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The potential for e-biking among the younger population: a study of Dutch students

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1 **The potential for e-biking among the younger population: a study**
2 **of Dutch students**

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36 **Abstract**

37 This study assessed the benefits and limitations of e-bike use for students participating in a
38 pilot in a university town in the Netherlands. It targets a gap in the literature regarding e-bike
39 use in early adulthood. Thirty-seven pilot participants completed a survey on their e-bike
40 experiences, and follow-up in-depth interviews were held with eight participants. Results
41 suggest there is a considerable potential for e-bike use among students. Participants valued e-
42 bike speed, ease of use, the enjoyable experience of assisted cycling and independency from
43 public transport schedules. Main impediments were the high costs of e-bikes, which have to
44 compete with low-cost regular bikes and free public transportation. The study was based on a
45 small, non-representative sample. Self-selection of participants and self-report of travel
46 behaviors may have affected the internal and external validity of the results. Yet, the study
47 offers first insights in the potential for e-bike use among younger populations. The positive
48 attitudes of students suggest increased acceptance of e-bikes for everyday use, and likelihood
49 of use in later life. Insights may guide future development of sustainable transport systems in
50 university environments specifically and society in general. Results reveal a high potential for
51 e-bikes to substitute public transportation use, but the high purchasing price makes it difficult
52 for the e-bike to compete with other transport modes.

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54 *Key words* – Electrically-assisted cycling, university towns, sustainable transport, mobility
55 behavior, commuting

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71 **1. Introduction**

72 Electrically-assisted cycling, or e-biking, is growing in popularity in many countries across
73 the world (Fishman & Cherry 2015). E-bikes combine propulsion by user pedaling with
74 assistance through a computer-guided electric motor. They permit cycling at constant and
75 augmented speeds against reduced physical effort, and enable cyclists to cover longer
76 distances in shorter amounts of time. Together with high energy efficiency compared to
77 conventional motorized transportation, this makes them potentially effective in reducing
78 traffic congestion, associated environmental problems, and increasing users' physical activity
79 levels. Thus, e-bikes can be considered a viable alternative to conventional motorized
80 transport on distances too long to cover by regular bike (Fyhri & Fearnley 2015).

81 Case studies in Europe, North America and Australia have suggested that e-bike use is
82 especially high among middle-aged and older adults (Fishman & Cherry 2015). Little is
83 known about its potential among younger populations. Yet, stimulation of e-bike adoption in
84 early adulthood may help to reduce demands on public transportation systems and can
85 possibly substitute younger adults' use of conventional motorized transportation now and in
86 later life.

87 The present study aimed to gain insight in the potential benefits and limitations of e-
88 bike use for young adults by evaluating an e-bike pilot among university students. These
89 insights may be used to develop indicators of future e-bike use in this population and
90 prospective developments in e-bike mobility in general. Before presenting the method and
91 results of the study, we first discuss university students' travel behavior, determinants of
92 behavior change, and we briefly review the current knowledge on e-bike mobility.

93 94 a. Student travel behavior

95 There is a general lack of understanding regarding university student travel behavior. Many
96 travel behavior studies are not inclusive of the unique travel patterns of students that are
97 closely tied to university land use, class schedules, recreation and work (Eom et al. 2009).
98 Yet, as pointed out by Balsas (2003), the distinctive character of university student
99 environments offers unique opportunities for communicating sustainability practices and
100 shaping future transportation patterns. As such, positive experiences with sustainable modes
101 of transport during university years can potentially play an important role in encouraging
102 sustainable travel behaviors (Zhou 2012).

103 The majority of student travel behavior studies to date have focused on U.S. university
104 campus environments. Eom et al. (2009) found that walking was a prime mode for students

105 living on-campus at the North Carolina State University, while driving was the prime mode
106 for off-campus residents. Walking or driving to the university may also be dependent on
107 commuting distance. For example, a study by Chen (2012) stressed differences between
108 college-town and urban universities, with the latter having higher rates of motorized (public)
109 transport use among students due to longer commuting distances. Other possible factors of
110 influence on student travel behavior are climate and weather. A study at the University of
111 California Los Angeles demonstrated generally high rates of cycling, walking and public
112 transport use, which potentially relate to the favorable climate (Zhou 2012). Indeed, a study at
113 the University of Idaho showed important fluctuations in mode use due to seasonal variations
114 (Delmelle & Delmelle 2012). Another study at Kent State University in Ohio showed low
115 walking and cycling shares throughout the year (Kaplan 2015), although it was pointed out
116 that weather was but one factor alongside time pressure, busy streets, safety concerns and
117 supportive infrastructures for walking and cycling. In sum, important factors in modal travel
118 choice of U.S. students seem to be distance, weather conditions and the presence of walking
119 and cycling-friendly environments.

120 Despite the barriers, U.S. cycling rates appear to be generally higher among students
121 than in the general population (Pucher et al. 1999). The same seems to apply to the western
122 European context. High rates of cycling in cities such as Groningen, Enschede (the
123 Netherlands), Münster, Freiburg (Germany), Ghent (Belgium) and Odense (Denmark)
124 correlate with the presence of large student populations (see Fietsberaad 2006). A possible
125 explanation is the low barrier of entry in terms of cost, and the potential to save money when
126 cycling to the university instead of using other modes (Shannon et al. 2006, p.247). In some
127 countries, student populations are also eligible to free or discounted public transport use (De
128 Witte et al. 2006). This is, for example, the case in the Netherlands, where high use of
129 congested urban public transport by students has provided an impetus for attempts at modal
130 shifts from train and bus to cycling and other forms of active commuting. In this context, the
131 general need to decrease reliance on conventional motorized transport makes e-bikes a
132 potentially interesting form of active travel to complement shares of walking and regular
133 cycling in the Netherlands.

