The role of attitudes toward the characteristics of bicycle commuting on the choice to cycle to work at various distances

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Summary

This paper analyses the influence of the attitudes towards bicycle characteristics (e.g. convenient, cheap, health) on the decision of being a commuter cyclist and on the decision to cycle to work every day. We assume that when the commute journey intensifies, either by distance or frequency, the attitudes towards cycling are more positive. Factor analyses revealed three underlying attitudinal factors towards cycling to work: awareness, direct trip-based benefit and safety. The decision to cycle to work is influenced by the factor 'direct trip-based benefit' at all distances, whereas the factor 'awareness' is only influential at long distances. The decision to cycle every day to work is again affected by the factor 'direct benefit'. The factors 'safety' and 'awareness' are important on shorter distances. Having a cycling habit increases the likelihood to cycle and to cycle with a higher frequency. The explaining power of the models on the bicycle mode choice is high. These findings indicate that attitudes and other psychological factors have a relatively strong impact on the commute bicycle mode choice.

1 Introduction

Recently, the bicycle has obtained a more prominent role in transport policy, due to the environmental and health benefits compared to the car. Developing policies to increase levels of cycling require knowledge of the determinants of bicycle commuting. Conventional research on bicycle mode choice is often based on utility theories, assuming that people decide the best possible transport mode available evaluating costs, time and effort. These studies offer insight in bicycle mode choice and the determinants of this choice taking 'hard' factors into account, such as socio-economics (for an overview see Heinen et al., 2010). These hard factors fail to explain why individuals in similar situations and with corresponding socio-economic characteristics make different decisions whether or not to cycle to work.

In this study, we expect that the bicycle commute mode choice decisions are also influenced by internal and social considerations, such as attitudes, norms and habits. The Theory of Planned Behavior (Ajzen, 1991) provides the base for the theoretical framework. This theory assumes that attitudes, the subjective norm, and the perceived possibility to perform a behavior affect the actual showing of a certain behavior. We also expect the influence of the value of bicycle characteristics to be more important for bicycle commute mode choice than for other transport modes, because we expect that people's opinions towards cycling are often stronger than opinions towards other transport modes.

Although at this moment there is research on the impact of attitudes on travel behavior, few studies focus on cycling behavior. In addition, existing research focuses mainly on the general attitude (the sum of all separate values) towards transport modes and does not specify the relation between the different attitudes and bicycle use. Moreover, the effect of attitudinal components of the transport mode in relation to the travel distance on mode choice and frequency is lacking in travel behavior research, and bicycling specifically. However, one would expect a relationship, namely that people with a more positive opinion towards cycling would (consider to) cycle over longer distances than individuals with a moderate or a negative attitude. To the authors' knowledge no research investigates the effect of a combination of attitudes and distance on bicycle use and bicycle frequency.

The first aim of this paper is to determine the differences in attitudinal components between cyclists and non-cyclists, and between full-time-cyclists and part-time-cyclist. The second aim is to analyze the influence of attitudinal factors on bicycle commuting at different distances. We assume that the attitude is more positive and plays a more prominent role as the cycling behavior intensifies, either by frequency or distance. We would expect that people with a more favorable attitude towards cycling and specifically, those who enjoy cycling more and attach more value to some of the outcomes such as health or environmental benefits, to cycle more often. Also a more positive attitude on certain attitudinal components would increase the likelihood to cycle over longer distances.

Bicycle commuting is defined as cycling the complete journey to work, and therefore individuals who cycle only a part of their commute journey are not considered bicycle commuters. This paper divides commuters in three groups. The first distinction is between cyclists and non-cyclists. The second distinction is made within the group of bicycle commuters. A commuter is considered a full-time-cyclist if this person cycle to work every working day. Individuals who alternate and only occasionally use the bicycle to travel the whole commute journey to work are considered part-time-cyclists.

2 Conceptual model

2.1 Framework

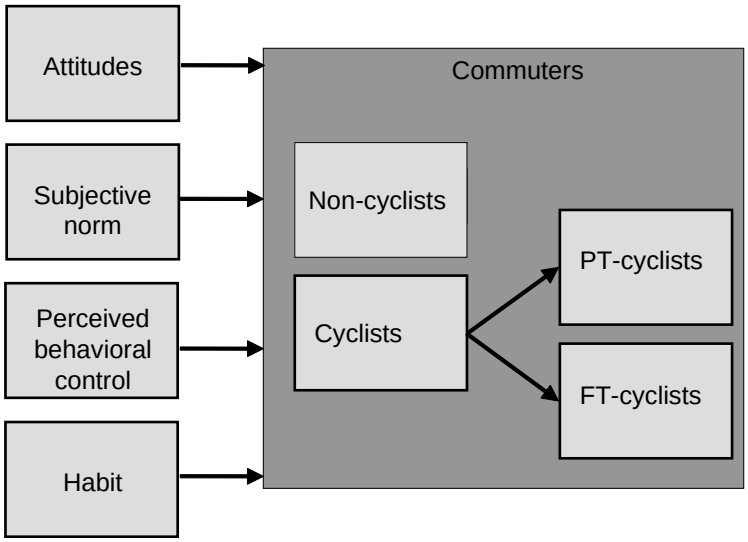
Physiological attitudinal theories provide the conceptual basis for this research. Handy (2005) has stressed that these attitudinal theories have obtained minor importance compared to economic theories in the study of travel behavior. However, previous research has found attitudes, norms and habit significantly influencing bicycle use (Gatersleben and Appleton, 2007; Gatersleben and Uzzell, 2007). Our prior research also suggests that such factors influence bicycle mode choice and should get more attention in bicycle research (Heinen et al., 2010).

