

The Impact of Regular Outdoor Cycling and Gender on Technology Trust and Distrust in Cars, and on Anxiety

Klemens Weigl^{1,2} 

¹Human-Computer Interaction Group, Technische Hochschule Ingolstadt (THI), Esplanade 10, Ingolstadt, Germany

²Department of Psychology, Catholic University Eichstätt-Ingolstadt, Germany

Keywords: Outdoor Cycling, Technology Trust, Cars, Anxiety, Age, Gender.


Abstract: Regular cycling is well-known for its numerous benefits on physiological and mental health. However, cyclists are confronted with numerous other road users with different modes of transport which are more harmful to nature and may be even more dangerous. As yet, there has been no study which focuses jointly on the potential influence of trust and distrust in cars, anxiety, age, and gender in the context of regular outdoor cycling. Consequently, we carried out a questionnaire study and queried 114 participants (60 female (34 cyclists); 54 male (32 cyclists)). We assessed trust and distrust in cars, trait anxiety in a non-clinical context, age, and gender. Our results reveal that cyclists rate distrust in cars with significantly greater values when compared to non-cyclists. Moreover, we found that women assign substantially lower ratings to trust and higher ratings to distrust in cars than men, regardless whether they are cyclists or not. Additionally, women report significantly higher values on anxiety in a non-clinical context. Finally, our results indicate that older people are less likely to engage with regular outdoor cycling. We conclude that female and male cyclists are more critical on distrust in cars than non-cyclists, though they are not more anxious.

1 INTRODUCTION

In recent years, regular outdoor cycling gained popularity for several reasons. First, cycling is associated with positive effects on physiological and mental health and wellbeing (Christmas et al., 2010; Warner et al., 2012; Laverty et al., 2013; De Hartog et al., 2010). Second, cycling attracted new attention, because climate change became one of the major challenges of the 21st century. Melting ice masses and glaciers, rising sea levels, acidifying oceans, climate fluctuations, and increasing carbon dioxide (CO₂) levels in the atmosphere negatively affect people, animals, and nature (Haines et al., 2006; G20, 2017; McMichael et al., 2006). Climatological research identified links between the anthropogenic influence and the unusually rapid rise in temperature which is due to the accumulation of greenhouse gases in the earth's atmosphere (McMichael et al., 2006; Chapman, 2007; Karl and Trenberth, 2003). Thereby, about 30 percent of all CO₂ emissions are attributed to the transport sector. Therefore, an increasing number of people ride a bicycle for environmental reasons.

1.1 Modal Shift to Cycling

Although the awareness of environmental problems and the positive effects of cycling is slowly increasing, the majority of all people around the globe, does not cycle regularly, if at all. Long-term cycling initiatives in cities which focus only on cycling infrastructure and on sports scientific support clearly indicated that they may have no influence on the adoption of bike riding compared to cities with no initiatives (Goodman et al., 2013a; Goodman et al., 2013b). However, other empirical studies on cycling safety (e.g., bike routes on less frequented roads or separating cyclists from traffic through infrastructure, etc.) also showed, that they may have a positive impact on attracting more people to cycling (Dozza and Werneke, 2014; Pucher and Dijkstra, 2000; Pucher and Buehler, 2008; Götschi et al., 2016). In general, cycling is highly interrelated with the interaction with other road users with different modes of transport. Thereby, trust in other vehicles, especially in cars, plays a crucial role. Trust in technology and user acceptance have attracted interest especially in the field of the mobility of the future such as automated driving (Körber et al., 2018; Payre et al., 2016),

^a  <https://orcid.org/0000-0003-2674-1061>

(Wintersberger et al., 2016; Wintersberger and Riener, 2016). However, even automated vehicles (AVs) are not capable of reducing the amount of CO₂ emissions to the same extent as bicycle or e-bikes. Despite the realistic scenario that AVs, public transport, e-scooters, and (e-)bicycles may constitute future road traffic, there are numerous people who are sceptical about technology and cars. Hence, it is necessary to study technology trust in relation with different means of transport. Additionally, it was found that cycling reduced the Hoffmann reflex which is deemed a neuromuscular substrate of anxiety (Bulbulian and Darabos, 1986; deVries et al., 1981; Petruzzello et al., 1991) as well as state and trait anxiety (Motl et al., 2004).

However, there exists no study which explores the relationship between regular outdoor cycling, technology trust and distrust in cars, trait anxiety in a non-clinical context, duration of the daily commute per car and by public transport, age, and gender.

