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Beyond 'good' and 'bad' cyclists

On compensation effects between risk taking, safety equipment and secondary tasks

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Structured abstract

INTRODUCTION

In France the number of injuries involving cyclists has risen over the last 10 years. With the widespread use of ICT devices, secondary tasks have become a major focus for transport safety research. They have also been identified as a predictor of collision. Although still scarce, this literature on cyclists' secondary tasks identifies a recurrent profile. Young cyclists are in the spotlight as they often use earbuds or headphones and combine such use with taking other major risks on the road. Despite their vulnerability, their group accounts for only 12% of severe fatalities, which is proportional to their share of the urban cyclist population. This paper explores other cyclist profiles in an attempt to understand the discrepancy between the perception of risk-prone behaviour and transport safety statistics.

METHODS

We seek to establish more nuanced profiles, i.e. cyclists who balance risk-taking and safety. In order to detect these profiles, we conducted 1,746 observations at 14 locations in the city of Besançon (France). For each observation we considered 30 variables that provide information on the cyclist's profile, secondary tasks, risks taken, and safety equipment.

RESULTS

These observed situations show that the two well-documented profiles (i.e. 'risk-prone' or 'risk-averse') together represent only 53.84% of our observations. We identify more mitigated profiles. Primarily a large group (37.29%) consists of middle-aged and elderly cyclists who are poorly equipped, who are rarely engaged in any secondary tasks, but who take occasional risks on the road.

CONCLUSIONS

Policies that aim to reduce the use of ICT devices on bike for all are necessary but not sufficient for reducing collisions. In addition to providing dedicated infrastructure, more targeted responses need to be provided to these different groups, such as focused actions on safety equipment and compliance with the traffic regulations for elderly cyclists.

42 1. Introduction

43 The widespread use of smartphones and the advent of devices designed to facilitate listening or
44 communication while cycling has given rise to a scarce but growing literature on cycling safety and
45 secondary tasks (de Waard et al. 2009; Huemer et al., 2019; Terzano, 2013).

46 It has been shown that the simple fact of performing secondary tasks while cycling can predict
47 collisions; this especially concerns teenagers and young adults (Goldenbeld et al., 2012). In so far
48 as they impair attention, perception, hearing and sight, secondary tasks are considered central to
49 cycling accidentology (e.g. Huemer et al., 2019; Terzano, 2013).

50 For instance, de Waard et al. (2014, 2015) have shown that the use of a hand-held phone has three
51 major impacts: (1) it increases reaction time to an auditory signal by 50%; (2) it significantly
52 decreases the number of objects detected in the visual periphery; and (3) it causes the cyclists to
53 keep more distance from the curb, and thus brings them closer to other road users especially cars.
54 These studies also report reduced attention to auditory signals if the cyclist is wearing an earpiece
55 (83% do not hear the signal).

56 Despite the existence of recent publications like the articles mentioned above, most of the literature
57 focuses on the risks of secondary tasks when driving a car. For instance, Olson et al. (2009) have
58 shown that a driver who texts a message is 23.2 times more likely to be involved in a safety-critical
59 event.

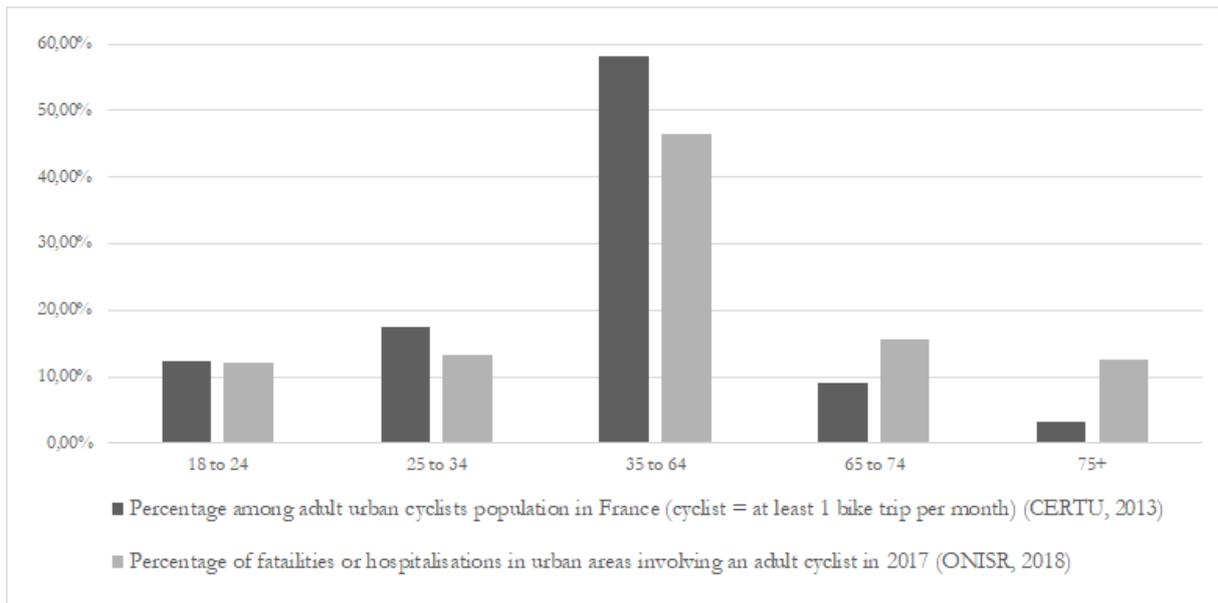
60 Other studies also examine the impact of secondary tasks realized by pedestrians: when the latter
61 talk on the phone, they tend to cross the street without looking significantly more often (Nasar et
62 al., 2008).

