Persuasive Technologies for Sustainable Smart Cities: The Case of Urban Mobility

Evangelia Anagnostopoulou[†]
ICCS, National Technical University of Athens, Greece, eanagn@mail.ntua.gr

Babis Magoutas
ICCS, National Technical University of Athens, Greece, elbabmag@mail.ntua.gr

Efthimios Bothos
ICCS, National Technical University of Athens, Greece, mpthim@mail.ntua.gr

Gregoris Mentzas
ICCS, National Technical University of Athens, Greece, gmentzas@mail.ntua.gr

ABSTRACT

In this paper, we study the effectiveness of personalized persuasive interventions to change urban travelers' mobility behavior and nudge them towards more sustainable transport choices. More specifically, we embed a set of persuasive design elements in a route planning application and investigate how they affect users' travel choices. The design elements take into consideration the style, the intensity, the target of persuasive interventions as well as users' characteristics and the trip purpose. Our results show evidence that our proposed approach motivates users on a personal level to change their mobility behavior and make more sustainable choices. Furthermore, by personalizing the persuasive interventions while considering combinations of interventions styles (in our case messages and visualizations) as well as adjusting the intensity of persuasive interventions according to the trip purpose and the transport modes of the routes which the user is nudged to follow, the effects of the persuasive interventions can be increased.

KEYWORDS

Persuasive technology, smart city, sustainability, urban mobility, design elements, personalization

1 Introduction

Humanity's future is set to be urban. Currently, over half of the global population lives in urban areas and 1.5 million people are added to urban environments every week [1]. This rapid population growth results to two conflicting issues. On the one hand, it leads to overexploitation of resources and an inadequate number of services failing to cover existing needs. On the other hand, sustainable development must be achieved to ensure citizens quality of life and well-being. Smart cities that leverage technological developments, including mobile technologies, sensors and connected infrastructures hold the promise of providing solutions to address problems from increased urbanization, including those concerning environmental sustainability and governance of services for efficient use of resources.

In current urban settings, rendering transport systems sustainable is a major problem as such systems have significant impacts on the environment, accounting for about 25% of the world energy consumption and carbon dioxide emissions [2]. Furthermore, recent reports show that the greenhouse gas (GHG) emissions from transport are increasing at a faster rate than any other energy using sector, especially in urban environments [3], rendering current practices unsustainable.

One way to improve the sustainability of mobility in smart cities is by increasing citizens' awareness of the negative impacts of their transport choices and proving means to nudge them towards the use of sustainable transport modes. This can be achieved by designing and implementing approaches based on information and communication technologies (ICT) that make travelers' aware of the environmental impact of travel mode

choices and by providing personalized persuasive interventions towards adopting transportation habits that result to less car usage and more use of public transportation, bicycles and walking.

Our work builds on the concept of persuasive technologies (PT) which guide users towards the adoption of desired attitudes or actions by infusing persuasive strategies in ICT applications that interact with the users [4]. PT have been successfully utilized in several application domains to support sustainable behaviors, such as health, education and environmental sustainability, including transportation (see e.g., [5], [6]).

More specifically, we study the effectiveness of personalized persuasive interventions to change user's transport behaviors towards more sustainable choices. For the purposes of our study we designed and developed a personalized persuasive approach which was integrated in a route planning mobile application. A set of design elements were defined which were tested in terms of their ability to influence the effectiveness of persuasive interventions in three real life pilots where users from the cities of Vienna (Austria), Ljubljana (Slovenia) and Birmingham (UK) used the route planning application for a period of 12 weeks. The outcomes of our study can be used by smart city transport authorities and persuasive systems designers in order to develop effective persuasive technologies for sustainable transportation.

The remainder of the paper is organized as follows. Section 2 provides more details on the concept of persuasive technologies and discusses the related work; Section 3 formulates the design elements of PT for urban transportation which are the focus of this paper; Section 4 provides an overview of the approach and system that was developed by considering the aforementioned design elements, and explains its main assumptions and functionalities; Section 5 presents the results which came out of the real life pilots; Finally, Section 6 concludes the paper with our final remarks and suggestions for future work.

