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Assessing the impacts of social norms on low-carbon mobility options

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ABSTRACT

Policymakers and scientists are paying increasing attention to how social norms can promote pro-environmental behaviour and sustainable energy use. We contribute to this field by experimenting with and assessing the impacts of social norms on low-carbon mobility options. Taking Sweden as a case study, we develop two complementary randomised controlled experiments to: 1) analyse the role of social norms in promoting the adoption of car sharing services (CSS) via descriptive and injunctive norms ($N = 720$); and 2) investigate potential crowd out effects when injunctive norms are used to promote a low-carbon transport hierarchy ($N = 730$). First-order effects show that social norms have a positive but marginal impact on the willingness to adopt CSS, and only injunctive norms have the potential to steer behaviour in the desired direction. Results also suggest that concerns about potential substitution effects between low-carbon transport options and CSS are not valid. With due limitations, our findings have various implications for policymaking, notably that for social norms to be effective, other policy instruments are critically needed. Of particular importance are the environmental effectiveness of CSS and complementarities between public transport and active mobility (i.e. walking and cycling).

1. Introduction

Social norms are often defined as (in)formal social considerations, patterns or unwritten rules that govern, guide or influence the behaviour and intentions of individuals, groups, communities or society (Nyborg et al., 2016; Thøgersen, 2006). According to the Theory of Normative Conduct (TNC) (Cialdini et al., 1990; Cialdini and Trost, 1998), two types of social norms can be identified: descriptive norms, which reflect the degree to which behaviour is perceived as collective; and injunctive norms, which denote the degree to which behaviour is supposed to be normally accepted or rejected. Building upon social cognitive theory (Simonson et al., 2003), the literature often distinguishes descriptive (i.e. perceptions or interpretations of "normal" behaviour) from injunctive norms (i.e. prescriptive or proscriptive beliefs about one's behaviour based on what others expect). A key differentiating aspect is the person's subjective perception of these realities, and not necessarily the "objective" behaviours or expectations of somebody else (Thøgersen, 2008). In the domain of sustainability, there is increasing evidence that social norms impact pro-environmental behaviours and energy use. In particular, there is growing empirical evidence that shows that what other people think and/or do is important to the way individuals behave or the choices they make (Farrow et al., 2017). In other words, individuals appear to internalise or pay close attention to normative information about other people's intentions, behaviours and expectations (Sparkman and Walton, 2017).

According to the TNC, social norms can guide the behaviour and intentions of people if they are salient. For example, it has been shown that providing information on other people's energy use can trigger competition among households, leading to reduced consumption (Allcott, 2011). Likewise, it has been found that willingness to purchase carbon allowances from the EU Emission Trading Scheme and permanently retire them is driven not only by price mechanisms, but also salient norms (Lindman et al., 2013). Furthermore, research reveals that normative concerns and social influence can have significant predictive power with respect to the participation and interest in smart energy systems (van der Werff and Steg, 2016), the adoption of solar PV (Mundaca and Samahita, 2020) and the willingness to purchase electric cars (Kim et al., 2014). From a policy perspective, as a whole, there is a growing a number of studies evaluating the impacts of social norms on pro-environmental behaviour (e.g. Farrow et al., 2017; Huber et al., 2018; Terrier and Marfaing, 2015; Vesely and Klöckner, 2017) and there is increasing consensus that social norm interventions (e.g. via

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comparative feedback) can be a (cost-) effective way to promote sustainable energy use (see e.g. Abrahamse et al., 2005; Andor and Fels, 2018; Dolan et al., 2012; Nolan et al., 2008). The literature highlights that social norms can be a driver of societal change, and expand the options that policymakers can draw on to address sustainability challenges (Farrow et al., 2017; Janssen, 2015; Kinzig et al., 2013; Nyborg et al., 2016).

The observations presented above also apply to the decarbonisation of the transport sector, which is crucially important to limit global warming to 1.5°C above pre-industrial levels. The transport sector acounts for 24% of direct CO_2 emission from fuel combustion, and road vehicles (e.g. cars) are responsible for nearly 75% of transport emissions (IEA, 2020). From a technology perspective, low-carbon mobility pathways are becoming abundant in the literature (see e.g. Gota et al., 2019; Haugen et al., 2021; Rogelj et al., 2018). When it comes behavioural policy measures, research in (environmental) psychology and behavioural economics stresses the role of social norms, particularly as a potential policy intervention that can address low-carbon mode choice and travel behaviour (Avineri, 2012; Metcalfe and Dolan, 2012). For example, it is argued that social norms can have an influence on an individual's decisions related to mode choice (Mattauch et al., 2016). By promoting alternative transport choices to private car use (e.g. public transportation, active mobility), social norms can also help to break habits and thus preferences for the status quo (Hoffmann et al., 2017; Lattarulo et al., 2019; Riggs, 2017). In fact, it has been shown that norms can affect the use of public transport (Tertoolen et al., 1998; Heath and Gifford, 2002) and resistance to changing car use habits (Nordfjærn and Rundmo, 2015; Liu et al., 2017). They can affect modal choices in long distance leisure travel, including the possibility that the trip is not made (Raux et al., 2015), and they have been found to be a cost-effective way to manage demand for a particular transport mode (Offiaeli and Yaman, 2020). This body of knowledge underscores that multiple cognitive and motivational factors affect travel mode choice, that social norms can influence and change transport behaviour, and that there is a also lack of quantitative experimental evidence from behavioural studies (Garcia--Sierra et al., 2015; Metcalfe and Dolan, 2012).

There is a vast amount of literature focusing on behavioural issues and the factors that determine the adoption of low-carbon mobility (e.g. beliefs, attitudes, values, socio-demographics, pricing, safety, geographical location, travel patterns, travel time, infrastructure) (see e.g. Abrahamse et al., 2009; Creutzig et al., 2019; de Coninck et al., 2018; Donald et al., 2014; Javaid et al., 2020; Shaheen and Cohen, 2012). In the context of this paper, low-carbon transport options are simply defined as those modes that are more fuel efficient and have zero or low emission levels (Zhao et al., 2020). Following the 'Avoid, Shift, Improve' policy framework for sustainable transport (Bakker et al., 2014), low-carbon transport options that are often identified and assessed in the literature include walking, cycling, public transport and various forms of electro-mobility (e.g. bikes, cars) (Cansino and Yñiguez, 2018; de Coninck et al., 2018; Gota et al., 2019; Gravett and Mundaca, 2021; Nakamura and Hayashi, 2013; Rogelj et al., 2018; Zhao et al., 2020).

Consistent with the above, and despite increasing interest in car sharing services (CSS) and its potential role in low-carbon mobility (Bocken et al., 2020; Ferrero et al., 2018; Hartl et al., 2018; Prettenthaler and Steininger, 1999), there appears to be no experimental analysis of the potential impacts of social norms. At the risk of oversimplification, CSS are often understood as a new transport mode "whereby consumers share access to cars rather than owning a car themselves" (Hartl et al., 2018, p. 88). The literature identifies various forms of CSS, including a 'two-way station-based' (Namazu and Dowlatabadi, 2018) model, where available cars are parked in pick-up stations and trips must start and finish at the same place. The 'one-way station-based' model (Ferrero et al., 2018) is similar to two-way use, but the journey does not need to end at the same station. Finally, in the 'free floating' option (Firnkorn and Müller, 2011), cars can be parked anywhere within an area served by an operator, and the journey can start and end at any point within this area.[1]

The introduction and development of the CSS market—and related business models—aims to transfer mobility from a product (car ownership) to a service provider. At its core, CSS promote the simple idea of increasing car use by reducing the time they are unused. In turn, the literature underlines the positive (theoretical) impacts of CSS in terms of reduced fuel consumption, air emissions, negative health impacts and urban road congestion (Ferrero et al., 2018; Hartl et al., 2018; Terama et al., 2018). Studies also reveal that CSS can substitute for public transportation, particularly among non-car owners (Ferrero et al., 2018; Martin and Shaheen, 2011) and have positive impacts on active mobility (Kent, 2014; Khan and Machemehl, 2017). Within this context, some studies suggest that social norms may influence CSS (Prettenthaler and Steininger, 1999), notably personal norms understood as a moral obligation or self-expectation to act (Ramos et al., 2020).

However, there is a dearth of experimental studies that simultaneously address low-carbon mobility and the role of CSS and social norms. One example is Kormos et al. (2015), who analysed the influence of fictional descriptive social norms on the willingness to reduce private vehicle use ($N = 78$). Similarly Bolsen (2009) exposed participants ($N = 196$) to normative messaging about energy conservation, and asked them to state how likely they would be to take different actions, including alternatives to private car use such as car sharing. However, the study did not measure the specific impacts on CSS. In a natural experiment, Bachmann et al. (2018) studied the determinants of ride sharing (i.e. a peer-to-peer form of CSS) and found that descriptive and personal norms can increase the intention to share rides ($N = 342$). Likewise, while Mou et al. (2020) found that social norms affected the intention to purchase a car among CSS users, there was no experimental manipulation. Nevertheless, to the best of our knowledge, there appears to be a lack of experimental studies that focus explicitly on the impacts of descriptive and injunctive social norms on CSS, and the policy implications for low-carbon mobility options (e.g. potential crowd out effects).

