Abstract

The aim of this study was to investigate the relative roles of the norm activation model (NAM), transport priorities and situational constraints (car ownership, distances, gender and age) while considering spatial heterogeneity on university trips among students in the winter season. A cross-sectional survey was conducted among university students (n = 441) at the two largest university campuses in Trondheim (Dragvoll and Gløshaugen), Norway. Linear mixed model analyses showed that Dragvoll campus, allocated in a more rural area of the city, was associated with more use of car and public transportation (bus or tram), and less active transportation (walking or bicycling) than Gløshaugen campus which is located in an urban area. While adjusting for spatial heterogeneity, the findings showed that situational constraints were somewhat more important for mode use than psychological variables. Car ownership was associated with more car use and less use of public transportation. Longer walking time from students' residence to university was related to more use of public transportation and less active transportation. Strong priorities of physical activity were related to less public transportation mode use and more use of active transportation. Increased awareness of the negative consequences of car use was associated with more use of active transportation and less car use. Those who strongly prioritized convenience when choosing transportation modes tended to use a car. To further promote sustainable transportation mode use on university trips among Norwegian students it may valid to focus on situational constraints. However, psychological variables such as the awareness of consequences component in the NAM and psychological priorities could also be relevant for students' mode use in this season.

Key words: Mode choice; Norway; winter; psychological; quality attributes; spatial heterogeneity

1. Introduction

Transportation mode use has important implications for both the environment and safety. For instance, it has been argued that car use is associated with more accidents and injuries than public transportation (Albertsson & Falkmer, 2005; Nordfjærn et al., 2014a). It is also well-documented that gasoline and diesel-based cars cause more noise and CO_2 externalities than public transportation and active transportation such as walking and bicycling (Banister, 2011; Parry et al., 2007). In addition, active transportation mode use is associated with improved public health, by for instance reductions in Body Mass Index (BMI) among those who tend to use active transportation modes more frequently (Brown et al., 2016; Dons et al., 2018). An important consequence is that policy-makers worldwide target to increase the use of public and active transportation and simultaneously reduce the use of gasoline or diesel-based cars especially in urban environments. The current study advances the literature by investigating the relative roles of psychological and situational factors for different types of mode use (public transport, active transport and car use) among students specifically in the winter season.

Promotion of public and active transportation may be particularly beneficial for repeated urban trips among the younger segments of the population. This is because young individuals are about to develop their transport habits, and they represent the future generation of mode users. Transport to/from the university further represents a large proportion of the total number of daily urban trips (Danaf et al., 2014; Khattak, 2011). More knowledge about how psychological and situational factors are related to transportation mode use on university trips among students is therefore prudent.

One of the more prominent psychological theories used to predict transportation mode use is the Norm Activation Model (NAM) (Schwartz, 1977). The NAM is constituted by three components: Awareness of consequences (AC), Ascription of responsibility (AR), and Personal norms (PN). The awareness of consequences component refers to whether or not individuals are aware of the consequences of behaviour with negative impacts on the environment, such as using a gasoline-based car to university. This factor is assumed to predict ascription of responsibility, which refers to whether the individuals perceive any personal responsibility for the negative consequences of a behaviour. Finally, ascription of responsibility predicts personal norms, which is constituted by a moral personal obligation to take action for the benefits of the collective (see also Schwartz, 1977 for details). Several studies have shown that personal norms are positively associated with pro-environmental mode choices and intentions to use such modes (Eriksson et al., 2008; Nordlund & Garvill, 2003; de Groot & Steg, 2008; Jakovcevic & Steg, 2013).

Studies carried out more recently, however, have suggested that the extent to which the context supports sustainable mode choices may affect the capability of the NAM to predict transportation mode use. Pro-environmental mode choices represent an altruistic behaviour, where a person to some extent gives up individual benefits (e.g. rapid and flexible mobility) to accommodate collective interests, such as cleaner urban environments. For pro-environmental mode choices to occur there has to be pro-environmental behavioural options in the physical environment, such as access to public transport and safe bicycle paths. In developing countries, for instance, public transportation is generally unreliable and can also be unsafe in regards of security issues, such as theft and violence (Gwilliam, 2003; Toroyan & Pedem, 2007). Studies conducted in these contexts, such as Iran, have shown that the role of the NAM for transportation mode use may be more negligible (Mehdizadeh et al., in press). Nordfjærn and Zavareh (2017) further reported that personal norms were less important for mode use than situational constraints, such as car access and walking time to a destination, for active mode choice preferences in Nanjing, China. Frankly, Collin and Chambers (2005) underlined about 13 years ago that situational factors should be included in models examining psychological theory in relation to transportation mode use. Stern et al. (1999) also denoted the potential importance of contextual constraints and possibilities of action as a potential parameter in the NAM. Nevertheless, the majority of studies that have examined this theory in relation to transportation mode use have tended to investigate the model isolated from such factors.

