DIGITAL COMMUTING: THE EFFECT OF SOCIAL NORMATIVE FEEDBACK ON E-BIKE COMMUTING – EVIDENCE FROM A FIELD STUDY

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Flüchter, Kristina, ETH Zurich, Zurich, Switzerland, kfluechter@ethz.ch

Wortmann, Felix, University of St. Gallen, St. Gallen, Switzerland, felix.wortmann@unisg.ch

Fleisch, Elgar, University of St. Gallen and ETH Zurich, Switzerland, efleisch@ethz.ch

Abstract

As a consequence of extensive urban growth, local transportation systems are facing enormous challenges, leading to massive investments in infrastructure and travel demand management measures to steer demand for specific travel modes. Meanwhile, technological advancements are creating unprecedented opportunities for collecting and utilizing travel data at previously unknown levels of detail. Such information may in the form of social normative feedback constitute a powerful tool for influencing human behaviour. Focusing on electric bicycles (e-bikes) as potentially central means of future transportation, this study evaluates whether IS-enabled social normative feedback can increase the usage of e-bikes for commuting. The results of a five-week field study and mixed effects logistic regression analysis support a positive impact of social normative feedback on e-bike commuting. We, however, also detect a negative effect on a group of participants with particularly long commuting distances, and effects of weather conditions and commuting distances on e-bike usage. Our findings add to existing research in the areas of travel mode choice, and social norms, and support policy makers in travel demand management. Ultimately, employers may view our findings as a source of inspiration for promoting the health of their employees and increasing the attractiveness of their places to work.

Keywords: e-bike, commuting, travel mode choice, social normative feedback.

1 Introduction

The world is currently experiencing the largest wave of urban growth in its history. By 2030 almost five billion people worldwide are expected to be living in towns and cities (OECD, 2012; United Nations Population Fund, 2007). This rapid development is posing enormous challenges for local transportation systems, which not only relate to congestion and travel times, but also to carbon emissions and quality of life for those living and working in the cities. Consequently, massive investments are being made into measures to improve urban infrastructure as well as into efforts to integrate transportation systems and actively manage demand for specific travel modes in such a manner as to improve mobility while at the same time decreasing pollution by reducing the dependence on cars and trucks. These measures, so-called travel demand management (TDM) measures (Fujii and Kitamura, 2003), for instance include congestion pricing and restricting access to specific areas for certain classes of vehicles (KPMG, 2011; McKinsey Global Institute, 2013; Urban Land Institute and Ernst & Young, 2013). In this context, projects promoting the usage of bicycles represent an important set of measures, which are specifically focusing on the sustainable development of transportation systems and seeking to promote green urban infrastructures. Usually, these efforts are addressing the traditional topics of infrastructure and availability, e.g. by investing in the improvement and expansion of bicycle track networks and the establishment of bicycle sharing systems (OECD, 2012; UNEP, 2010). More recently, electric bicycles have also been benefiting from such measures. E-bikes have been enjoying significant market success in recent years (ZIV, 2013) and offer a number of advantages over traditional bicycles, e.g. in terms of reach, effort and independence from local topography, which may qualify them as an important element of future transportation systems not only for leisure travel but also for commuting to work.

At the same time, technological advancements are creating unprecedented opportunities for collecting and utilizing travel data at previously unknown levels of detail. Today, several mobile devices and smartphone applications are for instance available, which allow bicyclists to track their trips and review their activity history, incl. frequency of usage and mileage (Dill, 2009; Hood et al., 2011; Lindsey et al., 2013; Van Hooff, 2013). Furthermore, building upon the unique availability of electrical power on e-bikes, first initiatives are exploring the implementation of sensing devices, which are even permanently attached to the e-bikes, thus enabling an even greater array of use cases (Bonnington, 2013). It is further known that such information may constitute a powerful tool for influencing human behaviour. With regard to social norms, Cialdini et al. (1991) for instance established that individuals often orient themselves towards others to understand which activity is commonly performed and which would in a given situation be appreciated by others. Various studies have successfully applied these findings and achieved changes in behaviour by providing information in the form of social normative feedback, e.g. increasing the reuse of towels in hotels (Goldstein et al., 2008).

We are therefore interested in understanding whether IS-enabled social normative feedback might in the future be suited to serve as relatively low-cost and scalable means of motivating and increasing the usage of electric bicycles, independent of large-scale investments in infrastructure. In the context of a theory-based building approach, this study seeks to evaluate in a first step whether IS-enabled social normative feedback, which can be generated and distributed without human interaction, can be an effective means for increasing e-bike usage. For this purpose, we have focused on the usage of e-bikes for commuting to work and conducted a field study with 32 users, who were provided with e-bikes for the duration of approximately four months. Users were randomly assigned to two experimental groups, one of which was invited to participate in a three-week e-bike commuting competition including social normative feedback on e-bike usage at the end of each week. We apply mixed effects logistic regression analysis and derive insights into the effect of our intervention on e-bike usage.

