

Exploring the Links Between Persuasion, Personality and Mobility Types in Personalized Mobility Applications

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Abstract. Recent approaches on tackling the problem of sustainable transportation involve persuasive systems and applications. These systems focus on changing citizens' behavior towards adopting transportation habits that rely more on the use of public transportation, bicycles and walking and less on private cars. A main drawback of existing applications is the limited use or lack of personalization aspects that consider differences in users' susceptibility to persuasive strategies. In this paper, we explore two user traits that can be used for personalizing the persuasive strategies applied to end users: personality and mobility type. More specifically, we present the results of a study where we examined the perceived persuadability of eight persuasive strategies on users of five personality types and three mobility types.

Keywords: Personality · Persuasion · Mobility type · Personalization

1 Introduction

Persuasive systems can provide the means to respond to sustainability problems arising from human activities. This kind of persuasive systems are commonly referred as “persuasive sustainability systems” and their aim is to foster sustainable behaviors and raise individuals' awareness of their choices, behavior patterns and the consequences of their activities [1]. In this paper we focus on the problem of sustainable transportation. The impact of humans' transportation habits on the environment are grave: transportation accounts for 20% to 25% of the world energy consumption and carbon dioxide emissions [2], while these emissions are increasing faster than in other energy using sectors, especially in urban environments [3]. Increased urbanisation and mobility solutions highly dependent on private vehicles aggravate this situation.

Recent approaches on tackling the problem of sustainable transportation involve persuasive systems and applications. These systems focus on increasing travellers' awareness of the environmental impact of travel mode choices and changing citizens' behaviour towards adopting transportation habits that rely more on the use of public

transportation, bicycles and walking and less on private cars [4]. Such choices lead to Green House Gas (GHG) emissions reduction, mitigating the effects on the environment while they are correlated with more healthy lifestyles, including increased exercise and less obesity [4]. Our recent review of related systems [5] has shown that persuasive systems in the context of personal mobility is an active area of research, with numerous approaches aiming to motivate more eco-friendly choices.

Typically, persuasive strategies are incorporated in applications that support the selection of routes and transportation means in everyday mobility needs [4, 5]. Common strategies include self-monitoring in the form of statistics that provide visualizations of users' past choices (e.g. graphs showing the emissions caused by the user's decisions), social comparisons where users are compared to peers and goal-setting along with rewards for achieving target behaviours (e.g. using more public transportation).

A main drawback of existing applications is the limited use or lack of personalization aspects [6] that consider differences in users' susceptibility to persuasive strategies. 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 [7].

However, further exploration of persuasive strategies' personalization for behavioural change towards sustainable mobility is required. Most existing studies on this topic have focused on personalization of persuasive systems in the health domain [8, 9]. In this paper we explore two user traits that can be used for personalizing persuasive strategies: personality and mobility type. We present the results of a study where we examined the perceived persuadability of eight persuasive strategies on users of five personality types and three mobility types. We developed eleven models examining the relationships between persuasive strategies and personality/mobility types and created persuasive profiles, i.e. ranked lists of strategies that can be employed to motivate sustainable behavior for specific user personality/mobility types.

The remainder of the paper is organized as follows. Section 2 provides a short background on personality and mobility types and the related work on personalized persuasion in the domain of mobility. Section 3 describes our methodology and the process we followed to analyse the collected data. Section 4 presents the results of our analysis. In Sect. 5 we discuss our findings and we conclude in Sect. 6 with our final remarks and suggestions for future work.

2 Background and Related Work

In this section we present the main concepts we examine in this paper.

Personality Traits. Personality is a key driver behind people's interactions, behaviors, and emotions and it is related to preferences and interests [10]. One of the most widely used models in the area of psychology for studies encompassing personality and human behavior is the big five factor model, which measures a user's personality in terms of five dimensions, namely Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism [11] (also known with the acronym OCEAN). Each user's personality type is associated with certain characteristics as shown in Table 1.