2 Background and Related Work

A number of applications have been developed over the last years which support users in shifting their behaviour towards more sustainable means of transportation by employing persuasive technologies. One of the first mobile persuasive applications was UbiGreen [7], which adapts the background graphics of the phone to provide visual feedback that aims to reduce car use and to encourage greener alternatives, including carpooling, public transport, and pedestrian modalities. Other examples of such applications include PEACOX [8], TRIPZOOM [9] and SUPERHUB [11].

According to the literature review by Anagnostopoulou et al. [12], several persuasive strategies such as behaviour feedback, social comparison, goal-setting, gamification, personalized suggestions and challenges have been used so far in PT for sustainable transportation, and new ones are being continuously developed. Indicative examples of how persuasive strategies are implemented include the following. Behavioural feedback: tracking a user's behaviour and providing visual feedback on the emissions caused by her/his choices; social comparison: comparing one's own mobility behaviour to that of others and presenting comparative information; personalized suggestions: providing system-generated suggestions that urge users to follow more environmental transportation modes. The implementation details (e.g. mobile route planning app versus web-based systems) of PT for sustainable transportation are quite diverse however, findings from the literature review of Klecha and Gianni [13] show that mobile devices are being prevalently used.

Regarding the effectiveness of such applications on behavioural change, a recent review of existing systems designed to promote sustainable travel behaviour [14] concludes that effect sizes are mostly small and methodologically robust studies are largely missing, hence no definitive conclusion yet can be derived.

An important and active area of research in persuasive technologies focuses on their personalization. Existing applications that integrate personalized persuasion try to personalize specific aspects of a single persuasive strategy and not the persuasive strategy per se. For example, in [15] an approach of personalizing challenges (competition strategy) is described, while in [7] an application that persuades users to make more sustainable choices through personalized suggestions and self-monitoring is implemented. In our previous work ([16]), we describe a first attempt to nudge users on a personalized level in order to change their mobility behavior and make more sustainable choices. Although the results were fairly positive, further exploration of persuasive strategies' personalization for behavioural change towards sustainable mobility is required. In more details, the full potential of persuasive technology to change user mobility behaviour remains untapped

due to the fact that the effectiveness of persuasive technology to nudge users towards sustainable mobility choices, depends on several features that have not been considered in a holistic and consistent manner in the design of systems used to deliver the persuasive interventions (e.g. mobile apps with their back-end services). In this paper we focus on the study of a set of features, hereafter called Design Elements (DE), which include the: personalization of persuasive interventions based on the characteristics of the individual (DE1); adaptation of interventions to the results of previous persuasive interactions (DE2); combination of different styles and forms of interventions (DE3); degree of persuasive interventions' intensity (DE4); target of persuasive interventions in terms of the specific transportation mode they are nudging the users to follow (DE5); the adaptation of persuasive interventions' intensity depending on the trip purpose (DE6).

3 Design Elements Influencing Persuasion

The aforementioned DEs along with the way they influence the effectiveness of persuasive interventions, are elaborated in this section. Note that these DEs have been taken into account for the design and development of an approach and the related persuasive system for the delivery of personalized persuasive interventions to change user mobility behaviour. The approach and application are described in Section 4, while Section 5 provides empirical evaluation results which show how the DEs affect the persuasiveness of the application.

DE1: Persuasive interventions specifically addressing each user and tailoring persuasive features to the individual. Personalizing persuasive technology is an important and active area of research at the human computer interaction community. Persuasive technology designers use many different persuasive strategies to change user behaviour, such as behaviour feedback, social comparison, goal-setting, gamification, personalized suggestions and challenges. However, people differ in their susceptibility to different persuasive strategies, i.e. a strategy that may be effective for an individual may not be that effective for another. Personalized approaches can be more successful than "one size fits all" as they can adapt the selected persuasive strategies to specific users, rather than the general audience and can sustain users' interest over time while providing better results [17].

