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EMPIRICAL RESEARCH

Ingredients for successful badges: evidence from a field experiment in bike commuting

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ABSTRACT

Despite the popularity of badges in gamification applications, there is a lack of research on how to design badges to increase target behaviour. Motivated by this gap, we conduct a large-scale field experiment in a commuting-by-bicycle programme to explore efficacies of different badge designs in motivating ridership. We systematically vary the *rewards, signifiers*, and *completion logic* components of badges. We find adding an option for sharing a badge on Facebook, as a reward for badge attainment, increases ridership. Changing the badge signifier from a self-interested frame to a pro-environmental frame does not make a difference. Changing completion logic from a fixed to a relative goal increases ridership only among frequent riders. These findings have direct implications for gamification design and provide useful directions for research into the motivations behind the design elements.

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1. Introduction

A badge is a token for marking an actor's achievement, status, or membership (Cruz et al., 2017; Hamari, 2017). From well-known implementations such as military medals and scout merit badges, badges are a popular way of rewarding positive behaviours and have been incorporated into video game platforms such as the Xbox and PlayStation. Not surprisingly, badges are among the most-used design elements for gamification, which refers to "the incorporation of game design elements into a target system while retaining the target system's instrumental functions" (Liu et al., 2017, p. 1013). Recent surveys report that badges are used in 61% of gamification studies that utilise achievement affordances (Bui et al., 2015; Koivisto & Hamari, 2019). Badges are standard features of many commercial implementations of gamification (e.g., Fitbit, LinkedIn, and Moodle), and have been used in a wide range of settings including learning, health, non-profit, marketing, and online platforms (Mutter & Kundisch, 2014).

Despite the widespread implementation of badges, the extant research on badge design is very limited. In general, a badge has three main components (Hamari & Eranti, 2011): *rewards, signifiers*, and *completion logic*. *Rewards* refer to benefits and affordances that accrue to the player as a result of earning the badge. *Signifiers* refer to cues associated with a badge, including the title, additional text, and visual signifiers such as icons. *Completion logic* refers to the conditions that must be met for the badge to be earned. Each of these components can be implemented in several different ways, leading to a large variety of badge designs. Yet very few studies have directly addressed badge designs. Other than Hamari (2013)'s research on the roles of clear goals and visibility and Kyewski and Krämer (2018)'s research on badge visibility, many aspects of badge design remain unexamined.

Research on badge designs is important for at least two reasons. First, the effectiveness of a badge system is a function of its design (Liu et al., 2017). So far, academic research on gamification has been slow in engaging and contributing to the design aspects of gamification systems and services that have been actively explored in practice (Rapp et al., 2019). This prevents researchers from evaluating gamification at its best and from explaining mixed findings that arise from very different designs (Koivisto & Hamari, 2019). Second, design insights are extremely important for gamification practice. Reports suggest that many gamification systems are expected to fail because of poor designs. Badge designers, in particular, face a large number of design choices, and insights on how to choose among them are important for fulfiling the promise of badges. For example, designers often spend a lot of time designing different badge signifiers without knowing how they may impact target behaviours.

To evaluate the efficacies of alternative designs, it is important to employ full randomisation and control conditions (Koivisto & Hamari, 2019). However, recent reviews of gamification research indicate a lack of such rigorous study designs. Our review of

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studies of badges finds a similar pattern: a majority of studies rely on qualitative interviews (Sitra et al., 2017) or stratified design experiments (Hakulinen et al., 2015). Randomised experiments could add a lot of value in complementing and validating the existing findings, but such studies are still rare in badge studies. To address the aforementioned gaps, we design and test alternative badge designs in a large-scale field experiment. We choose to implement a badge system within a bike commuting program at a large university. Bicycle commuting is an excellent research context for testing badge designs: despite many health and environmental benefits of bicycling, people do not ride bicycles to work or school as frequently as one would hope. We propose the use of gamification systems to promote bicycle ridership as a promotional mechanism.

We vary three components of a badge, namely *rewards, signifiers*, and *completion logic* by implementing two popular designs for each component. We test these alternative badge designs using a 2 × 2 × 2 between-subjects design in a seven-week large-scale field experiment. Our goal is to examine how different badge designs affect bicycle ridership, as measured by the number of bike riding days, among faculty, staff, and students of this university.

We contribute to the literature in two main ways: This is among the first studies that focus on the design aspects of badges. Our study design allows us to isolate the effects of individual design dimensions on target behaviours. This expands from the literature's early focus on the effects of mere availability of badges, thereby opening badge research to a wider array of design choices in contemporary gamification applications. Second, we add to the empirical literature surrounding gamification by conducting a large-scale randomised field experiment utilising badges in a manner similar to common commercial gamified systems. The details of the literature concerning the effects of badges and their design, and our hypotheses for the effects of each design feature, follow in the next subsections.

2. Literature

2.1. A brief overview of badges in games and gamification

Badges first appeared in wide use on the Xbox 360 console in 2005, termed "Achievements." Badges were optional to the game's main goals and had no direct in-game benefits. In the 2007 game *Assassin's Creed*, for example, an "Eagle's Will" badge was awarded to a player for "defeating 100 opponents without dying." Those who completed the game without unlocking the badge incurred no penalty. The main purpose of badges was to motivate players to take on more challenges beyond the game's primary objective and allow them to display their achievements within and across games.

Badges implemented in gamification settings, similar to those implemented in video games, are optional for task completion, which makes it quite easy to add badges to an existing system without significantly changing the system's mechanics. This may partly explain their popularity within gamification applications.

2.2. Design of gamified systems

Definitions of gamification necessarily invoke the structure of games. Deterding et al. (2011), for example, refer to gamification as "the incorporation of game design elements into a non-game system," (p. 10) while Liu et al. (2017, p. 1013) define gamification as "the incorporation of game design elements into a target system while retaining the target system's instrumental functions."

Gamified systems are *persuasive systems*, i.e., systems intended to influence behaviour (Blohm & Leimeister, 2013). They are distinct from games, which are characterised by "explicit rule systems, and competition or strife of actors in those systems toward discrete goals or outcomes" (Deterding et al., 2011, p. 11). Thus, while gamified systems utilise elements that are commonly found in games, their purpose is distinct in that they have the specific aim of trying to influence the behaviour of the user. As such, the design of gamified systems is focused on the persuasive power of the elements themselves, their effects on beliefs and/or behaviours, in contrast to games that utilise these elements to increase the hedonic value of the system.

