. In “BuzzTag”, on the contrary, players try to loose the buzz by tagging others. The game is developed in a way that face-to-face social interactions are not lost during play by including wireless devices that give feedback based on colors, vibrations or sounds.

Other studies introduce technology in game settings not only to improve the user experience, but also to modify gameplay based on automatic player measurements. Navarro et al. use heart rate measurements to adapt in-game actions in the “Webz of Wars” game [16]. Kinects and Wii Balance Boards sense player movement and heart rate monitors measure their level of exertion. The baseline heart rate of each player is measured right before the game starts, and is used to scale the power of the player attacks based on how much effort they are putting in. In a similar fashion, Stockhausen et al. also use heart rate measurements to affect gameplay elements in the “Beats Down” mobile game [17]. “Beats Down” is a “whack-a-mole” style of game, where the user needs to tap tiles that flash randomly for a brief moment. The game has two modes: in challenge mode, heart rate controls the speed of the flashing lights, allowing players to rack more points by increasing their heart rate (albeit with increased difficulty). In relax mode, players get a point multiplier that increases by lowering their heart rate. In both cases, heart rate measurements are used to change how the game plays out. Automatic measurement of exertion is used by Landry and Pares [18]. They use computer vision to estimate coarse physical exertion values for groups of players in the Interactive Slide. This slide consists of a camera-projector system in which players can slide down an inflatable slide to interact with objects projected on it. The system is able to adjust the tempo of the games, triggering varied amounts of physical activity. Such interactive environments, besides being enjoyable for users, can also be used as efficient research tools to look into certain design choices and the effects of these on, for example, the required amount of exertion.

Some studies opt for a specific type of gameplay adaptation, that of skill balancing. Skill balancing allows people with different skill sets to play together as if they had equal skills. This can be achieved by automating certain processes and measurements. For instance, Vicencio-Moreira et al. balance the skills of opposing players in a first-person shooter game by employing dynamic aim assistance [19]. They implemented two methods: “Bullet Magnetism”, which makes bullets home-in to the target within a given activation range, and “Area Cursor”, which increases the activation area for a target hit (akin to making the bullet bigger). The player with the least amount of kills is assisted, and the strength of the assistance is scaled based on how far behind he is. Their results show that the performance of the weaker player improves by assisting him based on his performance during the game. Stach et al. also attempted to adapt the game’s difficulty in the “Heart Burn” racing game to allow people of different fitness levels to compete by scaling their in-game performance to their heart rate [20]. To speed their virtual vehicles, players have to pedal on a stationary bicycle. Instead of measuring their cycling speed, heart rate monitors are used to measure players’ individual effort. In this way, the game is more balanced as players that have better physical condition have to exert themselves more than less fit players to achieve the same result. Although balancing games can be very beneficial when players of different skills play together, it is not a trivial task and should be approached carefully, as Altimira et al. showed in [21]. They try to balance opponent players’ skills in a Wii table tennis game and a normal table tennis game. Opposing players were asked to assess their own skill, and the self-assessed better player was given handicaps during game sessions (play with non-dominant hand, start with a 6 point disadvantage). They saw that in real-life scenarios, the handicaps helped the less skilled player, but in the Wii game the handicaps did not work. Moreover, they over-balanced the game, making it nearly impossible for the skilled player to win under the test conditions.

While games have much to gain from the use of technology, its improper use can harm other important aspects of the game. For example, Isbister addresses whether introducing technology can gracefully augment game experiences while retaining the important characteristics [7]. In real life, we connect with each other through physical experiences and that should not be any different in games. She further argues that social behavior can be easily lost during the process of introducing technology, for instance by staring at screens or projections instead of interacting with other players. Sturm et al. agree that embodied games can and should stimulate group play and social interactions. Both are strong motivators for engaging in physical activity [22]. Nonetheless, besides the social aspect of play, physical exertion can also be lost by introducing technology. In [23], Berthouze studies in detail how body movement can be related to engagement in games. One of the points she covers is the difference in strategies with which players approach a game: “hard-fun” and “easy-fun”. In the hard-fun strategy, players are solely concerned with winning and will exploit technology to their advantage. During the analysis of several physical games, they observed that hard-fun players limited their movements to the bare minimum since, in many cases, winning was easier when moving less [24]. This shows that not planning carefully how technology is introduced can harm important social and physical aspects of play.

