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Does commute duration attenuate the effect of travel mode choice on commute satisfaction?

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ABSTRACT

Many studies have found that both the chosen travel mode and travel duration have a strong effect on travel satisfaction. However, travel mode and duration are often related with each other, as active trips often have shorter durations than trips with motorized modes. As a result, the effect of travel mode choice on travel satisfaction may be attenuated by travel duration. Results from this study, using a sample of 1,430 respondents from Ghent (Belgium), indicate that commute mode and commute duration are strongly related with each other (with active trips having shorter durations than public transport trips), and that they both influence commute satisfaction. However, results from two-way ANOVAs and regression analyses indicate that duration has a stronger effect than travel mode and that the effect of travel mode is mainly moderated by duration. After controlling for duration, we only found a negative effect of car frequency on commute satisfaction. Satisfaction differences between active travelers and public transport users are mainly explained by short active trips and long public transport trips. As a result, policy measures trying to increase travel satisfaction should not focus on a modal shift away from public transport, but on decreasing (perceived) travel time of public transport trips.

1. Introduction

In the past decade, many studies have explored how people experience their travel and how satisfied they are with it (Chatterjee et al., 2020; De Vos & Witlox, 2017; Mokhtarian, 2019). Travel satisfaction studies have mainly focused on the determinants of travel satisfaction. Many of them found that satisfaction with travel differs by travel mode. Studies from various parts of the world found that active travel is usually perceived most positively, while public transport trips often result in low satisfaction levels (e.g., De Vos et al., 2016; Olsson et al., 2013; Singleton, 2019; St-Louis et al., 2014; Ye & Titheridge, 2017). Other satisfaction-related studies have focused on the influence of travel time on travel satisfaction. Despite a possible positive utility of travel in which people like certain aspects of their trip and do not automatically want to minimize travel time (Mokhtarian & Salomon, 2001; Singleton, 2017), studies found that travel duration has a negative influence on travel satisfaction. As trips become longer, travelers become less satisfied (e.g., Higgins et al., 2018; Morris & Guerra, 2015; Zhu & Fan, 2018a). The chosen mode and travel duration may also impact people's mood after travel, the performance of (and satisfaction with) activities at the destination, and life satisfaction, partly indirectly through travel satisfaction (e.g., De Vos, 2019a; Friman et al., 2017a,b; Glasgow et al., 2019; Loong et al., 2017; Waygood et al., 2019; Westman et al., 2017).

Travel mode choice and travel duration may be closely related. Although longer distances are often compensated by using faster (i.e., motorized) travel modes, studies have found that walking and cycling trips mostly have shorter travel times than public transport and car trips (Lades et al., 2020; Le et al., 2020; Mao et al., 2018; Morris and Guerra, 2015; Páez & Whalen, 2010; Schwanen et al., 2002; Ye et al., 2020), although some North American studies found shorter average travel durations for car trips than for active trips (Milakis et al., 2015; Whalen et al., 2013). Despite this relationship between travel time and chosen travel mode, past studies did not take into account their interaction in assessing travel satisfaction. Without accounting for travel duration, many studies have found clear and significant differences in travel satisfaction depending on the chosen travel mode (e.g., Smith, 2017; Thomas & Walker, 2015; Ye & Titheridge, 2017). Other studies found that travel duration has a clear impact on travel satisfaction, irrespective of the chosen travel mode (e.g., Olsson et al., 2013; Morris & Guerra, 2015). Some studies analyzed travel satisfaction by mode, and mostly

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found negative effects of duration on satisfaction when traveling by these modes (e.g., De Vos et al., 2016; St-Louis et al., 2014). Lades et al. (2020) and Legrain et al. (2015) found that duration negatively affects satisfaction, both for modes separately and all modes combined. Studies including both travel mode and duration as explanatory variables of satisfaction often found modest to weak effects – or less strong effects compared to effects in separate models – of duration, but especially of the chosen travel mode, on travel satisfaction (Lades et al., 2020; Lancée et al., 2017; Mokhtarian et al., 2015; Morris & Guerra, 2015; Singleton, 2019; Zhu & Fan 2018a,b).

In sum, existing studies have not paid great attention to how the interaction between duration and mode can affect satisfaction. Since both elements are interrelated, it is possible that the effect of travel mode on travel satisfaction is attenuated by travel duration. In this case, the negative effect of public transport use on travel satisfaction may be explained by long public transport trips, while satisfying walking and cycling trips may be explained by short durations of active trips. An overarching negative effect of travel time on travel satisfaction is reasonable since travel time cannot be spent on more rewarding activities and can be perceived as wasted time which people want to minimize (i.e., travel as a derived demand). The opposite effect, in which the impact of duration on satisfaction is moderated by travel mode (e.g., long trips being less satisfying because they are covered by public transport) seems less plausible. Despite that the impacts of trip characteristics on satisfaction differ by mode, there is no clear reason to assume that one mode would inherently be more enjoyable than another.[1]

In this study we will examine the effects of commute duration and travel mode on commute satisfaction. By analyzing a sample of 1,430 commuters residing in Ghent, Belgium, we test the hypotheses that commute satisfaction considerably differs according to duration and mode, and that the effect of mode on satisfaction is moderated by duration. In other words, we will explore whether travel duration, instead of travel mode, is the dominant predictor of travel satisfaction. Although some studies have started exploring the combined effects of duration and mode choice on travel satisfaction (Lades et al., 2020; Lancée et al., 2017; Morris & Guerra, 2015), the magnitude of individual and interaction effects remains unclear. Insights from this study can help to create policy measures which can enhance travel satisfaction of certain types of commuters, for instance, by stimulating a mode shift (for people with certain commute durations) or by attempting to reduce commute durations (for certain mode users). The remainder of this paper is organized as follows. In Section 2, the used data and methodology are described. The main results are shown in Section 3, while a discussion and conclusions are provided in Section 4.

