## Play&Go, an Urban Game Promoting Behaviour Change for Sustainable Mobility.

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**Abstract.** Designing more sustainable cities is increasingly pressing, and mobility behaviour plays an important role in how much cities are socially, economically and environmentally sustainable. We report our experience in deploying the third edition of an urban game that exploits gamification for promoting a positive behavioural change of mobility habits. This edition of Play&Go ran for 6 months and involved 635 active players who tracked their trips on sustainable transportation means such as by bike, bus, train and walking. Players tracked 54.293 trips in total, corresponding to 244.394 sustainable kilometres. We evaluated the user experience of Play&Go and its impact through questionnaires, interviews and game log analysis, and we report on players' participation and engagement, reported behaviour change and impact of different gamification motivational elements.

**Keywords:** Gamification, urban game, mobility, behaviour change, mobile app, personalization.

### 1 Introduction

Within a Smart City, mobility plays a fundamental role: the way in which citizens experience the city, access its core services and participate in the city life strongly depends on its mobility organization and efficiency [1]. In this context, the challenge that cities are facing is ambitious: on the one hand, administrators must guarantee to their citizens the right to mobility and to easily access local services, and on the other hand they need to minimize the economic, social and environmental cost of the mobility system. Dealing with this challenge requires a holistic approach to efficiently exploit existing mobility resources while integrating and promoting emerging mobility services (e.g., bike sharing, car sharing, carpooling, walking buses) to enable an integrated, efficient and sustainable mobility ecosystem. To this end, cities are planning and implementing interventions, even when innovative and expensive, are bound to fail if they are not combined with actions aimed at making citizens aware and involved in this process and to influence their mobility habits in a gradual but profound way [1].

In recent years, a significant effort has been undertaken to understand how interactive technologies can be leveraged to raise citizens' awareness, encourage participation, break bad habits and promote behaviour change towards a more sustainable lifestyle. To this extent, gamification is emerging as a persuasive

technology with significant potential [2, 3] and opportunities for application in the mobility domain [1, 4, 5, 6, 7, 8], as well as in several other domains in the environmental sustainability realm [9, 10, 11, 12, 13]. The key idea is to leverage on the motivational and persuasive power of games by designing motivational systems that properly exploit and embed game concepts and elements [14, 15] to pursue a change in the player's behaviour.

In this paper, we report on the third edition of Play&Go, a long-running open-field urban mobility game promoting voluntary travel behaviour change, which has been active in Trento, Italy, since 2016. The project implemented an iterative approach, each year improving the design and adding new functionalities based on quantitative and qualitative formative evaluations. While the first edition of Play&Go included basic game mechanics and trip tracking features, new elements have been introduced and optimized in subsequent editions. In particular, the third edition of the game included a significant technological improvement, such as a more efficient smartphone, as well as an improvement of the game mechanics with the introduction of personalized challenges. The third edition of Play&Go was active from September 9, 2017 to March 3, 2018, i.e. 181 days, 6 months and combined standard gamification elements (e.g., points, badges, leaderboards, real prizes) with personalized game content (i.e., challenges) that is tailored to the player's profile and is focused on encouraging a positive change in the player's behaviour. In this paper, we report on evidence emerging from game logs, questionnaires and interviews to investigate the effectiveness of Play&Go in terms of i) players' participation and engagement, ii) reported behaviour change, and iii) intrinsic and extrinsic motivational factors.

The article is structured as follows: we start with an overview of related work in Section 2; in Section 3, we present the design of the Play&Go game, and then proceed with an in-depth evaluation in Section 4. Section 5 concludes the paper with a discussion on the lessons learnt that will guide the redesign of future editions of the game and that may be useful to other researchers and practitioners aiming at designing games for urban sustainability.

## 2 Related Work

Gamification refers to the usage of game elements in contexts other than games [14]. Games are more than just an entertainment tool: they are now employed not only in entertainment, but also in other contexts such as technologies that aim at persuading to assume a positive behaviour change. Fogg [17] defined the concept of persuasion as "an attempt to shape, reinforce or change behaviours, feelings or thoughts about an issue, object or an action" (p. 225). Hence, making users understand and internalize complex world events, although being challenging, can be made simpler through simulation of these events in games. In fact, according to Semiotics, the meaning that users perceive of signs in the system is influenced by the context in which they encounter them [18]. To foster motivation, gamification employs elements and characteristics of entertainment games and applies them in contexts other than games [18, 19]. The main focus of game applications is not only the entertainment or enjoyment deriving from the interaction with the game, but also motivating the user towards an external "ulterior motive" [20], e.g., a positive behaviour change. Games can, indeed, function as cognitive frames and, therefore, can be used as a persuasive technology tool [21, 22].

In the last decade, there was an increase in the popularity of gamification, supported by research demonstrating its usefulness in keeping people engaged [3]. Gamification is particularly handy when it comes to the definition of experiences

aiming at educating citizens to assume sustainable habits in an enjoyable and playful way [23]. Gamification is generally prolific in application domains promoting environmental sustainability - i.e., sustainable behaviour [9], or healthy habits [24]. Its versatility allows an easy employment in various contexts such as energy consumption [10, 11, 12], sustainable mobility [4, 5, 6, 7, 8], green environmental missions [23], involvement of citizens in the government decisions [2] and exploration of the city [2].

Despite the initial hype of interest for gamified systems promoting environmental awareness and sustainability [22], studies showed that players' motivation tends to decay in time [2]. Therefore, a plan to reinforce this motivation is required [15]. This plan needs to be tailored on each user since a one-size-fit-all approach is proven to be detrimental [25]. Most importantly, players' individual skills and performance must be considered to keep them in the "flow" - a state in which they feel challenged enough but not frustrated by tasks out of their league [16]. In this regard, Procedural Content Generation is a powerful tool to enhance the game experience and to foster the retainment on a longer term, in that it dynamically generates game elements during the gameplay according to players' styles, abilities and preferences. This customization of game content is highly valuable in avoiding the feeling of frustration in players and in keeping them committed for longer to the game [26, 27]. By automatically adjusting the difficulty of playable units of content to balance players' satisfaction the required effort, Procedural Content Generation fits well in the concept of flow [16], which is recognized as a major factor for fun and retention [16, 28].