We expect three factors of the theory of planned behavior-attitudes, subjective norm and perceived behavioral control-to influence bicycle commuting (Figure 1). We follow the definition of Ajzen (1991) of attitudes. He defines attitudes as 'the degree to which performance of the behavior is positively of negatively valued'. The subjective norm is the perceived social expectancy to perform a certain behavior and the perceived behavioral control is the individual perception of the possibility to engage or not engage in a certain behavior. We also included habit in this research. The inclusion of habit implies that we assume that not all decisions to commute by bicycle are made after a rational evaluation of alternatives, but assumes that past behavior and behavior in other travel situation affects the bicycle commute mode choice. Evidence is available that not all decisions are made after rational evaluation of alternatives. To illustrate this, Bamberg and Schmidt (2003) found that respondents do not take every factor into consideration when making a decision with repetitive travel behavior. Verplanken et al. (1997) show that people investigate less information about their transport choice if they have a habit relating to the behavior.

Most travel studies define mode choice as the mode that is usually taken to work, the mode that is used for the main part of the journey, or the mode that is taken on a particular day. This entails making the implicit assumption that commuters use the same mode of transport every day. While this is not true in general, it is even less true of cyclists, who are more dependent on a number of daily changing factors, such as the weather, the need to transport loads, and so on. We therefore analyze how attitudes influence both full-time and part-time bicycle commuting. A full-time bicycle commuter is defined as someone who cycles to work every working day, while a part-time commuter cycles to work at least once a year. In addition, we limit our analysis to commuters who cycle the entire distance from home to work. We thus do not include commuters who use the bicycle for part of a journey, such as for travelling to the railway station.

Non-attitudinal characteristics of individuals (such as gender, age) and the built environment are not explicitly included in the conceptual model, as it is assumed that attitudes are (partly) derived from these characteristics. For example, a woman needing to travel by night through isolated areas might not feel safe enough to cycle or her social surrounding might discourage her. As a result of her circumstances-working at night, being female, and her built environment-her attitudes towards cycling to work are affected.

Figure 1: Research model



2.2 Distance

Distance is a main factor in the decision to cycle (Heinen et al., 2010; Dickinson et al., 2003; Timperio et al., 2006; Parkin et al., 2008). Some research only investigates travelers whose journey is shorter than an arbitrary chosen distance. This decision is defensible as most cycling trips are made until 10-15 kilometers. Other research includes distance as a continuous independent variable. The advantage of this method is that the outcome of a model shows the effect of every kilometer increase in distance. However, Van Wee et al. (2006) has argued that an increase in distance disproportionately discourages travelers to cycle as the physical effort needed also increases disproportionately. Moreover, Keijer and Rietveld (2000) show that at very short distances-until 2 kilometers-the bicycle is a less attractive mode of transport as many people choose to walk based on Dutch statistics for journeys to and from the railway station. These findings indicate that the decision to cycling may be affected by different attitudes and after the evaluation of different characteristics at different distances. It also shows that the effect of distance on cycling is not linear. We assume that cycling at shorter distances is affected by different attitudes than cycling at longer commutes. Commuters who cycle over longer distances are more likely to have favorable opinions towards cycling compared to short-distance bicycle commuters. These long-distance cyclists are assumed to attach more value to beneficial effect of cycling compared to car-commuting, such as the environment and their physical health instead of more practical reasons such as travel time. Therefore, we analyze the effect of attitudes on bicycle commuting for three distance groups: short distances from below 5 kilometers, medium-length distances between 5 and 10 kilometers, and longer distances from 10 kilometers and above.