134

135 b. Determinants of travel behavior

136 Research on people's willingness to switch to environmentally friendly modes of transport
137 has revealed that travel behavior, like most daily behaviors, ensues from automatic processes
138 or habits (Müggenburg et al. 2015). Such habits permit to avoid continuously thinking about

139 what we do, and therefore more efficiently allocate cognitive capacity to other tasks
140 (Klößner & Verplanken 2013). In particular the daily routine of commuting has been found
141 to be strongly determined by habitual processes. This firmly embedded routine typically
142 overrides conscious decision-making behavior (Guell et al. 2012). However, infrequent or
143 major life events can tilt routines and offer opportunities for shifting commuting habits. These
144 key events can interrupt habits and start a re-evaluation of mobility behavior through active
145 decision-making strategies (Müggenburg et al. 2015). Previous studies have stressed the
146 importance of experiencing e-bikes firsthand. The opportunity to try an e-bike for an extended
147 period of time can potentially start the process of re-evaluating habits (Popovich et al. 2014;
148 Fietsberaad 2013).

149 To students, the disruptive effect of trying an e-bike on commuting habits will depend
150 on the extent to which it suits their particular lifestyle. Also, it will have to offer distinct
151 qualities compared to other transport modes. Aspects for consideration are mode safety,
152 reliability, speed, ease of use, comfort and an enjoyable experience (Van Hagen 2011). We
153 briefly discuss previous research on the qualities and impacts of e-bikes in the next section.

154

155 c. Research on e-bike mobility

156 Much of the existing research on e-bike mobility has been conducted in China (Ji et al. 2012).
157 The high rates of Chinese adoption of scooter-style e-bikes, followed by a surge in e-bike
158 rider injuries and fatalities, led to an abundance of studies on e-bike safety (Bai et al. 2015).
159 Transferability of these insights to other contexts is limited, as in Europe and North America
160 bicycle-style e-bikes are more common (Dill & Rose 2012). Nonetheless, safety remains an
161 important issue. This is due in part to the popularity among older adults (Fietsberaad 2013).
162 First evidence shows that in particular older and physically impaired e-bike crash victims are
163 more likely to be hospitalized than victims of accidents with regular bikes (Schepers et al.
164 2014). Generally speaking, e-bikes seem to present slightly greater risks than regular bikes,
165 which may be largely due to their higher speed (Schepers et al. 2014; Vlakveld et al. 2015).

166 Yet, speed seems to be the most distinctive characteristic of e-bikes and a major
167 contributor to positive user experiences (Popovich et al. 2014). It has also been suggested that
168 e-bikes' elevated speeds facilitate competition with local public transport and rush-hour
169 driving (Fyhri & Fearnley 2015). Related to speed is the reduced physical effort due to pedal
170 assistance, which permits bridging longer distances and more complicated journeys. Jones et
171 al (2016) found that this is an important motivation for using e-bikes. Also, pedal assistance
172 could allow parents to more easily transport small children. However, e-bike batteries, which

173 give e-bikes their initial advantage, also restrict ease of use by adding to the weight and thus
174 limiting cycling range and levels of assistance (Rose 2012). Furthermore, battery visibility
175 might in some cases add to the social stigma of assisted cycling being ‘cheating’ (Jones et al.
176 2016).

177 Finally, an important issue in e-bike mobility research is health. Assisted cycling
178 requires lower levels of physical activity compared to conventional cycling. This is, among
179 other things, reflected in lower cardiovascular and metabolic effort and less respiratory
180 exchange (Sperlich et al. 2012). Other studies have demonstrated lower cycling intensities for
181 assisted versus non-assisted cycling (Simons et al. 2009; Gojanovic et al. 2011). Nonetheless,
182 while beneficial effects are clearly highest when substituting motorized travel, these studies
183 conclude that assisted cycling offers sufficient physical activity to comply with moderate-
184 intensity standards and thus promote good general health (Sperlich et al. 2012; Simons et al.
185 2009; Gojanovic et al. 2011).

186 In the remainder of this article, we present the details of a study on e-bike use among
187 university students in the town of Groningen, the Netherlands. The study was conducted as
188 part of a pilot initiated to explore the potential of the e-bike for reducing extensive use of
189 public transport by students. We used this unique opportunity to examine students’ personal
190 experiences with e-bikes, which have thus far received little attention in the literature.

191

192 **2. Method**

193 a. The pilot

194 In the spring of 2015 the local mobility office *Groningen Bereikbaar* organized e-bike pilots
195 at several educational institutions in the city of Groningen (200.000 inhabitants). One pilot
196 was conducted among students of the University of Groningen (30,000 students). The city of
197 Groningen, located in the Northern part of the Netherlands, is known for its high share of bike
198 use. This is the result of long-standing policy efforts in compact city planning, traffic
199 management and the development of an extensive and coherent bike infrastructure network
200 (Fietsberaad 2006). Yet, traffic in the city often gets congested because many students make
201 intensive use of buses and trains, which they can ride for free using a student transit pass. The
202 university pilot was set out to investigate whether the e-bike might substitute the high use of
203 buses and trains, and thereby may help to reduce students’ reliance on public transportation.
204 Pilot participants were recruited through the university, and e-bikes were supplied by a
205 commercial third party. Regular model e-bikes were used in the pilot, legally defined as
206 requiring propulsion by user pedaling and offering assistance up to 25 km/h. For this type of

207 e-bike, driver's license, insurance or helmet use are not mandatory, and the same traffic laws
208 apply as for conventional cyclists (Fietsberaad 2013). A total of 41 university students
209 participated in the pilot from February to May 2015, each using the e-bike for four to five
210 weeks. At the end, they were offered the possibility of buying an e-bike at a reduced price.
211 When returning the e-bike, students were asked to fill out a survey. Students who completed
212 the survey were then approached by the researchers for a follow-up in-depth interview.