Instead of designing a game that is designed specifically to promote social interactions or physical activity, we propose using technology to augment an existing playground game that inherently promotes these key aspects of play. We attempt to do so in such a way that it increases the enjoyment and engagement, without limiting players’ ability to express themselves socially or physically. Also, the technological enhancements should facilitate the collection of in-game player data to allow both the design of novel game interactions and the analysis of player behavior. In the following section, we describe the setup we used and the game we developed to achieve these goals.

III. The Interactive Tag Playground

The Interactive Tag Playground (ITP) is an interactive installation that uses sensor, sound and projection technology to enhance tag games. The ITP has been designed to retain the essence of a game of tag, while novel elements can be introduced to improve the game experience. For instance, the game can be modified to balance difficulty, restore engagement, or adjust physical activity levels. As we can systematically adjust the game logic, we can see how variations in game mechanics affect the play experience. Given that information about the players is automatically logged, the ITP doubles as a tool for research into the aspects that affect play experience.

The ITP consists of four Kinects located in the ceiling of the playground. The Kinects are situated in a grid-like setup, 4.0 meters apart from each other. Two projectors are also located in the ceiling, 4.0 meters apart, in between the Kinects (Figure 1). The ceiling is situated at 5.3 meters above the playing area, which allows us to track players in a 7×6 meters area. With the two projectors, we cover an area of approximately the same size. Four speakers are located on one side of the playground and are used to produce sound effects during the game. With this setup, the ITP is capable of supporting an easy-in, easy-out style of play, which fits its potential use as a public installation. Players can walk in, play the game, and walk out whenever they want, without the need of any assistant being present, or any sensor being equipped.

The ITP tracks players in the playing area and displays underneath them pulsating, neon-colored circles that leave bright trails upon movement (Figure 2). The colored circles are used to indicate player roles: taggers have orange circles, runners blue ones. When the game begins, a random player is chosen as the tagger. When a tagger manages to tag another player, the colors of their circles switch to indicate their roles

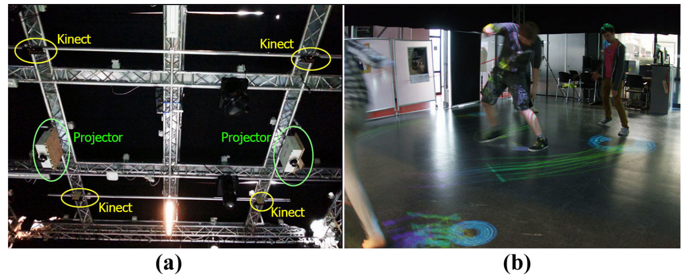


Fig. 1. (a) Disposition of the Kinects and projectors on the ceiling of the playground. (b) Playing area of the ITP

have changed, and a sound effect is played to indicate the event has happened. Instead of physically touching, in the ITP a tag occurs when a tagger is able to make his circle overlap with a runner’s circle. If a player is tagged, he is not allowed to tag the previous tagger back for two seconds, enforcing a cool-down period. If a tagger leaves the playing area, the system chooses another tagger randomly from the remaining players.

Fig. 2. Young adults playing tag in the ITP.

Figure 3 shows an overview of the ITP architecture. The most important components and tasks are described subsequently.

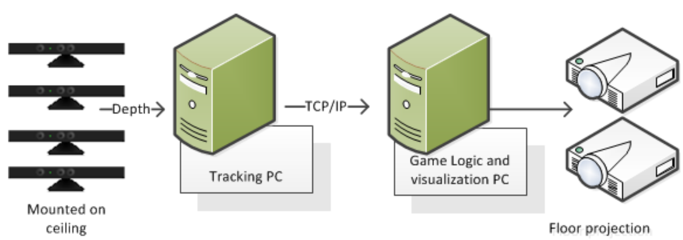


Fig. 3. Process overview of the ITP.

A. Player Tracking

We first detect players by thresholding the depth images from the Kinects. We only use depth images because the ITP projections would make the use of color images difficult. We filter the images to remove noise and enhance head-shoulder regions on each Kinect independently. Since we know the disposition of the Kinects and the distance between them, we can map the Kinect-specific coordinates to global coordinates. To solve the problem of duplicate detections of the same player, we merge detections that originate from different Kinects and are less than 50 centimeters apart.