Prior research on gamification primarily has been concerned with the addition of structures rather than the design of structures. While research on the design of individual elements is thin, prior surveys of users of gamified systems find that graphical representations of badges are preferable to non-graphical ones, and leaderboards are less important than badges (Kuo & Chuang, 2016). More recently, research on a "one-size-fits-all" design of (non-gamified) dashboards calls into question the use of non-personalised persuasive systems (Teasley, 2017).

As such, research directed at the design of gamification system elements is somewhat thin. The bulk of research activity on gamified systems focuses on the implementation of structures rather than the design of the structures (Koivisto & Hamari, 2019). We turn our attention to badges as a common and promising element of gamification design.

2.3. Effects of introducing badges

The effect of introducing badges has been most studied in educational settings, where third-party plugins and tools are available to course designers to add badges in learning management systems (e.g., Moodle and Blackboard). Within this context, before-and-after studies find that the addition of badges increases self-reported measures of self-efficacy (Yang et al., 2015) and engagement (Ding et al., 2017). Besides, using qualitative interviews, Sitra et al. (2017) find that the addition of badges increases a target behaviour such as course performance. However, these positive findings in education have been limited by the lack of a control group. Among studies using controlled experiments, badges increase participative behaviours like the time spent in the learning management system and the number of logins, but do not show a significant relationship with learning outcomes such as course grades (Hakulinen et al., 2013, 2015), and some studies are inconclusive about the effects of badges (Domínguez et al., 2013; Kyewski & Krämer, 2018). It should be noted that while these were controlled experiments, to prevent the risks of contamination among students who take the same course, the experiments employ stratified designs, applying the manipulations by class, rather than full randomisation.

Outside of education, researchers have studied the effect of badges in online community forums. Bornfeld and Rafaeli (2017) show that the addition of a badge incentive increases targeted behaviours. Users increase their contributions to the forums when they are about to earn a badge (Goes et al., 2016; Yanovsky et al., 2019); however, users' contributions drop significantly after they have just earned a badge (and are still far away from the next-level badge). These dynamic effects of badges are consistent with the goal-gradient and small-area hypotheses (Mutter & Kundisch, 2014, 2015), whereby behaviours ebb and flow as a motivating goal or sub-goal is approached and achieved.

Beyond these common gamification applications, studies in other areas have exposed mixed or even negative effects of badges. In the context of a peer-to-peer trading platform, Hamari (2013) shows that the mere implementation of badges does not lead to an increase in the target behaviour; but, users who actively monitor their own and others' badges show increased activity. This points to a possible social component to the badge's effect. Alternatively, a qualitative study by Rapp (2015) highlights that some users view badges as "useless, unless they could be exchanged with physical objects or monetary rewards" (p. 73) and others became disinterested because of a lack of variation (e.g., "Badges are all the same. They are only images", p. 74). Interviews conducted by Hakulinen et al. (2013) echo similar sentiments. These findings suggest a more instrumental, rather than intrinsic, motivation. Therefore, despite the suggestion by a recent meta-analysis that badges and achievements generally have a positive result on the target behaviour (Koivisto & Hamari, 2019), our literature review suggests that the effects of badges are more nuanced.

2.4. Design of badges

Signifiers are an obvious and frequent target for manipulation, as different images and text can be swapped to modify the badge. For example, at launch, Fitbit badges for daily steps were presented only as a numerical figure ("5,000", "10,000") and later changed to a shoe theme ("Boat Shoes", "Sneakers"). Reward aspects of badges have seen heterogeneous implementations as well: for example, rewards can be implemented in a manner such that earned badges are visible only to oneself (Auvinen et al., 2015; Sitra et al., 2017), while others are visible to others (Yang et al., 2015). In this example, the affordance awarded to the badge earner – the ability to display one's achievement – varies in different applications. Completion logic can similarly be presented to the user using different framing without modifying the underlying behaviour required to earn the badge ("Score 10 points" versus "Get a perfect score"). In each of these cases, the efficacy of the change (if any) is of interest to researchers as well as designers of information systems utilising these constructs.

One plausible reason for the mixed findings on the effectiveness of badges is that badges are not all the same. For example, some badges are visible to others, while other badges are visible only to oneself (Auvinen et al., 2015). Several studies explicitly categorise badges as having different status, e.g., awarding Gold, Silver, and Bronze badges (Kyewski & Krämer, 2018; Šuníková et al., 2018); while in others, badges are homogeneous in status with no badge outwardly indicated as superior (Hamari, 2013). Evidence suggests that not all badges are equally motivating (Hakulinen et al., 2015), and that badges may have heterogeneous effectiveness in terms of users' goals (Hamari et al., 2018).

Thus, while badge designs can vary quite considerably, existing research is thin on the effectiveness of alternative badge designs. To our knowledge, only two studies have explored the effectiveness of different badge designs. Hamari (2013) distinguishes badges with and without clear goals and those with and without the ability to view other users' badges, though he finds no significant differences for either factor. Similarly, Kyewski and Krämer (2018) also compare designs where users may or may not see other users' badges; they find no difference.

As suggested above, the literature also lacks a consensus on the sources of badges' motivational power. In most implementations, badges exist only as virtual imagery without tangible rewards or even physical tokens (e.g., a pin). Therefore, some researchers highlight the role of badges as an intrinsic motivator that provides a clear goal, immediate feedback, and a symbol of progress and mastery. However, badges do have an external locus of causality, in that they are awarded by an external entity (i.e., the system's designer) to influence users' behaviour. This is especially true where badges are publicised, which facilitates social comparisons and social proof. Perhaps because of these properties, several studies consider badges as external rewards (Cruz et al., 2017; Mutter & Kundisch, 2015). We believe that badges can serve both as an intrinsic motivator and an extrinsic one. Our focus in this study is on the design aspects of badges, and more specifically the perceived benefits that the badge elements can provide.

3. Research hypotheses

We draw on expectancy-value theory to understand the relationship between badge reward design elements and ridership. The expectancy-value theory is a long-standing perspective on how motivations influence people's persistence on (or choice of) achievement tasks (Eccles et al., 1998). It argues that individuals' persistence and vigour in an activity can be explained by the extent to which people expect to reach the outcome ("*expectancy*") and the attractiveness of the outcome ("*value*") (Eccles, 1983). The value component of the model is generally operationalised as a combination of importance and desirability (Eccles, 1983). Furthermore, it can be a function of both extrinsic rewards (which could include economic and social benefits) and intrinsic rewards such as enjoyment and satisfaction. Expectancy-value theory suggests that heightened expectancy and value can lead to higher persistence in a task.