Table 1. Personality Traits based on the Big Five model and associated characteristics.

Personality type	Characteristics
Openness	Appreciation for novelty or variety in experiences, diversity in interests
Conscientiousness	Organized, consistent, cautious and dutiful, less creative
Extraversion	Appreciation for environments with higher levels of stimulation, high energy, more activity and social life
Agreeableness	Cooperative, Adaptable, submissive, tolerant, generous, modest and trusting
Neuroticism	High susceptibility to anger, frustration, insecurity, pessimism, anxiety and negative emotions

The measurement of users' personality is performed using specific instruments. The best known for contexts in which participant time is limited, is the Big Five Inventory proposed by Rammstedt et al. [12]. This instrument consists of ten 5-point Likert scale questions used to get a measure of the five personality dimensions.

In the domain of social psychology the association between personality traits and persuadability is still under exploration. In their preliminary study, Hovland et al. [13] found that people with high Neuroticism scores tend to be more susceptible to social influence and to be persuaded by social comparison. However, studies examining the relationship between Extraversion and persuasion have found contrasting results. In several studies a negative impact of Extraversion on persuasion has been reported [14]. On the other hand, other studies report that extraverts tend to be susceptible to influence given their needs to be socially desirable [15]. In addition, Hirsh et al. [16] examined whether message-person congruence effects can be obtained by framing persuasive messages in terms of Big-Five personality dimensions, using a sample of 324 survey respondents. The participants judged an advertisement emphasizing a particular motivational concern as more effective when it was congruent with their own personality traits. Hence, their results suggested that adapting persuasive messages to the personality traits of the recipient can be an effective way of increasing their impact, highlighting the value of personality-based communication strategies.

The Big-Five model was used in [17] to guide the design of persuasive systems for combating obesity trends in teenagers. Specifically, the authors used Big-Five traits to recommend games and to select persuasive messages to encourage users to play. In the health domain, Halko and Kientz [9] reported statistically significant relationships between personality traits and persuasive strategies. They found a positive correlation between Neuroticism trait and the cooperation strategy. On the contrary, negative correlations were found between the Conscientiousness trait and social persuasive strategies. This finding may indicate that conscientious people may be less susceptible to the use of social persuasive technologies in the health domain.

Mobility Types. The term mobility type is used in order to segment travel behaviors into potential "mode switchers" and support mobility management policies. A widely-adopted classification of mobility types is provided in [18], see also Table 2. Each class represents a unique combination of preferences, worldviews and attitudes, indicating

that different groups need to be serviced in different ways to optimize the chance of influencing mode choice behavior.

Table 2. Mobility types as identified in [18].

Mobility type	Description
Devoted drivers	Prefer to use a car than any other mode of transport and they are not interested in reducing their car use
Image improvers	Like to drive, don't want their ability to drive to be restricted, but recognize that it would be good if they all reduced car use a little
Malcontented motorists	They want to cut down their car use but find that there are a lot of practical problems and issues with using alternative modes
Active aspirers	They feel that they drive more than they should and they would like to cut down
Practical travelers	They regard the car merely as a practical means of getting from A-B and largely use it only when necessary
Car contemplators	They do not have a car at the moment but would like one at some point in the not so distant future
Public transport dependents	Although they are not against cars in any way and think people should be allowed to use them freely, they don't like driving very much
Car-free choosers	They are not keen on driving and believe that cars and their impacts are something that need to be urgently addressed

For our analysis we grouped the mobility types of Table 2 into three classes: *Drivers*, i.e. people that actively use their car (Devoted Drivers and Image Improvers), *Potential non-Drivers*, i.e. people that want to avoid using their car (Malcontented Motorists, Active Aspirers, Practical Travelers) and *non-Drivers*, i.e. people who do not use a car (Car contemplators, Public Transport Dependents, Car-free Choosers).

