Who is ready to live a car-independent lifestyle? A latent class cluster analysis of attitudes towards car ownership and usage

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SHORT SUMMARY

The excess use of private cars for transportation has multiple negative effects on our society, and therefore, determining the underlying factors driving car usage among different groups of travellers could contribute to a more sustainable future. In this paper, we aim to identify and characterise traveller groups in terms of their car-related attitudes and how different sociodemographic attributes, behavioural characteristics (such as using cars as the primary mode of transportation), and their residential location accessibility vary amongst different population groups. Through Confirmatory Factor Analysis and Latent Profile Analysis we identify five different classes, namely car *detractors*, *hesitants*, *positives*, *friends*, and *lovers*. Overall, . We also see that the farther away households tend to be located from urban areas and public transportation facilities, the closer the relationship with cars. The results of this analysis will provide valuable insights into how to discourage the use of cars and promote more sustainable mobility.

Keywords: Car independence, car ownership, multi-modal transportation, latent profile analysis, sustainability

1. INTRODUCTION

Car usage, ranging from day-to-day commuting to weekend gateways, is playing a negative role in terms of traffic and climate change mitigation. This problematic situation is expected to continue increasing as road motor vehicles possession has been steadily growing in the last decade in OECD countries (OECD, 2022), in contrast to the hypothesis that car usage had reached a saturation point one decade ago (Goodwin & Van Dender, 2013). To address this problem, transport authorities improve and promote existing transportation alternatives such as public and active transportation options considering car drivers' perceptions (Abenoza et al., 2017; de Oña, 2022; Van Exel & Rietveld, 2010). The inherent idea behind this approach is that promoting better alternatives might make car users shift to more sustainable ways of mobility.

However, taking The Netherlands as an example, a country with excellent public transport infrastructure and plenty of safe and well-connected bike paths, private cars account for the majority (~40%) of the modal share in terms of the primary transport mode. Moreover, ~23% of those trips

are shorter than 2.5 km, and 40% are shorter than 5 km. In addition, there are several psychological aspects associated with the different dimensions related to travelling by car that influence the travel mode choice decision.

In this work, we aim to identify and characterise traveller groups in terms of their car-related attitudes and how different socio-demographic attributes, behavioural characteristics (such as using cars as the primary mode of transportation), and their residential location accessibility vary amongst different population groups.

2. METHODOLOGY

Our analysis is based on the Netherlands Mobility Panel (MPN) data, a representative sample of the adult Dutch population panel which every year gathers information at a personal, household, and a three-day travel diary (Hoogendoorn-Lanser et al., 2015). Given the Corona pandemic, we focused on the last even year before the start of the pandemic, 2018. In terms of the attitudinal questions, for each of the five modes analysed - car, train, bus/tram/metro (referred to as BTM, representing all urban public transport), bike, and walk - participants are asked about their overall opinion and about how they evaluate them in terms of being comfortable, relaxing, saving time, safe, flexible, pleasurable, and prestige. In addition, a set of 26 related to car usage and ownership experience were included in this specific wave in 2018. The final set of gathers 73 different attitudinal statements and 6,502 respondents answered all these questions in the sample. To handle the large number of attitudinal questions present in our dataset, we first carry out an exploratory factor analysis (EFA) to determine potential factors structures which we then use as a first step in composing a confirmatory factor analysis (CFA).

The Confirmatory Factor analysis resulted in a structure consisting of ten factors. These factors are related to the (i) convenience of cars, (ii) experience of driving, (iii) social status of car owners, (iv) own-car ideas, (v-ix) opinions on each of the five modes and (x) attitude to modal prestige. In general, car convenience is associated with ideas such as freedom, safety and how cars facilitate daily and personal activities, while driving experience is associated with the sense of control and adrenaline during driving. The social status factors are related to how people feel about having a car and the image it conveys to others, and the own-car ideas factor bundles those statements that pertain specifically to the possession of a car. Finally, there are five factors with similar characteristics, in which each respondent evaluates a series of seven attributes for the five different modes included in this study, while the prestige attributes are collected in the final factor.

Based now on these ten factors, we aim at estimating models for different numbers of subpopulations in order to study how these different groups differ in their relationship with cars, their sociodemographic characteristics, and the urban environment where they live. Since these factors are continuous variables (and not ordinal as the initial set of 73 statements), we estimate these groups through Latent Profile Analysis (Spurk et al., 2020). In the following, we use the term "classes" to refer to the different groups identified in the analysis. Afterwards, we characterize

each class based on its sociodemographic composition, and we explore if there are differences regarding their residential location choice and the corresponding accessibility.

