Persuasion profiles to promote pedestrianism: Effective targeting of active travel messages

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ABSTRACT

This study recommends novel strategies for tailoring messages to encourage walking, for use in travel planning, Mobility as a Service platforms and other apps which promote sustainable transport behaviour. We suggest strategies based on individual demographic and psychosocial factors derived from the findings of a study of the persuasiveness of different arguments to encourage walking. 402 participants from across the UK were recruited to evaluate 16 pro-walking arguments systematically varied by type of argumentation used, and the values to which they appealed. We explored interactions between these argument features and participants' personality, travel attitude, age and recent transport mode usage. We report several interesting findings, including that the types of argumentation used, participants' travel attitude, and their previous transport uses all had no effect on the perceived persuasiveness of messages. Factors which did have an effect on the perceived persuasiveness of messages included the age and personality of the participants and the value to which the message appealed. We also found several complex interactions between these factors, such as that those higher in agreeableness tended to rate arguments emphasising environmental benefits as more persuasive, and that younger participants tended to rate arguments appealing to the health benefits and convenience of walking as less persuasive.

1. Introduction

The use of persuasive technology to foster sustained behaviour change is an important emerging field in efforts to reduce car-use and otherwise respond to the various problems caused by our current transport systems. Sustainable mobility apps encompass a wide variety of designs and employ several different persuasive strategies, often underpinned by behavioural theory, to encourage users to reduce their car-use and adopt more sustainable transport behaviours (Cellina et al., 2019; Sunio et al., 2017). These include personalised travel planning in which detailed, user-orientated information about alternative transport options is provided to the user (Gabrielli and Maimone, 2013), gamification systems that encourage specific behaviours through point-scoring or competition with other users (Jylhä et al., 2013), and self-monitoring systems where statistics and visualisations provide information about users' past choices (Zhao & Baird, 2014).

Despite the diversity of persuasive strategies used in sustainable mobility apps, recent reviews of these apps have suggested that techniques for personalisation and tailoring are currently underdeveloped (Anagnostopoulou et al., 2016; Sunio et al., 2017). They note that while context dependent factors such as location are generally considered in app design, individual characteristics such as personality and attitudes are often omitted. This is despite a large body of evidence suggesting that individual responsiveness to persuasive strategies is linked to such factors (Hirsch et al., 2012; Alkış and Taskaya Temizel, 2015; Matz et al., 2017). These reviews suggest that the formulation of "persuasion profiles" is needed to effectively tailor mobility apps to the user and maximise the interventions' effectiveness. Furthermore, the need to encourage more sustainable transport practices remains critically important but is potentially threatened by preference-based apps such as Mobility as a Service (Pangbourne et al., 2020), unless they offer encouragement to travel by more sustainable modes.

A better understanding of the role of individual user characteristics on persuadability is necessary to develop such persuasion profiles. This study focuses on how these characteristics can be applied to tailor persuasive messaging aimed at encouraging a modal shift from private car-use to walking as a form of transportation. Persuasive messaging through mobile technology has been used to great effect in several areas, most notably in the field of public health (Head et al., 2013). Text-message based interventions have been shown to facilitate change for several health-related behaviours including weight management (Patrick et al., 2009), diabetes monitoring (Arora et al., 2014), smoking cessation (Free et al., 2009) and medication management (Badaway et al., 2017). A review of these interventions has shown that they are

significantly more effective when they tailored messaging to psychosocial factors (e.g. attitudes, self-efficacy) than when they do not (Head et al., 2013).

While persuasive messaging is common in many behaviour change domains, Anagnostopoulou et al. (2018) highlighted that research into which messages are most effective for encouraging sustainable mobility is currently lacking, providing little evidence to guide the process of tailoring. Recent studies have shown that persuasive messaging that is improperly targeted can not only be ineffective, but often counter-productive (Kaptein & Eckles, 2012). In this paper we present some experimental results which demonstrate the relative effectiveness of some strategies for promoting walking that are available to would-be persuaders, including argumentation and personalisation strategies; particularly in contexts where fine-grained persuasion profiles can be utilised (such as mobile apps). Whilst this is the first in a series of experiments, we chose to start with walking messages. There are two main reasons for this. Firstly, there is good reason to believe that the specific attributes of different transport modes mean that different push and pull factors are important to users, meaning that different benefits would need to be promoted. Therefore, given the lack of knowledge on effective message construction we decided to begin by investigating one mode at a time to reduce the potential for confounding factors. Secondly, there is a long-established road user hierarchy utilised in the field of road safety which has been widely recognised in urban and transport planning as a street user hierarchy that has significant public policy co-benefits. This hierarchy places walking at the top (Fischer et al., 2010).

The remaining paper is structured as follows. The literature review discusses current knowledge regarding travel attitudes, willingness to walk, persuasive strategies, personality and other psychosocial factors that might be useful for developing persuasion profiles. This is followed by a short section outlining some theory of argumentation necessary for understanding our approach. The study itself is then elaborated through three sections: method, results and discussion. The conclusion summarises how our results demonstrate that effectiveness of personalisation strategies for promoting walking can be enhanced by combining argument value with certain individual characteristics such as age and personality trait. We then highlight some potential applications.

2. Literature review

Research suggests that there are several common motivations for, and barriers to, walking, and that the associations between these and individual psychosocial factors is complex. For example, Bopp et al. (2012) found that one of the primary motivations for walking as a form of active commuting was the perceived health benefits, while a major barrier was a lack of time. However, motivations to walk for health reasons may depend on the extent to which the individual currently maintains a healthy lifestyle, currently walks for transport or recreational purposes, and engages in other physical activity (Clifton & Livi, 2005).

It has also been shown that people are similarly diverse in their motivations for reducing car-use for environmental reasons. While only a minority of the UK respondents surveyed felt that people should be allowed to use their cars as much as they liked even if it caused damage to the environment, 47% felt that there was no point in reducing their own car use unless others do (Department for Transport, 2018). These findings show the complex nature of motivations for reducing car use, particularly as they may relate to values such as health and environmental concern. However, the way such values interact with persuasive messaging is something that has not been specifically tested in mobility behaviour change research.

In addition to appealing to different motivations for walking, persuasive messaging allows the use of different persuasive strategies to motivate people to change their behaviour. Cialdini (2001) identified six key persuasive strategies that leverage common social tendencies to

significantly increase the chances an individual will be persuaded by a request; reciprocity (a tendency to pay back what we owe to others), commitment (a tendency to stick with what we've already chosen), social proof (a tendency to value popular opinion), authority (a tendency to value the opinion of those in positions of authority), liking (a tendency to comply with requests made by those we like) and scarcity (a tendency to want things that are exclusive or hard to come-by).

Numerous studies have shown that these principles are effective in increasing the persuasiveness of a message (e.g. Fogg, 2002; Oyibo et al., 2017). However, studies have also shown that there are significant differences in how each strategy is perceived. Orji et al. (2015) showed that of the six persuasive strategies, commitment and reciprocity were rated as the most persuasive strategies while social proof and scarcity were least persuasive.

Some promising research into the influence of personality on persuasion suggests that individual personality factors may impact the ways in which we evaluate and respond to persuasive messages. The role of personality in persuasion is complex, and research has generated some intriguing findings. For example, those high in neuroticism and low in openness to experience tend to respond more positively to persuasive strategies that employ social pressure and comparison than those low in neuroticism (Lepri et al., 2016; Thomas et al., 2017). Similarly, those high in openness or in agreeableness are most likely to be persuaded by authority strategies and those high in conscientiousness are most likely to be persuaded by reciprocity strategies (Oyibo et al., 2017). Messages framed to match characteristics associated with each personality trait have been shown to be more effective than those which do not. In experiments examining messaging to encourage voter-turnout (Gerber et al., 2013) and advertise products (Hirsch et al., 2012), it has been shown that messaging using persuasive strategies that are congruent with a participant's personality characteristics results in greater uptake of the desired behaviour.

Furthermore, personality has been shown to be highly correlated with several values which might be appealed to in persuasive strategies to increase walking. For example, high agreeableness, openness to experience and conscientiousness have all been shown to be linked to greater environmental concern and greater engagement in sustainable behaviours (Milfont & Sibley, 2012; Markowitz et al., 2012). However, while neuroticism has been linked to increased worry over health concerns, it has also been linked to low self-efficacy regarding changing health-related behaviours and a tendency to engage in behaviours detrimental to one's health (Lahey, 2009). This suggests the possibility that a message promoting the health benefits of walking might be less effective for a person high in neuroticism.

While research into the role of personality in mobility behaviour change is sparse, some recent findings have suggested that differences in personality may impact the effectiveness of strategies used to encourage modal shift. Anagnostopoulou et al. (2017) found that a combination of high agreeableness and low neuroticism was linked to the success of several persuasive strategies, including personalisation, praise and social comparison, that were not linked to other personality traits.