1.2 The Present Study

Consequently, we carried out a questionnaire study and investigated the following research questions (RQs) and hypotheses (Hs).

RQ1 (Trust and Distrust in Cars): How is the impact of female and male cyclists versus non-cyclists on trust in cars and distrust in cars?

- **H_{1,1}:** We hypothesize that female and male cyclists assign significantly lower ratings to trust in cars and sufficiently higher ratings to distrust in cars than non-cyclists, respectively.
- **H_{1,2}:** Across cyclists and non-cyclists, we expect women to report substantially smaller preferences on trust in cars and greater values on distrust in cars than men, respectively.

RQ2 (Anxiety): How is the influence of anxiety on female and male cyclists and non-cyclists?

- **H₂:** We assume that women assign noticeably greater ratings to trait anxiety in a non-clinical context than men, regardless if they are cyclists or not.

RQ3 (Age and Duration of Daily Commute): How is regular outdoor cycling associated with age, duration of the daily commute by car, and duration of the daily commute by public transport?

- **H_{3,1}:** We suppose that regular outdoor cycling is negatively correlated with age (i.e., younger people cycle more than older people).
- **H_{3,2}:** Moreover, we hypothesize no substantial association between regular outdoor cycling and

the duration of the daily commute by car or by public transport, respectively.

2 METHOD

2.1 Participants

We queried 114 participants of which 60 were female (34 cyclists) and 54 male (32 cyclists; cf. Table 1). The age of all participants varied between 21 to 85 years (M = 53.4; SD = 18.6). The mean age of women was 51.4 years (SD = 18.8) and of men 55.6 years (SD = 18.3). All participants were fluent in German the language in which the questionnaires were provided, consumed no alcohol or drugs, and reported no diagnosis of a psychiatric or neurological disorder. The duration of the daily commute by car was on average 28 minutes (SD = 24; n = 60), by public transport 33 minutes (SD = 32; n = 19), and by bicycle 13 minutes (SD = 15; n = 42). In total 51 participants possessed a general qualification for university entrance, 17 a university of applied sciences entrance qualification, 25 a high-school diploma, 19 a secondary modern school qualification, one person graduated from a polytechnic school, and one from a professional academy. Thirty-two participants reported that they never experienced a traffic accident. However, 56 reported that they experienced a non-severe, and 26 a severe traffic accident.

Table 1: Sample Sizes of Female and Male Cyclists and Non-Cyclists (N = 114).

	Cyclists	Non-Cyclists	Sum
Female	34	26	60
Male	32	22	54
Sum	66	48	114

2.2 Design and Materials

We conducted a cross-sectional questionnaire study and adopted a two factorial (2 x 2) between-subjects design with gender and cycling (i.e., cyclists vs. non-cyclists) as between-subjects factors (cf. Table 1). Our dependent variables were trust in cars, distrust in cars, and anxiety in a non-clinical context. We measured technology trust by the trust scale (Jian et al., 2000) with the two dimensions of trust (7 items; Cronbach's $\alpha = .87$) and distrust in technology (5 items; Cronbach's $\alpha = .88$) on a 7-point Likert scale anchored at 1 (not at all) and 7 (extremely). Typical items are "The system of car and driver offers safety." or "I am suspicious of the intentions, actions, and out-

put of the system of car and driver.” (Note: Due to technical problems, the data of one questionnaire item of the trust dimension were not transferred via the on-line system. Hence, we collected data from 6 instead of 7 items. However, the data of all other dimensions, scales, and demographic variables were complete.). Additionally, we assessed anxiety in a non-clinical context (7 items; Cronbach’s $\alpha = .65$) on a 7-level Likert scale ranging from 1 (applies not at all) to 7 (applies fully). Example items are ”It is difficult for me to talk with strangers.” or ”I try to avoid difficult things.” (Mohr and Müller, 2004).

2.3 Procedure

Before the beginning of the study, each participant received an introduction to the background of the study and was invited to ask questions throughout the entire study. Then everyone provided written informed consent. After this introductory part, all participants filled the questionnaire items of the trust scale, the questions of anxiety in a non-clinical context, and additional demographic variables such as age, gender, regular outdoor cycling (yes or no), duration of the daily commute by car, public transport, and bicycle. Upon completion of the questionnaire part, everyone received the contact details of the examiner, in case of any questions. All data for this study were collected anonymously and online via LimeSurvey (Version 3.12.1 + 180616). The examiner was either present (especially for older people) or could be reached by phone, email, or video-call during the entire study duration which ranged from 20 to 30 minutes. The participants did not receive financial compensation. However, all of them were invited to provide their email addresses if they were interested in the results of the study.