3. RESULTS AND DISCUSSION

Since the constructed factors are continuous variables (and not ordinal as the initial set of 73 statements), we estimate these groups through Latent Profile Analysis (Spurk et al., 2020). In the following, we use the term "classes" to refer to the different groups identified in the analysis. As a result, all of the analyses presented in this study are based on probabilistic calculations. We select a five classes model because the marginal decrease in BIC goes under 2%, the smallest class is big enough to study, and also the class membership is stable.

Overall, the five different classes vary in the way they relate to cars. We arrange them so that their attitudes towards cars become increasingly positive from left to right. We name these five classes "*car detractors*", "*car hesitants*", "*car positives*", "*car friends*", and "*car lovers*", respectively. These names are based on the distribution of the ten different factors, which are described next. When we calculate the expected share of these five groups, we see a bell-shaped distribution cantered around the third class, "the positives", as presented in Figure 1.

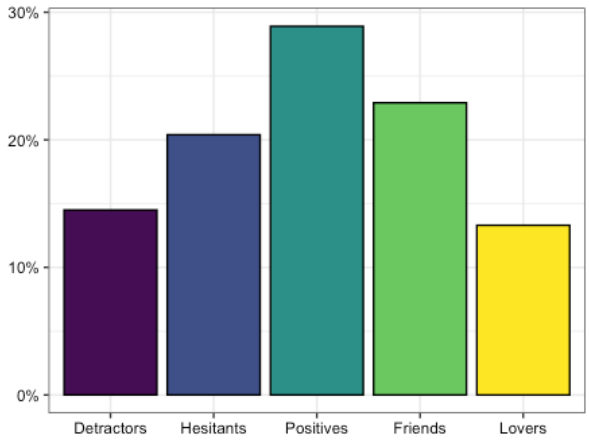

Figure 1. Classes' shares of sample respondents

In Figure 2, we present the 10th to 90th quantile range (grey line), the 25th and 75th quantile range (blue line), and the average (bullet) for each attribute and each class. The ten different factors obtained through the Confirmatory Factor analysis have the property that their respective average over the entire sample is fixed and equal to zero, denoted through a red dotted line in the figure. This property eases the comparison and allows us to identify differences among the latent groups. We also calculate and display the z-value for each attribute and class, assuming the null hypothesis of the mean being zero. We highlight in bold the z-values which imply significant differences from the sample average at the 95% confidence level.

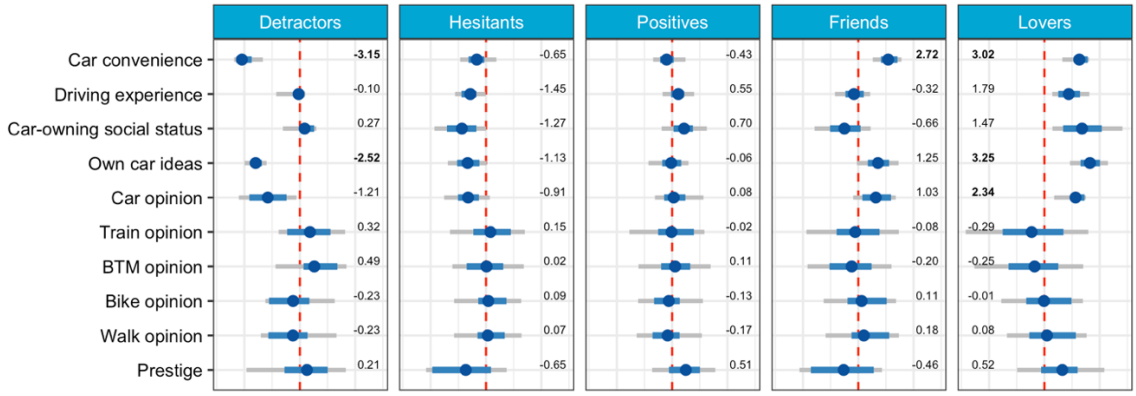

Figure 2. Factors distribution and share for each class

In general, we find that car convenience and attitudes towards both private cars and cars in general become more positive as we move from the *detractors* to *lovers*. *Detractors*, in comparison to other groups and the sample as a whole, report particularly low levels of convenience and positive opinions about cars. However, there are no significant differences between *detractors* and the overall sample with respect to driving experience and social status. Although not significantly different from the sample average, we observe that this group exhibits the highest appreciation for both trains and BTM among the different classes. *Hesitants* exhibit negative attitudes toward cars, but to a lesser degree than *detractors*. However, they have more negative attitudes towards the driving experience, social status, and the relevance of prestige factors. Together, these two groups make up 35% of the sample.

