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Predictors of public transport use among university students during the winter: A MIMIC modelling approach

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ABSTRACT

The current study aimed to examine attitudinal factors underlying the use of public transport in winter among university students. A self-administered questionnaire survey was conducted among 441 students at the two largest university campuses in Trondheim, Norway. A Multiple Indicators Multiple Causes (MIMIC) modelling approach was used to test relationships among constructs using an extended version of the theory of planned behaviour hypothesized to predict public transport use during the winter. Analyses revealed strong effects of social-normative influence and perceived behavioural control on the use of public transport. Social status attribution and perceived accident involvement probability had significant influences on the attitude. The findings suggest that campaigns promoting sustainable and environmentally friendly travel modes can benefit from highlighting the above factors while bearing in mind the demographic characteristics of the target population.

1. Introduction

Given its direct impact on urban quality of life (Gärling and Steg, 2007), road transport has been a focus area for authorities worldwide to ensure sustainable urban development (Banister, 2000; Kennedy et al., 2005). Considering its large potential of reducing negative effects of road transport, promoting the use of sustainable and environmentally friendly travel modes has attracted increased attention of both researchers and transport policy decision-makers (Gärling et al., 2014; Taniguchi et al., 2007). Subsequently, various measures have been developed and implemented in major cities and regions around the world to stimulate the wider use of public transport (Bamberg et al., 2011; Eliasson, 2008; Rotaris et al., 2010).

However, neither regulative disincentives for the use of private transport mode (e.g., congestion charge, fuel tax, road pricing, etc.) nor huge incentives for public transport improvements have delivered expected changes in travel mode choice among different urban populations (Litman, 2013; Stopher, 2004). In other cases, some of the regulative measures were perceived as too risky to be implemented by politicians due to low acceptability in the public and potentials of facilitating psychological reactance (Gärling and Schuitema, 2007; Schade and Schlag, 2003). Therefore, interest has been shifted to the question of what motives underlie urban residents' decisions to choose sustainable and environmentally friendly transport modes (Allen et al., 2019; Möser and Bamberg, 2008; Taniguchi et al., 2007; Taylor, 2007).

To contribute to the scientific literature about urban residents' motives, it seems worthwhile to systemically consider, discuss, and explore the contribution of personal factors in the context of sustainable and environmentally friendly transport mode choice. Therefore, this paper firstly reviews exiting research in the field of transport and environmental psychology, and then summarises and describes suggested relationships between important personal factors underlying the use of public transport. More specifically, the paper aims to examine attitudinal factors underlying public transportation use in winter among university students while controlling for socio-demographic characteristics (i.e., age and gender). A model based on the suggested relationships is subsequently tested using a Multiple Indicators Multiple Causes (MIMIC) modelling approach with data collected among university students.

The paper is organized as follows. Section 2 reviews the theoretical framework and personal factors, which are most often used in sustainable transport research, and discusses their implications for individuals' public transport use. It ends with a description of hypothesized relationships between important personal factors, together with the contribution of the paper. The method (Section 3) and results (Section 4) of a quantitative self-administered questionnaire survey study

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conducted to test the hypothesized relationships between the factors are then presented. In Section 5, the key findings of the study and their implications are discussed. Finally, a short conclusion, together with the limitations of the study, is presented in Section 6.

2. Literature review

2.1. Predicting the use of public transport: The theory of planned behaviour (TPB)

In addition to infrastructural factors, research in the field of transport and environmental psychology has identified two types of personal factors, i.e. socio-demographic characteristics and attitudinal (i.e., psychological) factors, as important for individual mobility (Allen et al., 2019; Hunecke et al., 2007). Accumulating empirical evidence in the transport research literature has subsequently revealed a wide variety of attitudinal factors exerting influence on voluntary choice of sustainable and environmentally friendly transport modes (Bamberg et al., 2007; Eriksson and Forward, 2011; Nordfjærn et al., 2014a; Zailani et al., 2016). Among the employed frameworks in these empirical works, rational choice models like the theory of planned behaviour (Ajzen, 1991) have often been used as an integrating framework for attitudinal factors underlying public transportation use.

The TPB and its predecessor – the theory of reasoned action (Ajzen and Fishbein, 1980), have had their influence on travel behaviour theories and empirical research since they were launched (Bamberg et al., 2011; Gärling et al., 1998). The TPB is often referred to as an expectancy-value theory (Fishbein and Ajzen, 1977), and it is claimed to be a general theory of social behaviour to explain many kinds of social behaviours (Ajzen, 1991). According to the TPB, behaviours that are under voluntary control are determined by deliberate cognitive information processing. The TPB postulates that behaviour is immediately predicted by behavioural intention, which is a person's motivation to carry out the behaviour (Fishbein and Ajzen, 1977; Ajzen, 1991). Meanwhile, behavioural intention is the result of the expectancy-value assessment process that involves attitudes toward specific behaviour, subjective norms, and perceived behavioural control (Ajzen, 1991).