The objective of this paper is, therefore, to understand the impacts of social norms on the willingness to adopt low-carbon mobility options. Using CSS as an entry point for the analysis, we report the results of two, complementary randomised controlled experiments in Sweden that: 1) analyse the role of social norms in promoting CSS adoption (i.e. 'nudging in') via descriptive and injunctive norms; and 2) investigate whether the promotion of CSS via injunctive norms crowds out public transport and active mobility options (i.e. 'nudging out'). Given the lack of quantitative evidence in this area, our research is both confirmatory and exploratory in nature. Based on the reviewed literature (Farrow et al., 2017; Ferrero et al., 2018), we aim to shed light on the extent that social norms can influence mode choice intentions. Our overall hypothesis is that social norms influence the willingness of CSS adoption (experiment 1) and low-carbon transport options (experiment 2). Consistent with the experimental research focusing on the impacts of social norms and the promotion of pro-environmental (transport) behaviour (Raux et al., 2015; Sparkman and Walton, 2017), our approach applies non-parametric tests for between-group comparisons, and logistic regressions for the identification and analysis of key determinants. Given the experimental and thus exploratory nature of our research, outcomes should be seen as a departure point for further analyses. The main research questions guiding this study are:

[1] See Curtale et al. (2021) and Ferrero et al. (2018) for a detailed description of car sharing user preferences.

- RQ experiment 1: To what extent can descriptive and injunctive social norms increase the willingness to adopt CSS?
- RQ experiment 2: What are the implications of using injunctive norms that promote low-carbon mobility via a low-carbon transport hierarchy (including and excluding CSS)?

We take Sweden as a case study, for various reasons. For example, while statistics are fragmented, recent figures indicate that more than 100,000 users access nearly 2000 cars made available by existing CSS[2] providers (Miljöbarometern, 2019a, 2019b). While CSS use is increasing, and despite the fact that it can be traced back to the mid-1970s (Bocken et al., 2020), the literature also highlights various empirical knowledge gaps. Local policymakers are unsure about how they should integrate CSS into the low-carbon transport hierarchy (Bocken et al., 2020). In particular, a recent public inquiry into CSS (SOU, 2020) raised various concerns, particularly regarding crowding out or substitution effects on public transport, but also potential complementarities with active transport modes such as walking and cycling. However, little is known about these aspects empirically. At the same time, national authorities see municipalities as the key actor to support the adoption of CSS (Plepys et al., 2015) and, in theory, the use of social norms to promote low-carbon transport is acknowledged (Nässén et al., 2015). Moreover, there are no experimental applications at national level, and there is a lack of information about potential CSS adopters (Sprei and Ginnebaugh, 2018). In addition, as the nation has become wealthier and purchasing power has increased, both the frequency and distance of travel have increased along with carbon emissions (Norden, 2016). The transport sector accounts for half of energy-related CO_2 emissions, suggesting that policy interventions must go beyond traditional instruments such as taxation (IEA, 2019). Finally, the COVID-19 pandemic has affected public transport uptake (Trafikanalys, 2021), and there is a risk that private car use will bounce back, or remain high, as the country recovers from the pandemic.

The objectives and specific hypotheses of our experiments are as follows. The first experiment assessed and compared the impacts of descriptive and injunctive norms on CSS. Based on the reviewed literature and existing policy knowledge gaps in Sweden (Frederiks et al., 2015; Smith et al., 2012; SOU, 2020), we defined two hypotheses:

H1a. Exposure to a descriptive social norm increases the likelihood of the adoption of car sharing compared to a control group.

H1b. Exposure to an injunctive social norm marginally increases the likelihood of the adoption of car sharing compared to those exposed to the descriptive social norm and a control group.

The aim of the second experiment was to analyse the influence of injunctive norms on decisions regarding low-carbon transport options, with the inclusion or exclusion of CSS in the decision-making framework. According to the theory of planned behaviour (Ajzen, 1991) and the norm-activation theory (Schwartz, 1977), injunctive norms are relevant factors that determine behaviour. Various studies have used these theoretical frameworks and found positive causal inferences between injunctive norms and environmental and energy issues (Biel and Thøgersen, 2007; Bonan et al., 2020; Farrow et al., 2017). In our case, injunctive norms were considered influential factors to promote modal shifts (Javaid et al., 2020), and experimental studies have shown positive relationships between injunctive norms and the choice of low-carbon transport options such as public transport and electric vehicles (Cherchi, 2017; Raux et al., 2015; Saleem et al., 2021). Taking into account these theoretical and empirical constructs, we investigated the extent to which the promotion of CSS (via an injunctive social norm) crowds out (or not) public transport and active mobility options. Based on the reviewed literature and existing policy knowledge gaps in Sweden (Bocken et al., 2020; SOU, 2020), we defined two hypotheses:

H2a. Support for low-carbon transport options (i.e. walking, cycling and public transportation) is triggered by an injunctive norm that promotes a low-carbon transport hierarchy, but excludes car sharing.

H2b. When car sharing is included in the hierarchy, fewer respondents favour the adoption of low-carbon transport. However, complementarities (0 = none; 3 = high) between car sharing and low-carbon transport options indicate perceived compatibility or substitution effects.

This paper is organised as follows. Section 2 provides details of our first experiment, including its design, methodology and results. Section 3 describes our second experiment, based on the same structure. In Section 4, and drawing upon our findings and current knowledge, we provide an overall discussion of various policy and methodological issues. Finally, we outline some concluding remarks in Section 5.

2. Experiment 1: descriptive and injunctive norms addressing CSS

2.1. Design and procedure

As stated above, the first experiment aimed to assess and compared the impacts of descriptive and injunctive norms on CSS. Participants were given a brief outline of our study, answered some questions about climate change and air pollution, and were presented with a description of CSS and its modalities (see Annex 1). Then they were randomly allocated to one of three groups (control, condition 1, condition 2). The control group was not exposed to any manipulation.

In condition 1, participants were exposed to the following descriptive social norm. It aimed to describe an actual and collective behaviour. Data and statements supporting this dynamic descriptive normative message were extracted from 'Miljöbarometern 2030' [3] (Miljöbarometern, 2019a):

> "*In Sweden, conservative estimates show that there are at least 100,000 drivers who currently use nearly 2,000 cars provided by existing car sharing services. According to 'Miljöbarometern 2030', it is encouraging to see that the number of users of car sharing services and the number of bookings is accelerating*".

In condition 2, participants were exposed to the following injunctive norm that addressed CSS and complementarities with low-carbon mobility as normative intervention artefacts. Data and statements supporting this normative message were extracted from official sources (see IEA, 2019; SCB, 2020; STEM, 2020; Trafikverket, 2013), including a recent public inquiry into CSS use (see SOU, 2020):

> "*In Sweden, the transport sector accounts for almost half of energy-related CO_2 emissions. To reduce air pollution and related health impacts, research shows that people need to use sustainable forms of transportation, including car sharing services. In Sweden, the transport sector needs to reduce its emissions by 70% in 2030 compared to 2010 levels. The adoption of car sharing services is an important part of reaching this goal.*"

After being exposed to the normative message, participants were

[2] These figures mostly include business-to-consumer (B2C) car sharing as well as private collectives' car sharing schemes, or car clubs (like 'Lunds Bilpool'). Peer-to-peer car sharing and ride sharing are *not* considered.

[3] This initiative collects official transport information across municipalities and national organizations. It supports the national policy effort known as 'Fossil Freedom on the Road' ('Fossilfrihet på Väg' in Swedish) and the climate target defined for the transport sector in the Climate Act (Klimatlagen). The initiative tracks a number of environmental indicators related to the transport sector (both national and municipal), including car sharing. For further information see https://2030.miljobarometern.se/.

asked to state how willing they were to adopt CSS on a four-point Likert-type scale (0 = very unlikely, 3 = very likely). Then they were asked to rate various factors affecting their willingness to adopt CSS (e.g. pricing, availability and age of the vehicle fleet, type of fuel/engine, convenience) on another four-point Likert-type scale (0 = not important, 3 = very important). Next, they were asked to answer questions about their perceptions of the environmental impacts of CSS, car ownership and socio-economic demographics (Table 1). A final question checked their level of attention. Participants were asked to recall their choice about their likelihood of adopting CSS, and those who gave an incorrect answer were excluded. Here, the aim was to approximate whether stated preferences were conscious. The final question resulted in 29 (control group), 28 (condition 1) and 35 (condition 2) participants being excluded from the analysis.

The study design, hypotheses and analyses were pre-registered on AsPredicted.[4]

2.2. Participants and randomisation

A market research firm (Norstat[5]) administered our online experiment and collected data via its website. A web panel of people living in Sweden was used for this purpose. Respondents ($N = 720$) were given a small token, but otherwise the experiment was not incentivised. The only inclusion criterion was to be at least 18 years old and therefore to have, or be in the position to apply for, a driver's license.