DE2: Incorporation of a learning component that allows the system to adapt the persuasive interventions towards sustainable travel choices based on previous experience. The view that the system has on a particular user, in terms of his/her susceptibility to the different persuasive strategies, can be dynamically and constantly updated through machine learning techniques, as users interact with the system. More specifically, user susceptibility to the different strategies can be dynamically updated by considering previous successful persuasive interactions with that particular user and other similar users. In this way, persuasive interventions can be dynamically adapted to the potentially changing user needs, sustaining their impact over time. The bigger the number of users receiving persuasive interventions and the number of persuasive attempts per user, the faster such a dynamic approach will converge to (i.e. identify) the best user susceptibility to the different persuasive strategies.

DE3: Combining different means of communicating persuasive interventions (e.g. textual messages with graphs) to nudge users to make more sustainable travel choices. Another important factor in the design of persuasive interventions is the way these are delivered. One of the most common methods refers to presenting feedback, suggestions and social comparison in the form of textual messages. Another method refers to presenting feedback about the mobility habits of users. This could be either by e.g. displaying graphs depicting the percentages of transport modes usage, or by showing money spent, calories burnt, and carbon dioxide emissions consumed.

Recent years have witnessed a remarkable increase in the adoption of visualization as a means to convey information through data. Visualizations aid human understanding of data by leveraging the human visual system's highly-tuned ability to see patterns, spot trends, and identify outliers by making data more accessible and appealing [18]. Although visualizations as a communication tool to inform users gains popularity, little research has been done to examine the effects of data visualization in influencing them or in making a message more persuasive [19]. For example in [20] the authors examine social visualisations, i.e. the visualization of individual's data in relation to that of others, as a tool in persuasive technology with the potential to cause behaviour change towards healthier lifestyles through social comparison.

Enabling different means of communicating persuasion, allows us to investigate, whether a message combining narrative and statistical evidence is more persuasive than a message using either narrative (i.e. textual persuasive message) or statistical evidence (i.e. persuasive visualization) alone. Evidence from the literature supports the aforementioned argument; see for example [21].

DE4: Adjusting the intensity of persuasive interventions. The intensity of persuasive interventions is a key factor in the design of persuasive systems as the frequency of persuasive attempts for changing users' behaviour can affect the effectiveness of interventions. For example, energy feedback research [22] suggests that frequent feedback is preferred and is more effective compared to less frequent feedback. It is also possible that frequent feedback can become repetitive to such an extent that users are annoyed [23]. The problem of personalizing the frequency and intensity of persuasive interventions to the needs of an individual recipient has been gaining interest over the last years, with the aim to increase interventions' effectiveness. This is because individuals may differ in how much support they want in general but also around specific moments in behaviour change [24]. For example, when changing behaviours some people may prefer only low frequency contact, others may want more intense support, while still others may need more support under specific situations.

Related studies have provided preliminary results which show that adapting the intensity of the persuasive interventions to the preferences and characteristics of individual users upgrades the interventions' persuasive capabilities [25]. In our previous work we have also confirmed that the intensity of persuasive attempts matters [16]. Therefore, one of the issues to be explored in this work is whether adjusting the intensity of persuasive interventions to the needs of an individual has an impact on the effectiveness of interventions.

DE5: Nudging users to sustain or intensify current green behaviour. A persuasive intervention that nudges users to change their mobility behaviour, includes the definition of the intervention's target in terms of a sustainable transportation mode. It is important to select the target of persuasive interventions based on the current typical mobility choices or habits of the individual, avoiding to driving him out of his/her comfort zone in a big extend. For example, it may be more difficult to nudge individuals who mostly use their car to begin using bike sharing than nudging them to begin combining the use of car with public transportation, i.e. park & ride, in certain occasions. Similarly, an individual who combines car with public transportation is easier to change his habits and take the bus instead of walking for long distances. In other words, since a radical behavioural change is rarely easy, it often requires a gradual progression of small steps toward a larger goal. In the same direction, nudging individuals to sustain or intensify their current green behaviour and supporting them to resist the temptation of using more unsustainable modes of transport seems to be more effective – at least in the short-term – than pushing them to get out of their comfort zone by completely changing their mobility behaviour to much more sustainable modes.