213

214 b. Survey

215 Of the 41 students who participated in the pilot, 37 completed the survey (22 men, 15
216 women). It was designed by the initiators of the pilot, and researchers were not involved in
217 the process. The survey comprised 16 questions, divided into five parts. In the first part
218 participants were asked about their travel behavior before and during the pilot using trip
219 counts by mode per week. The second part consisted of questions about participants'
220 motivations and experiences. Participants could indicate their main reason for participating in
221 the pilot from a checklist with response options 'try an e-bike', 'see whether it is a suitable
222 alternative to public transportation', 'see if it is faster', and 'other'. They were also asked
223 whether their expectations were met (answer options 'yes' or 'no', with the option of
224 explaining the reason for their response). In the third part participants were asked to rate their
225 experiences with the e-bike, with the options 'very good', 'good', 'fair', 'poor' and 'very
226 poor', and the option of explaining the reason for their response. An additional set of nine
227 statements addressed issues such as experience, ease of use, physical activity, safety and
228 image (e.g.: "Using an e-bike is fun"), with answer options 'strongly agree', 'agree', 'agree
229 nor disagree', 'disagree', 'strongly disagree'. In the fourth part of the survey participants were
230 asked whether they had bought an e-bike or were planning on doing so, and which factors
231 would help facilitate that decision (response options: 'price discount', 'rent with option to
232 buy', 'lease', 'provision of charging facilities'). Finally, the fifth part of the survey asked
233 participants whether sustainability had played a role in their decision to participate in the pilot
234 (response options 'yes' or 'no', with motivation) and whether they considered the e-bike to be
235 sustainable (open-ended).

236

237 c. Interviews

238 Semi-structured in-depth interviews with eight students (4 men, 4 women, mean age=25,
239 $SD=9.4$) were conducted to complement the survey data. We first recreated interview
240 participants' activity spaces by mapping the origins and destinations of the commute and

241 additional destinations reached by e-bike. This map served as a primer for the remainder of
242 the interview with the purpose of aiding participants' remembrance of travel behavior and
243 destinations reached during the pilot. Prior to the interviews we developed an interview guide
244 based on elements of travel mode satisfaction such as safety, reliability, speed, ease of use,
245 comfort and experience (Van Hagen 2011). A grounded theory approach was used for
246 interview coding (Hennink et al. 2011). Verbatim transcripts were anonymized and coded
247 using Atlas.ti. The resulting codebook was expanded and refined throughout the coding
248 process. Citations that supported conclusions were translated from Dutch to English by the
249 authors. To preserve confidentiality, all participants are referred to by their participant
250 numbers.

251

252 **3. Results**

253

a. Survey

254

Travel behavior

255 Table 1 provides an overview of participants' self-reported travel behavior in an average week
256 before and during the pilot. During the pilot phase, e-bike use increased significantly from 0%
257 to 87.0% of the total number of trips in an average week. This increase occurred mostly at the
258 cost of regular bike-use, which went down significantly from 56.3% to 5.1%. Bus use was
259 also significantly reduced from 20.8% to 2.3% during the pilot, as was combined bus/bike use
260 from 2.0 to 0.0%. The use of other transport modes (car use and walking) was also
261 significantly reduced from 14.3% to 3.3%. Although the use of the train, and combined
262 train/bus trips were somewhat reduced, these decreases were not significant. In general, the
263 introduction of the e-bike during the pilot period led to a shift from the regular bike and bus as
264 dominant transport modes to the e-bike as the dominant transport mode.

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274 Table 1 – Numbers and percentages of commuting trips by mode in an average week before
 275 and during the e-bike pilot

	Before pilot		During pilot		Difference	
	Nr of trips	%	Nr of trips	%	Chi ²	<i>p</i> -value
E-bike	0	0	187	87.0	359.06	<.001
Bike	138	56.3	11	5.1	137.13	<.001
Bus	51	20.8	5	2.3	36.62	<.001
Train	8	3.3	2	0.9	2.94	.087
Bike+bus	5	2.0	0	0	4.44	.035
Bus+train	8	3.3	3	1.4	1.72	.190
Other	35	14.3	7	3.3	16.79	<.001
Total	245	100.0	215	100.0		

276
 277 Respondents sometimes indicated that multiple modes were used before and during the pilot.
 278 Therefore, it was not possible to correctly assess mode substitution for all trips made.
 279 However, of e-bike trips that fully substituted trips done before the pilot (n=155), 58.3% were
 280 previously done by bike, 25.2% by bus, 3.3% by train, 3.3% by bus/train, 1.3% by bike/bus,
 281 and 8.6% was previously done using other modes (car or walking).

282
 283 *Motivations and expectations*

284 The main reason for participants to participate in the pilot was to ‘try out an e-bike’ (checked
 285 by 66% of the participants). The option ‘see if it is faster’ was checked by 22% of the
 286 participants, while the least checked reason was ‘see whether it is a suitable alternative to
 287 public transportation’ (11%). The majority (89%) stated that the e-bike lived up to their
 288 expectations.