Given the novelty of our work, there are very few similar studies that could serve as a basis to derive expected effect and sample sizes. To control for Type II error, we assumed a relatively conservative, medium effect size (Cohen's $d = 0.5$), combined with a 1% level of significance and 90% statistical power. This resulted in a minimum sample of 121 participants for each group. However, in practice, we were able to recruit 240 participants per group. Thus, at a 1% level of significance, experiment 1 could detect a small effect with 35% power, and a medium effect with 99.8% power in a two-sided test.

The socio-economic and demographic profile of participants is given in Table 2. Variables included geographical location, income, household size, educational level, gender and whether the household owned a car.[6]

Participants were randomly allocated to one of the three treatment scenarios using a recruit and deny strategy (Gandhi et al., 2016). A random number generator produced an integer ranging from 1 to 3, which was used to allocate participants to either: *i*) the control group ($n = 240$); *ii*) the descriptive norm condition ($n = 240$); and *iii*) the injunctive norm condition ($n = 240$). Descriptive statistics are shown in Table 2. Statistical tests (Kruskal-Wallis for categorical variables and a one-way between-group ANOVA for continuous variables) identified no differences for the majority of variables (see the last column of Table 2). The exception was location. However, the analysis showed that this variable was irrelevant to our results. Randomisation was thus found to be effective, and able to cancel any potentially confounding effects.

2.3. Data analysis

Various non-parametric statistical tests were applied to ascertain first-order effects and explore relationships between variables. A Kruskal-Wallis test was used to compare and check for significance across all groups, including effect size. If significant, *post-hoc* Mann-Whitney U tests were applied to examine differences among pairs of groups and a Bonferroni alpha-value adjustment was applied (0.05/3 tests = 0.017) to control for Type I error. The effect size was also calculated (0.1 = small effect, 0.3 = medium effect, 0.5 = large effect) (Cohen, 1988). With respect to the reasons given for the (non-)adoption of CSS by participants, we ran Chi-square (χ^2) tests to ascertain whether

Table 1
Variable definition in experiment 1.

Variable	Coding	Definition/range
Willingness to adopt CSS		
	0	Very unlikely
	1	Unlikely
	2	Likely
	3	Very likely
Product attributes		
a) Price, b) fleet, c) type of engine and d) convenience)	0	Not important
	1	Slightly important
	2	Important
	3	Very important
Complementarity between CSS and walking, cycling and public transport		
	0	None
	1	Low
	2	Moderate
	3	High
Environmental effectiveness of CSS		
	0	Not at all effective
	1	Slightly effective
	2	Effective
	3	Very Effective
Location		
	0	Rural area (below 50 inhabitants)
	1	Small rural town (50–199 inhabitants)
	2	Small urban area (200+ inhabitants)
	3	Urban area (10,000–199,000 inhabitants)
	4	Large urban area (+200,000 inhabitants)
Environmental knowledge of CSS		
	0	None
	1	Low
	2	Moderate
	3	High
Car ownership		
	0	Car-free household
	1	Household with a car
Income level		
	0	Less than 20.000 SEK
	1	20.000–29.999 SEK
	2	30.000–39.999 SEK
	3	40.000–49.999 SEK
	4	50.000–59.999 SEK
	5	60.000–69.999 SEK
	6	70.000–79.999 SEK
	7	80.000–89.999 SEK
	8	90.000–99.999 SEK
	9	100.000 SEK or up
Household size		
	1	Person
	2	People
	3	People
	4	People
	5	People
	6	People
	7+	People
Educational level		
	0	Less than high school
	1	Graduate high school
	2	Graduate trade/technical school
	3	Bachelor degree
	4	Master-level
	5	Licentiate or Ph.D. degree
Gender		
	0	Female
	1	Male

[4] For further information visit https://aspredicted.org/.
[5] For further information visit https://norstat.se/.
[6] Note that our sample is representative of the Swedish population for gender only (χ^2 (1, 720) = 0.211, $p = .64$). For income, household size, education level and age, tests showed statistical differences. This limitation is discussed in section.4.

Table 2
Descriptive statistics in experiment 1. M: Mean; Mdn: Median; SD: Standard Deviation; DV: Dummy Variable; CV: Categorical Variable.

	Control group (n = 240)		Condition 1: Descriptive norm (n = 240)		Condition 2: Injunctive norm (n = 240)		Difference between groups
	M/Mdn	SD	M/Mdn	SD	M/Mdn	SD	
Age (years)	48.3/48	18.37	45.6/44	17.00	45.4/44	17.57	F (2, 717) = 1.91, p = .148
Gender (DV)	0.49/0	0.50	0.51/1	0.50	0.48/0	0.50	χ^2(2, 720) = .54, p = .762
Income (CV)	1.78/1	1.81	1.87/2	1.67	1.85/2	1.85	χ^2(2, 720) = 1.70, p = .426
Household size (CV)	2.45/2	1.22	2.50/2	1.21	2.42/2	1.24	χ^2(2, 720) = .86, p = .649
Education level (CV)	2.31/2	1.49	2.63/3	1.44	2.40/3	1.45	χ^2(2, 720) = 5.72, p = .057
Location (CV)	2.62/3	1.15	2.94/3	1.01	2.76/3	1.15	χ^2(2, 720) = 9.42, p = .009
Car ownership (DV)	0.84/1	0.36	0.83/1	0.37	0.83/1	0.38	χ^2(2, 720) = .24, p = .887

there was a significant association between the willingness to adopt CSS and salient motives.

Second, multinomial logistic regressions were used to explore relationships among variables and, more importantly, identify key predictors. From a theoretical perspective, independent variables were identified from a variety of studies addressing consumer behaviour and CSS preferences. They include product attributes (Zoepf and Keith, 2016) such as price (Bardhi and Eckhardt, 2012), convenience (Katzev, 2003), type of engine (e.g. combustion, electric) and fleet (Ferrero et al., 2018). In addition, complementarities with low-carbon mobility options such as public transport, cycling and walking (Martin and Shaheen, 2011), environmental awareness (Neunhoeffer and Teubner, 2018), car ownership (Zhou et al., 2020) and the geographical location of (potential) users (Cohen et al., 2008) were considered. Socio-economic factors affecting CSS adoption (Prieto et al., 2017) were used as control variables (see Table 1) and the following multinomial logistic regression model was developed:

$$P_{jik} = \frac{e^{\beta_{jk}' X_{jik}}}{1 + \sum_{j=1}^{J-1} e^{\beta_{jk}' X_{jik}}} \tag{1}$$

where P_{ijk} is the probability of j occurring. Here, this is the likelihood (0 = very unlikely; 3 = very likely) of participant i willing to adopt CSS under condition k. β'X is the following vector of explanatory variables. *Product attributes*: direct or explicit product service attributes associated with CSS adoption, namely price, vehicle fleet, type of fuel/engine and convenience. *Complementarity*: perceived complementarities between CSS and other forms of low-carbon mobility. This was measured by three items ('How do you perceive complementarities between car sharing and: *i*) walking, *ii*) cycling and *iii*) public transport with car sharing services?' 0 = none; 3 = high) (α=.80). *Environmental effectiveness*: participants' perceptions of the effectiveness of CSS in reducing carbon emissions and air pollution. *Car ownership*: whether the respondent's household owned a car or not. *Location*: the location of the participant's household (e.g. a rural, small urban, or large urban area). *Environmental knowledge:* self-assessed level of knowledge about the environmental impacts of CSS. Consistent with the logistic regression, each was estimated as the maximum likelihood, with J as the baseline ('very unlikely'). $J-1$ represents the number of comparisons against the chosen baseline. Control variables (for robustness checks) included income, educational level, household size, gender and age.

Each model was bootstrapped based on 1000 samples and checked for goodness-of-fit using a Chi-square (χ^2) test to give an overall initial indication of how well the model performed. Cox and Snell's and Nagelkerke's were used as pseudo measures to indicate the amount of variation in the dependent variable and, more importantly, to compare models. Variance Inflation Factors (VIFs) were computed to test for multicollinearity and evaluate endogenous bias (a value above 5 was taken as evidence of this). Odds ratios (i.e. the constant effect of predictor X on the likelihood of an outcome) were also estimated for all independent variables as an effect size statistic. Whenever needed, correlation coefficients were also estimated to further support the analysis (r = 0.10–.29 small effect; r = 0.30–.49 medium effect; r = 0.50–1.0 large effect) (Cohen, 1988).