3 Research methods

3.1 Data collection

In 2008, we collected data through an internet survey in The Netherlands. This survey was conducted among a sample of employees of several large employers in Delft en Zwolle and residents of Delft (population 100,000), Zwolle (population 115,000), and two adjacent municipalities to Delft: Midden-Delfland (population 17,000) and Pijnacker-Nootdorp (population 38,000). Delft is a university town in the western part of the Netherlands, positioned in the south-west of the Randstad, a polycentric strongly urbanized area. Zwolle is a city outside this urban conurbation and has a large higher vocational education student population. Both cities (as many other Dutch cities) have many bicycle facilities, such as separate bicycle infrastructure. Both cities have a higher than Dutch average cycling percentage. The selection of the cities was based on the relative high chance of the participation of commuter cyclists and the different location within the Netherlands, possibly resulting in a difference in attitudes towards cycling. The respondents were approached in two ways. First around 3,500 invitation e-mails were sent to employees. We asked the employer to urge the employees to participate via e-mail and intranet. A chance of 40 lottery tickets worth 12 Euros was offered as an incentive. Secondly, residents were approached by post, using the local authorities address data. The addressees were randomly selected from the inhabitants between 18 and 65 years old, because of the focus on commuting. Possible respondents under 18 would lack the option of a car and 65 is the retirement age in the Netherlands. In total, 22,000 letters were sent (10,000 in Delft; 6,000 in Zwolle; 3,000 in Midden-Delfland; and 3,000 in Pijnacker-Nootdorp). With a response of 2,929 out of 22,000, the response rate was 13.3% among residents. 1,370 employees responded of the 3,500 requests, resulting in a 39% response rate. The total response rate is 16.9 percent. The questionnaire was presented as a survey on the commute mode choice. The specific focus on bicycle use was kept unknown to the respondents in order to avoid a bias towards cyclists or people with a favorable opinion towards cycling.

3.2 Variables

Table 1 provides an overview of the variables in our analysis. In this research we focus on the attitudinal components. We define attitudes towards bicycle commuting as the sum of all opinions towards the (bicycle) characteristics multiplied by the attached importance of these characteristics. The opinions of the characteristics were measured using 5-point Likert scales on a scale ranging from completely disagree (-2) to completely agree (+2), with questions such as “For me, cycling the whole journey to work is mentally relaxing”. Based on a literature review the following characteristics are selected (Heinen et al., 2010): environmental friendly, mentally relaxing, physical relaxing, comfortable, time saving, flexible, cheap, pleasant, privacy offering, status providing, healthy, safe traffic wise, socially safe and agreeing with their lifestyle. The importance attached to these opinions by the individual was asked by questions such as “For me it is important that my commute transport mode is mentally relaxing”. Respondents could answer these questions on a scale from not important at all (1) to very important (5). By multiplying the scores on the questions of the opinion and the importance of each aspect, we constructed the attitude towards the bicycle commute characteristics. The attitude towards bicycle commuting characteristic carries between -10 and +10.

The subjective norm is measured following the theory of planned behavior (Ajzen, 1991) and was asked after by the question “To what extent do important people in your surroundings think you should travel by bicycle to work”. Respondents could answer from “not at all” (1) to “completely” (5) on a five point scale. The perceived behavioral control is one’s own evaluation of the possibility to cycle to work. Respondent answered the question “To which degree do you consider it possible to travel your whole commute journey by bicycle?’. This variable was measured on a 5 point scale, from “not at all possible” (1) to “very much possible” (5). Finally, the bicycle habit is constructed following Verplanken et al. (2007). We ask which transport mode would be most likely to be used for ten different occasions, such as visiting friends and daily shopping. The amount of questions answered with “by bicycle” was counted.

Table 1: Overview of variables

		Mean	Std. Dev.
opinion on cycling to work	status providing	-0.80	1.12
	environmental friendly	1.65	0.81
	mentally relaxing	1.24	0.99
	physically relaxing	0.95	1.17
	comfortable	-0.01	1.17
	timesaving	-0.28	1.37
	flexible	0.46	1.31
	cheap	1.45	0.96
	pleasant	0.82	1.19
	privacy offering	0.12	1.17
	healthy	1.51	0.88
	traffic safe	0.30	1.11
	socially safe	0.25	1.05
	lifestyle	0.52	1.22
importance	status giving	1.76	0.96
	environmental friendly	3.62	0.89
	mentally relaxing	3.82	0.84
	physically relaxing	3.79	0.84
	comfortable	3.98	0.74
	timesaving	4.16	0.78
	flexible	4.20	0.75
	cheap	3.74	0.91
	pleasant	4.10	0.73
	privacy offering	3.38	1.03

	healthy	3.80	0.85
	traffic safe	3.90	0.84
	socially safe	3.66	0.92
	lifestyle	3.38	1.10
attitude towards bicycle characteristic	status providing	-1.16	2.18
	environmental friendly	6.13	3.37
	mentally relaxing	4.93	4.10
	physically relaxing	3.83	4.74
	comfortable	-0.08	4.91
	timesaving	-1.30	6.01
	flexible	1.94	5.76
	cheap	5.57	3.95
	pleasant	3.48	5.15
	privacy offering	0.50	4.21
	healthy	5.88	3.72
	traffic safe	1.26	4.61
	socially safe	0.95	4.22
	lifestyle	1.99	4.73
habit		4.39	2.71
subjective norm		3.11	1.34
perceived behavioral control		3.39	1.70