Based on the detections of each player, we log their movement using our real-time tracker. The tracker uses Kalman filters to estimate player locations in each frame. Kalman filters learn a motion model for each detection based on past movement, and predict future locations based on the model. In each frame, the prediction is corrected using the assigned detection's position.

B. Distributed Components

The ITP separates the game logic from the tracking system to facilitate the design and implementation of interactive rules. The setup consists of two computers: one that deals solely with the tracking and transmits the information over the network, and another one that receives this information and uses it to drive the game interactions (described in Section III-D). This implies that other computers could be used to control other type of tasks (e.g. projections, sounds), extend the effective playing area, or even set up a different playground elsewhere for distributed play.

C. Data Logging

The ITP logs the position information of all players as well as their roles during the game. This information can be used during the game to drive certain game interactions (e.g. display a circle underneath a player's location), or after the game to analyze player behavior (e.g. analyze how players move during the game). In this study, when the data is used during the game, it is used as it is collected, which means no processing is applied to it. Data that is used for post-hoc analysis of player behavior is interpolated to account for missing detections, and median filters are used to remove noise.

D. Interactive Tag Games

We implemented several variations of tag for the ITP: interactive tag with no interventions, tag with dynamic circle size, tag with arrows pointing to certain runners, and tag with power-ups. Each of these interventions was aimed at promoting specific behavior [25]. In the current study, we only use the dynamic circle size intervention, which balances players' skills by changing the size of their circles depending on the time a player has been a tagger (Figure 4). When a player is a tagger, his circle will slowly grow (up to a maximum size) as long as he remains the tagger, making it easier to tag other players as time goes by. On the other hand, when a player that has been a tagger for extended periods of time becomes a runner, his circle shrinks (down to a minimum size), making it easier to avoid getting tagged again.

IV. Evaluating User Experience

The ITP aims to improve the game experience by using technology to augment the game. As such, the first thing we evaluated is whether it manages to provide an engaging and fun experience of tag. To do this, we asked players to compare their experience when playing a traditional (uninstrumented) game of tag to an interactive game of tag. In addition to comparing both games, we looked into how players felt about the interactive elements of the ITP, and whether they thought the system was fair even with the adaptive circle size intervention.

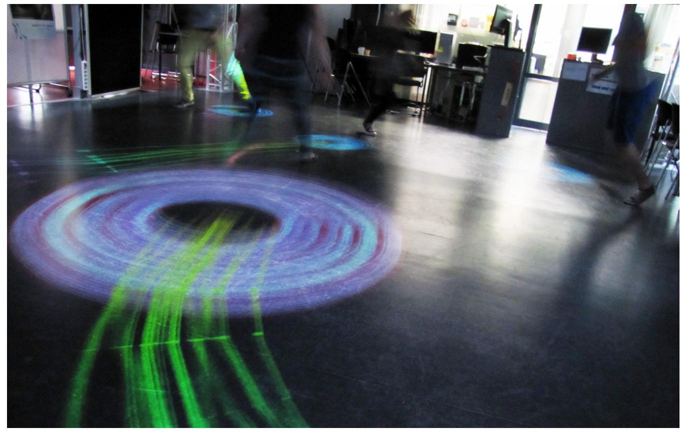


Fig. 4. An instance of the tagger's circle having grown in size

We recorded seven groups of people playing both normal and interactive tag. Both games took place in the ITP but for the normal tag, no sounds and visuals were used. All sessions were played with four players simultaneously, except for one in which we had five players. Each session lasted three minutes, for a total of six minutes of playing tag per recording session. In one session, only two participants filled in the questionnaire. In total, we obtained feedback from 27 participants. All participants were young adults.

After filling in a consent form, the players were explained that they would play two different sessions of tag: a traditional tag session and an interactive tag session. The order of the sessions was alternated between groups so as to not affect the results. When playing the interactive tag game, the fact that the circles' sizes changed was not mentioned at all. In between the sessions, there was a short break that lasted around one minute. After both sessions were played, the players were asked to fill in a questionnaire and afterwards were invited for discussion and feedback.

Below we present the used questionnaire, explain how it was constructed, and discuss the players' ratings. Afterwards, we describe our observations of the game sessions as well as the comments we received from the players in the feedback session.