## 2 Play&Go: game elements and enabling technologies



**Fig. 1.** Three screenshots of the mobile application, showing the homepage (a), the journey detail (b), and the player profile (c).

Play&Go is an urban game whose main goal is to promote, by virtual and real incentives, a voluntary behaviour change towards a more sustainable mobility habits. In order to participate in the game, a player needs to install the Play&Go mobile app (available on Android Play Store and Apple Store<sup>1</sup>), register to the game, and use the app for journey planning and tracking sustainable trips. The player can also use the app to check his/her status in the game (e.g., points and badges earned, game diary, challenge history, weekly and global leaderboards), share his/her results on social networks (i.e., Facebook or Twitter), and inspect the rules of the game and the weekly prizes. Figure 1 (a) shows the homepage of the app.

The Play&Go game contains different motivational gamification elements, which we describe in the following. First, in order to incentivize players to track their movements, the app assigns Green Leaves points for each tracked journey (see (b) in Figure 1). Supported transportation means are the sustainable ones and precisely, walking trips, bike, bus and train (see (a) in Figure 1). The points obtained depend on the kilometres travelled and the level of sustainability of the transportation means used. The most profitable way of moving is by walking, which gives 10 points per kilometre, followed by the bike, which awards 5 points per kilometre. As for the public transportation means - train and bus - they award 10 points for trips shorter than 1 kilometre, 15 points for trips between 1 and 5 kilometres, and 20 points for longer journeys. o avoid game abuse - for instance, the disproportionate and unnecessary use of transportation means - a design choice has been to introduce limits to the number of kilometres and trips that can be tracked by a player during a single day (i.e., 30 km by bike, 10 km by foot and 8 trips by public transport). Players can still track their movements but, when the daily limit is exceeded, no additional Green Leaves points are awarded.

Each tracked journey (see (b) in Figure 2) is subjected to an automatic validation procedure that assesses whether the trip is legal in terms of minimum length and compatibility with the declared transportation. The validation system is based on the smartphone GPS data, which allows to compute position and speed, as well as on the knowledge about routes and timetables of the public transportation means. If the trip is valid, the computed amount of Green Leaves points is assigned to the player. If players have recurrent journeys, i.e., daily commutes, they can plan them through the journey planner included in the mobile app, save them as recurrent journeys and use them anytime it suits them. The journey planner allows users to save multi-modal trips - i.e., trips with more than one means of transportation.

Players can monitor their history and achievements in their profile (see (c) in Figure 1), where they can keep track of their progress by a variety of **badges** symbolizing particular achievements, such as reaching a certain amount of Green Leaves, or using a specific transportation means (e.g., an additional bike badge is assigned every 10 trips by bike), or exploring mobility alternatives (e.g., when using a designated Park&Ride facility for the first time, i.e. parking lots with public transport connections, or exploring different Bike Sharing stations).

The game is structured in one-week timeframes. At the beginning of each week, an email is sent to all participants presenting personalized challenges, which grant Green Leaves points, and announcing the weekly **prizes**. At the end of the week, physical prizes are assigned to top players and a communication is sent via email with the recap of the weekly activity and the information about the winners.

In fact, the app contains a section dedicated to the weekly **challenges** (see (a) in Figure 2), in which players can keep track of the state of the current challenges and inspect the outcome of the previous ones. On the line of thought that a one-fits-all approach may be ineffective in the process of promoting a positive behaviour change,

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https://play.google.com/store/apps/details?id=it.smartcommunitylab.viaggiatrento.playgo&hl =en and https://apps.apple.com/it/app/viaggia-play-go/id1151014023

the main strength of the game is the employment of highly personalized weekly challenges. Play&Go exploits a Recommendation System (RS) [29] that, for each player, produces a list of personalized challenges by considering the player's game history, habits and skills, aiming at keeping the user in a state of flow [23]. The RS ranks the challenges according to their suitability for the specific player, computing for each one the expected difficulty for that player and a suitable reward.

The RS takes also into consideration the presence of thematic weeks. These weeks were characterized by a theme defined by a preferred transportation mean, i.e., the bike week, the impact zero week. For instance, during the bike week, different types of challenges promoted the use of the bicycle, tailored to the player's profile - i.e., players who were already familiar with the means were asked an improvement in terms of kilometres and trips travelled (e.g., "Do at least 30 km by bike during the current week to earn 200 Green Leaves"), players who were using the bike only in the weekend were asked to reach a certain target of km by bike three (or more) days in the week (e.g., "Do at least 1 trip by bike on 5 days during the current week to earn 200 Green Leaves"), while players who were new to the means were asked to try it (e.g., "Do at least 1 trip by bike during the current week to earn 250 Green Leaves"). The purpose of combining personalized challenges and thematic weeks is to find a good balance between the best choice for the player - i.e., requesting something that was challenging enough, but not impossible to do - and the administration of Trento promoting the initiative - which defined the thematic weeks. This is also a design choice to make the game attractive to and playable by newcomers (who were encouraged to compete in the short-term challenges and ranks), as well as to sustain participation of committed players in the long run and reward an improvement in their mobility habits.



(a) Weekly challenges

(b) Personal game diary

(c) Weekly leaderboard



Figure 2 (a) shows how the challenges are displayed to the player. They aim at improving, or maintaining, the player's performance in the game by asking them to reach a target (e.g., number of trips, number of kilometers) with a certain transport

means (e.g., by bike, foot, bus or train) within a certain time constraint (e.g., in one week, for at least two days in a week, for at least three days in a week). Upon completion, challenges award additional Green Leaves. This reward is calibrated to the difficulty of the challenge and based on the player performances.

Challenges, with respect to other game mechanics in Play&Go that reward the player performance, are specifically thought to promote and reward an improvement in the player's behaviour. Due to their nature, they play an important role towards the main objective of the gamified system: promoting a change in the mobility behaviour of participants.