The opinion towards cycling to work is on average positive. The opinion towards cycling to work is an average negative for the characteristics: status giving, timesaving and comfort. Most of the factors questioned are considered important. However, most respondents do not put much importance on the status that their commute mode choice might provide them. Most respondents use their bicycle occasionally, as is reflected in their bicycle habit. On average, respondents stated that they would use the bicycle 43% of the ten hypothetical occasions. This also means that for most situations another mode of transportation is chosen. Respondents reported a slightly positive score on subjective norm. This indicates that on average, the respondents feel that other people think positively towards the respondent cycling to work. The score above 3 on 'perceived behavioral control' indicates that most respondents perceive it as possible to cycle to work. However, individual differences are large on all items.

4 Results

This section presents the results of the analyses. Section 4.1 discusses the descriptive analyses and investigates the relationship between the attitude towards the different bicycle characteristics (attitudinal components), commute distance and bicycle commuting. Section 4.2 shows the results of the factor analysis on the attitudinal components in order to reveal the underlying attitudinal factors. In the third part of this section multiple logit models are tested in order to explain bicycle commuting. Section 4.4 describes the link between socio-economic variables and the constructed factors. These analyses enable us to make connections between personal measurable characteristics, such as gender and age, and their attitudes towards cycling.

4.1 Descriptive analyses of values, importance and attitudes towards bicycle commuting

Cyclists evaluate bicycle characteristics on average more positive compared to non-cyclists. They consider especially cycling more frequently environmental friendly, mentally and physically relaxing, comfortable, timesaving, flexible, cheap, healthy, pleasant and matching with their lifestyle in comparison to non-cyclists. FT-cyclists also evaluate bicycle characteristics generally more positive than PT-cyclists. FT-cyclists show more often a

positive opinion towards cycling on the characteristics mentally and physically relaxing, comfortable, time saving, flexible, cheap, pleasant, good, and matching with their lifestyle compared to PT-cyclist. Moreover, cyclists in general consider it important that their commute mode choice is environmental friendly, mentally and physical relaxing, cheap and healthy, but are less caring for comfort levels, time saving benefits and flexibility of their commute mode. These findings indicate that one's opinion towards characteristics of bicycle commuting and the importance of these characteristics of their commute mode choice are not always consistent.

Table 2 provides an overview of the means of the attitudinal bicycle commuting components and shows that cyclist compared to non-cyclists have significant higher means on all characteristics. Similarly, FT-cyclists have on average higher means than PT-cyclists. These findings indicate that individuals who have a more intense bicycle commute journey also evaluate bicycle commuting more positively. It remains, however, uncertain if the more positive attitudes result in the activity, cycling to work, or if the activity of cycling to work result in more positive attitudes.

The results could also be an outcome of commute distances. Thus, this influence of the commute distance on attitudes is investigated. An increase in distance corresponds with a decrease in the means of attitudes towards the different bicycle characteristics. The characteristics comfort, time saving, flexible, cheap, pleasant and corresponding with one's lifestyle show a significant decrease between the commute distance groups under 5 kilometer, between 5 and 10 kilometer and over 10 kilometer. The characteristic privacy, however, seems not distance sensitive. Looking at the cycling intensity, Table 3 shows that non-cyclists have significant lower means on attitudinal components compared to cyclists, if distance is taken into account. A similar relation is present between FT-cyclists and PT-cyclists, although the characteristics status giving, privacy offering, healthy, traffic safe and environmental friendly are only significant on some commute distances (Table 4). The choice to cycle every day seems to be affected by comfort, time, flexibility, costs, pleasantness, social safety and the correspondence with one's lifestyle. Moreover, the choice to cycle to work and the choice to cycle to work every working day seems partly depending on similar bicycle attitudinal characteristics.

Table 2: Mean of attitudinal characteristics per type of cyclist

	non-cyclists (2590)		cyclists (1709)			part-time cyclists (983)		full-time cyclists (726)		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
status giving	-1.37	2.29	-0.84	1.95	*	-0.95	1.83	-0.69	2.09	*
environmental	5.66	3.43	6.84	3.15	*	6.52	2.96	7.28	3.34	*
mentally relaxing	4.14	4.27	6.13	3.51	*	5.76	3.39	6.63	3.62	*
physically relaxing	2.93	4.84	5.19	4.23	*	4.60	4.25	5.99	4.08	*
comfortable	-1.37	4.89	1.89	4.24	*	1.06	4.07	3.01	4.20	*
timesaving	-3.30	5.72	1.72	5.10	*	0.10	4.91	3.90	4.51	*
flexible	0.42	5.99	4.26	4.50	*	3.27	4.58	5.61	4.02	*
cheap	5.00	4.18	6.44	3.40	*	5.98	3.30	7.07	3.43	*
pleasant	1.99	5.37	5.73	3.81	*	5.23	3.70	6.41	3.86	*
privacy offering	0.15	4.41	1.05	3.81	*	0.76	3.59	1.43	4.07	*
healthy	5.16	3.89	6.96	3.17	*	6.70	2.94	7.33	3.41	*
traffic safe	0.62	4.59	2.24	4.48	*	1.76	4.24	2.88	4.72	*
socially safe	0.35	4.22	1.84	4.05	*	1.30	3.71	2.58	4.36	*
lifestyle	0.43	4.56	4.35	3.93	*	3.50	3.68	5.51	3.96	*

paired sample t-test shows a significant difference * ($p<0.05$) between cyclists and non-cyclists; and part-time and fulltime cyclists