2.4 Supplementary Materials

We support the open science movement and supply the data set on OSF: <https://osf.io/q76dj/>.

2.5 Statistical Analyses

We set the significance level to $\alpha = .05$, if not stated otherwise (e.g., in case of Bonferroni correction). Therefore, all results with $p < \alpha$ are reported as statistically significant. The items of all questionnaires were positively coded. Hence, the sum scores were directly computed for the trust and distrust dimensions of the trust scale, and the anxiety dimension of the questionnaire on anxiety in a non-clinical context. For

all data analyses we applied IBM[®] SPSS[®] Statistics, Version 25 (IBM Corp., 2017).

In the beginning of the statistical analyses, we checked the statistical prerequisites and tested all data for normality and variance homogeneity. Concerning **RQ1** and **RQ2**, normality was met for 9 out of 12 conditions (2 (gender) x 2 (cycling) x 3 (trust, distrust, anxiety) = 12). We conducted parametric statistical analyses, because the cell sample sizes were all fairly equally balanced (cf. Table 1), and skewness and kurtosis as well as the QQ-plots revealed a good distributional behavior of the data. Additionally, we investigated **RQ3** and computed point-biserial correlations because of the dichotomous variable cycling (i.e., cyclists vs. non-cyclists).

3 RESULTS

RQ1 (Trust and Distrust in Cars): We applied a two-factorial multivariate analyses of variances (MANOVA) with gender and cycling as grouping variables and tested the two dependent variables trust ($H_{1.1}$) and distrust in cars ($H_{1.2}$). Thereby, we found that female and male cyclists assign roughly the same ratings to trust in cars as non-cyclists (cf. Table 2 and 3, and Figure 1). However, our results revealed sufficiently higher ratings to distrust in cars than non-cyclists, respectively (cf. Table 2 and 3, and Figure 2). Hence, we could only partly accept $H_{1.1}$. Across cyclists and non-cyclists, we found that women report substantially smaller preferences on trust in cars and greater values on distrust in cars than men, respectively. Therefore, we could accept $H_{1.2}$.

RQ2 (Anxiety): Then, we applied an univariate analysis of variances (ANOVA) and tested whether trait anxiety in a non-clinical context differs between female and male cyclists and non-cyclists, respectively. Our results revealed that women assign significantly greater ratings to trait anxiety in a non-clinical context than men, regardless if they are cyclists or not (cf. Table 2 and 4, and Figure 3). Hence, we could accept H_2 .

RQ3 (Age and Duration of Daily Commute): Finally, we investigated if regular outdoor cycling is associated with age, duration of the daily commute by car, and duration of the daily commute by public transport. We found that regular outdoor cycling is negatively correlated with age (i.e., younger people cycle more than older people) and could accept $H_{3.1}$. However, our data did not reveal a substantial association neither between regular outdoor cycling and the duration of the daily commute by car, nor by public transport. Therefore, we could not confirm $H_{3.2}$ (cf. Table 2 and 5).

Table 2: Mean Scores and Standard Deviation for Measures of Trust, Distrust, Anxiety, and Age as a Function of Gender and Cyclists versus Non-Cyclists.

Group	Trust in Cars		Distrust in Cars		Anxiety in a Non-Clinical Context		Age in Years	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Female								
Cyclists	22.50	7.12	19.06	5.79	19.74	6.12	46.47	19.70
Non-Cyclists	23.04	5.48	17.88	5.74	18.31	6.46	57.77	15.72
Male								
Cyclists	26.97	7.91	17.09	6.42	15.19	5.43	53.53	17.90
Non-Cyclists	27.59	6.40	13.05	5.75	14.18	5.18	58.59	18.77

Note. Trust, Distrust, and Anxiety ... sum scores of latent questionnaire dimensions.

Table 3: Two-way Multivariate and Univariate Analyses of Variances for the Measures of Trust and Distrust in Cars.

Source	Multivariate			Univariate					
	<i>F^c</i>	<i>p</i>	η^2	Trust in Cars			Distrust in Cars		
				<i>F^d</i>	<i>p</i>	η^2	<i>F^d</i>	<i>p</i>	η^2
Cycling (C)^a	3.28	.041	.06	.20	.659	.00	5.32	.023	.05
Gender (G)^b	6.59	.002	.11	11.86	.001	.10	9.02	.003	.08
C x G	1.19	.307	.02	.00	.975	.00	1.61	.21	.01

Note. Multivariate *F* ratios were generated from Pillai's statistic. Trust and Distrust in Cars ... sum scores of latent questionnaire dimensions.

