Steering Gameplay Behavior in the Interactive Tag Playground

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Abstract. This paper deals with steering player behavior in the Interactive Tag Playground (ITP). The ITP, an ambient environment instrumented with contact-free sensor technology and ambient display capabilities, enhances the traditional game of tag by determining when a valid tag has been made and visualising the current tagger. We present three modifications of the ITP that aim to steer the gameplay actions of the players. The modifications are intended to influence who will be chased next by the tagger; to make good players easier to tag and less skilled players harder to tag; and to influence the locations visited by the players. We report on a user study showing that two of the three modifications have a significant effect on the behavior of players in the ITP and discuss opportunities for future research that follow from this study.

1 Introduction

Digital and mixed reality games allow for interventions in the game state, game difficulty, or game behavior. Technology can be used to steer the physical behavior of players, which in turn can impact the experience. Personalized adaptation of the interventions allows people with different skills to play together, increasing fairness and engagement in a fun and challenging experience [1,3].

This paper deals with steering player behavior in the Interactive Tag Playground (ITP). The ITP enhances the traditional game of tag. It is a large interactive ambient installation equipped with technology to create a playful experience that stimulates physical and social interaction. In our ITP, players are automatically tracked and a circle is projected around them on the floor. The color of the circle represents the role of the player as a *runner* (blue) or a *tagger* (red). A tagger can tag a runner by letting their circles touch. If this happens, the colors of the circles switch.

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Playing tag can be fun and exhausting, and entails a lot of physical as well as social activity. In our playground we find that player behavior in the game of tag is very well defined according to players' roles. In play sessions with non-instrumented tag, we have also observed people getting bored and disengaged. This happened for example because they were less skilled and therefore had to be tagger for prolonged periods of time, or because they were running from a tagger who was not skilled enough, offering too little challenge. In the Interactive Tag Playground we try to implement subtle interventions that can steer player behavior into different patterns while keeping the engagement high and the game experience intact. If selected well, such interventions could help balance the game, re-engage players that are less involved, get players to move more and to interact more socially [9].

For this study we focus on steering specific gameplay actions of players through three superficial modifications of the game. We explore if it is possible to (1) directly steer the tagger's choice of whom to chase next by pointing an arrow to one runner, (2) balance the time that each player is a tagger by changing the size of each player's circle based on the time they have been a tagger so far, and (3) get players to move around to specific locations on the playing field by placing power-ups that can be picked up. In the long run, automatic measurements and interpretations of player behavior will help deploy such interactive elements in our ambient play environment at the right moment, to steer player behavior in desired patterns.

In order to test the effectiveness of the three modifications introduced to the ITP, we performed a user study with eight groups of four participants playing four different versions of the tag game. Three versions constitute the three modifications (arrow pointing at one runner, adaptive circle size, and power-ups in the playing field); the fourth version is the standard ITP tag game without modifications, used as a baseline for assessing player behavior. We use the automatic measurements of positions from the tracking and the roles logged by the ITP to investigate whether the player behavior changed in the expected ways.

The remainder of the paper is structured as follows. The next section discusses related work on steering behavior in interactive art installations and embodied games. Then, after briefly introducing our ITP, we explain in detail how we steer players' behavior for this study, and formulate hypotheses concerning the effect of these interventions. In Section 4 we present the setup of our user study, followed by the results and observations from the play sessions in Section 5. The paper finishes with a conclusion and a discussion of where we want to go next with our research on play in the ITP.

2 Steering Behavior in Embodied Games

In the last two decades a large amount of research has addressed (ambient) technologies influencing behavior and/or persuading people into behavior change [5]. Most studies investigate the system as a whole. Instead, Hamari et al. advise to look into the single relevant individual constructs and their effects. We follow this advise and separately look into the different types of affordances.

