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Existence, relatedness and growth needs as mediators between mode choice and travel satisfaction: evidence from Denmark

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Abstract Understanding the link between mode choice and travel satisfaction is essential for promoting sustainable travel by expanding utility theory to include also the eudaimonic value of travel. The study focuses on the hypothesis that more then it's functional value of arriving from A to B, mode choice creates travel experiences that answer high-order needs such as relatedness, autonomy and competence. This study enhances the framework for representing travel mode choice by incorporating the model of human needs as the missing link between mode choice and travel satisfaction. By developing and analysing a large-scale survey from the Greater Copenhagen Area in Denmark, this study empirically proves that

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commuting mode choice relates to travel satisfaction by answering functional, relatedness and growth needs. The Greater Copenhagen area represents a region where transit, bicycle and car each have large modal shares, hence enabling to validate the approach in a multimodal environment. Higher bicycle satisfaction relates positively to cycling self-concepts and self-efficacy and negatively to car self-concepts. Greater car use satisfaction increases with car self-concepts and transit use difficulties, and decreases with functional difficulties in car use and better cycling self-efficacy. Higher transit satisfaction mainly relates to experiencing difficulties with other modes. These insights can be used when formulating transport policies and prioritising resources aimed at achieving sustainable mobility patterns.

Keywords Mode choice · Travel satisfaction · Bicycle · Transit · Model of needs · ERG

Introduction

Understanding the motivators of habitual travel behaviour is essential to design effective transport policies for promoting and maintaining sustainable travel trends. Travel mode choice is an everyday decision of people whether commuting to work or visiting friends or family. For recurrent trips it is characterised by routine behaviour and based on previous experiences (Carrus et al. 2008). In contrast to making a deliberate mode choice travellers build up travel habits where the choice becomes default based on an expectation of obtaining desired results or goals (Gärling and Axhausen 2003; Aarts et al. 1997). De Vos et al. (2016) suggest that satisfaction plays a cyclical role in travel habit formation and thus affects individual long-term travel behaviour. While short-term trip-based mode choice and travel satisfaction is traditionally explained by utility theory, researchers have noted that there is an additional dimension to the travel experience which is associated with the desire to travel, or "travel-liking" attitudes (Mokhtarian and Salomon 2001; Ory and Mokhtarian 2005; De Vos and Witlox 2016). In a nutshell, besides the utility of getting from the origin to the destination, there is a sense of satisfaction that derives from the travel itself so that, as phrased by Ory and Mokhtarian (2005) to the destination is only half the fun. While travel-liking attitudes can explain in part a higher satisfaction and higher preference for travel, the *"new mobilities"* paradigm (Jensen 2009; Sheller and Urry 2006), suggests a complementary explanation. According to the "new mobilities" paradigm, more than spatio-temporal movement, travel has a deeper meaning for sense-making, satisfaction, social interaction and identity-production, allowing us to achieve our functional needs along with higher-order emotional needs of independence, self-actualization, self-esteem, and social needs (Jensen 2009). These ideas extend the wider view of the long-identified instrumental, symbolic and affective value of mode choice (e.g. Steg 2003, 2005) and takes a further step to capture human psychology beyond the already investigated role of lifestyle, attitudes, norms, perceptions, past experience and policy environments (e.g., Van Acker et al. 2010; Salvá et al. 2015; Sigurdardottir et al. 2013). This view also agrees with the research stream suggesting that travel behaviour is governed by a holistic experience comprising perceptions, emotions, past experiences, attitudes, and social climate (Abou-Zeid et al. 2012; Susilo and Cats 2014).

Travel satisfaction has been investigated mainly from the perspective of measuring travel satisfaction as cognitive and affective well-being as proposed by Ettema et al. (2011), associating travel satisfaction to level-of service variables, the characteristics of the built environment, mode related attributes and attitudes and individual socio-economic

characteristics (e.g., St-Louis et al. 2014; van Lierop and El-Geneidy 2016; De Vos et al. 2016; Ye and Titheridge 2017). In recent years travel satisfaction has been recognized as related to emotional well-being and life satisfaction (e.g. Abou-Zeid et al. 2012; Friman et al. 2017; Morris and Guerra 2015) and studies have analyzed the direct and indirect effect (through performance of activities at destinations) of travel satisfaction on life satisfaction (Bergstad et al. 2011; De Vos 2018). Yet, analysing the link between travel mode choice as a decision and travel satisfaction as an experience is still scarce (De Vos et al. 2016; De Vos and Witlox 2017) and understanding the underlying motivators of recurrent travel choices and its conceptualization in the context of well-being remains a challenge (Abou-Zeid et al. 2012).

The current study adds to the literature by suggesting the Theory of Needs as the behavioural paradigm underlying travel satisfaction beyond the functional utility of travel. Moreover, this study empirically shows that mode choice is related to travel satisfaction through satisfying the traveller's physical, emotional and self-esteem needs. Thus, this study verifies and explains the proposition of De Vos et al. (2013) that travel increases well-being through satisfaction of physical, relatedness and growth needs, namely by establishing social ties and social bonding, realizing personal goals and increasing the sense of autonomy and competence as drivers of personal growth. Chiu and Lin (2004) propose to derive a service-quality measure on the basis of the theory of human needs. In accordance, De Vos and Witlox (2017) see travel satisfaction as the missing link driving the formation of travel habits. Singleton (2018) proposes that 'travel eudaimonia' is related to security, autonomy, confidence and health. Shliselberg and Givoni (2018) express similar ideas in contextualising mobility capital by proposing that travel behaviour generates experiences that increase people's social, human, economic and cultural capital, thus generating a sense of autonomy, relatedness and competence which then contribute to a sense well-being. We offer to apply the theory of needs as a rigorous theory allowing to provide a solid behavioural explanation to what drives higher-order travel satisfaction beyond the functional value of travel. Specifically, while the importance of enhancing the instrumental value of travel services in terms of travel time, accessibility, reliability and other level-of-service aspects is uncontested (de Oña et al. 2016), we correlate mode choice and travel satisfaction through the mediator of satisfying human psychological needs, thus proposing Alderfer's (1969) ERG (Existence, Relatedness and Growth) theory as the missing link mediating between mode choice and travel satisfaction. The ERG theory is based on a threefold conceptualisation of human needs: (i) existence (i.e., functional needs), (ii) relatedness (i.e., sense of belonging and togetherness), and (iii) growth (i.e., self-actualization, fulfilment of inner potential and life opportunities). It was developed from Maslow's hierarchical theory of motivation (Maslow 1943), but has the advantage of assuming that each of the three domains can be satisfied independently. According to this view travel mode choice induces a sense of well-being, which is motivated by satisfying the three types of human needs: existence, relatedness, and personal growth needs of self-esteem and self-actualization. Notably, the link between mode choice and psychological needs is already discussed in the literature. Adolescents associate car-use with gaining travel independence and increasing spatial opportunities, self-image through financial status, prestige, and cool feeling, and role as future care-givers (Sigurdardottir et al. 2014). Transit use is correlated with self-esteem and respect for others through perceived spatial equity, price and travel mode fairness (Kaplan et al. 2014), and with 'relational value' through social climate appreciation (Salvá et al. 2015). Cycling enhances multi-dimensional self-esteem comprising of physical, competencies, growth, self-identity and life-values self-concepts (Spotswood et al. 2015). Bicycle lessons are beneficial in increasing cycling competencies,