[1] It is possible that satisfaction is positively or negatively affected by the travel environments that are specific to modes, such as infrastructure, quality of services, and congestion levels. For example, the comfort/convenience of the car and the possibility to perform activities while using public transport may positively influence satisfaction levels, while possible congestion, crowdedness, and the need to transfer may negatively affect satisfaction with car and public transport trips (e.g., Ettema et al., 2013, 2014; Smith, 2017). Active travel may be perceived as more satisfactory due to its physical activity and high travel time reliability benefit, and less satisfactory due to bad weather conditions (e.g., rain or snow), the presence of slopes, and the absence of adequate infrastructure for cyclists/pedestrians (e.g., Manaugh & El-Geneidy, 2013; St-Louis et al., 2014). Some studies have also indicated that (positive) attitudes towards the chosen travel mode (positively) influence satisfaction with trips using that mode (e.g., Mokhtarian et al., 2015; Ye & Titheridge, 2019). A large share of public transport users having rather negative attitudes toward public transport (i.e., 'captive' users who actually prefer to use another mode) may result in overall lower satisfaction levels of public transport users compared to people walking and cycling, who mostly have rather positive attitudes towards active travel (i.e., 'choice' users who travel with the preferred mode) (De Vos, 2018, 2019b). In this study, we will not take into account attitudes, but will focus on the effects of commute duration and mode frequency on commute satisfaction.

2. Data and methodology

2.1. Recruitment and sample characteristics

This study uses data from a 2017 online survey on travel behavior of recently relocated residents within the city of Ghent, Belgium, home to 260,000 residents. Within this city, we selected two internally homogenous sets of urban and suburban neighborhoods. Approximately 101,300 people live in these neighborhoods, accounting for 39.3% of all residents in the city of Ghent (situation 2017). The urban neighborhoods – located around the historical center – are characterized by a relatively high population density (8,000 inhabitants per km^2), mixed land uses and can be regarded as low-traffic areas with good public transport services. The suburban neighborhoods – located around three to six kilometers from the city center – have a considerably lower average population density (1,800 inhabitants per km^2), lower diversity, good car accessibility and limited public transport services. In February 2017, a total of 9,979 letters with an invitation to participate in an online survey were distributed to all households that relocated to the selected neighborhoods in the past two years (i.e., in 2015 and 2016). Eventually, 1,650 adults completed the survey, resulting in a response rate of 16.5%. In this study, we use the data from 1,430 respondents since we focus on commute satisfaction and therefore exclude respondents who were unemployed or retired (students were not excluded). For more information on the neighborhood selection and sample recruitment, see De Vos et al. (2018).

Table 1 shows that most respondents in our sample are highly educated (80.3%) and live in urban neighborhoods (67.6%). There are slightly more men than women in the sample (52.0% versus 48.0%) and most respondents are single (28.1%) or live together as a couple without (resident) children (37.3%). Around half of the respondents (50.7%) lives in a household with a monthly net income higher than €2,500.

Table 1
Respondents' socio-demographic characteristics (n = 1,430).

Socio-demographics	%	n
Personal characteristics		
Age distribution		
18–29	53.7	768
30–39	26.3	376
40–49	10.3	148
50+	9.7	138
Gender		
Female	48.0	687
Male	52.0	743
Education		
Low (no university or college degree)	19.7	282
High (university or college degree)	80.3	1148
Employment status		
Full time	83.9	1200
Part time	12.4	177
Student	3.7	53
Household characteristics		
Household composition		
Single	28.1	402
Single parent	6.0	86
Couple without children	37.3	533
Couple with children	15.9	227
Other (e.g., living with parents or friends)	12.7	182
Household net monthly income		
Less than €1,500	9.2	127
€1,500 - €2,499	41.1	566
€2,500–€3,499	19.8	273
€3,500 or above	29.9	412
Residential location		
Urban neighborhood	67.6	967
Suburban neighborhood	32.4	463
Household car ownership		
0	23.4	335
1	55.2	789
>1	21.4	306

Respondents in our sample are remarkably young, as more than half of them (53.7%) are younger than 30 years old. This is, however, not that surprising since young adults are – compared to older adults – more likely to relocate due to a considerable number of life events taking place during early adulthood (e.g., entry into the labor market, formation of a household with partner, having children). Furthermore, removing retired people from the sample resulted in a further overrepresentation of young adults. Nonetheless, other socio-demographics of our respondents, such as income and gender are comparable to the neighborhoods population (http://gent.buurtmonitor.be). Although our sample is not fully representative of the total population in the selected neighborhoods, the large sample size enables us to estimate relationships with ample confidence.

2.2. Key variables

2.2.1. Commute mode frequency and commute duration

Respondents were asked to indicate how often – on a five-point scale from *never* to *always* – they use the following modes to travel to and from work (or to and from school/campus for students): car; bus or tram; train; bicycle; or on foot (Table 2). Cycling is the most popular commute mode, since almost half of the respondents mostly or always cycles to work or school. Around one third of the respondents never uses the car while more than one third uses it mostly or always. Public transport and walking are chosen least: more than half of the respondents never walks or travels by public transport to work or school. Results also indicate that respondents do not always use the same mode for commuting (e.g., 461 respondents (32.2%) do not indicate to use a certain mode always, but at least two modes rarely to mostly), or have multimodal trips (e.g., 170 respondents (11.9%) indicate that they always use at least two modes).

Respondents were also asked to indicate what their average travel time (in minutes) is to their main work or school location.[2] Most respondents (65.9%) have a commute up to 30 min, with 6 to 10 min (15.6%) and 11 to 15 min (16.2%) being the most frequent commute times. 22.5% of the respondents have a commute duration between 31 and 60 min, while 11.6% of them commute longer than 60 min (Fig. 1). These commute durations are comparable to commute durations found in other studies (e.g., Páez & Whalen, 2010; Redmond & Mokhtarian, 2001; Ye et al., 2020). In the remainder of the paper, respondents will be grouped according to commute duration as follows: 0–10 min (n = 321), 11–20 min (n = 374), 21–30 min (n = 207), 31–45 min (n = 180), 45 + minutes (n = 296).

Table 2
Commute mode frequency.