DE6: Targeting persuasive interventions towards environmental friendly modes of transport mainly for leisure than commute trips. A traveller's decision on transport mode selection depends upon the value of travel time savings (VTTSs) [26], a measure used in the domain of transportation to define the value of every minute (time) that individuals save during their travels. The value of VTTSs varies for different trip purposes. For example, if an individual travels (commutes) to her/his work, the VTTSs is high since the individual wants to minimize the travel time as much as possible. Instead, when s/he travels for leisure purposes, the VTTSs is lower than commuting. Especially, when the VTTSs is lower than usual, it is more likely that the individual selects a more environmentally friendly route, which could take longer time to reach a destination (e.g. use of public transportation instead of a car).

Past research [27] has provided evidence on the variation of the VTTSs by country and trip purpose. Specific models are applied to produce VTTSs for business travel, commuting, and for other purposes in passenger transport, for 25 European Union Member states. Based on this study, for all the countries of interest for our work, i.e. Austria, Slovenia and UK, the VTTSs for commuting travels is higher than for leisure travels. Therefore, and after following the findings mentioned above, we assume that the persuasive interventions are more effective when the trip is made for leisure purposes than for commuting.

4 Personalized Persuasion for Sustainable Urban Mobility

For the purposes of our study, we have designed and implemented an approach for personalized persuasion in the context of sustainable mobility that incorporates all the design elements discussed in Section 3. The aim is to support transportation decisions for selecting more environmentally friendly routes that lead to emissions reduction in a smart city context. Our approach is integrated in a route planning mobile application developed as part of the EU-funded H2020 project OPTIMUM[1]. The overall design and architecture of our approach is presented in Figure 1. Our personalized persuasive approach relies on two complementary services: (i) the Route Recommendation Service (RRS) that operates on lists of alternative routes for travelling from A to B provided by a Routing Engine and identifies alternatives that match user context and preferences and are environmentally friendly and (ii) the Personalized Persuasive Service (PPS) that provides personalized persuasive features that nudge users to take an environmentally friendly route.

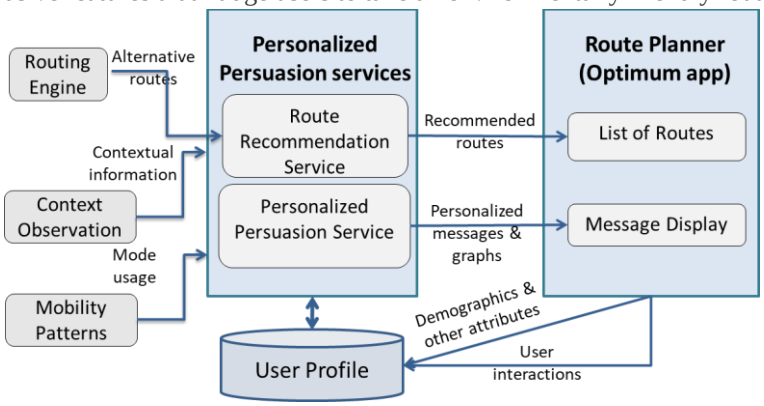

Figure 1: Overview of our personalized persuasion approach.

This paper focuses on the Personalized Persuasion Service (PPS), which implements the persuasive design elements described in Section 3. The aim is to persuade the user to take a particular route which is considered as optimal by the RRS. This route is the target for user persuasion. The PPS is called by the route recommendation service in order to attach a personalized persuasive feature to the route targeted for user persuasion. Persuasive features include tailored persuasive messages and graph-based visualizations.