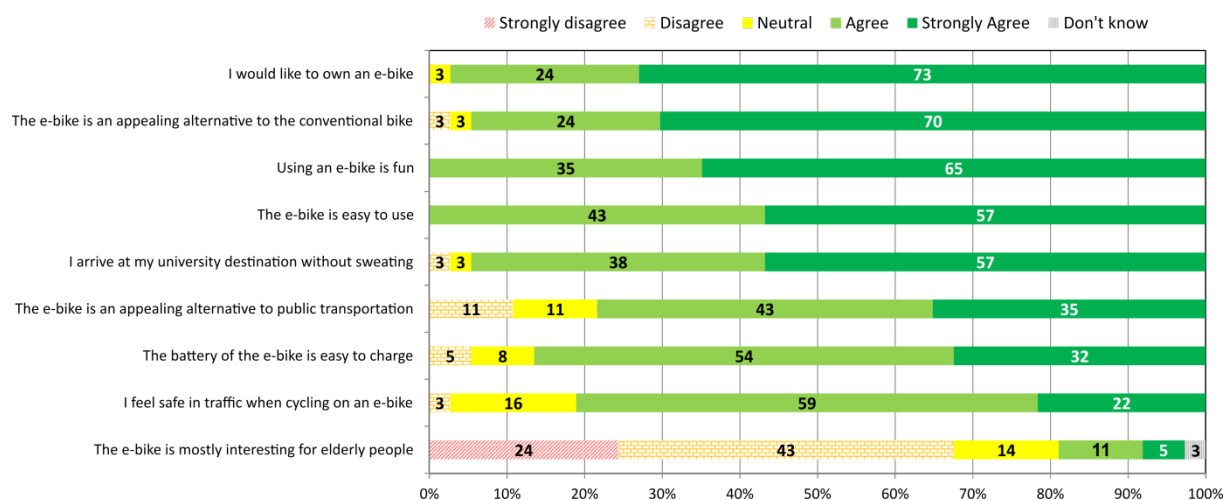
289
 290 *Experiences*

291 Students were almost unanimously positive about the e-bike, rating the experience as ‘great’
 292 (46%), ‘good’ (49%), or ‘fair’ (5%). Analysis of the comments reveals that the most
 293 commonly mentioned positive experiences were related to speed (mentioned 21 times, using
 294 words such as “fast” and “faster”), physical exercise (mentioned 12 times, using terms like
 295 “not/less tired”, “not/less sweaty”) and ease of use and comfort (mentioned 11 times). Three
 296 participants also mentioned negative aspects, stating that “the e-bike could go a little faster”,
 297 “it is a bit old-fashioned”, and “the battery runs low really quick. The majority of the
 298 participants also agreed that the e-bike was convenient to commute to and from the university
 299 (84%). Again, convenience was mostly linked to speed (mentioned 15 times), but ease of use,

300 saving time, independency from transit schedules and being less sweaty/tired upon arrival
 301 were also mentioned.

302 Figure 1 provides an overview of the responses to the nine statements on e-bike use.
 303 All participants agreed that using an e-bike is fun and that the e-bike is easy to use. Nearly all
 304 participants (97%) also agreed that they would like to own an e-bike, that the e-bike is an
 305 appealing alternative to the conventional bike (94%), and that the e-bike enables them to
 306 arrive at their destination without sweating (94%). A large majority also agreed with
 307 statements about the e-bike as an appealing alternative to public transportation (78%), easy
 308 charging of the battery (86%), and feeling safe in traffic when cycling on the e-bike (81%),
 309 while a large majority (67%) disagreed that the e-bike is mostly interesting for older adults.
 310 However, responses to these latter four statements were somewhat more ambivalent than
 311 responses to the other statements.

312



313

314 Figure 1 - Responses to nine survey statements on aspects of e-bike use (data labels in %)

315

316 Table 2 provides an overview of the correlations between participants' responses to the nine
 317 statements about e-bike use. The strongest positive correlations were found between the desire
 318 to own an e-bike and the statements that riding an e-bike is fun and that it is an appealing
 319 alternative to public transportation. There was also a strong, positive correlation between the
 320 view that it was an appealing alternative to conventional bike use and the statements that e-
 321 bike use was fun, that it was an appealing alternative to public transport, and the expressed
 322 desire to own an e-bike. A strong positive correlation was equally found between the view
 323 that the e-bike was fun to use, and statements that it was an appealing alternative to public
 324 transport and that it permitted to arrive at the university without sweating. Arriving without
 325 sweating was also found to strongly correlate with the statement that it was easy to charge.

326 Finally, a strong negative correlation was found between the view that the e-bike was an
 327 appealing alternative to public transport use, and the view that e-bikes were mostly suited for
 328 older people.

329

330 Table 2 – Correlations between statements about various aspects of e-bike use

	1	2	3	4	5	6	7	8	9
1. Would like own an e-bike	1.00								
2. Alternative to conventional bike	.46**	1.00							
3. E-bike is fun	.57***	.51**	1.00						
4. E-bike is easy to use	.13	.40*	.39*	1.00					
5. Arrive without sweating	.18	.17	.44**	.38*	1.00				
6. Alternative to public transport	.63***	.44**	.44**	.14	.40*	1.00			
7. E-bike is easy to charge	.24	.10	.20	.36*	.49**	.25	1.00		
8. I feel safe in traffic	.23	.23	.33	.31	.28	.04	.25	1.00	
9. Mostly for older people	-.24	-.25	-.09	-.04	-.03	-.33*	-.08	.12	1.00

331 * = $p < .05$, ** = $p < .01$, *** $p < .001$; Due to missing data, analyses are based on responses of 37 out of 41 participants

332

333 *Future intentions*

334 When asked how they thought about buying an e-bike, a large majority of the respondents
 335 (81%) stated that they had had a positive experience, but were not planning on buying an e-
 336 bike yet. Six participants considered buying an e-bike, whereas only one participant was “for
 337 sure going to buy an e-bike”. This participant currently commuted by bus, and indicated that
 338 independency from public transit schedules would be an important motivator. In general,
 339 when asked under which circumstances they would consider buying an e-bike, survey
 340 respondents mostly indicated “when the e-bike gets cheaper” (84%) and “if an appealing
 341 financing scheme is offered” (43%).

