Digital Interventions for Sustainable Urban Mobility: A Pilot Study

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Abstract
This paper presents results from a pilot study aimed to explore the design of behavior change interventions for sustainable urban mobility. Eight participants were provided with a mobile app deploying a novel combination of *goal-setting*, *self-monitoring*, *rewards* and *sharing* features in order to observe, over a month period, relevant changes in their transport choices and habits. The digital intervention produced an increase of sustainable transport choices of 14% and contributed to raise participants' environmental awareness, particularly regarding the consequences of their daily transportation choices.

Author Keywords
Sustainability; Contextual user study; Behavior Change Strategies; User-centred design

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design.

Introduction
Traffic in cities is responsible for about 40% of CO_2 emissions from road transport and 70% of other

Fig.1: Home screen of the Mobile app, showing how a user can decide to a) plan a journey, b) access past journeys, c) set their eco-goals

pollutants [6]. Making urban transport greener, more user-friendly and better organized is an important objective of the European Union in order to meet climate protection and energy saving goals, as well as to improve public health. This is also coherent with efforts in the field of Transport Demand Management (TDM) aimed to reduce travel by single-occupancy vehicles and to encourage alternative modes such as public transport and carpooling. Mobile phones are nowadays ideal tools to deploy for informing and influencing citizens' choices and research work has started to investigate how to best design mobile apps that can increase green behaviors [8, 9]. We have deployed contextual user research methods and a mobile app prototype for Android phone to explore how self-monitoring and data sharing [10] could facilitate participants' eco-friendly travel choices. Past work has shown that motivators such as public commitment, frequent feedback, and personalization can positively impact environmentally responsible behavior [1]. Also, feedback displays for energy consumption in home environments can help people to achieve savings [7], however it is not clear if the same results can be observed in the urban transportation field. Although in recent years interesting mobile apps have been proposed to support eco-friendly transportation behaviors (e.g., Carbon Diem [2] and Ecorio [5]), so far little research has been conducted for assessing their real impact on users' behavior. An initial contribution has been provided by the UbiGreen mobile prototype [9], able to semi-automatically sense and display information about transportation behavior, which has been tested in a 3 weeks' study in two U.S. cities. Our research has focused on understanding the effect of a novel combination of change strategies, deployed through a simple mobile app, on influencing participants' travel choices in a local context (middle size town of Trento, Italy).

Logging of user self-reports about their travel choices was set up in order to compare their travel choices and habits before and after the behavior change intervention. We describe the main findings collected, relevant to the user-centred design of digital interventions in support of sustainable urban mobility.

The Mobile App Design

We designed a mobile prototype for Android phones implementing basic logging and display features for inducing sustainable transportation choices. The mobile app (Fig.1) does not track the user travel paths (GPS data), but relies on user self-reported mode of transport over a day. The decision of relying on user self-reporting of data on transport mode was taken in order to avoid the mobile phone battery drain by the GPS tracker. It has of course the drawback of being less reliable with respect to automatic mode detection solutions. The motivational features provided, were inspired to previous work in relevant behavior change fields [11] and consisted in the following:

1) *Goal setting*: The user was invited to set weekly goals for mode of transport to use (e.g., car, carpooling, bicycle, walking, public transport) and choose their relative priority;

2) *Self-monitoring*: The user could track progress towards goals and check modes of transport used over a week in order to support self-reflection about the level of sustainability of the travel choices made;

3) *Rewards*: Personalized messages encouraging sustainable travel choices were sent to the user, according to his profile and travel behavior (derived from usage logs). These messages were prepared by the experimenters, simulating a future system

functionality in a Wizard-of-Oz style, and sent to the user by means of the prototype integration with a *Facebook* account set up for the study;
4) *Sharing*: A leaderboard of participants' eco-scores was weekly provided in order to observe the impact of social influence (e.g., competitive or collaborative reactions of participants) and make more interesting the app usage.
The mobile prototype provided also a local journey planning service (*ViaggiareinTrentino*) for supporting the user daily journeys across their urban setting.