Players are equipped with a diary of their activities, shown in Figure 2 (b), which lists the trips travelled, the achievements reached, and the challenges assigned. The diary has been inserted in order to support awareness about mobility and related sustainable choices. Through this page, players can also reach the detailed view of a specific past tracked trip, if it has been considered valid or not valid and the collected Green Leaves (see (b) in Figure 2).

**Weekly and global leaderboards** (see (c) in Figure 2) allow players to compare their performance to other players' in terms of collected Green Leaves, to motivate them to reach an even higher score through peer pressure. In fact, research proved that people value others' opinions and an individual's decision to assume a certain target behaviour is affected by how important the others perceive the behaviour to be and whether it is expected to be performed [30]. Furthermore, leaderboards promote social comparison, which can be an important provider of motivation [31].

**Final and weekly physical prizes** are another important motivational aspect of the game. There were 8 appealing final prizes: for example, the final prize for the player who collected the most points over the entire 6-months period was a paid vacation of 3 days in a hotel. However, the main intended emphasis was on weekly prizes, which were smaller but quantitatively many more, since three to four weekly prizes were awarded each week. A prize was assigned to the top player in the weekly leaderboard and the remaining prizes were assigned by draw on the weekly Top 50 (the 50 players with most points collected during the week). Weekly prizes included yearly subscriptions to bike sharing and car sharing, tickets for music shows, sporting events and museums. All the prizes were offered by local sponsors.

Assigning weekly prizes was a design choice to give every player the opportunity of feeling involved, since the weekly leaderboard was reset every week, and every player, including newcomers, started over with 0 points and had the same opportunity to be in the Top 50. In addition, once a player would win a weekly prize, s/he could not win prizes for the following 8 weeks. In this case, our intention was to prevent the most active players to win prizes every week, and to give the opportunity to win also to other committed players.

# 4 Evaluation of participation, user experience, behaviour change and motivation

In this section, we first report on the log analysis of participation during the third annual deployment of Play&Go. Then, we focus on players' mobility behaviour choices and reported user experience with the game, reporting on the analysis of game log, questionnaires and interviews.

## 4.1 Analysis of players participation and mobility behaviour from logs

During the 6 months in which Play&Go was active, we had a total of 1079 registered players. Trips were only valid if tracked within the province of Trento. 635 players (59% of the 1079 registrations) tracked one entire trip. This suggests that at least 40% of the players downloaded the app, registered with it and interacted with the interface, but did not use it on a regular basis. The reasons could be several, ranging from usability issues to different expectations towards the app and the game, to time or location constraints.



Fig. 3. Basic socio-demographic characteristics of the 1079 registered players.



**Fig. 4.** Classification of tracked trips and sustainable kilometres by transportation mean.

Figure 3 summarizes the basic socio-demographic characteristics of the players. Most of the users were aged between 20-35 (39%) or between 35-50 (30%). The game involved participants of both genders, with a slight majority of male participants (56%) over female ones (44%).

In 6 months, the players tracked 54.293 trips (see Figure 4), corresponding to 244.394 sustainable kilometres. Of these trips, the majority were walking trips (53%), followed by bike (21%), bus (19%) and train trips (7%). It is not surprising that the classification of sustainable kilometres by transportation means follows an opposite pattern, i.e. 42% of the kilometres were travelled by train and only 19% on foot. Indeed, one can expect fewer but longer train trips, while walking trips may be more frequent but shorter.

The evolution over time of the game is summarized in Figure 5. Figure 5 (a) shows the number of trips tracked by all the players for each day of the 6-months period, while Figure 5 (b) reports the daily number of active players (i.e. with at least one recorded trip in that day) in the same period. The differences between weekdays and weekends are visually noticeable: weekends are characterized by less trips (about half) than weekdays, and also by less active players. This suggests that Play&Go was mainly used for tracking daily work commutes, but also that leisure trips tracked during the weekend are not negligible. Therefore, we can hypothesize at least two major ways to use the app, one for tracking work-related trips during the week and one for tracking leisure-related trips during the weekend. From a longitudinal point of view, we can see that the number of active players started at around 40 and kept increasing up to the beginning of November 2018. Then it decreased, possibly due to the temperature drop at first, and then to the Christmas holidays. After this period, the number of active players and trips slowly started to raise again. This temporal analysis shows reasonable seasonal and bootstrap patterns and suggests the use of Play&Go was quite stable over time.



Fig. 5. Number of trips tracked (a) and of active players (b) over the 6-months period.

Each active player tracked on average 85.5 trips (SD=180.8) which corresponds to an average of 3.3 trips per week. The distribution of tracked trips is highly skewed, as it is common with participation activity in communities: few players tracked high number of trips, while the majority of players tracked few trips. Precisely, only one player tracked 1302 trips (on average, 7.2 trips for each day) but most players (110, i.e. 17.3%) tracked only 1 trip and 59 tracked 2 trips. Focusing on who participated more, 419 players (66.0%) tracked at least 5 trips, whereas 337 players (53.0%) tracked at least 10 trips. When considering sustainable distances, each player tracked on average 384 kilometres (SD = 1029). We also computed the number of *Active days* for each player, i.e. the number of days in which a player tracked at least one trip. *Active days* has a means of 23.6 days with a standard deviation of 37.6: this means that, on average, each player used the app for tracking at least one trip 23 days during the 6-month period. A fair amount of players (158, that is 24.9%) were active only 1 day. Participants who were active at least 5 days were 359 (56.5%) and participants who were active at least 10 days were 273 (43.0%). There was one participant who was active 175 days out of the 176 days of the game, meaning that this player tracked a trip every single day but one, including weekends and holidays.