Collectively, these findings suggest that personality could be an important tool in tailoring mobility behaviour change interventions, but more research is needed to clarify how these and other possible insights can best be used to tailor persuasive messages to their target audience. For example, age may also be an important factor in the way individuals evaluate pro-walking messages. Recent qualitative research has suggested that the primary reasons for active travel amongst young adults are cost-savings, flexibility, speed and the social aspects of walking, while health and environmental benefits are less important (Simons et al., 2014). Similarly, while young adults often acknowledge the health benefits of physical activity, they tended to see this as a future benefit rather than something they would benefit from at their current age (Giles & Brennan, 2015). As a result, they generally did not identify health improvement as a primary motivator for engaging in

physical activity. Currently little research has been done to quantify the effect these different motivations have on active travel arguments.

Finally, we seek to evaluate the impact of pre-existing travel attitudes and behaviour on the way people rate arguments persuasiveness. Recently several researchers have suggested the use of market segmentation techniques to categorise individuals into meaningful subgroups based on motivations for their travel behaviour. These subgroups (segments) can encompass affective (e.g. pleasure and social comparison), cognitive (e.g. time and cost evaluations), and attitudinal (e.g. feelings of social responsibility, environmental concern) motivations for travel behaviour (Anable, 2005). Segmentation methods such as these have been shown to effectively predict travel-mode choice and the likelihood of behaviour change (Anable, 2005; Hunecke et al., 2010, Semanjski et al., 2016) and it is therefore plausible that they should provide insights into the way people respond to active-travel related arguments (Pangbourne & Masthoff, 2016).

3. Argumentation theory

In this section we explain the rationale and design for testing the features of messages as arguments. The measures used to test the predictor variables will be covered in the materials section. In recent studies concerning persuasive technologies and behaviour change, particularly in the transport domain, most conceptualise the persuasion in terms of strategies. For instance, Anagnostopoulou et al. (2017) (see literature review above) tested several common persuasive strategies, including comparison, self-monitoring and praise. Praise as a persuasive strategy involves giving positive feedback when users achieve the desired goals; self-monitoring involves tracking user behaviour and providing feedback; and comparison involves comparing the users' performance to others. Thinking in terms of persuasive strategies is a natural and useful way to proceed when investigating the effectiveness of persuasive technologies, because it allows us to conceptualise the various persuasive elements combined in an interactive piece of persuasive technology as serving a single persuasive function.

However, it is worth noting that one persuasive strategy which is absent from every list is argumentation. There are good reasons why this might be the case, but the most obvious is that some variety of argumentation will be a feature of most of the persuasive strategies that are highlighted, and so it would not be easy to delineate argumentation as a distinct persuasive strategy alongside, for instance, suggestion and comparison. However, since argumentation will form an important part of a great many persuasive strategies, it is important to know what types of argumentation are more persuasive in different contexts. By reducing a persuasive strategy to an argument type with a similar rhetorical structure to that persuasive strategy, we can simplify our study (isolating only one persuasive feature rather than a set) and gather evidence concerning the persuasiveness of the argumentative element which may be used in a more complex complementary strategy.

In this study, therefore, we will focus on *messages*, analysed as pieces of informal argumentation, as the persuasive element to be tested. Messaging has been explicitly identified as a crucial feature of many persuasive strategies (Anagnostopoulou et al., 2017), and understanding messages as arguments, particularly in the context of behaviour change interventions, provides us with useful theoretical tools for understanding message efficacy and interaction with other active persuasive elements of various interventions.

For our purposes, then, a message is any piece of linguistic communication. An argument is a series of statements (premises) which offer reasons to believe another statement (the conclusion). Some messages, therefore, can be arguments, if they can be analysed as giving reasons to accede to a proposition. Persuasive messages can always be understood as arguments, since by definition a message which attempts to persuade someone to do a thing is a message which attempts to give a reason why the persuadee should accede to the statement "I should [do

the thing]".

While the type of argument describes the way in which its premises give logical support to its conclusions, there is another feature common to many arguments which attempt to persuade people to change their behaviour; an appeal to value. Without an appeal to value, an argument that one ought to do X instead of Y (walk instead of drive to work, for instance), provides little if any motivational force, just as a simple statement that one ought to change behaviour without any accompanying persuasive strategy is less likely to be effective (Fogg, 2002). Any plausible reason why one should walk instead of drive to work will appeal to some value or other: if walking is quicker, then this is an appeal to speed as valuable. If walking is healthier, then this is an appeal to health as valuable. If it is cheaper, then this is an appeal to inexpensiveness as valuable, and so on. Therefore, we also want to understand which, if any, value is the most persuasive when appealed to in an argument for sustainable transport uptake.

3.1. Argument type

The ways in which the premises of different arguments support their respective conclusions are described by argument schemes or types. Some of these are familiar from common usage; e.g. an argument from consequences is an argument that some action should (or should not) be undertaken, because there will be good (or bad) consequences as a result. Argument schemes have been extensively catalogued, and their function in various kinds of dialogue continues to be the subject of debate and study in the field of Argumentation Theory (Walton et al., 2008). It is relatively easy to associate some argument schemes with particular persuasive strategies. For instance, an argument ad populum (an argument that an action should be undertaken, or a proposition believed, because it is being done or is believed by a large number of other people), seems a natural fit with the persuasive strategy of social proof or comparison. It is a natural fit in that an argument ad populum that you ought to walk instead of drive to school seems to appeal to the same, or similar, reasons for walking to school as an app which shows you that more of your friends walk to school than drive.

However, an appeal to one similar kind of reason (in this case, that lots of other people do or believe something) is not the only factor at play in the persuasiveness of any given argument, and so we cannot say that an argument ad populum, for instance, is functionally equivalent to a broader persuasive strategy of comparison just by virtue of the fact that they appeal to a common type of reason. Hence, one value of this study is the isolation of argumentation as our persuasive strategy of interest, divorced from any broader persuasive strategy of which argumentation might form a part. In short, we are interested in evaluating argument schemes (which we henceforth describe as argument type) as a way of evaluating the simplest possible example of a genre of persuasive strategy, expressed as simple linguistic communication, divorced from any potentially confounding factors that may arise from embedding them in more complex technological or rhetorical interventions.

We aim to determine whether the argument type impacts the persuasiveness of a message intended to foster change in transport behaviour. We are particularly interested in whether any single argument type is especially persuasive in this domain, and whether there are significant differences in perceived persuasiveness between argument types. There are an enormous number of possible argument types available for testing, from which we selected the following four: ad populum, argument from consequences, argument from authority, and practical inference.

Our selection criteria for these four argument types was based on an analysis of the common argument types used in the Sustainable Transport Communications Dataset (STCD) (Wells and Pangbourne, 2016). After an initial survey of the STCD we found that arguments from consequences were the most common argument type, that arguments from authority were also extremely common (even more so if

arguments supplied by authoritative sources (e.g. the NHS) can count as arguments from authority by fiat). We also found that arguments ad populum were surprisingly uncommon (given their relationship to the persuasive strategy of comparison). We therefore decided to test these three argumentative strategies against one another, to see if there was any empirically sound reason for their relative (un)popularity. We also included a practical inference statement as a control; a practical inference being a statement of the form "you want to X, Y is a way of doing X, therefore you ought to do Y", with no further argumentation given.

3.2. Argument value

Aside from argument type, an appeal to value is the other important element common to arguments for a change in behaviour. We want to test which values are the most effective to appeal to in arguments to promote use of sustainable transport. Based on previous findings outlined above, and an analysis of the most common themes observed in the STCD (see above), we chose to compare the following four values: health (health benefits of walking as a form of transport), financial (the cost-savings to the individual as a result of walking as a form of transport), environmental (the environmental benefits and reduction in emissions as a result of walking as a form of transport) and convenience (the ease and time-saving of walking as a form of transport). As in our selection of argument type, two values were chosen based on their high rate of appearance in the STCD (health and finance) and two were chosen based on their relatively low appearance in the dataset (environmental value and convenience).

4. Method

4.1. Study design

In this study, we wanted to determine the strength of interactions among six key sets of independent variables on a single dependent variable – the perceived persuasiveness of an argument. By perceived persuasiveness we are referring to the extent to which a respondent would judge the argument as being effective in changing the behaviour of themselves and others. Previous research has shown that while using measures of actual behaviour change is best for understanding a message's efficacy, using measures of perceived persuasiveness is an appropriate proxy for actual message effectiveness when acquiring such data is difficult (Dillard et al., 2007). However, researchers in the persuasive technology field have not settled on a common method for this, and we have utilised a perceived argument strength measure (see below). Taking into account the relationships between all the features of our arguments and predictor variables, we expected to find differences in the persuasiveness of argument values and types. We also expected to find that there would be a significant interaction between argument features and predictor variables that would account for significant variation in persuasiveness ratings across our argument values and argument types.

We will be evaluating the persuasiveness of messages to encourage walking according to the following criteria: two features of the messages, and four features of the persuadee (predictor variables). The two features of the messages we will be evaluating are the argument type and the value to which the argument appeals. The four features of the persuadee we will be evaluating are personality traits, pre-existing attitudes to sustainable transport, age, and current most frequently used methods of transportation (see Table 1).

4.2. Sample

A sample of 402 participants currently residing in the United Kingdom and aged over 18 were recruited through Amazon Mechanical Turk. A check of the geographical spread of participants indicated that

Table 1
Predictor Variables.