In related work on interactive art installations and embodied games, we can distinguish between two types of behavior steering. One type aims to get people to initiate interaction with the interactive environment: an *invitation to play* [2,6]. Quite a few of those installations solicit specific behavior from the user by making that behavior the main or only means of interaction with the system. Examples are installations in which people form rings around a fountain to make the water respond [12] or in which people are invited to follow projected footsteps, interactively tracing a path on the floor [11]. The other type aims to solicit behaviors in the context of another activity to achieve additional goals. For instance, Landry et al. discuss an interactive playground that can indirectly control the tempo with which an embodied game is played [8]. We are interested in the second type. This distinction is similar to the different combinations of duration and type of behavior emphasized in Fogg's 'Behavior Wizard' grid for persuasive technology, a tool that acknowledges the importance of matching psychology to target behavior [4]. They suggest that new behavior that happens only once (e.g. someone making a movement to start interaction) versus an increase of behavior that has happened before (e.g. tagging someone more often), will require a different approach.

Another way the gameplay can be steered is adaptive balancing between players by assigning a handicap and by using dynamic difficulty adjustments to manipulate the status of the player and the placement and supply of items [7,10]. Balancing between players can help in letting people from different age groups and with different skills play together in an pleasurable experience [1]. It can also help in triggering the correct amount of challenge and increase the amount of movement [3]. In our current exploration to steer the gameplay we use a simple adaptive method, changing the size of the circles based on the time someone has been a tagger so far.

3 The Interactive Tag Playground

Our ITP is a large space where people can move freely, instrumented with ambient display capabilities and contact-free sensing technology. We project circles around the players' positions and their color indicates whether they are *tagger* (red) or *runner* (blue). Players can tag each other by letting their circles touch, upon which a bass drum sound is played. As often used in normal tag there is a *cooldown* period after a tagger tagged someone. In this period the tagger is not allowed to tag back the previous tagger. To visualize this we make the circle of the previous tagger semi-transparant during this two second period. To make it clear to the players that their circle moves with them, we also project a small trail behind the players.

At the start of the game one player is automatically assigned to be the tagger. In case a tagger disappears from the game (or from the tracking) for two seconds we re-assign another person to be the tagger. In the visualization we use pulsating circles, circles that grow and shrink a little in periods of four seconds. Each player has a random offset in this pulsation, creating a lively scene with different sized shapes even when people were standing still.

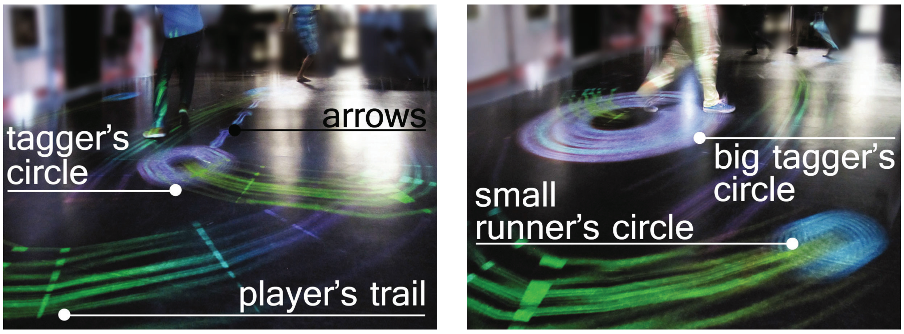


Fig. 1. Visualization (left) of the arrows and (right) the adaptive circles

The playground uses the depth-channel of 4 Kinects for tracking players. The Kinects are mounted to the ceiling and spread about 4 meters from each other at an approximate height of 5.3 meters. Two wide-angle projectors are also mounted to the ceiling and display the visualizations on the floor. One PC is connected to the 4 Kinects and is equipped with our tracking system to send the position of the players to another PC. The second PC uses this information to run the game implemented in Unity and display it with two the projectors.

The playing field that is covered with the projectors is approximately 6 by 7 meters. We use a black linoleum floor to project the neon-styled visualizations on (see Figure 1 and 2). The environment is darkened using curtains to improve the visualizations. We don't use any color information of the Kinect but only use the infrared based depth channels.