	Age	Occupation	Env. Awareness	Behavior change
P1	42	Project Manager	Stable	Improved
P2	33	Office Admin	Improved	Worsen
P3	30	Programmer	Stable	Improved
P4	29	Conf. assistant	Improved	Improved
P5	21	Student	Improved	Worsen
P6	22	Student	Stable	Improved
P7	31	Student	Improved	Stable
P8	28	Student	Stable	Stable

Table 1: Users' data and pre-post study

The Pilot Study

The ability to get *in situ* data at early stages of mobile apps development has been acknowledged before [3, 4]. Therefore we decided to adopt a rapid prototyping process, leveraging also on Wizard-of-Oz techniques, to be able to test *in situ* the effect of the digital intervention few weeks from the start of our design work. Eight participants took part to the study during the month of September 2012 (Table 1). We recruited them from a convenience sample of people that knew each other and had different mobility habits and needs (e.g., drivers with private car, non drivers etc.). All background information about their travel routines, needs, habits, and their willingness to adopt more eco-friendly behaviors (assessed also through the TTMC scale 1-5 [11]). After that, they used the mobile app prototype as follows: in week 1, participants just self-reported travel paths and mode(s) of travel used every day (e.g., car, carpooling, public transport, bike, walking) to enable us to log their mobility habits previous to any motivational intervention. In week 2-3-4 logging of participants' behaviors included also frequency of usage of the mobile app persuasive features. A final individual interview collected user experience feedback. Participants were refunded for the cost of Internet connection for the study duration.

Main Findings
Overall, participants enjoyed the use of the app over the 4 weeks, no one decided to retire from the study. All participants complied with the daily request of sending in their self-report of the modes of transport used. On average they used public or private transportation twice a day, travelling a distance of 3 to 15 km per journey to reach their destination. We analyzed all logs and interview data collected in order to: (1) understand the main factors influencing participants' daily transport choices, (2) measure the effect of the behavior change intervention on their transport choices. By comparing individual participants' mobility choices over *weekends vs working days* we found that participants' choices were more strongly constrained by the *physical characteristics of the local area* (presence of slopes, long distances to cover from neighbor villages to city centre, etc.) during working days, with respect to weekends when time constraints were perceived as less important and transport choices were more related to individual preferences and environmental attitudes. P3 and P4 for example used to choose public transport only over weekends, when delays had less impact on their activities and vehicles were not crowded like at rush hours. Some participants' said that the effect of the mobile app was to foster a better personal planning of urban travels over a day in order to optimize journeys (e.g., to reach workplace, do shopping, etc.). By considering the aggregated data on participants' transport choices over the 4 weeks, we observed that the use of the mobile application did have some effect on changing participants' behavior. Most of our participants were used to driving their

private car for reaching their working / studying place. However, by comparing the modes of transport used by participants during the first week of the study (no intervention) and the last week (intervention), we observed an improvement in the use of sustainable means of transport (excluding private car) of 14%. Regarding individual transport choices change, 2 participants showed a stable behavior, 4 participants improved their behavior by making more sustainable choices, and 2 participants showed their sustainable behavior decrease. Overall, this can be interpreted as a positive impact of the intervention, considered that most of our participants belonged more to the profile of 'car addicts' rather than 'convinced environmentalists'.

Conclusion and Future Work

This paper presents initial findings from a longitudinal investigation targeting participants that were not very green-oriented before the intervention. Although an improvement in their adoption of the target behavior was achieved (14%), longer periods of behavior change intervention are required in order to replace transport habits with more sustainable ones, especially if considerable sacrifices are to be made by the target users. The lessons learnt so far are currently informing our implementation of a refined version of the mobile prototype, integrating motivational and journey planning features. We plan to conduct longitudinal field trials of the integrated prototype in three European cities over 2013, involving a larger and representative sample of participants with different transportation needs, preferences and usage profiles.

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