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Changing Mobility Behaviour through Recommendations

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ABSTRACT
In this paper, we describe a road traffic behaviour and mobility case study that was implemented in June 2015 in the congested city of Luxembourg. We explain the development and deployment of the Gamified mobile application *Commutastic* that offers users incentives to undertake after work activities. With *Commutastic* we try to persuade users to change their commuting time so as to avoid the evening peak. Furthermore we investigate the behaviour change with focus groups and questionnaires. The preliminary data indicates that behaviour change is possible and that traffic reduction can happen on a bigger scale.

Keywords
Road Traffic, behaviour change, Gamification, mobile application

1. INTRODUCTION
The Commutastic study is part of the I-Gear (Incentives and Gaming Environments for Automotive Routing) [8] project that explores the use of gamification, serious and pervasive gaming in order to reduce road traffic in Luxembourg. Luxembourg is a heavily congested country due to the large number of cross-border commuters from Germany, France and Belgium [11] but also due to an elevated number of vehicle ownership [12]. Commutastic is a novel approach to tackle traffic problems during the after work peak time and thereby reduce the social, economic and environmental problems caused by congestion in Luxembourg. Although the study focuses on Luxembourg it was designed so that the underlying concepts can be applicable in other cities that suffer from large peak time commuter problems.

In this paper we focus on the development and implementation of the Commutastic mobile application that is a recommendation system for alternative after work activities. The Commutastic study addresses the following overall research challenge:

How can we change commuter behaviour in order to reduce traffic congestion in Luxembourg?

The principal idea is to change commuter behaviour and to encourage drivers to undertake new actions through the use of (Individual-) psychological and economic incentives drawn from digital game design. The approach is to encourage people to undertake alternative after work activities (e.g. going to the gym) instead of traveling home; thereby reducing the number of cars on the road at peak time and subsequently the level of congestion. The rationale is that by changing their own behaviour, users help other traffic participants and improve their own wellbeing. The latter aspects is deemed critical as the concept is presented in a way that argues that time stuck in traffic is wasted but that there are more pleasant alternatives out there. The incentives for the behaviour change are twofold; on the one hand, we apply gamification [4], meaning the use of (digital-) gaming elements such as badges, points, levels and so on in the non-gaming context of traffic. On the other hand, we provide concrete, monetary incentives such as free access to what is normally a paid service. This is called by positive psychologists "extrinsic" rewards, such as money, material goods, status, or praise, and it always carries the risk of hedonic adaptation. However, intrinsic rewards (autotelic), such as positive emotions, personal strengths, social connections, are renewable [10] and they are as well triggered by the larger context of doing something good while reducing traffic and enhancing wellbeing.

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The objective of Commutastic is to explore the use of gamified mobile applications and real life incentives to change the traffic behaviour of the commuting workforce.

The tool is a gamified smartphone application that suggests users alternative after work activities in order to prevent them from driving during the rush hour. We consider Commutastic as a rule based, goal oriented (*ludus* [3]) pervasive game that breaks spatial borders and can be played anywhere in Luxembourg City [cf. 9].
Taking a *ludus* perspective we see traffic as a game, in which participants: I.) Accept the road traffic regulations, II.) Perform actions, for example travel from A to B in order to do C and III.) Reflect about the previous points, feeling for instance either good or bad about their commute. We add a gamification layer on top, when we invite the Commutastic participants to I.) Accept our mobility game rules and II.) Perform slightly different activities or at different times. Lastly we III.) Make the conclusion stage more explicit by reinforcing positive experiences such as skipping traffic, providing concrete feedback with points, badges etc.
The design of Commutastic is based on earlier work called Driver Diaries, which identified the commuter patterns and activities within those patterns of drivers in Luxembourg.

2. PREVIOUS WORK
The Commutastic application has been designed based on a thorough understanding of the issues faced by commuters in Luxembourg, such as behaviours, constraints and challenges. Our target group are people that work in Luxembourg City although they may be residents in France, Belgium, Germany or Luxembourg. The issues were identified through the Driver Diaries (DD) approach [7]. The DD methodology consists of an

online questionnaire, a mobile application with GPS tracking and focus group interviews. Using the DD questionnaires, iOS and Android mobile applications we monitored mobility behaviour of more than 100 professionals from Luxembourg and neighboring countries. This phase of the study was iterated twice, lasting for two weeks each time. The DD questionnaire showed that most (cross-border) commuters leave their workplace between 18:00 and 19:00 (about 45%), 20% leave between 17-18:00 and about 20% between 19:00-20:00. Commuters undertake certain activities after their working hours, such as shopping and leisure activities (e.g. sports), cultural events or having a drink. Most of the activities after working hours last longer than 60 minutes and the participants usually travel on their own. The DD served to capture requirements and therefore as an indispensable precursor of the Commutastic recommender application.