2.4. Results

2.4.1. First-order effects

The Kruskal-Wallis test revealed a marginal, but statistically significant effect on the willingness of adopting CSS across the three groups, $K\text{–}W$ (2, 720) = 6.14, p = .046, η^2 = 0.01. The mean for the injunctive norm condition (condition 2) was higher (M = 1.01) than for condition 1 and the control group (see Fig. 1 and Table 3). *Post-hoc* Mann-Whitney tests revealed that the only significant effect was found in the injunctive norm condition. No significant difference was found between the control (M = 0.82) and the descriptive norm (condition 1) (M = 0.95), U = 26,524, z = −1.60, p = .110. We thus retained the null hypothesis under H1a. The only significant difference was found between the control group and the injunctive norm condition, U = 25,314, z = −2.44, p = .015, r = 0.11. We found a marginal, but non-significant difference between injunctive and descriptive norm conditions (U = 27,591, z = −0.84, p = .4, r = 0.04). We thus partly retain H1b, as the injunctive norm condition resulted in a statistically higher likelihood compared to the control group, but not compared to the descriptive norm group.

A priori, and based on the reasons for (non-)adoption provided by the participants, results showed that car ownership was a key variable in CSS adoption. The Chi-square test identified a significant association (χ^2(3, 720) = 109.02, p = .000) and a large effect size (Φ = 0.38). Across all groups, participants who stated that it was 'very unlikely' or 'unlikely' that they would adopt CSS said that this was because 'I already have a car' (see Table 4) and the Kruskal-Wallis test revealed no significant difference across all groups ($K\text{–}W$ (2, 541) = 2.18, p = .335). It is interesting to note that pricing was a marginal reason (<2.5%) for non-adoption. Similarly, across all groups, participants who stated that it was 'likely' or 'very likely' that they would adopt CCS said it because 'I do

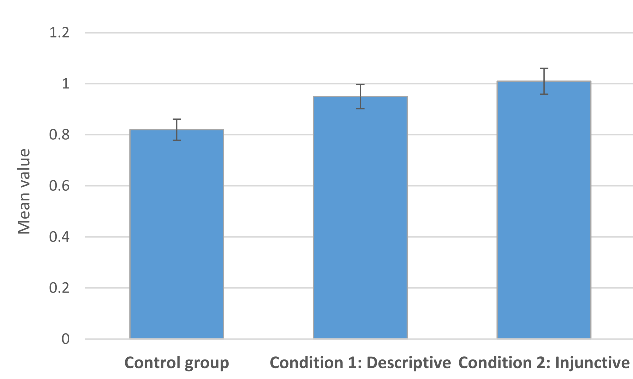

Fig. 1. Results of experiment 1. Participants' stated willingness of adopting car sharing (CSS) (0 = very unlikely, 3 = very likely) services across control, descriptive and injunctive norm groups. Error bars represent 95% confidence intervals.

Table 3
Stated willingness of adopting car sharing services across groups.

	Control group		Condition 1: Descriptive norm		Condition 2: Injunctive norm	
	Frequency	%	Frequency	%	Frequency	%
Very unlikely	97	40.4	85	35.4	80	33.3
Unlikely	97	40.4	94	39.2	88	36.7
Likely	39	16.3	50	20.8	62	25.8
Very likely	7	2.9	11	4.6	10	4.2
Total	240	100	240	100	240	100

not have a car' (see Table 5) ($K–W$ (2, 179) = 1.78, p = .410).

Interestingly, some people who *do* have a car expressed their willingness to adopt CSS (e.g. R3: 'I have a car, but want to give up private car ownership' or R4: 'I have a car, but I would like to test different models before buying a new car'). In addition, Table 5 (R6 and R7) shows that a relatively high percentage of participants perceived complementarities between CSS and low-carbon mobility as an important motive for CSS adoption. The analysis revealed a significant association between these two variables across all groups ($\chi^2(9, 720) = 279.99$, p = .000, $\Phi = 0.36$) and this result was confirmed by the regression analysis (details below).

2.4.2. Main determinants of treatment conditions

Multinomial logistic regressions across the two conditions identified a set of shared determinants driving the likelihood of CSS adoption. Here, important determinants were: 1) complementarities between CSS and low-carbon mobility options; and 2) the perceived environmental effectiveness of CSS. These results were statistically robust when controlling for socioeconomic and demographic variables, although age was an important factor. However, as suggested by the main effects, differences between the two outcome conditions are explained by (marginal) differences in parameter estimates and corresponding odds ratios. Condition 1 was associated with a relatively wider set of significant determinants than condition 2. Furthermore, household car ownership played a more important role under condition 1, while product attributes such as fuel, price or convenience were significant in specific cases. Location did not play a significant role. This could be explained by the fact that the majority of participants lived in urban areas (approximately 70% in each treatment condition; see also Table 2), where CSS and low-carbon transport options are available. No collinearity issues were identified (all VIF<5). See the Supplementary Material for full results.

In condition 1 (the descriptive norm), the initial model (i.e. with no control variables) was statistically significant (χ^2 (27, 240) = 160.28, p = .000) and explained between 48.7% (Cox & Snell R^2) and 53.5% (Nagelkerke R^2) of the variance of CSS likelihood. The strongest predictors were complementarities between CSS and low-carbon mobility, perceived environmental effectiveness, car ownership and the type of engine, where odds ratios were relatively high. For example, a one unit increase in complementarity between CSS and low-carbon mobility increased the odds of CSS adoption by 9.25. A one unit increase in the perceived environmental effectiveness of CSS changed the odds of CSS adoption by 13.15. Results were robust (χ^2 (42, 240) = 190.16, p = .000) to the introduction of control variables (Table 6) and the explanatory capability of the model increased (Cox & Snell R^2 = 54.7%; Nagelkerke R^2 = 60.1%). Age was also a significant predictor. For example, in the case of 'very likely' CSS adoption, a one year increase in age changed the odds ratio by 0.88. In other words, *ceteris paribus*, the odds of a younger person being 'very likely' to adopt CSS was 1.13 (=1/0.88) times higher than an older person. To some extent, this specific result seems consistent with the negative correlations we found for age and climate change awareness (r = −.11, p = .038), and age and household size (r = −.19, p = .002).

In condition 2 (the injunctive norm), the initial model was also statistically significant (χ^2 (27, 240) = 129.57, p = .000) and explained between 41.7% (Cox & Snell R^2) and 45.7% (Nagelkerke R^2) of variance. In addition to the main predictors mentioned above, price and convenience were statistically significant factors. For example, a one unit increase in pricing (i.e. lower prices) changed the odds of CSS adoption by 2.38. The introduction of control variables (χ^2 (42, 240) = 170.19, p = .000) also increased the explanatory capability of the model (Cox & Snell R^2 = 50.8%; Nagelkerke R^2 = 55.7%). Here again, complementarities between CSS and low-carbon mobility, and the perceived environmental effectiveness of CSS were important predictors, with odds ratios of 8.02 and 23.28 for the 'very likely' condition, respectively (Table 6). Similarly, age was also a significant predictor: as age decreased by one year, people were 1.08 (=1/0.92) times more likely to adopt CSS. In this specific case, we once again found negative correlations between age and climate change awareness (r = −.18, p = .002), and age and household size (r = −.21, p = .001), which can help us to better understand these results.

3. Experiment 2: injunctive norms and low-carbon mobility options

3.1. Design and procedure

The aim of the second experiment was to assess the influence of injunctive norms on decisions regarding low-carbon transport options, with the inclusion or exclusion of CSS in the decision-making framework.

As in Experiment 1, participants were briefly introduced to the purpose of the study. They were asked to answer questions about climate change and air pollution and presented with the following climate policy statement:

> "*Sweden's long-term climate target is to have zero net greenhouse gas emissions by 2045 at the latest. The target for the transport sector*

Table 4
Reasons for 'very unlikely' and 'unlikely' adoption of CSS as mobility option.

	Control group		Descriptive norm		Injunctive norm	
	Frequency	%	Frequency	%	Frequency	%
R1: I already have a car	106	54.6	101	56.4	79	47
R2: It can be too expensive	3	1.5	2	1.1	4	2.4
R3: I'm concerned about air pollution	1	0.5	0	0	0	0
R4: It can create more traffic congestion	0	0	0	0	0	0
R5: Hygiene, cleanliness and health related issues	3	1.5	8	4.5	8	4.8
R6: Because long distance to reach the car	26	13.4	12	6.7	22	13.1
R7: Inconvenience related to parking availability and booking system	18	9.3	18	10.1	16	9.5
R8: It is no longer socially acceptable to drive or have more cars	1	0.5	0	0	1	0.6
R9: I prefer to use public transportation, walking and cycling as much as possible	19	9.8	12	6.7	17	10.1
R10: Other	17	8.8	26	14.5	21	12.5
Total	194	100	179	100	168	100

Table 5
Reasons for 'likely' and 'very likely' adoption of CSS as mobility option.