Table 3: Attitudinal of characteristics for non-cyclists and cyclists divided by distance categories

	NC									C					
	<5			5-10			>10			<5		5-10		>10	
	Mean	SD		Mean	SD		Mean	SD		Mean	SD	Mean	SD	Mean	SD
provides status	-1.18	2.30		-1.21	2.25	*	-1.45	2.28	**	-0.90	1.92	-0.94	1.98	-0.36	1.91
environmental benefits	5.88	3.40	**	5.90	3.51	**	5.58	3.34	**	6.86	3.13	6.81	3.24	6.87	3.03
mentally relaxing	4.54	4.04	**	4.24	4.41	**	4.01	4.30	**	5.90	3.52	6.45	3.66	6.69	2.96
physically relaxing	3.75	4.57	**	3.12	4.82	**	2.62	4.91	**	5.21	4.06	5.28	4.42	5.12	4.37
comfortable	0.20	4.85	**	-1.47	4.85	**	-1.88	4.76	**	2.28	4.20	1.49	4.26	0.94	4.05
time-saving	-0.23	5.62	**	-3.27	5.27	**	-4.38	5.46	**	3.09	4.62	0.22	4.90	-1.72	5.07
flexible	1.82	5.37	**	0.85	5.65	**	-0.18	6.15	**	4.82	4.14	3.87	4.73	2.51	5.02
cheap	5.47	3.95	**	5.05	4.04	**	4.85	4.23	**	6.74	3.29	6.18	3.57	5.62	3.43
pleasant	3.15	4.90	**	2.04	5.19	**	1.59	5.49	**	5.71	3.75	5.85	4.02	5.69	3.64
offers privacy	0.01	4.20	**	0.09	4.38	**	0.21	4.48	**	0.69	3.76	1.29	3.83	2.19	3.67
health benefits	5.53	3.99	**	5.55	3.59	**	4.96	3.87	**	6.88	3.17	7.13	3.27	7.11	2.87
traffic safety	1.18	4.74	**	0.88	4.62	**	0.37	4.46	**	2.46	4.54	2.14	4.28	1.51	4.61
socially safe	0.75	4.25	**	0.40	4.42	**	0.23	4.10	**	1.96	4.08	1.76	4.01	1.62	3.89
lifestyle	1.48	4.66	**	0.26	4.49	**	0.12	4.48	**	4.42	3.88	4.31	4.16	4.19	3.64

paired sample t-test shows a significant difference **(p<0.05), *(p<0.1) between cyclists and non-cyclists at similar distances

Table 4: Attitudinal of characteristics for full-time and part-time cyclists divided by distance categories

	PTC									FTC					
	<5			5-10			>10			<5		5-10		>10	
	Mean	SD		Mean	SD		Mean	SD		Mean	SD	Mean	SD	Mean	SD
provides status	-1.13	1.76	**	-1.03	1.90		-0.40	1.82		-0.70	2.04	-0.74	2.13	-0.13	2.35
environmental benefits	6.40	3.05	**	6.53	2.87	**	6.77	2.87		7.27	3.14	7.39	3.84	7.39	3.79
mentally relaxing	5.22	3.40	**	6.13	3.46	**	6.58	2.96		6.52	3.52	7.09	3.97	7.29	2.93
physically relaxing	4.32	4.03	**	4.92	4.36	**	4.92	4.43	*	6.02	3.92	6.02	4.47	6.21	3.93
comfortable	1.33	4.00	**	0.94	4.17	**	0.57	3.94	**	3.15	4.18	2.63	4.23	2.97	4.06
time-saving	1.65	4.52	**	-0.82	4.66	**	-2.46	4.72	**	4.40	4.30	2.34	4.72	2.32	5.07
flexible	3.80	4.15	**	3.11	4.87	**	2.19	4.96	**	5.75	3.92	5.41	4.03	4.29	5.04
cheap	6.23	3.28	**	5.93	3.24	**	5.38	3.43	**	7.21	3.22	6.69	4.14	6.89	3.17
pleasant	4.96	3.60	**	5.53	3.89	**	5.47	3.60	**	6.39	3.76	6.50	4.21	6.89	3.63
offers privacy	0.06	3.31	**	1.08	3.80		2.04	3.51		1.27	4.04	1.73	3.86	3.00	4.44
health benefits	6.41	3.06	**	7.00	2.75		6.98	2.86	*	7.30	3.22	7.40	4.14	7.82	2.87
traffic safety	1.80	4.29	**	2.04	4.01		1.26	4.47	*	3.07	4.68	2.34	4.79	2.84	5.19
socially safe	1.27	3.70	**	1.46	3.81	**	1.26	3.56	**	2.60	4.31	2.38	4.35	3.61	4.96
lifestyle	3.26	3.57	**	3.57	3.96	**	3.88	3.49	**	5.47	3.86	5.81	4.16	5.89	4.02