Features of Arguments	Features of Persuadees
Argument Type	Travel Attitude Segment
Argument Value	Personality trait
	Demographics (Age, Gender)
	Recent travel behaviour

most large conurbations were represented; there were few participants in more rural regions and none in North Wales, Northern Ireland and South West England. The participants consisted of 274 males, 120 females and 8 participants who did not specify gender. There were 80.3% identifying as "White" ethnicity, 6.7% as "Asian/Asian British", 6.4% as "African/Caribbean/Black British", 4.5% as "Mixed/Multiple Ethnic Groups" and 1.9% as other ethnic group. We did not have the opportunity to select our sample to be representative during our recruitment process. However, the sample closely matches the ethnic distribution of the UK (Office for National Statistics, 2016). The range of ages in our population was skewed towards younger participants with 46.4% aged 18–29, 34.6 aged 30–39, 15% aged 40–49, 2.7% aged 50–59 and 1.1% aged 60 and over. Although our population is also unrepresentative in terms of gender the analysis suggested that this was not significant (see below). As the study included reading and comprehending written arguments, participants' English reading ability was tested using a Cloze Reading Comprehension Task. Participants who failed this test were excluded from the study.

4.3. Materials and measures

The questionnaire was designed and accessed through Qualtrics online survey platform. Arguments used in the study were derived from the STCD and other materials found in various public online campaigns, charity websites, news reports and government documents. For example, the following argument, "Doctors and scientists agree that regularly walking even short distances has substantial health benefits" was adapted from the NHS "Livewell" webpage[1]. Each argument was based on information reliably sourced from peer reviewed or government sources. Sixteen arguments were developed in total and were manipulated on the two argument variables, value and type (see Fig. 1 for the arguments used).

Our predictor variables were assessed using the following measures:

4.3.1. Personality

One of the most commonly used models of personality is the five-factor model which theorises that people differ on five broad personality traits. A list of these personality traits and their descriptions are included in Table 2. Several measures of the five-factor model exist but we chose to use the Mini-IPIP (Brent Donnelan et al., 2006), a shortened version of the 50-item International Personality Item Pool measure (Goldberg, 1999), due to its short administration time and comparable level of validity with its parent measure.

4.3.2. Travel attitude

We chose the segmentation method of categorising travel attitude to assess its usefulness in tailoring sustainable travel arguments to individuals. Following on from previous work using travel attitude segmentation to understand the effectiveness of messaging (Pangbourne & Masthoff, 2016), we used the "Golden Questions" tool developed by Anable & Wright (2013) to segment participants into one of eight travel attitude segments. Due to limited numbers of participants in some segments, and a need for heterogeneity across groups for our analysis, these segments were further combined into three groups based on

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[1] https://www.nhs.uk/live-well/exercise/walking-for-health/.

		ARGUMENT VALUE			
		Convenience	Environmental	Financial	Health
ARGUMENT TYPE	**Ad Populum**	Most people who start walking more say that convenience is one of the top three benefits.	94% of people believe we should walk more to help the environment	Most people who walk more say that saving money is one of the top five benefits	95% of adults agree that walking is a good way to stay healthy
	Authority	Doctors and scientists have shown that walking is the most convenient way to exercise while getting where you need to go	Scientists say that walking more is a good way to help the environment.	The award winning personal finance blogger Ricky 'Skint Dad' Willis saved over £3,400 a year by using alternatives to driving, particularly by walking more.	Doctors and scientists agree that regularly walking even short distances has substantial health benefits
	Consequence	Walking could get you to work quicker than driving or public transport, with less chance of traffic jams or delays.	Choosing to walk for short journeys will decrease your carbon footprint, and help to offset the dangers of climate change.	Walking could save you a lot of money, costing you less on fuel, car repairs and even insurance.	Regular walking can buy you three to seven additional years of life. It could also improve your mood, exercise your brain and reduce your risk of heart failure.
	Practical Inference	Walking is a convenient and efficient way to travel.	Walking is an environmentally friendly way to travel.	Walking is the least expensive way to travel.	Walking is a healthy way to travel.

Fig. 1. A matrix of the sixteen messages by the argumentation features (argument value and argument type).

Table 2
Characteristics associated with high scores for each of the five personality traits measured by the mini-IPIP (Brent Donnelan et al., 2006).

Personality Trait	Associated Characteristics
Openness to Experience	Imagination, artistic interest, emotionality, adventurousness, intellect, liberalism
Conscientiousness	Self-efficacy, orderliness, dutifulness, achievement-striving, self-discipline, cautiousness
Extraversion	Friendliness, gregariousness, assertiveness, high activity-level, excitement-seeking, cheerfulness
Agreeableness	Trust, morality, altruism, cooperation, modesty, sympathy
Neuroticism	Anxiety, anger, depression, self-consciousness, impulsiveness, vulnerability

participants likelihood to alter their travel behaviour; "Drivers", "Potential Non-Drivers" and "Non-Drivers". This three-fold grouping has been used in relevant recent work and has shown significant differences in the best persuasive strategies for individuals (Anagnostopoulou et al., 2017). Descriptions of each segment and the groups they belong to are displayed in Table 3.

4.3.3. Persuasiveness

To assess our dependent variable (the persuasiveness of each argument) participants completed an amended version of a self-report measure of perceived argument strength developed by Zhao et al. (2011). Participants rated eight questions on a Likert scale from 1 to 5 and the mean of these scores was calculated to create an overall persuasiveness rating score. The measure assesses participants' cognitive responses to each argument as opposed to any intrinsic feature of the argument itself and was selected precisely because we hoped to understand what factors influence an argument's perceived persuasiveness rather than the argument's rational strength. It was also chosen because it uses multiple different argument appraisal methods including ratings of affective reactions, believability, confidence to carry out the behaviour and likelihood it would convince a friend. This study extends on the work by Anagnostopoulou et al. (2017) by including a validated, multi-item measure of argument strength as opposed to a single self-report question.

Table 3
Mobility group descriptions based on Anable & Wright (2013) and Anagnostopoulou et al. (2017).

Group	Segment	Description
Drivers	Devoted Drivers	Prefer to use a car more 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 we all reduced car use a little
Potential Non-Drivers	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 Travellers	They regard the car merely as a practical means of getting from A-B and largely use it only when necessary
Non-Drivers	Car Contemplators	They do not have a car now 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 or can't drive
	Car-Free Choosers	They are not keen on driving and believe that cars and their impacts are something that need to be urgently addressed

4.4. Procedure

Participants were re-directed to the Qualtrics online survey after registering to complete a "Human Intelligence Task" (HIT) that was advertised as a survey looking into the effectiveness of travel related persuasive arguments. Only participants who were registered as living in the UK on their Amazon accounts were eligible to register and take part. After obtaining informed consent, participants completed the Cloze test which consisted of four questions to assess their English reading comprehension. Participants were required to get all questions correct in order to meet inclusion criteria for the study. Those who did not pass were informed they were not eligible to participate in the study and were not able to complete the survey. Eligible participants were then asked some basic demographic questions including age and gender. We also asked participants for the first 3–4 characters of their UK postcode. This was used to identify regions of the UK in which respondents were located without revealing their full address.

Participants were also asked to estimate the number of journeys under two miles that they had undertaken in the past week, the transport modes they used for these journeys, and the most common mode of transport that they had used. This distance was chosen because data suggests that a majority of UK citizens believe they could complete journeys of under 2 miles as easily by walking as they do by car (Department for Transport, 2017a). These questions served two purposes: firstly, they allowed us to gather information about current travel behaviours for short distance journeys; and secondly, they primed participants to think about their own short distance journeys in preparation for evaluating arguments relating to these types of journeys.

Participants then completed the argument evaluation stage. Each participant was presented with four arguments to evaluate in total. The arguments presented were pseudo-randomised so that each participant evaluated exactly one argument featuring each argument type and exactly one featuring each value. For example, a participant may have been presented with the following arguments; (1) environmental argument from consequence, (2) financial argument from authority, (3) convenience argument ad populum and (4) health argument by practical inference. For each argument, participants were asked to "imagine the statement was given as a reason to walk journeys under 2 miles similar to the ones you reported earlier". They were then asked to rate the strength of the argument using the perceived argument strength scale and were provided with a section for written text where they could leave any further comments about the argument.

After completing the argument evaluations, participants then completed the Golden Questions questionnaire and the Mini-IPIP. These were included at the end of the survey to reduce demand characteristics and make it less likely that they would make the connection between travel attitudes, personality and the evaluation of arguments. Following completion of the study, participants were debriefed of the aims and objectives of the study and provided with a completion code that they

were informed should be entered into the MTurk recruitment page in order to claim their remuneration. All participants were paid £1.88 for taking part in line with UK minimum wage for a 15-minute task.

5. Results

5.1. Data transformations

Prior to analysis persuasiveness ratings were normalised using a square transformation to correct for a left skewed distribution. The resulting scale runs from 1 (low perceived persuasiveness) to 25 (high perceived persuasiveness). An anomaly was also found in the content of the Convenience-Authority argument which contained some elements relating to the value of health. We believe this caused inflated ratings of the persuasiveness for this argument as it mirrored that of the Health-Authority argument and appeared abnormally high for a convenience argument compared to the rest of the data set. To correct for this, we calculated the mean difference between persuasiveness ratings of arguments appealing to health and convenience values (mean difference = 3.03) and subtracted this from all Convenience-Authority argument ratings, to compensate for the influence of the health value in the argument.