In addition to differing contexts in regard of available transport options and their feasibility in different countries, such variations may also be present within countries. In Trondheim, Norway for instance the average temperatures varied between 17.3°C in July and 13.1°C in August to -3.5°C in February and -2.6°C in March, 2018 (Yr, 2018). The winters are usually rather long lasting from late October through March. Snowy conditions coupled with low temperatures may complicate both bicycling and walking in the winter season. Under such circumstances, the role of situational factors (e.g. walking distance to the university, car access and availability of public transportation nearby the residence) for transportation mode use to the university may become more profound and render psychological processes, such as the NAM, to be less impactful in the psychological decision-process. To the best of our knowledge, no studies using the NAM have examined its role for mode use specifically in the winter season.

In the winter season, it is likely that quality attributes (i.e. what people focus on and prioritize when choosing mode of transport) of transportation modes are particularly important in the mode choice process. For example, students may put a stronger emphasis on flexible and rapid travel and safety regarding accidents when they choose transportation modes to university in the winter season, because accidents are more likely and trips may be more time consuming in the winter. Moreover, during extreme conditions, such as snowy and windy weather coupled with low temperatures in winter, active commuting may be inconvenient or unfeasible compared to summertime. As such people may amend their mode use in this period and use more public transport or car. During summer time in Norway people can rather easily use active transportation as Norway does not have an extremely hot climate compared to countries in e.g. Southern Europe which can pose a challenge with respect to convenience and feasibility of active commuting during extreme summer heat. Previous work conducted among Norwegian commuters showed that people who prioritized flexibility and efficiency tended to use a car in (non-season specific) urban commute, while commuters who focused on safety and comfort tended to use public or active transportation (Nordfjærn et al., 2014b). Findings in the general Norwegian public reflected that individuals who prioritized flexible travel tended to use a car, while those who focused on convenience tended to use public transportation (Şimşekoğlu et al., 2015). The convenience dimension mainly consisted of items related to costs and travelling time. Car use in Norway is expensive, partly due to a government driven push factor taxing scheme where car drivers pay substantial tolls, insurances and parking fees. In addition, public transport such as buses are prioritized in the traffic system with dedicated driving lanes etc. These could be important reasons for why those who prioritized convenience mainly used public transport. In line with these empirical findings, a review on quality attributes that may attract car users over to public transportation concluded that service reliability, costs, accessibility, as well as comfort, safety, and convenience could be important in order to promote public transportation mode use among car users (Redman et al., 2013). However, a limitation in the empirical knowledge base regarding transport priorities is that the studies did not specify the season in which travelling occurred and none of the studies cited above focused specifically on students' university trips. The role of specific psychological and situational factors may diverge according to the specific transportation modes in question. For instance, distances may be particularly important for less use of active transportation and may promote use of public transport and car. These tendencies may be particularly prominent during the winter season. Students who prioritize safety and security may prefer to use public transport, as active transport and car use has higher accident risks during the winter period. Those students who have strong priorities of exercise may also be more prone to use active modes in the winter season. Car ownership is likely to be associated with scripted car use and is mainly expected to predict more use of car.

An additional contribution of the current study to the literature is that it will adjust for geographical variation/spatial heterogeneity across two universities with substantially different allocations and topography, while examining psychological and situational constraints related to mode use on university trips among students in the winter. Spatial heterogeneity is present when there is variation in independent variables across geographical space (Xu et al., 2017. Neglecting spatial variation may lead to biased estimations and incorrect conclusions (Gourieroux & Visser 1997; Mannering et al., 2016). The two largest campuses, Gløshaugen and Dragvoll, in the current study area of Trondheim, Norway are located about 7 kilometers from each other. Dragvoll is located outside the city center of Trondheim in a more rural area, while Gløshaugen is located in close proximity to the city center. It is likely that there will be substantial variation in variables relevant to mode use due to spatial heterogeneity among students clustered in these two campuses. For instance, most students tend to live in central areas of the city and the walking distance from most residences to Dragvoll campus will thereby exceed the walking time from most residences to Gløshaugen. It is thus likely that more people will use active transportation to Gløshaugen, while trips to Dragvoll will more often be undertaken by public transportation or car. Although many students choose to settle in central areas or in close proximity to their respective university campuses, this is not true for everyone. None of the campuses included in the current study provide housing facilities for students at the campus locations. Thus, there is a random component in where the students reside as well as the distances and topographical environments they must travel through to reach their campus.

1.2 Aim of the Study

The core aim of the current study was to investigate the relative roles of norm activation, transport priorities and situational constraints for transportation mode use (i.e. active transportation, public transportation and gasoline or diesel-based car use) while considering spatial heterogeneity on university trips among students in the winter. The situational constraints considered in the current study are car ownership, distances, gender and age.

2. Method and materials

2.1. Procedure

The results are based on a cross-sectional self-administered survey conducted at the two largest university campuses in Trondheim, Norway (Dragvoll and Gløshaugen) in the period February through April, 2018. Dragvoll campus is located in a rather sparsely populated rural area of Trondheim (about 6.5 kilometers from the city center), while Gløshaugen campus is located in a more densely populated area less than 2 kilometers from the city center. About sixty psychology students affiliated with the project conducted the data collection. These assistants were divided into eight groups, each containing 5-8 persons. The students were recruited by convenience sampling at different locations inside and outside the university facilities (e.g. by the entrance to cafeterias and by the entrance to the university buildings) from Monday to Thursday 09:00 AM – 15:00 PM. Demographic characteristics among non-respondents (i.e. gender, estimated age and reasons for not participating) were registered. All participating subjects received oral information about the confidentiality of responses and secure data storage. They were also ensured anonymity and the voluntary nature of participation was highlighted. In addition to recruitment at the campuses, students were also recruited in four lectures, two at each campus. After consent from the course instructors, questionnaires were distributed to students during the lectures and completed during the lecture break. Anonymous studies are exempt from formal ethical review according to Norwegian ethical research standards. To secure that the methodological procedures were aligned with good ethical standards, a case officer at the Norwegian Center for Research Data was consulted both orally and in writing. The officer considered the procedures to be well-aligned with ethical standards and that the integrity of the respondents was adequately handled.