A. Questionnaire

To fit our evaluation purposes, we designed a questionnaire (see Table I) based on the Revised Gaming Engagement Questionnaire (GEQR) of Berthouze [23]. Our questionnaire consists of four dimensions. The first two dimensions were used to compare the game experiences of the interactive tag and normal tag (A-Enjoyment, B-Immersion). The GEQR questions used for this dimension had to be rephrased to accommodate the comparison of the conditions. The last two dimensions evaluate elements of the ITP independently (C-

Gameplay, D-Enjoyment of Game Elements). The questionnaire has two additional categories (Balance/Fairness, Skill Level) that do not necessarily measure the same construct, but evaluate related issues interesting for this study.

We constructed the questionnaire using questions from the GEQR, and added questions not present in the GEQR when needed. For instance, for the Enjoyment dimension, we added Q1-3. In total, we omitted nine out of the 24 questions in the GEQR that were less relevant for our research interests. We used a Likert scale which ranged from 1 (Disagree) to 7 (Agree), and therefore had to rephrase all questions from *How much...?*, to statements for which the participants had to specify their level of agreement/disagreement. In the printed questionnaire, all the questions were put in a constant randomized order. Our modified version of the questionnaire has not been validated, but we do present the Cronbach's alpha for each dimension to show the questions have been grouped coherently for this study. It must be noted that Q14 and Q22 are reversed (r) when calculating dimension statistics because of their direction with respect to the other questions. We now discuss the findings per dimension.

1) Enjoyment (A): The Enjoyment dimension contains five questions (Q1-5) related to whether the players have more fun playing the interactive tag than normal tag. We checked the answers for consistency by calculating the Cronbach's alpha, which yielded a value of 0.88. This means that the questions indeed measure a single construct. The mean of the answers for the enjoyment dimension was 5.37, and the standard deviation (σ) was 1.06. To find out whether interactive tag was enjoyed better than normal tag, we performed a two-tailed one-sample t-test against the mean of the Likert-type scale (4). This showed a significant effect ($t(26) = 6.7, p < 0.001$) in the direction of more enjoyment during the interactive sessions. The tests allow us to confidently state that the players enjoyed the interactive game more than playing traditional tag.

2) Immersion (B): The Immersion dimension contains four questions (Q6-9). With these questions we wanted to find out if people lose themselves while playing in the ITP more than they do during normal tag. Cronbach's alpha was 0.71, implying that there is a fair correlation between the items. The mean for the answers was 4.93, with $\sigma = 0.93$. Q8, which looks into whether players feel they lost track of time in the interactive tag more than during normal tag, obtained a slightly higher rating than the others questions. Again, we used a two-tailed one-sample t-test to check for statistical significance, and the result again showed a significant effect ($t(26) = 5.2, p < 0.001$) in the direction of more immersion during the interactive session. From this follows that players were more immersed during the game of tag played interactively compared to playing normal tag.

3) Gameplay (C): We used six questions for the Gameplay dimension (Q10-15). This dimension evaluates how effective the controls, graphics and mechanics of the game are. When we calculated the Cronbach's alpha for this dimension, the value was quite low, at 0.48. Due to the various components in the system and some network issues, there was a lag of about half a second in the movement of the circle. We presume this low alpha is related to this as gameplay is positively affected when delays between a player's actions and the system's response are small. Indeed, upon closer examination of the individual questions, we noticed that removing the questions affected by the delay (Q10 and Q14), the value of alpha increases to 0.74.

The mean for this dimension, if we take into account all questions, was 4.96 ($\sigma = 0.56$). If we remove the two questions mentioned above, the mean was 5.82 ($\sigma = 0.71$). We can see that Gameplay is scored rather high if we do not take into account the lag. However, even when including the questions affected by the lag, the mean is still leaning towards the positive scale of Gameplay. Players felt good about how the game played out. However, we feel it would be beneficial if the lag problem is mitigated.

4) Enjoyment of Game Elements (D): The Enjoyment of Game Elements dimension is composed of three questions dealing with players' rating of the graphics, sound and theme and context of the game (Q16-18). The Cronbach's alpha for this dimension was 0.35. The low alpha value is due to Q17, which asked about the audio effects of the game. Some players did not notice there were any sounds being played while playing. This may be caused by players being immersed in the game or because the sounds were not loud enough. If we take into account all questions, the mean for the dimension was 5.31 ($\sigma = 0.75$). If we leave out the question about sound, the mean increases to 5.61 (alpha increases to 0.63) with a $\sigma = 0.79$. Even without Q17, alpha is still not very high, which may indicate that these questions would fit better in different dimensions. Regardless, under the current structure, the results convey that players enjoyed the game elements overall. Nonetheless, we need to address the sound not being noticed.