enlarging the activity space, increasing the activity participation and travel independence, and improving the feelings of self-esteem, self-confidence and empowerment (van der Kloof et al. 2014). Last, the transport system is perceived as essential for gaining safety and security in health, employment and social stability, in particular among low-income households, and failing to achieve these needs may result in physical, social, geographical, and economic social exclusion (Lucas 2012). Thus, as suggested by Taniguchi et al. (2014) and Mateo-Babiano (2016) and in accordance with the 'new mobilities' paradigm it is equally important to look at the travel experience from the perspective of meeting a wide spectrum of human needs.

The remainder of the paper presents the proposed framework and mathematical model followed by their empirical validation, namely the questionnaire design, the sample and the model estimates. Last, we discuss the results and offer policy implications.

Methodology

Behavioural framework

The hypothesised behavioural framework, outlined in Fig. 1, relates travel mode choice with travel satisfaction through answering human needs. It is based on a general feedback mechanism between mode choice and satisfaction similar to the framework proposed by De Vos and Witlox (2017) and Shliselberg and Givoni (2018) connecting travel behaviour to experiences that promotes a sense of autonomy, relatedness and competence as a source of eudaimonic well-being. Nevertheless, our framework focuses only on the first part of the feedback loop, which is the link between travel behaviour and satisfaction. Our framework adds the ERG theory of needs as the missing link between travel experience and travel satisfaction including instrumental travel satisfaction and eudaimonic well-being. While both De Vos and Witlox (2017) and Shliselberg and Givoni (2018) relate travel experiences to well-being outcomes, we offer the underlying behavioural theory that help explaining the proposed connection. Gärling et al. (2002) explain that while the assumption of human needs forms the basis to some motivational theories, others contemplate needs as choice outcomes, as proposed also by Chiu and Lin (2004). Thus satisfaction of needs plays a dual role similarly to the cyclical process in which travel satisfaction derives and drives recurrent choice (De Vos and Witlox 2017). Hence, satisfaction and mode usage do not only depend on traditional attributes of the transport system, but also on how well transport

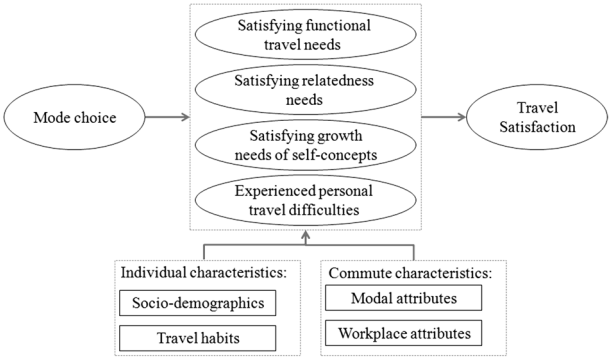

Fig. 1 Behavioral framework

modes are perceived to satisfy higher order needs. When choosing a travel mode, travellers are rewarded in terms of an experienced level of satisfaction. The satisfaction is memorised and to some extent influences future mode choices (Gärling and Axhausen 2003). Gärling et al. (2002) also suggest that the sense of satisfaction is related not only to the positive feedback attained when needs are satisfied but also on negative feedback when difficulties arise as a result from the mode choice. As difficulties are a measure of perceived behavioural control, the perceived difficulties complement the ERG theory by adding functional and psychological barriers affecting the level of satisfaction by impeding self-efficacy expectations (Bandura 1977). In this sense, perceived mode-specific difficulties are a type of mode specific attitudes, thus combining the view Gärling et al. (2002) and De Vos and Witlox (2017) suggesting that travel satisfaction is associated with travel-related attitudes and mode choice and that the latter two are correlated. Finally, feedback deriving from recurrent mode choice strengthens the travel mode commitment and habit, until the goal driven behaviour becomes script-based and the bi-directional relationship between mode choice, satisfaction of needs and travel satisfaction becomes cyclical and entangled (Gärling et al. 2002; Gärling and Axhausen 2003; De Vos and Witlox 2017). The general framework accommodates both single- and multiple-mode commuting routine as travel mode combinations act similarly with respect to difficulties and satisfaction of needs.

The proposed framework in this study encompasses the following research hypotheses:

H1 Satisfying functional and emotional needs of relatedness and growth positively relates to mode use frequency.

H2 Travel satisfaction positively relates to the ability of the travel mode to satisfy individual needs, and negatively correlated with the mode specific difficulties.

H3 bicycle and car use are positively related to togetherness and growth while public transport use is mostly correlated with functional needs.

The first two hypotheses match the ideas expressed by Gärling et al. (2002), De Vos and Witlox (2017) and Shliselberg and Givoni (2018). The third hypothesis stems from the literature regarding the instrumental, symbolic and affective motives for car use (e.g., Steg 2005) and the added value of the bicycle in generating positive self-concepts (e.g., van der Kloof et al. 2014).