The design and implementation of persuasive messages is described in our previous work [16]. The messages are presented in the route selection screen of the OPTIMUM mobile app as shown in part 1 of Figure 2 and implement the persuasive strategies of self-monitoring, comparison, suggestion and rewards. We have defined 125 persuasive messages with each one implementing a single strategy. Multiple messages have been designed per persuasive strategy, while all of them are context-aware, in the sense that they are valid for specific contexts. For example, the message "Today it's sunny! Take the opportunity to walk" will be presented to the user when the context "Nice weather" is active. The contextual elements used in our pool of messages capture the context in which the travel behaviour takes place. We have defined eight binary contextual variables (i.e. their value can be true or false) as follows: i) three variables based on personal travel behaviour characteristics (increased car / public transportation usage the previous period, caused emissions increasing compared to other users); ii) three variables based on trip-related characteristics (the destination is in a biking or walking distance, the duration of the route is similar to driving); iii) one variable based on weather status (nice or bad weather); iv) one variable based on rewards for sustainable route choices. Note that for the calculation of trip related context variables, users provide their preferences, including a maximum walking and bike distance preference, as well the ownership of a bicycle during registration. The graph-based visualizations that communicate statistical information about users' mobility habits, aim to nudge users towards sustainable choices by employing social comparison and self-monitoring persuasive strategies.

[1] http://www.optimumproject.eu

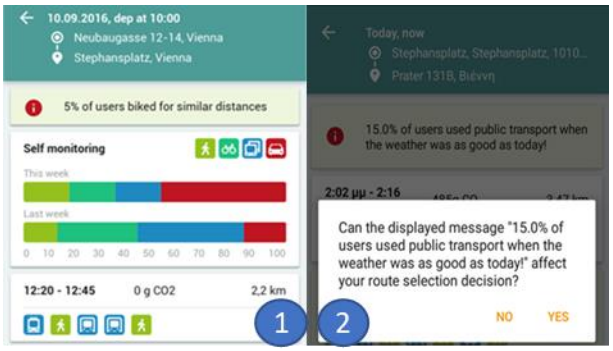

Figure 2: 1) persuasive messages and graph, 2) popup message to gather feedback on the impact of interventions.

The PPS tailors the persuasive messages and visualizations to the individual, with the aim to maximize the impact of the persuasive attempts. For personalizing the persuasive interventions, we rely on the concept of user persuadability, i.e. user susceptibility to different persuasive strategies. This is identified implicitly, i.e. without the need of explicit user involvement, and dynamically, i.e. after some attempts to persuade the user. The approach makes use of users' personality profiles as well as previous successful persuasive interactions of that particular user and other similar users. To address the so-called cold start problem according to which the system has not enough information for new users, we have developed a persuadability model that identifies users' susceptibility to different strategies on the basis of personality that is subsequently identified through a list of questions asked during user registration. For a detailed description please refer to [16].

Our approach combines persuasive visualizations with textual persuasive messages, in the sense that a user can be nudged to follow an environmentally friendly route by attaching to that route (i) a textual persuasive message, or (ii) a persuasive visualization, or (iii) both a textual message and a persuasive visualization. The persuasive strategies of self-monitoring and social comparison are implemented through both textual persuasive messages and persuasive visualizations, while the strategies of suggestion and reward are implemented solely through the textual persuasive messages. Only combinations of messages with persuasive visualizations that implement the same persuasive strategy are allowed, while the persuasive strategy to be used in each case is identified by considering the persuasive strategy that each user is more susceptible to.