We posit that different badge-reward design elements can affect people's perceived value of a badge and thus their accomplishment of the task of interest – bike riding. We focus on three badge design features in turn within three key aspects of badges identified earlier – rewards, signifiers, and completion logic.

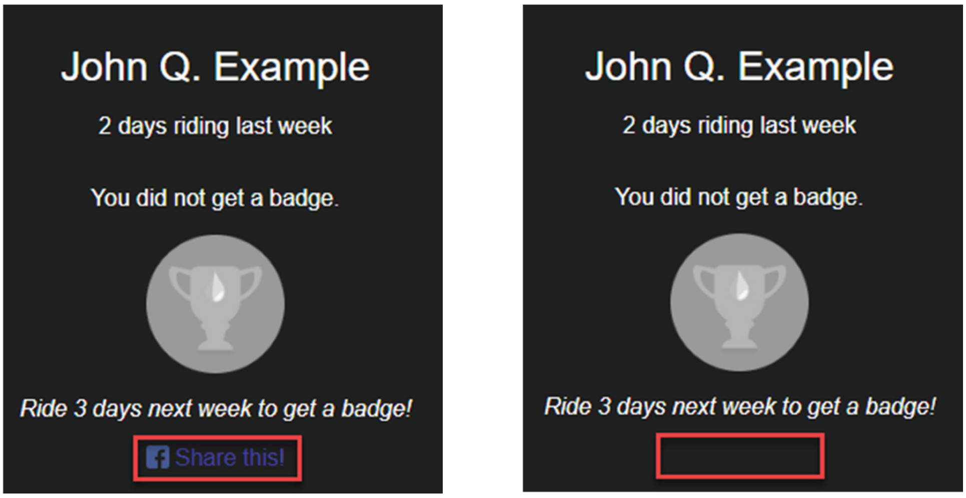
3.1. Rewards: with or without a sharing option

As a reward, every badge has a specified goal for its achievement. As such, the reward of a badge serves at least two functions. First, it provides a clear goal which can be used to guide a user's behaviour, and immediate feedback for achieving that goal (Hamari, 2017). Second, it serves as a reminder to the user of having achieved the goal. This is especially true in cases where a user actively monitors their badges (Hamari, 2013), and acts as a record for the rediscovery of prior actions and maintaining motivations of consistency (Zhang et al., 2014).

When a badge is not visible to others, the benefits of a badge are goal-motivation and self-signalling, i.e., actions that help an individual maintain a positive self-concept even in the absence of social or economic benefits (Gneezy et al., 2012). For example, a "star rider" badge reminds users that they are physically active, which can make them feel good about themselves, providing some degree of self-benefit. When there is a possibility that a badge can be shared on social media, however, an individual may obtain additional rewards from earning the badge. Just like a scout may derive added benefits from displaying merit badges to others, the promise of an ability to share badges on social networks can have added benefits such as social acceptance, status, and relationship maintenance (Dunne et al., 2010; Lee & Ma, 2012). For example, knowing that a bicycle-commuting badge can be shared among Facebook friends may provide an incentive to gain or maintain a social image of being physically active and healthy that would be desirable to share. Prior research shows that social image is a powerful motivation for behaviour ranging from choosing food (McFerran et al., 2010), engaging in pro-environmental behaviour (Goldstein et al., 2008), and choosing to get seasonal vaccinations (Milkman et al., 2011), among several others. According to expectancy-value theory, an individual spends more effort in achieving an outcome when it is seen as more valuable (Eccles, 1983). Expectancy-value models of motivation are predictive in many empirical tests, including in sports participation (Eccles & Harold, 1991), as well as in moderating the relationship between achievement goals and outcomes (Plante et al., 2013). Therefore, we expect a badge design with a sharing option to induce a higher ridership than one without.

Notably, the above argument relies on the *anticipated* value of a badge. It does not require that an individual has earned the badge or shared it in the past. Doing so might provide additional benefits; but, in the present study, we focus on the possibility of sharing itself as a possible source of added benefit. As long as an individual expects additional value from social sharing (should she earn the badge), the expectancy-value theory holds that she would work harder towards the badge. If a fraction of the population cares about sharing the badge on social networks, the average effect will be positive compared to the lesser value of a badge without the sharing option. Badge examples used in the study are in Figure 1. We hypothesise:

H1 (***Rewards***)*: A badge design with a link to share the badge on Facebook leads to higher ridership than a design without such a link.*



With a Sharing Option — Without a Sharing Option

Figure 1. Two reward designs: with or without a sharing option.
Note: The differences between designs are highlighted. In the left panel, we display the link whether the user earned the badge or not.

3.2. Signifiers: self-interested vs pro-environmental framing

The second component of badges are signifiers, including visual elements like the title, image, and additional text associated with the badge. A signifier denotes the type of achievement and distinguishes it from other achievements. Some badges recognise self-focused achievements, such as those used in military and scouting contexts. Others adopt a prosocial or pro-environmental framing. Stack Overflow, a knowledge-sharing network, has badges titled “Lifeboat” (for answering poorly-rated questions with good answers) and “Sportsmanship” (for voting up answers that are competing with one’s own), recognising the prosocial nature of desirable actions and framing them in a positive light. Other implementations emphasise the pro-environmental nature of achievements, such as “eco scores” in cars for driving in a manner that minimises emissions.