63 A comparison of current literature on these three types of users shows that the effects of secondary
64 tasks diverge between them. Notably, according to several studies realized in the Netherlands, 70%
65 of bicycle crashes are single-vehicle crashes; half of these collisions involve structural elements
66 (Goldenbeld et al., 2012; Schepers, 2008, 2009). It therefore constitutes a risk more to themselves
67 than to other users like pedestrians or other cyclists (Terzano, 2013).

68 The literature identifies a typical profile with risky behaviour. Younger (generally male) cyclists,
69 more exactly teenagers and young adults, tend to engage more frequently in secondary tasks
70 involving ICT devices. These cyclists also usually combine these secondary tasks with taking risks
71 with regard to traffic regulations, and they fail to wear safety equipment such as helmets. All this
72 makes them particularly prone to serious injuries or fatalities in the city (Goldenbeld et al., 2012).

73 Most of the literature emphasizes combinations of equipment and behaviour (complying with
74 traffic rules: using cycle paths, stopping at traffic lights, etc.) that tend to distinguish two specific
75 profiles. The first applies to risk-taking cyclists, who are rather young, often boys, poorly equipped,
76 prone to engaging in secondary tasks, riding fast, and breaking the traffic law. The second applies
77 to risk-aware cyclists who do just the opposite. This rather normative dualism between 'good' (risk-
78 averse) and 'bad' (risk-prone) cyclists does not help in thinking about the diversity and multi-
79 factorial nature of safety-related cycling practices.

80 Moreover, a careful analysis of road safety data for France shows that young cyclists (18-24 y.o.)
81 are obviously exposed to the risk of fatalities or serious injuries. That said, when we compare this
82 figure with their share in the population of regular or more occasional urban cyclists, we find that
83 their fatalities or hospitalisations rate is simply proportional to their number (see Figure 1)
84 (CERTU, 2013; ONISR, 2018).



85

86 *Figure 1: Share of fatalities or hospitalisations in French urban areas, and share of the population of adult urban*
 87 *cyclists, by age group*

88 Obviously, cyclists are not always responsible for the collisions they are involved in. That said, the
 89 substantial number of serious collisions for elderly cyclists raises questions as they are globally not
 90 particularly involved in secondary tasks, they are generally better equipped, and generally take few
 91 risks but still experience a high number of severe collisions, well in excess of the cycling population
 92 they represent (see Figure 1). Part of the explanation for these fatalities and hospitalisations
 93 overrepresentations comes from the ‘frailty bias’ (Evans, 2001; Hakamies-Blomqvist, 1998, 2003).
 94 Indeed, compared to younger populations, older people are more often injured or hospitalized after
 95 a collision.

96 We designed this study through a partnership with the local authority (*Grand Besançon Métropole*)
 97 which was particularly concerned with cycling safety. While for most modes of transport, the
 98 number of fatalities and injuries is decreasing in French cities, there was an increase in both these
 99 indicators for cyclists over the period 2007–2018, partly attributed to secondary tasks and the
 100 ensuing decreased attention span (ONISR, 2018).

101 A systematic and wide-ranging analysis of all behaviours on the road, but also an analysis of
 102 equipment and areas frequented, is therefore necessary in order to gain a better understanding of
 103 this risk-taking, in a more sophisticated and realistic classification than a division between ‘good’
 104 and ‘bad’ cyclists. It only takes a brief period of observation of urban cyclists to realize that many
 105 other combinations can be found between types of cyclists, their equipment, their secondary tasks,
 106 and their (non-)compliance with traffic regulations. For example, Kirchner et al. (2015) and de
 107 Waard et al. (2010) show that cyclists adapt their speed when interacting with mobile phones.

108 The broader hypothesis that we seek to test in this paper is the existence of compensatory effects
 109 for a large proportion of the cycling population, between the use of safety equipment, risk-taking,
 110 and secondary tasks in the different areas frequented. For example, cyclists with little safety gear
 111 may tend to moderate their speed and may tend to prioritize reserved bicycle lanes in order to limit
 112 collisions with motorized vehicles. Another example, on the other hand, people with different
 113 safety items (helmet, reflective tape, and jackets) may tend to feel safe and may ride faster and
 114 occasionally break the rules of the road.