3.1 Steering Behavior Through Gameplay Elements

In our current interactive tag game we implement three different gameplay elements to influence the behavior of players. In this study we look whether our implementation was successful in achieving the targeted changes. We tried to influence gameplay in three ways: use arrows to suggest someone to be tagged, adaptive circle sizes in order to change the amount of time someone is a tagger, and power-ups to make players move more to certain positions. These three elements will be explained in further detail below.

Arrows. In playing tag one of the main choices to be made is whom to tag. In the 'arrow' version of the game, we try to influence that choice. To this end we use arrows pointing towards a random player, see Figure 1. Every time a player is tagged the arrows will point to another random player again. The only difference when someone with the arrow is tagged instead of someone else, is a slight change in the sound that is played. No further restrictions or changes follow from the assignment of the arrow.

We expect that these arrows will influence the decision of the tagger on whom to tag. This should lead to runners being tagged more often when they have an arrow pointing at them. Therefore, for the arrow condition we hypothesize:

Hypothesis 1. *A person with an arrow pointing at him/her are tagged more.*

Adaptive Circles. The adaptive circles are used to balance out the time players have the tagger role. This is achieved by adjusting the size of the circles of both taggers and runners. For instance, by making a tagger's circle bigger, it becomes easier for him to tag others. The size of the circle of all players is adjusted solely based on the time they have been taggers. When a player has been a tagger for more than the average amount of time, $\frac{gameTime}{\#players}$, then (a) when he is a tagger, his circle grows and (b) when he is a runner, his circle shrinks. The rationale behind this is that players that have been taggers for prolonged periods of time are either having difficulties tagging others or avoiding being tagged. This adaptation makes it easier for them to tag other players, and harder for other players to tag them. On the other hand, when a player's tag time is below the average, then (a) when he is a tagger, his circle shrinks and (b) when he is a runner, his circle grows. This is the opposite case as before, where we want to make it harder for this player to tag others and make it easier for others to tag him.

The formula for the circle adaptation is applied to every player in each frame, and is defined as:

$$addedSize = prevAddedSize + (\frac{timeBeingATagger}{gameTime} - \frac{1}{players}) * K \qquad (1)$$

where K is a constant that was empirically set to suit a 2 minute game, and the *prevAddedSize* variable is the size of the circle in the previous frame. To prevent the circles from getting too big or too small, predefined values where set to limit the minimum and maximum sizes. When a player switches roles, there is a small time window in which their circles quickly reset to their normal size before starting to shrink or grow.

We expect that this adaptive size will lead to a more balanced game in terms of the duration each player is a tagger. The differences between the duration of people being a tagger during one session should thus go down in the adaptive version of the game. Therefore, for the adaptive circle condition we hypothesize:

Hypothesis 2. *The variation, per group, in the duration of each player being a tagger, is lower for the adaptive game than for the standard game.*

Power-Ups. With power-ups we try to influence which locations the players visit during the game, steering players towards specific locations in the playing field. In previous work we have seen that runners often move near the border of the playground and the taggers move near the center. In our ITP we distributed power-ups outside these standard positions, power-ups for runners are in the

Fig. 2. Visualizations (left) of the *shrink* power-up and, the *minions* and the *shield* in use and (right) someone trying to collect a *shield* power-up

center and power-ups for the taggers are at the edges of the playground, see Figure 5. Power-ups were intended for either the tagger or the runner, the power-ups for the runners can't be gathered by taggers and vice versa. This way, it should be possible to steer players away from their normal playing strategy with respect to locations visited.

We implemented four types of power-ups. For the tagger there is a *grow* power-up and a *minions* power-up. The grow power-up increases the player's circle size and the minions power-up adds three small balls that rotate around the circle that can be used to tag someone with as well. For the runners there is a *shrink* power-up and a *shield* power-up. The shrink power-up shrinks the size of the circle. The shield power-up will create a 'force field' around the player, that slows down the speed with which the circles follow the real world location of the players in that force field. Both make it harder to get tagged. Both the runners and the taggers have one power-up that directly influences their size and one power-up that influences an area outside their circles.