5) Balance/Fairness: We included four questions to cover the category of Balance and Fairness (Q19-22). These questions inform us whether players feel the ITP allows them to play tag, and whether they feel the game is helping skilled or unskilled players. Q19 and Q22, which deal with how the ITP allows players to play tag, had a mean of 4.11 and 4.41(r), respectively. This shows that players felt the game neither interfered with their ability to play, nor did it allow them to show all their skills. Although ideally players would have felt the game allowed them to demonstrate all their tagging skills, it is still important that they do not think the game limits their ability to do so.

Q20 and Q21 deal with the issue of Balance, and whether players feel anyone was receiving help from the ITP when playing. A high value for the mean would signify players felt the game helped a particular type of player, depending on the question. The mean for Q20 was 4.63 and for Q21 4.04. This shows that players had a feeling that the ITP was helping less skilled players, but in overall were not very pronounced in their judgment. The reason for this could be that we accelerated the growth of the circles for this study since the sessions were quite short. For longer sessions, the growth would be considerably slower, making it less noticeable. For skilled players, the mean is effectively four, which implies they did not feel it helped or hurt skilled players. We feel the results show the game is able to modify the circle size based on tagger time, in an effort to balance out skill levels, and still feel fair to the players.

6) Skill Level: The last 5 questions belonged to the category of Skill Level (Q23-27). These questions were included to obtain background information on the physical abilities of

TABLE I. QUESTIONNAIRE USED IN THE EVALUATION OF THE ITP, WITH MEANS PER QUESTION AND DIMENSION. SCALE 1 STANDS FOR DISAGREE AND SCALE 7 FOR AGREE.

Question	Item mean	Dim. mean
A - Enjoyment		
1) The interactive tag game made me laugh (more) than the normal tag game	5.22	
2) I would recommend the interactive tag game over the normal tag game	5.22	
3) I liked playing the interactive tag game more than the normal tag game	5.33	5.37
4) I am more interested in further exploring the interactive tag games environment than playing normal tag	5.56	
5) I am more interested in playing the interactive tag game again than normal tag	5.52	
B - Immersion		
6) I felt more involved in the game when playing the interactive tag than when playing normal tag	4.85	
7) I was more engaged in the game when playing interactive tag than when playing normal tag	4.89	4.93
8) I felt I lost track of time more when playing interactive tag than when playing normal tag	5.27	
9) I felt I was inside the game while playing interactive tag more than during normal tag	4.70	
C - Gameplay		
10) I was able to anticipate what would happen next in response to the actions I initiated	4.69	
11) The controls for the game were appropriate	5.81	
12) The controls for the game felt natural	5.70	4.96
13) I was able to clearly identify what game pieces/objects/models represented	5.81	
14) I experienced delay between my actions and the expected outcomes within the game	1.81(r)	
15) I understood the graphics of the game	5.93	
D - Enjoyment of Game Elements		
16) I enjoyed the graphics of the game	5.70	
17) I enjoyed the sound effects in the game	4.69	5.31
18) I enjoyed the context and theme of the game	5.52	
Balance / Fairness		
19) The game allowed me to demonstrate my ability of playing tag	4.11	
20) I think the game helps less skilled players	4.63	4.30
21) I think the game aids skilled players	4.04	
22) The game interferes with my ability to play tag	4.41(r)	
Skill level		
23) I am physically active	4.70	
24) I consider myself to be in good shape	4.59	
25) I exercise regularly	4.26	4.83
26) I enjoy physical activity	5.78	
27) I consider myself a good tag player	4.81	

players and their self-assessed ability to play tag. The mean for this category was 4.83 ($\sigma = 1,12$) and its Cronbach's alpha was 0.78. The high value of the alpha suggests that this category could be considered a dimension on its own. We added this category to explore how the self-assessed ability of the players correlated with the Enjoyment and Immersion dimensions. In this regard, looking independently at all the questions related to a player's physical abilities (Q23-26), we did not find any correlation to the Enjoyment or Immersion dimensions. Considering that the physical fitness of the participants varied greatly, this means the game is enjoyable for people who reported a good physical condition as well as those who did not. We also hypothesized that players that considered themselves in good shape (Q24) would usually think they make good tag players (Q27). However, we did not find any correlation between the two questions. Interestingly, we did not find any correlation of Q27 with any dimension, which shows that players found the game enjoyable independent of whether they thought they were good at tag.