	Never	Rarely	Occasionally	Mostly	Always
Car frequency	494 (34.5%)	298 (20.8%)	91 (6.4%)	181 (12.7%)	366 (25.6%)
Bus/tram frequency	797 (55.7%)	372 (26.0%)	87 (6.1%)	94 (6.6%)	80 (5.6%)
Train frequency	840 (58.7%)	241 (16.9%)	63 (4.4%)	96 (6.7%)	190 (13.3%)
Cycling frequency	442 (30.9%)	199 (13.9%)	115 (8.0%)	275 (19.2%)	399 (27.9%)
Walking frequency	743 (52.0%)	218 (15.2%)	99 (6.9%)	237 (16.6%)	133 (9.3%)

2.2.2. Commute satisfaction

Respondents' satisfaction with their commute was measured by asking them to what extent they agree – on a five-point scale from *totally disagree* (1) to *fully agree* (5) – on the following six statements: 1) *I am satisfied with my commute trips; 2) When I think about my commute trips, the positive aspects outweigh the negative; 3) I do not want to change anything about my commute trips; 4) My commute trips provide me with positive feelings; 5) My commute trips go well;* and *6) I could not imagine my commute trips to go any better.* These statements have been used in previous studies using this data (i.e., De Vos et al., 2019, 2021) and have shown to capture commute satisfaction in a reliable way. Since the internal consistency (i.e., the average inter-item correlation) of the six items measuring commute satisfaction is high (Cronbach's alpha = 0.94), a variable representing commute satisfaction was created by averaging the scores on the six statements. The average commute satisfaction score is 3.57, indicating that respondents are generally rather satisfied with their commute trips.

2.3. Methodology

In this study we first test the relationship between travel mode frequency and commute duration using chi-squared tests. Since respondents may use more than one mode to travel to work, or may not always use the same mode, we segmented respondents based on their commute patterns (section 3.1). We used k-means cluster analysis that maximizes the differences between each cluster and similarities between members of the same cluster. The frequency of mode use for all five modes (on a scale from 1 to 5) and commute duration (using the five classes described above: 0–10 min., 10–20 min., 20–30 min. 30–45 min., and 45 + min.) were used as variables to segment the respondents. We produced solutions for predefined numbers of clusters ranging from two to seven. The number of clusters is primarily determined based on the criteria of interpretability and maintenance of large enough cluster sizes.

In Section 3.2 we examine how travel mode and commute duration influence commute satisfaction. Using one-way ANOVAs, we explore whether average commute satisfaction levels differ according to the use of various modes, commute duration, and the clusters developed in Section 3.1. Five two-way ANOVAs were then performed to see how commute duration, mode frequency, and the interaction between both influences commute satisfaction, for all five travel modes. In Section 3.3 we also estimate a set of linear regression models to measure the effects of mode frequency and commute duration on commute satisfaction.[3] First, three models were measured, one measuring the effect of mode frequency, one measuring the effect of commute duration, and one measuring the effect of both mode frequency and duration on satisfaction. Doing so enables us to capture both the separate effects of mode frequency and duration on satisfaction, but also makes it possible to see to what extent the effects of mode frequency and commute duration weaken after controlling for each other. Finally, five linear regressions were performed, one for each of the five commute time categories (0–10 min., 11–20 min., 21–30 min., 31–45 min., and 46 + min.). This allows us to isolate the effect of mode frequency and to see whether mode

[2] Since respondents may not always use the same mode(s) for commuting, their commute time may vary by day. Since we first asked respondents in the survey to indicate their mode frequency followed by their average commute time, we assume that respondents with varied commutes reported the average commute time of various commute trips (with different modes) instead of the average commute duration of the most common commute (with a certain (combination of) mode(s)).

[3] Although it is possible to include interaction terms (between mode frequency and duration) as independent variables in linear regressions, these interaction terms (e.g., car frequency * commute duration) and their effects on commute satisfaction are difficult to interpret. The two-way ANOVAs in Section 3.2 present these interaction effects more clearly. Furthermore, the main goal of the linear regression models shown in Table 5 is to measure which variable (i.e., mode frequency or commute duration) affects commute satisfaction most, not to take into account possible interaction effects (between mode frequency and duration).

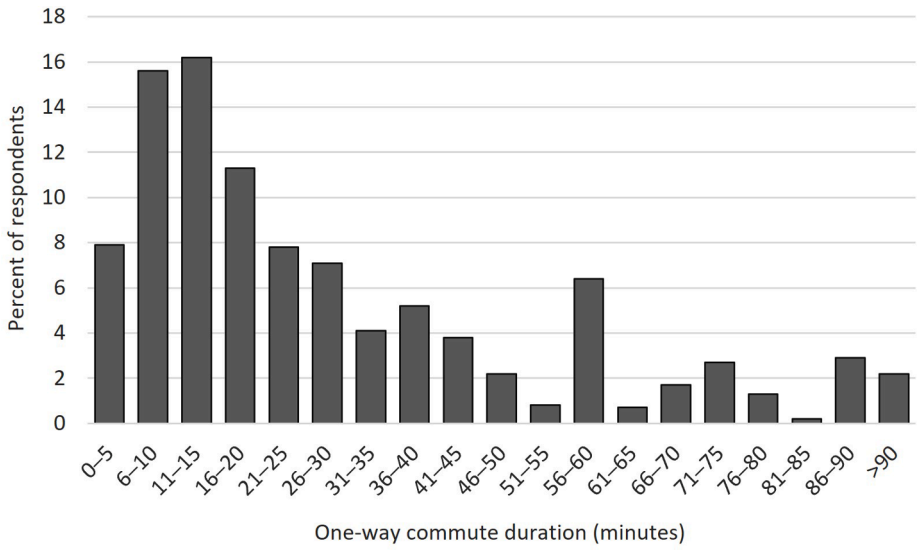

Fig. 1. Distribution of respondents' commute duration.

frequency impacts commute satisfaction within a certain duration category.