2.1.1. Sample

The final sample included 441 university students. In total, 257 (58%) students were recruited from Dragvoll campus and 184 (42%) from Gløshaugen campus (see also Table 1). Among these students, 150 (34%) were recruited from the campuses, while 291 (66%) were sampled from lectures. The Dragvoll campus response rate was 80% and at Gløshaugen the response rate was 84% (pooled response rate = 82%). The two lectures at Dragvoll achieved a total response rate of 90%, while the two lectures at Gløshaugen obtained an 82% response rate (pooled response rate = 87%). There were 206 (47%) males and 229 (53%) females in the sample. The mean age was 23.06 years (SD = 4.83, range = 19-61 years). In total 98% (n = 428) of the sample was 30 years or below. In regards of car ownership, 91 (21%) students reported that they or their spouse owned a car. There were no significant age differences between respondents (n = 441) and non-respondents (n = 33) ($t = 0.18$, $df = 419$, n.s.). Meanwhile, non-respondents were somewhat more likely to be male (67%) than the respondents (47%) ($\chi^2 = 4.51$, $df = 1$, $p <.05$). The most frequently reported causes for non-responses were that the students were on their way to a lecture or did not have time to participate in the survey.

2.2. Questionnaire and measurement instruments

The measurement instruments were given to the students by a coherent paper-based questionnaire devised in Norwegian language. The questionnaire included demographic items regarding each respondent’s gender and age. Two items were used to record information about time use in hours and minutes that the respondents would need by walking or by using a non-electric bicycle from their residence to their university. Similarly, one item asked about the estimated time used to walk from the student’s residence to the public transportation waiting point that would be natural to use when travelling to the university by public transportation. These three items were converted to total minutes before they were accommodated into the analyses. Car ownership was measured by asking the respondents whether they themselves or their spouse owned a car (no, yes). Car ownership was measured instead of car access because ownership is likely to be a more robust predictor of car use. Car ownership is more likely to facilitate scripted and automatic car use behaviour (Aarts et al., 1998). The main alternative for non-car owning students who still want to use a car is to be passengers of friends or family members. If one is passenger of a car this usually requires more planning and will probably be more sporadic and under more conscious control than if a person owns a car.

Eight items requested the respondents to report how often they generally travelled to/from the university with eight transportation modes in three modal categories in the winter season (November – March): (1) public transportation modes including bus and tram, (2) active transportation modes including walking, jogging/running, bicycle (non-electric) and bicycle (electric), and (3) car including as a driver or passenger of a gasoline- or diesel-based car. The responses were recorded on a six-point scale from (0) never to (5) five days or more a week. The modes were selected based on previous knowledge about urban transportation mode use in Norway (e.g. Rundmo et al., 2011) as well as the local transportation situation in Trondheim, Norway, which solely has buses and one tramline as the public transportation mode options. The questionnaire also asked about the use of sole electric car use or hybrid combustion/electric battery engine car use as a driver or passenger, as these cars are becoming highly prevalent among the general Norwegian public (Bjerkan et al., 2016; Şimşekoğlu, 2018). However, only 10 students reported use of these cars once a week or more on university trips and this modality was excluded from further analysis as it would likely cause Type II error in analyses. As the total number of days with trips to/from university for different students was varying, the share of each of the three modal categories with regard to the total number of days for each student was considered in analyses. For instance, a student who had reported three days taking either bus or tram and two days by walking among the five days to/from university is equivalent to 60% use of public transportation, 40% use of active transportation and 0% car use.

The NAM was operationalized by a previously validated measurement instrument (Abrahamse et al., 2009; de Groot & Steg, 2008). The instrument contained a total of 19 items asking respondents to evaluate their awareness of consequences (e.g. 'Car use causes exhaustion of scarce resources, such as oil'), ascription of responsibility (e.g. 'I feel joint responsibility for the exhaustion of fossil fuels by car use') and personal norms (e.g. 'I do not feel guilty when I use the car even though there are other feasible transportation alternatives available'). The students reported their level of agreement to the 19 statements on a Likert scale ranging from (1) strongly disagree to (5) strongly agree.

Transport priorities were measured by a revised version of a previously validated instrument deployed in several previous empirical accounts (e.g. Nordfjærn et al., 2014b; Nordfjærn & Rundmo, 2015). The students were asked to rate the relative importance of different quality attributes when choosing transportation modes to/from the university (e.g. costs, flexible travel and safety regarding accidents and security factors such as theft or harassment). The responses were obtained by a Likert scale ranging from (1) not at all important to (5) very important.