	Control group		Descriptive norm		Injunctive norm	
	Frequency	%	Frequency	%	Frequency	%
R1: I do not have a car	11	23.9	19	31.1	20	27.8
R2: I have a car, but I need an extra car temporarily	1	2.2	5	8.2	4	5.6
R3: I have car, but want to give up private car ownership	9	19.6	5	8.2	17	23.6
R4: I have a car, but I would like to test different models before buying a new car	5	10.9	6	9.8	9	12.5
R5: I do not have a car, but would like to test different models before buying a new car	1	2.2	2	3.3	1	1.4
R6: I do not have a car, and I would like to complement car sharing with public transport	7	15.2	8	13.1	11	15.3
R7: I do not have a car, and I would like to complement car sharing with walking and/or cycling	8	17.4	13	21.3	6	8.3
R8: Other reason	4	8.7	3	4.9	4	5.6
Total	46	100	61	100	72	100

(excluding domestic aviation) is a reduction of 70% by 2030 compared to 2010 levels".

Then, participants were randomly allocated to treatments. The control group was not exposed to any intervention. In condition 1, participants were exposed to an injunctive norm that included both prescriptive and proscriptive elements (Farrow et al., 2017; Thøgersen, 2006), and the notion of the low-carbon transport hierarchy (LCTH). While the prescriptive component in the norm is expressed by the 'appropriateness' of the desirable behaviour (i.e. "*to reduce emissions in the transport sector, citizens are encouraged to follow the Low-carbon Transport Hierarchy … …. are the most sustainable options*"), the proscriptive component is conveyed by the 'inappropriateness' of the undesirable behaviour (i.e. "*car use and air travel are the least preferred options").* Several sources (Gota et al., 2019; Gravett and Mundaca, 2021; Miljöbarometern, 2019c; Nakamura and Hayashi, 2013; Rogelj et al., 2018; STEM, 2020; UK Energy Saving Trust, 2019) were used to construct this hierarchy based on the environmental effectiveness of different transport options (i.e. their ability to reduce carbon emissions and air pollution) in the form of the following message:

"*To reduce emissions in the transport sector, citizens are encouraged to follow the Low-carbon Transport Hierarchy. Walking, cycling and public transport are the most sustainable options, and single occupancy car use and air travel are the least preferred options*" (see Fig. 2, panel a).

In condition 2, participants were exposed to an almost identical normative message and hierarchy, with the only difference being the inclusion of car sharing. Here, the message was as follows:

"*To reduce emissions in the transport sector, citizens are encouraged to follow the Low-carbon Transport Hierarchy. Walking, cycling, efficient public transport and car sharing (where consumers share access to cars rather than owning a car themselves) are the most sustainable options, and single occupancy car use and air travel are the least preferred options*" (see Fig. 2, panel b).

Then participants were asked to state the willingness of adopting (or choosing) low-carbon transport (i.e. walking, cycling and public transport) rated on a four-point Likert-type scale (0 = very unlikely, 3 = very likely). The remainder of the method followed the procedure given for Experiment 1, including the attention check. The latter resulted in the exclusion of 29 (control group), 27 (condition 1), and 22 (condition 2) participants. Here again, the experiment was pre-registered on AsPredicted.

Table 6
Estimated coefficients and odds ratio for predictors that are significant in at least one outcome category. Model (bootstrapped based on 1000 samples) predicting the likelihood of adopting CSS under the two conditions and with control variables. Reference category 'very unlikely'. ***p < .01, **p < .05, *p < .1.

Outcome category	Condition 1: Descriptive norm		Condition 2: Injunctive norm	
	b (S.E.)	Odds Ratio	*b* (S.E.)	Odds Ratio
Unlikely				
Price	0.21 (0.21)	1.23	0.14 (0.21)	1.15
Fleet	0.01 (0.24)	1.00	−0.23 (0.24)	0.79
Fuel engine	0.32 (0.19)*	1.38	−0.27 (0.19)	0.75
Convenience	−0.29 (0.26)	0.74	0.52 (0.27)*	1.69
COMPL_LC_Mob_CSS	0.73 (0.21)***	2.09	0.61 (0.22)***	1.85
Environmental effectiveness CSS	0.66 (0.30)**	1.94	0.20 (0.29)	1.22
Car ownership	0.04 (0.74)	1.04	−0.36 (0.60)	0.69
Age	−0.019 (0.011)*	0.98	−0.03 (0.01)***	0.96
Likely				
Price	0.33 (0.32)	1.39	0.76 (0.31)**	2.14
Fleet	−0.44 (0.36)	0.64	−0.79 (0.32)**	0.45
Fuel engine	0.73 (0.28)***	2.07	−0.04 (0.25)	0.95
Convenience	−0.21 (0.40)	0.80	0.11 (0.35)	1.12
COMPL_LC_Mob_CSS	1.42 (0.32)***	4.17	1.38 (0.30)***	4.00
Environmental effectiveness CSS	1.91 (0.43)***	6.75	0.49 (0.37)	1.64
Car ownership	1.82 (0.81)**	6.22	0.72 (0.64)	2.05
Age	−0.05 (0.01)***	0.94	-.079 (0.01)***	0.92
Very likely				
Price	−1.26 (1.04)	0.19	0.85 (0.66)	2.35
Fleet	1.16 (1.00)	3.20	0.21 (0.21)	1.23
Fuel engine	2.41 (0.96)***	11.20	0.91 (0.74)	2.49
Convenience	1.88 (1.37)	6.58	−0.91 (0.87)	0.40
COMPL_LC_Mob_CSS	3.64 (1.05)***	38.40	2.08 (0.78)***	8.02
Environmental effectiveness CSS	3.05 (1.06)***	21.12	3.14 (1.13)***	23.28
Car ownership	4.65 (1.60)***	105.23	2.35 (1.36)*	10.50
Age	−0.12 (0.05)***	0.88	−0.04 (0.03)	0.95

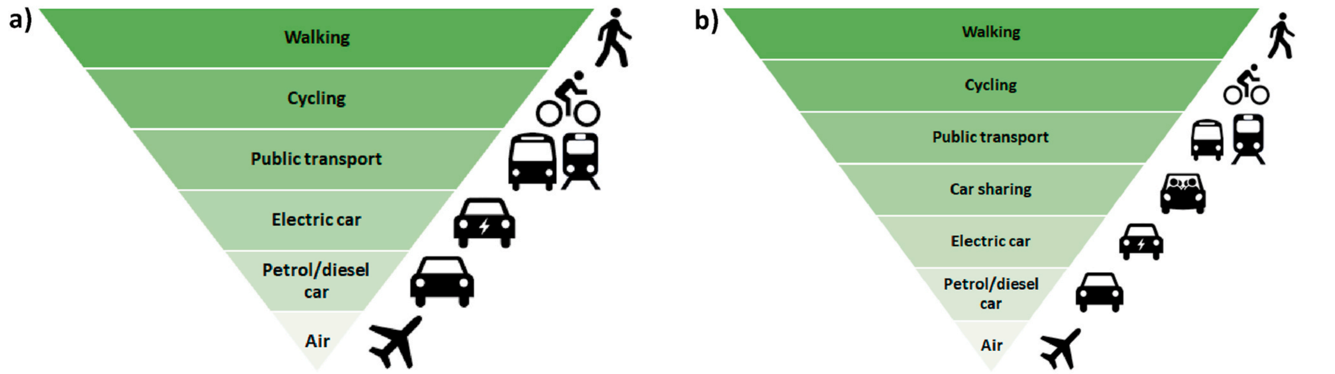

Fig. 2. The low-carbon transport hierarchies (LCTH) used for condition 1 ′injunctive norm without car sharing' (panel a), and condition 2 'injunctive norm with car sharing' (panel b).

3.2. Participants and randomisation

Participant selection and randomisation followed the method given in section 2.2. In this section, we outline differences to the procedure used in Experiment 1. In Experiment 2, 730 respondents were recruited and randomly allocated to: *i)* the control group (n = 240); *ii*) the injunctive norm *without* car sharing in the LCTH (n = 250); and *iii*) the injunctive norm *with* car sharing in the LCTH (n = 240).

In addition to the socioeconomic and demographic variables listed in Table 1, participants were asked about mobility patterns, perceived complementarities among low-carbon mobility options, their environmental effectiveness, the number of cars the household owned and their environmental awareness (Table 7). The latter was measured via two items (i.e. 'tell us whether you agree with the following statement about: *i*) Climate change: Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history; and *ii*) Air pollution: Outdoor air pollution is a major threat to human health and the climate system') (α = 0.75).

As in Experiment 1, statistical analyses found no significant differences for the majority of variables (see Table 8). The only exception was car ownership (i.e. owned number of cars); however, this variable was not found to be relevant in our analysis. Again, this indicated that the randomisation procedure was effective and cancelled any potentially confounding effects.[7]

3.3. Data analysis

See section 2.3 for details of the analysis. The vector of explanatory variables is drawn from the literature on the determinants of low-carbon transport options. They include *mobility patterns* (Schoenau and Müller, 2017), *car ownership* (Mattioli, 2014), *environmental awareness* (de las Heras-Rosas and Herrera, 2019), the perceived *environmental effectiveness* of transport options (Scheepers et al., 2014; Zachariadis, 2005), household *location* (Beaudoin et al., 2015), and socioeconomic and demographic factors such as income (Gota et al., 2019).