2 Theoretical background and related work

2.1 Travel mode choice and commuting by bicycle

The decision of travel mode choice, i.e. the selection of a certain means of transportation in a given situation, has been the subject of investigation by primarily transportation researchers for several decades. While research started with exploring relatively simple relationships, e.g. whether travel might be explained by urban form, interdisciplinary research has in the meantime developed more complex research agendas. Today, various models seek to explain travel mode choices for specific contextual situations, taking into consideration not only environmental and socio-economic factors, but also a potential impact of e.g. attitudes or habits (Scheiner and Holz-Rau, 2007; Gärling and Fujii, 2009).

Heinen et al. (2010) provide a comprehensive overview of the literature and specifically examine determinants for commuting to work by bicycle. They identify five groups of determinants of bicycle commuting: the natural environment, the built environment, socio-economic factors, psychological factors, and a group of utilitarian factors which the authors label cost, travel time, effort and safety.

With regard to the natural environment, Heinen et al. (2010) highlight that the landscape and weather are found to have a large influence on the decision to cycle as well as on the frequency of cycling. According to the authors, the presence of hilliness and slopes has a negative effect on cycling, as do deteriorating weather conditions. While, with regard to weather conditions, evidence on the impact of precipitation on bicycle commuting is mixed (Nankervis, 1999; Cervero and Duncan, 2003), the negative influence of low temperatures has been confirmed in several studies (Nankervis, 1999; Parkin et al., 2008).

The built environment includes aspects such as the urban form, infrastructure and facilities at work. Most notably in this context, trip distance has been found to have a significant negative effect on the usage of bicycles in general as well as for commuting specifically (Hunt and Abraham, 2007; Heinen et al., 2010; Heinen et al., 2013; Weinert et al., 2007).

The relationship between socio-economic factors and cycling is ambiguous and researchers are currently lacking clarity on the causality as well as the direction of the relationship. While most studies for instance conclude that men are more active cyclists than women, some researchers have produced contrary findings (Dickinson et al., 2003; Witlox and Tindemans, 2004; Heinen et al., 2010).

Recently, research has been focusing on the potential influence of psychological factors on cycling. Building on e.g. the theory of planned behaviour (Ajzen, 1991), factors such as attitudes, social norms and perceived behavioural control as well as habits are being examined as potential influencers of travel mode and bicycle usage decisions (Bamberg, 2012; Bamberg et al., 2003; de Bruijn et al., 2009; Aarts et al., 1997; Verplanken et al., 2008; Fujii and Kitamura, 2003). To date, however, only limited amount of work has been conducted into the relationship between these psychological factors and cycling (Heinen et al., 2010). And while some findings appear to support an impact of psychological factors on cycling (Heinen et al., 2013; Bamberg et al., 2003; De Bruijn et al., 2009), in other studies, variations in attitudes cannot improve models of cycling choice behaviour (Hunt and Abraham, 2007).

Finally, cost, travel time, effort and safety have been found to be important for cyclists and appear to influence mode choice. However, these factors have been found to be particularly important when evaluated in comparison with alternative means of transportation while knowledge on the impact on cycling frequency is limited (Heinen et al., 2010).

In light of the insights from existing literature described above, we expect the usage of the e-bikes in our field study to be affected primarily by factors associated with the natural environment and the built environment. As all participants of our field study share the same working location, we do not expect a significant impact from aspects regarding the infrastructure or facilities at work (cp. section 3.1). However, we do expect that e-bike usage in our field study will still have been affected by weather conditions as well as differences in commuting trip distances across participants. Therefore, we put forward the following hypotheses:

H1: Deteriorating weather conditions have a negative effect on the usage of e-bikes for commuting

H2: Increasing commuting distance has a negative effect on the usage of e-bikes for commuting

2.2 Social normative feedback

Social norms have been found to exert a powerful influence on human behaviour as individuals often look to social norms in order to gain an understanding of social situations and to be able to react effectively, particularly in cases of uncertainty (Cialdini, 2001). As detailed by Cialdini et al. (1991) in their focus theory of normative conduct, the concept of social norms encompasses two separate sources of human motivation, i.e. descriptive norms and injunctive norms. Descriptive norms refer to the perception of what most people do (the norm of ‘is’), while injunctive norms relate to what most people approve or disapprove of (the norm of ‘ought’) (Cialdini et al., 1991). A common method of activating social norms and providing guidance regarding socially desired behaviours is through the use of feedback. By this means, social norms have been utilized in the last two decades to alter a wide spectrum of behaviours, such as towel reuse (Goldstein et al., 2008), energy consumption (Loock et al., 2011), or littering (Cialdini, 2003).