Personalized Persuasion in Mobility Apps. Existing applications that focus on personalized persuasion in mobility apps try to personalize specific aspects of a single persuasive strategy and not the persuasive strategy per se. For example, in [19] an approach of personalizing challenges (competition strategy) is described, while in [20] an application that persuades users to make more sustainable choices through personalized suggestions and self-monitoring is implemented. Gabrielli et al. [21] describe a mobile application that motivates users to make sustainable transportation choices using goal-setting, self-monitoring and personalized notifications. Froehlich et al. [22], describe a transport application which adapts the graphics to provide visual feedback in order to reduce driving and to make personalized recommendations.

3 Study Design and Data

In this study we examine the perceived persuasiveness of eight persuasive strategies, namely *comparison*, *self-monitoring*, *suggestion*, *simulation*, *cooperation*, *praise*, *personalization* and *competition*, on users of different personality and mobility types. Out of the landscape of persuasive strategies we select those based on the work of Orji et al. [23] since these fit well to our envisaged application of motivating sustainable mobility choices. Table 3 provides an overview of how the selected strategies can be applied in the mobility domain.

Table 3. Selected persuasive strategies and how they can be used in the domain of mobility.

Strategy	Description
Comparison	Comparison of one's own mobility behavior to that of others
Self-monitoring	Tracking user behavior and providing feedback on the emissions caused by his/her choices
Suggestion	System generated suggestions that urge users to follow more environmental transportation modes
Simulation	Graphical representations presenting the impact of mode choices on the environment
Cooperation	Challenges such as a bicycle commuter challenge where users co-operate to meet certain targets (e.g., meeting a 100 km per month target per team)
Praise	Positive feedback when users achieve or exceed eco-efficiency goals
Personalization	Route planners that remember past preferences, frequently chosen means of transport and simplify the processes of finding the most sustainable travel choice
Competition	Online competitions to motivate mobility-related behavior change (e.g., taking the bicycle instead of the car, taking the train instead of the plane)

3.1 Procedure and Participants

In order to gather the data required for our analysis, we designed a simple questionnaire that captures personality, mobility type and user susceptibility to the persuasive strategies. The questionnaire consists of three parts. The first part contains demographics and ten questions about participants' personality as defined in [12] which provide a short instrument for measuring personality. The second part contains questions for identifying the mobility type of the participants. To collect these data, we use the scale defined in [18], along with the three classes of mobility types define in Sect. 2. The third part concerns user susceptibility to the selected persuasive strategies (i.e. persuadability). Following the approach described in [8], we present each persuasive strategy in a storyboard showing a character and her interactions with a mobile application that aims to support her to use more environmentally friendly transportation options. The use of storyboards alleviates the burden of implementing the application and then gathering feedback, provides the means to collect responses from diverse populations with a visual language that almost anybody can read and understand [24] and allows us to collect

adequate volumes of data needed for building and validating our persuadability model. Figure 1 provides an example of one of the storyboards.

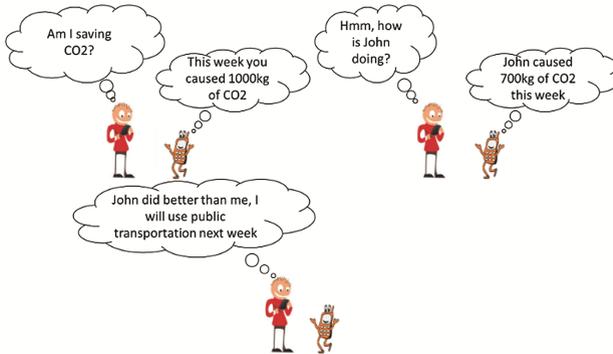


Fig. 1. Example storyboard representing the comparison persuasive strategy.