A person's beliefs about the probability of consequences of the behaviour and his or her assessment of these consequences are suggested to form his or her attitudes toward the behaviour. In a similar vein, a person's belief about whether important others would approve or disapprove the behaviour may shape the person's subjective norm (Fishbein and Ajzen, 1977; Ajzen, 1991). Further, a person's beliefs about the presence of factors that may facilitate or impede the performance (i.e. barriers and facilitators) of the behaviour are believed to form his or her and perceived behavioural control, which can directly influence behaviour (Ajzen, 1991). However, the extent to which perceived behavioural control reflects objective actual behavioural control that person has remains open to discussion. Perceived behavioural control has been used as a proxy variable to practical barriers in numerous studies (e.g. Bamberg and Schmidt, 2003; Nordfjærn et al., 2014a). It is also possible that the role of this component is subject to seasonal variation, as practical barriers may have a more important role for travel behaviour in wintertime, particularly in countries with long snowy winters such as Norway. Further, the effects of attitudes, subjective norms, and perceived behavioural control on behavioural intention depend on the person and the situation (Miller, 2005).

As a parsimonious theoretical framework, the TPB provides a base for integrating other significant constructs and their operationalizations within the theory (Heath and Gifford, 2002). The TPB has been widely applied with other factors aimed to improve the explanatory power of the TPB in explaining the use of public transport (Eriksson and Forward, 2011; Nordfjærn et al., 2014a; Zailani et al., 2016). Consequently, intervention measures like transport planning, public transport marketing, and travel awareness campaigns have been developed with the premise that changes in the beliefs described in the TPB should lead to behaviour change (Möser and Bamberg, 2008; Taylor, 2007).

2.2. Social status attribution and perceived accident involvement probability

In the present study, we suggest expanding the TPB by adding two potentially useful variables: social status attributed to public transport use and perceived accident involvement probability with the use of public transport in winter. Based on the original TPB, an individual's attitude towards public transport use is a function of his/her beliefs about the probability of consequences of public transport use and his or her assessment of these consequences. Accordingly, an individual's belief or view that using public transport is associated with certain social status (or belongingness to certain social class/group) can also influence his/her evaluation of travel mode alternatives (Anable and Gatersleben, 2005; Hunecke et al., 2010). In other words, the individual's beliefs or views about social status attributed to public transport use can contribute to the formation of his/her attitude towards the use of public transport (e.g., Steg, 2005). There is empirical evidence suggesting that public transport may be perceived as a travel mode alternative for those with low socioeconomic status (Zhang et al., 2016). Another study by Nordfjærn et al. (2014a) found that social status attribution in the expectancy-value assessment of accessible beliefs formed attitudes toward public transport use.

In a similar vein, subjective assessment of accident involvement probability or individual judgement of risk is a relevant psychological construct in behaviour and decision in an uncertain situation (Rogers, 1975; Rosenstock, 1974). Since the risk of accident involvement is generally lower for public transport than private transport (Bouyer et al., 2001; Fyhri and Backer-Grøndahl, 2012), it could be argued that individuals who consider car accidents as the major risk would become motivated to use public transport modes more frequently to reduce the risk (Rogers, 1975). However, empirical evidence indicates that people tend to underestimate their accident involvement probability with the use of a private car (McKenna, 1993). It is also suggested that individuals tend to overweight the likelihood of negative events in public transport (Nordfjærn et al., 2014b). This discrepancy, i.e. the actual risk of accident involvement and perceived probability of such events, has prompted researchers to examine the role of probability and consequence estimates for travel mode use. One of these studies found that subjective probability assessments were more important for mode use (Rundmo et al., 2011).

Moreover, an uncertain situation can have a significant impact on individuals' cognitive processes and decision making (Miller, 2005). Uncertain conditions can, therefore, exert influence on subjective assessment of the probability of accident involvement (Allen et al., 2020; Rundmo et al., 2011). This also aligns with assumptions in the psychometric paradigm, arguing that risk perception partly is a function of the hazard characteristics in question (Slovic et al., 1980). Research has shown that uncontrollable meteorological conditions (e.g., visibility, temperature, wind speed, rain, and snow) are among the causes that lead to traffic accidents (Andersson and Chapman, 2011; Maze, Agarwal and Burchett, 2006). The problem becomes particularly serious in colder northern settings (e.g., Northern America, Scandinavia) in winter, where the weather is characterized by snow, ice, freezing temperatures, and slippery roads (Andreescu and Frost, 1998; Fridstrøm et al., 1995). According to the Prospect Theory (Kahneman and Tversky, 2013), individuals give more weight on losses/negative impacts than gains/positive impacts during decisions involving uncertainty. This implies that people may perceive a high risk of accident involvement with public transport in winter due to uncontrollable meteorological conditions.