The DD focus group interviews captured underlying motivations and mobility related behaviours that could not be studied via the DD application and the questionnaire. During the focus group interviews, many participants expressed their concern with data privacy and that they did not feel comfortable having their location tracked via GPS. Liberty/ freedom of action and comfort are important factors to the participants. Moreover, they pointed out that the battery time of the mobile phone is reduced by constant GPS tracking. The focus group participants' opinion regarding incentives was split. Almost half of the participants expressed that they would only be motivated by concrete incentives to change their behaviour, while the other half conveyed that gamification elements like badges, points and levels would work as motivator. Finally, some focus group participants were concerned about safety when using a potential gamified mobility app in the car.

The results from the DD study were used to inform the design of the Commutastic study.

3. APPROACH

There are different approaches to reduce traffic congestion, such as supplementary infrastructure, improved traffic management or vehicle-to-vehicle communication [2]. We follow the approach of changing the behaviour of traffic participants. This can be achieved by a) distributing traffic over time, b) distributing traffic over space, or c) reducing the space occupied per traffic participant.

The required behaviour changes differ within each approach. Approach a) requires that we convince people to change the time when they participate in traffic. Approach b) requires that we convince people to change the roads that they use while approach c) requires that we convince people to change their mode, for instance biking, walking or using public transports instead of their individual car. The Commutastic study uses mainly approach a). Within a) there are two related options. The first is to change the time when people leave their home or their offices.[1] The second option, which we focus on in Commutastic, is to motivate people to do interim stops, for example an activity before going home, and thereby taking them out of the peak time traffic.

3.1 Overview

The Commutastic study consists of three parts:

1) A mobile application that recommends four different after-work activities to the users,

2) Focus groups aimed at exploring user actions and motivations, and

3) Questionnaires that evaluate the impact of the application.

The first part was finished in June 2015 while part two and three are ongoing at the time of writing (July 2015). The design reflections and the practical considerations that we followed for the mobile application are presented in Table 2. They are based on the results of the DD.

3.2 The Commutastic Application

The application was developed and implemented as a case study in Luxembourg City in June 2015 with 90 registered participants and over 50 registered user actions. We succeeded in signing partner agreements with four well known companies in Luxembourg City: an exclusive fitness club, a state supported multi-sports center featuring an Olympic swimming pool with a sauna and wellness area, the Museum of Modern Arts and the biggest cinema complex in Luxembourg. Each of the four partners offered one activity per weekday free to each user. Additionally there were special activities that were offered only one time per week.

Table 1. Design considerations and Implementation

DD results	Design consideration	Implementation
Privacy/ battery draining issue due to GPS	Verify location without GPS	Use QR codes at destination to verify location/time
85% Leaving work 17:00-20:00	Activity window 17:00-20:00	Starting time of activities 17:00-20:00 (rush hours)
Don't travel far for after work activities	Activities close to the workplace	Luxembourg, Kirchberg area
Shopping, leisure and sports are most prominent	Activities cover sport, culture and having drinks	Two sport, two culture activities
Liberty to do/ not do an activity	Freedom of choice for the user	No minimum usage restrictions
Motivation: gamification and monetary	Incentivize virtually and monetary	Gamified aspects (points, level, badges) and free entrance
Safety while driving main concern	Application does not require interaction while driving	Application can be used before driving and after arrival
Routine mobility behaviour	Remind alternatives	Push notifications

3.3 The Users

The study participants work in Luxembourg City, use a car to commute and use an iPhone with data connection as a work or private phone. Users were recruited with the help of a network on Corporate Social Responsibility (IMS), through newspapers (L'Essentiel, Chronicle) and Internet science and innovation portals (science.lu, IT one, innovation.public.lu).

The users mostly worked in the financial district of Luxembourg City (Kirchberg) and lived either in Luxembourg or in the neighboring countries.