3. Results

3.1. How are travel mode and commute duration related with each other?

Fig. 2 shows that commute duration differs by mode frequency. Commuters who never travel by car often have either rather short commutes (perhaps with active travel modes) or long commutes (perhaps by public transport). Those mostly or always using the car often have commute durations between 10 and 45 min, leaving out the very short or long commutes. Respondents never using bus or tram have varied commute durations, while those frequently (mostly/always) using bus or tram have rather long commutes, i.e., around half of them longer than 30 min. A similar pattern, yet more pronounced, can be found for train use. Respondents never commuting by train mostly have short commutes (80.1% have commutes up to 30 min), while frequent train users have very long commute durations (73.4% travels more than 45 min to work). Those never cycling have rather varied commute durations (although long durations slightly dominate), while frequent cyclists often have short commutes (73.4% up to 30 min). Commute durations are evenly distributed for respondents never walking, while those frequently walking often have short commutes (55.9% up to 20 min), although a considerable part of them (26.8%) have commutes over 45 min. The latter group may be commuters combining walking with public transport use. Outcomes of Chi-squared tests indicate that – for all travel modes – commute duration significantly varies according to the frequency of mode use (at $p < 0.01$).[4] In general, the results in Fig. 2 are consistent with the earlier studies indicating that active travel has the shortest durations and public transport (train in particular) has the longest durations (e.g., Mao et al., 2018; Morris and Guerra, 2015; Páez & Whalen, 2010; Schwanen et al., 2002).

The cluster analysis shows five groups of respondents that have distinctive travel patterns (Fig. 3). *Cluster 1* represents respondents with a high frequency of bus/tram use and intermediate levels of commute duration. Members of this cluster also walk or use the train occasionally. Respondents in *cluster 2* mainly walk or cycle to and from work (or school) and have short durations. *Cluster 3* represents the frequent train users with high travel durations. Members of this cluster also walk and cycle frequently, probably to travel to and from the railway station. Members of *cluster 4* are typical car users with intermediate duration levels. Finally, *cluster 5* represents cyclists with low travel durations.

Table 3 shows the sociodemographic characteristics of these five clusters. The *first cluster (bus/tram users with intermediate durations)* is the smallest one and represents people who mostly do not live with children, have relatively low incomes and low education. The *second cluster (short active travelers)* mainly consists of respondents living in urban neighborhoods, having low incomes, and are mostly women. The *third cluster (long train users)* represents respondents who do not live with children, live in urban neighborhoods and are highly educated.[5] *The fourth and largest cluster (car users with intermediate durations)* has the highest share of respondents with resident children and respondents living in suburban neighborhoods, and is dominated by men living in relatively high income households. The *final cluster (short cyclists)* is characterized by well-educated respondents with a relatively high income.

3.2. What are the (combined) effects of travel mode and commute duration on commute satisfaction?

Table 4 clearly shows that commute satisfaction differs by commute mode and commute duration. For respondents traveling by car and public tranport, we found that frequent travelers (using the mode mostly or always) have significantly lower commute satisfaction levels compared to those using the mode never or rarely. Similar, yet opposite effects were found for active travelers. Respondents mostly or always cycling or walking are generally more satisfied with travel compared to those never or rarely traveling actively. Commute duration also has a clear effect on travel satisfaction. Satisfaction levels are highest for short commutes and lowest for long commutes, and satisfaction levels significantly decrease when commutes become longer. Despite some studies suggesting that satisfaction levels may only start to decrease once the ideal or tolerable commute time has been exceeded (Ermagun et al., 2022; Humagain & Singleton, 2021; Milakis & van Wee, 2018), results in Table 4 (and also Figs. 4 to 8) suggest a linear negative impact of commute duration on commute satisfaction. Respondents in clusters

[4] *Rarely* and *occasionally*, and *mostly* and *always* were grouped together in order to maintain robust group sizes (e.g., only one respondent indicated to always commute by train and no longer than 10 min).

[5] Cluster 3 probably represents urban respondents commuting by train to larger cities Antwerp and especially Brussels (where a lot of jobs for highly educated workers are concentrated).

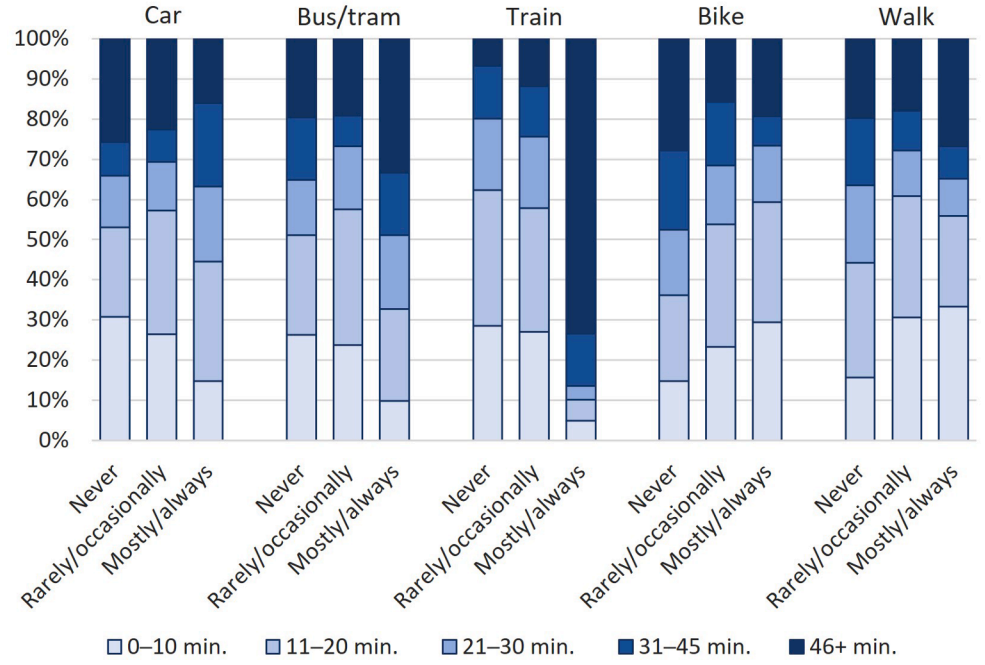

Fig. 2. Commute duration according to the use of travel modes.