paired sample t-test shows a significant difference **(p<0.05), *(p<0.1) between full-time and part-time cyclists at similar distances

4.2 Factor analysis on bicycle attitudinal characteristics

This section aims at indentifying the main bicycle attitudes by factor analysis. The included attitudinal characteristics as described in section 4.1 are tested for underlying constructs. We deleted the characteristic 'status giving' from the analysis, based on the low communality (<0.3). Therefore, we continued with 13 remaining characteristics. We found three factors using the Oblimin method, with delta 0, which explained almost 66% of the variance (see Table 5). This method provided interpretable factors and has the advantage over orthogonal rotations such as the Varimax method that the factors can correlate with each other, which is in social sciences expected (Hair, 2006). 'The use of orthogonal rotation results in a loss of information if the factors are correlated' (Costello and Osborne, 2005, p 3), which can be expected among attitudes towards cycling.

The first factor is labeled 'direct trip-based benefit' as it is mainly constructed by the characteristics timesaving, comfortable, and to a lesser extent flexible and pleasant. The variables with high scores on the second factor are environmental friendliness, healthy and mentally relaxing. Therefore, the second factor is labeled 'awareness'. The third factor has high scores on socially safe and traffic safe, and therefore is labeled 'safety'.

Table 5: Factor scores of the attitudes towards bicycle characteristics

	Factor		
	direct benefit	awareness	safety
comfortable	0.712		
flexible	0.658		
mentally relaxing		-0.717	
healthy		-0.774	
cheap		-0.559	
lifestyle	0.530		
physically relaxing	0.313	-0.527	
environmental		-0.822	
pleasant/nice	0.554	-0.367	
privacy offering			0.315
socially safe			0.917
timesaving	0.815		
traffic safe			0.746

Values below 0.3 are not reported

4.3 Factors influencing bicycle commuting

This section discusses the effect of attitudes and factors on the decision to commute by bicycle to work. Additionally the decision to commute by cycle to work every day instead of alternation of mode of transportation is tested by binary logit models. The factors are calculated by the Anderson-Rubin scores of the factor analyses. The advantages of this method to construct factor scores are that 'factor scores have reasonably high correlation with their estimated factor' and 'factor scores have a mean of 0 and a standard deviation of 1' (Distefano, Zhu and Mîndrilă, 2009, p. 9). According to Scott Long and Freese (2006), the McKelvey-Zavoina ρ^2 is the best approach for explaining the proportion of variation for binary logit models of the available measures of fit. The reported odds ratios can be interpreted as the chance that someone chooses to cycle after a one-unit change in a predicting variable. For example, an odds ratio of 1.1 for a specific factor indicates that with every point of

increase in that factor, the chance of that person being a cyclist (as opposed to being a non-cyclist) increases, and well by multiplying with 1.1. We should note that some factors correlate with other variables.

Table 6 shows the effect of habit, the subjective norm, perceived behavioral control and the constructed factors on the chance to commute by bicycle in the three distance categories. Individuals, who indicated to cycle for many other purposes, have a higher chance as well to cycle to work at all distances. A positive perceiving of the possibility to cycle to work also affects the choice to cycle to work positively. On every distance, people are more likely to cycle if they perceive this activity as possible. However, the subjective norm only influences the decision to commute by bicycle on short distances. On longer distances workers are not affected by their perception what their social environment expect them to travel with. This indicates that cycling over longer distances is a decision made based on individual consideration, not taking opinions of others into account. On shorter distance workers are influenced by opinions of others. The constructed factor 1 (direct benefit) influences the choice to cycle on every distance. The more individuals consider the bicycle beneficial in terms of timesaving, comfort and flexibility and simultaneously attach importance to these benefits, the more often they are commuter cyclists. On commute distances between 5 and 10 kilometers and above 10 kilometers, a higher score on the factor 'awareness' results in a higher chance to cycle to work. This finding indicates the awareness of the effect of their cycling behavior on the environment and health stimulates cycling on more intense commute trip in terms of distance.