2.3. Age and gender differences in the use of public transport

As mentioned earlier, socio-demographic characteristics (e.g., age and gender) are also considered relevant personal characteristics of

potential importance for individual mobility (Allen et al., 2019; Hunecke et al., 2007). Given that numerous studies have shown an attitude-sustainable behaviour gap (e.g., Aschemann-Witzel and Niebuhr Aagaard, 2014; Frederiks et al., 2015), researchers (e.g., Mohd, 2013; Torgler et al., 2008) have suggested examining the effects of socio-demographic characteristics (e.g., age and gender) on the relationship of the attitude-sustainable behaviour. Drawing on the gender role theory (Eagly, 1997), Wai and Bojei (2015) argued that females are communal-oriented and behave with the expectation of interpersonal rewards. Hence, females are suggested to act pro-environmentally more often than males (Do Paco et al., 2009; Torgler et al., 2008). To the best of our knowledge, no previous studies have investigated gender differences in the structural relations of the TPB predicting public transport use in wintertime among university students. Relying on the socio-emotional selectivity theory (Carstensen et al., 1999), Wai and Bojei (2015) further suggested that young adult cohorts see the future as open-ended in contrast to older adults. Subsequently, the young adult cohorts prioritize knowledge-acquisition goals over emotional regulation. This probably leads these cohorts to explore new ways and methods of a pro-environmental lifestyle (D'Souza et al., 2006; Torgler et al., 2008). However, there is inconsistent empirical support for age and gender differences in pro-environmental behaviours (Aschemann-Witzel and Niebuhr Aagaard, 2014; Frederiks et al., 2015).

Based on the literature review above, we propose an adapted version of the TPB extended with social status attribution and perceived accident involvement probability to predict the use of public transport in winter (see Fig. 1). In the model, it is hypothesized that social status attribution and perceived accident involvement probability would exert significant influences on attitude towards public transport use. Perceived behavioural control and attitude are suggested to predict intention to use public transport, while subjective norm indirectly influences intention via attitude and perceived behavioural control as suggested by Bamberg et al. (2007). Intention and perceived behavioural control are proposed to determine the use of public transport in winter. A Multiple Indicators Multiple Causes (MIMIC) modelling approach is used to examine the latent theoretical constructs controlling for the effects of socio-demographic characteristics (i.e. age and gender).

This study makes the following contributions. Firstly, the study contributes to further understanding of the role by both attitudinal (i.e., psychological) and demographic factors in the use of public transport through simultaneously examining their impact. Secondly, it has rarely been investigated how subjective assessment of accident involvement probability affects people's attitude toward the use of public transport. The suggested framework illuminates that there is a potential for integration between concepts from the TPB and risk research when it comes to sustainable mobility behaviour. Lastly, the study will suggest managerial implications that would facilitate policymakers in student cities to design and implement sustainable transport policy measures.

3. Method

3.1. Data collection procedure

The results are based on a cross-sectional paper-and-pencil self-administered questionnaire survey conducted at the Norwegian University of Science and Technology's two main campuses in Trondheim, Norway, between February and April 2018. The respondents were obtained by convenience sampling at various allocations inside and outside the university buildings, during regular office hours 09.00 – 15.00. Estimated age, gender, and reasons for non-participation among non-respondents were registered on a dedicated form.

All potential respondents received oral information about the confidentiality of responses. They were assured about anonymity and secure data storage. The voluntary nature of the study was also illuminated to all approached respondents. Due to the fully anonymous nature of the study, it was not formally processed by the Norwegian Centre for Research Data. Meanwhile, the study was presented both orally and by written information to this ethical board, and the study procedures were approved.

3.2. Sample

The gross sample included in a total of 441 university students resulting in an 82% overall response rate. The resulting dataset was then examined through R (Version 3.6.2; R Core Team, 2019) and various R-packages (e.g., *mice, psych, tidyverse*) for the accuracy of data entry, missing values, univariate or multivariate outliers, and fit between their distribution and the assumption of multivariate analysis. Eight cases with missing values on gender and age were excluded first. Further, six cases were univariate outliers because of their extremely low *z* scores on age. These cases were also dropped from the dataset. The remaining study variables were then examined for missing data patterns to make sure that no more than 5% of data were missing for anyone pairing. This led to the deletion of three cases from the dataset. The gross N = 441 was thus reduced to N = 424. Distribution of the variables, pairwise linearity, and the assumption of multivariate analysis were checked. There was no major violation of assumptions evident in the final dataset (N = 424), which consisted of 223 female respondents and 201 male respondents (see Table 1). There were more female respondents from the Dragvoll campus and more male respondents from the Gløshagen campus. This was comparable to the gender composition of campuses. The age of the respondents ranged from 19 to 30 years, and the overall

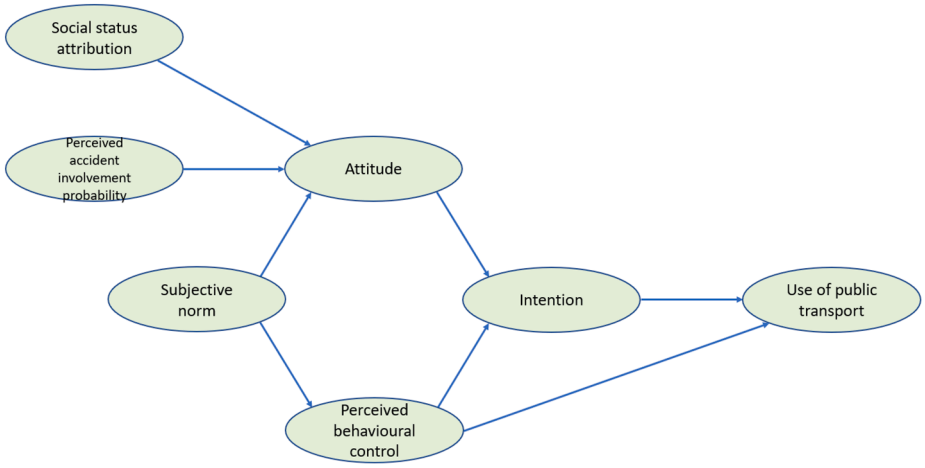

Fig. 1. Hypothesized model predicting university students' public transport use in winter.