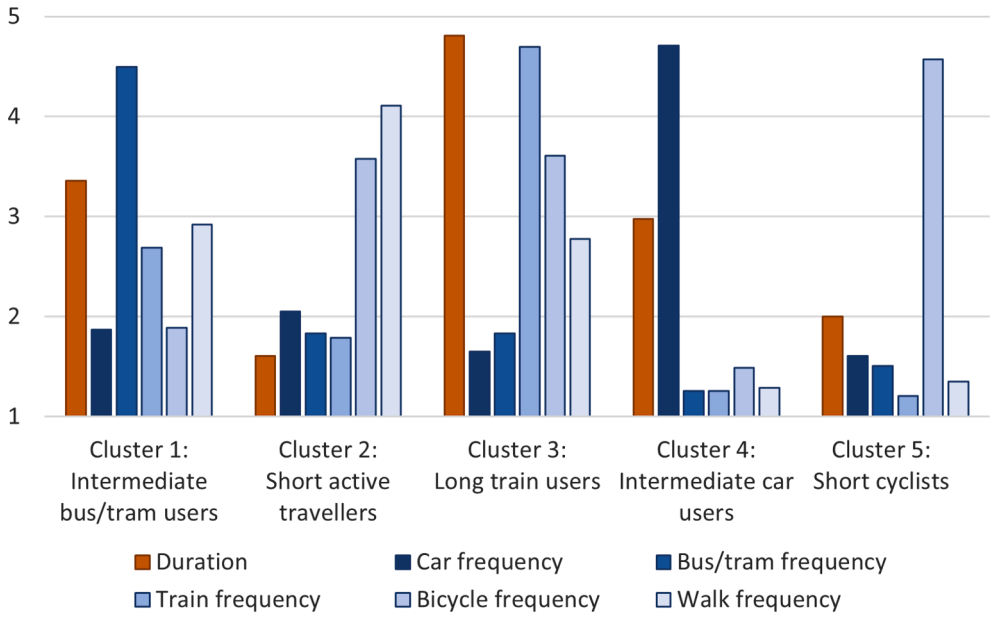

Fig. 3. Segmentation of respondents according to commute duration and mode use frequency.

Table 3
Cluster members' socio-demographic.

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Age	32.7	32.8	31.8	32.9	32.4
Female	52.7%	53.9%	45.4%	42.1%	51.8%
University/college degree	55.0%	81.9%	95.4%	73.8%	87.7%
Monthly income ≥ €2,500	42.6%	35.1%	48.8%	55.0%	55.4%
Presence of children	14.5%	16.1%	13.9%	24.1%	20.4%
Urban residence	71.0%	84.8%	86.6%	51.2%	65.1%
n	131	243	216	473	367

with short commute durations (i.e., clusters 2 and 5) have significantly higher levels of satisfaction compared to members of clusters with intermediate levels of commute duration (i.e., clusters 1 and 4), and especially respondents in the cluster with long commute durations (i.e., cluster 3). Between the clusters with intermediate levels of duration, the one characterized by bus/tram use (cluster 1) has higher satisfaction levels than the one characterized by car use (cluster 4), while no satisfaction differences were found between the two clusters with short durations. Overall, the results indicate that both mode frequency and duration influence satisfaction, but that the effect of duration is stronger.

In order to see which of the two elements – i.e., duration or mode use – has the strongest effect on satisfaction, and whether interaction effects exist, five two-way ANOVAs were performed (i.e., one for each mode).

Table 4
Commute satisfaction according to mode frequency, commute duration, and cluster membership.

Mode frequency, duration, cluster membership		Avg. commute satisfaction
Car frequency	1. Never	$3.82^{3,4,5}$
	2. Rarely	$3.78^{3,4,5}$
	3. Occasionally	$3.52^{1,2,5}$
	4. Mostly	$3.45^{1,2,5}$
	5. Always	$3.14^{1,2,3,4}$
Bus/tram frequency	1. Never	$3.56^{2,4,5}$
	2. Rarely	$3.71^{1,4,5}$
	3. Occasionally	3.59
	4. Mostly	$3.30^{1,2}$
	5. Always	$3.27^{1,2}$
Train frequency	1. Never	$3.77^{4,5}$
	2. Rarely	$3.64^{4,5}$
	3. Occasionally	$3.65^{4,5}$
	4. Mostly	$3.17^{1,2,3,5}$
	5. Always	$2.78^{1,2,3,4}$
Cycling frequency	1. Never	$3.29^{3,4,5}$
	2. Rarely	$3.37^{3,4,5}$
	3. Occasionally	$3.61^{1,2,5}$
	4. Mostly	$3.71^{1,2,5}$
	5. Always	$3.88^{1,2,3,4}$
Walking frequency	1. Never	$3.47^{2,4,5}$
	2. Rarely	$3.76^{1,3}$
	3. Occasionally	$3.45^{2,4}$
	4. Mostly	$3.70^{1,3}$
	5. Always	3.71^{1}
Duration	1. 0–10 min.	$4.41^{2,3,4,5}$
	2. 10–20 min.	$3.89^{1,3,4,5}$
	3. 20–30 min.	$3.52^{1,2,4,5}$
	4. 30–45 min.	$3.01^{1,2,3,5}$
	5. 45 + min.	$2.60^{1,2,3,4}$
Clusters	1. Intermediate bus/tram users	$3.37^{1,2,3,4}$
	2. Short active travelers	$4.23^{1,3,4}$
	3. Long train users	$2.74^{1,2,4,5}$
	4. Intermediate car users	$3.18^{1,2,3,5}$
	5. Short cyclists	$4.21^{1,3,4}$

Note: ^{1,2,3,4,5} = significantly different from groups 1, 2, 3, 4, 5 respectively at $p < 0.05$ using one-way ANOVAs with post-hoc multiple comparison analysis using the least significant difference (LSD) method.

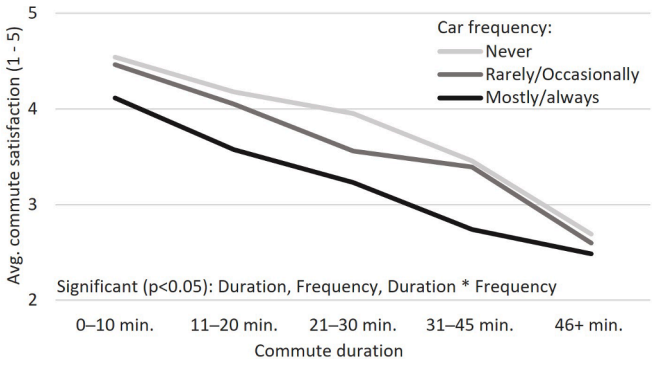

Fig. 4. Commute satisfaction according to commute duration and car frequency.