We now move to the analysis of participants' engagement with the game by computing the *frequency of usage*. For each player, we first computed the *timespan* as the difference in days between the first tracked trip and the last tracked trip; in fact, since the participation was open, each user could join and leave the game at any point. Then, frequency of usage is computed as the ratio between the number of active days and the player *timespan*. For example, a player who tracked the first trip on October 1st and the last trip on October 30th had a timespan of 30 and, if s/he was active 6 days in this time range, the *frequency of usage* would be 6 divided by 30, that is 0.2. Therefore, a *frequency of usage* of 1 means that player was active on the app every single day of their *timespan*. Here we restrict our analysis to participants with at least 10 active days, because computing ratios for players with very few active days would produce unreliable statistics. The 237 participants with at least 10 active days have an average frequency of usage of 0.57 (SD=0.25), suggesting that engaged players used the app more than half of the days in which they were actively participating in the game. For each player, we also computed the average amount of daily trips, as the total number of trips over the number of active days. Again, we restrict this analysis to the 237 more engaged participants who were active for at least 10 days. The mean is 3.1 (SD = 1.56) indicating these players tracked on average 3 trips per day. Figure 6 shows the distribution in 0.5-sized bins of the average amount of daily trips for these engaged players.



**Fig. 6.** Number of players (y-axis) who registered a certain number of daily trips (x-axis). Only active players (active for at least 10 days) are considered.

#### 4.2 User experience and reported behaviour change

In this section, we report on participants' user experience with the game and on their mobility habits. From a methodological point of view, we used questionnaires and

interviews, first exploring selected aspects of the game experience with a larger audience through a questionnaire, and then focusing on more specific themes with a smaller group of participants through semi-structured interviews.

We submitted the questionnaire as a game challenge to all the registered users during the last two weeks of the experimentation (February 2019), assigning Green Leaves points for filling it in. The questionnaire contained 9 multiple-choice questions with 6 choices each, and was completed by 94 players.

As for the interviews, we contacted by email 10 participants randomly selected from those who had tracked at least ten trips, asking for their interest to participate in a short interview. Of these, 4 volunteered for the interviews. Since we were interested in collecting feedback also from players who had been active for a certain period but then quit, we asked the 4 respondents if they could suggest other participants with these characteristics. In this way we were able to reach and interview other 3 players. In total, we conducted 7 semi-structured interviews (4 females; average age=41; SD=17), which were carried out, according to the respondents' preferences and availability, face to face (4 participants), by telephone (2) or by email (1).

We start by reporting the questionnaire analysis, first describing the basic characteristics of the respondents, and comparing them with the average player, to better position and interpret their opinions.

The 94 respondents tended to be more active compared to the 635 total players: they had an average of *active days* of 80.1, which is higher than the average computed over all the players (23.6 days). Also, the average *timespan* of respondents was 133.8 (all players, 49.5). Considering that the entire game was active for 176 days, they were active 76% of the days, including weekends and holidays. Moreover, the *average amount of daily trips* was 4.2 while this indicator, computed for participants who were active for at least 10 days, was 3.1. On the other hand, the gender of respondents is in line with respect to all the participants: 42 respondents (46%) were female and 48 males (51%; 4 did not provide this information), while in the general population of players there were 44% female and 56% male participants.



**Fig. 7.** Distributions of ratings regarding the appreciation of the game (a), reported change of habits thanks to the game (b), and persistence of behaviour change after the game (c).

These characteristics indicate that the 94 respondents do not represent the average Play&Go participant: self-selection bias can be quite common when the members of a population are free to reply to a questionnaire or not. In our case, this resulted in a higher response rate among the most active and engaged members of the game. To overcome this limitation, we complemented our analysis with interviews including three participants who were active during a period but then quit the game.

Nonetheless, we believe the questionnaire analysis can provide interesting insights in how the game had an impact on participants' mobility behaviours.

The first question was "How would you rate your game experience during these weeks?" (1=very negative, 6=very positive). Figure 7 (a) shows the distribution of ratings; the mean is 4.9 (SD=1.0), indicating that respondents appreciated the game

Another item asked: "Would you participate in a future edition of the game?" and allowed to indicate "yes", "no" and "I don't know". This item received 84 "yes", 10 "maybe" and 0 "no", again suggesting a satisfying appreciation and willingness to be involved again in the future.

The next item we analyze starts considering the perceived impact on players' mobility behaviour with the question "how much did you change your mobility habits thanks to the game?". Again, the respondents could choose one among 6 options (1=not at all, 6=very much). Figure 7 (b) shows the distribution of the ratings: the mean is 3.8 (SD=1.3), which suggests the game had a positive impact on the respondents' beliefs about their behaviour change. The questionnaire also asked "Which transportation means did you try for the first time thanks to the game?". 16 players (17%) reported to have tried for the first time public transportation, 6 Park&Ride, 6 bicycling to work and 4 bike sharing as a result of their participation in the game, suggesting that, according to the respondents' perception, the game was at least marginally effective in encouraging players to try different means of transportation.

Next, we investigated how much the reported change was permanent in participants' beliefs and intentions, with the question "if you have changed your habits thanks to the game, will you keep your new mobility habits as suggested by the app also after the game?". The mean is 4.5 (SD=1.4) and the distribution of ratings is reported in Figure 7 (c). In line with the previous analysis of questionnaire items, these data suggest a success in keeping positive behaviour change.

However, we must consider that, especially when self-assessing their own behaviour, people can be biased, therefore a more thorough analysis of mobility patterns is needed to verify if the behaviour change is really consistent in time. One limitation preventing a rigorous investigation of the impact on behaviour change is that the game is, by design, centered on promoting sustainable mobility, and does not allow users to keep track of unsustainable trips, i.e. car trips. To assess a possible behaviour change based on real mobility data, development efforts should be directed towards incentives for tracking every type of mobility, not only the sustainable ones. However, the trade-offs of a redesign in this direction should be also carefully considered, to achieve a more complete dataset without undermining the persuasive effect of the game towards more desirable sustainable mobility patterns.



Fig. 8. Behaviour change in terms of preferred transportation means used.

Here, we approximated the behaviour of players before the game by means of another questionnaire submitted at the registration time. Respondents declared the number of kilometres they usually did daily, and which was their main transportation mean, including the personal car. At the end of the experimentation, we selected the players that tracked in the app a number of kilometres at least equal to the ones they declared to travel in the initial survey. We compare self-declared mobility behaviour with the trips tracked by players with the Play&Go app. Figure 8 shows such hypothesized shifts.