Survey design and administration

An online survey was tailored in order to investigate our proposed behavioural framework. The survey consisted of four parts: (i) general travel habits and commute characteristics; (ii) ERG dimensions; (iii) mode-specific difficulty statements; (iv) individual and commute characteristics. While previous studies (e.g. De Vos et al. 2016) explored the relation between utility and experience utility in leisure trips, the current study focuses on commuting trips, which constitute 37% of all trips in the Greater Copenhagen Area, larger than any other trip purpose. The statements were tailored to the commute mode choice context.

Respondents were asked about their travel trends as the frequency of travelling by each mode (i.e., car, bicycle, public transport) and whether they travelled with others in their commute. Walking as a main commuting mode was not elicited because it is rare. According to recent national statistics in Denmark, in 2013 walking comprised only 3% of the

home to work journeys compared to 66% by car, 20% by bicycle and 11% by public transport (Haubold 2014). Larsen (2010) also reports a share of 3–5% walking trips for commuting purpose explains it by the travelled distance. According to the Danish travel survey, the average walking distance is 680 m, while the average commuting distance is 12.3 km and while for trip distances of 500–750 m there are equal shares of people walking, cycling and driving a car, walking trips drop to less than 8% for trips distance of 2 km (Larsen 2010). Accordingly, we consider only the most prominent commuting modes of car, bicycle, and public transport. The mode choice frequency was measured on a Likert scale ranging from rarely to daily, with 2–3 times monthly, once weekly, and 2–3 times weekly as intermediate points. Travel habits were elicited independently per mode to allow for multimodality over time (Cherchi and Cirillo 2014; Schlich and Axhausen 2003). Respondents were also asked to rate the level of satisfaction they associate with commuting by each mode on a 5-point Likert scale from very dissatisfied to very satisfied.

The statements measuring the human needs (ERG) dimensions were defined based on a literature review of the most important attributes for travel satisfaction (van Lierop et al. 2018; de Oña and de Oña 2015; Susilo and Cats 2014; De Vos et al. 2016). We hypothesize the ERG constructs to be related to travel satisfaction, in line with Gärling et al. (2002). As a result the phrasing of the ERG constructs was conducted in accordance with the approach of Chiu and Lin (2004) interpreting the ability to satisfy individual needs both from the individual and the service quality perspective. In this respect, some of the statements regarding the satisfaction of needs can also be interpreted as positive attitudes towards a specific mode (e.g., "I feel mentally strengthened when I cycle") while others are expressing travel needs that are not necessarily mode specific (e.g., "It is important for me to travel with my colleagues"). The identified attributes were combined with statements on the perceived mode-specific travel difficulties. A total of 50 statements were phrased, namely fifteen on existence needs, ten on togetherness needs, eleven on growth needs, and fourteen on mode-specific travel difficulties. The statements were measured using the 5-point Likert scale ranging from strongly disagree to strongly agree.

Existence need items investigated functional needs when travelling such as health, safety, time and monetary savings, reliability and multi-tasking during travel. They included travel time and costs, avoiding travel hassles such as congestion, parking, and transfers, being able to carry personal belongings, and being able to work or have privacy during the trip.

Relatedness need items investigated the ability to form or enhance interpersonal relationships, feeling part of a group, and conforming to social norms. Interpersonal relationships are formed or enhanced during commuting by spending quality time travelling together with family, friends, and colleagues, and helping others by giving a ride to significant others. In accordance with Danish cycling culture, norms and traditions, feeling part of a group or community was expressed as participating in bike-to-work campaigns or exercising with friends. Conforming to norms was related to individual perceptions regarding the behaviour of people in the social circle of the individual in terms of their commute mode choice.

Growth need items related to developing self-concepts associated with physical ability, competencies (e.g., self-efficacy, overcoming challenges), self-identity related to environmental sustainability and fitness, social self-concept (e.g., social status, prestige), self-actualisation and self-esteem derived from a general optimism, and feeling of life satisfaction.

The perceived difficulties in the commute mode context were expressed as the perceived ease associated with using a specific mode. Travel difficulties are mode specific by definition: for transit, they are its perceived accessibility, speed, price, crowding and reliability;

for cycling, they are weather, hilliness, travel distance and traffic safety; for car use, they are travel expenses, driving stress, perceived difficulties to find parking, traffic safety and traffic congestion.

Individual characteristics included socio-economic information and past travel experiences. The commute characteristics comprise the perceived time and cost associated with the modal choice and situational attributes, namely the home-work distance, parking availability, transit availability at the workplace, and bicycle facilities.

The questionnaire was distributed online to commuters in the Greater Copenhagen Area in June 2016. The questionnaire had identical Danish and English versions and can be provided upon request. Respondents were recruited through 6000 firms that are all the firms with more than five employees registered in the list of the Danish Bureau of Statistics as located in the region. The selection criterion of at least five employees served to indicate firms that have office location, require commuting and are of sufficient size to participate in the Danish bike-to work campaign. University networks and the social media further distributed the questionnaire, which allowed reaching a large and heterogeneous group of commuters at modest costs.

Mathematical model

The questionnaire items and the observed individual characteristics led to the formulation of a structural equation model (SEM) to test the hypothesised behavioural framework. SEM allows accommodating measurement errors when the explanatory and the dependent variables are latent multi-dimensional constructs, and modelling simultaneously endogenous latent constructs, their relationship with exogenous observed variables, and their correlation pattern.