While, to the best of our knowledge, there is no information publically available regarding the impact of social normative feedback on the usage of bicycles or electric bicycles, the potential of psychological methods to modify human behaviour has recently been recognized by researchers in the area of travel behaviour. Gärling and Fujii (2009) draw attention to the success of so-called travel feedback programs (TFPs) in reducing car usage and increasing public transport usage. TFPs are soft measures, which intend to change travel behaviour, usually from automobile to non-automobile travel by means of feedforward or feedback information. A number of different measures are considered to fall under the definition of a TFP, which may be limited to the provision of customized information, request goal setting or plan formation activities, or provide motivational support. Studies suggest that the implementation of such TFPs may reduce car usage by up to 27% (Fujii and Taniguchi, 2006; Gärling and Fujii, 2009).

In view of the research findings regarding social norms and social normative feedback described above, we assume that social normative feedback will also have a positive effect on the usage of electric bicycles for commuting, i.e. we hypothesize:

H3: Social normative feedback has a positive effect on the usage of e-bikes for commuting

Social normative feedback has however also been found to have negative effects under certain conditions. Schultz et al. (2007) for instance suggest that descriptive norms may have differential effects depending on whether individuals are above or below a referred average. They observed that after receiving descriptive social normative feedback, individuals who had already demonstrated a desirable behaviour, subsequently adjusted to the descriptive norm, i.e. started to show less desirable behaviour (Schultz et al., 2007). In the case of e-bike commuting, the intention is to increase the frequency of usage (cp. section 3.3). We expect that this incentivizing may frustrate those participants, who need to cover particularly long commuting distances, since they have to spend more time and effort e-biking in order to achieve the same level of usage frequency as other participants with shorter commutes. Hence, we suggest that frequency of usage-focused social normative feedback has a negative effect on the usage of e-bikes for commuting by long distance commuters:

H4: Frequency of usage-focused social normative feedback has a negative effect on the usage of e-bikes for commuting by long distance commuters

3 Field study

3.1 Design and participants

In order to test our hypotheses we conducted a field experiment with 32 participants. The study encompassed two experimental groups (competition and control group) to which participants were randomly assigned, with 20 participants in the experimental group and 12 in the control group. The participation in an e-bike commuting competition was designed as a between-subject factor, which was present in the treatment group and absent in the control group.

The participants (14 women, 18 men) were employees of a Swiss insurance company (30) and of the local university (2), which we had provided with e-bikes for the period of approximately four months to evaluate the suitability of e-bikes as a means of transportation for commuting to work. They were at the age of 22 to 64 years (M = 35.3; SD = 11.9) and all participants worked at the same office location in Eastern Switzerland. The decision to approach these organisations was made for two reasons. First, since the research focus was on the activity of commuting by e-bike, the selection of participants with the same office location was important in order to avoid a distortion of results due to different conditions at the workplace, e.g. with regard to bike racks or showers (Heinen et al., 2013). Second, the offices of the selected organisations are located on a hill, making it practically impossible to commute to work without overcoming some altitude. Thereby the potential impact on the results of different altitude profiles, which participants have to cover on their way to work (Parkin et al., 2008; Heinen et al., 2010), could be limited. In the course of the field experiment, 9 of the participants did not submit sufficient information, leaving a group of 23 participants, 14 in the experimental group and 9 in the control group, from which we obtained valid data for our analysis.

3.2 Procedure and measurements

For the purpose of the field experiment, all participants were equipped with an e-bike for the duration of approximately four months. Individual e-bike models were allocated to the participants based on their age, gender, height, weight and distance of their commute, as well as on preferences, which the participants had indicated in an online survey. Thereby, a good fit between the participants and their respective e-bikes could be achieved, which further enhanced comparable conditions of e-bike usage across participants. In order to avoid a distortion of results from the newness of the e-bikes to the participants and a consequently potentially increased usage of the e-bikes during the first weeks, the participants were given ten weeks to get used to their e-bikes before measurements started.

The participants were then asked to provide information about their e-bike usage over a period of five weeks. As any self-reporting design entails potential inaccuracies from incorrectly reported activities and the risk of adverse effects on sample size due to participants dropping out because effort is perceived as too high, particular focus was placed on the simplicity and brevity of the self-reporting process. Hence, an online survey was sent to the participants only once a week, at the end of each week, rather than on a daily basis. The participants were asked to set checkmarks in one to four boxes per day of the past week in order to indicate whether they had used their e-bike to go to work or to go home after work or during their leisure time or not at all. Additionally, participants were asked to provide one further non-compulsory information, capturing the mileage of their e-bike as per the end of the week, which they could find on the e-bike tachometer.

3.3 Intervention

After two weeks of observation we invited the participants in the treatment group to participate in an e-bike commuting competition. The participants were informed that the competition would run for the duration of three weeks and that the person, who would use the e-bike the most often to commute to work during this timeframe would win the competition. The participants were also informed that they would receive an overview of their respective rankings at the end of each week as well as a comparison of their e-bike usage with that of the other participants. Figure 1 illustrates the experimental setup.