All power-ups that are collected last for 25 seconds. Upon collection, the power-up disappears; every 10 seconds a new one appears that can be gathered. When a power-up is collected an accompanying sound is played. For the sake of experimental control, there are 8 positions at which the power-ups appear. Four around the center for the runners and four spread around the sides of the playground for the taggers (see Figure 5 in Section 5).

We expect that people will gather the power-ups and be in those (unusual) locations more often than in the normal condition. We therefore hypothesize:

Hypothesis 3a. *Locations visited by the runners change structurally in the power-ups game, runners will be near the middle of the playing field more often.*

Hypothesis 3b. *Locations visited by the taggers change structurally in the power-ups game, taggers will be near the edges of the playing field more often.*

4 User Study

With the ITP we investigated the effects of the previously described elements. We created four versions of the ITP, one for each game element and one without these game elements. We used a within-subject design: for each modified version of the game, we compared the measurements from players playing that version to the measurements from the same players playing the standard game as baseline.

4.1 Participants

In total 32 participants participated (27 male, 5 female), divided in eight groups of four participants playing the four versions of the game. Participants were mostly university students aged between 18-30 years. Some of the participants had participated in a previous user study involving the adaptive circle version of the ITP.

4.2 Procedure

Participants were asked to read and sign an informed consent form. The consent form also contained the explanation of the game, including a description of the power-ups. It also explained that four different types of versions of the ITP would be played, one with arrows, one with power-ups and two with just circles. We briefly explained the game and procedure of the user test. Each version was played for two minutes resulting in eight minutes of play in total. The order in which the games were played was semi-randomized. In each game the first player recognized by the tracking system was selected as the tagger. Players were given time to rest between each game session. Once they all agreed they were ready, the next session was started.

During the game two of our researchers were sitting directly outside the playground to start the game, observe the gameplay, check the tracker, and when necessary respond to questions about the playground.

After all the games were finished there was time for a group discussion of about 5 minutes. We asked questions like *'With a few keywords, how would you describe the experience of the playground?'*, *'Which different versions did you recognize, in which order and how do you think these versions work?'*, *'Which version did you like most?'* The entire session including filling in the consent form and discussion took around 30 minutes.

5 Results and Discussion

Before presenting the results for the three hypotheses, we will first present some qualitative observations and findings from the group discussions. We will then look into the quantitative results of the three targeted effects for each intervention separately. We will also discuss the implications of the results per element, taking into account the observations and findings from the discussions where relevant.

5.1 Group Discussion and Observations

Concerning the technical setup, there was a noticeable lag between the movements of the players and their circles following their movement, due to tracking and communication delays. When we asked the players about it, some found it irritating but most thought it made the game more interesting. You had to incorporate a different strategy, predicting the movement of the players, their circles and then trying to cut them off. As one group put it *'Is it a bug or a feature? [..] At the start it is frustrating, later on it became a part of the game'*. As for the tracking accuracy, in most locations players could stand shoulder to shoulder and still be recognized correctly by the system. Nonetheless, at some games players were switched when they were close to each other and made quick turns. At some other occasions, the tagger was reassigned to another player when a tagger was not recognized for some time by the tracker. We have observed around 10 of these glitches over all sessions. This led to discussion in the group and laughter as well as frustration.

When we asked players which game they liked most, 71% preferred the one with power-ups, 21% liked the one with adaptive circles and 8% the normal one. We also asked players to state some keywords describing the playground. Recurring responses were: '*sweaty, hot, tiring, exhausting, good exercise, interesting, cool, fun* and *innovative*'. This shows that players were having physical exercise and that they enjoyed it. Another clear sign of the performed activity was the visible sweat, red faces and the heavy breathing. Overall players were extremely positive about the mix of physical activity and technological enhancement.

Observations regarding the arrows. In all sessions, players noticed early on that they could tag anyone and not just the player that was being pointed at. This could be recognized by their chasing behavior and by remarks made during the game. We observed that the one initially being chased, seemingly often the one with an arrow pointing at them, was not always the one getting tagged eventually.