115 In order to test our hypothesis, a field observation campaign was conducted in Besançon (France)
116 to jointly analyse several dimensions potentially explaining urban cyclists' behaviour with regard to
117 safety.

118 2. Case study, material and methods

119 Our observation seeks to respond to several limitations in the literature. First, most of the
120 observational protocols are limited to a small number of locations, usually along routes that are
121 well equipped for cyclists, and where bicycle traffic is substantial (de Waard et al., 2015; Huemer et
122 al., 2019). This type of observational protocol allows a maximum number of cyclists to be observed
123 and limits double counting. Moreover, observing along routes separate from motor traffic also
124 allows more secondary tasks to be observed. However, these observations are therefore limited to
125 a few types of cycling situations, and do not allow for the observation of behaviour in a set of
126 differentiated situations (such as cycling in car traffic or crossing a pedestrian precinct).

127 Secondly, observational studies of secondary tasks while cycling are mainly conducted in cities with
128 well-equipped infrastructure for cyclists (such as separate paths, or priority at the traffic lights) and
129 where cycling is a frequent mode of transport. For example, Braunschweig (Germany) where
130 cycling had a modal share of 15% in 2004, or Groningen (the Netherlands, 60% in 2017) are
131 considered in de Waard et al., 2015 and Huemer et al., 2019 (EPOMM, 2020). Although these cities
132 are seen as models for increasing the modal share of cycling, they do not represent the majority of
133 cases in Europe (Raser et al., 2018). We present a study conducted in a city where cycling is less
134 central, whether in terms of modal share or in terms of density of cycling facilities.

135 Our study was conducted in Besançon which is the second most populated city in the Bourgogne-
136 Franche-Comté region of France with 117,000 inhabitants including a large student population
137 (23,000). The modal share for bike-use is 3% (Grand Besançon, 2015). Although fairly compared
138 with Danish or Dutch cities, this percentage is typical of medium-sized French cities. The local
139 authority (*Grand Besançon Métropole*) has furthermore reported a doubling of this modal share since
140 2008 and considers there are 4,000 cyclists for 15,000 bike trips every day in Besançon (Grand
141 Besançon, 2015). This rather low cycling modal share can be explained by many geographical, social
142 and cultural factors, but also by cycling facilities that are quantitatively less significant than in the
143 cities mentioned above and whose quality is sometimes criticized by local cycling associations.
144 There are 110 km of reserved bicycle paths in the conurbation of Besançon for 193,000 inhabitants,
145 i.e. 0.57 metres of track per inhabitant. This indicator is at least three times lower than for Nordic
146 cities with equivalent populations (e.g. Odense, Turku, Aalborg, Örebro) (Bono, 2014; Mueller et
147 al., 2018).

148 For cyclists as for other vehicle conductors in France since 2015, most secondary tasks are illegal,
149 namely the use of an earpiece or making a phone call, or sending a message. Hence, we have chosen
150 a methodology that relies on observation rather than on reported frequencies that may often be
151 underestimated in such cases.

152 Observations were made on 12 March 2020, five days before the French lockdown measures due
153 to the COVID-19 pandemic, from 3 pm to 7 pm. The weather was sunny. The temperature was
154 15 °C. The sun went down around 6:30 pm. This observation was conducted as a workshop with
155 undergraduate geography students. To ensure that the observation was very detailed, two students
156 (three in the most crowded places) positioned themselves to be able to observe the same cyclist
157 behaviours without being seen. For example, one group stayed in a car, another was in a café. We
158 tested student positions on 20 February and 5 March 2020 from 3 to 6 pm. During these two

159 sessions, students were also trained to complete the observation grid to improve inter-coder
 160 reliability. The study was conducted in accordance with French data privacy policy. Firstly, we
 161 observed only adults, even though teenager behaviours are a topical issue. Secondly, we used direct
 162 observation with no video recording.

163 In this study, what we observed were ‘situations’, each made up of a particular person (A) with
 164 particular equipment (D) behaving in a particular way in terms of secondary tasks (B) and risk-
 165 taking (C) in a particular place (E). At the top of each coding sheet, we recorded the observation
 166 location, the date, the weather, and the time. Two points need to be made. First, regarding speed
 167 (c3), observers were asked to indicate ‘0’ when the cyclist was stationary, voluntarily standing astride
 168 their bike, and not waiting at a traffic light, ‘1’ when the cyclist was pushing their bicycle, ‘2’ when
 169 the cyclist was riding at a normal or reduced speed, and ‘3’ when the cyclist was riding too fast, in
 170 a manner that was risky for others. Another precautionary point concerned compliance with the
 171 traffic regulations (c2) as this information was central to our study. The infringements identified
 172 did not concern the lack of regulatory equipment, or riding with one or no hands, or excessive
 173 loading or possible excessive speed, as this information was already taken into account elsewhere.
 174 Here infringements concerned only either failure to obey traffic signs, riding in areas prohibited to
 175 cyclists or riding against the flow of traffic.