Again, this approach has some limitations, in that car trips are not trackable in Play&Go. Therefore, we cannot be certain that players replaced the car with more sustainable transportation means. Even though we applied the aforementioned restrictions on the players considered, two other scenarios could have happened: (1) in the questionnaire, participants underestimated the number of kilometres performed daily, or (2) participants started to travel more, and hence, the kilometres tracked represent a percentage of their actual and increased mobility. In these cases, the shift cannot be precisely evaluated because the number of kilometres travelled by car could have remained unchanged, but the number of kilometres tracked with sustainable means could have increased.

In order to reduce these limitations, we complemented the previous analysis with interviews.

All interviewees used sustainable means for their daily commute to work or to the university prior to the game, for both ethical and economic reasons: "the reasons are economic but also ecological, I really want to value and give visibility to the people who use sustainable means" (P1). They used a variety of sustainable transport means, either the bus or train, or they walked or cycled to work. Three participants combined different means to get to work, for example P1 combined the bicycle to get to the train station, the train, the bus, and then walked to the office, P2 walked to the train station, took the train and then walked to the office, and P6 cycled or walked to the train station, took the train and then cycled to work. Three participants used instead one prevalent mode of transport, either the bicycle (P3), the bus (P7), or walked to the university (P4). Despite already being active promoters of sustainable mobility, participants declared that they experienced small changes to their mobility behaviour during the game, especially motivated by the opportunity to collect additional Green Leaves thanks to the challenges, and therefore rise in the ranks and participate in the prize draw. For example, P3 stated that "when you've almost reached your 500 points goal, you'd go for a walk when in other circumstances you'd have gone by car [...]. For sure, if before the game I used more often my car to go to work, during the game I always used the bicycle to score more points". P4 reported that during the game she walked more than usual, extending her trips to gain Green Leaves and win the challenges: "I've always liked walking, but with this game I always try to extend my journey, to change the path, score more points and win the challenges". Interestingly, she also stated that she "kept this change after the game, walking a lot even without using the app". This behaviour change, initially triggered during the game, was later established as a habit: "it became a habit, I cannot do without it". Consistently with this, P7 also reported to have slightly changed her mobility behaviour: "while before the game I always used the bus to get to work, now sometimes I take it on my way to work, but at the end of the day I walk home. For sure, in the weekend I'm stimulated to use the bicycle, which I didn't used that much before, because this game is really engaging".

Because the game aimed at promoting the use of a variety of sustainable transportation means, specific challenges awarded additional points for tracking trips with specific means. According to the interviewees' responses, these challenges were successful when they required minimal effort, while they did not work when the benefit did not exceed the effort. For example, P4 reported that the game "*stimulates you to use alternative means of transport, and I liked this a lot. Sometimes I used the bus because of the challenges.* [...] Later, after the game, I kept using it sometimes, for example when I'm late. I always have a bus ticket with me". Consistently with this,

P7, who was used to the bus to go to work, stated that "the game encouraged me to use other means besides the bus. I have a year-round pass, so I would be tempted to take the bus, but in the weekend I use the bicycle instead". On the contrary, when the effort of changing means of transport was perceived as greater than the potential benefit, players did not accept these challenges. For example, P4 reported "I used the bus, but I did not like the bicycle, because I keep it in the basement, and it takes too much effort to go and take it".

## 4.3 Motivation for behaviour change and attitudes towards the game elements

#### 4.3.1 Intrinsic motivation

According to Self-Determination Theory [32, 33], people's willingness to change their behaviour depends on their motivation and has been applied to several domains in behaviour change interventions, for example for promoting active lifestyle [34]. Self-Determination Theory conceptualizes motivation on a continuum from amotivation (no intention to change) through increasing levels of internal selfregulation, and finally to intrinsic motivation. Whereas amotivation means a lack of purpose or intention to change one's behaviour, extrinsic motivation refers to engaging in a behaviour not for its inherent pleasure, but to obtain some external reward. At the end of this continuum, intrinsic motivation pertains to an action undertaken for the inherent pleasure and satisfaction the activity itself provides.

In the interviews, we aimed to understand participants' motivation to engage in sustainable mobility and to participate in the game, and we uncovered different types of intrinsic motivation. Two participants were primarily motivated by ecocentric values, i.e., the aim to preserve the environmental system. For example, P1 reported: "I use sustainable means of transport because it's an ecological choice. I really want to value and acknowledge the people who move in sustainable ways. [...] I want to value who makes this choice because it's time consuming but there's a minor environmental impact.". Participants were also motivated by the different positive consequences of sustainable mobility on their psychological wellbeing. For instance, P1 reported a car accident she had when she used to drive to work, after which she started using the train, initially motivated by the peace of mind of a low-risk transportation option: "I had a car accident on the freeway on my way home, and after that I decided to use the train". P2 mentioned traffic-related stress: "I am from Rome, and I have a car there, but I avoid it as much as I can, although it is more difficult to use sustainable means of transport. My reasons are to avoid pollution, traffic, personal stress associated with traffic.". P4 stated that walking to the university cleared her mind: "I like the idea of walking, because it sharpens my mind, it helps me a lot. I definitely noticed physical and mental benefits, because you blow off some steam, and in the morning I am sharper, this is very good.". In addition to this, P6 referred to the positive emotional effect of togetherness and social-belonging, the idea of being part of a community: "If they are going to do the award ceremony, I like the idea of meeting the people who participate in the game, seeing the faces of the other participants, of understanding what kind of people play this game". Finally, P6, mentioned the benefits of increasing her awareness about how much she moved in sustainable ways: "I really liked seeing how many kilometres I personally make, because I didn't realize... since I began I was stunned by how many kilometres I travel by train and by bike. [...] I'm interested in keeping track of it.". Awareness of

mobility patterns was also mentioned in the questionnaire by 7 respondents out of the 54 who provided a reply to the open question "What did you like the most in Play&Go?".