Table 7 reports the outcome of the binary logit models analyzing the effect to cycle every day to work. The habit to cycle influences the chance to cycle full-time to work positively, similar to the decision to cycle at all. Cyclists are more inclined to cycle to work every day at all distances if they cycle for other purposes as well. The subjective norm towards cycling only affects the cycling frequency of cyclists living within 5 kilometers from their working location. The own expectation of the possibility to cycle does not at all influence the commute cycling frequency. This finding is as expected, because a person is likely to consider cycling to work possible in order to cycle, but to cycle on a daily basis he or she considers other characteristics which might prevent a commuter to cycle on a specific day. The factor 'direct benefits' strongly influences the decision to cycle on a daily basis. With every point increase in this factor the chances of cycling more than double. Moreover, on commute distances shorter than 5 kilometer and longer than 10 kilometer, a high score on the factor safety results in a higher probability to cycle every day to work. This means that individuals considering cycling not at all dangerous and do not attach importance to safety-either traffic safety or social security-are more likely to cycle every day to work than individuals who consider cycling an unsafe transport mode. It remains uncertain why safety concerns do not affect commute cycling on distances between 5 and 10 kilometer. The factor 'awareness' is important in the decision on short distances until 5 kilometers. This indicates that individuals who consider cycling environmental friendly, healthy and mentally relaxing are more inclined to cycle to work every working day. This positive perception of cycling does not affect this choice on longer distances however.

The explanation power of the model of the bicycle mode choice model is higher than the explaining power of the models of the individual choice to cycle to work part-time or full-time. This means that the decision too cycle to work is explained to a large extent by psychological factors, such as attitudes, norms and habit. This finding provides evidence to the importance of the psychological factors on bicycle mode choice and the need of including these factors in future analyses. Additionally, The explanation power of the models of a commute distance of 10 kilometers or more is the highest. This indicates that the attitudes, habit and norms are more influential on longer distances to the bicycle mode choice and bicycle frequency. This confirms the hypothesis that commuters with a more intense bicycle commute journey and still cycling to work, have more positive attitudes towards bicycle commuting.

As we used two different approaches to collect data-among inhabitants and among employees-we tested the influence of the data collection method on bicycle commuting.

Tested with bivariate analyses the data collection method was only significant on distances below 5 kilometers on the cycling frequency. Among the commuter cyclists the participants recruited among the inhabitants are more likely to cycle full-time compared to participants recruited among the employees with commute distances below 5 kilometers. Including the data collecting method in the full logit model resulted in an insignificant effect, meaning that the two data collections did not have a significant effect on the outcomes.

Table 6: Cycling to work

	<5km					5-10km					10>km				
	Odds Ratio	SE	z	P>|z|		Odds Ratio	SE	z	P>|z|		Odds Ratio	SE	z	P>|z|	
habit	1.154	0.03	5.50	0.000	**	1.077	0.04	2.07	0.038	**	1.106	0.04	2.78	0.005	**
subjective norm	1.102	0.06	1.90	0.058	*	1.115	0.08	1.47	0.142		1.119	0.09	1.38	0.169	
pbc	2.293	0.17	11.32	0.000	**	2.497	0.26	8.84	0.000	**	2.925	0.20	16.02	0.000	**
FAC1	1.747	0.15	6.65	0.000	**	1.984	0.22	6.18	0.000	**	1.681	0.18	4.79	0.000	**
FAC2	0.970	0.07	-0.44	0.661		0.834	0.08	-1.99	0.047	**	0.563	0.07	-4.90	0.000	**
FAC3	1.099	0.07	1.45	0.146		0.966	0.09	-0.38	0.704		0.989	0.10	-0.11	0.910	
	n=1531					n=784					n=1863				
	r2=0.35					r2=0.47					r2=0.56				

p<0.1 *; p<0.05 **

Table 7: Full-time or part-time commute cycling

	<5km					5-10km					10>km				
	Odds Ratio	SE	z	P>|z|		Odds Ratio	SE	z	P>|z|		Odds Ratio	SE	z	P>|z|	
habit	1.118	0.03	3.84	0.000	**	1.182	0.06	3.17	0.001	**	1.209	0.11	2.18	0.029	**
subjective norm	1.114	0.06	1.94	0.053	*	1.145	0.11	1.40	0.162		0.933	0.16	-0.40	0.692	
pbc	1.164	0.15	1.17	0.241		1.402	0.35	1.53	0.177		1.500	0.37	1.62	0.105	
FAC1	2.184	0.23	7.54	0.000	**	2.166	0.37	4.58	0.000	**	2.288	0.65	2.90	0.004	**
FAC2	0.845	0.07	-2.14	0.032	**	0.943	0.12	-0.47	0.640		0.991	0.25	-0.04	0.971	
FAC3	1.256	0.09	3.32	0.001	**	0.974	0.12	-0.22	0.829		1.432	0.27	1.91	0.057	*
	n=1027					n=391					n=248				
	r2=0.16					r2=0.19					r2=0.26				

p<0.1 *; p<0.05 **

4.4 Attitude and socio-demographics

Knowledge about the relationship between the constructed factors and socio-demographics is useful to target policies. Therefore, regression analysis is conducted to test the relation between the three factors and socio-demographic variables: age, gender, car ownership (yes-no), after-tax income per month (<1500€; 1500-3000€, >3000€), having a partner (yes-no), and having children within the household (yes-no).