In addition, the distribution of these five classes is centred around what we denoted as *car positives*, as these individuals hold slightly positive attitudes towards driving experience, car-owning social status, and also towards modal prestige. This fact suggests that this class of users have a positive impression of what owning and using a car means. Interestingly, we found no significant differences between this class and the sample for any of the attributes.

The *car friends* group exhibits significantly more positive attitudes towards car convenience and car opinions compared to the other three groups already described and the sample as a whole. However, they do not share this positive attitude towards driving and social status, suggesting a potential willingness to consider alternative modes if they are similarly convenient. Conversely, *car lovers* display very positive attitudes towards cars across all variables and report more negative impressions of other modes, particularly trains and buses. These two groups together make up for just over 36% of the sample, and when including the more neutral but still pro-car *car positives* class, they account for 65% of the sample.

Afterwards, we are interested in the analysis of the socio-demographic composition of each identified latent class. This way, we can identify particular differences which might help us understand better who is represented by each of these attitudinal groups. To aid our analysis, we use Figure 3 to present the distribution of 13 attributes for each class, with a color code indicating the percentage-wise difference from the sample average. This visualization facilitates the identification of those attributes' levels that are either under- or over-represented in each class. Looking at

Figures 3a and 3b, which show *detractors* and *hesitants*, respectively, we see that there are no gender differences for detractors, but women are overrepresented amongst hesitants. The share of people older than 60 years old in both classes and younger people in the case of *detractors* is higher than in the sample as a whole. Both classes have a higher proportion of people who own a public transport card and fewer who never use bike as a means of transportation. Most *car* detractors do not own a car, whereas households who have only one car are overrepresented in the *hesitants* class. In terms of car access, *detractors* tend not to have a driving license, while households who have a car available but not freely accessible are overrepresented amongst *hesitants*. Both *detractors* and *hesitants* are characterized by a higher proportion of smaller households: with one and two persons per household, respectively. Regarding the central class, *car positives*, there is no evident difference between their socio-demographical distribution and the sample's average (Figure 3c).