The model contained four sets of equations: measurement equations (Eq. 1) linking the measurement indicators (questionnaire items) to the latent ERG and difficulty constructs; structural equations (Eq. 2) associating the latent attitudinal constructs with individual socioeconomic characteristics; structural equations (Eq. 3) relating the explanatory and the mediator latent constructs; structural equations (Eq. 4) linking the latent mediators to the dependent variable.

$$I_{rn} = Z^*_{ln}\alpha_r + \nu_{rn} \quad \text{and} \quad \nu_n \sim N\left(0, \Sigma_\nu\right) \quad \text{for } r = 1, \ldots, R \tag{1}$$

$$Z^*_{ln} = S_{ln}\beta_l + \omega_{ln} \quad \text{and} \quad \omega_n \sim N\left(0, \Sigma_\omega\right) \quad \text{for } l = 1, \ldots, L \tag{2}$$

$$Z^*_l = Z_i\beta_i + \varphi_l \quad \text{and} \quad \varphi_l \sim N\left(0, \Sigma_\varphi\right) \quad \text{for } l = 1, \ldots, L, \quad i = 1, \ldots, K \tag{3}$$

$$Y_{in} = Z^*_{ln}\beta_z + \xi_{in} \quad \text{and} \quad \xi_n \sim N\left(0, \Sigma_\xi\right) \quad \text{for } i = 1, \ldots, I \tag{4}$$

where I_{rn} is the value of an indicator r of the latent construct Z^*_{ln} as perceived by respondent n, Z^*_{ln} is the value of latent construct l for respondent n, S_{ln} is a vector of M respondents' observed individual characteristics, and Y_{in} is a vector of travel users' satisfaction levels. Error terms are expressed as elements ω_{ln}, ν_{rn}, ξ_{in} of the vectors following a normal distribution with respective covariance matrix Σ_ω, Σ_ν, Σ_ξ, while parameters to be estimated are α_r, β_l, β_i, and β_z. Considering R indicators translates into writing R measurement equations and estimating an $(R \times 1)$ vector α of parameters (i.e., one parameter is estimated for each equation), while considering L latent constructs translates into writing L structural equations and estimating an $(M \times L)$ matrix of β parameters (i.e., M parameters are estimated for each equation).

The vector α of parameters of the measurement equations and the vector β's of parameters of the structural equations were estimated using Mean- and Variance-adjusted Weighted Least Squares (WLSMV) (Muthén and Muthén 2017). The goodness-of-fit was measured using the relative CFI (comparable Fit Index) and the absolute Root Mean Square of Approximation (RMSEA).

Results

Sample characteristics

The survey yielded 1481 complete responses (92.7% of the survey entries), which is an adequate sample size for the chosen statistical approach of a structural equation model considering the often used rule of thumb of minimum criterion of 1000 observations, or ten responses per indicator (Nunnally et al. 1967). Table 1 describes the sample socio-economic characteristics in comparison with the values found in the Danish national travel survey from the Greater Copenhagen Region, which are shown in brackets for comparison.

The sample characteristics are reasonably in line with the survey aim and scope to target commuters in the Greater Copenhagen Area. The sample is gender balanced and includes adults in the working age, most of the respondents are full-time employees and either reside or work in the study area. The commuting destination indicates the existence of both radial and local commuting patterns, in line with the mono-centric metropolitan structure. The car ownership is in line with the one in the region according to the Danish Bureau of Statistics, and the same applies to the distribution of commuting distance with an average commute of 20 km, and 38.7% of the sample commuting up to 10 km each way. The sample corresponds to the Danish national travel survey apart from education, income and workplace location, which is reasonable considering that the employees were recruited through companies rather than directly.

Figure 2 illustrates the travel frequency and satisfaction with each of the three modes and shows their correspondence. The level of satisfaction is generally high and similar for the car and the bicycle as commute modes, compared to transit for which only less than 40% are satisfied or very satisfied. The modal shares of car, bicycle and transit at least 4–5 times a week or daily are respectively 42, 31 and 17%, in line with the modal shares of 45, 32 and 18% in the region according to the Danish National Travel Survey.

Factor analysis

Exploratory factor analysis (EFA) was used to obtain insights about the underlying constructs of existence, relatedness and growth needs and the travel difficulties. This was chosen due to the flexibility of EFA as compared to confirmatory factor analysis (CFA) as it was possible to analyse the structure between survey items where some were mode-specific, e.g. items related to growth needs and travel difficulties, and some were a combination of mode-specific and generic, e.g. items related to existence needs and relatedness needs. The EFA effectively reduced the number of factors for the subsequent SEM.

The survey data showed good internal consistency with Cronbach's alpha = 0.792, and good sampling adequacy with Kaiser–Meyer–Olkin (KMO) = 0.884 measured on all survey statements with no single items having a measure of sampling adequacy of less than 0.70. The determinant of the Spearman correlations matrix equal to 7.4E−12 established

Table 1 Sample characteristics, compared with the Danish national travel survey

Variable	Categories (values from the national survey are presented in brackets)				
Gender	Male	Female			
	44.6 (46.7)	55.4 (53.3)			
Age	18–30	30–45	46–65	> 65	
	13.0 (30.7)	37.2 (26.0)	47.2 (41.4)	2.6 (2.0)	
Car accessibility	Yes	No			
	68.4 (78.4)	31.6 (21.6)			
Family status	Single no children	Couple no children	Single with children	Couple with children	Other
	14.3 (15.9)	31.3 (29.9)	4.7 (3.7)	44.0 (34.5)	5.7 (16.0)
Employment status	Full time	Part time	Other		
	87.6 (74.0)	7.6 (26.0)	4.9		
Monthly income ($)	0–3000	3000–4500	4500–6000	6000–7500	> 7500
	6.0 (32.8)	15.6 (15.7)	35.0 (14.5)	23.0 (12.0)	20.3 (25.1)
Education level	High-School	Tertiary	Bachelor	Graduate	
	7.2 (11.7)	23.3 (38.3)	22.4 (29.6)	47.2 (20.4)	
Commute origin	Copenhagen	Suburbs	Rural		
	40.0 (36.8)	34.5 (32.6)	25.5 (30.6)		
Commute destination	Copenhagen	Suburbs	Rural		
	51.3 (43.4)	44.5 (32.1)	4.2 (24.5)		
Commute distance (km)	0–5	5–10	10–20	20–30	> 30
	17.3 (13.5)	21.4 (16.2)	25.5 (17.4)	13.8 (17.8)	22.1 (35.1)