Table 1
Characteristics of the sample.

	Total (n = 424)	Female (n = 223)	Male (n = 201)
Age			
Range	19–30	20–30	19–30
Mean	22.65	22.27	23.06
S.D.	2.21	1.97	2.39
Campus			
Dragvoll (%)	248 (58.49%)	167 (67.34%)	81 (32.66%)
Gløshaugen (%)	176 (41.51%)	56 (31.82%)	120 (68.18%)
S.D. = standard deviations			

mean age was 22.65 (SD = 2.21). The mean age of female respondents was 22.27 (SD = 1.97), and of male respondents was 23.06 (SD = 2.39). The age difference between female and male respondents was statistically significant as determined by one-way ANOVA (F (1, 422) = 14.13, $p < .001$).

3.3. Questionnaire

The study questionnaire included items operationalizing the constructs specified in the hypothesized model. The items were adapted from previous studies (Bamberg and Schmidt, 2003; Bamberg et al., 2007; Nordfjærn et al., 2014a). The following constructs were analyzed in this study.

Social status attributed to public transport use was assessed by three items related to respondents' views of public transport use. The items were "ss1: Public transport is primarily for people with a low income", "ss2: It is only the radical left who take the bus to campus" and "ss3: What means of transport one uses tells a lot about one's social status". These items were rated using a five-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

Perceived accident involvement probability with the use of public transport in winter was measured by "aip1: How likely do you think it is that you are exposed to an accident/personal injury when/if you use the bus as a means of transport in the winter?" and "aip2: How likely do you think it is that you are exposed to an accident/personal injury when/if you use tram as means of transport in the winter?". The measure was recorded on a scale ranging from "most unlikely" (1) to "most likely" (5).

Attitude towards public transport use was assessed by the following two items: "att1: I do not like to take the bus, it is too crowded" and "att2: It is tiresome to take public transport to and from the university". The respondents reported their level of agreement to these statements on a five-point scale ranging from "strongly disagree" (1) to "strongly agree" (5). These two items were later reverse coded to make higher scores reflect favorable attitudes towards public transport use.

Subjective norm was measured by two items reflecting normative beliefs about whether significant others think the respondent should use public transport to university. The first item, "sn1: Most people who are important to me would support me in a decision to use public transport from where I live to the university", was scored on a five-point scale ranging from "very unlikely" (1) to "very likely" (5). The second item, "sn2: Most people who are important to me would wish that I use public transport from where I live to the university", was rated using a five-point scale ranging from "strongly disagree" (1) to "strongly agree" (5).

Perceived behavioural control was also assessed by two items. Respondents rated the difficulty of "pbc1: Daily use of public transport (e.g., bus, tram) from where I live to the university is" on a five-point scale ranging from "very difficult" (1) to "very easy" (5). Respondents also indicated "pbc2: My freedom of choice when it comes to daily use of public transportation from where I live to the university" on a five-point scale ranging from "very bad" (1) to "very good" (5).

Intention to use public transport was measured by a single item, "int1: My intention of using public transport to the university in the future is", with the response option ranging from "very weak" (1) to "very strong" (5).

The use of public transport mode in winter was assessed by "upt1: How often do you use public transport mode when you go to and back from the university in winter?" The measure was recorded on a scale ranging from "never" (0) to "five days or more per week" (5). The

Table 2
Descriptive statistics and internal consistency of the measures, and standardized factor loadings from the confirmatory factor analysis (N = 424).