176 In all 1,881 situations were observed. We decided to remove 135 observations of cyclists who used
 177 public bikes (*VéloCité*). These bikes are already equipped with certain safety devices by default, their
 178 use leads to no helmet usage and so could bias our analysis. The study was therefore based on the
 179 remaining 1,746 observations.

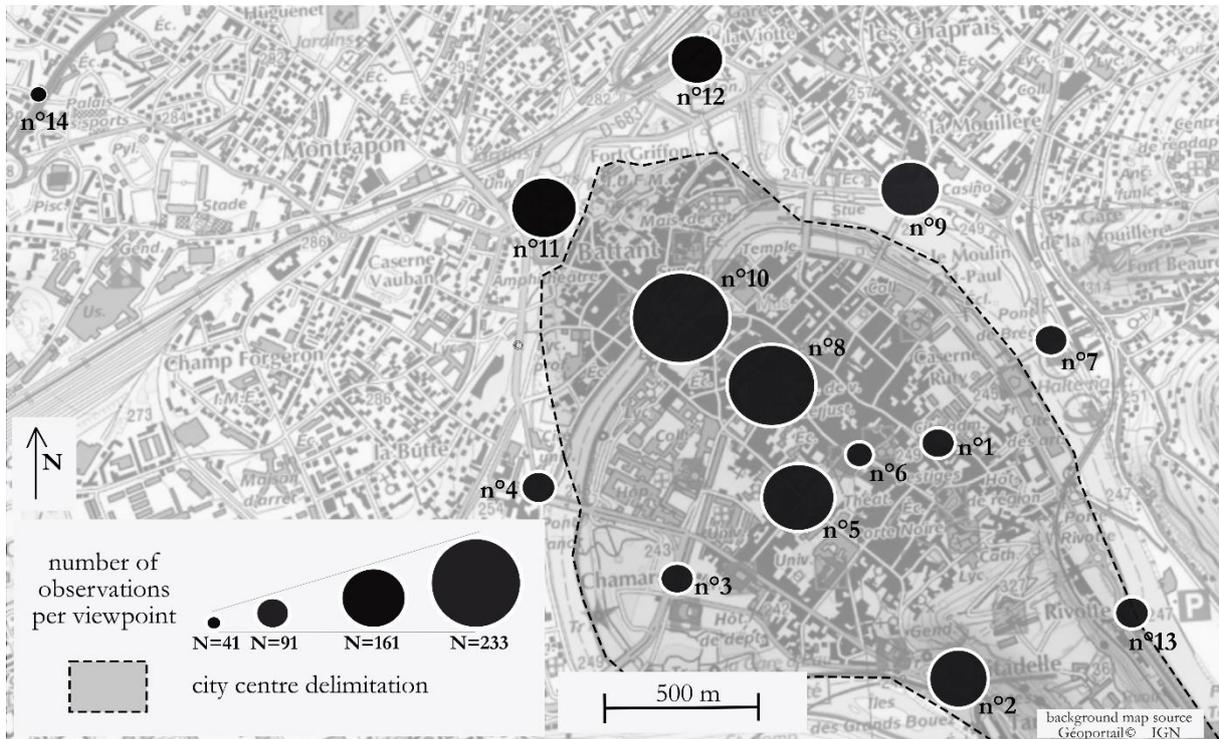
180 We selected 14 observation points in partnership with the local authority’s Transport and Mobility
 181 Department. These points correspond to major paths taken by cyclists in the city centre. The areas
 182 taken into consideration differ greatly with regard to the sharing of public space (Table 1).

Obs. point	Number of observations	Is cycling assigned to a dedicated path or road lane?	Is the road shared with motorized vehicles ? (if yes, what is the speed limit for cars?)	Are there tram rails at this location?	Is the path shared with pedestrians ?
1	82	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> / 30	<input type="checkbox"/>	<input type="checkbox"/>
2	152	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
3	82	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
4	86	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> / 30	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
5	175	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> / 30	<input type="checkbox"/>	<input type="checkbox"/>
6	73	<input type="checkbox"/>	<input checked="" type="checkbox"/> / 30	<input type="checkbox"/>	<input type="checkbox"/>
7	84	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> / 50	<input type="checkbox"/>	<input type="checkbox"/>
8	210	<input type="checkbox"/>	<input checked="" type="checkbox"/> / 30	<input type="checkbox"/>	<input checked="" type="checkbox"/>
9	147	<input type="checkbox"/>	<input checked="" type="checkbox"/> / 50	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
10	233	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
11	161	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
12	130	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
13	90	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
14	41	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/> / 50	<input type="checkbox"/>	<input type="checkbox"/>

183 *Table 1: Characteristics of the fourteen observation points*

184 In the case of co-presence with motorized vehicles, the maximum traffic speed could also vary
 185 (30km/h or 50km/h). As the centre of Besançon is split (in terms of urban form) between a very
 186 dense historical centre with narrow one-way streets and low speed limits and more recent districts

187 with wider traffic lanes, we also took as a variable whether the observation point was in the historic
188 centre or not (variable e1) (Figure 2).