342

343 *Sustainability issues*

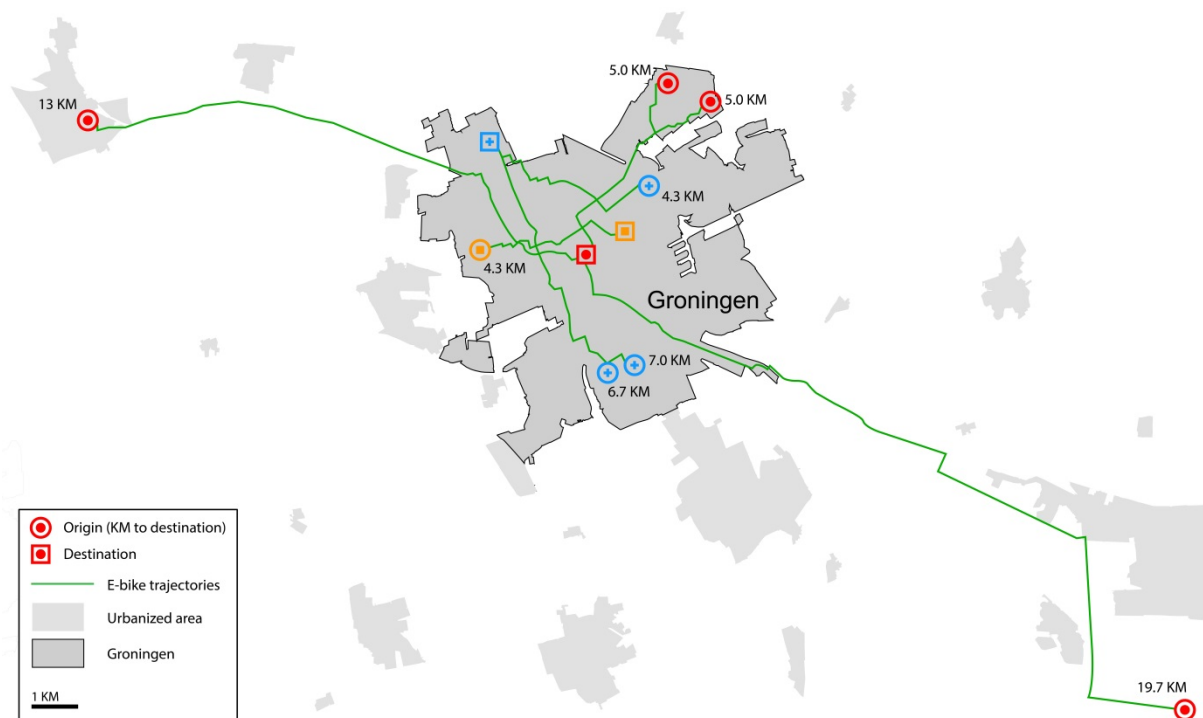
344 Finally, the majority of participants (59%) stated that environmental issues were no
 345 motivation for participation in the e-bike pilot. Sixty-two percent of the participants stated
 346 that they had used less motorized transport during the pilot. To some of the participants
 347 (16%), using the e-bike did not feel sustainable, as they previously used a conventional bike.
 348 Three participants (8%) saw the e-bike as more environmental-friendly than the bus, but also
 349 noted that the energy use of the e-bike made it less sustainable than regular cycling.

350

351 b. Interviews

352 Figure 2 shows the origins and destinations of the eight interviewees. Interviewee
 353 characteristics are detailed in table 3. Two lived in an inner suburb, four in an outer suburb,

354 and two outside the city. Most participants were young adults in the age between 18 and 27
 355 year. One participant was an older student aged 48. We included this older participant because
 356 she lived at a longer distance from the university and previously travelled mainly by car. This
 357 enabled us to gain some insight into the benefits and limitations of the e-bike compared to the
 358 car.
 359



360
 361 Figure 2 - Interviewees' origins, destinations, e-bike commuting routes and distances
 362

363 Table 3 – Interviewee characteristics

Interviewee	Age	Sex	Distance to university	Main commuting mode before pilot	Alternative commuting mode before pilot
1	23	F	4.3	Bike	Bus
2	21	M	7.0	Bike	Bus
3	23	M	6.7	Bus	Bus
4	24	M	4.3	Bike	Bus
5	27	M	5.0	Bike	Car
6	21	F	5.0	Bus	Bike
7	18	F	13.0	Train	Bike
8	48	F	19.7	Car	None

364
 365 The most mentioned reasons for using the main commuting mode were that the mode
 366 was the fastest, had the most direct route, or offered time control. Choice for alternative

367 modes was mostly related to the weather. Most interviewees had clear expectations of e-bike
368 use before the pilot, anticipating less physical effort (mentioned three times), faster commutes
369 (mentioned two times), and easy use (mentioned two times). Yet, two interviewees explicitly
370 stated not knowing what to expect. Others indicated that they had been hesitant to participate
371 at first as they considered the e-bike something for older adults or “lazy individuals”.

372

373 *“I thought, an e-bike, that’s something for softies, I really don’t need that”*
374 (Interviewee 2)

375

376 In line with the survey results, interviewees were unanimously positive about the e-bike in
377 retrospect. They praised speed (mentioned four times), and ease of use and reduced effort
378 (both mentioned three times). Most interviewees also achieved a reduction of their travel
379 times.

380

381 *“I noticed I didn’t have to leave 30 or 35 minutes in advance anymore. If I left 20*
382 *minutes in advance, that would do. I’d have more time”* (Interviewee 4)

383

384 Concerning physical effort, headwind proved less influential, which resulted in being less
385 sweaty on arrival compared to using a regular bike.