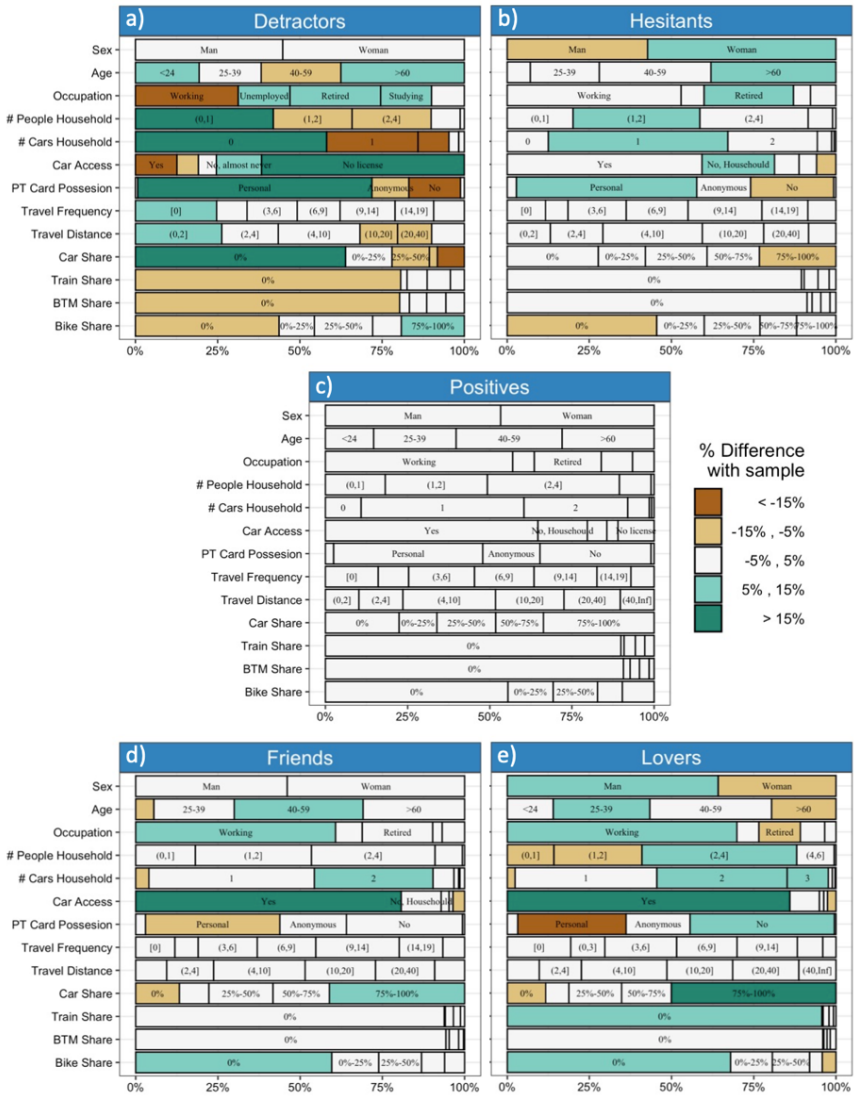

Figure 3. Socio-demographic characterisation of a) *car detractors*, b) *car hesitants*, c) *car positives*, d) *car friends*, and e) *car lovers*.

Figures 3d and 3e present the socio-demographic characteristics of *car friends* and *lovers*, respectively. *Car lovers* are predominantly male, while there is no gender difference for *car friends*. Both groups have a higher proportion of working-age people and households with at least two cars, and they also have greater car access than the overall sample. They are also less likely to own a personal public transport card and have a higher percentage of individuals who never bike. *Car lovers* also have a higher share of people who never use the train. There are no significant differences between these classes and the overall sample in terms of their travel distance and travel frequency.

The previous analysis does not take into account where each respondent lives. Therefore, we will examine the geographic distribution of the five latent classes across the Netherlands and how various urban environment variables are distributed within each class. This analysis is important as we expect that the factors that influence car usage affinity will vary depending on the built environment conditions. We calculate the distance between all households and the nearest urban area, train station, metro or express tram stop, tram stop, and bus stop (based on different frequency thresholds) and then average those based on class membership rates. The results of this analysis are presented in Table 1.

Table 1: Average and 10th to 90th quantile range of the distance to different locations for each the classes

Distance to	Detractors	Hesitants	Positives	Friends	Lovers
Urban area [km]	15.06 (1.7 - 35.1)	15.35 (2.2-35.0)	17.07 (2.5-37.1)	16.39 (2.8-35.4)	18.56 (3.3-38.3)
Train station [km]	3.07 (0.5-7.8)	3.55 (0.6-8.9)	3.87 (0.7-9.5)	3.79 (0.7-8.8)	4.09 (0.7-9.6)
Metro, express tram stop [km]	50.10 (0.9-132.4)	48.36 (1.6-122.8)	53.62 (2.0-128.0)	51.25 (2.0-125.4)	58.83 (2.3-133.4)
Tram stop [km]	54.37 (0.4-134.7)	53.857 (2.1-128.4)	59.09 (2.6-130.6)	57.36 (3.3-129.8)	64.50 (4.6-138.9)
Bus stop >4 /hr [km]	1.07 (0.1-2.7)	1.26 (0.1-3.3)	1.48 (0.2-4.2)	1.48 (0.2-4.4)	1.71 (0.2-5.4)
Bus stop >2 /hr [m]	460.04 (99.0-836.8)	549.48 (110.0-1057.6)	607.21 (113.0-1313.3)	612.87 (114.0-1345.7)	659.60 (113.0-1378.4)
Bus stop >1 /hr [m]	297.19 (94-515.94)	348.20 (103-587)	345.33 (104-603.4)	359.95 (103-610)	354.16 (99-656)
Bus stop [m]	275.21 (92.7-474.5)	307.93 (98.0-520.9)	304.64 (101.0-542.0)	313.01 (99.0-545.0)	307.51 (95.0-579.5)

The proximity of households to urban areas and public transportation facilities varies depending on the degree of affinity with cars: *detractors* and *hesitants* tend to be closest to urban areas, followed by *positives* and *friends*, while *lovers* tend to reside farther away. In terms of distance to the closest train station, *car lovers* are, on average, one kilometre (+33%) farther away than *detractors*. The situation is different for metro and tram stops, as *car lovers* are significantly

farther away from these facilities, while the other classes are comparatively closer to each other. Regarding bus stops, the frequency threshold is an important factor. Although there are no major differences between the classes for any bus stop, *car detractors* are significantly closer to high-frequency bus stops. This distance increases, as expected, for the other classes, particularly for *car lovers*.

Finally, we are also interested in the distribution of household location urbanization level and also the respondents' perceptions about parking and accessibility in their neighbourhoods. These results are presented in Table 2. The urbanization level varies from non-urbanized to very highly urbanized, while the scale used by respondents to indicate their opinions varies from strongly disagree to strongly agree.