To analyse the effect of personality types on persuasiveness ratings, scores on each of the five personality traits were split into 3 groups based on their percentiles – lowest third (LOW), middle third (MID), highest third (HIGH). This was done for two reasons: firstly, distribution of scores across all five personality traits was non-normal and heavily left-skewed making regression analysis difficult. We assume that this left-skewed distribution is an artefact of the short form of the IPIP survey, since we manually excluded participants who we suspected of line-crossing (giving the same answer for each question). Secondly, grouping of personality traits into percentiles is often used to make the findings easier to interpret, and research has shown that using groupings of three equal percentiles is a more effective way to capture variability in a dataset than using two (Gelman and Park, 2009). Finally, we also condensed participants into three groups of "Under 29", "30–39", "40 and older" to create a heterogenous distribution of participants across age groups.

5.2. Statistical analysis

A linear mixed-effects model was used to account for variation between participants. The effects of argument type, value, segment group, gender, age, primary mode of transport and the five personality factors (Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism) on the persuasiveness ratings of arguments were assessed along with the following 2-way interactions: Value:Type; Value:Segment; Type:Segment; Age:Value; Age:Type; Value:Each of the personality factors; Type:Each of the personality factors. The model

specified random effects, which consisted of adjusting errors for clustering within-participants using a random intercept model. All other variables were included as fixed effects in the model. All significance values were 2 tailed with α = 0.05. Interactions that did not reach significance were removed from the final model; below we report statistically significant interactions (any possible interaction not discussed did not reach significance).

5.3. Predictor variables

A significant main effect of age on persuasiveness ratings of arguments was observed ($F_{2,322}$ = 3.73, p = 0.026, η_p^2 = 0.02). Post-hoc tests between the three levels showed that on average, 30–39 year olds (M = 15.18, SD = 5.86) rated all arguments as significantly more persuasiveness than participants 29 and under (M = 14.25, SD = 4.77, p = 0.046, d = 0.18) and 40 + year olds (M = 13.65, SD = 4.59, p = 0.012, d = 0.26). No significant differences were found between 18 and 29 and 40 + year olds. There was a small difference between persuasiveness ratings of participants in the Drivers segment (M = 13.30, SD = 4.33) and Non-drivers segments (M = 14.05, SD = 4.61) but this was not significant. There were similarly non-significant effects for the other predictor variables of gender and main travel mode.

Of all the big-five personality traits, only conscientiousness was found to have a significant impact on the persuasiveness ratings of arguments ($F_{2, 321}$ = 3.71, p = 0.026, η_p^2 = 0.02). Post-hoc analysis showed that those HIGH in conscientiousness (M = 15.11, SD = 4.95) generally rated all arguments as significantly more persuasive than those LOW in conscientiousness (M = 13.84, SD = 5.01, p = 0.009, d = 0.26). No significant differences were found between perceived persuasiveness ratings of those MID in conscientiousness (M = 14.70, SD = 4.78) and those LOW or HIGH in conscientiousness across all arguments.

5.4. Argument types and values

A significant main effect of both argument type ($F_{3,998}$ = 13.32, p > 0.001, η_p^2 = 0.03) and value ($F_{3,1007}$ = 35.16, p > 0.001, η_p^2 = 0.09) on persuasive ratings of arguments was observed. Post hoc tests between the four values revealed that health arguments (M = 15.90, SD = 7.41) were rated as significantly more persuasive than financial (M = 14.45, SD = 7.52, p < 0.001, d = 0.18), environmental (M = 14.77, SD = 7.42, p = 0.001, d = 0.12) and convenience (M = 12.37, SD = 7.72, p < 0.001, d = 0.36) arguments. In addition, convenience arguments were rated as significantly less persuasive than both financial (p < 0.001, d = 0.21) and environmental arguments (p < 0.001, d = 0.24). No significant differences were found between financial and environmental arguments. This suggests that arguments for walking are most effective when they appeal to the value of health and least effective when they appeal to the value of convenience (see Fig. 2).

Post-hoc tests between the four argument types revealed that only authority arguments (M = 15.33, SD = 7.31) were rated as significantly more persuasive than practical inference statements (M = 14.59, SD = 7.37, p < 0.001, d = 0.09). Authority arguments were also rated as significantly more persuasive than arguments ad populum (M = 13.42, SD = 7.31, p < 0.001, d = 0.37) and consequence arguments (M = 14.11, SD = 7.31p < 0.001, d = 0.14). Arguments ad populum were shown to be the least persuasive and were rated as significantly less persuasive than consequence arguments (p = 0.027, d = 0.07) and practical inference statements (p > 0.001, d = 0.13). No significant differences were found between consequence arguments and practical inference statements. This suggests that authority arguments are the only argument type that are significantly more persuasive than our control (practical inference statements). Furthermore, not only were ad populum arguments the least

persuasive, they were rated as significantly less persuasive than any other type of argument including our control. This suggests that arguments ad populum are not only ineffective but perform considerably worse than using no argumentation strategy at all.

A significant interaction effect was also observed between argument type and value on the persuasiveness ratings of arguments ($F_{9,1227}$ = 2.49, p > 0.008, η_p^2 = 0.01). Fig. 3 shows differences between the persuasiveness ratings of each type when compared to the mean ratings for each value. It is necessary to point out that the differences between the convenience arguments may have still been skewed towards authority arguments, despite our best efforts to transform the data. As a result, we will not comment on the differences between convenience arguments here. However, univariate tests for differences across the remaining three values showed that there were significant differences between type for the value of health ($F_{3,1249}$ = 3.45, p = 0.018) and environment ($F_{2,1249}$ = 7.24, p < 0.001), but not for financial arguments.

While health-ad populum and environmental-ad populum arguments were less persuasive than other argument types, there is little difference between financial-ad populum and any other financial argument. Similarly, while health-authority and environmental-authority arguments were rated as more persuasive than other argument types relating to the same value, no significant difference was found for financial-authority arguments and other financial arguments. This suggests that while authority arguments are most effective, and arguments ad populum least effective, this makes less of a difference for arguments relating to the financial benefits of walking compared to other values. The Table 4 below gives the mean and standard deviations with the most persuasive highlighted with bold text.

5.5. Interactions between predictor variables and argument type and value

No significant interactions were found between argument type and any of the predictor variables. However, several significant interactions were found between value and our predictor variables. We found a significant interaction between participant age and value ($F_{6, 1049}$ = 4.90, p < 0.001, η_p^2 = 0.03). Fig. 4 shows means and standard deviations of persuasiveness ratings for each age group across the four argument values.

Post-hoc tests revealed that key differences were found between age groups for the values of health, financial and convenience. Health arguments were rated as significantly less persuasive by 18–29 year olds (M = 15.41, SD = 6.09) than 30–39 year olds (M = 16.84, SD = 6.38, p = 0.023, d = 0.23), but no significant differences were found between 40 + year olds and 18–29 year olds or 30–39 year olds (see Table 5 below). This suggests that the persuasiveness of health arguments is not increasing uniformly with age but rather peaks between 30 and 39 years old (this effect can be seen in Fig. 5). We discuss this below.

Financial arguments were rated as significantly less persuasive by 40 + year olds (M = 12.58, SD = 6.03) than 18–29 year olds (M = 15.10, SD = 6.12, p = 0.001, d = 0.41) and 30–39 year olds (M = 15.66, SD = 6.41, p < 0.001, d = 0.48). However, there was no significant difference between 18 and 29 year olds and 30–39 year olds. This suggests that past the age of 40, the persuasiveness of financial arguments for walking significantly decreases (see Table 5).

For convenience arguments, it was found that 18–29 year olds (M = 11.24, SD = 6.26) rated them as significantly less persuasive than 30–39 year olds (M = 12.79, SD = 6.59, p = 0.017, d = 0.24) and 40 + year olds (M = 12.97, SD = 6.27, p = 0.033, d = 0.28) but no significant difference was found between 30 and 39 year olds and 40 + year olds (see Table 5). The overall trend for convenience arguments suggests that younger participants find convenience benefits of walking less persuasive than older participants.