In addition, given our interest in the role of CSS in the LCTH, we explored perceived *complementarities* between CSS and low-carbon transport options via three questions ('How do you perceive complementarities between car sharing and: *i*) walking; *ii*) cycling; and *iii*) public transport?') (α = 0.84). As in Experiment 1, all models were bootstrapped (based on 1000 samples) and checked for goodness-of-fit. VIFs and odds ratios were also computed.

[7] However, we must note that our sample is representative of the Swedish population for gender only (χ^2 (1, 730) = 0.056, p = .81). Once again, tests showed statistical differences for income, household size, education level and age. This limitation is discussed in section.4.

3.4. Results

3.4.1. First-order effects

Overall, participants stated a relatively high willingness (Mdn = 2) to adopt low-carbon transport options (i.e. walking, cycling and public transport) across all groups (see Fig. 3 and Table 9). The Kruskal-Wallis test revealed an overall significant effect, K–W (2, 730) = 9.99, p = .007, η^2 = 0.014. The mean (M = 1.92, n = 240) was highest in condition 2 (*with* car sharing in the LCTH) compared to the other two groups (control group: M = 1.76; n = 240; and condition 1: M = 1.68, n = 250). *Post-hoc* tests revealed that only condition 2 generated a significant effect, in particular compared to condition 1, U = 25,578, z = −3.04, p = .002, r = 0.14. We thus retain the null hypothesis under H2a.

Although the difference between the control group and condition 1 was marginal and insignificant, U = 28,691, z = −0.90, p = .365, it was interesting to note that mean of the former was slightly higher then the latter. A detailed review of the data highlighted some subtle differences. For example, in the control group, the correlation between the likelihood of adopting low-carbon transport and the perceived environmental effectiveness of both active (r = .31, p = .000) and public (r = 0.25, p = .000) transport modes was higher compared to participants under condition 1 (r = 0.13, p = .029; r = 0.17, p = .006; respectively). We found similar, albeit marginally higher correlations between environmental awareness and the outcome variable for both active mobility (r = 0.23 in the control group *vs* r = .22 in condition 1) and public transport (r = 0.22 in the control group *vs* r = .19 in condition 1). We hypothesise that environmental awareness, which was marginally higher in the control group (see Table 8), could have driven this subtle (and non-significant) difference.

That said, we also retained the null hypothesis in H2b. Contrary to concerns reported in the literature, our data showed that in condition 2, with the car sharing option in the LCTH, participants were more willing to adopt low-carbon transport options. In all groups, we observed a significant association between the likelihood of adopting low-carbon transport and perceived complementarities with CSS (χ^2(9, 730) = 262.3, p = .000), with a large effect size (Φ = 0.35). These aspects suggest that concerns about potential substitution effects between low-carbon mobility and CSS are not valid. On the contrary, efforts to ensure effective synergies need to be underlined. In fact, we observed that the direction of perceived complementarities between low-carbon mobility and CSS was relatively high across all groups (Mdn = 2) with no significant differences between them, K–W (2, 730) = 0.099, p = .95.

3.4.2. Main determinants of treatment conditions

On the one hand, multinomial logistic regressions highlighted a set of statistically significant predictors across both conditions. They include environmental awareness and mobility patterns of active transport (α = 0.73). On the other hand, the results also highlighted (subtle) differences that explain specific outcomes across the two conditions. For example, while location and complementarities between CSS and low-carbon

Table 7
Variable definition in experiment 2. For socio-economic and demographic variables, see Table 1.

Variable	Coding	Definition
Willingness to adopt/choose low-carbon transport		
	0	Very unlikely
	1	Unlikely
	2	Likely
	3	Very likely
Mobility patters for active and public transport		
	0	Never use …. . as a mean of transportation
	1	Less frequent than before the pandemic
	2	The same as before the pandemic
	3	More frequent than before the pandemic
Environmental awareness		
	0	Strongly disagree
	1	Somewhat disagree
	2	Undecided
	3	Somewhat agree
	4	Strongly agree
Environmental effectiveness of transport options (e.g. *cycling, walking, public transportation)*		
	0	Not at all effective
	1	Slightly effective
	2	Effective
	3	Very Effective
Complementarity between CSS and walking, cycling and public transport		
	0	None
	1	Low
	2	Moderate
	3	High
Car ownership (i.e. number of cars)		
	0	Car
	1	Car
	2	Cars
	3	Cars
	4+	Cars

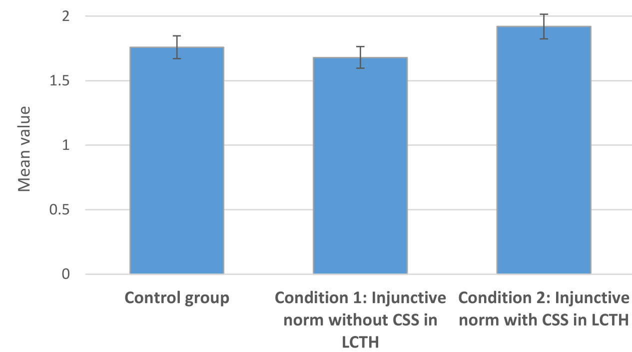

Fig. 3. Results of experiment 2. Participants' stated willingness of adopting low-carbon mobility options, namely walking, cycling and public transport (0 = very unlikely, 3 = very likely) across the control and treatment groups. LCTH: Low-carbon transport hierarchy. Error bars represent 95% confidence intervals.

Table 9
Stated willingness of adopting low-carbon transport options across groups. LCTH: Low-carbon transport hierarchy.

	Control group		Condition 1: Injunctive norm *without* car sharing in LCTH		Condition 2: Injunctive norm *with* car sharing in LCTH	
	Frequency	%	Frequency	%	Frequency	%
Very unlikely	16	6.7	24	9.6	10	4.2
Unlikely	63	26.3	67	26.8	55	22.9
Likely	124	51.7	123	49.2	119	49.6
Very likely	37	15.4	36	14.4	56	23.3
Total	240	100	250	100	240	100

mobility played a significant role in condition 1, the effect of active transport patterns was much more pronounced in condition 2. No collinearity issues were identified (all VIF<5). See the Supplementary Material for full results.

In condition 1, the initial model (with no control variables) was statistically significant (χ^2(24, 250) = 178.35, p = .000) and explained between 51.4% (Cox & Snell R^2) and 56.6% (Nagelkerke R^2) of the variance. The most significant determinants were complementarities between CSS and low-carbon transport options (odds ratios between 2.01 and 8.47), mobility patterns of active transport (odds ratios between 2.43 and 6.05) and environmental awareness (odds ratios between 2.76 and 4.42). As most participants lived in urban areas (~70%), where accessing workplaces/schools using public transport or active mobility options is plausible, location also played a significant role (odds ratios between 2.53 and 4.66). After the introduction of control variables (see Table 10), the model remained statistically significant (χ^2 (39, 250) = 186.49, p = .000) and its explanatory capability increased (Cox & Snell R^2 = 53.0%; Nagelkerke R^2 = 58.3%). The main determinants remained significant and their effect marginally increased (e.g. from 8.47 in the initial model, to 9.13 in the second model for 'complementarities' in the 'very likely' category). Interestingly, no significant effect was found for any of the socioeconomic or demographic variables.

In condition 2, the initial model contained a relatively small set of significant predictors. In particular, environmental awareness, active transport patterns, the perceived environmental effectiveness of active transport (α = 0.87), and complementarities between CSS and low-carbon mobility were significant. The initial model (χ^2 (24, 240) = 181.07, p = .000) and its explanatory capability (Cox & Snell R^2 = 53.1%; Nagelkerke R^2 = 58.9%) was slightly higher compared to condition 1. Notably, the effect of active transport patterns was much more significant compared to condition 1. The odds ratios tell us that as the frequency of using active transport increased, the change in the odds of being 'likely' or 'very likely' to adopt sustainable mobility was 17.72 and 27.27, respectively. Unlike condition 1, location was not a significant predictor. Consistent with the results under experiment 1, in which location did not play a role, we hypothesise that location was

Table 8
Descriptive statistics in experiment 2. M: Mean; Mdn: Median; SD: Standard Deviation; DV: Dummy Variable; CV: Categorical Variable.