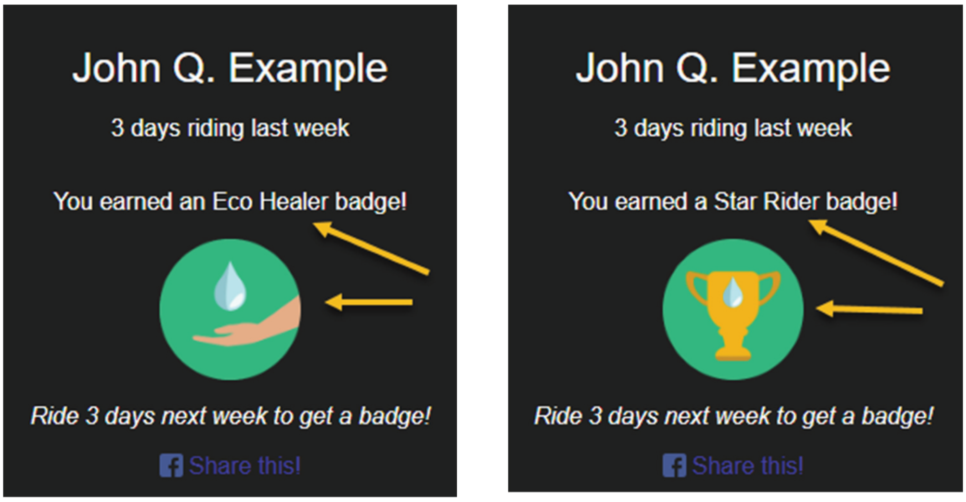
Message framing is known to affect the perceived benefits of a health activity (Li & Chapman, 2013), and thus, according to the expectancy-value theory, may affect motivation. But the research on the effectiveness of self-interested versus pro-environmental framing is scant and mixed. The primary purpose of a pro-environmental/prosocial act is to do something positive for the environment or others, but research shows such an act can also increase one’s psychological welfare, creating a positive experience of “helper’s high” or “warm glow” (Andreoni, 1989; Erlandsson et al., 2016). Dunn et al. (2008) report that people who spend money on others report a higher level of happiness than those who spend money on themselves. Taufik et al. (2015) demonstrate experimentally that a sense of acting environmentally friendly can elicit a warm glow. Many participation sports events for charity use a prosocial or pro-environmental framing (e.g., “5 K for Cancer” and “walk for animals”) to attract participants and donors (Filo et al., 2011). There is growing evidence that pro-environmental or prosocial framing can be more motivating than self-interested framing (Steinhorst & Klöckner, 2018), especially when prosocial benefits are framed in the context of the local community (Bain et al., 2012). In the domain of health behaviours, field studies show that healthcare professionals increase hand hygiene when the sign of soap dispenser emphasises patient safety rather than personal safety (Grant & Hofmann, 2011). A more recent study shows that the prosocial framing of COVID-19 prevention messages is more effective than self-interested framing (Jordan et al., 2020). Despite these positive findings, several prior studies in vaccination research have found mixed results on prosocial framing, suggesting that the advantage of prosocial/pro-environmental framing could be context-dependent (Hendrix et al., 2014; Rudd et al., 2014).

In the context of commuting by bicycle, there are both self-interested and pro-environmental benefits. On one hand, increased riding can be viewed as self-interested (e.g., wellness benefits). On the other hand, bicycle commuting cuts carbon emissions, reduces stress on costly infrastructure (e.g., roads, public transit, and parking), and imposes fewer hazards to pedestrians. While both self-interested and pro-environment framing can be relevant, we believe that pro-environmental framing has an advantage because university employees and students may be predisposed to be pro-environmental given the university’s long commitment to environmental sustainability.[1] When we use a badge to frame bicycle ridership as environmentally friendly (Figure 2), it increases the salience and accessibility of pro-environmental benefits. For those university employees and students who are environmentally-minded, such a pro-environmental framing could be more motivating than emphasising self-achievements. Hence, we hypothesise:

H2 (***Signifier***): *A badge design with a pro-environmental framing leads to higher ridership than one with a self-interested framing.*

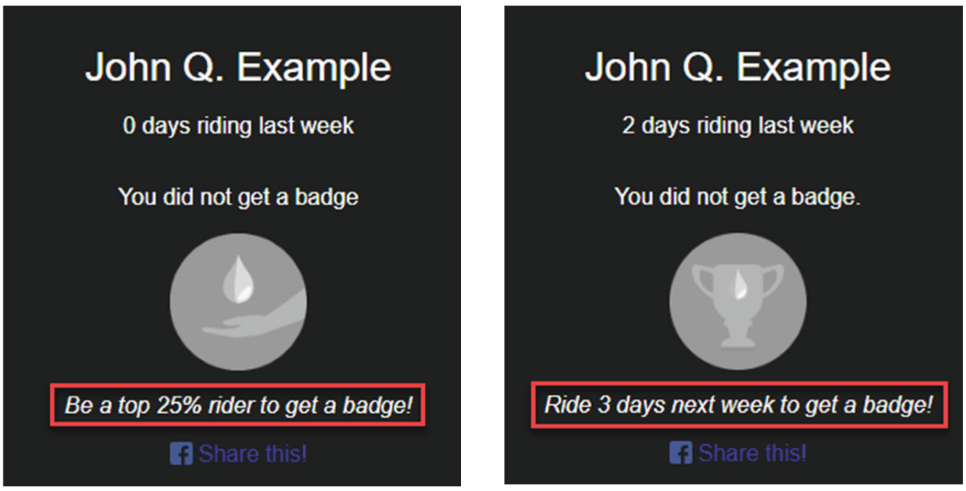
3.3. Completion logic: relative vs. fixed goals

The third component of badges, the completion logic, has to do with the expectancy of goal attainment. We distinguish two major categories of completion logic employed by gamification systems (Elliot & McGregor, 2001). First, there are fixed goals, which do not depend on the actions of others ("Walk 10,000 steps"). Second, there are relative goals, which require the user to perform at a rate relative to others ("Walk the most steps today of your friends"). A fixed goal does not leave any ambiguity in what an individual needs to do to earn a badge whereas a relative goal is uncertain because it depends on how well others will perform. Examples from our study of each goal type are shown in Figure 3. While an exact goal offers a stopping point, a relative goal does not, and this lack of a stopping point has led to participants mindlessly accumulating, or continuing past the point of



Pro-environmental Self-interested

Figure 2. Two signifier designs: pro-environmental vs. self-interested.
Note: Differences between conditions are highlighted with arrows.



Relative Goal Fixed Goal

Figure 3. Two completion logic designs: relative goal vs. fixed goal.
Note: Differences between conditions are highlighted.

satiation (Hsee et al., 2013), an effect which is especially robust in tasks that the participant finds enjoyable (Riedel & Stüber, 2019).

People may also find a relative goal more stimulating (Demetrovics et al., 2011; Santhanam et al., 2016). The literature on intrinsic motivation suggests that an uncertain outcome is important for keeping a person intrinsically motivated and challenged (Deci & Ryan, 1985; Malone & Lepper, 1987). According to Malone and Lepper (1987), a challenging activity must provide goals such that goal attainment is uncertain; a fixed goal can be seen either trivially easy or impossibly difficult, thus offer little stimulation. For frequent riders especially, reaching a fixed goal of 3 rides per week is not as stimulating as being in the top 10%. In sum, the inherent uncertainty associated with a relative goal can be stimulating and induce a higher level of effort. We therefore hypothesise:

H3 (*Completion Logic*): *A badge with a relative goal leads to higher ridership than one with a fixed goal.*