2.3. Statistical procedures

Descriptive statistics were applied to examine characteristics of the sample. To test potential differences between respondents and non-respondents in gender and age, Chi-square (χ^2) analysis and independent samples t-tests were applied, respectively. Pearson's correlation coefficients were calculated to estimate bi-variate correlations between all study variables. Confirmatory Factor Analysis (CFA) was used to confirm the three-factor structure of the NAM instrument reported in previous work; awareness of consequences, ascription of responsibility and personal norms (e.g. de Groot & Steg, 2008; Lind et al., 2015). This measurement model was specified with five manifest items receiving loadings from the awareness of consequences latent factor, six items from the ascription of responsibility factor and eight items from the personal norms factor. Fit indices were used to determine the correspondence between the specified measurement model and the data. These indices included the Root Mean Square Error of Approximation (RMSEA) with 90% confidence interval (CI 90%) and the Comparative Fit Index (CFI). Although it is not a feasible indicator of model-data fit, the χ^2 with corresponding degrees of freedom (df) and significance level was also reported. For a model to reflect tolerable fit to the data, the RMSEA should have a value below .08 and the CFI should be around .90 or above (Kim & Bentler, 2006; Tabachnick & Fidell, 2007). The Cronbach's alpha and average inter-item total correlations (AIC) were calculated as reliability indices for each scale. The alpha should approach .70 and the AIC .30 for the items to represent a coherent scale (see Hair et al., 2010 for details).

Variance inflation factor (VIF) values were calculated and inspected to examine the assumption of non-collinearity among predictors in regression analysis. Collinearity issues are likely present when the VIF values exceed 4.00 by a tolerance less than 0.20 (Hair et al., 2009). Three linear mixed model analyses (Singer & Willett, 2003) were used with an unstructured covariance matrix and random intercept (aimed at considering spatial heterogeneity) to investigate predictors of transportation mode use (i.e. public mode use, active mode use and car use) among the students. The predictors of mode use were entered as fixed effects.

Linear mixed models were used instead of traditional multiple linear regression analyses since the respondents were nested in two different campuses with spatial heterogeneity that might be important to consider. The analyses were carried out by two steps. First, a model which solely included the campus variable was tested for each of the three transportation modes to investigate whether the campus variable had a significant effect on the three dependent mode use variables. Second, an additional model was tested for each of the three mode use outcomes where the psychological and situational constraints variables were entered as covariates. In these models, all covariates were entered as fixed effects, while campus was entered as a random intercept to account for its unique variance (Hedeker et al., 1994).

2.4. Factor structure and reliability of the instruments

2.4.1. Transport priorities

The dimensional structure of transport priorities in the current sample has been reported in full detail elsewhere (Egset & Nordfjærn, 2019). Since the previously validated scale was slightly adjusted and a few new additional items were added to this scale, a principal component analysis (PCA) was carried out. The PCA showed that the measure of transport priorities segmented into four dimensions which explained 67% of the total variance; Safety and security (e.g. protection against terror), exercise (e.g. physical fitness), convenience (e.g. frequency of departures) and flexibility (e.g. flexible time of departure). All four dimensions had alpha values around .70 and AIC values above .30.

2.4.2. Norm activation instrument

A CFA showed that the initial model containing 19 NAM items had improvement potential [χ^2 = 549.24, df = 149, p < .001, RMSEA = .078 (CI 90% = .071; .085), CFI = .87]. By visual examinations of the factor loadings, two items in the ascription of responsibility factor were found to have factor loadings below .40 (i.e. ‘Solely politicians can stop global warming’ and ‘In principle, one person cannot decrease the problems of car use’). After removal of these two items, the model was found to have satisfactory fit to the data [χ^2 = 343.25, df = 116, p

<.001, RMSEA = .067 (CI 90% = .059; .075), CFI = .92]. The factor structure of the NAM was thus considered adequate for further analyses.

3. Results

3.1. Descriptives of the study variables

The characteristics of the current sample are shown in Table 1. As displayed, the strongest transport priorities in this student sample were related to transport convenience and flexibility. The students also reflected rather strong priorities of safety and security in transport, whereas the priorities were weaker in regards of physical activity in relation to transport. Further, the students reported relatively high awareness of the negative consequences of car use and strong personal norms. The ascription of responsibility component was somewhat lower than the two remaining NAM components. On average, the students had 50 minutes to walk to the university with this time reduced to about half when using a non-electric bicycle. On average, the share of public transportation mode (bus and tram) use of students was around 61.52%, 31.33% of the trips were by active transportation (walking, jogging, bicycling non-electric and electric), while a total of 4.70% used a gasoline or diesel-based car as a driver or as a passenger. In addition, 2.47% of respondents reported other modes of transportation.

