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E-bike trials’ potential to promote sustained changes in car owners’ mobility habits

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Abstract

Modal shifts hold considerable potential to mitigate carbon emissions. Electric bikes (e-bikes) represent a promising energy- and carbon-efficient alternative to cars. However, as mobility behaviour is highly habitual, convincing people to switch from cars to e-bikes is challenging. One strategy to accomplish this is the disruption of existing habits – a key idea behind an annual e-bike promotion programme in Switzerland, in which car owners can try out an e-bike for free over a 2-week period in exchange for their car keys. By means of a longitudinal survey, we measured the long-term effects of this trial on mobility-related habitual associations. After one year, participants’ habitual association with car use had weakened significantly. This finding was valid both for participants who bought an e-bike after the trial and those who did not. Our findings contrast the results of other studies who find that the effect of interventions to induce modal shifts wears off over time. We conclude that an e-bike trial has the potential to break mobility habits and motivate car owners to use more sustainable means of transport.

Keywords

Mobility-related habitual associations, long-term impacts, sustainable transport, e-bike, trial, behaviour change
1. Introduction: The challenge of changing habitual travel behaviour

Shifts toward more environmentally friendly transport modes hold considerable potential to mitigate global carbon emissions (1). Especially in developed countries, cars are still the main mode of transportation, but electric bikes (e-bikes) represent an attractive alternative. This is not only due to their high energy and carbon efficiency, but also a variety of other features, including cost savings, health benefits and avoiding traffic congestion (2, 3). While e-bikes may also replace walking or conventional biking, the evidence from the available field studies suggests that purchasing an e-bike results in considerable substitution of car usage (2, 4-10).

However, while e-bike sales have shown rapid growth rates, e-bikes still represent a niche product that appeals mostly to the ‘dark green’ or ‘early adopter’ segments (2, 3, 6, 11-14).

Moving e-bikes from a niche to the mainstream is challenging. One major reason for this is that most travel behaviour is highly habitual (15-17) and generally occurs in stable contexts (including entrenched travel routes and times and established travel purposes, as well as the utilised modes of transportation), making behavioural change difficult (18, 19). Yet, disruptions of stable contexts have demonstrated a considerable potential for altering individuals’ mobility-related habits. Examples include highway closures, which may nudge car drivers to try out public transportation (20), or strikes, such as the London Underground strike of 2014, which led to lasting changes in mobility behaviour among about 5% of all affected travellers (21). In addition, natural disasters, such as hurricanes (22), and personal life events, such as a serious injury (23), qualify as disruptions that are sufficiently strong to induce changes in individuals’ mobility patterns.

While external disruptions often occur in a sudden and random manner, many behaviour-change programmes use the same principle. They deliberately introduce contextual changes to promote a shift toward more sustainable behaviour. In the mobility field, providing people with the option of experiencing alternative modes of transportation seems promising in breaking deep-rooted mobility habits, especially if these opportunities co-occur with contextual changes in individuals’ private lives (e.g. moving) (24, 25). For instance, the results of previous...
research suggest that providing a free travel card for public transportation to habitual car
drivers can trigger significant changes in modal choices toward more efficient modes of
transportation (26-31). Yet, longitudinal analyses that assess the long-term effect of these
interventions are scarce, and those that exist suggest that for most participants, the effects of
the interventions start wearing off after the end of the intervention (27, 28, 30).

While most of the available interventions focus on the switch from cars to public transportation,
there have also been three studies on e-bikes (10, 11, 32). These studies showed that trying
out an e-bike for 2–4 weeks is a promising approach to breaking participants’ mobility habits,
resulting, inter alia, in a higher willingness to purchase an e-bike (11), lower habitual
association with car use directly after the trial (32) and interest in using e-bikes more often in
the future (10). However, none of the previous studies provided a longitudinal assessment of
whether the context disruption caused by an e-bike trial is strong enough to induce long-term
shifts in participants’ mobility-related habits. This is the main objective of the present study.

2. Method

2.1. Intervention design

The annual Bike4Car campaign programme in Switzerland seeks to break car drivers’ habitual
behaviour. In this programme, organised by a Swiss environmental nongovernmental
organisation (NGO), car owners are offered a free trial of an e-bike over a 2-week period in
exchange for their car keys. In 2015 was implemented in collaboration with bike retailers
making e-bikes available to the participants; the Swiss Federal Office of Energy, which
supported the programme with an intense national ad campaign (TV, internet and posters);
and 32 cities responsible for local promotion. Between May and September 2015, 1854 car
owners participated in Bike4Car. After the end of the programme, participants were offered a
coupon to purchase an e-bike for a reduced price. Reductions varied by retailer. The largest
participating retailer offered a reduction of 500 CHF (approx. 425 Euro), covering around 20-
25% of the price of an e-bike. By November 2015 10% of participants used their coupon to buy an e-bike.