Table 2: Responses distribution for different urban variables for each of the classes

Urban variable		Detractors	Hesitants	Positives	Friends	Lovers
Urbanization Level	Non urbanized	6.5%	7.3%	8.5%	9.2%	11.5%
	Low	15.9%	20.7%	23.2%	22.1%	24.4%
	Moderate	15.2%	17.3%	19.2%	18.3%	17.6%
	High	33.7%	31.0%	30.1%	32.0%	31.7%
	Very High	28.8%	23.7%	19.0%	18.4%	14.9%
My neighbourhood has a sufficient number of parking places	Strongly Disagree	5.7%	4.5%	3.8%	5.5%	5.5%
	Disagree	15.0%	15.4%	14.1%	14.9%	16.1%
	Neutral	18.1%	13.2%	13.4%	13.1%	11.7%
	Agree	32.6%	36.8%	39.2%	29.0%	23.6%
	Strongly Agree	24.0%	30.0%	29.0%	37.4%	42.6%
	Unknown	4.6%	0.1%	0.5%	0.1%	0.5%
My neighbourhood is easily accessible by car	Strongly Disagree	1.6%	1.1%	0.9%	1.1%	1.1%
	Disagree	4.1%	2.0%	1.9%	1.4%	2.1%
	Neutral	12.9%	4.0%	3.4%	2.3%	2.1%
	Agree	39.7%	38.9%	41.0%	20.8%	19.7%
	Strongly Agree	37.8%	54.0%	52.5%	74.4%	74.7%
	Unknown	4.0%	0.0%	0.2%	0.0%	0.4%
My neighbourhood is easily accessible by bicycle	Strongly Disagree	1.3%	0.9%	0.6%	0.5%	0.7%
	Disagree	2.0%	1.0%	1.6%	0.8%	1.4%
	Neutral	8.4%	0.9%	1.4%	0.8%	1.6%
	Agree	34.2%	31.5%	37.9%	16.9%	17.7%
	Strongly Agree	52.9%	65.5%	58.1%	80.7%	78.2%
	Unknown	1.2%	0.1%	0.4%	0.3%	0.4%
My neighbourhood is easily accessible by Public Transport	Strongly Disagree	5.6%	7.2%	5.3%	8.9%	7.9%
	Disagree	9.3%	13.1%	14.6%	14.2%	10.8%
	Neutral	16.8%	15.0%	16.7%	15.3%	17.4%
	Agree	37.8%	37.4%	38.4%	27.9%	27.1%
	Strongly Agree	29.1%	26.7%	23.4%	32.2%	35.0%
	Unknown	1.5%	0.6%	1.6%	1.5%	1.8%

Based on these results, *car detractors* and *hesitants* are more likely to live in highly- and very highly-urbanized areas, while *friends* and *lovers* are more likely to live in non- or low-

urbanization areas. In the case of parking facilities, respondents' answers are generally similar, except for *friends* and *lovers* who strongly agree more frequently with the statement that there are enough parking spaces in their neighbourhoods. When asked about accessibility by car, a considerable gap can be observed between *car lovers* and other classes. About 75% of *car lovers* or *friends* strongly agree that their neighbourhood is easily accessible by car, while this figure drops to under 40% for *car detractors*. A similar trend is observed for bike accessibility, where approximately 80% of *car friends* and *lovers* strongly agree that their neighbourhood has good bike accessibility, whereas only 53% of *detractors* do.

4. CONCLUSIONS

Based on the analysis of the distribution of ten latent attitudinal factors, we identify five different sub-population groups which vary in terms of car ownership and usage ideas. In addition, we can also observe differences in their sociodemographic characteristics. As expected, more positive car attitudes are associated with higher car ownership and access and reduced use of public transportation modes. Noticeably, there are no significant differences in terms of travel frequency and trip length distribution, which suggests the differences come mostly from modal preference and not from the associated activities.

The place where people live and their personal circumstances are also relevant variables when studying car ownership and usage. In summary, we observe that the farther away households tend to be located from urban areas and public transportation facilities, the closer the relationship with cars, and vice-versa. Thus, policies that either aim to restrict or reduce car use need to acknowledge that not every car user behaves the same: reactions will vary depending on their attitudinal characteristics.

We aim to continue this research by now analysing how these different groups of the population may differ in terms of relative access to opportunities. For example, we intend to identify groups of people who hold negative attitudes towards cars but don't have sufficient access to alternative modes of transportation. These individuals may feel like they have no choice but to rely on cars, even though they would prefer not to. By conducting this analysis, we aim to gain valuable insights into how to identify and address the barriers that prevent people from choosing more sustainable transportation options and ultimately lead to a more environmentally friendly and equitable society.

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