Table 1. Sample characteristics (n = 441)

Indicator	*n* (%)/*M* (*SD*)
Gender (male) *n* (%)	206 (47)
Age *M* (*SD*)	23.06 (SD = 4.83)
Campus *n* (%)	
Dragvoll	257 (58)
Gløshaugen	184 (42)
Car ownership (yes) *n* (%)	91 (21)
Ascription of responsibility *M* (*SD*)	2.91 (.89)
Awareness of consequences *M* (*SD*)	3.70 (.61)
Personal norms *M* (*SD*)	3.26 (.80)
Priorities of safety and security *M* (*SD*)	3.54 (1.11)
Priorities of physical activity *M* (*SD*)	2.58 (1.00)

Priorities of convenience *M* (*SD*)	4.28 (.60)
Priorities of flexibility *M* (*SD*)	3.64 (.96)
Time to walk from residence to university (total minutes) *M* (*SD*)	50.00 (56.91)
Time to walk from residence to closest public transport point (total minutes)	5.27 (6.41)
Time to bicycle from residence to university (total minutes) *M* (*SD*)	25.25 (50.60)
Public transportation mode use in the winter	323 more than 1% (61.52%)
Active transportation mode use in the winter	191 more than 1% (31.33%)
Car use to the university in the winter	44 more than 1% (4.70%)

n exceeds the total sample size for mode use because some students used several modes

3.2. Correlations between the study variables

Bi-variate correlations between all study variables are shown in Table 2. As could be expected, public transportation mode use was positively correlated with belongingness to Dragvoll campus, which is allocated in a more rural area outside the city core in Trondheim. Students belonging to this campus also used less active transportation modes and more car than students at Gløshaugen, which has a more central allocation.

Males used somewhat more active transportation than females, while increased age was slightly associated with less public transportation mode use. Higher ascription of responsibility was positively correlated with car use, while high awareness of consequences was positively associated with active transportation mode use and negatively correlated with car use. Personal norms were overall weakly associated with the three mode use outcomes, albeit slightly related to less car use.

Priorities of physical activity was rather strongly associated with active transportation mode use and negatively associated with public transportation mode use. Students with strong priorities of convenience reported less public transportation mode use in the winter season. Students who reported longer walking time from their residence to the university reported more use of public transportation and car, and accordingly less use of active transportation. Those who had longer walking time to the closest public transportation mode point going to the university tended to use less public transportation.

Students who reported longer time required to bicycle from their residence to the university were more likely to report less active transportation and more car use. Car ownership was also strongly correlated with less use of public transportation and strongly associated with more car use. Students who reported high use of public transportation reported less active transportation mode use and less use of car. Active transportation was also negatively correlated with car use in the winter.

Table 2. Correlations between the study variables

Indicator	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
(1) Campus (Dragvoll)	-	**-.35**	-.03	**.10**	.08	.06	**.12**	-.07	**-.10**	.05	**.29**	.04	**.22**	-.03	**.39**	**-.50**	**.13**
(2) Gender (male)		-	**.10**	**-.19**	**-.11**	**-.26**	**-.30**	**-.14**	**-.15**	**-.16**	-.07	-.01	**-.10**	-.03	-.06	**.09**	-.06
(3) Age			-	-.02	.04	.08	**-.19**	.00	**-.17**	**-16**	.09	**.11**	.04	**.10**	**-.10**	.09	.00
(4) Ascription of responsibility				-	**.23**	**.29**	**.10**	.09	.02	.05	.03	-.01	**.10**	**.13**	.01	.07	**.17**
(5) Awareness of consequences					-	**.56**	-.03	.03	-.02	-.02	-.04	.00	.06	**-.16**	-.01	**.10**	**-.18**
(6) Personal norms						-	.02	**.18**	.03	.00	-.04	.02	-.03	**-.10**	-.02	.08	**-.14**
(7) Priorities of safety and security							-	**.26**	**.31**	**.44**	-.02	.04	-.06	-.06	.03	.02	-.01
(8) Priorities of physical activity								-	**.14**	**.24**	**-.14**	.08	**-.12**	.02	**-.24**	**.27**	-.04
(9) Priorities of convenience									-	**.29**	-.04	-.04	-.01	-.02	**-.11**	.07	.08
(10) Priorities of flexibility										-	.01	.04	.07	.03	-.01	-.04	.09
(11) Time to walk from residence to university											-	**.44**	**.66**	**.13**	**.19**	**-.37**	**.13**
(12) Time to walk from residence to closest public transport												-	**.24**	.07	**-.13**	.04	.05
(13) Time to bicycle from residence to university													-	**.14**	.07	**-.22**	**.22**
(14) Car ownership (yes)														-	**-.17**	-.04	**.40**
(15) Public transportation mode use in winter															-	**-.86**	**-.26**
(16) Active transportation mode use in winter																-	**-.16**
(17) Car use in winter																	-

Significant coefficients in bold

3.3. NAM, transport priorities and situational constraints predicting car use on university trips in the winter

3.3.1. Public transportation mode use

Examinations of VIF values and tolerance levels showed that the highest VIF value was 2.20 and the lowest tolerance value was .45. This suggest that multicollinearity was not likely to be an issue in the linear mixed model. Table 3 shows that the base linear mixed model (Model 1) solely including campus location showed that Dragvoll campus, which was the location with the longest distance to the town centre, was associated with more use of public transportation ($z = 33.79$, $p = .000$). Model 2, including all covariates and campus as a random effect, further showed that while accounting for spatial heterogeneity generated by campus location car ownership was the strongest predictor of less public transportation mode use on university trips in the winter. Higher estimated walking time from the students' residence to the university was associated with more public transportation mode use. A relation was also revealed between higher estimated time to walk to the closest public transportation point heading to the university and less public transportation mode use. Higher estimated time to bicycle to the university was also somewhat associated with less use of public transportation. Among the psychological variables, none of the NAM components were associated with public transportation mode use. However, strong priorities of physical activity were associated with less public transportation mode use in the winter, whereas there was a tendency for strong priorities of convenience to be associated with less public transportation mode use.