#### 4.3.1 Extrinsic motivation: the gamification elements

Extrinsic motivation for behaviour change refers to taking action to obtain some external reward. Questionnaires and interviews revealed that the major motivational elements related to extrinsic motivation were prizes and the gamification features that increase the likelihood to win them, which are individually described later in this section. Interviews also pointed out other minor types of extrinsic motivation, such as saving time and money, or the reward of winning a challenge with a peer. For example, P6 stated: "If I was to take the car, I would waste time, with all the traffic". P1 and P6 mentioned saving money as a motivational element to use sustainable means of transport: "I definitely choose to use sustainable means to save money" (P1); "80 km per day with a car, it costs you more than a train pass" (P6). P4 mentioned the fun of being higher than her boyfriend in the leaderboard: "Very often I had more points than my boyfriend, and more than once I happened to be higher in the leaderboard, so there was competition between us. This was fun".

However, the main extrinsic motivational elements were the ones within the game, described in Section 3. The questionnaire asked to assign a value from 1 (most appreciated) to 7 (least appreciated) to each one of the 6 motivational elements. The most appreciated elements were **challenges**, which received an average score of 2.8 (SD=2.0), followed by **leaderboards** with a score of 3.3 (SD=1.8). The ratings of the 6 motivational elements are reported in Table 1.

**Table 1.** Average rating received by the 6 motivational elements (1=most appreciated, 7=least appreciated).

Motivational element Average rating		SD
Challenges	2.78	2.04
Leaderboards	3.33	1.80
Points (Green Leaves)	3.98	1.93
Weekly prizes	4.01	2.08
Final prizes	4.43	1.95
Badges	4.45	1.72

The questionnaire also contained three optional open questions: "What did you like the most in Play&Go?", "Is there something that you didn't like in Play&Go?", "Do you have any suggestion or idea to improve the app and the game Play&Go?".

54 respondents replied to the first open question and 17 of them specifically mentioned challenges as one of the things they liked the most in the game. First, we explore challenges as an extrinsic motivational element, then we continue with each gamification element listed in Table 1, ordered by user preference.

#### Challenges

To provide an overview on interaction patterns with the challenges, we first report basic statistics about how many challenges players received and how many of them were successfully completed. Players received 2 challenges each week, starting from the second week of game, plus 3 challenges not related to mobility performances (2 surveys and 1 event participation): the maximum number of challenges received was 53, considering that the 2018 editions lasted 26 weeks. The average number of received challenges was 39.3 (SD=12.0). 62% of the players (391 out of 635) received at least 40 challenges and 82% (518 players) received at least 30 challenges. These data show that most players had several chances to interact with challenges.

As it might be expected, not all the challenges were completed. On average, each player completed 6 challenges (SD=8.6). Only 119 players (18.7%) completed at least 10 challenges and, for instance, 77 players (12.1%) were not able to complete any challenge and 156 (24.6%) completed only 1 challenge and 106 (16.7%) completed 2 challenges.

Since challenges emerged as an important motivational element for the 94 responders to the questionnaire, it is important to analyze statistics about completed challenges for them. The respondents received on average 40.3 challenges, which is similar to the average over all the players (39.3) with a similar standard deviation (12,8 versus 12.0). On the other hand, when we consider completed challenges we get a different picture: the 94 respondents completed on average 19.6 challenges (SD=11.3) while the 635 players completed 6.0 challenges (SD=8.6): these data are in line with those presented in Section 4.2 and suggest that respondents are not prototypical players, therefore their appreciation for challenges should be considered also according to this. 44 respondents (46.8%) completed at least half of the proposed challenges, and 17 (18.0%) completed at least 75% of the proposed challenges.

However, there were aspects of the challenges that were not appreciated by respondents. Out of the 43 replies for the questionnaire open question "Is there something that you didn't like in Play&Go?", 8 mentioned challenges with negative comments such as "impossible", "absurd" or "not well explained". What is considered impossible is of course subjective and depends on individual habits and commitment, as stated in this comment: "Some challenges were impossible for me because I never use public transportation since I prefer walking". Here, the challenge is not impossible per se but requires a behaviour change that is considered "impossible" by the respondent. Another respondent complained about the personalization of challenges: "I didn't think it was right that some players received simpler challenges than others, in terms of required kilometres or number of days, and also that, given the same challenge, the awarded points were different".

In order to complement what emerged from the questionnaire, we also investigated challenges in the interviews. All the interviewees were aware of the challenges and considered them an important motivational element, mainly because they provided additional points upon completion. P3 "Yes, I know challenges were there, I have used them. They have been very motivating because they gave a large incentive in terms of points and so you could re-enter in the leaderboard and so you could win prizes". The additional points were also mentioned as a successful incentive for changing behaviour as for example by P6: "That day I changed my behaviour because I say to myself '200 points got so easily!', I left there my bike <...> I took the bus together with students and then I also got back with the bus".

In other cases, the aim of the challenge towards provoking a behaviour change was not effective. P2 "I saw the challenge to walk 2 kilometres, I got stimulated and I did it. There was the challenge to fill a questionnaire and I did it. And also, other challenges that I did for getting points. Then, the app told me 'Take the bus twice' and I didn't do it. At that point my interest in challenges decreased. I think they tried to get me back by telling me to walk but it was too late".

Similarly, P4 reported how challenges could be upsetting when requiring excessive effort: "I also took the bus because there was a challenge, the only one I didn't like was the bicycle <challenge>, because I keep it in the basement, and it takes too much effort to go and take it. Anyway, sometimes I took the bus that is still a green transportation mean".

<sup>&</sup>lt;sup>2</sup> Standard deviation

In summary, it seems challenges are a well-known motivational element, also because they are the predominant content in the weekly email to participants. However, they were mostly liked because they award additional points, which increase the chances of getting prizes. Moreover, challenges also aim at triggering behaviour change, and this sometimes encompasses a friction with habits: in this case, the challenges can be effective but also annoying. Thus, it is important to tailor them very well to the specific player, maybe proposing behaviour change as "additional" challenges with an adequately inviting number of points.