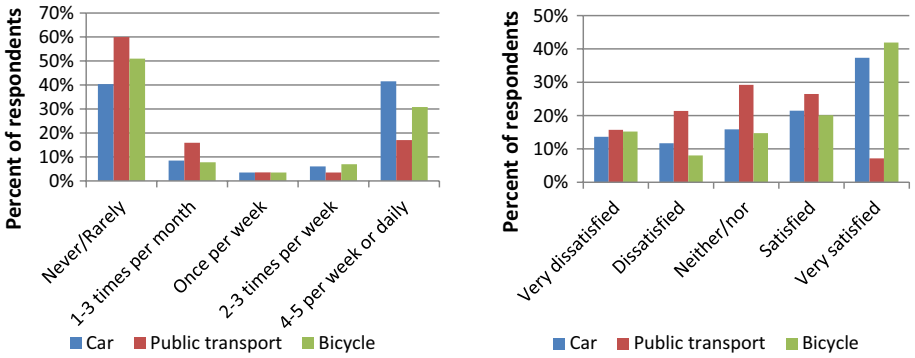

Fig. 2 Frequency of use (left) and level of satisfaction (right) with car, transit and bicycle for the commute trip

the existence of correlations without multi-collinearity, and the Bartlett's test for sphericity rejected the null hypothesis of an identity correlations matrix. Principal axis factoring with orthogonal Varimax rotation generated the seven factors in Table 2 where the dominant items were defined as those with an absolute value greater than 0.30 (Kline 1994). The internal consistency for each factor was good as the Cronbach's alpha's were all above 0.70 (Miller 1995).

Factors F1, F2, F4, and F5 are about satisfaction of personal needs, while in F3, F6 and F7 the phrasing is more about person's difficulties associated with the mode. Factor F1 "positive cycling self-concepts" is associated with the ability of commuting by bicycle to satisfy growth needs of self-efficacy, self-actualization, optimism and self-esteem. Factor F2 "travel togetherness" incorporates all survey statements related to relatedness needs, including joint travel, shared travel experiences, helping others and participating in joint activities related to the social milieu and work environment. Factor F3 "functional difficulties associated with car use" includes statements related to the preference for avoiding difficulties associated with car use and are related to negative driving experience such as difficulties to find parking, congestion, driving stress, etc. Factor F4 "positive car self-concepts" incorporates statements associated with the ability of commuting by car to satisfy growth needs of self-efficacy, travel independence and social status. Factor F5 "satisfying functional needs" relates to personal functional needs such as arriving safely on time, saving time and being able to travel when needed without worrying about transfers. Factor F6 "cycling self-efficacy" gathers statements related to the person's coping with challenges while cycling, i.e. reversed travel difficulties, such as the weather conditions, hilly terrain, distance and traffic. Factor F7 "functional difficulties in transit" includes the personal experience or perception of transit being slow, expensive, crowded and unreliable.

Model estimation results

The model was estimated using the standard WLSMV estimator in MPlus, due to the violation of normally distributed data for all items according to the Shapiro–Wilk test, and because it provides the best option when modelling ordered data such as 5-point Likert data (Brown 2006). The tested model revealed goodness-of-fit measures in terms of RMSEA equal to 0.050, which is consistent with the recommended values (Hu and

Table 2 Rotated factor matrix loadings

Factor name	Item	Factor loading
F1 Positive cycling self-concepts (0.916)	It is important for me to get exercise	0.528
	It is important for me to get fresh air	0.512
	I feel mentally strengthened when I cycle	0.878
	I feel on top and with good energy when I cycle	0.894
	I enjoy challenging myself physically when I cycle	0.736
	I feel good about myself when I cycle	0.853
	I feel good about contributing to the environment when I cycle	0.657
F2 Travel togetherness (0.890)	It is important for me to travel with my colleagues	0.776
	It is important for me to spend quality time together with others on the way	0.753
	It is important for me to bring/collect others on the way	0.483
	It is important for me to exercise by bicycle with friends	0.852
	It is important for me to talk about a shared hobby related to travel mode	0.857
	It is important for me to participate in Bike-to-Work campaigns	0.684
	It is important for me to be part of a bicycle culture	0.774
F3 Car use functional difficulties (0.818)	It is important for me to save money	0.397
	It is important for me to avoid driving stress	0.473
	It is important for me to avoid road congestion	0.465
	It is important for me to avoid worrying about parking	0.509
	I believe it is important not to contribute to congestion	0.362
	Transit is inaccessible to me	−0.332
	Driving a car is too expensive for me	0.523
	Searching for parking takes too long for me	0.643
	Driving a car is too stressful for me	0.763
	Driving a car is too dangerous for me	0.602
	Driving a car is too unreliable (congestion) for me	0.657

Table 2 (continued)

Factor name	Item	Factor loading
F4 Positive car self-concepts (0.905)	I live life to the fullest when I drive my car (e.g. By listening to music)	0.673
	Driving a car is a cool way to travel	0.829
	Driving a car makes me feel optimistic and high-on-life	0.877
	Driving a car makes me feel that I get the most out of every situation	0.758
	I feel more independent when I drive a car	0.610
F5 Satisfying functional needs (0.746)	It is important for me to arrive safely	0.531
	It is important for me to carry my things	0.568
	It is important for me to save time	0.496
	It is important for me to go wherever and whenever I want	0.477
	It is important for me to have privacy during my transport	0.309
	It is important for me to avoid congestion in transit	0.506
	It is important for me to avoid having to change transport mode/line	0.565
	It is important for me to arrive on time	0.574
F6 Cycling self-efficacy (0.756)	Biking is difficult for me because of the weather (R)	0.548
	Biking is difficult for me because of the terrain (R)	0.681
	Biking is difficult for me because of the distance (R)	0.688
	Biking is dangerous for me due to other traffic (R)	0.448
F7 Functional difficulties in transit (0.756)	Transit is too slow for me	0.559
	Transit is too expensive for me	0.575
	Transit is too crowded for me	0.731
	Transit is unreliable for me	0.645

(R)—Reversed coding in the case of negatively-phrased items; Cronbach's alpha in parenthesis

Bentler 1999). The CFI equal to 0.903 is far above the recommended minimum values for empirical data (Browne and Cudeck 1992).