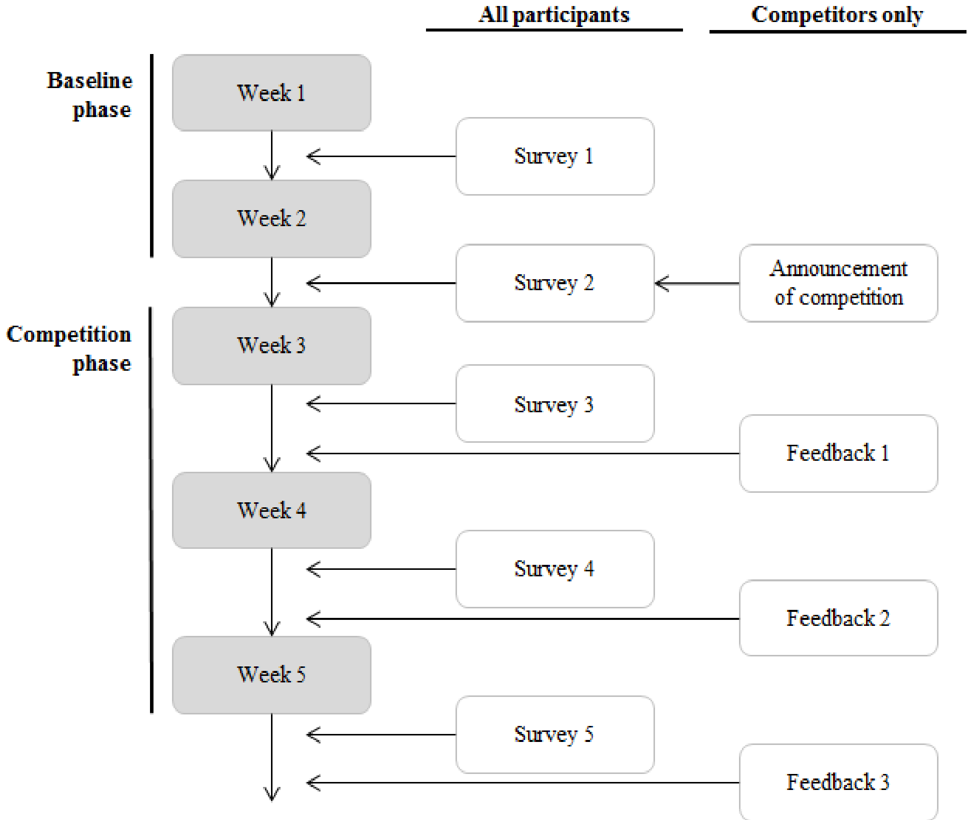

Figure 1 Illustration of experimental setup

At the end of each week of the competition, participants in the treatment group (competitors) subsequently received an e-mail, informing them about their current ranking in the competition and providing an overview of their activity during the past week as illustrated in figure 2. With regard to the overall ranking in the competition, only the number of commutes by e-bike during the three-week competition period was taken into consideration. We used injunctive normative feedback in the form of a podium to display this information. In the lower section of the feedback mailing, the participants additionally received descriptive normative feedback about their e-bike usage during the past week. Specifically, they were informed how often they had used their e-bike to commute to work and how many kilometres they had covered on their e-bike during the past week in comparison with the respective average values of all participants in the treatment group. Also, an overview was provided of the share of participants in the treatment group who had used their e-bike for commuting per day of the past week, including a labelling of those days, on which the addressee of the feedback had used his or her e-bike for commuting.