However, as noted above, we recognise that a relative-goal badge may not motivate all individuals equally. Frequent riders may benefit more from a relative-goal design for a few reasons. First, they are more likely to compare favourably to the general population (Liu et al., 2013). For them, comparing with the best has more benefit than completing a fixed goal since they are more likely to see the goal as reachable yet still uncertain. The uncertainty of the relative goal provides excitement and challenge to the frequent rider. In contrast, infrequent riders face an unfavourable comparison with their peers, which is demotivating (Epstein & Harackiewicz, 1992). The less frequent rider views the uncertainty as putting the goal more out of reach compared to a clear fixed goal. We expect a positive interaction between an individual's past performance and the competition goal structure:

H4: *Compared to a fixed-goal badge, a relative-goal badge is more effective in motivating ridership among frequent riders than among infrequent ones.*

4. Methods

4.1. Research context and technology

To promote physical activity and reduce its carbon footprint, a large university in the midwestern United States developed a bicycle commuting program to encourage faculty, students, and staff to bike to the university. The program relies on a Radio-Frequency Identification (RFID) technology developed at the university in conjunction with a third-party vendor. The technology has two components: an RFID chip attached to a bicycle and an RFID reader station with directional antennae that can detect the RFID chips installed on riders' bicycles up to 30 feet away. The RFID stations record the unique serial number associated with each chip and the time of the scan. A successful scan also produces a beep notification to the rider. Each station uses a solar-powered wireless modem to upload data to a central database.

The bicycle commuting program places RFID stations around the university at common entry and exit points, as well as around the metro area along busy bikeways. Due to the cost of stations, they are placed at strategic locations to capture at least one scan for people commuting to the University. They cannot reliably determine the distance or amount of cycling done by an individual, however. Therefore, the program office believes that the number of riding days is the most valid measure of activity afforded by the technology.

The program uses a few incentives to encourage commuting by bicycle. For university faculty and staff, the program offers reimbursement of insurance premiums for *frequent riders*, i.e., defined as those who ride at least twelve days a month or, equivalently, 3 days per week. For student frequent riders, the program enters them into a lottery for 10 USD gift cards donated by local businesses. Students are not offered insurance premium reductions or direct cash incentives because of tax implications.

To enrol in the bicycle commuting program, users fill out a sign-up form in which they provide their name and university email address and obtain a free RFID chip at one of the many tabling events or by contacting the program office directly. They attach the RFID chips to their bicycles and register the chips online to enable ride tracking. Users of the program have access to the program's web portal where a dashboard shows information about their ride history and program-related information (Appendix 2). Before this study, the program office sent out non-personalised newsletters via email about once a month.

For this study, we redesigned the newsletters and dashboard to accommodate badges. The redesigned newsletter went out on each Sunday. It contained the name of the user, the number of days riding in the past week, and a badge (See Appendix 1 for an example newsletter). If the user did not win a badge in that week, we displayed a greyed-out version of the badge. Finally, the newsletter had a short text description of how to earn a badge. We also redesigned the web portal to match the redesigned new letter. Specifically, the central panel of the dashboard showed the same information as the newsletter (Appendix 2).

4.2. Participants

At the start of the study period, the program's database recorded 4,235 users. We excluded 2,260 users who had no rides during the preceding academic year under the assumption that they were no longer with the university. We sent redesigned weekly newsletters to the remaining users each Sunday unless the user opted out or the user did not ride in the past week. All users of the bicycle commuting program had the option to visit the program's portal to see their badge results at any time.

4.3. Experiment conditions

We conducted a field experiment with participants randomly assigned into one of eight conditions forming a 2 (with or without sharing) × 2 (fixed or relative goal) × 2 (pro-environmental or self-interested) between-subjects design. We limit our analysis to riders who had registered for the bicycle commuting program on or before the beginning of the study period. This resulted in a panel of 1,975 users observed over seven weeks for a total of 13,825 unique user-week pair observations. Table 1 illustrates the distribution of users across conditions.

For the reward conditions, we manipulated the availability of a sharing link (Figure 1). Users in the *with-sharing* condition were presented with a link that reads "Share This!" next to a Facebook icon. The link was visible even if users did not earn a badge this week. Users in the *without-sharing* condition did not see such a link. Contamination is a common concern when experimenting with a social network. Particularly, users in the without-sharing group could infer their experiment condition by observing badges shared by others. To minimise the risk of contamination, we made the sharing link non-functional: when users followed the "Share this!" link, they would see an apology that the feature was under construction. As argued earlier, this design also allowed us to isolate any effects of the anticipation of social sharing, separate from the effects of any subsequent sharing.

For the signifier conditions, we manipulated the badge image and caption (Figure 2). Users in the *self-interested* achievement group could earn a "Star Rider" badge with an image of a trophy that emphasised self-interested achievements. Users in the *pro-environment* achievement group could earn an "Eco Healer" badge with an environment-themed image.

Table 1. Distribution of participants across experiment conditions.

		Completion Logic	
Signifiers	*Rewards*	Fixed-goal	Relative-goal
Self-interested	Without sharing	247	269
	With sharing	231	247
Pro-environmental	Without sharing	230	262
	With sharing	243	246

For the completion logic conditions, we manipulated the instructions for earning a badge (Figure 3). The instruction for the *fixed* goal condition reads "Ride 3+ times to earn a badge." For the *relative* goal condition, the instruction read "Be in the top 25% of riders." The goal of 3 riding days per week corresponded with the original goal of twelve riding days per calendar month. We chose the top 25% as the relative goal, because historically approximately the top 25% of users completed three riding days per week. In the actual implementation, we awarded all users a badge if they rode three or more days in a week, regardless of condition, intending to manipulate the user-facing design (the manipulation of interest) while holding constant the mechanism underlying the badge award.

4.4. Procedure

Data collection took place over seven weeks, from March 19 2016, to May 6 2016. The period spanned from the end of the university's spring break to the beginning of finals week. This period was chosen for several reasons. First, due to the nature of the weather in the local area, a large portion of the school year is inaccessible to casual bicyclists without specialised gear and, in some cases, tires. Furthermore, many students bring their bicycles off-campus (e.g., to parents' houses) at Thanksgiving and retrieve them at Spring Break. A visual representation of bicycle trips (across the full year) supports this (Figure 4).

4.5. Model specification

We chose the number of riding days per week (*RidingDays*) as our dependent variable. The number of riding days is more suitable than the number of rides or riding distance because the former can be more faithfully captured by the RFID technology and also because of our interests in daily commuting.

The number of riding days in different weeks for the same user may be correlated. Therefore, a pooled regression, which ignores such correlations, is not appropriate. A fixed-effects model is not appropriate either since there was no variation of treatment for the same user. We employed a random-effects panel-data regression model that allows observations of the same user to share a common term drawn from a normal distribution. To accommodate the count nature of the dependent variable, we also analysed a zero-inflated Poisson model as a robustness check and found similar results (see details in Appendix 3).