B. *Observations and Feedback*

All participants stated that the interactive tag game was very enjoyable and exhausting. Some players remarked that the circle seemed a little hard to control at the beginning of the game session because of the slight lag, but they got used to it. They said that it forced them to be more strategic, since they had to predict where people were going instead of just chasing them. Consequently, feinting movement became incredibly useful as it allowed the runner to escape.

In the session with five players, the space was considered quite small. When playing with four players, most felt the playing space was adequate for the interactive tag. For normal tag, they felt the space was too small with four or five players. The difference in opinions is related to the way people tag each other in each version of tag. In the interactive tag, people had to make sure their circle came into contact with the other player's circle, which meant players had to look down from time to time and run a bit slower. In normal tag, there was no need to look down, which meant people could run faster. Moreover, they could use their arms to extend their tagging reach. This could be solved by increasing the circle size to approximate an arm's reach. More importantly, the size of the circle can be changed depending on the specific situation, not only to change the tagging range. This means the ITP could be located effectively in smaller spaces. Even though players run slower in the interactive tag than in normal tag, this does not necessarily mean the exertion is diminished as players would be able to play longer before exhausting themselves.

In the interactive sessions, sounds were used to signal tag occurrences but some players did not notice them due to their involvement in the game. The change in circle size was noticed by all players. The reason for the change, however, was not guessed by most. Many of them thought that their movement speed was the reason behind the change, stating that moving slowly made the circle grow. While moving slowly leads to prolonged periods of being a tagger, speed was not taken into account in the estimation of size change rate. This shows that we were able to intervene the game without people realizing exactly what was going on. This observation is important because it shows that carefully designing interventions can change the course of the game without affecting how players perceive the game. Specifically, we can balance the game without conveying feelings of unfairness.

In both the normal and interactive game sessions, besides tag game behavior, we could also witness an abundance of social interaction between the players. People were yelling at each other, making jokes, making fun off, and seeking revenge when tagged (e.g. see Figure 5). This is very important because it means the game, in its interactive version, still promotes social elements of play. Players are not only playing with the system, but actually with each other, and the system acts as a moderator. Also for physical exertion, we could witness significant investment from players in both normal and interactive tag sessions. Again, this signals that the interactive elements in the ITP allow players to physically exert themselves as they would in normal tag games. We look into this in more depth in Section V.

Fig. 5. Player performing a short dance after tagging another player in the ITP

V. Analysis of Play Behavior

In the previous section, we evaluated the player experience through questionnaires and showed that the ITP indeed enhances the traditional tag experience. We also observed that physically active and playful, social behavior was still exhibited during the game sessions. This demonstrates the usefulness of the ITP as an entertainment installation, but its use goes beyond solely providing an engaging game experience. The in-game data that is gathered during play from the system can also yield useful information. This information can be used during the game for multiple purposes (e.g. adaptation, steering, evaluation), but also for post-hoc analysis of interesting aspects of play. For this study, we use the position data of the players to do a preliminary, objective analysis on whether the ITP promotes physical exertion. We only analyze the interactive tag sessions since the traditional tag sessions were un-instrumented and thus, we did not track or log the location of the players.

A. Player Speed and Exertion

Player speed can provide useful information in regards to how the game plays out, but can also inform about the amount of physical activity of the players during the game. Intuitively, it would be reasonable to say that taggers should move faster than runners in order to tag them. The ITP allows us to verify our intuitions by providing the necessary data to measure this. In Figure 6, we can see the frequency of the speeds that players moved at, based on their role. It is evident that the speed is not very different, but taggers run at higher speeds more often than runners. Including all sessions, the average speed of runners was 1.01 m/s, whereas taggers moved at 1.18 m/s. Using the position data, we can also analyze how much distance players actually covered during the game session. On average, each player covered 206.1 meters in three minutes of play, with taggers and runners covering 232.8 and 197.7 meters respectively. This can give us an idea on how much players exerted themselves during the game.