Finally, participants 40 + years old (M = 13.61, SD = 5.88) rated environmental arguments as significantly less persuasive than both
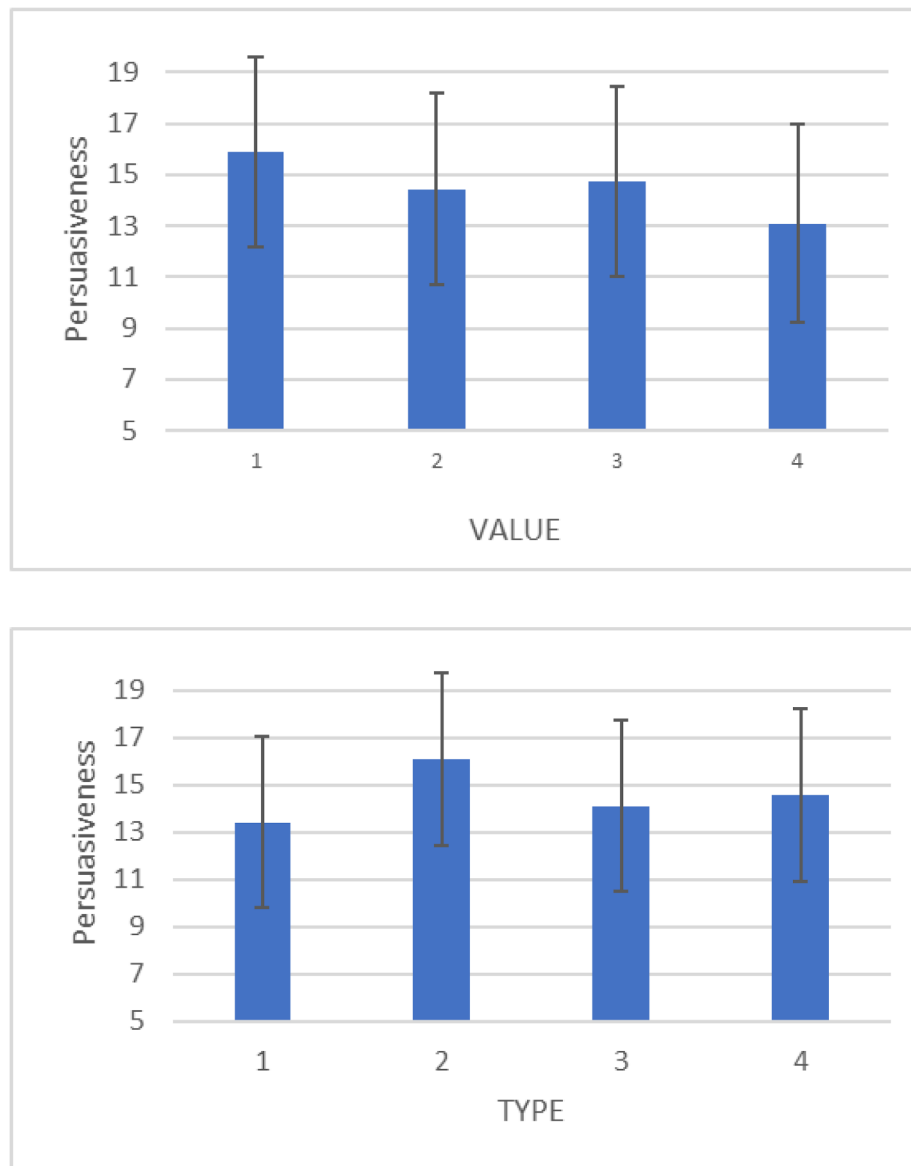
Fig. 2. Means and standard deviations for persuasiveness ratings of each argument value (top) and type (bottom) (note that the persuasiveness rating scale runs from 1 to 25 and the axis is truncated in the figure). For VALUE 1 = Health, 2 = Financial, 3 = Environmental and 4 = Convenience. For TYPE 1 = Ad Populum, 2 = Authority, 3 = Consequence and 4 = Practical Inference.

18–29 (M = 15.25, SD = 6.02, p = 0.033, d = 0.27) and 30–39 year olds (M = 15.44, SD = 6.25, p = 0.022, d = 0.30) (see Table 5). Overall, there appears to be a trend towards younger participants rating environmental and financial arguments as more persuasive, with older participants rating health and convenience arguments as more persuasive.

Of the five personality traits measured, only agreeableness was found to have a significant interaction with argument value ($F_{6, 1005}$ = 2.99, p = 0.007, η_p^2 = 0.02). No significant differences were found between the three agreeableness levels for health, financial, or convenience arguments, but significant differences were found for environmental arguments. Those LOW (M = 13.52, SD = 6.32) in agreeableness rated environmental arguments as significantly less persuasive than both those MID (M = 15.05, SD = 6.33, p = 0.017, d = 0.24) and HIGH (M = 15.73, SD = 5.98, p = 0.004, d = 0.36) in agreeableness (see Table 6).

The difference in persuasiveness between MID and HIGH agreeableness for environmental arguments was not found to be significant. As can be seen in Fig. 5, there is trend towards those higher in agreeableness rating environmental arguments as more persuasive than those lower in agreeableness.

6. Discussion

In this section we discuss the results of our analysis and consider the implications of our findings with reference to the design of messaging to encourage walking. We will focus on how the findings relate to the development of effective behaviour change messaging, and the usefulness of travel attitude segment, personality and age for persuasion profiling and message tailoring.

6.1. Impact of predictor variables on message persuasiveness

We did not find significant differences between average persuasiveness ratings of all arguments for Non-drivers and Drivers, nor did we find significant differences between Potential non-drivers and Drivers. In addition, travel attitude segment showed no significant interactions with either argument value or argument type. Therefore, our
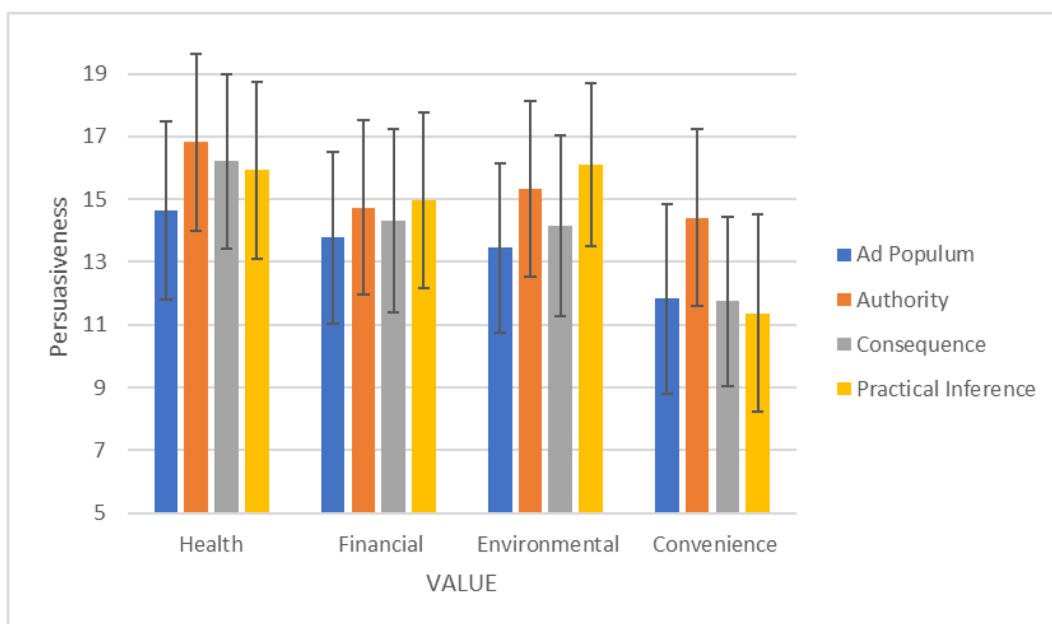
Fig. 3. Means and standard deviations of persuasiveness ratings for each argument type across the four argument values (note that the persuasiveness rating scale runs from 1 to 25 and the axis is truncated in the figure).

findings suggest that the segmentation of individuals into Drivers, Potential non-drivers and Non-drivers, as outlined by Anagnostopoulou et al. (2017), is not an effective strategy for identifying individuals who may be encouraged to change their travel habits through persuasive messaging, nor is it an effective method for identifying the best persuasive strategies for an individual.

These findings are at odds with previous research suggesting that segmentation methods for travel behaviour might be effective for the tailoring of messages (Anagnostopoulou et al., 2017; Pangbourne and Masthoff, 2016). However, it should be noted that limitations in our sample group mean we cannot conclude segmentation is completely ineffective for this purpose. The lack of participants for some of the segments suggested by Anable and Wright (2013) meant that our population had to be condensed into three distinct sub-groups (albeit that these sub-groups are comparable to those used by Anagnostopoulou et al., 2017). It might be the case that a sample which was representative across a larger range of attitude segments would have produced different results. However, it might also be the case that segmentation by travel attitude is not an effective way to target behaviour change messaging, although it may be a useful tool in designing other elements of behaviour change interventions.

6.2. Impact of argument type on message persuasiveness

While we found significant differences in the perceived persuasiveness of argumentation types, we found our results surprising. We expected to find that the use of argumentation would usually increase

overall persuasiveness; resulting in arguments from authority, arguments from consequence and arguments ad populum being rated as more persuasive than practical inference statements. However, we found that only authority arguments were significantly more persuasive than practical inference statements. This is contrary to previous work on argumentation demonstrating that the use of persuasive strategies and argumentation strategies should increase the persuasiveness of a given message (Fogg, 2002).

However, it does suggest that authority arguments can be especially effective in developing persuasive messaging to encourage walking. We suggest that this is because of the relationship with health, and the relative ease (for most people) of walking itself. The recently published findings of Thomas et al. (2019) also suggest that arguments from authority (sometimes known as 'expert opinion') are more persuasive for behaviour change messages in health (and also cyber security).

However, argumentation type showed no significant interactions with any of the predictor variables. This suggests that whilst arguments from authority are the most persuasive rhetorical structure for walking messages generally, manipulating argument type is not a useful strategy for tailoring arguments to an individual's personality, travel attitudes, age or previous travel behaviour. These results bring into question the importance of the use of argumentation methods in travel behaviour change communications and conflict with existing research into the role of personality in the effectiveness of persuasive strategies (Oyibo et al., 2017).