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Figure 2: Fourteen observation points have been selected in and around the city centre

191 As the observation lasted several hours with 14 observation points corresponding to the places
192 most frequented by cyclists, some cyclists must have been observed several times. Insofar as we
193 seek to identify situations in which cyclists behave in one way or another, these double counts are
194 not detrimental to our observation as we observed situations rather than cyclists, allowing us to
195 assess both the persistence of certain behaviours and the relevance of the types of areas frequented
196 for safety-related behaviour.

197 In order to estimate multiple counts of cyclists, though, we looked for identical profiles in several
198 observations by taking into account the variables that are consistent between two observations
199 points: gender, age group, equipment, whether they are sports cyclists or cycle as part of their job
200 (delivery person or police officer). In all 722 different profiles were identified with an observation
201 frequency of 2.38 times per profile. As a result, we can state that our observation corresponds to
202 approximately 720 different people. Our observation therefore corresponds to 18% of the 4,000
203 estimated daily cyclists which is substantial.

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3. Results and discussion

3.1. Few secondary tasks, but other risky behaviours

In general, the unsafe behaviours we are trying to observe and understand are rather rare. This is especially true for secondary tasks (Table 2).

	Variables	Modalities	N=	%
A 'Cyclist profile'	A1: Gender	[1 = man]	1,135	65.46%
		[0 = woman]	599	34.54%
	A2: Age category	[18-35]	784	44.95%
		[36-60]	837	48%
		[60+]	123	7.05%
	A31: Cycling alone	[1= yes]	1,545	88.49%
	A32: Cycling with someone on the bike	[1= yes]	80	4.58%
	A 33: Cycling with someone alongside	[1= yes]	119	6.82%
A34: Transporting something	[1= yes]	64	3.67%	
A4: Cycling for sport (i.e. the person observed is dressed like a sports cyclist)	[1= yes]	94	5.38%	
A5: Professional on bike (i.e. mainly delivery people and three police officers)	[1= yes]	116	6.64%	
B 'Secondary tasks'	B1: Listening	[1= yes]	97	5.56%
	B2: Phoning	[1= yes]	14	0.80%
	B3: Manipulating screen	[1= yes]	6	0.34%
	B4: Looking at screen	[1= yes]	11	0.63%
	B5: Talking	[1= yes]	101	5.78%
	B6: Eating	[1= yes]	4	0.23%
	B7: Smoking	[1= yes]	8	0.46%
C 'Risk-taking'	C1: Number of hands on handlebars	[0]	14	0.80%
		[1]	113	6.48%
		[2]	1,618	92.72%
	C2: Traffic compliance	[0 = no]	192	11%
C3: Speed	[0= standing]	72	4.13%	
	[1= walking w. bike]	35	2.01%	
	[2= moderate]	1,065	61.10%	
	[3= riding briskly]	571	32.76%	
D 'Equipment'	D11: Normal bike	[1= yes]	1,408	80.64%
	D12: E-bike	[1= yes]	307	17.58%
	D2: Helmet	[1= yes]	563	32.25%
	D3: Cycling jacket	[1= yes]	120	6.87%
	D4: Light-coloured clothes	[1= yes]	223	12.77%
	D5: Reflecting stripes	[1= yes]	247	14.15%
	D6: Bicycle headlight	[0= no light]	981	56.19%
[1= not in function]		636	36.43%	
[2= in function]		129	7.39%	
E 'Areas frequented'	E1: City centre	[1= yes]	1,097	62.83%
	E2: Dedicated cycle path	[1= yes]	1,083	62.03%
	E3: Riding through motorized traffic	[1= yes speed limited to 30km/h]	626	35.85%
		[2= yes speed limited to 50km/h]	272	15.58%
	E4: Tram rails at the intersection	[1= yes]	678	38.83%
E5: Path shared with pedestrians	[1= yes]	1,291	73.94%	

Table 2: Observed situations

216 Only two secondary tasks stand out: ‘listening via an earbud or headphones’ (5.56% of the total
217 observations) and ‘talking to someone’ (5.78%). The fact that these two secondary tasks emerge is
218 consistent with recent literature (Huemer et al., 2019). That said, they occur less frequently than in
219 Braunschweig (2019) where the corresponding percentages were 13.1% and 7% (Huemer et al.,
220 2019). Part of this discrepancy could be explained by the fact that these latter observations were
221 conducted exclusively on dedicated cycle paths. It is also possible that the French legislation
222 banning the wearing of headphones since 2015, although its existence is still largely unknown to
223 the public, may have contributed to a lower level of these secondary tasks. Apart from these two
224 secondary task, the others (eating, smoking, looking at/manipulating a screen or phoning) are very
225 marginal as they are recorded in less than 1% of the total observations.