#### Leaderboards

Leaderboards were the second gamification element according to the questionnaire (see Table 1). Leaderboards received an average rating of 3.33 (SD=1.80). Again, to this regard it should be reminded that respondents to the questionnaire were on average active players. For instance, respondents got an average number of Green Leaves points of 13,149, while the overall average was 3457. This suggests that the 94 respondents were solidly occupying the Top 50 leaderboard (both weekly and global). In fact, most of the interviewees reported dissatisfaction with the leaderboards mainly because they were populated always by the same, very active players (and interviewees were not among them, with the exception of P6). P2 reported: "They also give a prize in the Top 3 but there is no hope to enter in it. The Top 3 was always the same, there were these 3 exalted people that I don't know what they were doing but they were always on top". Similarly, P7 stated: "you always see the same person in the leaderboard, this is a bit demotivating, you think you will never arrive there. I would stretch the timespan in which you cannot win a second prize, or I would allow players to win the weekly prize only once and then the final prize, in order to give a chance also to the other players".

Leaderboards (and their relative stability and inaccessibility) were also mentioned as causes for quitting the game. P2 reported: "At first I was enthusiastic about the game, I liked it, however then there was this problem that it was difficult to enter the Top 50 which is the main aim for which one plays, so <...> when I saw that I was not able <to enter the Top 50>, I abandoned". And P7 "I suggested the game to some friends, they started playing but then they quit using the app because you always see the same person and they were a bit demotivated". This feeling of never being able to reach the top positions and to be excluded was perceived by most players, and is one of the known shortcomings of global leaderboards [35].

In the open field of the questionnaire for suggesting improvements, a respondent proposed to "*Create groups for challenging selected players in which there is a separate leaderboard*". This is the idea of social leaderboards, which might mitigate the negative effect of global leaderboards [35], however it is not straightforward to imagine how to assign prizes to local leaderboards.

Both interviewees and respondents to the questionnaire mentioned the fact that in this Play&Go edition many cyclists (with free time and passion) often occupied the first positions but that they were not using the bicycle for work-related trips but for leisure. A reply in the questionnaire about not appreciated aspects stated *"It's a pity you can never reach the first positions because there are the retired cyclists who have a lot of free time for practicing sport"*. And also P4 *"in the first positions it was very hard because those people were doing many but really many kilometres, I believe they were those going with the bicycle, by the mountains. Those players are unreachable, period"*. This point opens the discussion about how points in general are assigned to the different transportation means, which is what we are going to analyze in the following section.

#### Points (Green Leaves)

Points are at the base for all the other gamification elements: they define the player position in the leaderboard, which determines their possibility of winning a prize. But, taken alone, they are not in general motivating. Only one interviewee, P4, mentioned points as a motivational element by themselves, P4: "Of all the 6 motivational elements, the one motivating me the most are the green leaves, the leaves because I was winning many of them, because walking a lot, I accumulated really a lot".

In general, mentions to points both in interviews and in the questionnaire were related to complaints about how points get assigned to the different transportation means. For example, out of the 43 replies to the open question in the questionnaire "Is there something that you didn't like in Play&Go?", 11 respondents mentioned how points get assigned. Typically, questionnaire respondents and interviewees suggested to give more points to the transportation means they used the most. Complaints from different questionnaires (fields about complaints or suggestions): "the few points you receive for walking and bus trips", "points given to bicycle/foot should be more than bus/car sharing because they are different in terms of CO2 emissions", "less point to electric bike", "Bicycle is favoured with respect to bus", "Less points given to bicycle with respect to walking". Again: "give more value to those who do a lot of short trips without car because they work in town" and "Users who live further to their workplace have advantage in earning points", and "The points they give for train is extremely small (I receive 40 points)" (P6).

In general, as already stated in the previous section, participants complained about the fact that for getting many points and being competitive they needed to track very long trips on foot or by bicycle either during the evening, after work, or during the weekend. The players who used sustainable transportation means for work-related trips stated that they could not reach the first positions, which were perceived within reach only to those with the passion and time to track lots of leisure-related trips (walk or bicycle) during evenings, weekend or their copious free time if they are retired and no more working. P6 reported: "I check the other participants and how many points they have. Those who have lots of points are those who track 30 kilometres per day, but for pleasure, by bicycle. Of course 30 kms by bicycle are better than 30 kms by car but they can. All the kilometres I do with the bicycle are those I track for work. I walk in my free time, Saturday and Sunday. But the rest is entirely for work. I have many points, I am always in the first 7 but I will never reach the first ones in the leaderboard because I checked, and they have kilometres and kilometres of bicycle trips but I can't come back home <after work> and start making kilometres by bicycle"

In general, how to assign points touch on the very strategic goal of which behaviour (and changes of behaviour) the Play&Go game wants to value more, and this is a strategic decision with a lot of tradeoffs which we will discuss in the next section about lessons learnt.

#### Weekly and Final Prizes

Out of the 54 respondents who wrote something with regard to the open question "What did you like the most in Play&Go?", only 5 of them mentioned prizes as one of the things they liked the most in the game. In addition to this, according to the questionnaires prizes were the least appreciated element in the game, followed only by badges (see Table 1). Weekly prizes got an average position of 4.01 (with 1 being the best and 7 being the worst) and final prizes of 4.43.

Actually, prizes are the final motivational element and are assigned based on the scores provided by other gamification elements: challenges award points that sum to the ones from tracking trips, points define the player's position in leaderboard, and one's position in leaderboard gives access to the possibility of winning the weekly prizes.

However, a comment to the questionnaire noted "Without prizes probably nobody would use the app". Even if this is probably a bit too extreme, it seems reasonable to assume that a substantial number of players participated in Play&Go because of the prizes. This clearly emerged from the interviews. Actually, all the interviewees (but P1) mentioned prizes as the best incentive and motivator:

P3 "weekly prizes were the most incentivizing thing and final prizes relatively so, because they could be more incentivizing because they are larger but <...> now that professional cyclists have arrived <...> it is impossible to reach them and so they lost their value."