^aCycling ... cyclists versus non-cyclists. ^bGender ... women versus men.

^cMultivariate *df* = 2, 109. ^dUnivariate *df* = 1, 110.

Text in bold highlights statistically significant findings.

Table 4: Two-way Univariate Analyses of Variances for the Measure Anxiety in a Non-Clinical Context.

Source	Anxiety		
	<i>F</i> (1,110)	<i>p</i>	η^2
Cycling (C) ^a	1.12	.276	.01
Gender (G)^b	15.22	.000	.12
C x G	0.04	.850	.00

Note. Anxiety ... sum score of the latent questionnaire dimension.

^aCycling ... cyclists versus non-cyclists.

^bGender ... women versus men.

Table 5: Point-biserial Correlation Coefficients of Age, Duration of the Daily Commute by Car, and Duration of the Daily Commute by Public Transport with Cycling.

Variable	Cycling ^a		
	<i>n</i>	<i>r</i>	<i>p</i>
Age	114	-.22	.019
Commute by Car ^b	60	-.09	.502
Commute by Public Transport ^b	19	-.17	.482

^aCycling ... cyclists (= 1) versus non-cyclists (= 0).

^bDuration measured in minutes.

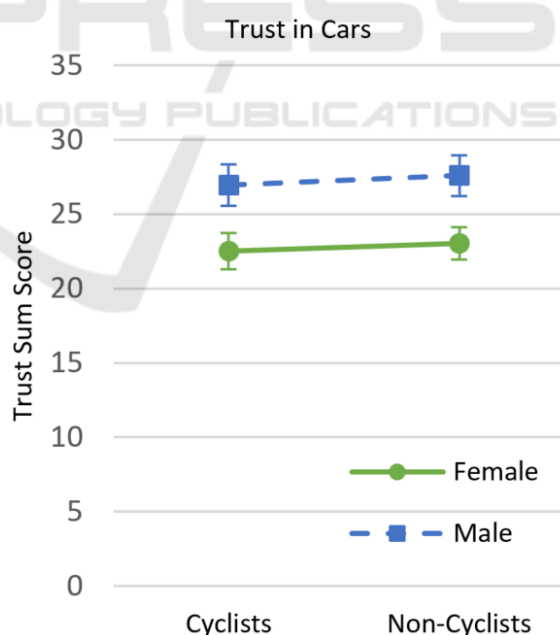


Figure 1: Means and standard errors of the mean for trust in cars as a function of gender and cyclists versus non-cyclists.

4 DISCUSSION

The purpose of this cycling study was to investigate the influence of regular outdoor cycling and gender

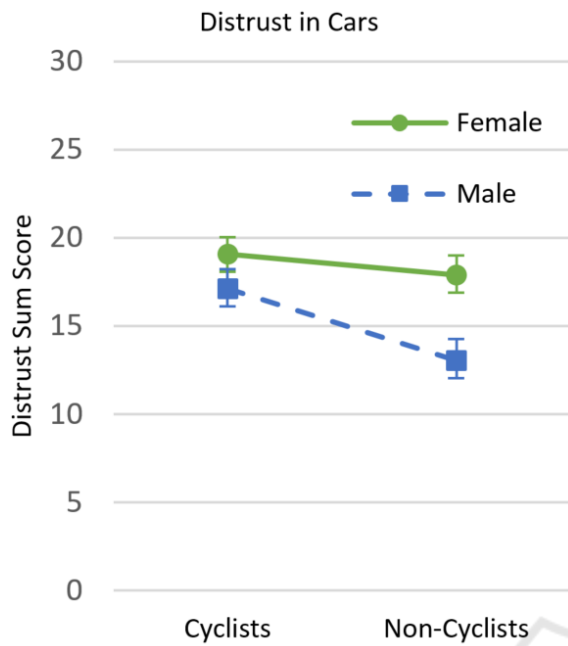


Figure 2: Means and standard errors of the mean for distrust in cars as a function of gender and cyclists versus non-cyclists.