The PPS controls the selection of the persuasive feature (i.e. messages or visualizations) that is presented to the user through the mobile application. Part 1 of Figure 2 depicts a sample screen where both a textual message and a persuasive self-monitoring visualization are presented with the aim to nudge the user to bike. As already mentioned, the user could be presented with similar screens with the textual message only or the persuasive visualization only. Moreover, our approach integrates mechanisms that adjust the intensity of persuasive interventions. This is performed with the use of a message throttling function that prevents displaying the same message or similar messages several times in a row, especially if they receive negative user feedback about their persuasive effect. A similar approach was followed for persuasive interventions employing visualizations. In addition, the intensity of interventions is adjusted according to the user trip purpose that is automatically inferred by the application. An indicative example is the following: suppose a user who mainly uses her/his car for everyday transportation. The intensity of persuasive interventions should be low for this user when traveling to work, whereas it could be higher for leisure trips as the chances of switching to more environmentally friendly modes should be higher in that case. For inferring the trip purpose of the user, we make use of information from external services which include Foursquare, and a location detection module which can automatically infer the users' home and work address based on previous visit patterns, in case such information has not be explicitly provided by users through the settings page of the route planning app.

5 Results

To test our approach and the effectiveness of the proposed persuasive design elements we setup a pilot study in three European cities which allowed us to investigate the mobility behavior, the travel mode choices as well as the attitudes and experiences of participants while using the OPTIMUM route planning app. During the pilot study, users from the city of Vienna, Birmingham and Ljubljana installed and used the OPTIMUM application to plan their everyday urban trips. The duration of the pilot study was 12 weeks, from May to July 2018. Altogether 72 participants took part in the study. They were equally distributed regarding gender (35 male, 35 females, 2 N/A), and the age range was between 17 and 66 years (mean 34.7, SD 11.9).

Users participated in two hours kick-off workshops where the topic of our study in general was presented. The workshops were performed in groups of up to nine people and with given dates. Users were chosen by their possibility to join a workshop, their gender, age, and car usage. During the kick-off workshop participants downloaded and installed the OPTIMUM app from Google Store on their mobile phone. Also, the subjects filled in an online questionnaire before the pilot. In this pre-pilot questionnaire, we asked participants to provide details on their travel preferences and past travel behaviour.

In addition, fifteen telephone interviews with selected users who actively used the OPTIMUM were conducted during and after the pilot to get a detailed status update. Interviews lasted approximately 30 minutes. Topics covered during the interviews included the general impression of the app, user experience related topics, opinions about persuasive messages and their influence on travel mode choices and personal environmental awareness. Finally, closing workshops were conducted after 12 weeks. During these workshops, participants filled in a post-pilot online questionnaire. The post-pilot questionnaire contained questions regarding usage and user experience of the app, the usefulness of the persuasive interventions as well as their influence on participants' actual travel behaviour and environmental awareness.

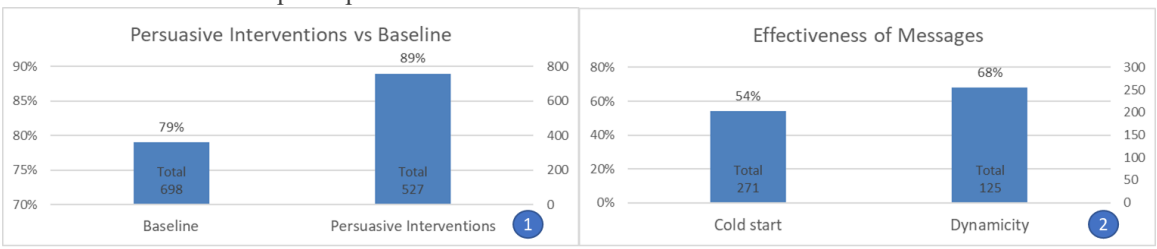

Figure 3: Percentage of route requests where users check the details screen of routes containing sustainable modes of transport (including walking, bicycle and public transportation) 1) in the baseline vs personalized persuasive interventions periods, 2) in the case of cold start vs dynamic approach.

Both quantitative and qualitative data were collected to gather as much insight as possible. For the data analysis, we took into account logged user interactions with the OPTIMUM app, the mobility and the personality type of participants and responses to the questionnaires. In order to better understand the behaviour and usage patterns of the users several means to collect data regarding these aspects were implemented. Data collection and analysis focused on the persuasive messages data and the GPS data. Specifically, whenever the user searched for a possible route with the app, the requests were collected and logged over the time of the pilot, thereby providing us the possibility to analyse users' activity about their route requests. In addition, the app automatically recorded the GPS-tracks and sensor information of the users' phones, and this data was then used to automatically impute the travel modality of the users.