We included the following indicators as independent variables: *proEnv* (1 if the badge has a pro-environmental framing), *relative* (1 if the badge has a relative goal), and *withSharing* (1 if the badge has a sharing option). We define a *frequent rider*

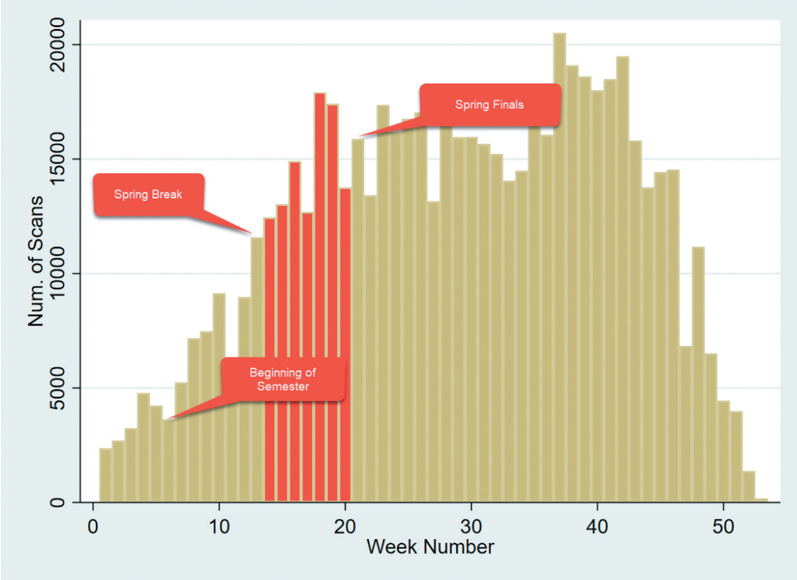


Figure 4. Rides per week, all years (The selected study time frame is in red).

(*freqRider*) as a user who rode three or more days in the previous week (and thus won a badge). We tested alternative thresholds of 2+ and 4+ riding days and obtained similar results. To test Hypothesis H4, we included an interaction term between *relative* and *freqRider*. We also included a person fixed effect α_i and an error term ε_{it}, in our model specification:

$$\begin{aligned} RidingDays_{it} = {} & \beta_1(proEnv) + \beta_2(withSharing_i) \\ & + \beta_3(relative_i) + \beta_4(freqRider_{it-1}) \\ & + \beta_5(relative_i * freqRider_{it-1}) + \alpha_i \\ & + \varepsilon_{it} \end{aligned}$$

Table 2. Random effects regression with interaction.

DV = *RidingDays*	Coefficient (Std. Err)	t(13,824)	P-Value
withSharing	0.044* (0.019)	2.28	0.022
proEnv	0.015 (0.019)	20.70	0.443
relative	−0.029 (0.021)	1.38	0.168
freqRider$_{t-1}$	3.473*** (0.026)	135.52	< 0.001
*relative * freqRider$_{t-1}$*	0.122*** (0.036)	3.35	0.001
Constant	0.422*** (0.020)	20.95	< 0.001
Wald $\chi^2(4)$	38,068.83		< 0.001
Overall R^2		0.820	

* p ≤ 0.05 *** p ≤ 0.001

4.6. Results

Across all 13,825 user-week pairs, there were 3,058 (22.1%) badges, roughly equal to our prior estimate of 25%. Fourteen users, out of 967 assigned to the *with-sharing* condition, clicked the social sharing link. This suggests that 1.45% of "with-sharing" users attempted to share, which is broadly in line with reported response rates of other studies with similar call-to-action campaigns via email (Jung et al., 2018).

We summarise the regression results in Table 2. The addition of a social sharing option produced a significant positive effect on ridership ($\beta = 0.044, p = 0.022$), supporting **Hypothesis H1**. This suggests that the anticipation of possible sharing, as an additional reward of badges, was sufficient to increase the perceived value of the badge and impact ridership, though the effect size was small (0.044 riding days). Compared to a self-interested achievement framing, a pro-environmental framing did not produce a significant change in ridership ($\beta = 0.015, p = 0.443$), failing to support **Hypothesis H2**. Thus, calling the badge "eco-healer" and adopting eco-themed imagery did not alter the perceived value of the badge as hypothesised, though signifier choices are often a central concern of badge designers.

There was a clear significant effect of being a frequent rider in the previous week ($\beta = 3.473, p < 0.001$), suggesting that previous frequent riders, on average, registered 3.473 more riding days than the rest. This main effect is entirely expected and straightforward: frequent riders who, on average, maintained a higher level of ridership (Alós-Ferrer et al., 2016). More active riders tended to continue to be more active and vice versa.

The main effect of setting a relative goal of the top 25% did not achieve statistical significance within the model, failing to support **Hypothesis H3**; but, the result needs to be interpreted in light of the statistically significant interaction in the model. There was a statistically significant interaction between *relative* and *freqRider* ($\beta = 0.122, p = 0.001$), supporting

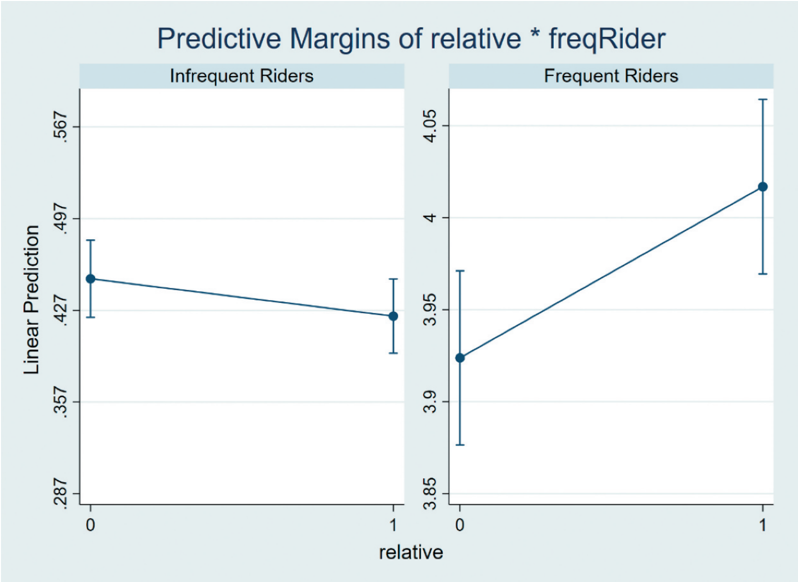


Figure 5. Interaction between freqRider and Relative (with 95% CI).
Note: different ordinate scales were used for two types of users to allow for a better view of the interaction effect.