Tables 3 and 4 show the parameters estimates, the standard errors and critical ratios (C.R.)—ratio of parameter estimate, showing the significance of each parameter. Table 3 presents the structural equations linking the latent ERG constructs and the perceived difficulties to socio-economic characteristics, and Table 4 shows the structural equations relating the travel satisfaction to the ERG constructs and the perceived experience travel difficulties. Figure 3 shows the path diagram of the model structure with solid lines denoting positive relation, dashed lines denoting negative relation. Figure 3 shows only the significant effects at a 0.05 significance level.

Table 3 Estimates of the structural equations linking the ERG constructs to the socio-economic characteristics

Factor name		Est.	C.R.
Positive cycling self-concepts (F1)	Male	−0.107	−2.43
	Car availability	0.156	2.84
	Home location: Copenhagen suburbs	0.104	2.13
	Bicycle travel time greater than 30 min	0.260	5.32
Travel togetherness (F2)	Age 45–65	−0.180	−1.88
	Education: vocational	−0.326	−2.58
	Education: Tertiary	−0.374	−2.70
	Education: Bachelor	−0.357	−3.03
	Education: Graduate	−0.548	−4.96
	Workplace location: Copenhagen city	−0.314	−3.21
Car use functional difficulties (F3)	Male	−0.070	−1.55
	Car availability	−0.124	−2.33
Positive car self-concepts (F4)	Age 30–45	−0.298	−3.69
	Age 45–65	−0.346	−4.23
	Car availability	0.121	2.01
	Education: Bachelor	−0.211	−2.00
	Education: Tertiary	−0.399	−4.09
	Student	−0.288	−1.87
	Workplace location: Copenhagen suburbs	−0.206	−2.55
Satisfying functional needs (F5)	Male	−0.224	−4.10
	Age 45–65	−0.191	−2.25
Cycling self-efficacy (F6)	Male	0.200	4.55
	Income: high	0.159	3.01
	Travelling with children	0.124	1.52
	Monthly travel costs less than 500 DKK	0.342	3.16
	Travel time: less than 10 min	0.459	4.59
	Travel time: 10–50 min	0.374	6.49
Functional difficulties in transit (F7)	Age 30–45	−0.427	−4.45
	Age 45–65	−0.436	−4.48
	Age higher than 65	−0.834	−4.21

Table 4 Estimates of the structural equations relating the travel satisfaction with the latent ERG constructs and travel mode use

Dependent (mediator) variables	Explanatory variable	Direct effect		Total effect	
		Est.	C.R.	Est.	C.R.
Positive cycling self-concepts (F1)	Perceived transit use frequency	−0.098	−3.58	−0.129	−4.27
	Perceived bicycle use frequency	0.214	6.36	0.396	12.89
	Perceived car use frequency	–	–	−0.262	−10.85
Travel togetherness (F2)	Perceived bicycle use frequency	0.105	2.31	0.105	2.31
Car use functional difficulties (F3)	Perceived transit use frequency	0.097	3.23	0.097	3.23
	Perceived bicycle use frequency	0.129	3.65	0.129	3.65
	Perceived car use frequency	−0.492	−13.19	−0.492	−13.19
Positive car self-concepts (F4)	Perceived bicycle use frequency	−0.127	−3.32	−0.127	−3.32
	Perceived car use frequency	0.367	8.59	0.367	8.59
Satisfying functional needs (F5)	Perceived transit use frequency	−0.068	−1.86	−0.097	−2.66
	Perceived car use frequency	0.123	2.43	0.346	8.01
	Perceived bicycle use frequency	–	–	−0.033	−3.12
Cycling self-efficacy (F6)	Perceived transit use frequency	−0.189	−7.02	−0.189	−7.02
	Perceived bicycle use frequency	0.350	10.97	0.350	10.97
	Perceived car use frequency	−0.292	−7.57	−0.292	−7.57
Functional difficulties in transit (F7)	Perceived transit use frequency	−0.075	−2.00	−0.075	−2.00
	Perceived car use frequency	0.323	6.99	0.323	6.99
Car satisfaction	Car use functional difficulties (F3)	−0.311	−10.37	−0.311	−10.37
	Positive car self-concepts (F4)	0.232	8.89	0.232	8.89
	Cycling self-efficacy (F6)	−0.065	−1.79	−0.065	−1.79
	Functional difficulties in transit (F7)	0.139	5.08	0.139	5.08
	Perceived bicycle use frequency	–	–	−0.092	−4.65
	Perceived transit use frequency	–	–	−0.028	−2.00
	Perceived car use frequency	–	–	0.302	10.36
Transit satisfaction	Car use functional difficulties (F3)	0.127	3.58	0.127	3.58
	Satisfying functional needs (F5)	−0.052	−1.53	−0.052	−1.53
	Cycling self-efficacy (F6)	0.063	1.70	0.063	1.70
	Functional difficulties in transit (F7)	−0.274	−6.68	−0.295	−7.92
	Perceived bicycle use frequency	–	–	0.040	2.76
	Perceived transit use frequency	–	–	0.026	1.78
	Perceived car use frequency	–	–	−0.187	−6.39
Bicycle satisfaction	Positive cycling self-concepts (F1)	0.366	12.38	0.366	12.38
	Positive car self-concepts (F4)	−0.101	−3.72	−0.101	−3.72
	Cycling self-efficacy (F6)	0.232	6.90	0.354	11.45
	Perceived bicycle use frequency	–	–	0.239	11.17
	Perceived transit use frequency	–	–	−0.091	−5.98
	Perceived car use frequency	–	–	−0.201	−9.36

Table 4 (continued)

Dependent (mediator) variables	Explanatory variable	Direct effect		Total effect	
		Est.	C.R.	Est.	C.R.
Correlation patterns	Car satisfaction – transit satisfaction	0.107	3.94	–	–
	Car satisfaction – bicycle satisfaction	0.117	4.11	–	–
	Transit satisfaction – bicycle satisfaction	0.125	4.40	–	–