P2 "exclusively weekly prizes that motivate me a lot, then the challenges, all the others are not motivating for me"

P5 "I set my goal of remaining every week in the Top 50 <to get extracted for prizes>"

P4 "the goal was to enter the Top 50, in order to be among those who could win the prizes when extracted, period.

P7 "actually my main motivation for using the app is winning the weekly prize, because the final prize is impossible, you need lots of points. Maybe a retired person or someone with a lot of free time can do it, but <using it> only during the week, I believe this is not feasible."

P6, on the other hand, which was always in the 7th position, was motivated by the final prize, and specifically the 3-day holiday.

#### Badges

The least appreciated motivational elements in the questionnaire were "badges", for which the average rating was 4.45 (SD=1.72). They were also mentioned only twice by interviewees, and P4 did not even remember the presence of badges in the game "sincerely, badges, I don't know and ... it can be, I have received a leaf and another small blue coin". P3 argued directly about their motivational power and possible reasons for it: "badges have null value as incentive, meaning that, if getting a badge would give you more points, then it could have a meaning; otherwise, just for having the small icon that nobody sees, for me the value is almost null".

This comment might suggest that badges could have a larger and more positive impact as motivational elements if they would be associated with points and also if they could become more visible, for example near the nickname of players in their pages or on the leaderboards.

#### 5 Conclusion and lessons learned

The third edition of Play&Go counted 635 players who tracked at least one trip, with more than a half (337 players) tracking at least 10 trips. According to the questionnaires and interviews, players appreciated the game and reported a behaviour change towards more sustainable mobility patterns. One limitation of the questionnaire is self-selection bias, in that the 94 respondents were among the most active users. To overcome this limitation, we included in the interviews players who had been active in the game for some time but then quit. Participants stated that they experienced a behaviour change toward sustainable mobility, and that they maintained their new mobility habits after the game ended. Data suggest that, while this behaviour change was initially triggered during the game leveraging on the extrinsic motivation related to the opportunity to win a prize, it was later established as a longterm habit. Of course, self-reports alone are not enough to prove such behaviour change, and an open issue for redesign relates to the deployment of features aimed at obtaining a baseline that can be exploited to effectively measure players' behaviour change. This would mean to motivate people to track also non sustainable trips, at least for a short period at the beginning of their game experience. A possibility to be further explored is to reward players, in the first game stages, to let the app run in background and track all trips taken. On the one hand, this baseline could be exploited to compute the impact of the game in terms of behaviour change, and on the other hand it could be used to reward the improvement, rather than the performance of the player.

This would also be an opportunity to direct development efforts towards the resolution of the usability issues reported by the players. In the open question of the questionnaire "Is there something that you didn't like in Play&Go?", 13 out of 43 respondents mentioned tracking problems and 3 lamented too much time required by the app to validate trips and hence assign points. In fact, the current version of the app needs a continuous and simultaneous access to the Internet (for reaching Play&Go servers) and to the GPS. If the access to the Internet or GPS is lost for several minutes the trip is not tracked, and this fact was lamented also by interviewees. Related to this, feedbacks were also related to battery drain, which is caused by having the Internet and GPS always running during the trip. In the questionnaire and interviews, players suggested to provide visual feedback during tracking in order to let the user know if everything is up and running. Someone also suggested to let players auto-certificate trips in case of software problems.

With regard to participation patterns, the evolution of tracked trips over time (Figure 5) highlights a noticeable difference in the usage patterns between working days and weekends, which were characterized by less trips and less active players. This, consistently with the results from the questionnaires and interviews, suggests the possible presence of at least two user profiles: players who mainly use the app to track daily commutes, and players who use it for leisure trips. The presence of these user profiles is also supported by the reported user experience with leaderboards: while, on the one hand, they were the second most appreciated gamification element in the game, both respondents to the questionnaire and interviewees reported dissatisfaction with them because they believed the top ranks were populated by the same active players with plenty of free time to track leisure trips. This opens the opportunity for redesign both in terms of point assignment rules and the differentiation of user profiles, or purposes of use of the app. Point assignment rules define how many points are awarded to different transportation means, including the maximum number of points per day for each mean and possibly the definition of daily and weekly time bands for earning points with specific means. The differentiation between user (or trip) profiles refers to the possibility to distinguish users (or trips) based on the purpose of use of the app (i.e., commuting or leisure). The main strategic question behind this is the type of mobility that Play&Go aims to reward. If it is sustainable transportation for commuting, then leisure trips, which typically occur by bicycle and on foot (i.e., running or walking) and during evenings and weekends, should probably be counted separately or not at all. Of course, it would be difficult to discriminate between commuting and leisure trips, and the game should probably rely on a certain level of auto-certification. Therefore, this issue is very open and trade-offs needs to be carefully considered; what we learnt from the third edition of Play&Go is that, given the current point assignment rules, and despite the daily limits imposed by the game, the top ranking positions in the leaderboard were solidly occupied by players who had both the passion and the opportunity to track several kilometres by bicycle and on foot, probably in their free time, and that other players felt excluded from the opportunity to reach the top positions even with their best efforts. A design choice that might mitigate this issue and could be a challenging area for future work is the introduction of level-based leaderboards, where players compete for real and virtual prizes only with their peers, both in terms of expertise and performance.

We conclude with a comment about personalized challenges. Although being, in this and in past editions, the most appreciated and motivating game element for players, issues emerged from the collected feedback. Having thematic weeks influencing the recommendation of challenges and proposing sudden shifts of transport habits (e.g., from bus to bike or walk) has proven to be annoying for some players. A design choice that might be worth considering is the possibility of providing a set of alternative challenges, all targeted to the player's performances in terms of difficulty and requiring an improvement in terms of mobility habits, and let the player choose the one to be fulfilled.

In this paper, we described the game platform and reported on its deployment in terms of user participation, user experience, mobility patterns and motivational elements with game log analysis, questionnaires and interviews. The results suggest a positive impact in users' perception of a behaviour change towards more sustainable mobility patterns and highlighted interesting areas of improvement that we believe can not only be applied to Play&Go, but also to other digital games for sustainability.

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