For mode frequency, (i) *rarely* and *occasionally*, and (ii) *mostly* and *always* were grouped together for the ease of interpretation and to ensure large enough group sizes (when combined with the five duration options). Results show that commute satisfaction is affected by both duration and car frequency. Satisfaction levels go down when duration and car frequency increase. Also interaction effects were significant, indicating that car frequency influences commute satisfaction, but not for trips longer than 45 min (Fig. 4). For both bus/tram use and train use, we only found significant negative effects of duration on satisfaction, while the frequency of public transport use does not have a separate effect on satisfaction (Figs. 5 and 6). The negative effect of commute

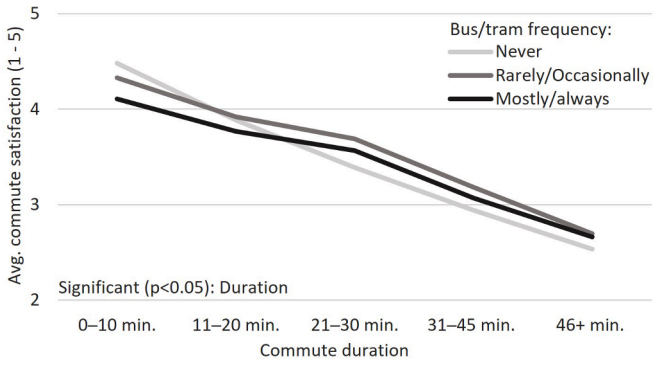

Fig. 5. Commute satisfaction according to commute duration and bus/tram frequency.

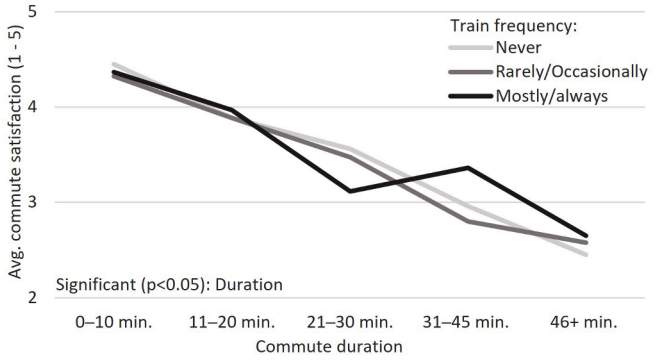

Fig. 6. Commute satisfaction according to commute duration and train frequency.

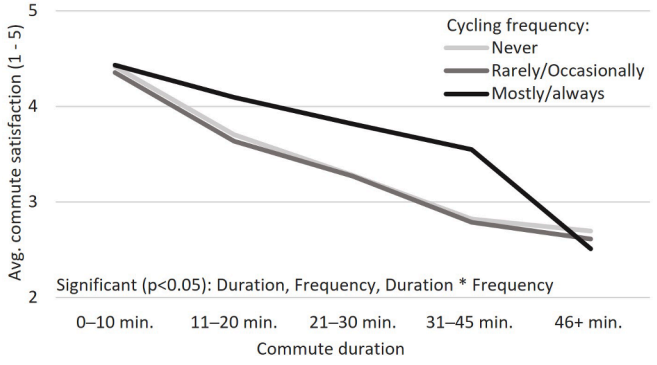

Fig. 7. Commute satisfaction according to commute duration and cycling frequency.

duration on satisfaction seems partly non-linear for frequent train users since satisfaction slightly raises for those traveling 31–45 min, but clearly declines for train users with a commute exceeding 45 min (Fig. 6).

Commute satisfaction is – besides affected by duration – at the same time also influenced by cycling frequency. A higher cycling frequency results in higher levels of satisfaction. The interaction effects indicate that cycling frequency only affects satisfaction for trips between 11 and 45 min, and not for trips up to 10 min or longer than 45 min (Fig. 7). Finally, we found that commute satisfaction is not affected by the frequency of walking, only by duration (Fig. 8). Although both duration and mode frequency have significant effects on satisfaction for car use and cycling, the effects of duration are far stronger than the effects of mode frequency (F-values of duration (210.7 and 178.3 for car and

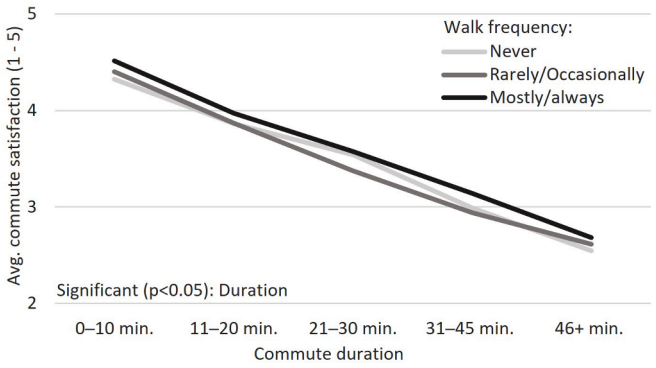

Fig. 8. Commute satisfaction according to commute duration and walking frequency.

cycling, respectively) are considerable higher than those of mode frequency (53.0 and 22.8 for car and cycling, respectively)). In sum, it can be argued that – based on two-way ANOVAs – commute duration has a stronger effect on satisfaction than mode frequency, especially for public transport use and walking.