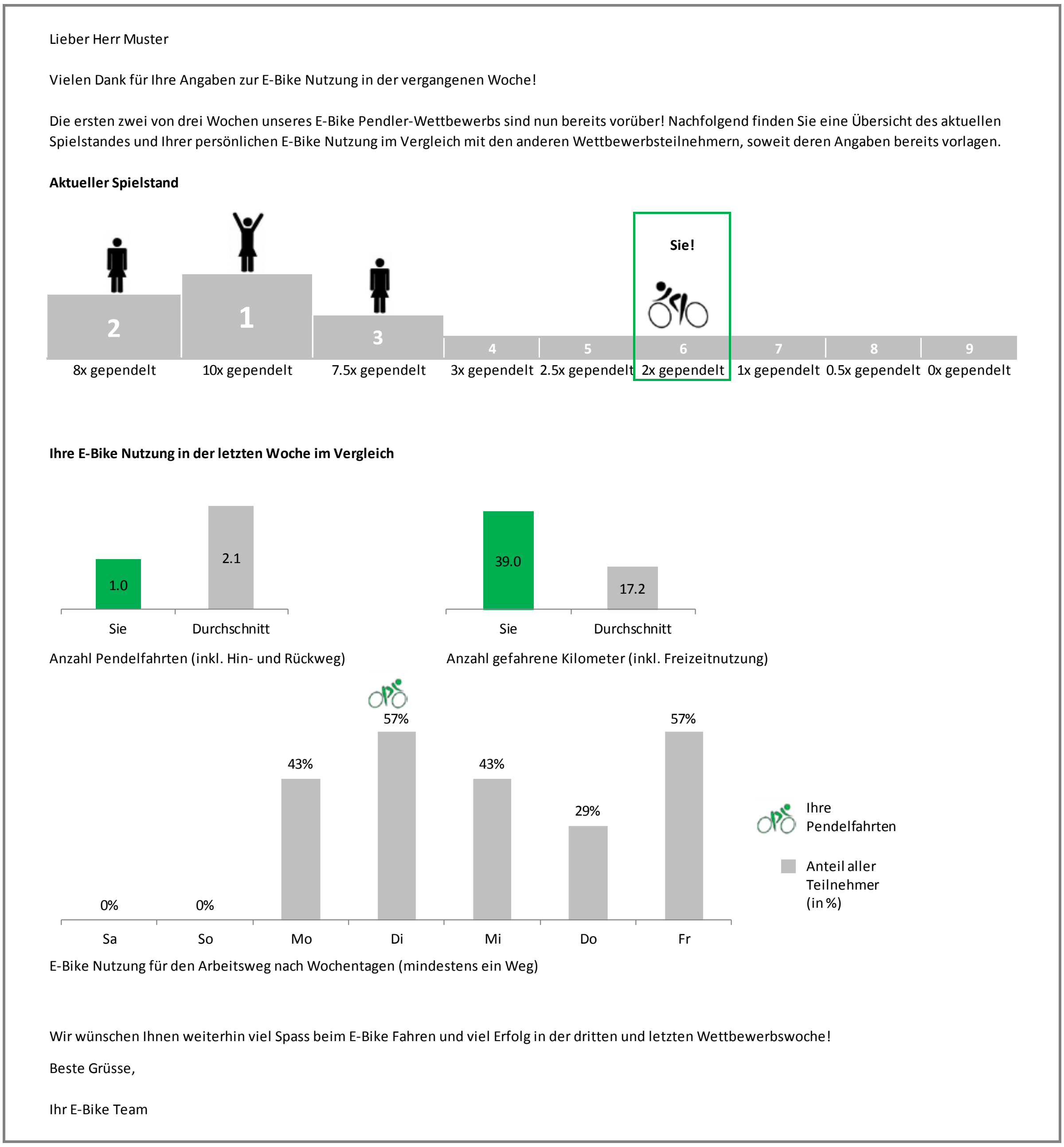

Figure 2 Feedback provided to participants of e-bike commuting competition

4 Analysis and results

4.1 Method of analysis

To test our hypothesis we applied mixed effects logistic regression (Faraway, 2006) for two reasons: we have a binary outcome variable (e-bike used for commuting: yes/no) (1) and multiple outcomes per subject (e-bike usage for each day of the experiment) so that we treat the variable “subject” as a random effect (2). Three binary predictor variables and one non-binary predictor variable are used. Competition phase depicts the phase of the experiment (competition or baseline phase). Competitor depicts the group membership of the rider (competitor or non-competitor). Both variables are not only used to test H3 and H4 but also to eliminate time and group effects respectively, which could potentially bias the test of the hypotheses: for example, even if the competitors are chosen randomly they could still travel considerably less or more. This bias should be reflected when testing the hypotheses, e.g. if competitors generally travel much more than non-competitors this should not be attributed to the competition. The third binary predictor variable, long distance rider, reflects the commuting distance of the subject (long distance rider or short distance rider) and is used to test H2. Long distance riders are considered riders with a commuting distance of over 5km as it has been shown that bicycles' share in travel mode decisions decreases rapidly for distances longer than 5km (Van Wee et al., 2006; Bergström and Magnusson, 2003). Temperature (daily average) is leveraged as a non-binary predictor variable to test H1.

To test H3 and H4 our model has to include two interaction effects: "competition phase x competitors" and "competition phase x long distance rider x competitors". In addition, we had to incorporate one further interaction effect in order to avoid highly misleading results with respect to H4. The descriptive analysis of the results revealed that weather conditions during the baseline phase were much better suited for e-bike commuting than the corresponding conditions during the competition phase (cp. section 4.2). It is known that short distance riders show a different commuting behaviour under winter conditions than long distance riders (Bergström and Magnusson, 2003). Therefore "competition phase x long distance rider" is included as the last interaction effect.

4.2 Descriptive results

Figures 3 and 4 provide descriptive statistics for the experiment. As highlighted in figure 3, not all field study participants use their e-bike to commute to work every day. Instead, during the period of observation, the share of participants, who used their e-bike for commuting at least one way, i.e. either to go to work or to go home after work, varies between 57% and 12% on any given day. The highest share of active e-bike commuters was observed on the first day of week two, the lowest on the last day of week five. Overall, levels of e-bike usage for commuting are declining over the period of observation.