Construct/item	Mean	S.D.	S.E.	α	Λ
Social status attribution				0.66	
ss1: Public transport is primarily for people with a low income [1 = strongly disagree, …, 5 = strongly agree]	1.65	0.88	0.04		0.76
ss2: It is only the radical left who take the bus to campus [1 = strongly disagree, …, 5 = strongly agree]	1.36	0.70	0.03		0.57
ss3: What means of transport one uses tells a lot about one's social status [1 = strongly disagree, …, 5 = strongly agree]	1.71	0.87	0.04		0.55
Perceived accident involvement probability				0.74	
aip1: How likely do you think it is that you are exposed to an accident/ personal injury when/if you use the bus as a means of transport in the winter? [1 = most unlikely, …, 5 = most likely]	1.90	0.86	0.04		0.88
Aip2: How likely do you think it is that you are exposed to an accident/ personal injury when/if you use tram as means of transport in the winter? [1 = very unlikely, …, 5 = very likely]	1.67	0.75	0.04		0.67
Attitude				0.62	
att1*: I do not like to take the bus, it is too crowded [1 = strongly disagree, …, 5 = strongly agree]	3.46	1.12	0.05		0.58
att2*: It is tiresome to take public transport to and from the university [1 = strongly disagree, …, 5 = strongly agree]	3.21	1.09	0.05		0.78
Subjective norm				0.84	
sn1: Most people who are important to me would support me in a decision to use public transport from where I live to the university [1 = very unlikely, …, 5 = very likely]	3.93	1.38	0.07		0.88
sn2: Most people who are important to me would wish that I use public transport from where I live to the university [1 = strongly disagree, …, 5 = strongly agree]	3.25	1.27	0.06		0.83
Perceived behavioural control				0.65	
pbc1: Daily use of public transport (e.g., bus, tram) from where I live to the university is… [1 = very difficult, …, 5 = very easy]	4.11	1.09	0.05		0.64
pbc2: My freedom of choice when it comes to daily use of public transportation from where I live to the university is … [1 = very bad, …, 5 = very good]	3.54	1.15	0.06		0.22
Intention [a]					
int1: My intention of using public transport to the university in the future is… [1 = very weak, …, 5 = very strong]	3.53	1.44	0.07		0.98
Use of public transport in winter [b]					
upt1: How often do you use public transport mode when you go to and back from the university in winter? [1 = never weak, …, 5 = five or more days per week]	3.17	2.03	0.10		0.82

S.D. = standard deviations, S.E. = standard error, α = Cronbach's alpha, λ = standardized factor loadings from the confirmatory factor analysis
[ab] single indicator latent construct
* reverse coded

summary of the measurements is shown in Table 2.

Finally, some demographics, e.g. the respondent's gender, age, and place of study (i.e., campus) were also included in the questionnaire.

3.4. Analytical procedures

R (Version 3.6.2; R Core Team, 2019) and various R-packages (e.g., *mice, psych, tidyverse*) were used for data management and preliminary descriptive analysis. None of the variables with missing values was imputed.

The measures were examined for reliability by Cronbach's alpha. In line with recent recommendations, Cronbach's alpha above 0.60 is considered as tolerable (Tavakol and Dennick, 2011). Cronbach's alpha is, however, assumed to be biased by a small number of items (Hair et al., 2014). A confirmatory factor analysis (CFA) was subsequently run to test the discriminant validity (factorial structure) of the measurement models of seven latent theoretical constructs. The measurement model should be reasonable (i.e., good convergent and discriminant validity) because all other structural paths, e.g., either specific causal paths and/or covariates in the model, build upon a sound measurement model.

After establishing a valid measurement model, a Multiple Indicators Multiple Causes (MIMIC) modelling approach was used to test the hypotheses on the direction and strength of the relationships between latent theoretical constructs (see Fig. 1), controlling for the effects of covariates, i.e. age and gender. The MIMIC modelling is a specific case of Structural Equation Modelling (SEM), which consists of a measurement model (i.e., the relations between latent theoretical constructs and its indicators) and a structural model (i.e., the casual relationships among latent theoretical constructs) (Jöreskog and Sörbom, 1996). Besides, the MIMIC model integrates additional variables or covariates assumed to influence the latent theoretical constructs while testing hypotheses on the direction of effects between these latent constructs (Proitsi et al., 2011).

The *lavaan* package (Rosseel et al., 2019) was used to conduct both the CFA and MIMIC modelling. The full information maximum likelihood estimation (FIML) was employed to deal with item nonresponses. With FIML, model parameters are estimated from all available data (Peyre et al., 2011). As such, FIML not only minimizes the loss of information and statistical power but also leads to unbiased parameter estimates (Arbuckle et al., 1996), even in the case of non-normal data (Enders, 2001).

For both the measurement model and the MIMIC model, several criteria were used to assess the model fit. A non-statistically significant χ^2-test relative to the degrees of freedom would indicate a better fit of the theoretical model to the observed data. However, the χ^2-test is sensitive to sample size (Barrett, 2007). The model fit was also evaluated by using the comparative fit index (CFI), the Tucker-Lewis Index (TLI), and the root mean squared error of approximation (RMSEA). For both CFI and TLI, values of 0.95 or greater suggest a very good fit (Hu and Bentler, 1999). RMSEA value under 0.05 indicates an excellent fit (Jöreskog and Sörbom, 1996).

4. Results

4.1. Test of the measurement model

Descriptive information about the items and internal consistency of the measures are shown in Table 2. All measurements, except intention and use of public transport in winter that were measured by a single item each, showed tolerable to good internal consistency, i.e. standardized Cronbach's alpha ranged between 0.62 and 0.84 (Tavakol and Dennick, 2011). However, the reported Cronbach's alpha yields no information about the factorial structure, i.e. the discriminant validity, of the measures. Therefore, a confirmatory factor analysis (CFA) simultaneously testing the postulated measurement models of the seven latent theoretical constructs was conducted.