[1] We inquire this option in another upcoming study with an application called *Leave Now.*

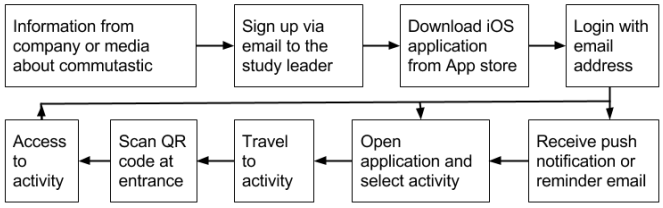

Figure 1. Participation process from the user perspective

Registrations for the study were accepted and recorded via email after which users could download the Commutastic application from the App Store and login the first time using their email address. Afterwards, users could open and interact with the application at any time without the need to register (Fig1).

3.4 Activities

In order to effectively motivate people to delay their commute to after rush hours we identified activities that match their interests in terms of starting time, activity duration, location etc. and provide incentives for these four activities. Two activities are focused on sports (d'Coque and Ellipse fitness) and two on culture (Utopolis, MUDAM). With these partners we offered free activities at each of the four locations between 17-20:00 during the working days for the experiment duration of three weeks.

Table 2. Overview over after work activities

Location	Type	Standard activity	Special activities
MUDAM	Culture	Entry and drink	Guided tour, artistic performance, after work party
d'Coque	Sports	Swimming and fitness	Sauna and wellness
Utopolis	Culture	Movie	3D movie and glasses
Ellipse fitness	Sports	Training	After work Party

4. IMPLEMENTATION

The Commutastic application is not a traditional recommender system in the way that it is not a personalized system that filters information and shows only relevant, personalized information in a specific location or context [1]. The application, however, is clear and transparent in its aim to change user behaviour. The underlying concept of congestion avoidance is explicitly stated. We implemented gamification elements such as a player profile, levels, points and badges. These specific elements were selected as being the most pertinent for our target group, as found in previous studies [6].

The Commutastic Application is composed of two main parts, the interface of the mobile application and the server backend.

4.1 The Interface

To explore the structure of the Commutastic mobile application we discuss the interface, which embeds incentives and gamification elements in an intuitive manner.

In the main page of the game users see their name, their points and last badge earned (Fig. 2). Users can access their profile page from the main view in which they can see their earned badges alongside their not yet unlocked badges. Furthermore in the main page four available activities are displayed. As shown in Table 1, activities are categorized into normal and special. Special activities took place on certain days of the study of which the user was informed by a special band in the corner of the activity selection button and by push notifications/email.

Figure 2. Main screen with gamification elements

When the user selects an activity, the details of the offered service are shown alongside a map together with the address of the facility. In order to reduce distraction while driving the application requires no interaction from the driver. In order to access the facility for free the user must scan a QR code placed in the respective entrance area using the Commutastic app. The user receives the confirmation from our server and shows the confirmation screen to the employee of the facility in order to get access.

4.2 The Backend

According to the DD study iOS and Android are the most used mobile operating systems within our target user group. We decided to use iOS as our experimentation platform and developed the Commutastic application for iPhone. We used Xcode and Objective-C as our development environment. We implemented most of the logic of the application and data storage on the server side to have a higher degree of flexibility. Therefore we could modify the mobile client without going through the review process of the application again, which seems to be the optimal choice for an experiment with a duration of three weeks.

In order to comply with Luxembourgish privacy and data protection laws, we host our backend and data storage on a local server. As described above QR codes were used to detect the user's location only at the moment of scanning. Our backend server is developed using a flexible full stack web development framework called web2py along with a MySQL server for storing the data. All the logic behind the app, such as calculating points and badges etc. are executed in the backend.

For sending push notifications to our users we took advantage of a third party service called Parse. The usage of Parse complied with data protection laws since we only send public messages without disclosing user data.

5. PRELIMINARY DATA OVERVIEW

The two cultural after work activities, the cinema and the museum, have been frequented the most by the Commutastic users during our study. The sports locations (fitness center and swimming pool) accounted for less than 30% of the user actions.

During our study, most users undertook after work activities on Fridays and Mondays, accounting for 70 % of all user actions (Fig. 3). This only partially confirms the DD findings where users

also indicated Monday for after work activities. We inquire about this point further in the focus group interviews. However, one out of three Tuesdays of our study period was a national holiday, which means that most companies were closed and there were no after work activities could be offered.