2.2. Data collection

The following analysis is based on a longitudinal series of two online surveys of all participants of the 2015 Bike4Car programme. The organising NGO sent the link to the first questionnaire by email to participants immediately after they signed up for the trial. Between May and July 2016, about one year after the start of the programme, all participants were asked to fill out a follow-up questionnaire. To ensure a sufficiently high response rate, email reminders were sent to the participants in each study wave. As an incentive for participation, all respondents were entered into a lottery for attractive e-bike- or bike-related prizes sponsored by the programme partners. Questionnaires were available in German, Italian and French, which are the three official languages of Switzerland. As almost no participants chose the Italian option, the following analyses focus on the German and French questionnaires only.

2.3. Sample

The responses used for the analyses came from $N = 405$ participants who fully completed the pre-trial questionnaire. Compared to the overall participation in the Bike4Car programme ($N = 1854$), this corresponds to a response rate of 22%. Moreover, $N = 300$ participants completed the follow-up questionnaire (response rate = 16%). The responses used for the analyses in this paper come from the $N = 144$ participants who completed both the pre-trial and follow-up questionnaires (combined response rate = 8%, see supplementary materials A for further details). Table 1 provides an overview of the samples. It shows that, compared with the Swiss population (33, 34, 35), well-educated men were overrepresented among the survey participants. In addition, more than half of participants lived in households with two or more cars indicating that the programme reaches a target group with a real potential for mobility-related energy savings. The sample characteristics of the participants were comparable in the pre-trial and follow-up questionnaires.
Table 1. Sociodemographic characteristics of the sample compared to the Swiss population

<table>
<thead>
<tr>
<th>Sociodemographic characteristics</th>
<th>Swiss population statistics</th>
<th>Pre-trial (N = 405)</th>
<th>Follow up (N = 300)</th>
<th>Pre-trial and follow up (N = 144)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>50% (33)</td>
<td>65%</td>
<td>70%</td>
<td>72%</td>
</tr>
<tr>
<td>Mean age (SD)</td>
<td>42.1 (33)</td>
<td>43.3 (10.5)</td>
<td>43.9 (10.4)</td>
<td>43.6 (10.7)</td>
</tr>
<tr>
<td>University degree</td>
<td>27% (34) #</td>
<td>57%</td>
<td>56%</td>
<td>54%</td>
</tr>
<tr>
<td>Vocational training</td>
<td>38% (34) #</td>
<td>29%</td>
<td>32%</td>
<td>31%</td>
</tr>
<tr>
<td>0 car in household</td>
<td>22% (35)</td>
<td>2% §</td>
<td>2% §</td>
<td>1% §</td>
</tr>
<tr>
<td>1 car in household</td>
<td>49% (35)</td>
<td>44%</td>
<td>45%</td>
<td>43%</td>
</tr>
<tr>
<td>2 or more cars in household</td>
<td>29% (35)</td>
<td>54%</td>
<td>53%</td>
<td>56%</td>
</tr>
</tbody>
</table>

Notes: *Education level of permanent population in Switzerland between 25 and 65 years old (34). § Although car owners were the programme’s target group, interested people who did not own a car were not excluded from the trial.

2.4. Questionnaires

Mobility-related habitual associations. All questionnaires included the response frequency measure that Verplanken and colleagues (36) developed, which Thøgersen and Møller (28) also used. They listed nine typical mobility-related situations and asked participants to choose the means of transport that spontaneously came to mind for each one. These situations are described on a rather general level and participants are asked for spontaneous reactions. This is why Verplanken et al. (36) argue that participants’ reactions draw on “pre-existing schemas or scripts about mode choice in general” (36: 290) which are dominated by habits. Although authors claim that this instrument does measure habits (36, 28), it does not measure actual behaviour but rather habitual associations. The following nine situations were taken from Thøgersen and Møller (28) and adapted slightly to better fit the Swiss context: ‘picking someone up from the railway station’, ‘visiting a friend in the closest city’, ‘visiting the mountains with friends for a day’, ‘commuting to work’, ‘doing sports’, ‘going for a walk in the forest’, ‘going shopping in the closest supermarket’, ‘going to the closest post office’ and ‘visiting somebody in the countryside’. Participants could choose from a list of seven options, including car, motorcycle, train, bus/tram, bicycle, e-bike and walking (see supplementary materials B for further details). The number of times participants mentioned each means of transport was...
taken as an indicator of participants’ mobility-related habitual associations. For each participant, a sum score for each chosen means of transport was calculated, with possible scores of 0–9.