Since both the intention and use of public transport were measured only by a single item (int1 and upt1, respectively), they were treated as single indicator latent variables in the CFA. This was done by (1) fixing the observed indicator's factor loading to 1, and (2) fixing its unstandardized error term to a value 'δ' on basis of the indicator's sample variance and known psychometric information (e.g., reliability coefficient). The function, δ_x = VAR(X)*(1 − rho), where VAR(X) is the variance and rho is the reliability of the observed indicator, suggested by Brown (2006) was employed. Based on the estimates of reliability coefficient for intention to use public transport (i.e., Cronbach's $\alpha = 0.95$) and actual public transport use (i.e., Cronbach's $\alpha = 0.66$) in the literature (e.g., Bamberg et al., 2007), and the variances of the observed single indicators in our dataset (i.e., VAR (int1) = 2.08 and VAR (upt1) = 4.12), the unstandardized error for int1 and the unstandardized error for upt1 were constrained to 0.10 and 1.40 respectively.

To identify the measurement model, error variances of the two perceived behavioural control items were allowed to covary. The measurement model fitted the data very good ($\chi^2 = 80.42$, df = 45, p = .001; CFI = 0.98; TLI = 0.97; RMSEA = 0.043). As shown in Table 2, all standardized factor loadings, except for pbc2t, were greater than 0.50. Moreover, except for perceived accident involvement probability and social status attribution, positive and significant correlations between the other five latent theoretical constructs were observed ($p < .001$). Perceived accident involvement probability and social status attribution were negatively correlated with attitude ($p < .01$).

4.2. Multiple Indicators Multiple Causes (MIMIC) model

Establishing a reasonably good fitting measurement model allowed us to examine the hypotheses on direction and strength of relationships between the latent theoretical constructs in the model, controlling for the effects of covariates. Age and gender were used as covariates in the MIMIC model as mentioned in analytical procedures. The MIMIC analysis verified the hypothesized model structure, and the model had a good fit ($\chi^2 = 131.02$, df = 70, $p < .001$; CFI = 0.97; TLI = 0.95; RMSEA = 0.033). Table 3 shows the estimated path coefficients for the latent theoretical constructs, the effects of covariates on the latent theoretical constructs, and explained variances of the latent theoretical constructs in the MIMIC model. The visual illustration of the MIMIC model and results are shown in Fig. 2.

In line with the theory of planned behaviour and our hypothesis, public transport mode use in winter among university students was significantly predicted by intention to use public transport ($\beta = 0.57$, $p \leq 0.001$) and perceived behavioural control ($\beta = 0.42$, $p \leq 0.001$). In addition, perceived behavioural control had also a significant indirect influence on public transport mode use in winter as perceived behavioural control strongly predicted intention to use public transport ($\beta = 0.81$, $p \leq 0.001$). Meanwhile, favorable attitude towards public transport use also had a significant and positive direct influence on intention ($\beta = 0.14$, $p \leq 0.001$). Subjective norm was confirmed to exert significant influence on perceived behavioural control ($\beta = 0.99$, $p \leq 0.001$) and on attitude towards public transport use ($\beta = 0.31$, $p \leq 0.001$). Attitude towards public transport use was also significantly influenced by perceived accident involvement probability with the use of public transport in winter ($\beta = -0.21$, $p \leq 0.01$) and social status attributed to public transport use ($\beta = -0.35$, $p \leq 0.001$), as expected.

As a covariate in the MIMIC model, age had a significant effect on social status attributed to public transport use ($\beta = 0.12$, $p \leq 0.05$). Age had no statistically significant impact on the remaining latent theoretical constructs in the model. The results also showed that there were significant gender differences on the intention to use public transport ($\beta = -0.21$, $p \leq 0.01$), on perceived behavioural control ($\beta = 0.18$, $p \leq 0.05$), on perceived accident involvement probability with the use of public transport in winter ($\beta = -0.22$, $p \leq 0.001$) and on social status attributed to public transport use ($\beta = 0.21$, $p \leq 0.001$). Male students reported higher perceived behavioural control over using public

Table 3
Path coefficients and explained variances from the Multiple Indicators Multiple Causes Model (MIMIC) results (N = 424).

Dependent	*Predictors and covariates*	B	S.E.	β	R^2
Use of public transport					0.90
	Intention	0.68***	0.15	**0.57**	
	Perceived behavioural control	1.19***	0.37	**0.42**	
	Age	0.03	0.04	0.04	
	Gender [c]	0.03	0.19	0.01	
Intention					0.76
	Perceived behavioural control	1.93***	0.18	**0.81**	
	Attitude	0.29***	0.09	**0.14**	
	Age	0.02	0.04	0.04	
	Gender	−0.59**	0.19	**-0.21**	
Perceived behavioural control					0.98
	Subjective norm	0.48***	0.04	**0.99**	
	Age	−0.01	0.02	-0.04	
	Gender	0.21*	0.09	**0.18**	
Attitude					0.27
	Subjective norm	0.18***	0.04	**0.31**	
	Social status attribution	−0.36***	0.10	**-0.35**	
	Perceived accident involvement probability	−0.19**	0.07	**-0.21**	
	Age	−0.03	0.02	-0.10	
	Gender	0.03	0.09	0.02	
Subjective norm					0.02
	Age	−0.04	0.03	-0.07	
	Gender	−0.21	0.13	-0.09	
Perceived accident involvement probability					0.07
	Age	−0.04	0.02	-0.12	
	Gender	−0.32***	0.08	**-0.22**	
Social status attribution					0.07
	Age	0.04*	0.02	**0.12**	
	Gender	0.27***	0.08	**0.21**	

B = unstandardized path coefficients, S.E. = standard error, β = standardized path coefficients
Significant (* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$) standardized path coefficients in bold
[c] Gender (female = 0, male = 1)

transport and attributed more negative social status to public transport use than female students. At the same time, male students had a lower intention to use public transport and assessed a lower accident involvement probability with the use of public transport in winter than female students.