	Control group (n = 240)		Condition 1: Injunctive norm *without* car sharing in LCTH (n = 250)		Condition 2: Injunctive norm *with* car sharing in LCTH (n = 240)		Difference between groups
	M/Mdn	SD	M/Mdn	SD	M/Mdn	SD	
Age (years)	48.3/48	18.37	45.6/47	17.2	46.6/47	17.11	F (2, 727) = 1.40, p = .247
Gender (DV)	0.49/0	0.50	0.52/1	0.50	0.49/0	0.50	χ^2(2, 730) = .46, p = .792
Income (CV)	1.78/1	1.81	1.66/1	1.62	1.88/2	1.79	χ^2(2, 730) = 2.19, p = .333
Household size (CV)	2.45/2	1.22	2.23/2	1.18	2.37/2	1.23	χ^2(2, 730) = 4.83, p = .089
Education level (CV)	2.31/2	1.49	2.24/2	1.49	2.37/2	1.46	χ^2(2, 730) = 1.48, p = .476
Location (CV)	2.62/3	1.15	2.74/3	1.14	2.79/3	1.13	χ^2(2, 730) = 3.63, p = .163
Car ownership (DV)	1.27/1	0.89	1.37/2	0.78	1.25/1	1.00	χ^2(2, 730) = 11.5, p = .003
Env'l awareness (CV)	3.53/4	0.77	3.52/4	0.77	3.51/4	0.78	χ^2(2, 730) = .09, p = .954

Table 10
Estimated coefficients and odds ratios for predictors that were significant in at least one outcome category. The model (bootstrapped based on 1000 samples) predicted the likelihood of adopting low-carbon transport options (i.e. public and active transport) under the two conditions and with control variables. Reference category: 'very unlikely'. LCTH: Low-carbon transport hierarchy. COMPL_LC_Mob_CSS: Complementarity between low-carbon mobility and car sharing services. ***p < .01, **p < .05, *p < .1.

Outcome category	Condition 1: Injunctive norm *without* car sharing in LCTH		Condition 2: Injunctive norm *with* car sharing in LCTH	
	b (S.E.)	Odds Ratio	b (S.E.)	Odds Ratio
Unlikely				
COMPL_LC_Mob_CSS	0.15 (0.36)	1.17	0.29 (0.71)	1.34
Environmental awareness	1.63 (0.46)***	5.11	1.47 (0.63)**	4.35
Env'l effectiveness active transport	0.07 (0.45)	1.08	−0.21 (0.61)	0.88
Env'l effectiveness public transport	0.66 (0.48)	1.94	0.02 (0.89)	1.02
Mobility patterns active transport	0.90 (0.47)*	2.47	1.73 (0.85)**	5.64
Location	0.98 (0.31)***	2.68	0.23 (0.53)	1.26
Gender	0.73 (0.69)	2.08	−1.69 (1.12)	0.18
Likely				
COMPL_LC_Mob_CSS	0.77 (0.36)**	2.17	0.97 (0.72)	2.65
Environmental awareness	1.22 (0.45)***	3.38	0.98 (0.62)	2.66
Env'l effectiveness active transport	0.22 (0.45)	1.24	0.47 (0.67)	1.60
Env'l effectiveness public transport	0.93 (0.49)*	2.54	0.41 (0.67)	1.52
Mobility patterns active transport	1.72 (0.48)***	5.60	3.06 (0.89)***	21.32
Location	1.09 (0.32)***	2.98	0.61 (0.55)	1.84
Gender	0.34 (0.70)	1.41	−1.36 (1.16)	0.25
Very likely				
COMPL_LC_Mob_CSS	2.21 (0.50)***	9.13	1.39 (0.74)*	4.04
Environmental awareness	1.62 (0.62)***	5.07	1.42 (0.72)**	4.13
Env'l effectiveness active transport	0.46 (0.64)	1.58	1.77 (0.90)**	5.89
Env'l effectiveness public transport	1.33 (0.60)**	3.78	1.43 (0.98)	4.19
Mobility patterns active transport	1.77 (0.61)***	5.90	3.43 (0.94)***	31.11
Location	1.58 (0.42)***	4.86	0.79 (0.58)	2.20
Gender	0.10 (0.82)	1.11	−2.05 (1.21)*	0.12

insignificant because the majority of participants live in urban areas, where CSS is mostly already available and complementarities with public transport and active mobility were more present or salient. The model remained significant following the introduction of control variables (χ^2 (39, 250) = 198.42, p = .000) and its explanatory capability increased (Cox & Snell R^2 = 56.4%; Nagelkerke R^2 = 62.6%) (see Table 10). A relatively limited set of significant predictors was identified, particularly for 'unlikely' and 'likely' outcome categories. However, the effect of active transport increased substantially, with odds ratios equal to 21.32 and 31.11 for 'likely' and 'very likely' adoption, respectively. With the exception of gender, none of the socioeconomic or demographic variables were significant.

Finally, patterns for public transport were non-significant across both conditions and models (K–W (2, 730) = 2.97, p = .22). This seems to be consistent with the COVID-19 pandemic and the fact that the majority of participants (e.g. 45% in condition 2) stated that they used public transportation 'less frequent than before the coronavirus pandemic' (*Mdn* = 1). On the other hand, a majority (e.g. 53% in condition 2) used active travel 'the same as before the coronavirus pandemic' (*Mdn* = 2), and the remainder (e.g. 20% in condition 2) stated that they used it 'more than before the pandemic', K–W (2, 730) = 2.67, p = .26.

4. Discussion

Taken together, the results of both experiments confirmed that the use of social norms can have a positive impact on the willingness to adopt low-carbon transport options, including CSS. First-order effects indicated the presence of a limited, positive impact. In both experiments, we observed that the effect size was small (η^2 = 0.01). In particular, we found that only injunctive norms had the potential to steer behaviour in the desired direction. The presence of main effects also suggested that concerns about potential substitution between low-carbon transport options and CSS are not valid.

Despite these small effect sizes, our findings support the growing literature (see e.g. Farrow et al., 2017; Nyborg et al., 2016) on the effectiveness of social norms as potential policy interventions. They seem consistent with previous policy-oriented experiments that assess the effectiveness of social norms applied to energy use (Andor and Fels, 2018; Nisa et al., 2019; Schultz et al., 2007) and, importantly in our case, with transport (Cherchi, 2017; Liu et al., 2017; Raux et al., 2015; Riggs, 2017; Saleem et al., 2021; Zhang et al., 2015). Furthermore, results highlight the behavioural factors (or 'anomalies') that support the use of social norms in policy interventions from a theoretical perspective (e.g. they can act as a reference point in people's dependent preferences (see Kahneman and Miller, 1986)), as earlier findings suggest that consumers use the behaviour of others, or the predominant group behaviour, to guide their decisions, particularly under uncertainty or information asymmetries (see Gelfand and Harrington, 2015). However, we must acknowledge that research has also shown insignificant effects of injunctive norms applied to energy use (Allcott, 2011) and active mobility (Bourke et al., 2019).[8] This underlines that results are likely to be context-specific and policy generalisations must not be encouraged.

Turning to our research questions, the following overarching policy answers emerge. The results of experiment 1 show that an injunctive norm has the potential to increase the willingness of CSS adoption. While a descriptive norm also has the same effect, the size is marginal and not statistically significant compared to the control group. The descriptive norm, even if it included some dynamic elements (i.e. people's behaviour is changing over time) (Sparkman and Walton, 2017), appeared incapable of increasing the willingness to adopt CSS. Logistic regressions also reveal a more complex picture: *i)* the complementarities between CSS and low-carbon mobility options (i.e. public and active transport), and *ii)* the perceived environmental effectiveness of CSS are particularly important. These two determinants (in addition to specific product-service features, such as pricing) appear to be preconditions for an injunctive norm to be effective, and they have important policy implications, which are discussed below. Age is another key factor, and it seems that targeting younger people (prior to the purchase of a car) may be an appropriate measure to foster CSS use if the conditions mentioned

[8] No impacts of injunctive social norms are also found for sustainable food choices (Salmivaara et al., 2021).

above are met. For the specific role of car ownership, the results reported in the literature are mixed, which is also consistent with our findings. For example, some studies indicate that CSS contributes to reduced car ownership, with reduced mileage and emissions (Katzev, 2003; Lane, 2005; Meijkamp, 1998; Rabbitt and Ghosh, 2016). This appears to be consistent with the statement 'I have a car, but want to give up private car ownership' (23.6% of respondents). However, the literature also reports that car owners are unwilling to give up their car, and that CSS mostly substitutes for a second or third car (Ferrero et al., 2018; Nijland and van Meerkerk, 2017). CSS can also introduce users to new vehicle technology (Zoepf and Keith, 2016) and potentially increase demand for car ownership in the future. These claims seem to be consistent with the 12.5% of respondents in our study who stated, 'I have a car, but I would like to test different models before buying a new car'.

The results of experiment 2 show that an injunctive social norm may promote a LCTH. Importantly, we found no evidence of crowd out effects between low-carbon mobility options and CSS in particular. However, once again, perceived complementarities between low-carbon mobility and CSS played an important mediating role, reflected in a large effect size ($\Phi = 0.35$). Furthermore, perceived environmental effectiveness and mobility patterns of active transport options were found to be relevant. Both of these aspects have significant policy implications (see below). As a whole, our findings regarding complementarities between low-carbon transport options and CSS in both experiments are very consistent not only with the related literature (see e.g. Ferrero et al., 2018; Katzev, 2003; Plepys et al., 2015), but also with calls for further research on the integration of CSS with low-carbon mobility options (Becker et al., 2017; Cervero et al., 2007; Firnkorn and Müller, 2015; Kent, 2014).