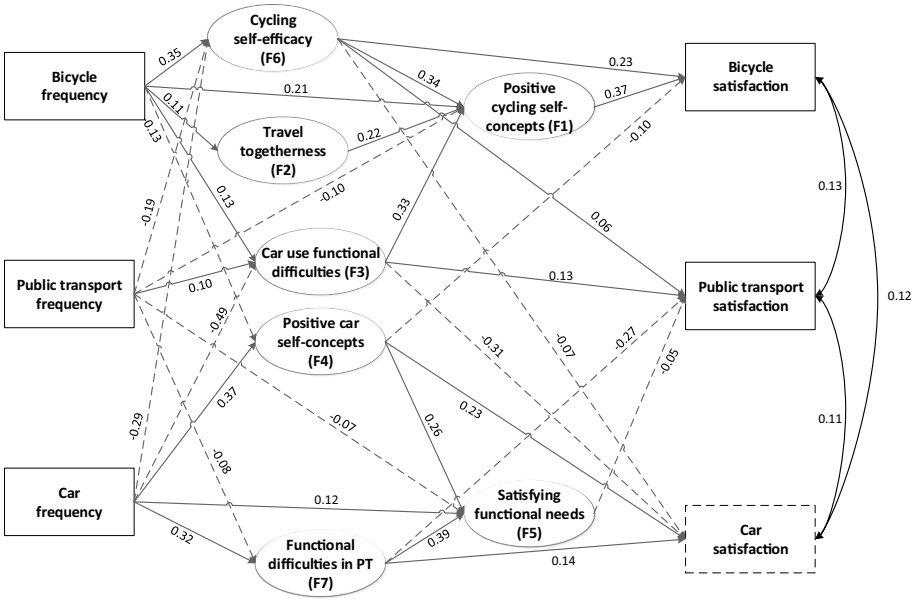

Fig. 3 Model structure relating the mode use to satisfaction via the ERG constructs

Discussion

The relation between mode choice, ERG needs, experienced difficulties and travel satisfaction

The model structure confirmed hypothesis H1 that experienced mode choice is positively and significantly related to the perceived existence, relatedness and growth needs, as well as negatively correlated to the perceived difficulties. The model structure confirms hypothesis H2 that travel satisfaction is related not only to functional needs, but also to relatedness and growth needs. Furthermore, needs satisfaction varies across modes, which is mostly evident when comparing positive self-concepts for bicycle (F1) and car (F4). Despite being similar concepts of higher-order needs the model results suggest that travel self-efficacy leads to the development of positive self-concepts for bicyclists whereas this is not the case for car and public transport users. Moreover, the model confirms H3 that bicycle and car

use are positively related to togetherness and growth while public transport use is mostly correlated with functional issues.

The level of satisfaction with the commute mode is generally high and similar for the car and the bicycle as commute modes, compared to transit in line with previous studies (De Vos et al. 2016; Morris and Guerra 2015; St-Louis et al. 2014; Ye and Titheridge 2017). The specific results show that higher bicycle satisfaction is linked positively to cycling self-concepts and self-efficacy, and negatively to car self-concepts. Higher cycling frequency and lower car and transit use frequency are associated with increased perception of cycling self-efficacy and travel togetherness. The two factors have equal role as mediators between cycling frequency and cycling self-concepts, namely higher cycling frequency leads to better feelings of self-efficacy and togetherness motivating a better feeling of self-actualization and self-esteem, which in turn leads to higher satisfaction. This hierarchy agrees with Maslow's pyramid of needs where growth needs are higher-order than relatedness and functional needs. Nevertheless, in agreement with the ERG model, the relatedness needs are satisfied in parallel to the functional needs and the two are almost equally important in developing cycling self-concepts. Functional difficulties associated with car use also link positively to cycling self-concepts, establishing the car and bicycles as the main competitors in the Danish transport arena.

Greater car satisfaction associates positively with car self-concepts and transit use difficulties, and negatively with functional difficulties in car use and cycling self-efficacy. Positive car self-concepts are related positively to car use and negatively to cycling frequency. The functional difficulties in car use are associated with higher transit and cycling frequency and lower car use, while perceived difficulties in transit use are associated with higher car use and lower transit use. However, the strongest influence to car satisfaction is the functional difficulties of the car itself, which also influences public transport satisfaction positively, and positive cycling concepts leading to higher bicycle satisfaction.

Greater transit satisfaction correlates positively with greater difficulties in car use and negatively with difficulties in transit use and the ability to satisfy travel needs by car. The importance of these factors shows that the car, rather than the bicycle, is the main competitor of transit, and that the use of transit derives by existence or functional needs. Greater transit satisfaction links to lower perceived cycling self-efficacy, meaning that transit satisfaction is greater for people who feel less comfortable in using the bicycle or the car.

The correlation patterns across the satisfaction from the three modes show positive correlations, meaning that higher satisfaction from a certain mode translates into higher general satisfaction also from the other modes. Namely, people whose needs are satisfied feel satisfied with the transport system in general, and dissatisfaction from one mode translates into a system-wide dissatisfaction.

The relationship between the ERG needs, experienced difficulties and respondents' characteristics

Cycling self-concepts are stronger for women, while cycling self-efficacy is stronger for men, indicating gender differences in satisfying growth needs. For women, cycling satisfies mainly self-identity of being sportive and environmentally sustainable, optimism, and self-esteem, while for men cycling satisfies physical challenges, namely self-efficacy and developing competencies. Cycling self-concepts are stronger for people cycling half an hour or more in their commuting trip, suggesting reciprocity between the development of cycling self-concepts and the cycling amount. Cycling self-efficacy is stronger for people travelling

with children (albeit not statistically significant), possibly due to the need to serve as role models, and people with local travel patterns, as indicated by the low travel costs and time.

Positive car self-concepts increase with car availability and young age. Namely, young people and people with higher levels of car availability develop stronger car self-concepts. Functional difficulties are perceived as stronger by women and people with lower car availability levels, indicating again a reciprocity effect, namely people who see functional difficulties in driving have lesser tendency to own a car and vice versa. Functional travel needs such as multi-tasking, safety, and privacy, are associated positively with women and are perceived as more important at both younger and third age, indicating a shift in the travel preferences with life-cycle stages.

Travel togetherness is more important at younger ages, for people working in city centre locations, and seems to diminish with education length. This points to the possibility of needs being determined by lifestyles. Young travellers prefer to travel together with friends and young families with their children.