Table 3. Linear mixed model predicting public transportation mode use on university trips in the winter

	Model 1				Model 2			
Parameter	Estimate	t-value	p-value	95% CI	Estimate	t-value	p-value	95% CI
Intercept	41.83	14.20	.000	36.04; 47.62	116.92	4.10	.001	55.94; 177.90
Campus (Dragvoll)	33.79	8.75	.000	26.20; 41.37				
Subject campus random effect					411.77	6.34	.001	212.45; 635.80
Ascription of responsibility					1.00	0.43	.664	-3.56; 5.58
Awareness of consequences					-3.53	-0.91	.362	-11.15; 4.08
Personal norms					0.03	0.01	.992	-5.88; 5.94
Gender (male)					4.22	0.96	.340	-4.46; 12.89
Age (years)					-0.61	-1.58	.114	-1.37; 0.15
Priorities of safety and security					2.65	1.30	.194	-1.35; 6.64
Priorities of physical activity					-8.23	-3.98	.000	-12.30; -4.17
Priorities of convenience					-6.19	-1.83	.069	-12.85; 0.47
Priorities of flexibility					1.50	0.66	.511	-3.00; 6.02
Time to walk from residence to university (total minutes)					0.18	3.86	.000	0.09; 0.28
Time to walk from residence to closest public transport point (total minutes)					-1.62	-4.40	.000	-2.34; -0.90
Time to bicycle from residence to university (total minutes)					-0.10	-2.04	.042	-0.20; -.004
Car ownership (yes)					-19.45	-4.00	.000	-29.01; -9.88
Fit statistics								
-2Log likelihood	4494.80				3896.10			
AIC	4496.80				3900.10			
BIC	4500.88				3907.97			

CI = Confidence interval

Public transport = sum score of bus and tram

3.3.2. Active transportation mode use

The base linear mixed model (Model 1) for active transportation showed that Dragvoll campus was associated with less active transportation mode use in the winter ($z = -41.78$, $p = .000$). As shown in Table 4, the final model (Model 2) reflected that while adjusting for spatial heterogeneity awareness of negative consequences of car use was associated with more active transportation mode use. Strong priorities of physical activity were also positively related to active mode use. Among the situational constraints, increased required time to walk to the university was associated with less active transportation mode use, whereas increased time to walk to the closest waiting point for public transportation was related to more active mode use to the university.

Table 4. Linear mixed model predicting active transportation mode use on university trips in the winter

	Model 1				Model 2			
Parameter	Estimate	t-value	p-value	95% CI	Estimate	t-value	p-value	95% CI
Intercept	55.67	20.86	.000	50.43; 60.92	116.92	4.10	.001	55.94; 177.90
Campus (Dragvoll)	-41.78	-11.95	.000	-48.65; -34.91				
Subject campus random effect					-22.34	-7.12	.001	-35.42; -14.21
Ascription of responsibility					-2.83	-1.40	.161	-6.81; 1.14
Awareness of consequences					9.24	2.74	.006	2.62; 15.86
Personal norms					0.16	0.06	.952	-4.98; 5.29
Gender (male)					-4.78	-1.24	.214	-12.32; 2.77
Age (years)					0.68	2.03	.043	0.02; 1.34
Priorities of safety and security					-0.49	-0.28	.782	-3.97; 2.99
Priorities of physical activity					8.67	4.83	.000	5.14; 12.21
Priorities of convenience					1.13	0.38	.703	-4.67; 6.92
Priorities of flexibility					-3.48	-1.75	.081	-7.40; 0.44
Time to walk from residence to university (total minutes)					-0.25	-5.96	.000	-0.33; -0.17
Time to walk from residence to closest public transportation point (total minutes)					1.36	4.23	.000	0.73; 1.99
Time to bicycle from residence to university (total minutes)					0.08	1.82	.070	-0.01; 0.16
Car ownership (yes)					-1.92	-0.46	.650	-10.24; 6.39
Fit statistics								
-2Log likelihood	4407.66				3790.98			
AIC	4409.66				3794.98			
BIC	4413.75				3802.85			

CI = Confidence interval

Active transportation = sum score of walking, jogging/running, bicycling (electric assisted and non-electric assisted).

3.3.3. Car use

The final step was to investigate predictors of car use on university trips in the winter season. As shown in Table 5 (Model 1), Dragvoll campus was associated with more car use in the winter ($z = 4.79$, $p = .005$). The final model (Model 2) showed that the strongest predictor of car use was car ownership. Ascription of responsibility was associated with more car use, while increased awareness of consequences was related to less car use. Stronger priorities of convenience were associated with more car use to the university, and this was also true for increased time to bicycle to the university. More required time to walk to the university was slightly associated with less car use.