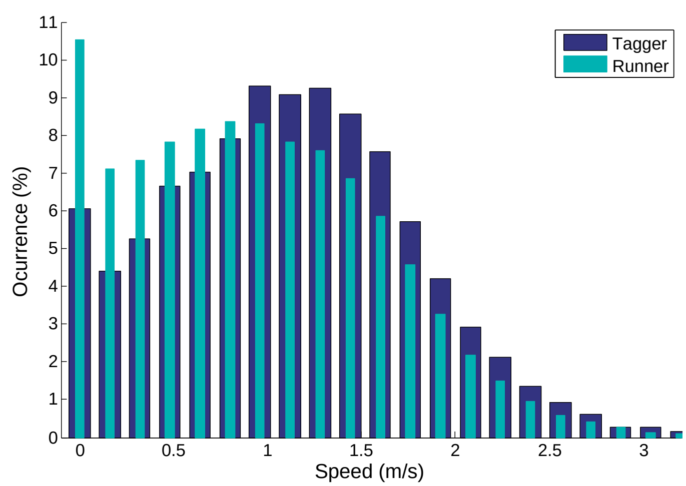
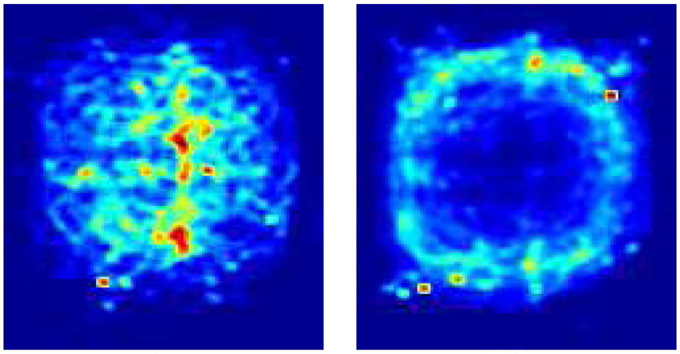


Fig. 6. Frequency of speeds at which players moved during the game sessions

B. Player Position

Analyzing how players move during the game can provide useful information for designing game interventions. In Figure 7, we can see the areas of the playground were players spent most of their time when they had a certain role. We can see that taggers remain largely around the center of the playing area, whereas the runners tend to move around the sides. This follows from the fact that taggers can maximize their chance of tagging if they remain near the center, the closest point to anywhere in the playground. On the other hand, runners try to maximize their distance to the tagger, which is why they move around in circles around the edges. Although it could have been possible to deduce this by observing game sessions, it would only be an approximation of the actual behavior. The ITP allows us to measure exactly where players have been, how long, which places are the most visited, etcetera.



(a) **(b)**

Fig. 7. Heatmap of player location based on the role: (a)Tagger (b)Runner

C. The ITP as a Research Platform

The fact that the ITP gathers information about the players' behavior in real-time allows researchers to design novel ways of interacting with the system. In the case of player position, we have found player movement trends based on their roles. This information could be used to design game interventions that, for instance, aim at changing or steering behavior. One could define safe zones in the playground where players are invulnerable to being tagged, and locate these areas near the center of the playground to see if players are willing to take risks in exchange of advantages. As such, players could be steered towards demonstrating more risk-seeking behavior. In this study we already used the data that the ITP provides for the game balancing intervention. The ITP is able to track the roles of the players during the game, and because of this we can estimate the time the player has been a tagger. This would be very hard to achieve by observing the game and, even then, the information could not be used directly in the game.

Another possible use of the information is in the automatic evaluation of certain goals. We have shown that we can measure the speed and average distance covered of players in the ITP, and can even analyze these per person or based on their role. Using this information, we could automatically evaluate whether a playground is able to promote physical activity without the need of questionnaires, direct observation, or manual annotation of game recordings. Moreover, other behavioral cues could be analyzed just as easily to evaluate other goals. For instance, by analyzing the distance between pairs of players or which player tags which player the most, we could study and evaluate social interactions during the game.

It is also important to mention that even though in this study we analyze the behavior of players during an interactive tag game, the analysis could be performed on other types of games without complications. Since the data logging and measurement do not depend on the game logic module, the data gathering would not be affected by implementing other types of games. This would be very helpful in games implemented through iterative design paradigms, as the in-game data could help speed up the analysis of each prototype.