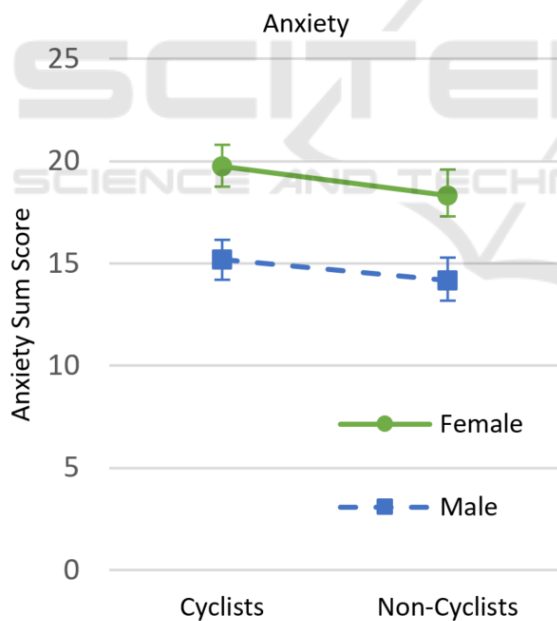


Figure 3: Means and standard errors of the mean for anxiety in a non-clinical context as a function of gender and cyclists versus non-cyclists.

on technology trust and distrust in cars, and on non-clinical anxiety. Our findings highlight crucial interrelations of these important technology-related dimensions and contribute to the new trend on cycling research with the overarching goal to facilitate a modal

shift to cycling.

The first objective was to study the impact of female and male cyclists versus non-cyclists on trust in cars and distrust in cars (RQ1). Our findings indicate that female and male cyclists may have roughly the same technology trust in cars as non-cyclists. However, cyclists seem to have a greater distrust in cars than non-cyclists. Additionally, women tend to be more critical than men because of their stated smaller preferences on trust in cars and greater values on distrust in cars, whether or not they are cyclists.

Our second objective was to investigate the influence of non-clinical anxiety on female and male cyclists and non-cyclists (RQ2). We found that women seem to have greater trait anxiety in a non-clinical context than men, regardless if they are cyclists or not. These findings are in line with other previous studies which, however, did not focus on cycling (Bahrami and Yousefi, 2011; Hantsoo and Epperson, 2017; Howell et al., 2001; Kendler et al., 1992; McLean and Anderson, 2009; Pigott, 2003; Yonkers et al., 2003).

The third objective was to elaborate if regular outdoor cycling is associated with age, duration of the daily commute by car, and duration of the daily commute by public transport (RQ3). The results indicate that younger people cycle more than older people.

Interestingly, we found no association between regular outdoor cycling and the duration of the daily commute by car or by public transport, respectively. However, this finding is based on smaller sample sizes than all other results mentioned before.

As yet, to the best of our knowledge, there exists no cycling study which focuses jointly on technology trust and distrust in cars, anxiety, age, and duration of the daily commute. Hence, our results provide an important link to begin to fill this research gap. Nevertheless, in future studies, it will be necessary to address these research questions again with greater sample sizes and in relation with other personality traits. Thereby, it could be highly interesting to also focus on the impact of environmental perception on the decision whether or not someone regularly rides a bicycle. Additionally, it should be also focused on policies which positively promote active urban travel in relation with larger health and environmental benefits, instead of focusing solely on lower-emission motor vehicles (Woodcock et al., 2009).

5 CONCLUSION

In this study, we highlighted the impact of regular outdoor cycling and gender on trust and distrust in cars, and on anxiety to foster the understanding of cy-

clists and non-cyclists. In doing so, we contribute to this newly emerging global debate of the necessity to support cycling for modal shift to tremendously reduce the amount of CO₂ emissions, if people regularly choose the bicycle as means of transport (also in combination with public transport) instead of the car. On top of this, cycling is associated with numerous health benefits for people. In the following, we sum up the highlights of our study:

1. Cyclists and non-cyclists report roughly the same ratings of technology trust in cars.
2. Cyclists report substantially greater values of technology distrust in cars than non-cyclists.
3. Regardless if someone is a cyclist or not, women assign smaller values to trust in cars, and greater values to distrust in cars than men, respectively.
4. Although women assign significantly greater ratings to trait anxiety in a non-clinical context than men, it has no mediating positive or negative effect on cycling.
5. Regular outdoor cycling is negatively correlated with age. Hence, older people should be motivated and supported more than younger people by local campaigns of policy makers and cycling activists.

Mobility of the future will not only be constituted with automated vehicles, but also to a large extent with (electric) sensor bicycles which will be able to communicate with all means of transport. Hence, future studies will be unequivocally necessary to better understand psychological and motivational aspects of regular outdoor cycling.

ACKNOWLEDGEMENTS

I am very grateful to Eva Quednau for collecting these data.

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