386

387 *“I have to cross all these fields. That’s where you notice the difference, since there’s*
388 *usually so much wind there”* (Interviewee 7)

389

390 Interviewees mentioned differences in preparing for the commute. One interviewee better
391 prepared her clothing and gear, and charged music onto her phone for the longer commute.
392 Others mentioned e-bike charging as an extra action to get used to.

393

394 *“Ten minutes before leaving, I’d have to start putting on my gear, my raincoat, my*
395 *headphones (..) but I got used to that, it wasn’t a big deal”* (Interviewee 8)

396 *“Every day, I would take the battery out, so first thing in, I would put the battery back*
397 *in, and then get on my bike”* (Interviewee 4)

398 *“It’s not a lot of extra actions, but you have more things to think about”* (Interviewee
399 3)

400

401 i. Safety & reliability

402 Interviewees felt safe, but needed some time to get accustomed to the e-bike. Seven
403 interviewees indicated that the elevated speed contributed to hazardous situations. Shifting
404 gears and judging other road users sometimes proved problematic.

405

406 *“It took me a couple of days to find out how fast I could go on different intersections,*
407 *when to shift gears” (Interviewee 8)*

408 *“In the beginning, I didn’t even think of the possibility that it could be more*
409 *dangerous. Then, I almost fell of my bike, and I realized I had to adapt, I had to mind*
410 *my speed in the bends” (Interviewee 5)*

411

412 In response to the question how they dealt with relative unsafety, participants mentioned
413 taking the time to get used to the bike and more pro-active cycling. Higher speeds also led to
414 differences in dealing with fellow road users. Interviewees mostly felt these issues were a
415 matter of cyclists’ own responsibility, and that further regulation was not required. Yet, some
416 reckoned that regulations could be desirable to ensure safety for some groups of people, for
417 instance older adults or the very young.

418

419 *“I see regulation as a last resort, for when the day comes that people can’t think for*
420 *themselves anymore. (..) How do you enforce e-bike laws and regulations? It’s such a*
421 *rigorous measure” (Interviewee 4)*

422 *“If you’re considerate, if you are careful, it shouldn’t be that dangerous. Same goes*
423 *for people cycling high speeds on a conventional bike” (Interviewee 5)*

424

425 Activity space mapping showed that all interviewees also used the e-bike for other purposes
426 than commuting, such as grocery shopping (mentioned by 6 interviewees), going to the library
427 (mentioned by 4 interviewees), attending social events (mentioned by 3 interviewees), and
428 recreational riding (mentioned by 2 interviewees).

429 Figure 3 shows a map of the different activities that interviewee 4 undertook with his
430 e-bike.



431

432 Figure 3 - Destinations reached by e-bike by one interviewee during the pilot

433

434 Several participants stated that the e-bike enabled them to more easily combine activities.

435

436 *“Coming home late, you would more easily be inclined to go to campus and go work*
 437 *out than with the regular bike, because you can get there really fast. Using the*
 438 *conventional bike, I would pass. Using the e-bike, well, I get there quickly”*
 439 *(Interviewee 3)*

440

441 Finally, we probed the technical complexity of the e-bike. Most interviewees were confident
 442 to solve minor issues that resemble those of a regular bike such as gears, brakes or tires.
 443 However, problems concerning electronics and propulsion mechanics would require help
 444 from the outside. To cover the costs of such repairs, most interviewees indicated a willingness
 445 to consider leasing a bike in the future if a maintenance service is included.

446

447 ii. Speed & ease of use

448 In line with the survey results, interviewees greatly enjoyed the speed of the e-bike. Yet, they
449 would have liked pedal assistance at higher speeds.

450

451 *“The first time at full speed, I thought ‘wow, it’s so fast!’ But you get used to that, and*
452 *on the longer sections I would think, ‘faster, faster’!”* (Interviewee 6)

453 *“I think it’s no different from my regular cycling speed. I think it could go faster. But*
454 *then again, I would probably also say that if the assistance was 35 km/h. It’s never*
455 *enough”* (Interviewee 3)

456

457 As a consequence of increased speeds, interviewees were busier overtaking other cyclists and
458 generally more alert when cycling. Especially during rush hours, participants were not always
459 able to cycle at full speeds. For most participants, however, having an e-bike did not lead to
460 taking different routes. One interviewee mentioned having changed routes from the usual
461 commute, arguing that minimized effort offered possibilities to try other routes that might be
462 more fun. Furthermore, interviewees mentioned the convenience of higher speed in relation to
463 bridges (mentioned 3 times), and headwind and long, straight sections of bike paths (both
464 mentioned 4 times). Finally, the easier acceleration offered by the electrical assistance meant
465 that interviewees felt less hindered by stops along the way, such as traffic lights or
466 intersections.

467 We probed ease of use of the e-bike and consequences for mental effort. Half of the
468 participants mentioned little to no significant changes to their commuting routines which
469 affected that ease. Two interviewees mentioned calmer commutes. The most important
470 consequences of e-bike use were slight changes in time and day planning, which were
471 generally experienced as positive. For six out of eight interviewees, the e-bike meant a shorter
472 travel time and thus time gain, translating in an earlier arrival for some, but meaning leaving
473 home later for others.

474

475 *“Leaving home at the same time, I would get here earlier, meaning less of a hurry to*
476 *get to class. I could get a coffee, or fill my water bottle, so it’s a calmer commute”.*
477 (Interviewee 4)

478

479 Independence from bus and train schedules was repeatedly mentioned as an important
480 advantage. However, bike parking then became an issue. Six out of eight interviewees agreed

481 that the e-bike was more prone to theft than their regular bike, the other two were neutral.
482 Although some stated to better lock the bike or park it inside their home, others said not
483 having done anything different.