3.3. To what extent are differences in commute satisfaction according to travel mode explained by commute duration?

In order to further explore the extent to which duration influences the relation between mode use and travel satisfaction, we performed three linear regression models with commute satisfaction as dependent variable; one with mode frequencies as independent variables (model 1), one with commute duration (in minutes) as independent variable (model 2), and one with both mode frequencies and duration as independent variables (model 3). In these three models, we controlled for socio-demographic characteristics by including age, gender, education, income, presence of children, and residential location as independent variables (Table 5). Model 1 finds that all modes except cycling have a significant effect on satisfaction. Car use and public transport use have a negative effect, while walking has a positive effect. The negative effects of car use and train use are strongest; using these modes mostly or always – compared to never using them – has a strong negative effect on commute satisfaction. Model 2 indicates that duration has a strong negative effect on commute satisfaction, a far stronger effect than the effects of mode frequency in the first model. This is also represented by the R^2 value. The R^2 value of the model including duration (0.38) is considerable higher than the R^2 value of the model including mode frequencies (0.26), indicating that duration explains a large share of the variance in satisfaction, a larger share than the frequencies of all modes together. Model 3 shows that duration remains significant and strong while the effects of mode frequency become less strong. Only car frequency maintains a significant negative effect on satisfaction, while a moderate positive effect of mostly/always walking (compared to never walking) on satisfaction was found. This model explains 45% of the variance in commute satisfaction. Of the socio-demographics, only age and to a limited extent education have a (positive) effect on commute satisfaction.

In order to isolate the effect of mode frequency on commute satisfaction and control for duration, we performed five linear regressions – one for each duration category – with mode frequencies as independent variables and commute satisfaction as dependent variable (Table 6). The effects of mode frequency on satisfaction according to the different duration categories are considerably weaker compared the same effects in the model with all respondents (model 1 in Table 5). Car use continues to show strong effects. For all duration categories, except for the model with respondents commuting longer than 45 min, mostly or always traveling by car (compared to never using the car) has a negative effect on commute satisfaction. The use frequency of other modes only has limited effects. We only found a moderately positive effect ($p = 0.049$) of mostly/always cycling on satisfaction in the 31–45 min model, and a negative effect ($p = 0.004$) of mostly/always cycling in the 46 + minutes model (compared to those never cycling). The latter may indicate that cycling trips longer than 45 min may result in physical exhaustion, negatively affecting commute satisfaction. Commute trips longer than 45 min are also more positively perceived by older respondents and men.

Table 5
Linear regression models for commute satisfaction.

	Model 1		Model 2		Model 3	
	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.
Socio-demographics						
Age	**0.01**	**2.93**	**0.01**	**3.50**	**0.01**	**3.08**
Female	0.07	1.28	0.03	0.58	−0.00	−0.02
University/ college degree	0.04	0.63	**0.16**	**2.73**	0.09	1.51
Monthly income ≥ €2,500	−0.01	−0.19	−0.03	−0.60	0.01	0.18
Presence of children	0.01	0.09	0.02	0.32	0.04	0.59
Urban residence	−0.04	−0.58	*0.11*	*2.03*	−0.03	−0.59
Mode frequency (ref. category = never)						
Car frequency						
- Rarely/ occasionally	−0.08	−1.17			*−0.12*	*−2.07*
- Mostly/always	**−0.80**	**−10.59**			**−0.60**	**−9.04**
Bus/tram frequency						
- Rarely/ occasionally	−0.03	−0.40			−0.01	−0.10
- Mostly/always	**−0.29**	**−3.23**			−0.13	−1.73
Train frequency						
- Rarely/ occasionally	**−0.27**	**−3.94**			−0.09	−1.55
- Mostly/always	**−1.22**	**−16.89**			−0.05	−0.63
Bike frequency						
- Rarely/ occasionally	0.07	1.01			−0.08	−1.31
- Mostly/always	0.11	1.51			0.02	0.28
Walk frequency						
- Rarely/ occasionally	*0.18*	*2.59*			0.01	0.22
- Mostly/always	**0.34**	**4.83**			*0.13*	*2.13*
Commute duration (min.)			**−0.03**	**−28.49**	**−0.03**	**−21.63**
n	1378		1371		1371	
R^2	0.26		0.38		0.45	

Note: italic = significant at $p < 0.05$; bold = significant at $p < 0.01$. Respondents not providing information regarding their income (52 respondents) and reporting a commute duration of more than 120 min (8 respondents) were removed from the analyses.

4. Discussion and conclusions

4.1. Summary of the results

In this study, we analyzed the interaction between commute duration and travel mode frequency, and how this influences commute satisfaction. We found that duration is associated with mode choice. Those frequently walking or cycling often have rather short commute durations (<20 min.), while public transport users, especially train users often have long commutes (30 + min.). Frequent car users are more or less evenly distributed over all duration categories. A cluster analysis revealed that respondents can be categorized as cyclists or active travelers with short durations, car users or bus/tram users with intermediate levels of duration and train users with long durations. Respondents frequently (mostly/always) using the car or public transport have significantly lower satisfaction levels compared to infrequent users,

Table 6
Linear regression models for commute satisfaction, grouped per commute duration.

	0–10 min.		11–20 min.		21–30 min.		31–45 min.		46 + min.	
	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.	Coef.	t-stat.
Socio-demographics										
Age	0.00	−0.31	0.01	1.47	0.00	0.38	0.01	1.14	**0.02**	**2.94**
Female	0.06	0.70	*0.17*	*2.12*	−0.07	−0.61	−0.07	−0.47	**−0.32**	**−3.00**
University/college degree	0.07	0.63	0.09	0.83	0.23	1.61	0.11	0.65	−0.09	−0.51
Monthly income ≥ €2,500	0.05	0.56	−0.05	−0.56	−0.03	−0.29	0.12	0.86	−0.03	−0.30
Presence of children	0.18	1.55	0.02	0.19	0.07	0.50	−0.24	−1.28	−0.08	−0.53
Urban residence	−0.04	−0.34	0.05	0.47	−0.07	−0.52	−0.11	−0.69	0.05	0.31
Mode frequency (ref. cat. = never)										
Car frequency										
- Rarely/occasionally	−0.02	−0.24	−0.11	−1.01	*−0.32*	*−1.98*	−0.17	−0.75	−0.07	−0.57
- Mostly/always	**−0.54**	**−4.22**	**−0.59**	**−4.41**	**−0.55**	**−3.05**	**−0.68**	**−3.41**	−0.26	−1.19
Bus/tram frequency										
- Rarely/occasionally	−0.19	−1.93	−0.13	−1.36	0.27	1.81	0.17	0.81	0.20	1.53
- Mostly/always	−0.39	−1.83	−0.33	−1.95	0.18	0.89	−0.23	−1.02	−0.05	−0.31
Train frequency										
- Rarely/occasionally	−0.10	−0.88	−0.04	−0.35	−0.19	−1.21	−0.14	−0.73	0.11	0.58
- Mostly/always	−0.11	−0.52	0.13	0.54	−0.63	−1.96	0.13	0.63	0.23	1.07
Bike frequency										
- Rarely/occasionally	0.01	0.04	−0.14	−1.18	0.01	0.07	−0.08	−0.43	−0.19	−1.14
- Mostly/always	−0.15	−1.14	0.00	0.02	0.20	1.10	*0.37*	*1.99*	**−0.40**	**−2.88**
Walk frequency										
- Rarely/occasionally	0.11	1.01	−0.01	−0.08	−0.12	−0.68	−0.30	−1.40	0.08	0.48
- Mostly/always	0.19	1.69	0.09	0.71	−0.03	−0.18	−0.19	−0.82	0.09	0.66
n	321		374		207		180		296	
R^2	0.12		0.15		0.20		0.22		0.12	