Observations regarding the adaptive circles. Certain players tried to make their circles grow with their movements. For instance, one tried to make a gesture with his hands and another tried to stand still. Most players recognized that the circles were growing or shrinking. However, most players thought it was related to the speed of running. Most of the people preferring the adaptive circles were from a group with an injured and a less skilled tagger in their midst, represented as session 8 in Table 2, but in this study we were not explicitly looking into how balancing might influence the game experience.

Observations regarding the power-ups. We heard and saw players exploring the effects of the power-ups, they were engaged in this exploration and discussed their findings with others. Therefore, we now think that by occasionally

Table 1. Table showing the percentages of players tagging someone who has been assigned an arrow in the arrow game version

Group	1	2	3	4	5	6	7	8	avg
%	46.2	50.0	37.5	50.0	50.0	40.0	50.0	23.1	43.35
# tags	13	18	8	10	12	15	8	13	12.1
# arrow tags	6	9	3	5	6	6	4	3	5.3

adding new kinds of power-ups over time, we might regain engagement of players that were less involved and increase social interaction. During the games there were at least two players explicitly hiding the power-up from the tagger by standing on top of it, making it almost invisible as their circle covered the power-up.

5.2 The Effect of Arrows

To investigate the effect the arrows had on the behavior of players, we logged which players were tagged in each game and whether they had an arrow pointing to them. With this we looked at Hypothesis 1.

Over the eight sessions, 43.3% of the players tagged were players that had arrows pointing towards them, see Table 1. The percentages of being tagged with an arrow, D(8)=.257, p=n.s., did not deviate significantly from normal. A two-tailed one sample t-test comparing to chance-level (0.33) does show a significant effect ($p < 0.05$) in the expected direction of people being tagged more often when an arrow is pointed at them. In our experiments pointing an arrow at someone in the ITP increased the chance of getting someone tagged more often.

Therefore, arrows might be used to make people more physically active and interact with each other more. For instance, it could be used to engage people that were less active in the game by pointing the arrow to them, or it could encourage people to walk more by assigning an arrow to someone further away. In addition, this offers another potential way of balancing the game, by pointing arrows at the players that had the lowest amount of tag time.

5.3 The Effect of Adaptive Circles

During the games we logged which player was the tagger, to investigate the effect of the adaptive circles (see Table 2). With this we looked at Hypothesis 2.

The standard deviations for the adaptive, $D(8) = 0.959, p = 0.803$, and for the baseline condition, $D(8) = 0.972, p = 0.910$, did not deviate significantly from the normal distribution. A two-tailed paired sample t-test comparing the standard deviations of the normal and adaptive sessions, showed a significant effect ($p < 0.05$), in the direction of the expected decrease for the adaptive version. This significant decrease shows we can balance the game: adaptive circle sizes lead to less variation in the duration of each player being a tagger. We strongly believe that balancing helps in making the game suitable for differently skilled players.

Table 2. Table showing the percentage of being a tagger per player for each session (s#), and the standard deviation in the session. On the left the adaptive condition, on the right the baseline unmodified game. Played with four players, the baseline percentage of being a tagger during this game is 25%. We highlighted the players being taggers the **longest** and the *shortest* percentage of the game.

s	std	players			
s1	13.3	29.7	**38.8**	*7.10*	24.3
s2	1.62	**27.0**	24.7	*23.1*	25.2
s3	8.81	*14.8*	21.9	**35.5**	27.8
s4	7.64	**32.1**	19.7	*17.2*	31.0
s5	6.80	22.7	*18.8*	**34.7**	23.8
s6	4.34	**30.7**	24.6	*20.1*	24.7
s7	4.46	26.3	26.5	**28.7**	*18.5*
s8	7.32	*17.4*	20.5	28.9	**33.2**
avg	6.79				

s	std	players			
s1	9.14	*14.6*	21.4	28.0	**36.0**
s2	20.0	25.1	26.0	**48.9**	*0.00*
s3	20.7	16.3	**55.7**	*10.4*	17.6
s4	11.2	**37.3**	*14.0*	31.6	17.1
s5	17.5	33.5	17.3	**44.4**	*4.86*
s6	4.97	28.1	**29.4**	24.1	*18.4*
s7	16.9	**47.9**	*8.06*	25.9	18.1
s8	26.5	6.38	37.5	*0.00*	**56.2**
avg	15.9				