Overall, the MIMIC model explained 2% of the variation in the subjective norm, 7% in both perceived accident involvement probability and social status attributed to public transport use, 27% in attitude towards public transport use, 76% in intention to use public transport, 90% in the use of public transport and 98% in perceived behavioural control over using public transport, respectively.

5. Discussion

This study tested an adapted version of the TPB extended with social status attribution and perceived accident involvement probability with public transport use in winter. The magnitude and direction of the relationships between latent theoretical constructs were examined by a Multiple Indicators Multiple Causes (MIMIC) modelling approach, which allows controlling for the effects of covariates, i.e. age and gender of the study participants.

In line with the TPB (Ajzen, 1991), the results of the present study demonstrated that university students' intention and perceived behavioural control of using public transport significantly predict university students' use of public transport in winter. In addition to a direct impact on the use of public transport in winter, perceived behavioural control also affected the use of public transport indirectly via intention. This is expected as an individual's perception of the ease or difficulty in performing a specific behaviour is important to the evaluation of behavioural options (Ajzen and Fishbein, 1980). Practical barriers such as weather conditions exert a strong influence on transport mode choice (Böcker et al., 2016). In particular, the winter conditions may pose further restrictions on active transport mode choice (Agarwal and Collins, 2016; Nahal and Mitra, 2018). As a result, university students could have a perception that it is easier to use public transport when salient objective situational constraints (e.g., icy and slippery winter roads and cold weather) are evident in winter.

The intention, which was the strongest predictor of public transport use in winter, was significantly influenced by the attitude towards the use of public transport and perceived behavioural control as mentioned above. This finding is consistent with the theory of planned behaviour

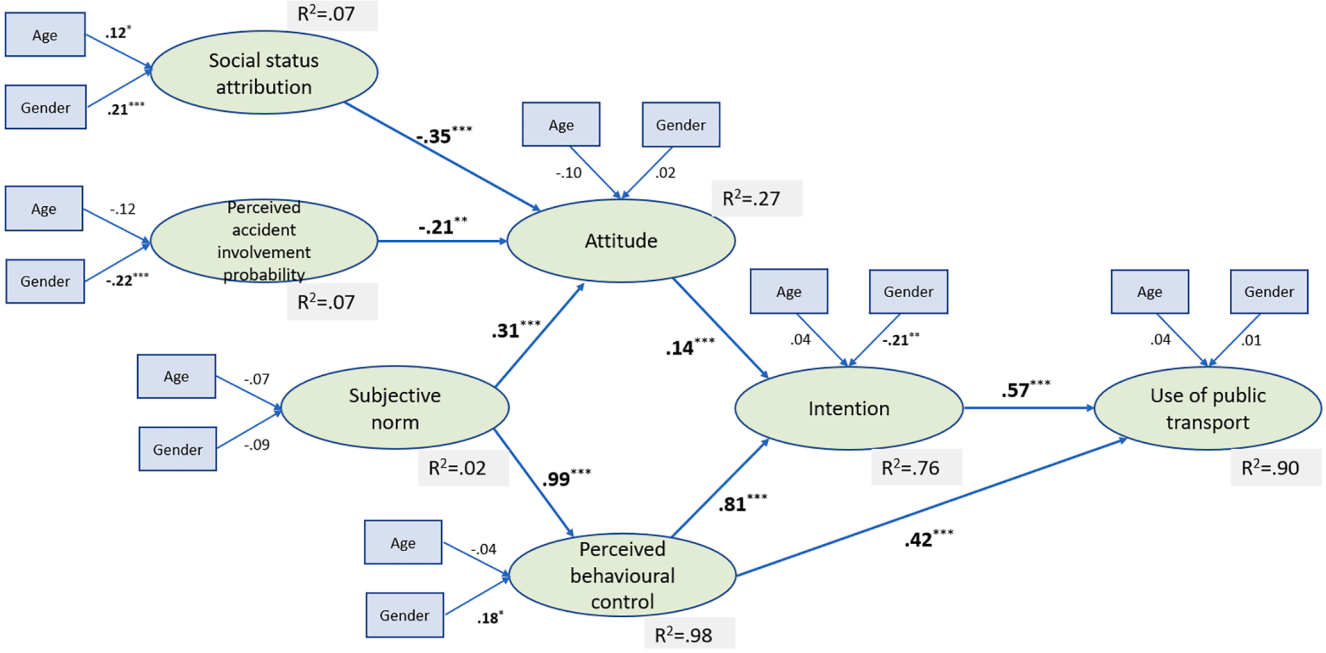

Fig. 2. Multiple Indicators Multiple Causes Model (MIMIC) with standardized path coefficients and explained variances.Significant (* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$), standardized path coefficients in bold.