Therefore, whilst it is evident that authority arguments are the most effective type of argumentation, it is worth considering that if simple

Table 4
Mean and Standard Deviation for each argument type across the four argument values. Combinations with highest mean persuasiveness rating are highlighted in bold.

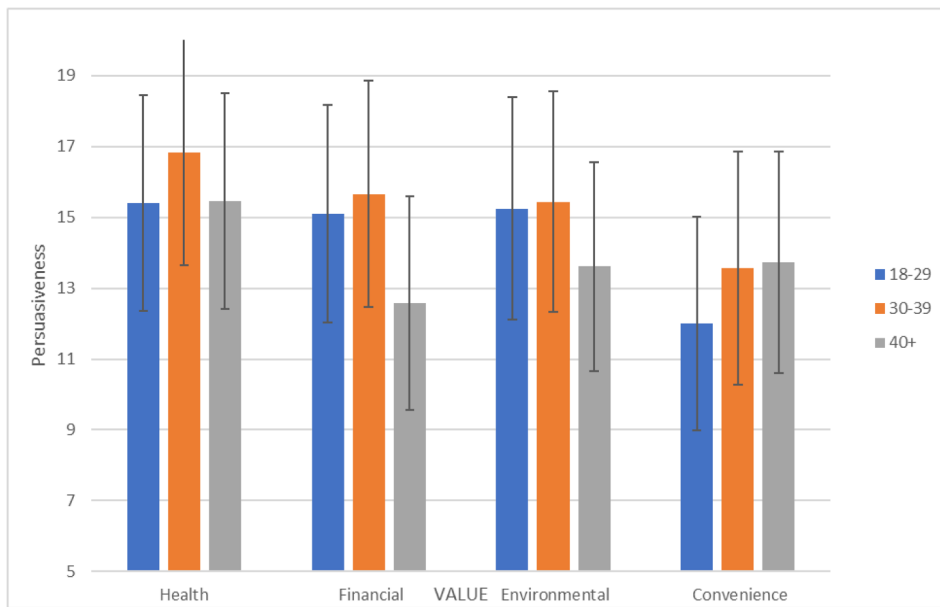|	Ad Populum		Authority		Consequence		Practical Inference	
	M	SD	M	SD	M	SD	M	SD
Health	14.64	5.67	**16.83**	5.65	16.22	5.56	15.92	5.63
Financial	13.77	5.49	14.74	5.59	14.33	5.83	**14.95**	5.60
Environment	13.45	5.43	15.33	5.57	14.17	5.76	**16.11**	5.17
Convenience	11.82	6.04	**14.41**	5.65	11.74	5.40	11.37	6.29

Fig. 4. Means and standard deviations of persuasiveness ratings for each age group across the four argument values (note that the persuasiveness rating scale runs from 1 to 25 and the axis is truncated in the figure).

Table 5
Mean and Standard Deviation for persuasiveness ratings across each age group across four argument values. Most persuasive values for each age group highlighted in bold.

	18–29		30–39		40 +	
	M	SD	M	SD	M	SD
Health	**15.41**	6.09	**16.84**	6.38	**15.46**	6.01
Financial	15.10	6.12	15.66	6.41	12.56	6.03
Environment	15.25	6.02	15.44	6.25	13.61	5.88
Convenience	11.24	6.26	12.79	6.59	12.97	6.27

Table 6
Mean and Standard Deviation for persuasiveness ratings across each agreeableness group across four argument values. Mean persuasiveness ratings higher than 15 are highlighted in bold.

	Low agreeableness		Mid agreeableness		High agreeableness	
	M	SD	M	SD	M	SD
Health	**15.32**	6.48	**15.45**	6.28	**16.94**	6.23
Financial	13.81	6.50	14.64	6.26	14.89	6.22
Environment	13.52	6.39	**15.05**	6.15	**15.73**	6.18
Convenience	13.53	6.70	12.38	6.44	13.37	6.35

practical inference statements perform as well as many argumentation strategies, and if this is the case for all people regardless of attitudes, personality or age, then we suggest that more focus needs to be applied

to the other aspect of argumentation, i.e. message content, especially the values to which a message appeals, rather than basing a persuasive strategy on logical or rhetorical structure.
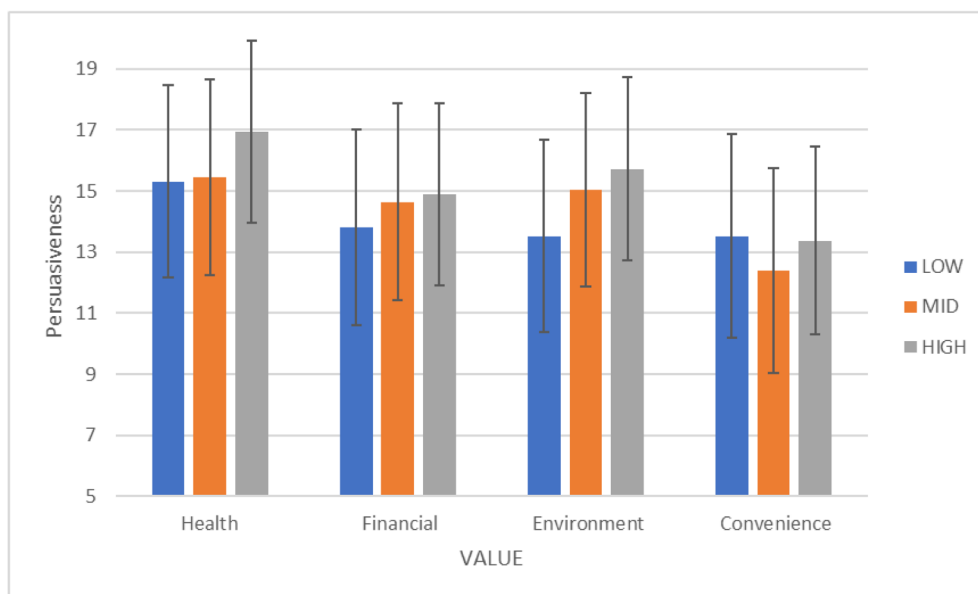

Fig. 5. Means and standard deviations of persuasiveness ratings for each agreeableness group across the four argument values (note that the persuasiveness rating scale runs from 1 to 25 and the axis is truncated in the figure).

6.3. Argument value and its interactions with personality and age

Our analysis of the persuasiveness of argument values showed that health arguments were found to be the most persuasive (this is visible in each figure). This finding supports previous work demonstrating that the perceived health benefits are a strong motivator for active travel (Bopp et al., 2012; Cellina et al., 2019) but to our knowledge this is the first study to show empirically that messages framed with a health value are rated as more persuasive by potential persuadees. This is an important finding for the design of active-travel campaigns as it suggests that to reach the widest audience, it is important to emphasise the health benefits over and above other benefits such as cost or environmental benefits.

However, interactions between argument values and our predictor variables highlighted significant variation in how participants responded to different value framings, notably by age and agreeableness (though not forgetting the association between general perceived persuasiveness and conscientiousness highlighted in the results section). Participants aged 18–29 yrs and 40 + yrs rated arguments appealing to health at around the same level, whereas those aged 30–39 yrs rated them significantly higher (see Fig. 4). This supports other studies suggesting that younger participants tend not to be motivated by the health benefits of walking and are instead more persuaded to walk for other reasons including cost and flexibility (Simons et al., 2014; Giles & Brennan, 2015). However, we were surprised that we did not observe a linear trend, as the appeal of the health value peaked in the 30–39 yrs group, as can be seen in Fig. 4. We consider it likely that the bias in the sample towards younger participants may have had an effect on this result.

The finding that different values appeal to different age groups was somewhat reinforced by our finding that participants under the age of 40 tended to rate financial arguments as significantly more persuasive than participants aged 40 and over. This may represent a difference in financial stability with younger participants more likely to feel the impacts of, say, the increased cost of driving, and value cost savings of alternatives. Indeed, previous research has shown that the cost impacts of driving is one of the primary motivators for younger people to reduce their car use and use walking as a form of transport (Simons et al., 2014).

Somewhat unexpectedly, we also found that younger participants tended to rate convenience arguments as less persuasive than participants between the age of 30–39. This is a surprising result, given that rates of car ownership and likelihood to drive in this age group is comparatively lower than in older age groups (Chatterjee et al., 2018), and that those without regular access to a car are statistically more likely to rely on walking for transport purposes (Department for Transport, 2017b). However, findings suggest that rather than seeing an increase in walking as an alternative to driving, young adults have tended to replace or supplement their car use with journeys on public transport (Chatterjee et al., 2018). While UK statistics show a small difference in the rates of younger people and older people walking (Department for Transport, 2017c), it is possible that younger people perceive short walking journeys as less convenient than the alternatives, compared to older people who use alternative transport methods less frequently. To better understand this effect a comparison between persuasive messages for walking and alternative forms of sustainable transportation is needed.

The big-five personality trait of agreeableness was found to be another important individual characteristic that showed a significant interaction with argument value (as shown in Fig. 5). In line with previous findings that have shown a relationship between agreeableness and environmental concern (Milfont & Sibley, 2012; Markowitz et al., 2012, cf. Brick & Lewis, 2016) we found that those low in agreeableness were least likely to be persuaded by environmental arguments for walking. This suggests that the personality traits should be taken into account when choosing which value to use for framing walking

messages, particularly to avoid the counterproductive effect found by Kaptein & Eckles (2012).