226 In Besançon, other types of risky behaviours are more common. For example, traffic violations
227 were observed in 11% of situations, cyclists riding briskly in 32.76% of cases, and having only one
228 hand or none at all on the handlebars in 7.28% of cases. Safety equipment is not the norm: 56.19%
229 of cyclists do not have headlights and 67.75% do not wear helmets. Safety equipment of other
230 kinds is even rarer.

231 3.2. Cumulative effects towards dangerous or safe behaviours

232 In order to identify the correlations between profiles, behaviours, equipment, locations, and the
233 possible existence of cumulative or compensatory effects concerning cycling safety, we generated
234 a table of interactions among variables (Figure 3). The significance of these pairwise interactions is
235 tested through Chi-square tests (randomized so that the nominal 5% Type I risk of an individual
236 test is valid, despite sometimes low sample sizes in the corresponding contingency tables). The sign
237 of the correlation is calculated based on the numerical encoding of all variables (which are all binary
238 or ordinal). Positive correlations are shown in red, negative ones in blue. Only significant
239 correlations appear in dark colours. From this table with multiple correlations ($n=435$ among which
240 167 are significant at the $\alpha=5\%$ level hence a false discovery rate of $0,05*435/167=13\%$), it is
241 possible to distinguish results that sometimes involve cumulative effects (one intensifies the other)
242 and sometimes compensatory effects (one moderates the other).

243 The first thing that stands out in this graph is the presence of a ‘red square’ of positive correlations
244 between items of safety equipment (d-d square). When cyclists have one piece of safety equipment,
245 it is very likely that they will have others. Electric bikes usually come with a higher level of safety
246 equipment whereas cyclists with ‘normal’ bikes tend to have less safety equipment. This is
247 consistent with the formation of two contrasting groups, equipment-wise: risk-averse cyclists, who
248 have at least two pieces of safety equipment (involved in $n_{obs}=535$ observations) and risk-prone
249 ones, who have none at all ($n_{obs}=615$).

250 As for secondary tasks, they are not positively correlated to each other, and are significantly
251 correlated with few of the other variables (b-b square). This is probably linked, at least in part, to
252 the rarity of their occurrence. Besides, it is understandably difficult, from a practical point of view,
253 for cyclists to engage in several secondary tasks at once.

254 Listening with an earpiece (b1) is clearly the prerogative of young, male cyclists: compliance with
255 traffic regulations is negatively and significantly correlated with this, and these cyclists keep a lower
256 number of hands on the handlebars. They also wear helmets less. This use of the earpiece does not
257 seem to depend at all on the diversity of places frequented. It is therefore used as much on a
258 reserved bicycle path as in the middle of car traffic.. .

259 Talking to someone on a bicycle (b5) is more likely to be done by young to middle-aged cyclists,
260 most often carrying a child in a back seat. For these people, the emphasis is on safety with helmets
261 being very frequently worn, reflective strips increasing their visibility, and reduced speed and so
262 greater (though not significantly so) compliance with traffic regulations. Although the number of
263 hands on the handlebars is significantly lower, it is worth specifying that this is the case when the
264 bike is stationary or when the cyclist is pushing the bike. Risk-taking is therefore limited.

265 Although for these variables there is a polarization between at-risk groups and more cautious
266 groups, we can also distinguish variables that tend to offset each other and which characterize other
267 cyclists whose risk-taking seems more controlled.

268 3.3. Compensatory effects between risk and safety

269 In the middle of Figure 3, the correlations between speed, number of hands on the handlebars and
270 compliance with traffic regulations seem to show compensating effects (c-c square). Indeed, speed
271 is negatively correlated with observance of the rules of the road. Speed could be a compensation
272 for risk-taking (e.g. running a red light) or, conversely, non-compliance with traffic regulations
273 could be due to wanting to ride fast. On the other hand, speed is positively correlated with the
274 number of hands. In other words, cyclists who break the rules of the road riding at high speed tend
275 to do so with full control of their bike. The three kinds of risky behaviours (high speed, non-
276 compliance with rules and less than two hands on the handlebar) are associated only 9 times in
277 1746 observations (0.05%, among whom exclusively men, 7 of whom are between 18 and 35 years
278 of age).

279 Riding an electric bicycle (d12) also has a compensating effect. Certainly, as we saw earlier, these
280 cyclists are better equipped, especially with helmets. That said, the feeling of security that this
281 probably gives them might encourage them to ride faster, and often too fast in relation to the areas
282 they ride through (c3). These cyclists also have a tendency, albeit a statistically insignificant one, to
283 commit more traffic offences than others (c2).

284 Other correlations also support this line of reasoning. For example, wearing of a helmet (d2) is
285 correlated with a higher speed (c3) that is regularly dangerous for other users. Some secondary
286 tasks, which impact attention, seem to be compensated for by reduced speed and most often by
287 cyclists stopping their travel. Telephoning (b2) or talking (b5) are negatively correlated with speed
288 (c3). In these cases, cyclists frequently stop or get off their bikes to walk. It seems, then, that the
289 term 'secondary task' is sometimes debatable.