Table 5. Linear mixed model predicting car use on university trips in the winter

	Model 1				Model 2			
Parameter	Estimate	t-value	p-value	95% CI	Estimate	t-value	p-value	95% CI
Intercept	1.91	1.48	.141	-0.64; 4.46	2.97	.263	.793	-19.25; 25.16
Campus (Dragvoll)	4.79	2.82	.005	1.45; 8.12				
Subject campus random effect					2.28	1.46	.018	0.26; 4.48
Ascription of responsibility					3.27	3.16	.002	1.24; 5.30
Awareness of consequences					-5.43	-3.16	.002	-8.81; -2.04
Personal norms					-1.57	-1.18	.239	-4.20; 1.05
Gender (male)					0.30	0.15	.879	-3.53; 4.13
Age (years)					-0.02	-0.09	.930	-0.35; 0.32
Priorities of safety and security					-1.23	-1.36	.174	-3.00; 0.54
Priorities of physical activity					-0.56	-0.61	.543	-2.36; 1.25
Priorities of convenience					3.35	2.23	.026	0.39; 6.30
Priorities of flexibility					1.40	1.37	.171	-0.60; 3.40
Time to walk from residence to university (total minutes)					-0.04	-1.98	.048	-0.08; -0.01
Time to walk from residence to closest public transportation point (total minutes)					0.16	0.99	.322	-0.16; 0.48
Time to bicycle from residence to university (total minutes)					0.07	3.29	.001	0.03; 0.12
Car ownership (yes)					14.66	6.79	.000	10.41; 18.91
Fit statistics								
-2Log likelihood	3773.57				3281.08			
AIC	3775.57				3285.08			
BIC	3779.66				3292.95			

CI = Confidence interval

Car use = sum score of personal car (gasoline- or diesel-based engine) as a driver or passenger

4. Discussion

To the authors' best knowledge, the current study is the first to examine the relative roles of psychological factors and situational constraints for transportation mode use among students on university trips specifically in the winter season, while accounting for spatial heterogeneity. The current study was conducted in a Northern Scandinavian setting, where low temperatures and snowy conditions generally characterize the relatively long-lasting winters. The findings suggested that situational constraints were overall more important than psychological factors for mode use in this season. However, the awareness of consequences component in the NAM theory, priorities of convenience and priorities of physical activity were of some importance for mode use in the winter.

As expected, the results revealed spatial heterogeneity between the two campuses included in the study. The students belonging to the more rural campus had a stronger propensity to use public transportation and car, while students from the urban campus used more active transportation, such as bicycling and walking. The topographic environment around Dragvoll is characterized by many long hills, dense forests and mountains. These factors may facilitate more use of public transport and car in the winter, while making active transportation mode use challenging for many. Similar spatial heterogeneity is probably common in cities with several campuses and the relative importance of such spatial variation can be enhanced in the winter season, where walking and cycling over long distances may be perceived to be uncomfortable. An implication is that car use may be reduced in the winter by development of fast and efficient public transportation to campuses with more remote allocations, while putting more efforts into development of bicycling and walking paths to campuses with a more central allocation.

The current results suggested that car ownership was substantially associated with more use of car and less use of public transportation on university trips. This is in agreement with findings based on data collected in other seasons showing that access to a car is related to more car use and less public transportation (Limtanakool et al., 2006; McDonald, 2008). Restrictions on car use and push measures, such as limited parking space and road tolls, may act as measures to push students towards alternatives to car use. Coupling such push measures with pull measures, such as development of bicycle and walking paths and making public transportation more attractive may be particularly efficient (see also Gallego et al., 2013). By making it economically unattractive to own a car, while facilitating public or active mode use, one can potentially prevent that a rather large sub-population of the Norwegian public become car users in the future.

A longer time required to walk from students' residence to the university was associated with less active transportation mode use and more public transportation mode use in the winter. Moreover, those who reported a longer time to walk from their residence to the closest public transportation waiting point reported less use of public transportation, but more use of active transportation in the winter season. With the exception of more time required to bicycle, which was associated with more car use, none of the time estimates were associated with car use. This could suggest that students turn to public transportation when the time required to walk is considerable in the winter. This is likely due to that public transport offers more comfort and less exposure to rough weather than walking over longer distances in winter. Active transportation seems to become the most viable alternative when the public transportation mode point is allocated far from students' residence. When bicycling to the university is estimated to take more time, car may become the most likely option. This implies that the students in the current sample do not necessarily choose unsustainable transportation in the winter even when it takes a long time to walk to the university or the closest waiting point for public transportation heading to the university. High-speed bicycling paths that are kept free from snow and ice during the winter may contribute to more use of bicycles and less car use among students in this season.

Among the psychological variables accommodated in the current study, priorities of physical activity were strongly associated with elevated use of active transportation, while this factor was related to less use of public transportation in the winter. Transport priorities focusing on physical activity may reflect a wider lifestyle where health and physical activity is important. As such, students scoring high on these priorities may perceive the trip to university as an opportunity to exercise rather than to represent mere transport. Steg (2005) argued that car use has important symbolic and affective functions for their users by, for instance, reflecting social status and power. It is possible that this assumption also applies to active transportation. Norwegian culture has a strong emphasis on physical activity and general public health, particularly among the young segments of the population (Bakken, 2017). Many students may as such perceive the trip to university as an opportunity to exercise and to express an active lifestyle. This line of reasoning is reinforced by the fact that the current findings showed that students who focused on functional aspects of transportation, such as punctuality, frequency of departures, travel costs and travel time (i.e. priorities of convenience), tended to use car on university trips in the winter season.