Our results also suggest that social norms are not a panacea. Rather, they strongly indicate that supportive policy instruments remain relevant pre-conditions for social norms to be effective. For example, perceived complementarities between CSS and public and active transport modes suggest that public investment in integrated low-carbon transport systems is a relevant policy instrument. Likewise, the perceived environmental effectiveness of CSS suggests that pricing mechanisms (e.g. congestion charging) and regulations (e.g. parking restrictions) are other relevant (local) policies that promote environmentally effective alternatives to private car use. The importance of certain product attributes (e.g. the type of fuel) highlight the relevance of regulatory approaches that address energy efficiency, zero-emission mandates and low-carbon fuel standards.

Furthermore, our results underscore the importance of information programmes that focus on the synergies, pros and cons, or potential trade-offs between CSS and low-carbon transport options. Examples include the integration of CSS with active transport. Improving, monitoring and verifying the environmental credentials of CSS seems to be crucially important (e.g. via performance standards and labelling schemes) to support information programmes. These aspects highlight the role of policymakers and local authorities in not only correcting incompatibilities, but also supporting complementarities between CSS and low-carbon transport. Opportunities to ensure the environmental effectiveness of both options must be identified, maximised and properly communicated.

The design and implementation of social norms also needs to be handled carefully. For example, the literature shows that social influence can be exercised in multiple ways (e.g. peer effects, group feedback) and that face-to-face interactions, or interactions with known sources appear to be equally or more effective than the more impersonal and anonymous social norms we tested (see e.g. Abrahamse et al., 2005; Mundaca and Samahita, 2020). This suggests that the agent or choice architect behind the messaging is an important moderator. Any unintended policy consequences (or side effects) also need careful consideration (Farrow et al., 2017; Metcalfe and Dolan, 2012). We have already noted that CSS can introduce users to new vehicle technology and potentially increase future demand for car ownership (see also R4 in Table 5). This means that policymakers need to closely observe any potentially adverse effects and be ready to act or adjust policy interventions (e.g. congestion charges, parking restrictions). A related concern is the 'boomerang' or 'moral licensing' effect (Allcott, 2011; Andor and Fels, 2018; Richter et al., 2018), where people who know that they outperform the norm feel 'licensed' to relax their environmental behaviour, or make less effort in other domains, for example, by increasing energy use at home. This is consistent with the finding reported in Farrow et al. (2017), who note that communicating injunctive norms may have unwanted behavioural effects. All these issues underline the importance of policy experimentation to identify, reduce or minimise potential adverse effects.

From a methodological perspective, several aspects and limitations merit attention. First, while descriptive and injunctive norms were distinguished in experiment 1, we did not test an explicit descriptive norm in experiment 2. Therefore, further research is needed to examine the relative advantage of an injunctive norm in this particular case; including how and to what extent people actually perceive normative messaging (cf. Farrow et al., 2017). Consistent with the literature (Thøgersen, 2008), future research should also address the interaction between the two at the individual level (e.g. whether the adoption of CSS among current users does depend on descriptive and injunctive norms), including the presence of, and connections with social desirability bias, in which respondents provide 'socially acceptable' answers and do not report their 'true' preferences (King and Bruner, 2000). Further research (e.g. via a field experiment) is also needed to understand how social norms participate in decision-making processes related to transport mode choices (see Garcia-Sierra et al., 2015), and whether normative messaging can indeed generate boomerang effects. Whereas the focus of our study was on the difference between experimental groups (i.e. effect size) and refrained from analysing the prevalence of specific attributes in the larger Swedish population (e.g. income, household size), we do have to acknowledge that our sample is representative for gender only. This naturally imposes limits to external validity claims and warrants future studies with a nationally representative sample.[9]

Second, and as the reader may have noted, no manipulation checks were run. This methodological decision was taken for several reasons. For example, manipulation checks can function as an intervention and may alter or distort the effects of an experiment (Hauser et al., 2018). As our treatments conveyed different normative and value messaging, any checks could have interacted, amplified or even undone the (hypothesised) effects of the treatments. Furthermore, in the specific context of our research, we could not identify any study that clearly showed how manipulation checks were designed and implemented (see e.g. Raux et al., 2015; Riggs, 2017; Saleem et al., 2021; Zhang et al., 2015). Manipulation checks can also lead to Type I error, and undermine the effectiveness of randomisation (Kotzian et al., 2020). In fact, we were surprised to find that this procedure is an important source of uncertainty, and indicated as a methodological challenge in experimental social psychology studies (Ejelöv and Luke, 2020). Thus, and to the best of our knowledge, much more research is needed to assert whether manipulation checks are (or not) beneficial when experimenting with social norms and low-carbon mobility. Alternatives such as non-verbal, observational and behavioural measures (Hauser et al., 2018) should, however, be assessed as part of the experimental design.[10]

Third, the fact that our experiments were run during the COVID-19 pandemic (December 2020–January 2021) likely affected the preferences and mode choices of participants. It should be noted that in the second experiment, 41.5% of participants stated that they were using public transport 'less frequently than before the pandemic' (*Mdn* = 1), which seems to be consistent with an average reduction of 11% in

[9] Because the issue of sample representativeness has not been explicitly reported in previous (relatively) similar studies (see e.g. Bamberg et al., 2007; Kormos et al., 2015; Raux et al., 2015), we speculate that other researchers have probably confronted the same challenge.

[10] Something that we were not able to do due to a lack of resources and COVID-19 restrictions.

national demand for public transport in 2020 (Trafikanalys, 2021). These issues have several implications, including policy aspects. Logically, post-pandemic studies are needed to better understand the impacts of social norms on mode choices under 'normal' conditions. Furthermore, it can be argued that public transport may need to be incentivised among users once the pandemic is over –particularly if the preference for private car use bounces back from the 15% reduction in 2020 (Trafikanalys, 2021). Our study suggests that injunctive norms may be a way to achieve this. At the same time, our results regarding active travel indicate that better integration with public transport and car sharing will need to be the subject of further policy assessments (see also R6 and R7 in Table 5). In particular, this finding highlights that the economic and social benefits of active travel need to be integrated into social norm studies that address low-carbon mobility (cf. Kent, 2014; Smith et al., 2017).

5. Conclusion and policy implications

The objective of this paper was to better understand the policy implications of using social norms to promote the adoption of low-carbon mobility options. We used car sharing services (CSS) as an entry point and explored the potential impacts for low-carbon mobility in general. Given the lack of quantitative evidence in this area, our research was both confirmatory and exploratory in nature and we developed two randomised controlled experiments in Sweden. With due limitations, we found that injunctive social norms are effective in increasing the willingness to adopt both CSS and low-carbon transport options. Although the effect sizes were small, our results are consistent with previous studies that identify social norms as effective policy interventions. Our findings also suggest that concerns about potential substitution between low-carbon transport options and CSS are invalid. On the contrary, complementarities and the perceived environmental effectiveness of CSS and low-carbon mobility options –particularly active transport– play a significant role. The latter observation underscores that an ambitious and effective policy portfolio (involving e.g. performance standards, congestion charges, information campaigns) is crucially important for social norms to be effective, and foster behaviour change in the desired direction. In particular, our results suggest that if policymakers want to promote CSS via social norms, its environmental performance should be effectively measured, monitored and improved, and complementarities with public transportation and active mobility ensured. Our results confirm that addressing (or removing) barriers for behaviour change in low-carbon transport is a complex task, and that policy outcomes are often a function of user preferences, decision-making processes, mobility service characteristics, infrastructure, policy environments and the social context.

CRediT authorship contribution statement

Luis Mundaca: Conceptualization, Methodology, Formal analysis, Data curation, Visualization, Writing – original draft, Writing – review & editing. **Rocío Román-Collado:** Formal analysis, Writing – review & editing. **José M. Cansino:** Formal analysis, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.enpol.2022.112814.

Annex 1. Description of car sharing to the participants in Experiment 1

The original version of the text presented below was in Swedish. The sources used to develop this text are indicated in section 1, where the description of car sharing is also elaborated.

"*Car sharing is the practice of sharing access to a car for travelling (*e.g. *for commuting purposes) rather than drivers owning a car themselves.*

Car sharing services take various forms, for example:

- Two-way station-based, where available cars are parked in pick-up stations and trips must start and finish in the same place.
- One-way station-based, which is similar to a two-way use but the journey does not necessarily need to end at the same station.
- Free floating, where cars can be parked anywhere within an area served by an operator and the journey can start and end at any point within this area.

Car sharing services can be offered by companies (where there is a for-profit operator which owns and provides access to a fleet of vehicles), individuals (where access to cars is facilitated by an online platform, cars are owned by peers and are lent from user to user, often for profit) or cooperatives (where members get financing together to sustain a joint ownership of vehicle(s), often non-for-profit).

*Car sharing is a membership-based service available to all qualified drivers. Among others, factors affecting its adoption include price, type of service, availability and features of shared cars and convenience (*e.g. *distance to car, parking availability, booking system)*."

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