290 Cycling on the tram tracks (e4) seems to involve cyclists who are particularly equipped with visibility
291 and lighting devices. Although it is forbidden to ride there, these are frequented areas because trams
292 are not frequent (one every 10 minutes in each direction on average) and no other vehicles are
293 allowed. Apart from a rare but potentially very serious collision with a tram, these areas also present
294 the risk of pedestrians crossing without looking as they would do in a pedestrian zone. Getting
295 cyclists to equip themselves with lights and reflective devices, and probably also with bicycle bells,
296 might be one way to adapt to the specific dangers found in these environments.

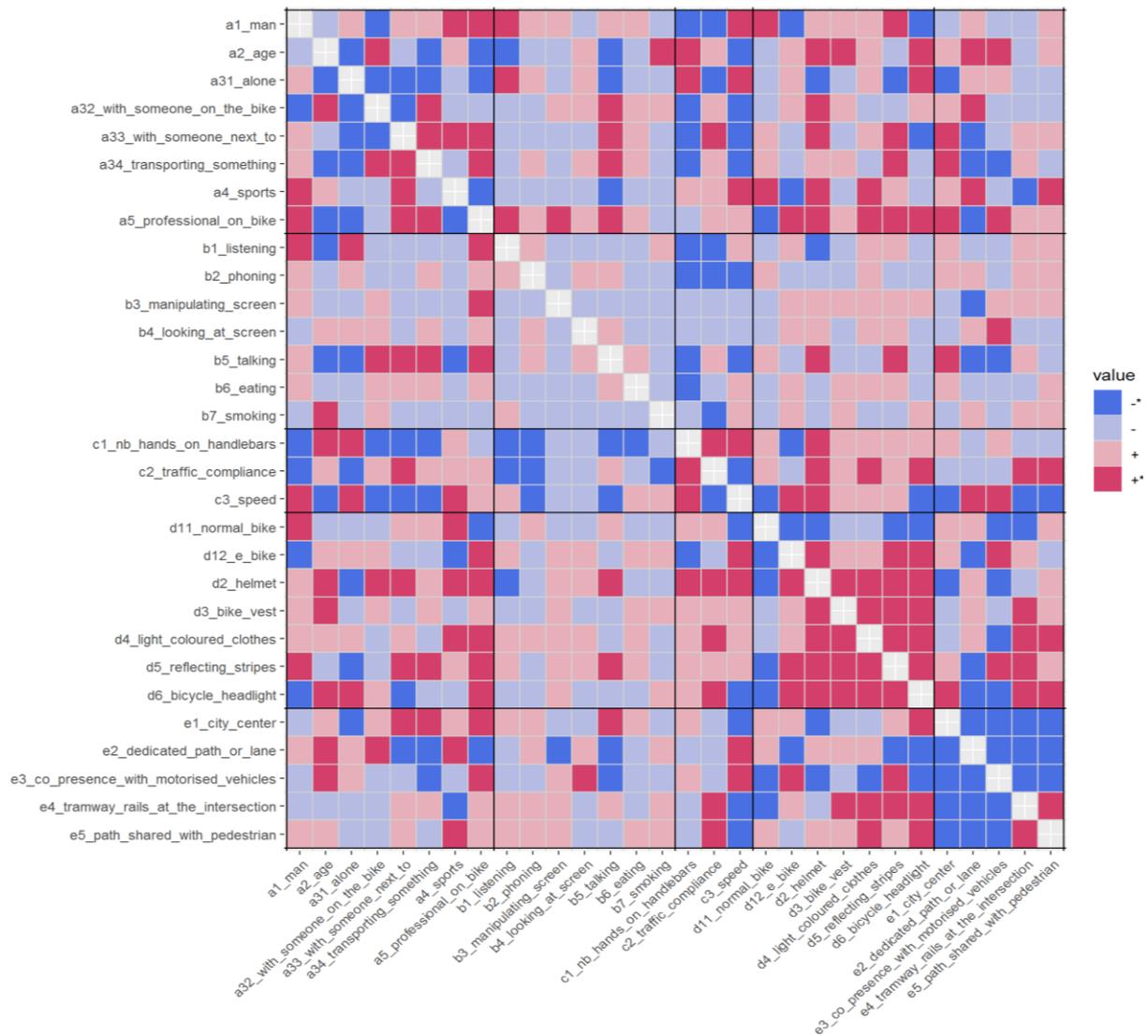


Figure 3: Interactions between variables (negative in blue, positive in red, darkest colours corresponding to significant interactions)

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4. Cyclist profiles related to safety

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We carried out a hierarchical clustering analysis of our data, which enabled us to analyse multivariate profiles beyond pairwise interactions of variables. We carried out this analysis on all variables except those relating to the areas crossed since we wanted to focus on people's profiles. We calculated the distance between individuals as simple euclidean distances (all variables being either binary, coded as 0/1 or ordinal, coded e.g. as 0/1/2). We then carried out the clustering (Ward's method) and selected several clusters (5) that maximised the ratio of minimal intercluster distance to maximal intracluster distance (Figure 4).