484

485 *“Around where I live, bike theft is very common. And to be honest, I was surprised that*
486 *this one didn’t get stolen”* (Interviewee 4)

487 *“I double-locked the bike, as to not invite people to steal it. But then again, that’s what*
488 *I always do”* (Interviewee 1)

489

490 iii. Physical effort, comfort and experience

491 Overall, interviewees agreed that using the e-bike led to changes in physical exercise. It led to
492 reduced or no fatigue, less sweating and less strain compared with regular cycling. Apart from
493 mentioning the pleasures of more comfortable commuting, three interviewees said the e-bike
494 brought them a well-needed increase in physical activity.

495

496 *“Traveling by train is really passive. Riding the e-bike, you’re actually putting in*
497 *effort (..) and it gives you the feeling of doing good!”* (Interviewee 7)

498

499 Yet, for two interviewees this would be a reason not to buy an e-bike.

500

501 *“I would like to have more physical exercise, because that’s better for me. That would*
502 *for me be a reason not to use an e-bike, that would definitely be a point of concern”*
503 *(Interviewee 2)*

504

505 Interviewees were unanimously positive about their cycling experience, and all mentioned the
506 fun of commuting by e-bike and everyday cycling.

507

508 *“I enjoyed the sunrise, the dew in the fields, the birds, the train passing by. And I*
509 *thought, well, I’ll be later than you, but at least I’m exercising!” Then, arriving at the*
510 *university: “the janitor would look at me and say: ‘you biked, didn’t you? I can see*
511 *that, your eyes are vivid, you have a blush on you’. So yeah, I would be happier upon*
512 *arrival”* (Interviewee 8)

513 *“It was definitely fun. I especially enjoyed the headwind. I would arrive at the*
514 *university, not tired at all, but you’re cycling, you get the fresh air”* (Interviewee 6)

515

516 iv. E-bike image

517 In the survey, participants tended to disagree with the statement that e-bikes are mostly
518 interesting for older adults. In the interviews, the social stigma of assisted cycling being
519 something for older adults was mentioned and did play a role for five of the eight
520 interviewees. However, all of them stressed that it was not something that mattered to them
521 personally, but might be a barrier to e-bike use for others. Some mentioned that e-bikes are
522 not well-known. Pilots might help improve this image, as to the interviewees, their image of
523 the e-bike image had changed through participation.

524

525 *“When I told people I had an e-bike, a lot of them said, ‘isn’t that something for older*
526 *people?’ I said, try it! And they all liked it. So I really think that the image is bad... it’s*
527 *being related to older people, and no one knows how much fun it really is”*
528 (Interviewee 6)

529 *“Organizing pilots like these, I think that that would help. Looking at myself, I’ve*
530 *really had a great experience (..) and people who like it share their experiences with*
531 *people around them”* (Interviewee 1)

532

533 Most interviewees adjusted their initial view of the e-bike and three of them admitted that it
534 was more of a positive experience than they thought beforehand. Four interviewees also
535 stressed that they had gained insight in how they could benefit from e-bike use. A majority of
536 the interviewees said they would recommend it to others, although not for use by older adults:

537

538 *“Of course, it’s practical; they would have to put in less physical exercise. But the*
539 *chance of falling is much bigger. And if they fall, they are more easily injured”*
540 (Interviewee 5)

541

542 v. Purchasing an e-bike

543 Despite their enthusiasm about using an e-bike, six out of eight interviewees stated that they
544 do not need an e-bike at this point in their lives as they were getting around easily and cheaply
545 with their current modes of transport. In line with the findings of the survey, they indicated
546 that the availability of free public transport and low cost regular cycling made that the
547 advantages of the e-bike were not considered worth the investment.

548

549 *“You know, students in Groningen consider 800 or 1000 euro’s a lot of money for just*
550 *a bike. For the price of an e-bike, I could easily buy seven or eight other, normal*
551 *bikes”* (interviewee 4)

552
553 Only one survey respondent expressed the desire to buy an e-bike as alternative to current bus
554 commutes. For interviewee 8, an older student who commuted by car and had the longest
555 commute of all interviewees, participation in the pilot did lead to a re-valuation of her
556 commuting habits and a higher probability of purchasing one in the near future.

557
558 *“In one, or four years (..) For me, the reason to participate was to see whether the e-*
559 *bike can replace my car trips. And that’s exactly what happened. So for me personally,*
560 *the pilot was of great value. But that doesn’t mean that the next step is to immediately*
561 *buy one. It needs some time”* (interviewee 8)

562
563 Interviewee eight, who had the second-longest commute of all interviewees and travelled by
564 train, had recently bought a new, regular bike. She indicated that she would have taken an e-
565 bike into consideration, had the pilot been held before that purchase:

566
567 *“I had bought a new bike just before [the pilot], so that was unfortunate. Otherwise, I*
568 *would have thought about it”* (interviewee 1)

569
570 Thus, the willingness to buy an e-bike, or willingness to consider doing so, seems slightly
571 higher among respondents that currently commute by motorized transportation, and in the
572 case of the interviewees, live outside of the city and commute longer-distances on a day-to-
573 day basis. For those living in the city and doing short commutes by bus and bike, the e-bike
574 was not considered worth the investment. However, alternatively, interviewees mentioned to
575 be open to e-bike leasing. To the one interviewee commuting by car, a maximum monthly fee
576 of 50€ would be a maximum. Other interviewees indicated price ranges between 10 and 30€ a
577 month. Finally, despite the relatively low willingness to buy, all mentioned that the pilot led
578 them to be more open to buying and using e-bikes at later life stages, as an alternative mode to
579 bus, train and car use.