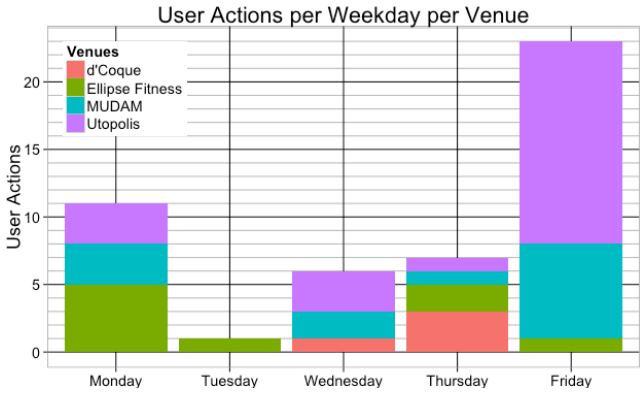

Figure 3. User action distribution over study period

Commutastic users start their after work activities later at the beginning of the week. In the middle of the week the starting time of the activities is less spread (Fig. 4). On Tuesdays we recorded only two user actions in total, which might again be due to the national holiday.

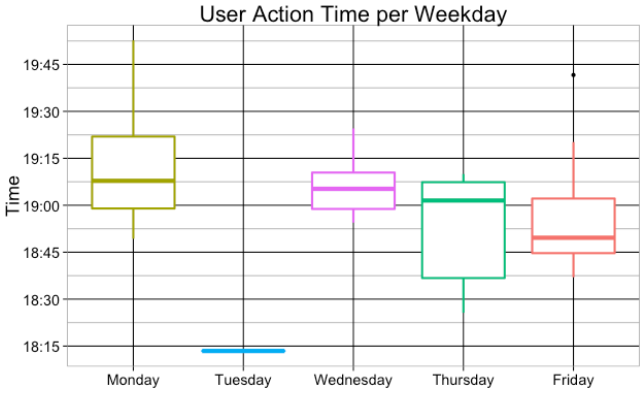

Figure 4. User action starting times

The median activity starting time on Fridays is 20 minutes earlier than on Monday.

5.1 DISCUSSION AND FUTURE WORK

Commutastic is a follow up study of the Driver Diaries which was used as a way to identify activity patterns within the Luxembourg commuter base. Our preliminary results indicate that a number of findings were confirmed both within the DD and the Commutastic Study while others did not seem to emerge. For example the starting time of the activities corresponds to the leaving work time we recorded with the Driver Diaries. However the percentage of users that followed our recommendations was lower than indicated by the DD. At the time of writing the focus group interviews had not been conducted so we cannot provide an indication as to what the reasons may be.

The Commutastic study represents a real-world implementation of a Gamified smartphone application that recommends alternative actions to commuters in Luxembourg. It explores how behaviour changes can be conceived and designed through the use of a mobile application and incentives.

The data collected shows that we can motivate users to do after work activities with a gamified mobility application. The data set is not sufficient to conclude that all user actions are behaviour changes. However, it was strongly indicated by our partners that they consider the users as additional visitors of their location which indicates behaviour change. The presented data allows no conclusion about whether the main driver for behaviour change were the gamification incentives, such as points, badges and levels, or the monetary ones. We will further investigate this with the questionnaire and the focus group data in order to find out about the motivations for user actions. It appears that cultural activities with low planning requirements that can be executed spontaneously are more attractive for our population than sports activities that require additional equipment.

For a future recommender application, the deployment on new, emerging wearable devices such as smartwatches would be advocated in order to provide a better and seamless user experience for mobility recommendation applications [5] but other fields of recommendation, such as indoor mobility are possible (cf. the Coffee Games in: [6]).

In conclusion, we have presented the development and the early results of a study of a gamified commuter application which is designed to reduce traffic congestion by recommending alternative courses of action. We believe the approach is relevant as it recommends activities which are beneficial to both the individual and wider society, is relatively low-cost to implement and is fully transparent in it's objectives to the end-users. Therefore, we think that this approach can be adapted and used in other cities with important commuter congestion problems. Furthermore, we have summarized an approach from requirements capture (DD) through to the end application (Commutastic), which places emphasis on small changes in behavior and associated recommendations. Future work includes completing the focus groups and possibly exploring the use of other devices (e.g. smartwatches) and more advanced recommendation approaches.

6. ACKNOWLEDGMENTS

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