and previous research evidence (Ajzen, 1991; Eriksson and Forward, 2011; Nordfjærn et al., 2014a; Zailani et al., 2016). Although subjective norm was not hypothesised to directly predict intention in the current study, the strong influence of subjective norm on both perceived behavioural control and attitude indicated that subjective norm had a salient effect on the intention to use public transport indirectly. This finding indicates there is a stronger social-normative influence on students' evaluations related to public transport use. This is in line with Kelman's (1958) social influence theory and Bandura and Walters (1977) social learning theory. Firstly, social influence, i.e. referent others' influence, is a powerful process shaping an individual's beliefs, attitudes, and subsequent actions. Secondly, by observing referent others and directly copying their behaviour, an individual learns relevant social beliefs and norms through compliance, identification, and internalization processes. Given that higher education institutions being the forefront of education for sustainability (Cortese, 2003), environmental issues are often discussed and debated. Subsequently, university students either comply or identify with or internalize prominent others' viewpoints about sustainability and environmental issues through social learning. This may result in a stronger social-normative influence on university students' pro-environmental behaviours like public transport use observed in our study.

Besides, the present study is the first to examine the impacts of social status attribution and perceived accident involvement probability with public transport use in winter. Though situational characteristics like meteorological conditions have been acknowledged as significant factors for road accidents (Andersson and Chapman, 2011; Maze et al., 2006), how subjective assessment of accident involvement probability affects people's attitude toward the use of public transport has rarely been investigated. The results of this study demonstrated that perceived accident involvement probability and the view that 'public transport is for the less well off' had significantly negative influences on attitude. This indicates that uncertain situations like meteorological conditions might exert an impact on people's attitudes through individuals' assessment of accident probability in that given condition. Moreover, the results also suggest that it is still common to perceive that lower social status is associated with the use of public transport. Though, such a view seems to be more prevalent among older students and males.

Meanwhile, the non-significant impact of age on intention and public transport use in winter among university students cannot be used to object suggestions, which are based on the socio-emotional selectivity theory (Carstensen et al., 1999), that younger adults often have orientation and inclination to pro-environmental behaviours (D'Souza et al., 2006; Torgler et al., 2008; Wai and Bojei, 2015). In the present study, the respondents' age ranged from 19 to 30 years (mean age = 22.49), which can be regarded as a homogenous age cohort in relation to inclination and use of public transport. Hence, it seems that the influence of age on pro-environmental behaviours like public transport use can only be evident when different age cohorts are under investigation.

The findings regarding significant gender differences on intention and perceived behavioural control are quite interesting. Although reporting higher perceived behavioural control over using public transport, male students indicated lower intention to use public transport than female students. This is in line with suggestions based on the gender role theory (Eagly, 1997) that females and males differ in their orientation and inclination to pro-environmental behaviours (Do Paco et al., 2009; Torgler et al., 2008; Wai and Bojei, 2015). It appears therefore that public transport use in winter among female students and male students is strongly influenced by different proximal factors of the behaviour.

6. Conclusions

The current study suggests that proximal attitudinal factors exert substantial influence on the use of public transport in winter among university students. The findings of this study showed a strong social-normative effect, a significant influence of social statues attributed to public transport, and perceived accident involvement probability on the use of public transport among the student population. Considering that students comprising almost a fifth of the population where the study was conducted, the results of the research carry important implications for sustainable transport policy measures to be implemented in similar student cities. The findings suggest that campaigns promoting sustainable and environmentally friendly travel modes can benefit from interventions highlighting the above discussed attitudinal aspects for university students while bearing in mind the possible gender differences. That is stimulating social-normative influence and working with perceived accident probability being a central part of campaigns promoting sustainable and environmentally friendly travel modes. The findings further illuminate that there is a potential for integration between concepts from risk research and TPB when it comes to public mobility behaviour.

There are, however, several potential limitations in this study. It is possible that the actual use of public transport might be lower than the self-report due to for example social desirability bias (Fisher, 1993). While being critical to self-report measures, it is worth noting that a high correlation between self-report measures and actual behaviour exists (Corral-Verdugo and Figueredo, 1999; Kormos and Gifford, 2014) and alternative methods of data collection (e.g., travel diaries, GPS travel apps, etc.) also have the advantages and disadvantages (Coolican, 2014). Also, due to the distinct socio-demographic characteristics of the sample (i.e., exclusively being university students), the results of this study could not be generalized to the public. Lastly, the situational element of winter was not captured in each of the measurements in the study. Nevertheless, it would be assumed that most of the variables in the hypothesised model, except the three constructs which captured the winter element i.e., perceived accident involvement probability, perceived behavioural control, and use of public transport, might not be substantially affected by the winter conditions and may be rather stable across seasons.

CRediT authorship contribution statement

Alim Nayum: Formal analysis, Writing - original draft, Writing - review & editing. **Trond Nordfjærn:** Investigation, Methodology Writing - review & editing.

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