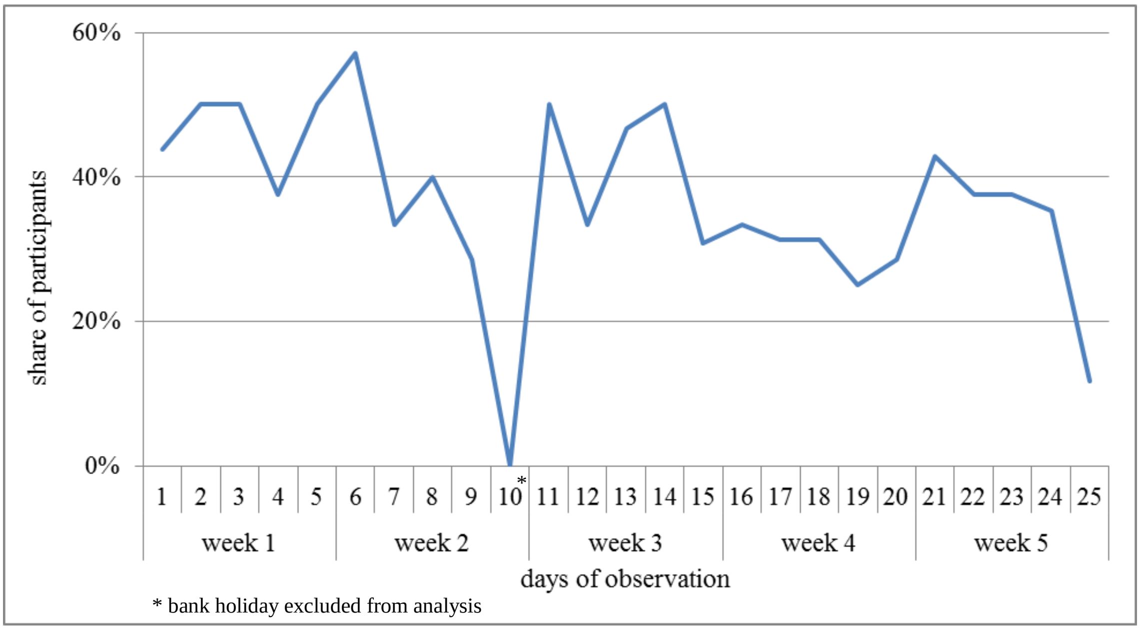

Figure 3 Overview of share of field study participants who used e-bike for commuting per day

Figure 4 illustrates the weather conditions at the location of the field study during the observation period (MeteoSwiss, 2013). It becomes obvious that weather conditions during the competition phase (weeks three to five) have deteriorated compared to the baseline phase. The average daily temperature drops from up to 18.7°C on day two to -0.2°C on day 24. In addtion, weeks three to five are characterized by more frequent precipitation compared to weeks one and two. It should further be noted, that precipitation already took the form of snowfall on days 16, 20, 24 and 25.