To measure the perceived persuasiveness of the strategies we adopt the measure described in [8], i.e. each storyboard is followed by a set of four questions as follows: (i) “The mobile app would influence me.” (ii) “The mobile app would be convincing.” (iii) “The mobile app would be personally relevant for me.” and (iv) “The mobile app would make me use more environmentally friendly transportation means”. The questions were measured in a 7-point Likert scale ranging from “1 = Strongly disagree” to “7 = Strongly agree”. In order to ensure that participants understood the strategy depicted in each storyboard we added one comprehension question asking them to identify the illustrated strategy from a list of 4 different strategies (“What strategy does this storyboard represent?”).

We collected data using Amazon Mechanical Turk (AMT) that provides access to a large user base. Past studies have shown that the quality of the results compares to that of laboratory experiments when the setup is carefully explained and controlled [25]. Note that we set geographic restrictions in order to involve users from the US and Europe only. We gathered a total of 320 responses and after filtering out incomplete responses and responses from participants who answered the comprehension question incorrectly, we retained 120 valid responses for our analysis, 50 from Drivers, 41 from Potential non-Drivers and 29 from non-Drivers.

3.2 Data Analysis

For the analysis of our data we follow the approach of [23] and use the Partial Least Squares Structural Equation Modelling (PLS-SEM) method [26, 27]. The PLS-SEM method allows estimating complex cause-effect relationship models with latent variables. It is based on a structural equation model which is composed of two sub-models: the measurement model and the structural model. The measurement model represents the relationships between the observed data and the latent variables, while the structural model represents the relationships between the latent variables. An iterative algorithm

solves the structural equation model and estimates the latent variables by using the measurement and structural models in alternating steps.

We choose PLS-SEM for our analysis because it can test theoretically supported linear and additive causal models. SEM can be used to treat unobservable, hard-to-measure latent variables. PLS is a soft modelling approach to SEM with no assumptions about data distribution. Also, it is recommended when the sample size is small, for applications with little available theory, when predictive accuracy is paramount and when the correct model specification cannot be ensured.

Before feeding the collected data in the PLS-SEM and in order to examine the relationships between the user personality/mobility type and the persuadability of various strategies, we performed an EFA (Exploratory Factor Analysis, i.e. a statistical procedure that identifies the number of latent factors in a set of variables) to determine the appropriate number of factors in our data. First we verified the suitability of our data for factor analysis with the Kaiser-Meyer-Olkin (KMO) sampling adequacies [28]. The results (KMO value 0.94) showed that our data were suitable for factor analysis [29]. EFA was performed through Principal Component Analysis (PCA) using SPSS.

Regarding the PLS-SEM analysis, the first step concerns the creation of the method's measurement and structural models that were described above. In our case, we created the PLS-SEM models by using the SmartPLS 3.0 tool [26]. We used the PLS algorithm in the same tool to estimate the path coefficient (β) for each PLS-SEM model. Then, we used the bootstrap resampling technique to calculate standard error (SE) for each structural path. Finally, we calculated t-statistics and their corresponding p values were used for testing significant differences between path estimates.

To examine the perceived persuasiveness of the eight persuasive strategies on users of different personality types, we created eight different PLS-SEM models, one for each persuasive strategy. Figure 2 depicts as an example the PLS-SEM model created to examine the correlations between personality types and the comparison strategy.

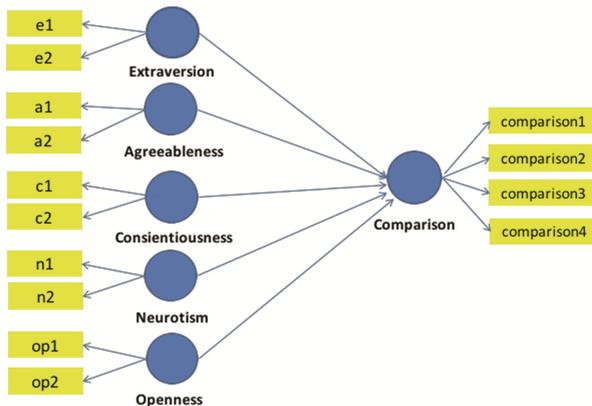


Fig. 2. PLS-SEM model examining the relationships between personality type and comparison