We also found that those high in conscientiousness were increasingly likely to find our messages persuasive. Regardless of the value an argument appealed to, participants high in conscientiousness were more likely to be persuaded by pro-walking arguments. This is both an important insight into the design of persuasive messaging to encourage walking, and also an important contrast with our findings on the effect of personality on argument type, where we found no observable interactions: the distinction within persuasive strategies between their argument type and the value to which they appeal is one which matters in the design of persuasive messaging.

6.4. Future work

The primary limitation of this study is that it deals with self-reported levels of persuasion for each persuasive message. This is very different from measuring the actual impact of messages on behaviour over time. It is possible participants may report that a message is highly persuasive yet not change their travel behaviour. Limitations are also introduced as a result of our sample recruitment strategy. The age and gender of the sample are both imbalanced. Whilst we did not find that this introduced excessive bias, particularly in relation to gender, there possibility remains that some of our findings in relation to age should be understood accordingly. Future work should aim to test the findings outlined here in real-world persuasive systems such as mobile phone apps where actual behaviour change can be measured. The results described here provide a foundation on which these systems can be developed and tested to further our understanding of how best to encourage sustainable mobility.

It is also important to note that we only examined a relatively small selection of possible argumentative strategies and values which could possibly be appealed to in communications promoting active travel. It may be possible that there is some combination of argument type and/ or value which we did not include that could show stronger interaction effects than those which we observed. However, we believe our results are grounds for a sceptical position on whether further work would show this to be the case.

It should also be noted that this study has not aimed to provide a comprehensive account of behaviour change in the sustainable mobility domain. We acknowledge that numerous structural, environmental and psychosocial factors impact an individual's travel behaviour choices, and that persuasive messaging can only be a relatively small part of the support needed to manifest sustainable behaviour change. For example, the postcode data revealed that most of our participants are residents of built-up, densely populated areas, who are more likely to have better environments for walking journeys of up to two miles. Therefore, we can have relative confidence that our findings regarding walking messages are relevant in urban areas, but less confident for less dense areas with less pedestrian infrastructure. However, the results of this study should be used alongside our existing knowledge of effective behaviour change strategies to pursue further research into what methods may be effective to promote behaviour change on an individual level.

Finally, the results described here focus only on walking as a form of transportation and cannot necessarily be generalised to other sustainable transport modes. Further research must be done in order to understand what constitutes persuasive messaging for other transport modes, especially considering motivations and barriers for uptake of these modes may be significantly different for each. It is also necessary to understand more about how persuasiveness is affected by playing modes off against one another in messages. However, the findings of this study may be able to be used as a comparison to other transport modes, allowing researchers to understand differences and similarities in personalised persuasion techniques across mobility types.

7. Conclusion

This study has provided an insight into designing effective methods for structuring persuasive messaging to encourage walking as a form of transportation. These results are especially useful for those interested in creating travel planning and other apps with features to encourage sustainable behaviour change: such apps can make use of highly individualised persuasion profiles using data gathered from their users. We have here suggested several ways in which messages can be targeted towards certain individuals to maximise their persuasive potential by drawing on certain personal characteristics and combining that with particular message structures and values. In particular, our results give reasons to believe that tailoring pro-walking messages on the basis of travel attitude is unlikely to be an effective persuasive strategy, whereas personality traits appear to be a promising characteristic on which to personalise messages. In the case of walking, the traits of agreeableness and conscientiousness are most strongly connected to perceived persuasiveness.

We have also shown that argument type matters far less when it comes to the persuasive potential of a given pro-walking message than the value to which the argument appeals. While some argument types (arguments from authority in particular) perform better than others overall, that effect was smaller than the differences apparent between the appeals to different values. Furthermore, it is very notable that some argumentative strategies (arguments ad populum in particular), associated with persuasive strategies which have previously been thought to be extremely effective, performed worse than our practical inference control messages featuring minimal argumentative content. That arguments ad populum performed badly is in line with Orji et al.'s (2015) findings that social proof is one of the least persuasive strategies. Not only that, but we found that manipulating argument type is unlikely to be an effective means of tailoring a persuasive message by any of the criteria we tested. This should simplify the composition of messages, as it doesn't appear to be necessary to use a particular argument type, though we do recommend avoiding arguments ad populum in walking messages.

However, for argument value we found strong evidence to support the idea that health is the most effective value to which pro-walking messages should appeal. We also found several cases in which the age of a potential persuadee significantly affects which values they respond to favourably. Younger people, for instance, tend to be more concerned with financial and environmental value, and older people with health and convenience. This suggests that age remains a variable that is relevant in constructing persuasion profiles, as it affects the choice of value to which the argument should appeal.

We also found that personality traits may be an effective means of targeting pro-walking messages in certain circumstances: those who are high in conscientiousness may be more persuadable in general, while those who are higher in agreeableness tend to find environmental arguments in particular more persuasive than those who are not high in agreeableness. Whether these results are generalisable beyond walking, to other active, or otherwise sustainable travel modes, will be the subject of future work.

Our findings represent the first in a series of message persuasiveness experiments to investigate the ways in which argumentation theory and the psychology of personality might be used to inform the design of behaviour change interventions targeting different transport modes. As we noted in our introduction, these interventions are increasingly in the form of mobile apps, and in our opinion our findings are especially useful for that purpose. Apps which can make use of data on their users' personality traits and age (either inferred from tracked behaviour, or else explicitly acquired via questionnaire) will be in an excellent position to tailor arguments by type and value in order to present the message most likely to succeed for any given user. Transport authorities may wish to strongly steer Mobility as a Service apps in particular to include such persuasion in order to avoid perverse negative impacts from their use (Pangbourne et al., 2020).

There are obviously design and ethical challenges inherent in this approach: the collection of personal data on personality without infringing on the privacy or wearing on the patience of the user may be difficult. However, travel planning apps which use messages as a part of their persuasive toolkit should take note of these findings: that pro-walking messages can be made reliably more persuasive by attending to personality trait and argument value, whereas other possible variables, such as attitudes and travel behaviour, are less impactful than we might suppose.

CRediT authorship contribution statement

Kate Pangbourne: Conceptualization, Funding acquisition, Project administration, Methodology, Supervision, Writing - review & editing. **Sam Bennett:** Methodology, Investigation, Data curation, Formal analysis, Validation, Software, Writing - original draft. **Al Baker:** Data curation, Methodology, Conceptualization, Writing - original draft.

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References

Alkış, N., Taskaya Temizel, T., 2015. The impact of individual differences on influence strategies. Personality Individual Differ. 87, 147–152. https://doi.org/10.1016/j.paid.2015.07.037.
Anable, J., 2005. 'Complacent Car Addicts' or 'Aspiring Environmentalists'? Identifying travel behaviour segments using attitude theory. Transp. Policy 12 (1), 65–78.
Anable, J.W., Wright, S.D., 2013. Work Package 7: Golden Questions and Social Marketing Guidance Report, Deliverable 7.8.4 SEGMENT Project No. IEE/09/250759-SEGMENT.
Anagnostopoulou, E., Bothos, E., Magoutas, B., Schrammel, J., Mentzas, G., 2018. Persuasive technologies for sustainable mobility: state of the art and emerging trends. Sustainability 10 (2128). https://doi.org/10.3390/su10072128.
Anagnostopoulou, E., Bothos, E., Magoutas, B., Schrammel, J., Mentzas, G., 2016. Persuasive technologies for sustainable urban mobility. arXiv preprint arXiv:1604.05957.
Anagnostopoulou, E., Magoutas, B., Bothos, E., Schrammel, J., Orji, R., Mentzas, G., 2017. Exploring the Links Between Persuasion, Personality and Mobility Types in Personalized Mobility Applications. In O.-K. H.-d.-P. de Vries P., Persuasive Technology: Development and Implementation of Personalized Technologies to Change Attitudes and Behaviors. PERSUASIVE 2017. Lecture Notes in Computer Science, 10171. Springer, Cham.
Arora, S., Peters, A.L., Burner, E., Lam, C., Menchine, M., 2014. Trial to examine text message-based mHealth in Emergency Department Patients with Diabetes (TExT-MED): a randomized controlled trial. Ann. Emerg. Med. 63 (6), 745–754.
Badaway, S.M., Barrera, L., Sinno, M.G., Kaviany, S., O'Dwyer, L.C., Kuhns, L.M., 2017. Text messaging and mobile phone apps as interventions to improve adherence in adolescents with chronic health conditions: a systematic review. JMIR mHealth uHealth 5 (5). https://doi.org/10.2196/mhealth.7798.
Bopp, M., Kaczynski, A.T., Besenyi, G., 2012. Active commuting influences among adults. Prev. Med. 54 (3–4), 237–241.
Brent Donnelan, M., Oswald, F.L., Baird, B.M., Lucas, R.E., 2006. The mini-IPIP scales: tiny-yet-effective measures of the big five factors of personality. Psychol. Assess. 18 (2), 192–203.
Brick, C., Lewis, G.J., 2016. Unearthing the "Green" personality: core traits predict environmentally friendly behavior. Environ. Behav. 48 (5), 635–658.
Cellina, F., Bucher, D., Mangili, F., Veiga Simão, J., Rudel, R., Raubal, M., 2019. A large scale, app-based behaviour change experiment persuading sustainable mobility patterns: methods results and lessons learnt. Sustainability 11 (9), 2674. https://doi.org/10.3390/su11092674.
Chatterjee, K., Goodwin, P., Schwanen, T., Clark, B., Jain, J., Melia, S., Middleton, J., Plyushteva, A., Ricci, M., Santos, G., & Stokes, G., 2018. Young people's travel – What's changed and why? Review and analysis. Project Report. Department for Transport, Bristol.
Cialdini, R.B., 2001. Harnessing the science of persuasion. Harvard Bus. Rev. 79 (9), 72–79.
Clifton, K.J., Livi, A.D., 2005. Gender differences in walking behavior, attitudes about walking, and perceptions of the environment in three Maryland communities. Res. Women's Issues Transp. 2, 79–88.
Department for Transport, 2017. British Social Attitudes Survey 2016: Public attitudes towards transport. Retrieved from https://assets.publishing.service.gov.uk/

government/uploads/system/uploads/attachment_data/file/640297/british-social-attitudes-survey-2016.pdf.