**e-Bike purchase.** The follow-up questionnaire asked participants if they or a member of their household had bought an e-bike since the end of the programme. In the responses, 117 participants (39%) stated that they had not purchased an e-bike, 50 (17%) reported that they intended to buy an e-bike in the upcoming months and 133 (44%) indicated that they had bought an e-bike.

2.5. **Statistical analyses**

All questionnaires were matched for analyses. Statistical analyses were carried out using the Software IBM SPSS Statistics 24. They included repeated measures ANOVAs, paired-samples t-tests (two-tailed) and one-sample t-tests (two-tailed).

3. **Results: Long-term impacts of the trial on mobility-related habitual associations**

Of all modes of transportation, participants displayed the strongest initial (i.e. pre-trial) habitual associations with cars, followed by bicycles and walking. Participants in the e-bike trial reported stronger habitual associations with car, bike and e-bike use compared to a representative sample of the average Swiss population (see Table 2). This data has been collected in a separate survey among a sample that is representative to the Swiss population with respect to characteristics such as gender, age, educational level and income (37). The observed differences between both samples are another indicator that the programme reached a relevant target group.

<table>
<thead>
<tr>
<th>Sum score</th>
<th>Pre-trial $M (SD)$, ($N = 405$)</th>
<th>Representative sample $M (SD)$, ($N = 1476$)</th>
<th>$t (df)$, $p$-value</th>
<th>Effect size $r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>4.32 (2.00)</td>
<td>3.47 (2.63)</td>
<td>8.53 (404), $p &lt; .001^{***}$</td>
<td>.39</td>
</tr>
</tbody>
</table>
Table 3 displays the mean sum scores for the different means of transport reported in the pre-

Table 3. Comparison between the mean sum scores of mobility-related habitual associations in the pre-

<table>
<thead>
<tr>
<th>Sum score</th>
<th>Pre-trial M (SD), (N = 144)</th>
<th>Follow-up M (SD), (N = 144)</th>
<th>t (df), p-value</th>
<th>Effect size r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>4.26 (1.99)</td>
<td>3.74 (1.91)</td>
<td>3.54 (143), p &lt; .001***</td>
<td>.28</td>
</tr>
<tr>
<td>Bicycle</td>
<td>1.81 (1.55)</td>
<td>1.69 (1.63)</td>
<td>0.99 (143), p = .32</td>
<td>.08</td>
</tr>
<tr>
<td>By foot</td>
<td>1.12 (1.14)</td>
<td>1.22 (1.14)</td>
<td>-1.19 (143), p = .24</td>
<td>.10</td>
</tr>
<tr>
<td>Train</td>
<td>0.95 (0.87)</td>
<td>0.99 (1.00)</td>
<td>-0.45 (143), p = .65</td>
<td>.04</td>
</tr>
<tr>
<td>E-bike</td>
<td>0.31 (1.02)</td>
<td>0.90 (1.50)</td>
<td>-4.70 (143), p &lt; .001***</td>
<td>.37</td>
</tr>
<tr>
<td>Bus/tram</td>
<td>0.19 (0.52)</td>
<td>0.21 (0.51)</td>
<td>-0.28 (143), p = .78</td>
<td>.02</td>
</tr>
<tr>
<td>Motorcycle</td>
<td>0.26 (0.70)</td>
<td>0.15 (0.57)</td>
<td>2.45 (143), p = .02*</td>
<td>.20</td>
</tr>
<tr>
<td>Other</td>
<td>0.06 (0.26)</td>
<td>0.10 (0.39)</td>
<td>-1.30 (143), p = .20</td>
<td>.11</td>
</tr>
</tbody>
</table>

Notes: Sum scores are between 0 and 9, with 9 signifying the most pronounced habitual association related to specific means of transport. *** p < .001. One-sample t-tests (two-tailed).
Table 4. Comparison of mean scores of mobility-related habitual associations in the pre-trial and follow-up questionnaires for buyers and non-buyers. Means (SD) and standard deviations (SD).

<table>
<thead>
<tr>
<th>Sum score</th>
<th>Buyers (n = 53); M (SD)</th>
<th>Non-buyers (n = 91); M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-trial</td>
<td>Follow-up</td>
</tr>
<tr>
<td>Car</td>
<td>3.85 (1.69)</td>
<td>3.04 (1.13)</td>
</tr>
<tr>
<td>e-bike</td>
<td>0.42 (1.28)</td>
<td>2.06 (1.73)</td>
</tr>
</tbody>
</table>

Notes: Sum scores are between 0 and 9, with 9 signifying the most pronounced habitual association related to specific means of transport.