In order to investigate the effect of "*DE1: Persuasive interventions specifically addressing each user and tailoring persuasive features to the individual*", we measured the impact of our personalized persuasive framework on behavioural change. Commonly this is measured by monitoring users' behaviour before and after the use of the persuasive technologies in order to observe whether users change their actions. However, as it is not always possible to measure or accurately determine actual behavioural change, we measured whether users viewed the details screen of routes containing sustainable modes of transport (including walking, bicycle and public transportation) in cases where users received and in cases where users did not receive persuasive interventions. In order to be able to measure this we had a baseline period of one week

when users did not receive persuasive interventions. Part 1 of Figure 3 shows the percentage of routes for which users checked the details screen of a sustainable route in case they received personalized persuasive interventions and the baseline.

To investigate the effect of "*DE2: Incorporation of a learning component that allows the system to adapt the persuasive interventions towards sustainable travel choices based on previous experience*", we compared the impact of persuasive interventions in the cold start case compared to the dynamic approach. As mentioned in Section 4, in the cold start case, the service selects the persuasive strategy that is more appropriate based on the static user persuadability model, while in the dynamic approach the selection of the persuasive strategy is performed by considering previous successful persuasive interactions of that particular user and other similar users. Part 2 of Figure 3 shows that the dynamic approach can be considered more effective as users viewed the details of routes containing sustainable modes of transport in 66% of the cases when adaptation of persuasive interventions was used compared to 54% when the learning component was not active.

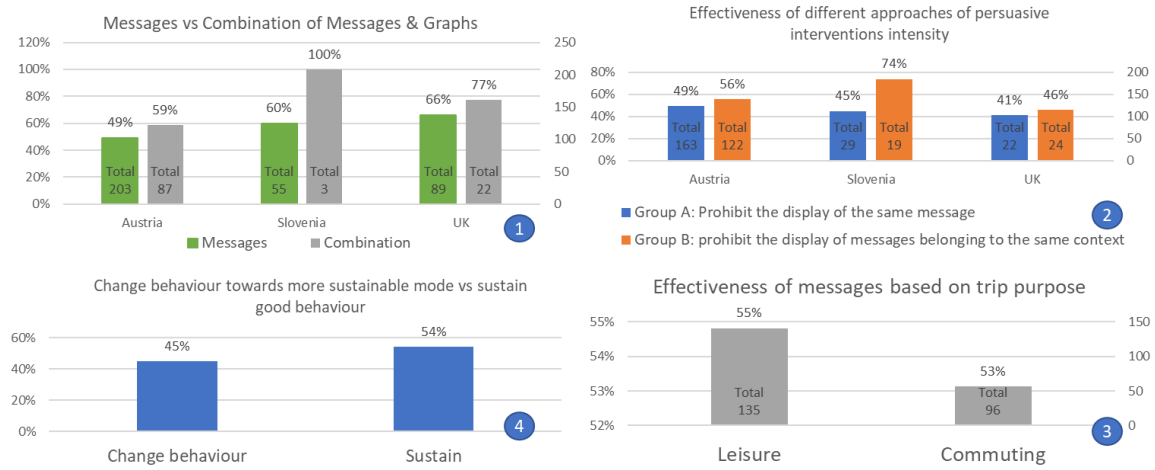

Figure 4: Overview of the effects of the design elements DE3 (1), DE4 (2), DE5 (3) and DE6 (4).