Department for Transport, 2017. National Travel Survey: England 2017. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/729521/national-travel-survey-2017.pdf.

Department for Transport, 2017. Transport Statistics Great Britain 2017. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664323/tsgb-2017-print-ready-version.pdf.

Department for Transport, 2018. British Social Attitudes Survey 2017: Public attitudes towards transport. Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/724855/british-social-attitudes-survey-2017.pdf.

Dillard, J.P., Weber, K.M., Vail, R.G., 2007. The relationship between the perceived and actual effectiveness of persuasive messages: a meta-analysis with implications for formative campaign research. J. Commun. 57 (4), 613–631.

Fogg, B.J., 2002. Persuasive technology: using computers to change what we think and do. Ubiquity 3. https://doi.org/10.1145/763955.763957.

Free, C., Whittaker, R., Knight, R., Abramsky, T., Rodgers, A., Roberts, I.G., 2009. Txt2stop: a pilot randomised controlled trial of mobile phone-based smoking cessation support. Tobacco Control 18 (2), 88–91.

Fischer, E.L., Rousseau, G.K., Turner, S.M., Blais, E.J., Engelhart, C.L., Henderson, D.R., Kaplan, J.A., Keller, V.M., Mackay, J.D., Tobias, P.A. and Wigle, D.E., 2010. *Pedestrian and bicyclist safety and mobility in Europe* (No. FHWA-PL-10-010).

Gabrielli, S., Maimone, R., 2013. Digital interventions for sustainable urban mobility. In: Proceedings of the ACM conference on Persuasive and ubiquitous computing adjunct publication - UbiComp '13 Adjunct. ACM Press, New York, New York, USA, pp. 119–122.

Gelman, A., Park, D.K., 2009. Splitting a predictor at the upper quarter or third and the lower quarter or third. The American Statistician 63 (1), 1–8.

Gerber, A.S., Huber, G.A., Doherty, D., Dowling, C.M., Panagopoulos, C., 2013. Big five personality traits and responses to persuasive appeals: results from voter turnout experiments. Political Behaviour 35 (4), 687–728.

Giles, E.L., Brennan, M., 2015. Changing the lifestyles of young adults. J. Social Mark. 5 (3), 206–225.

Goldberg, L.R., 1999. A broad-bandwidth, public-domain, personality inventory measuring the lower-level facets of several five-factor models. In: In: Mervielde, I.D. (Ed.), Personality psychology in Europe Vol 7. Tilburg University Press, Tilburg, The Netherlands, pp. 7–28.

Head, K.J., Noar, S.M., Iannarino, N.T., Grant Harrington, N., 2013. Efficacy of text messaging-based interventions for health promotion: a meta-analysis. Soc. Sci. Med. 97, 41–48.

Hirsch, J.B., Kang, S.K., Bodenhausen, G.V., 2012. Personalized persuasion: tailoring persuasive appeals to recipients' personality traits. Psychol. Sci. 23 (6), 578–581.

Hunecke, M., Haustein, S., Böhler, S., Grischkat, S., 2010. Attitude-based target groups to reduce the ecological impact of daily mobility behavior. Environ. Behav. 42 (1), 3–43.

Jylhä, A., Nurmi, P., Sirén, M., Hemminki, S., & Jacucci, J., 2013. MatkaHupi: a Persuasive Mobile Application for Sustainable Mobility. In Proceedings of the 2013 ACM conference on Pervasive and ubiquitous computing adjunct publication - UbiComp '13 Adjunct, pp. 227-230.

Kaptein, M., Eckles, D., 2012. Heterogeneity in effects of online persuasion. J. Interactive Mark. 26 (3), 176–188.

Lahey, B.B., 2009. Public health significance of neuroticism. Am. Psychol. 64 (4), 241–256.

Lepri, B., Staiano, J., Shmueli, E., Pianesi, F., Pentland, A., 2016. The role of personality in shaping social networks and mediating behaviour change. User Model. User-Adapted Interaction 26 (2–3), 143–175.

Markowitz, E.M., Goldberg, L.R., Ashton, M.C., Lee, K., 2012. Profiling the "pro-environmental individual": a personality perspective. J. Pers. 80 (1), 81–111.

Matz, S.C., Kosinski, M., Nave, G., Stillwell, D.J., 2017. Psychological targeting as an effective approach to digital mass persuasion. PNAS 114 (48), 12714–12719.

Milfont, T.L., Sibley, C.G., 2012. The big five personality traits and environmental engagement: associations at the individual and societal level. J. Environ. Psychol. 32 (2), 187–195.

Office for National Statistics, 2016. 2011 Census aggregate data. UK Data Service (Edition: June 2016). DOI: DOI:10.5257/census/aggregate-2011-1.

Orji, R., Mandryk, R.L., Vassileva, J., 2015. Gender, age, and responsiveness to Cialdini's persuasion strategies. Int. Conf. Persuasive Technol. 147–159.

Oyibo, K., Orji, R., Vassileva, J., 2017. Investigation of the influence of personality traits on Cialdini's persuasive strategies. In: Proceedings of the Personalization in Persuasive Technology Workshop. Persuasive Technology, pp. 8–20.

Pangbourne, K., & Masthoff, J., 2016 Personalised Messaging for Voluntary Travel Behaviour Change: Interactions between Segmentation and Modal Messaging; Universities Transport Studies Group 2016 Conference Proceedings: Bristol, UK.

Pangbourne, K., Mladenović, M., Stead, D., Milakis, D., 2020. Questioning mobility as a service: unanticipated societal and governance implications. Transp. Res. Part A: Policy Pract. 131, 35–49.

Patrick, K., Raab, F., Adams, M.A., Dillon, L., Zabinski, M., Rock, C.L., Griswold, W.G., Norman, G.J., 2009. A text message-based intervention for weight loss: randomized controlled trial. J. Med. Internet Res. 11 (1). https://doi.org/10.2196/jmir.1100.

Semanjski, I., Lopez Aguirre, A.J., De Mol, J., Gautama, S., 2016. Policy 2.0 platform for mobile sensing and incentivized targeted shifts in mobility. Behavior. *Sensors* (Basel) 16 (7). https://doi.org/10.3390/s16071035.

Simons, D., Clarys, P., de Bourdeaudhuij, I., de Geus, B., Vandelanotte, C., Deforche, B., 2014. Why do young adults choose different transport modes? A focus group study. Transp. Policy 36, 151–159.

Sunio, V.R., Schmöcker, J.D., & Estuar, M.R.J., 2017. Implementation of a mobility behavior change support system in Manila Philippines. In: 2017 IEEE 20th International Conference on Intelligent Transportation Systems (ITSC): Workshop Implementation, pp. 324-329.

Thomas, R.J., Masthoff, J., Oren, N., 2017. Adapting Healthy Eating Messages to Personality. In P. O.-K.-d.-P. de Vries, Persuasive Technology: Development and Implementation of Personalized Technologies to Change Attitudes and Behaviors. PERSUASIVE 2017. Lecture Notes in Computer Science, 10171, pp. 119-132. Springer, Cham.

Thomas, R.J., Masthoff, J., Oren, N., 2019. Can I influence you? Development of a scale to measure perceived persuasiveness and two studies showing the use of the scale. Front. Artificial Intelligence 2, 24.

Walton, D., Reed, C., Macagno, F., 2008. Argumentation Schemes. Cambridge University Press, Cambridge.

Wells, S., Pangbourne, K., 2016, June. Using Argumentation within Sustainable Transport Communication (Vol. 1,. College Publications, pp. 781–801.

Zhao, J., Baird, T., 2014. 'Nudging' Active Travel: A Framework for Behavioral Interventions Using Mobile Technology. In: Transportation Research Board 93rd Annual Meeting, no. 14-4106.

Zhao, X., Strasser, A., Cappella, J.N., Lerman, C., Fishbein, M., 2011. A measure of perceived argument strength: reliability and validity. Commun. Methods Meas. 5 (1), 48–75.