The explaining power of the conducted regression analyses is low: 2%, 7%, and 1% for factor 1, 2 and 3 respectively. This indicates that most factors can be limited explained by socio-demographics. Moreover, the increase in explaining power of the logit models is also limited with the inclusion of socio-demographics. These findings indicate that the attitudinal factors offer an additional explanation for the reason to commute by bicycle and the cycling frequency.

5 Conclusion

5.1 Summary & Discussion

This paper investigated the effect of attitudes on bicycle commuting. We have investigated the relationship of attitudes on the chance of being a cyclist and the cycling frequency,

controlling for distance. Data were collected via an internet survey in the Netherlands with over 4,000 respondents, including 1,600 cyclists. Factor analysis shows that three factors can be constructed out of the attitudes: direct benefit, awareness and safety.

Results indicate that attitudes are very influential in the decision to be a commuter cyclist. Also the choice to cycle to work on a daily basis is affected by personal attitudes. The explaining power of the model is high, which indicates that attitudes explain bicycle commuting to a large extent. The most important factor is the 'direct trip-based benefit', which indicates that individuals base their bicycle mode choice decision to a large extent on direct benefits in time, comfort and flexibility. Individuals who commute over longer distances have on average a more positive attitude towards bicycle commuting than respondents who cycle over shorter distances. These results support our hypothesis that individuals have a more positive attitude as the bicycle commute behavior intensifies.

The cause-and-effect between attitudes and bicycle commuting is uncertain. We can not conclude that this relation is causal as a result of the analyzing methods. Besides of the explanation provided by us, that a positive attitude results in more intense cycling behavior, it could well be that a more intense cycling behavior will result in more positive attitudes towards cycling to work.

This study is conducted in the Netherlands, known for high cycling rates and an in general positive attitude towards cycling. This research location might have affected the research outcomes. The importance of the factor safety might be higher in countries lacking bicycle infrastructure. In countries where the bicycle is not a main transport mode the factor direct benefit might be less and the factor awareness more influential. Nevertheless, this study shows that in a country where the bicycle is a common transport mode the practical aspects are still influence the commute mode choice most, but awareness of long-term effect and safety do affect bicycle commuting as well. .

5.2 Research and policy recommendations

The importance of the factor 'direct trip-based benefit' indicates that individuals decide to cycle based on very practical considerations: time, comfort and flexibility. Policy makes could increase the speed of a bicycle journey and its comfort by providing better and more direct infrastructure, direct routes and short waiting time at crossings among other measures.

Our analyses have shown that the attitude of a person explains this persons' decision to cycle. Therefore, emphasizing the benefits of cycling could result in more awareness of these 'direct trip-based benefits' in a more positive attitude and simultaneously a higher number of commuters and a higher cycling frequency. The significance of the factor 'awareness' on the choice to cycle to work indicates that individuals who consider health, environment and mental relaxation important are more likely to cycle on long distances. Stressing both the personal importance of cycling to work (health) as the societal benefits (environment) might change individuals' attitudes and simultaneously their behavior. In case of short commuting distances this awareness had no effect, indicating that most short distance commuters do not significantly put more importance to the factor 'awareness' than other commuters. Safety is important in the decision to cycle everyday. Respondents who consider cycling safe are more likely to cycle always. This finding could be explained by the fact that in the Netherlands an unsafe feeling is a deterrent to cycle in some situations such as at night, but generally does not effect the decision to cycle.

A first challenges for future research relates to the causality between cycling and attitudes (see section 6.2). With this knowledge, policy makers could encourage cycling more effectively. If cycling results in a more positive attitude, policies could focus on encouraging individuals to try cycling in order to increase the share of cycling in commuting. However, if more positive attitudes result in an increase in cycling, policies should aim at creating a more positive image of the bicycle by communication or conditions in the (built) environment could be improved to provide bicyclists with a more pleasant or direct commute journey. Related to this point, it is still unclear how cycling attitudes are formed. What makes that someone likes cycling? In what way consider individuals cycling relaxing? This knowledge is essential to increase cycling rates. If it is known which groups of people would like cycling based on

specific factors, individuals with identical characteristics could be encouraged more effectively.

Finally, this research has shown that the decision to sometimes cycle to work and the choice to cycle every day are affected by different attitudes, 'awareness' is a determinant fo the decision to be a bicycle commuter and 'safety' is important on the decision to cycle every day. Current policies focus on both decisions simultaneously. In order to encourage cycling more effectively, different programs should be implemented to either encourage new cyclist to cycle or to persuade current cyclists to cycle every day.

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