To examine the differences and similarity in the perception of the eight strategies by the three mobility types, we followed a similar approach. We created 3 different models, one for each mobility type, since in contrast to personality traits that characterise users in different degrees each, mobility types are mutually exclusive, i.e. each individual is characterised by exactly one of them. We therefore divided the participants into three groups based on their mobility type and for each group we created a model exploring the correlations between the relevant mobility type and the eight persuasive strategies.

4 Results

4.1 Results of Personality Type - Persuasive Strategies Relationship

The structural PLS-SEM models used in this case determine the perceived persuasiveness of the various strategies on users of different personality types. In order to measure how strong the various relationships between personality types and persuasive strategies are, we calculated the level of the path coefficient (β) and the significance of the path coefficient (p). Path coefficients measure the influence of a variable on another. The individual path coefficients (β) obtained from our models are summarized in Table 4. The table presents the results for $p < 0.05$.

Table 4. Relationships between personality type and persuasive strategies (* means $p < 0.1$).

Personality type	CMPR	SEMT	SIML	SUGG	CMPT	COOP	PRAS	PERS
Extraversion	–	–	–	–	–	–	–	–.17
Agreeableness	.19	.20*	.16*	.11	–	.19*	.23	.22
Neuroticism	.24	.23	.25	.27	.25	–	.20	.31
Openness	–	–	–	–	–	–	–	–
Conscientiousness	–	–.17*	–	–	–	–	–	–

CMPR = comparison, SEMT = self-monitoring, SIML = simulation, SUGG = suggestion, CMPT = competition, COOP = cooperation, PRAS = praise, PERS personalization

The results show that there are relationships between persuasive strategies and personality types. More specifically, agreeableness and neuroticism are positively and significantly associated with many strategies, extraversion and conscientiousness are negatively associated with a single strategy each, while openness is not related to any strategy. The positive and significant correlations suggest that users of the corresponding personality types are persuaded by the relevant strategies and can therefore be motivated to adopt sustainable behaviour by using these strategies. Table 5 shows the best and the worst strategies to persuade users towards making more sustainable mobility choices based on their personality type.

It is important to take special care not only in deciding on which strategies to employ to motivate behaviour performance for each personality type, but also which strategies to avoid in order not to deter users from performing the target behaviour. The results from our model will be used to decide the most appropriate strategy for each user in order to recommend sustainable routes in the most convincing way.

Table 5. Best/worst strategy for each personality type.

Personality type	Best strategies	Worst strategies
Agreeableness	Praise, Personalization, Self-monitoring, Cooperation, Comparison, Simulation, Suggestion	–
Neuroticism	Personalization, Suggestion, Competition, Simulation, Comparison, Self-monitoring, Praise	–
Conscientiousness	–	Self-monitoring
Extraversion	–	Personalization

4.2 Results of Mobility Type - Persuasive Strategies Relationship

The individual path coefficients (β) obtained from our PLS-SEM models in the case of mobility type are summarized in Table 6. The table presents the results for $p < 0.05$. The mobility types of Table 6 have been defined in Sect. 2.

Table 6. Relationships between the mobility type and persuasive strategies.

Mobility type	CMPR	SEMT	SIML	SUGG	CMPT	COOP	PRAS	PERS
Drivers	0.66	0.58	0.51	0.50	0.62	0.54	0.62	0.60
Potential non-Drivers	0.58	0.54	0.46	0.58	0.56	0.52	0.50	0.46
Non-Drivers	0.60	0.68	0.52	0.60	–	–	0.60	–

Table 7. Best strategy for each mobility type.