To understand the effect of "*DE3: Combining different means of communicating persuasive interventions (e.g. textual messages with graphs) to nudge users to make more sustainable travel choices*", we analysed the impact of persuasive messages versus a combination of messages and graphs. In this case, we measured the impact through a popup message which explicitly asked users whether the persuasive interventions affected their decisions (see part 2 of Figure 2). Part 1 of Figure 4 shows users' feedback for the two different approaches. The reported feedback shows that the combination of messages and graphs was more effective than messages alone only in all pilot cities. To study the effect of "*DE4: Adjusting the intensity of persuasive interventions*", we created two groups of users for which messages were throttled using two different methods. For the first group (Group A) we applied a throttling mechanism which prohibited the display of the same persuasive message before a number of persuasive attempts has taken place in the meantime. For the second group (Group B) we applied a mechanism which prohibited the display of messages belonging to the same context before a number of persuasive attempts has taken place in the meantime. Note that in our approach the unique persuasive messages (125) are significantly more than unique contexts (8) which results to a lower intensity of persuasive interventions for Group B users. Part 2 of Figure 4 summarizes the feedback from the users. We observe that the messages were more effective for Group B users where the intensity and repetition of the messages was lower. The reported feedback shows that the less repetitive the persuasive messages, the most effective seem to be.

To investigate the effect of "*DE5: Nudging users to sustain or intensify current green behaviour*", we compared the effectiveness of persuasive interventions depending on the target of persuasion in two cases. In the first case the system nudges users to follow more environmentally friendly routes that those they commonly take (e.g. a user who mainly takes his car will be nudged to follow public transportation or walk) whereas in the second case the system nudges users to continue following sustainable routes they already

take (e.g. a user who mainly takes public transportation will be nudged to continue taking public transportation). The results presented in part 3 of Figure 4 show that the effectiveness of persuasive interventions sustaining users' behaviour is 54%, while the effectiveness of persuasive interventions that nudge users to follow more environmentally friendly routes is 45%.

To identify the impact of "*DE6: Targeting persuasive interventions towards environmental friendly modes of transport mainly for leisure than commute trips*" we checked the effectiveness of persuasive interventions for different trip purposes. Part 4 of Figure 4 depicts the effectiveness of persuasive interventions for leisure and commuting purposes. The results show evidence that persuasive interventions are more effective for leisure purposes than for commuting.

6 Conclusions and Future Work

In this paper, we propose a set of persuasive design elements that can be incorporated into persuasive applications for urban mobility to nudge travelers towards more sustainable transport choices. The design elements have been taken into account for the design and development of an approach and related route planning application, which was used to empirically investigate how they affect the persuasiveness of interventions. Our results show evidence for a direct and measurable impact of the implemented persuasive interventions and the potential of persuasive features such as the persuasive messages and graphs to affect travel behaviour. Moreover, our results indicate that the personalization of persuasion can nudge users towards the selection of environmentally friendly routes.

We find evidence that the combination of messages and graphs was more effective than messages only which means that persuasive technology designers should combine persuasive messages with graphs to ensure greater persuasive impact. We also observed that the less repetitive the persuasive messages, the most effective they are. Moreover, we found that the effectiveness of persuasive interventions is higher for leisure purposes than for commuting. Based on these results, persuasive technology designers should provide solutions that are not too pressing and should consider the trip purpose as the interventions' effectiveness greatly depends on this factor. Furthermore, our results indicate that nudging users to select sustainable modes that they have already used is more effective. This means that a persuasive target should not be selected on the basis that a route is greener than the typical transportation choices of the user but also consider modes the user is familiar with and support him/her to sustain or intensify current green behaviours as well as to resist the temptation of using more unsustainable modes of transport. Since a behavioural change is rarely easy and often requires a gradual progression of small steps toward a larger goal, the persuasive target among two routes that are both more sustainable than the route which the user typically takes, should be the one that is more similar to the typical user choice.

However, we must note that the short time frame of the evaluation did not allow us to gather enough data which would allow to test the statistical significance of the proposed interventions. Future work should focus on delivering largescale and longitudinal evaluations in order to establish a solid opinion on the long-term impact of persuasive technologies at promoting desirable behaviours in the area of urban mobility in smart city contexts.

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