Note: italic = significant at $p < 0.05$; bold = significant at $p < 0.01$. Respondents not providing information regarding their income (52 respondents) were removed from the analyses.

while frequent active travelers have significantly higher satisfaction levels compared to those never or rarely walking or cycling. Commutes with short durations clearly have higher levels of satisfaction compared to commutes with long durations, while clusters characterized by short commutes (i.e., primarily active travelers) have significantly higher satisfaction levels than clusters characterized by long commutes (i.e., primarily train users). Despite both mode frequency and duration having significant effects on commute satisfaction, differences in duration result in larger variations in satisfaction, compared to differences in mode frequency.

Two-way ANOVAs revealed that for all modes, duration has a significant (negative) impact on satisfaction. Only for driving and cycling, the mode frequency plays a significant role. Frequent car users have lower satisfaction levels compared to those never or rarely using the car (except for commutes of more than 45 min), while those frequently cycling are more satisfied than irregular cyclists (at least for commutes between 10 and 45 min). Linear regression models show that both mode frequency and commute duration have significant impacts on satisfaction in separate models. However, when including both elements in one model, the frequency of bus/tram use and active travel becomes insignificant. Linear regression models per duration category show that only car frequency remains its (negative) influence on satisfaction (except for 45 + min. commutes), while the effect of other modes becomes insignificant or modest at best. In sum, the results indicate that duration has a stronger effect on travel satisfaction than mode frequency, especially when controlling for each other. Only car use has a clear and negative impact on satisfaction, even after accounting for duration. Despite studies indicating a positive utility of travel and travel time being perceived positively (e.g., Jain & Lyons, 2008; Mokhtarian & Salomon, 2001), our study suggests a strong negative effect of commute duration on travel satisfaction. This can mainly be explained by the opportunity cost of travel, i.e., time spent on commuting cannot be spent on more rewarding activities (such as social or leisure activities). Although people may not always want to minimize commute time (as it can be a useful transition between home and work), their actual commute time may exceed their ideal commute time, especially for trips with motorized modes (Humagain & Singleton, 2020; Páez & Whalen, 2010; Redmond & Mokhtarian, 2001; Ye et al., 2020).

4.2. Policy implications

Results from this study provide valuable new insights. Although many studies have indicated that active travel results in high satisfaction levels and public transport use in low satisfaction levels, this study shows that these differences can be (mainly) explained by short active trips and long public transport trips. This study therefore suggests that there is no reason to assume that public transport use is inherently less satisfying, or active trips inherently more satisfying than trips with other modes. Hence, policy measures trying to enhance travel satisfaction and subjective well-being of commuters should not necessarily focus on a modal shift. Decreasing the duration of public transport trips can be more effective. This could be done by increasing the spatial and temporal coverage of public transport, creating more dedicated bus or tram lanes, and other forms of priority (e.g., traffic-light priority at intersections) in urban areas, or by reducing commute distances by stimulating people to move closer to their job and create a higher land use mixture (increasing the job-housing balance). Alternatively, making public transport trips more comfortable, productive, or enjoyable (e.g., by increasing comfort and seating capacity, and/or providing free Wi-Fi and power sockets) can reduce the perceived travel time, which can positively influence satisfaction levels. Lowering travel distances by increasing density and diversity of residential neighborhoods (and stimulating people to live there) may also convince people to switch from motorized to active travel, which mostly has shorter durations and therefore higher satisfaction levels.

The negative effect of car frequency on commute satisfaction (even after controlling for duration) may be explained by congestion levels since most people commute during peak hours. Smith (2017), for instance, found that congestion levels have a strong negative impact on satisfaction with car trips, a much stronger effect than of congestion on satisfaction with bus trips. Policy measures trying to reduce congestion may therefore positively affect satisfaction with car trips. However, some of these measures (e.g., creating extra car lanes) may just attract more car users and only result in a temporal decline in congestion (i.e.,

induced travel demand). Policies restricting car use, such as sustainable urban mobility plans, low-emission zones, and road pricing/congestion charging, seem more desirable since lower congestion levels are the result of lower car use (and a shift towards public transport and active travel), and not of increased car infrastructure. Since congestion is mostly caused by commute travel (during peak hours), future studies should analyze whether car frequency still has a significant negative effect on travel satisfaction (when accounting for duration) for travel purposes less affected by congestion (e.g., leisure travel). Since some studies – in contrast to our findings – found clear effects of mode choice on travel satisfaction after controlling for duration (e.g., Lades et al., 2020; Mokhtarian et al., 2015; Zhu & Fan, 2018a), more studies focusing on satisfaction impacts of mode and duration are needed, using various methodologies (for data collection and analysis) and with a considerable diversity with respect to geographic and cultural context.

5. Author statement

J. De Vos: Data collection, study conception and design, literature search and review, analysis and interpretation of results, manuscript writing; H.T.K. Le: Interpretation of results, manuscript editing; M. Kroesen: Manuscript editing; all authors read and approved the final manuscript.

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