Mobility type	Best strategies
Drivers	Comparison, Competition, Praise, Personalization, Self-monitoring, Cooperation, Simulation, Suggestion
Potential non-Drivers	Comparison, Suggestion, Competition, Self-monitoring, Cooperation, Praise, Simulation, Personalization
Non-Drivers	Self-monitoring, Comparison, Suggestion, Praise, Simulation

The results summarized in Table 6 show that all mobility types are positively and significantly associated with many strategies. Table 7 shows the best strategies to persuade users towards making more sustainable mobility choices based on their mobility type.

5 Discussion

In our exploratory study we found statistically significant relations between personality types and persuasive strategies for all personality types except from openness. Our study shows that people with high scores in the personality trait of openness were not persuaded from any strategy.

In addition, we found that the best strategy for people with high agreeableness is praise, i.e. they prefer to get a reward, in order to change their behaviour. Personalization and self-monitoring are also good strategies to persuade these people, i.e. they may prefer to see their actual past and current states to meet their goals. A correlation between this personality type and comparison was also identified in [7]. Moreover, our results indicate that the best strategy to persuade people with high neuroticism scores is personalization. Furthermore, suggestion and competition are convincing strategies for these people.

We didn't find any positive correlation of people with a high score in the personality traits of conscientiousness and extraversion with any persuasive strategy. We found only negative correlations with self-monitoring and personalization strategies, respectively. Thus, people who are conscientious or extravert may not prefer any strategy to persuade them. Our results are also confirmed by Halko [7], who found only negative correlations between extraversion and persuasive strategies.

Table 8. Best strategies based on the personality and mobility type.

Personality/Mobility type	Best strategies
Drivers with high agreeableness scores	Praise, Comparison, Self-monitoring, Cooperation, Personalization, Simulation, Suggestion
Potential non-Drivers with high agreeableness scores	Comparison, Self-monitoring, Praise, Cooperation, Suggestion, Personalization, Simulation
Non-Drivers with high agreeableness scores	Self-monitoring, Praise, Comparison, Suggestion, Simulation
Drivers with high neuroticism scores	Personalization, Comparison, Competition, Praise, Self-monitoring, Suggestion, Simulation
Potential non-Drivers with high neuroticism scores	Suggestion, Comparison, Competition, Self-monitoring, Personalization, Simulation, Praise
Non-Drivers with high neuroticism scores	Praise, Self-monitoring, Suggestion, Comparison, Simulation

Our study highlighted differences in the perceived persuadability of the eight persuasive strategies on users of the three different mobility types. As it is observed the three most convincing persuasive strategies for Drivers are comparison, competition and praise. Potential non-Drivers are more susceptible to comparison, suggestion and competition, while non-Drivers to self-monitoring, comparison and suggestion.

Thus, based on the above results, knowing the mobility and personality type of users we can persuade them using the strategies that are more convincing. If the individual has high scores in Extraversion, Openness or Conscientiousness, which are not significantly and/or positively associated with any persuasive strategy, the selection of the most convincing strategy can be done based on her mobility type. In case the individual has high agreeableness or neuroticism scores she can be persuaded by taking into account both her personality and mobility types. Table 8 presents best strategies in case personality and mobility types of the individual are combined on the basis of an average of the corresponding correlations.

6 Conclusions

In this paper, we examined the perceived persuasiveness of eight persuasive strategies on users of five personality types and three mobility types. We found positive statistically significant correlations between Agreeableness and Neuroticism and seven persuasive strategies each. In addition, we found relationships between the three mobility types and almost all the persuasive strategies. Finally, we combined the results from our models in order to identify user persuadability on the basis of both personality and mobility types. Based on the developed personality-based and/or mobility-type based persuadability models, we will build a personalised persuasion service that will select the most appropriate persuasive strategies based on the personality and/or the mobility type of each user in order to nudge him/her towards more sustainable transportation modes. Our next step is to implement a mobile application that recommend routes and tries to persuade users to make more sustainable mobility choices based on the envisaged personalised persuasion service.

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