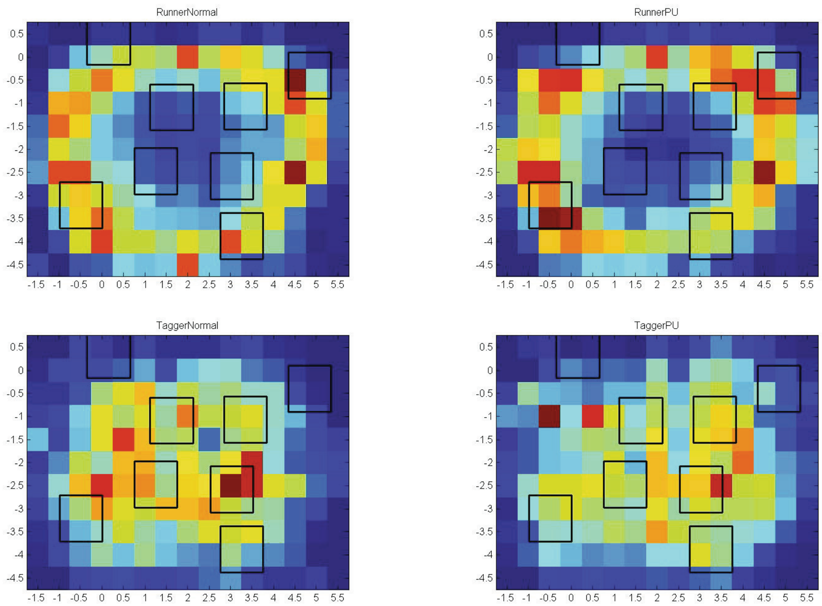
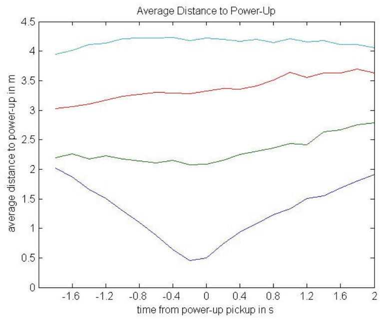


Fig. 3. Heatmaps of players' positions for the different versions, showing the locations of the power-ups with black rectangles. Runners' positions are shown in the top (T) images. In the left (L) images we show the positions in the baseline unmodified version of the game and in the right images the positions in the power-up version. TL: runners' in unmodified, TR: runners' with power-up, BL: taggers' in unmodified and BR: taggers' with power-ups.



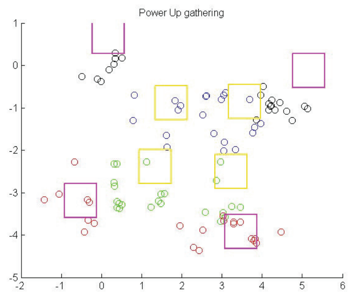


Fig. 4. The average distance to where a power-up was collected in a 4 second window around the powerup pickup. In blue, the player being closest in this window, in green the player being 2nd closest, in red 3rd closest and in cyan the player that was furthest away.

Fig. 5. The players position's when they gathered the different types of power-ups for tagger (black and red) and the runners(green and blue). The actual placement of the power-ups for the taggers (magenta) and for the runners (yellow) are shown with rectangles.

5.4 Power-Ups

We know that in tag, runners often move near the border of the playground and the taggers move near the center, see Figure 3. In this figure we can see that the distribution of location of players for the normal interactive tag version indeed follows this pattern. We have put power-ups in the ITP to see if we could change the location of players. We distributed the power-ups outside the 'standard' positions, power-ups for runners are in the center and power-ups for the taggers are at the edges of the playground.