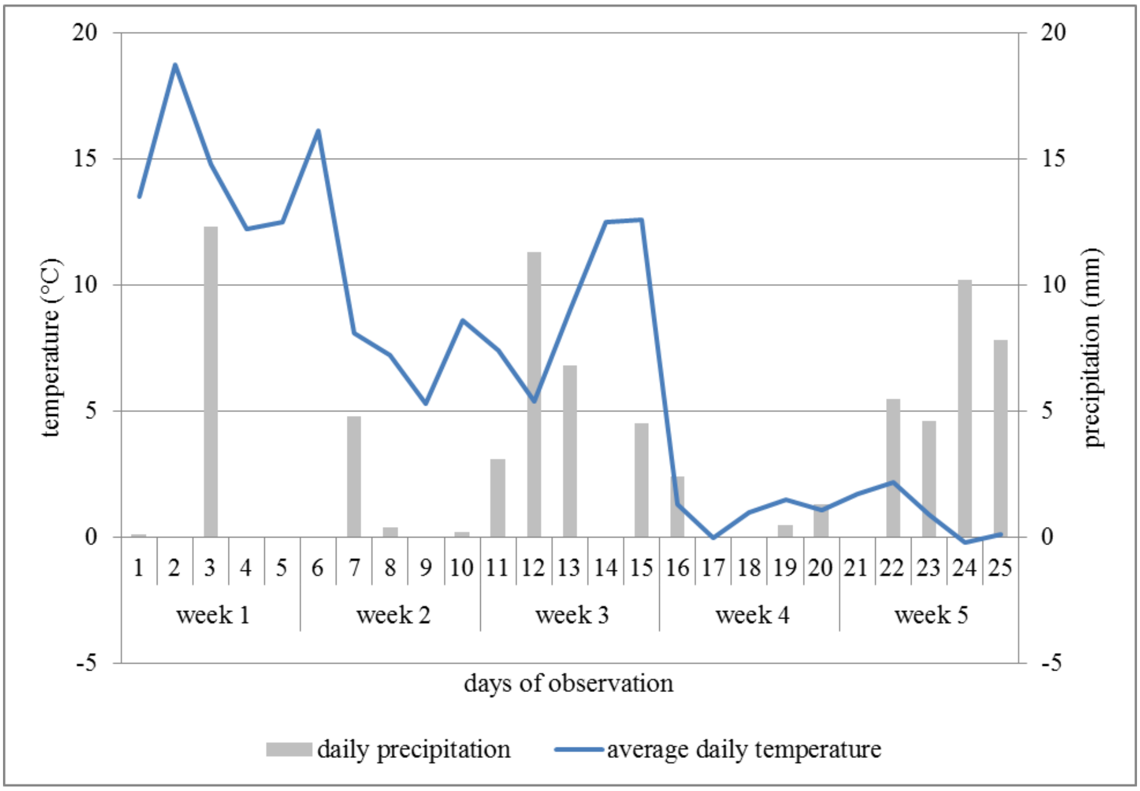

Figure 4 Weather conditions during observation period

4.3 Hypothesis testing

The mixed effects logistic regression model (cp. table 1) revealed that the daily average temperature has a marginal positive (odds ratio as measure of effect size > 1) effect on commuting probability. However, this effect was not significant. We therefore do not find support for H1. Nonetheless, it is striking to see that there is a considerable significant effect of the variable “competition phase” on commuting probability. Given that the weather conditions of the baseline phase were generally much better suited for e-bike commuting than the corresponding conditions of the competition phase, with respect not only to temperature but also precipitation, the variable “competition phase” could also be viewed to serve as a variable representing weather conditions. On the basis of this variable, support for H1 would be provided. Next, despite a random assignment of participants to the treatment and control groups, we detected that the probability of e-bike usage for competitors was higher than for non-competitors. Yet, this effect was not significant. We did however find long distance riders to cummute significantly less than short distance riders and thus support for H2. The corresponding odds rate is 0.09, i.e. short distance riders are 1 ÷ 0.09 = 11.1 times more likely to commute by e-bike than long distance riders. In addition to these main effects we found a significant interaction effect between competitors and competion phase supporting H3. Also, we found a positive significant interaction effect between competition phase and long distance riders. Finally, the three-way interaction between competitors, competion phase and long distance riders was significant, providing evidence for H4. Overall, the model is signifcant (Wald $\chi^2(7) = 17.09$, $p < 0.05$).

	Odds Ratio	Std. Err.	z	P>z
Main Effects				
Temperature	1.03	0.03	1.04	0.151
Competition phase (CP)	0.19	0.15	-2.07	0.019
Competitors (C)	5.19	5.76	1.49	0.069
Long distance riders (LDR)	0.09	0.10	-2.21	0.014
Interaction Effects				
CP x C	6.30	5.21	2.22	0.013
CP x LDR	18.52	23.46	2.30	0.011
CP x LDR x C	0.03	0.04	-2.56	0.005

Table 1 Results of mixed effects logistic regression analysis

5 Discussion

5.1 Summary of key findings

In this paper, we investigated whether social normative feedback can be an effective means for increasing the usage of e-bikes. We focused on electric bicycles as opposed to traditional bicycles for two reasons. First, e-bikes may qualify as a central element of future transportation systems as they have been enjoying considerable market success in recent years and because of their advantages over traditional bicycles e.g. in terms of reach and independence from local topography. Second, due to their unique access to electric power, e-bikes could in the future be suited to being equipped with IS devices and applications to collect and display IS-enabled social normative feedback in a relatively low-cost and scalable fashion. Our findings are derived from a five-week field study with 32 participants and have been analysed by means of mixed effects logistic regression.

With regard to our first hypothesis, that deteriorating weather conditions have a negative effect on the usage of e-bikes for commuting, we found that average daily temperature did not have a significant effect on e-bike usage. However, there was a significantly lower probability that participants, irrespective of their participation in our intervention, used their e-bikes during the last three weeks of observation compared to the first two weeks of observation. At the same time, we observed that weather conditions generally deteriorated during the time of observation, including drops in temperature as well as frequent precipitation and even snowfall. We therefore suggest that the significant effect for this variable may be attributed to the worsening weather conditions, providing weak support for our hypothesis. We gain further confidence in this interpretation from various survey comments, which we received from the participants of our field study, who frequently mention weather-dependency as a negative aspect of e-bike usage: “The e-bike can only be used if the weather is good.”, “E-bike usage is weather-dependent.”, “It would have been better to conduct the field study in spring.”

Our second hypothesis, that increasing commuting distance has a negative effect on the usage of e-bikes for commuting, was confirmed in our analysis, which is not surprising. Some survey comments from the participants of our field study also refer to this aspect, e.g. “My trip distance from home to work is too long. It takes me 50 minutes.” However, while the probability of e-bike usage is considerably lower for long distance riders in general as well as for all participants during the competition phase, we also found a significant interaction effect between competition phase and long distance riders. This finding might indicate that those long distance riders, who do use their e-bikes despite the long distances they have to cover, are less impressed by deteriorating weather conditions and display a more stable usage behaviour.