VI. Conclusions and Future Work

Introducing technology in game settings can enhance the game experience by providing improved interactions or automated methods that allow for the tailoring of experience for different players. However, there is the risk of negatively affecting key characteristics inherent to play, such as social interactions between players or the amount of physical activity required to play. In this paper, we have evaluated whether we can enhance the traditional tag game experience using the Interactive Tag Playground (ITP). This is an interactive installation that allows players to play interactive tag games while stimulating physically active and social behavior, just as the traditional game of tag does. Additionally, we have shed some light into how the ITP can facilitate research and analysis of in-game player behavior by analyzing the speed and movement patterns of the players during the game.

The evaluation of the ITP was conducted by recording seven groups of students playing three minute sessions of both interactive and traditional tag. After playing both versions, they were asked to fill in a modified version of the Revised Game Engagement Questionnaire (GEQR) and took part in a round of discussions. Their behavior was analyzed using the data obtained by the ITP and shown to provide interesting insights into their behavior. In total, 27 players participated in the evaluation.

The results of the questionnaire show that the ITP is able to positively enhance tag games. Although this can be due to the novelty effect, we feel confident that the game can sustain extended periods of gaming. The two dimensions used to compare the game experience, Enjoyment and Immersion, show a statistically significant preference towards the interactive tag game. The dimensions used to evaluate the elements of the interactive tag game, Gameplay and Enjoyment of Game Elements, also score positively. The interactive elements were affected by lag due to network issues during our experiments, which in turn affected the game experience. Despite this problem, players still enjoyed the game. The results of the questionnaire also show that the ITP, through its digital elements, is capable of adapting the gameplay and game mechanics subtly. Players did not feel the game favored skilled or unskilled players. This indicates that there are opportunities for balancing skill levels, which can lead to potential improvements in game enjoyment and prevent play from breaking down. The Balance category also showed that players did not feel the game interfered with their ability to play tag games, although it did not allow them to show all their skills either. Lastly, the Skill Level category provided useful insights about the demographic of the players. The results demonstrate that the enjoyment of the game did not depend on whether the players were good at tag or were physically active, which is promising for a potential deployment of the ITP as a public installation.

Observations made during the interactive tag game sessions demonstrate that the ITP is also able to promote social and physical interactions. We could observe people running around yelling, attempting to jump circles or pushing people to use them as shields. The ITP elicits physical exertion by allowing players to move freely while playing, mediates the interactions between players, and still allows them to interact amongst themselves while doing so. We feel this is an important achievement as we were able to augment the game to make it more enjoyable, without limiting these key aspects of play.

The data gathered automatically by the ITP during the game sessions can serve many purposes. In this study, we present a preliminary analysis on player behavior regarding movement and physical exertion. We identified movement patterns that players adopt during gaming that are clearly related to the two roles of the game. We also calculated the speed at which players moved during the game, and found differences between both roles. Furthermore, we were able to calculate the distance that players covered while playing. With this method, we can get an idea of the level of exertion of the players, and feel it is a first step in the direction of automatic and unobtrusive measurement of exertion. More importantly, we showed that it is possible to accurately analyze behavioral cues such as speed or position, which would not be possible (or would be very time-consuming) through other methods such as observation or manual annotation.

The ITP manages to enhance traditional tag games while still promoting social and physical aspects of play, but we feel much more can be accomplished using the technology at hand. In this study, the logging capabilities of the ITP have only been used to analyze player behavior offline, as well as balancing player skills based on the time a player has been the tagger. In the future, we would be interested in exploring additional cues to balance skills and potentially improve the game experience. For instance, movement speed could be used to determine how good a player is at tag. Cumulative distance to taggers could also convey how good a player is at positioning himself in the playground to avoid taggers. Balancing skills is not the only possible use for this information, as we would be very interested in implementing and testing interventions to restore engagement, modulate physical activity, or give handicaps to players that attempt to cheat. The automatic data logging of the ITP would help in analyzing whether these interventions improve or hinder the game experience. It would also be interesting to see if the game is enjoyable for children as well. Based on the findings discussed in this paper, we feel confident that the ITP is an entertainment platform capable of enhancing games while facilitating opportunities for in-game, automatic analysis of player behavior or post-hoc evaluation of goals. add something more about the game being fun

Acknowledgments

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