Hypothesis H4. That is, for frequent riders, assigning a relative goal of reaching the 25% led to 0.122 more riding days than assigning a fixed goal of 3 rides. To further understand the interaction effect, we plot the impact of the relative goal on two types of users – frequent and infrequent riders – as illustrated side-by-side in Figure 5. As is evident from Figure 5, there was an inversion of slopes for the two types of users (note that we used different magnitudes on the ordinate scales between the two graphs for better visual comparison). Among users who rode 3 or more days in the previous week, having a relative goal increased their ridership levels ($t(3056) = 2.833, p = 0.002$). Among users who rode less than 3 days, the opposite was observed ($t(10765) = -2.160, p = 0.015$). In other words, a relative goal did have value for those who were active riders in the past; but, it was demotivating and had a negative value for the others. Thus, contrary to **Hypothesis H3**, there is not a general benefit associated with the relative goal that is universally observed across all riders. The direction of the effect varies across riders, depending on their riding frequency.

5. Discussion

Motivated by a lack of research on how to design badges despite their widespread use, we designed and evaluated different badge designs in a large-scale field experiment in a biking commuting program. We systematically varied the design of three badge components, namely *rewards, signifiers*, and *completion logic*. For the *rewards* component, we showed that merely adding an option for social sharing was able to increase ridership, even though we prevented actual sharing in this experiment. This finding is consistent with the expectancy-value theory, which suggests that anticipated rewards, in this case, the social rewards of sharing one's achievement on social networks, can motivate behaviours.

Our manipulation of a badge's signifier did not produce a desirable impact, however. We hypothesised that a pro-environmental signifier, implemented through pro-environmental caption and imagery, would elicit the psychological rewards associated with warm glow and thereby motivate ridership. Our results showed no difference between this design and a design that emphasised self-interested achievements. Several possibilities may account for this finding. First, the pro-environmental signifier was not objectively superior to the self-interested signifier, and a relative comparison between the two will not detect a difference between two equally effective (or ineffective) treatments. Furthermore, the pro-environmental treatment may have been ineffective in eliciting emotional responses from users. The changes in the badge graphic and caption may have been too subtle for users. Alternatively, it could be that too few riders shared the pro-environmental value.

Finally, for the completion logic component of the badge design, a relative-goal design was not different from a fixed-goal badge in terms of overall ridership. Interestingly, a deeper analysis showed that a relative-goal design had different effects depending on the user type: it led to increased ridership among frequent riders compared to a fixed goal, but decreased ridership among the rest. Frequent riders, who compare favourably to other riders, could be motivated by the uncertainty afforded by a relative goal. The inherent uncertainty of relative performance outcomes may have caused them to exert extra effort. In contrast, infrequent riders are more motivated by a fixed goal, possibly because a fixed goal is already hard to reach for them. Adding the uncertainty of a relative goal and the prospect of an unfavourable comparison are demotivating for them.

5.1. Contributions to literature

We contribute to the literature of gamification by providing new insights on the efficacies of different badge design components. First, we do not find evidence that badge signifiers, which appear to be a focus of many badge-based gamification applications, consistently drive behaviour as much as might be hoped, with the caveat that we test only pro-environmental versus achievement-oriented signifiers. Though we believed that a pro-environmental-themed badge signifier would resonate with some riders, it did not achieve the desired effect. Research on prosocial behaviours suggests that to elicit such behaviours, both value alignment and salience of signifiers are required (Bénabou & Tirole, 2006). In our context, merely manipulating the badge signifiers seems inadequate for accomplishing such goals, though further study on a variety of different signifiers is required before making general claims about the lack of efficacy in signifiers.

Second, our findings on badge rewards highlight the potential of exploiting the synergy between badges and social sharing. In our experiment, the perception of being able to share an earned badge on Facebook brought enough added value to increase ridership. Though our observed effect was small, one should keep in mind that we adopted a conservative design where actual sharing cannot occur. In a real implementation where badges could circulate on social networks, perhaps the effect may be stronger.

Third, our findings showcase the interaction between badge designs and user characteristics. Specifically, the effect of a relative-goal design for frequent riders is the opposite of that for infrequent riders. We are not alone in alerting such interaction effects of gamification. In the gamification framework developed by Liu et al. (2017), the interaction between gamification elements and user characteristics is highlighted as an important area of research. Relative goals and the related gamified elements such as social comparisons, competition, and leaderboards are all capable of differentially impacting users. The interaction effect holds two important implications. First, some of the mixed findings may arise from the interactions – if we only analysed the main effect of the relative goal, we may have incorrectly concluded that it did not affect ridership. Second, the interaction effect calls for personalisation. Understanding that users react differently to a relative goal suggests that it may be more beneficial to prioritise relative goals for frequent riders and fixed ones for infrequent ones.

5.2. Contributions to practice

Our field experiment with different badge components offers several insights for designers of gamification badges. First, on the issue of badge rewards, it appears fruitful for badge designers to pursue the use of additional rewards associated with a badge. Indeed, many successful badge programmes, such as Stack Overflow's badge system, are more about additional social rewards (e.g., reputation and status). We showed that making a badge sharable can increase the target behaviour but there are other ways of enhancing rewards associated with a badge, such as by adding meta-game elements such as points associated with badge completion, or instrumental rewards such as coupons.

On the issue of badge signifiers, our results sounded a cautionary tale. Anecdotal evidence suggests that badge designers spend a lot of time designing badge signifiers. Though there are reasons to believe that some signifiers may work better than others, our results suggest that merely swapping badge title, imagery, and text may not be enough to persuade users. Either designers spend their energy elsewhere or they should ensure that users are aligned with the values associated with the signifier design. This could be done by pilot testing to verify how users react to a particular badge signifier and/or launching campaigns to increase user's alignment with chosen badge signifiers.

In terms of competition logic, our results suggested that a relative goal was more appropriate for users with higher performance whereas a fixed goal worked better for the other users. A personalised approach to the completion logic design may be more fruitful. For example, the designer could use a tiered badge system where lower-performance users face a fixed-goal badge and, once they reach higher performance, a relative-goal badge would be instituted.

5.3. Limitations of the study and future research

Given the nature of the field experiment, we embarked on certain design decisions that may limit the generalisability of our findings. Foremost is the sharing link's redirection to a non-active page. This was the result of a trade-off between the risk of contamination and the ecological validity of a true social sharing link, especially since the experiment was run over multiple weeks. We deemed the risk of leakage to be the greater threat and thus adopted the redirection design that would lead to a more conservative estimate of the effect. For similar reasons, our implementation of the relative goal abstracted away more ecologically valid design features such as leaderboards.