Challenging the assumptions in the NAM, the current study showed that personal norms were not related to any of the three main transportation modalities in wintertime. This finding opposes several previous studies which examined the NAM in relation non-season specific mode use (e.g. Lind et al., 2015; Eriksson et al., 2008; Nordlund & Garvill, 2003; de Groot & Steg, 2008; Jakovcevic & Steg, 2013), but aligns with studies which have shown that the role of the NAM framework may be negligible when conducted in contexts where situational constraints may be more important for mode choice than altruistic considerations (e.g. Mehdizadeh et al., in press; Nordfjærn & Zavareh, 2017). The Norwegian winter season may also represent such a context, with snowy and windy conditions together with low temperatures. Intriguingly, however, components at the base level in the causal framework of the NAM, not theoretically assumed to be directly associated with mode choice behaviour, were found to have significant relations to car use and active transportation mode use in the current study. Students who reported high awareness of the negative consequences of car use tended to use less car and more active transportation to the university. It is possible that interventions targeting awareness of the consequences of action or inaction in regard of mode use could further improve upon the sustainable transportation mode use patterns reflected by Norwegian students.

Ascription of responsibility was associated with more car use in the current study; an association which is the opposite as predicted in the NAM as the theory assumes this factor to be negatively associated with mode use that have negative environmental impact. Several recent studies have also shown that ascription of responsibility is related to less environmentally sound mode use in different populations (e.g. Lind et al., 2015; Şimşekoğlu, 2018). This could reflect that those who use car to the university perceive themselves as more responsible for reducing the negative impacts of car use due to their actual behaviour, while those who tend to use public transportation do not perceive a similar responsibility for the negative consequences of car use. This aligns with self-perception theory where people shape their attitudes by observations of their own behaviour (Bem, 1972). Whether these findings reflect a misconceptualisation in the NAM or in the operational measurement of this specific NAM component is an interesting avenue for further research. On the other hand, in alignment with the NAM personal norms was associated with car ownership in bivariate analyses in the current study. It has been argued that car ownership represents one of the strongest situational constraints of transport mode use (Klöckner & Friedrichmeier, 2011) as people who own a car tend to use it in a script-based manner (Aarts et al., 1998). The results lend some support to the theoretical assumption that promotions of strong personal obligations to avoid car use is associated with a lower likelihood of car ownership.

On a more general note, students in this Norwegian sample reflected noteworthy sustainable transportation mode choices. A total share of 93% of the trips to the university was conducted by sustainable modes (public transportation 61.52%; active transportation 31.33%). Owning a car is relatively expensive in Norway and we cannot exclude the possibility that many of the students would have used a car to university if this option was economically feasible to them. A substantial challenge for policy makers is to entail push and pull factors in a manner where this large group of young adults continue their sustainable mode choices also after completing university.

4.1. Limitations

Although this is the first study to investigate the relative importance of psychological and situational factors for students' transport mode use to university in the winter, it would have been ideal to also have mode use data for the summer. An important avenue for further research is to compare the importance of situational constraints and psychological variables across the winter and summer seasons. The study was cross-sectional and this excludes the possibility of decisive causal conclusions. The data were also based on self-reports which could lead to social desirability bias. However, the anonymous nature of the study and the fact that the questionnaires were self-administered likely reduced the probability of such bias. While it is common to use self-reported estimates of travel time and distances by active transport in transportation research (e.g. Bergström & Magnusson, 2003; Collins & Chambers, 2005; Şimşekoğlu et al., 2015; Javid et al., 2016), research has shown that people who use more active transportation tend to give more accurate estimates of travelling time by these modes than those who use less active transport (Sims et al., 2018). In order to reduce such potential bias, future studies could obtain individual addresses of the responses and calculate exact distances with computer tools such as Google maps. This was not conducted in the present study in order to keep the survey anonymous. Furthermore, distance estimates by map coordinates do not yield accurate information about the time used to walk or bicycle the distance as this is subject to strong variation both due to seasonal and individual factors. Finally, to investigate the importance of quality attributes in further detail future studies could include a measure of trip chains, for instance whether students have to change between modes during the trip or combine the university trips with other errands such as shopping or picking up children in kindergarten etc.

4.2. Conclusions

The current study has shown that situational constraints overall may be more important than psychological factors for transportation mode use on university trips among students in the winter. Although the students in the sample reflected rather sustainable transportation mode use, a potential increase in use of these modes could be achieved by focusing on students’ motivation for physical activity, using push and pull measures to reduce the probability of car purchase and to increase the awareness of the negative consequences of car use. Keeping active mode paths free from snow and ice during the winter may increase the feasibility of active transportation use on university trips in the winter among students. Future studies could continue to examine season-specific transportation mode use and implement comparisons between psychological and situational predictors of transportation mode use on university trips across the summer and winter seasons.

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697