For habitual associations with car use, the repeated-measures analysis of variance (ANOVA) showed a significant main effect of time, $F(1) = 14.53, p < .001, \eta_p^2 = .09$, this indicated that participants had a weaker habitual association with car use one year after Bike4Car (see Table 3 for M and SD). Furthermore, the significant main effect for e-bike purchase, $F(1) = 9.14, p < .01, \eta_p^2 = .06$, indicated that on average, over both time points, habitual associations with car use were less pronounced for e-bike buyers compared to non-buyers. The interaction effect between the two variables time and e-bike purchase was not statistically significant, $F(1) = 2.12, p = .15, \eta_p^2 = .02$ (see Figure 1). This suggests that the programme had a long-term effect on participants’ habitual associations with car use, regardless of whether they would go on to purchase an e-bike.

For habitual associations with e-bike use, we found a significant main effect of time, $F(1) = 52.43, p < .001, \eta_p^2 = .27$, as well as a significant main effect for e-bike purchase, $F(1) = 39.94, p < .001, \eta_p^2 = .22$. These main effects were further qualified by a significant interaction effect between the two variables time and e-bike purchase, $F(1) = 53.85, p < .001, \eta_p^2 = .28$. This finding indicates that only participants who bought an e-bike after the programme exhibited increased habitual associations with e-bike use one year later. For non-buyers, habitual associations with e-bike use stayed practically the same over time (see Table 4 and Figure 1).
Figure 1: Change in habitual associations with car use and e-bike use over time for buyers and non-buyers of e-bikes. Main effects of time and purchase behaviour and their interaction on habitual associations with car use (left side) and e-bike use (right side; \(N = 144\)).

4. Discussion and conclusions

In line with previous research (11, 15, 16, 21, 24, 26, 27), our study findings indicate that disruptions of individuals’ mobility context may trigger changes in habitual travel choices. Bearing in mind that our study did not measure actual habits but rather habitual associations it provides strong evidence that exchanging one’s car keys for an e-bike for just a few weeks influences long-term habitual associations with car usage, and that this change persists even a year after the end of the intervention. This contrasts the findings of other studies who find that the effect of interventions wears off over time (27, 28, 30). While this decrease in habitual associations with car use was most pronounced for participants who did buy an e-bike following the trial, participants who did not change their mobility context displayed a significant long-term shift away from car use as well. Furthermore, it is noteworthy that this shift in habitual associations could be observed after a winter season has passed; which is usually cold, rainy and sometimes even snowy in Switzerland, and thus, not ideal for riding a bike – electric or not.

We can point to several plausible explanations for the observed persistence of the intervention’s effect mobility-related habitual associations. One is the strength of the habit disruption induced by the programme, as participants were required to hand over their car keys
for the 2-week duration of the trial. Hence, participants could not rely on their cars for
commuting, shopping or leisure activities; instead, they had to organise their day-to-day
activities around their e-bikes. Most studies that offer participants free use of public
transportation as an alternative to cars (26, 27) may not have been able to provide a strong
enough disruption, as they do not require participants to completely forgo the use of their cars.
Furthermore, while habitual car drivers may have some misconceptions about public
transportation (20), most people in Switzerland have experience with using it, which makes it
improbable that they are positively surprised by a trial. In contrast, since it is still a niche mode
of transportation, most participants may not have any previous experience with riding an e-
bike. Hence, during the 2-week trial, participants may have had novel, first-hand experiences
of the benefits of e-bikes, including health benefits, time savings or the realisation that steep
slopes – a key barrier to conventional cycling (2, 3, 11, 32) – are much less of a challenge than
they may have expected.

In this study it was not possible to track participants’ actual travel behaviour over time. This is
an important direction for future research using for example tracking devices and travel diary
studies. Still, the observed shifts of participants’ mobility-related habitual associations hint that
e-bike trials hold a considerable potential in terms of promoting sustained energy and carbon
efficient travel behaviour. Thus, policy-makers should consider supporting programmes that
enable people to experience the benefits of novel means of transport directly. Creating options
for such experiences has the potential for promoting sustainable mobility behaviour, and such
measures may also be useful in inducing behaviour change related to the use of other energy-
related services.

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**Author contributions**

CM contributed to the development of questionnaires, data analysis, and paper writing. SH and YB contributed to the development of questionnaires and paper writing.

**References**