In terms of measurement, the technology allowed measures of "the number of riding days" but not riding distance or other, more precise measures of activity. The system could be gamed, for instance, by riding to the nearest reader and then returning. However, we consider the likelihood of this to be minimal. Still, a more refined measure would be of use.

One direction for research is to follow up with studies of the underlying motivations suggested by our findings in a field setting. For example, when we allow an individual to share a badge, a higher level of ridership was observed compared to those who did not have this option. Future research could further determine the boundaries of additional rewards which will enhance the efficacy of a badge, both of a social and individual nature.

We conclude by noting the inherent limitation of selecting three badge manipulations from a virtually boundless set of possibilities, including the visibility of badges, the aesthetic value of a badge image, other ways of enhancing badge rewards, and badges linked to a competition. Our study demonstrates that the design of a badge can affect the behaviour targeted by the badge, and we urge researchers to proactively consider the specifics of badge design when studying gamified information systems.

Note

1. The university's Board of Regents adopted a policy on Sustainability and Energy efficiency in 2004, stating that "The University is committed to incorporating sustainability into its teaching, research, and outreach and the operations that support them."

Disclosure statement

No potential conflict of interest was reported by the authors.

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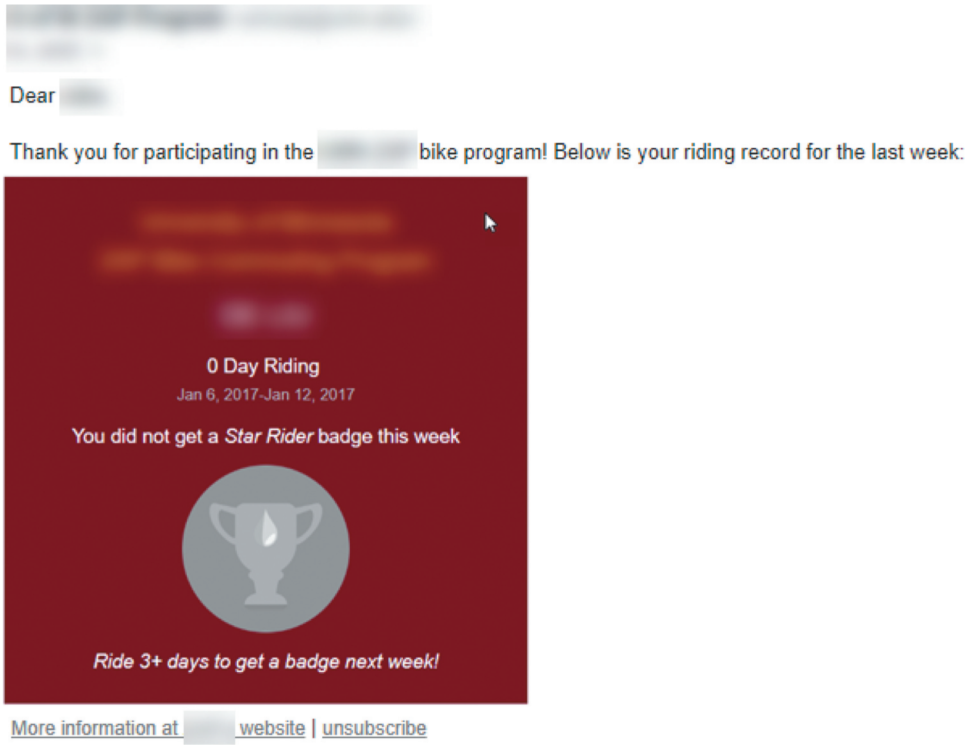
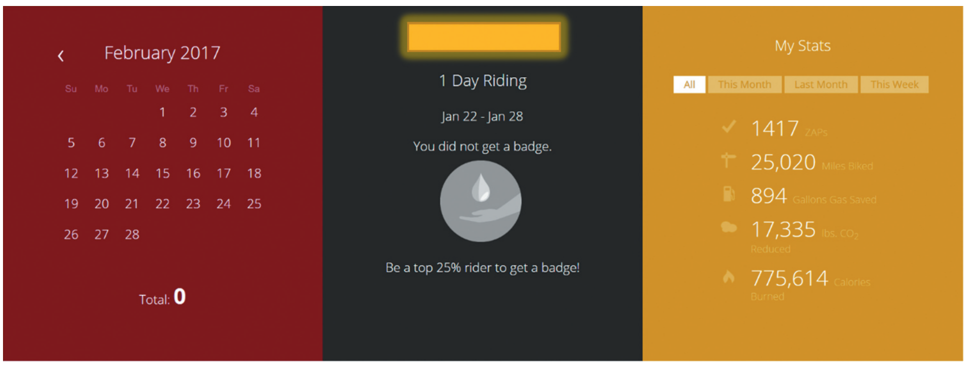
Appendix 1. Email Newsletter

(University name and awardee blurred for peer review)



Appendix 2. Dashboard

(User name blurred for peer review)



Appendix 3. Robustness Check

We supplement the random effects panel model with a zero-inflated Poisson model. This is a two-stage model: First, we run a zero model which models whether the user would take zero rides because of structural factors (i.e., a decision not to engage in riding behaviour unrelated to the treatment). Second, we fit a standard Poisson model of the number of rides a user would take, contingent on their receptivity to treatment (stage 1). This differs from a hurdle model in that it allows for a treated user to still have zero rides. Since the treatments were assigned exogenously, we use the self-reported miles to home as a covariate in the inflation model of stage 1. The results of the two-stage model are reported below. As observed, they mirror those of the random-effects panel-data regression model presented in Table 2 within the text.

Stage 1: Zero-Inflation Model

Miles to Home	−.0107463	158.3883	−0.00	n.s.
Constant	−20.34891	828.2411	−0.02	n.s.

Stage 2: Poisson Model

	Coef.	Std. Err.	z	P > z
Sharable	0.027+	0.015445	1.75	0.081
Pro-env	0.005	0.015472	0.35	0.730
Relative	−0.08*	0.033341	−2.4	0.016
$freqRider_{t-1}$	2.505***	0.026717	93.77	< 0.001
$Relative*freqRider_{-1}$	0.107**	0.037642	2.85	0.004
Constant	−1.070***	0.026085	−41.04	< 0.001

+ p ≤ 0.10 * p ≤ 0.05 ** p ≤ 0.01 *** p ≤ 0.001