Concerning the impact of social normative feedback on e-bike commuting, we find both of our hypotheses confirmed. First, social normative feedback appears to indeed have a positive effect on the usage of e-bikes for commuting. We see this finding further corroborated by comments of field study participants who had been allocated to the treatment group and thus received the social normative feedback provided as part of the e-bike commuting competition: “Good idea.”, “Very good comparison among participants.”, “It would have been motivating to compare myself to the other participants if the weather had been better.”, “It was interesting to see how often the others use their e-bikes.”, “The comparison with other users was interesting.” Second, frequency of usage-focused social normative feedback appears to entail negative effects on the usage of e-bikes for commuting by long distance commuters. Again, this result appears reasonable also on the basis of remarks provided by participants of our field study, where long distance riders criticized the incomparability of activities in the competition: “It somehow wasn’t measurable, as distances were too diverging. If it had been about kilometres only, I would e.g. have been in the top ranks. Therefore, it’s not measurable for me.”

5.2 Implications for theory and practice

While our results are of course based on the evaluation of findings from a relatively small sample, they may suggest a number of implications for theory as well as practice. With regard to travel mode choice theories and transport literature, our findings lend support to the significant influence of distance and weather on the usage of electric bicycles. In terms of social norms, we note that social normative feedback appears to be effective in changing behaviour also in a travel mode context, thereby adding to the work of e.g. Gärling and Fujii (2009) around the effectiveness of travel feedback programs. In addition, the negative impact of our frequency of usage-focused competition on long distance riders lends support to the notion that social normative feedback may also cause undesired behaviours, as indicated by Schultz et al. (2007).

For practice, while in our study, data collection was still conducted by means of self-reporting, technological advancements are fast progressing and creating ever new opportunities for collecting and displaying information at decreasing costs. Measures such as the e-bike commuting competition designed in this study could in a next step become more heavily automated and scalable through the use of IS. Our research findings indicate that measures incorporating social normative feedback may be effective means for steering travel mode choice decisions to a certain degree. Hence, we provide evidence for the notion that a further development of such approaches appears promising and may eventually help address challenges in local transportation systems even when significant investments in infrastructure are not possible. At the same time, our results may lend support to the notion that feedback systems will have to go beyond simplistic ‘one size fits all’-approaches if negative side effects are to be avoided, e.g. travel distance might have to receive special consideration in the feedback for long distance e-bike riders. Finally, our results hopefully also constitute a source of inspiration for employers, who are striving to position their companies as attractive places to work and at the same time seeking to promote the health of their employees. The offering of feedback programs or commuting competitions at work may attend to both objectives by creating positive image effects for the employer as well as establishing more healthy commuting behaviours of employees.

5.3 Limitations and future research

Some limitations need to be considered in the assessment of our contribution. First and foremost, although many of our findings are highly significant, they are based on a small group of 32 participants in our field study and specifically a subset of 23 participants from which we obtained valid data for our analysis. This of course limits the generalizability of our findings and calls for a repetition of the study with a much larger sample. Additionally, the duration of our observation was limited to a timeframe of five weeks and the field study was geographically confined to Eastern Switzerland, which might further restrict the generalizability of our results. Furthermore, the experiment was conducted during the months of October and November, whereas bike riding is primarily a warm weather endeavour. Hence, it is possible that the experiment might have produced different results if conducted during summer. However the timing of the experiment may also be viewed as an opportunity, as it allowed for the investigation of the impact of changing weather conditions on e-bike commuting in H1 and enabled the authors to show that the social normative feedback provided to the participants in the experiment had an effect on their usage behaviour despite the deteriorating weather conditions at the time. Next, participants took part in our field study voluntarily, so that we cannot entirely rule out the possibility that they might be particularly interested in cycling and thus create a bias of our results. Also, the fact that field study participants were working in the same company means that they could communicate across treatment conditions. It is unclear whether and how this may have influenced the results. Finally, the use of a self-reporting approach for data collection constitutes a potential source of inaccuracies in our data. We cannot entirely rule out that participants may have incorrectly filled out the surveys despite the simplicity and brevity of the survey design.

Future research should therefore continue to address the potential of social normative feedback for changing behaviour with regard to travel mode choice decisions. An investigation of these effects based on a broader data basis and particularly larger samples should be very insightful. Researchers might further be interested in investigating the design of social normative feedback in such a manner as to avoid undesired behavioural changes of subgroups as evidenced in our field study. An exploration of the long-term effects of such social normative feedback programs would be greatly interesting, as would an examination of the underlying psychological mechanisms leading to behavioural changes in travel mode choices and a potential influence of communication among participants in feedback designs. Finally, additional work into the technical feasibility and requirements of information systems, which would be capable of collecting the data upon which social normative feedback can be based and of displaying this feedback to the users, would be highly valuable.

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