We separately saved the positions of taggers and runners, as the power-ups were placed at different locations for these different roles. With this data we looked at Hypothesis 3. For every frame in the recordings of a session, we calculated the distance of runners and taggers to the center of the playground. Table 3 shows the average distance of runners and taggers to the center of the playground, and the standard deviation. A paired sample t-test does not show an effect on the average distance per group (N=8) between the baseline unmodified game and the power-up game for either runners or taggers.

Several reasons could help to explain the lack of effect. Only one player would gather the power-up and once gathered would directly leave that spot. In Figure 4 we plotted the average distance to the power-ups in the period surrounding a power-up being collected. We can see that players approach the power-up's position, and once its collected they move away again from this position. Furthermore, there were only a maximum of 12 power-ups to be collected each session and they appeared 10 seconds apart. Finally, the the size of the player's circle and of the power-up also diminishes the intended effect. The player's circle had to touch the power-up; the player himself did not need to be at the actual center

Table 3. Table showing the average distance to the center of the playing field, and standard deviation, for runners and taggers in the baseline unmodified version and the power-up game

	baseline		power-up game	
s	runner	tagger	runner	tagger
s1	3.82(1.71)	3.14(1.57)	4.62(1.61)	3.99(2.02)
s2	3.96(1.71)	3.81(1.84)	4.24(1.71)	3.81(2.06)
s3	3.84(2.04)	3.37(1.75)	4.62(1.87)	3.53(1.71)
s4	4.18(1.59)	4.15(1.63)	3.99(1.73)	3.47(2.11)
s5	4.54(1.78)	4.24(1.92)	4.04(1.69)	3.45(2.08)
s6	4.81(1.66)	3.73(1.49)	4.38(1.60)	4.12(2.01)
s7	4.27(1.79)	3.98(1.74)	4.30(1.55)	4.25(1.74)
s8	4.20(1.65)	3.92(1.67)	4.19(1.71)	3.48(1.94)
avg	4.20(1.74)	3.79(1.70)	4.30(1.68)	3.76(1.96)

position of the power-up but could remain a few steps away from it (see Figure 5).

We didn't find a significant effect in the locations visited by players. The players did however like the power-ups and over all sessions 85 from the 96 power-ups were gathered. Power-ups clearly are a useful mechanism to steer people, but not in the way we planned.

6 Conclusions and Future Work

We showed that it is possible to some extent to steer in various ways the behavior of participants during a game of interactive tag in the Interactive Tag Playground, although caution is needed in generalizing these results given the relatively low number of participants. The adaptive circles showed a clear balancing effect on the duration of each player being a tagger; the arrow pointing at someone showed an effect on whom would be tagged next. The power-ups did not lead to a visible effect on distribution of the locations of the players. Nonetheless, players did gather them and therefore went towards the chosen positions at least for a very short duration. Moreover, most players preferred the session with the power-ups. We believe this gives room for trying out other more long-lasting game mechanics to influence the position of players.

We believe the work we present shows an important aspect of successfully steering behaviors in playgrounds. In the future, this could be made adaptive, using the right timing and recognition of relevant player behavior to trigger such interventions, these behavior steering elements can help in attaining end goals such as promoting physical exercise and social interactions with a playful experience. We will use an improved playground implementation to explore these possibilities using measurements that indirectly indicate engagement, interactions and movement, e.g. person chased, distance walked or the average or top-speed of a player. As the power-ups did not show an effect yet, we will also look into other type of game mechanics to influence the locations of players. For instance, something similar to the shield power-up but making it affect a certain corner of the playing field.

The observation that people find ingenious strategies, such as hiding power-ups, and are able to incorporate shortcomings of a game as a feature, the lag, signifies the importance to look further into qualitative side-effects of introducing game elements as well. One aspect that has drawn our attention even more in our observations of childrens' non-instrumented play, is the 'break-down of play': play stopping, without the players agreeing to end the game, for several reasons including engagement drops, over-heated discussions or key-players leaving. In our research we will work towards a more thorough investigation on the break-down of play influenced by the interactive elements of the ITP and the endless possibilities of steering behavior to prevent this.

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