580
581
582

583 4. Discussion

584 This study explored the benefits and limitations of e-bike use for university students. We
585 linked with an e-bike pilot at the University of Groningen to gain insight in travel choices and
586 individual experiences of students using the e-bike. Results indicate considerable potential for
587 student e-bike use. Students valued e-bike speed, ease of use, the enjoyable experience and
588 independency from public transport schedules. They stressed the importance of cyclists' own
589 responsibility in dealing with safety issues and saw little use in increased regulation. Barriers
590 to e-bike use after the pilot proved to be the high costs, and competition with low-cost regular
591 bikes and free public transportation. Despite the barriers related to the high price, our findings
592 support that there is a potential for e-bike use among a student population, and that gaining
593 experience with an e-bike through participation in a pilot may increase likelihood of e-bike
594 use in later life, and increase the acceptance of e-bikes as a suitable mode for everyday use.

595 Earlier studies have stressed the importance of a high speed and ease of use in e-bike
596 use (Popovich et al. 2014; Johnson & Rose 2015; Dill & Rose 2012). Students appreciated
597 these factors as well. They mentioned the enjoyment of speed, reduced effort, and mitigation
598 of wind influence to be central to their travels during the pilot. Also, it enabled them to reach
599 more destinations in shorter amounts of time. This is in line with other findings that stressed
600 the benefits of improved mobility and accessibility compared to bus use (Cherry et al. 2016).
601 Ease of use was also found to be an asset, confirming that effortless usage of an e-bike favors
602 a positive opinion, which can in turn leads to higher use (Wolf & Seebauer 2014).
603 Disadvantages were also mentioned, such as the preparations prior to the commute and the
604 need for secure parking. Popovich et al (2014) found e-bike users to be worried more about
605 the risk of theft. To students however, this was not seen as an important impediment, which
606 may be related to the fact that they did not personally own the bike.

607 Previous research suggests that users of conventional e-bikes are at higher risk of
608 injury than regular cyclists (Fishman & Cherry 2015). The present study showed that students
609 mostly attribute potential safety hazards to other e-bike users rather than to themselves. While
610 they expressed being aware of the risks, they stressed how own responsibility and adaptive
611 cycling mitigates that risk. We found little support for increased policy regulations.

612 Finally the goal of the e-bike pilot was to initiate a modal shift towards e-bike use. The
613 present study showed that students were very keen on using the bike while it was available to
614 them without any costs, and that having an e-bike led not only to decreased use of regular
615 bikes, but also to a decrease in bus rides, as aimed for by the initiators of the pilot. However
616 the willingness to buy was very low. Earlier studies mentioned purchase price of e-bikes as a

617 main barrier to e-biking (Jones et al. 2016). Students' relatively lower purchasing power and
618 availability of low-cost alternatives like regular cycling and public transportation are a main
619 barrier to student e-bike use. Interestingly, the social stigma of e-biking as a form of cheating
620 (Jones et al. 2016) was not a barrier to e-bike use by students. Some of them mentioned being
621 aware of the stigma of e-bikes being 'something for older people', but this did not hinder
622 them in using one themselves. This might in part result from what Peine et al (2016) have
623 termed the 'rejuvenation of e-bikes': newer e-bike designs being tailored to different, younger
624 adopter categories, thereby breaking with existing stereotypes.

625 A main strength of the present study is that it evaluated e-bike use in a population that
626 has thus far received little research attention, and to whom communication of sustainable
627 practices holds high potential in shaping (future) sustainable travel behavior. However, the
628 study is not without limitations. First, we took no objective measurement of changes in travel
629 behavior, so there is a risk of self-report bias. Another important limitation is that the
630 researchers were not involved in the survey design. The survey had shortcomings with respect
631 to collection of participant characteristics (age, home location, trip purposes), and definition
632 of terms such as safety and sustainability, which might have been interpreted differently.
633 However, the data were informative and were complemented with carefully formulated
634 interview questions. Finally, the sample was small, non-representative and self-selected.
635 Therefore, the findings might not be generalizable to other populations. However, students
636 were offered the opportunity to try an e-bike for free, and some interviewees stated to not
637 exactly know what an e-bike was prior to the pilot or what pilot participation entailed. Thus,
638 self-selection may not have been very strong because students might have participated
639 regardless of their view on e-bikes.

640 Future research may further explore e-bike use and its potential for use in early
641 adulthood using objective registrations of travel behavior, for example by means of GPS
642 tracking. By combining such studies with representative surveys among larger samples, more
643 insight could be gained into the factors that enable a modal, sustainable shift from
644 conventional motorized transport to e-bike use. Issues of self-selection may be addressed by
645 conducting experimental studies, in which participants are randomly assigned by the
646 researchers to conditions of using an e-bike or control conditions.

647 A main practical impediment to e-bike use among students was found to be its high
648 purchase price and the competition with cheap regular bikes and public transportation. Future
649 studies may further examine this relationship and the possibilities of providing students with
650 more appealing options such as e-bike financing, leasing or renting.

651 In general the results of the present study support the idea that e-bike use can be
652 effective in replacing excessive use of free public transportation by students. These insights
653 may be used in future efforts directed at realizing a modal shift in student travel behavior. The
654 positive attitudes of students towards e-bike use indicate increased acceptance of e-bikes as an
655 everyday mode of transport and suggest likelihood of use in later life. Finally, our findings
656 provide support for the method of e-bike pilot testing in attracting new user groups.

657

658 **5. Conclusion**

659 Persistent high levels of conventional motorized transportation around the world continue to
660 underscore the importance of adopting more sustainable transport alternatives such as the e-
661 bike. Our findings show that students highly valued e-bike use, although the high costs of e-
662 bikes cannot compete with low-cost regular bikes and free public transport. Yet, the present
663 study suggests that giving young adults the opportunity to try an e-bike may increase their
664 acceptance of e-bikes for everyday use in the present and in their future lives.

665

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