The perceptions regarding the functional difficulties related to transit diminish with age, with young people showing the greatest dislike for transit.

We found a positive correlation (small but significant) between satisfaction by different modes, so people who are more satisfied with travel are more satisfied with all modes and the ones that are less satisfied are less satisfied with all modes. This finding suggests that there is a higher dimension of satisfaction common to all modes similar to findings from the studies of De Vos et al. (2016), St-Louis et al. (2014) and Ye and Titheridge (2017) who found that a preference for a certain mode can (positively or negatively) affect travel satisfaction when using other modes. The ERG theorem, empirically validated in the current study, provides an interesting explanation to these results. When ERG needs are satisfied, travellers develop a positive stance towards travel in general, thus increasing their satisfaction also with other travel modes compared to people whose ERG are not met during travel.

Limitations and further research themes

While the current study provides important insights, the data source used in this study is not without limitations. First, this study uses cross-sectional data, which is less efficient than panel data to investigate the assumptions of the relationship between need satisfaction and travel use because it cannot capture trip-level modal shifts. Further research could investigate the consistency of results across other travel purposes and population groups. Second, our data does not include joint trips because commuting trips are mostly individual trips. Nevertheless, for leisure travel joint travel needs to be considered. Third, it seems like, there is an attitudinal shift, where the younger generation shows more negative attitudes towards public transport. There are studies addressing the impact of life events such as child birth, income change or retirement on mobility biographies (e.g., Lanzendorf 2010) and studies focusing on changing travel trends towards multi-modality and more sustainable modes among younger generations (e.g., Kuhnimhof et al. 2012; DelBosc and Currie 2013). However, there is little knowledge regarding attitudinal changes towards travel modes among younger generations, which remains a theme for further research. Last, a challenge of comparing different travel satisfaction from different travel modes is that the difference on how individual value and change/adjust their satisfaction may differ overtime and perhaps differ between en-route and ex-post the trip. The questionnaire in this study applies to the overall satisfaction of commuters with their commuting choices overall rather than per trip. In this study, we asked commuters to contemplate on their satisfaction from

their modal choice rather than to rank their satisfaction on a trip-by-trip basis. The distinction between 'trip satisfaction' and 'satisfaction with daily travel' is important because of the major difference between the two concepts (e.g., De Vos and Witlox 2017). The questionnaire also elicited the weekly frequency of taking each mode so the satisfaction is evaluated for commuting trends rather than on a trip-by-trip basis. The proposed approach is reasonable because satisfying relatedness and growth needs take time but further research could address the trip-based need satisfaction for comparison.

Conclusions

This study provides empirical evidence that the interdependence of mode use and travel satisfaction is related to the ability of the travel mode experience to satisfy functional and emotional human needs of relatedness and growth. Similarly to De Vos et al. (2016) who investigated leisure trips, we show that also for commuting trips, travel encompasses subjective well-being. Specifically, while the traditional utility-based approach considers only the attributes of the transport mode, the results show that, social and self-esteem needs increase travel satisfaction for commuting trips. Thus, the results confirm the hypothesis that positive travel experience and attitudes towards travel modes are related not only to level-of-service parameters, but also to their ability to satisfy emotional needs by triggering feelings of togetherness, self-efficacy and positive self-concepts. In addition, while traditional research focuses on travel disutility embedded in the attributes of the transport, this study shows that negative emotions and evaluation relate to individual difficulties, thus personalizing also the disutility. The results empirically confirm previous studies suggesting similar relations (e.g., De Vos and Witlox 2017; Shliselberg and Givoni 2018).

Policy wise, the findings show that increased sense of self-efficacy, togetherness, and positive self-concepts are strong motivators of satisfaction. Hence, encouraging their development in relation to sustainable modes and relevant branding may result in successful long-term shift towards sustainable travel. The results show that, at least in Denmark, the main competitor of the car is the bicycle as commute travel mode, not only because both are private modes, but also because both are related to the formation of positive self-concepts that lead to higher self-esteem. This advantage of the bicycle is an important consideration in the decision to integrate bicycle and transit use and in promoting bicycle infrastructure. Because according to De Vos and Witlox (2017) habit formation is based on a cyclical process driven by recurrent travel satisfaction, emphasis should be on long-term policies and promotion of sustainable travel from an early age. An important question for discussion is the transferability of the Danish results to other countries. The ERG theory of needs stems from the area of psychology and while the prioritization of needs may vary across population and circumstances, the general theory holds universally. The motivator for conducting the study in Denmark is the ability to examine satisfaction of needs and difficulties in a multi-modal environment due to high accessibility and use for all transport modes. In a multi-modal environment, people experience different modes and are thus able to evaluate the suitability of the various modes to their functional and emotional needs based on their travel experiences. Because satisfaction of needs is a choice outcome, these results would be difficult or nearly impossible to obtain in car-oriented or transit-oriented travel environments where people become captives of one mode or have a limited modal accessibility and choice. Nevertheless, results from more recent studies in Poland and on Polish immigrants in Denmark show that cycling answers existence, growth and relatedness needs also

for Poland (Kaplan et al. 2018a, b), which encourages the transferability of our results also to other countries. Hence, while the transferability of the results to other countries merits further exploration, Denmark can serve as a benchmark for understanding the functional and emotional effects of each mode and their relation to travel satisfaction when choice is fully available.

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Authors' contribution All authors contributed jointly to this study. The idea for the study, the application of the ERG theory was initiated by Sigal Kaplan and developed in collaboration with Yoram Shiftan. Floridea di Ciommo hosted Jesper Ingvardson for a short term scientific mission (STSM) in which he developed the survey under joint supervision with Sigal Kaplan. The data analysis was conducted by Jesper Ingvardson under the supervision of Sigal Kaplan and João de Abreu e Silva, who hosted Jesper Ingvardson for an STSM and advised on the paper writing and revision process. The data collection was facilitated and the Danish aspects of the study were advised by Otto Anker Nielsen. The paper writing was conducted by Sigal Kaplan and Jesper Ingvardson and assisted by comments from the other co-authors.

Compliance with ethical standards

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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