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For each variable, the sixth histogram represents its distribution for the entire population under consideration. Results are calculated for the 1719 observations without missing information. As this observation was conducted in a particular environmental context and circumstances, these five classes cannot be extrapolated to other places or times.



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Figure 4: Five classes of cyclists and their related profiles, behaviours and equipment

314 The first class, with a relatively small number of situations (n=82, 4.78% of observed situations),
 315 is mainly made up of people who are stationary or pushing their bicycles. These people phone more
 316 than others, they listen with earpieces, and speak a little more than the average, although all these
 317 secondary tasks are still very rare. There is a slight over-representation of women and younger
 318 people. This therefore nuances the image of young people who take risks, since some of them stop
 319 to engage in a secondary task without taking any particular risk.

320 The second class of situation is better documented in the literature. It concerns a larger group of
 321 observations (n=812, 47.23%). These are mostly young men who are alone, who listen the most
 322 on a headphone or earpiece, who least obey the traffic rules, who ride fastest, who have little safety
 323 equipment and in particular very rarely a helmet and a light. It is the second-best equipped group
 324 in e-bikes.

325 Class 3 corresponds to a large number of observations (n=640, 37.29% of observed situations)
 326 concerning older cyclists, mainly equipped with ‘normal’ bikes but little equipment other than a
 327 headlight. This group wears helmets only at the average level for all observations, which remains
 328 rather low (32.25%). Although they are rarely engaged in any secondary tasks, relatively frequent
 329 traffic offences are noticed for this group, which is the second largest in terms of traffic law
 330 violations and speeding. This group seems to be less well documented in the literature.

331 The fourth class includes a smaller number of observed situations (n=112, 6.52%). They concern
 332 a majority of middle-aged women, more than half of whom are carrying someone (usually a child
 333 in a bicycle seat). These people may also occasionally transport something or interact with other

334 cyclists. Apart from talking with someone, no other secondary tasks were observed. This group has
 335 the highest rate of e-bike riding, with the highest helmet wearing rate. Quite counter-intuitively,
 336 some risk-taking is to be noted, especially in terms of high speed probably due to the greater use
 337 of e-bikes. This group seems to be often forgotten in the safety policy concerning speed.

338 The last group is made up of situations (n=73, 4.25% of observed situations) involving, for nearly
 339 half the number, people who cycle as part of their job, many of whom are delivery riders. As a
 340 result they are rather well equipped with helmets and reflective stripes as part of their work outfit.
 341 They fully comply with traffic regulations, and they find themselves in a variety of situations: at a
 342 standstill or walking to consult and manipulate their smartphone screen (waiting for an order),
 343 riding very fast, or riding more slowly to find a delivery location. They are almost systematically in
 344 a group and talk more than the other people observed. This is a group in which young men are
 345 over-represented. On the whole they do not appear to exhibit risky behaviour on the road.

346 To sum up, we establish five main profiles (Table 3) to go beyond ‘good’ and ‘bad’ cyclists.

	N_{obs} (%)	Dominant profile	Over- represented equipment	Risk-taking	Over- represented secondary tasks
Class 1	82 (4.78%)	Young, women	Light	Few risks taken, walking or standing	Only talking
Class 2	812 (47.23%)	Young, men	No equipment; substantial share of e- bikes	Multiple and frequent	Listening with earpiece or headphones
Class 3	640 (37.23%)	Middle aged and old, men	Headlight	In the average	No secondary tasks
Class 4	112 (6.52%)	Middle aged, women, transporting a child	Large share of e-bikes, helmet, vest, headlight	No infringement but sometimes high speed	Only talking
Class 5	73 (4.25%)	Delivery workers, in group of cyclists	Reflecting stripes, helmet, headlight	Few risks taken	Talking frequently when standing or walking

347 *Table 3: Five dominant cyclist profiles related to safety*

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5. Conclusions

355 Our hypothesis about the existence of compensatory effects in terms of cycling safety is validated.
 356 Even though we identify the two well documented extreme profiles that either accumulate all

357 possible risks or avoid them all (classes 2 and 4 respectively), these types of profiles appear only
358 812 and 112 times respectively, i.e. 53.84% of the situations observed.

359 As a result just under half of urban cyclists are in the in-between group, which compensates
360 between risk-taking and safety. These compensatory effects sometimes tend to reduce part of the
361 risk associated with secondary tasks while cycling. For instance, our study shows that a significant
362 number of cyclists (class 1) either stop on the side of the road or walk next to their bikes to make
363 phone calls and interact with their phones. This group includes an overrepresentation of young
364 people that challenges their image as a risk-prone population.

365 Our study also exposes the existence of "in-between" behaviours, particularly in Class 3 (37.3% of
366 observed situations). This class is composed of mainly middle-aged and elderly male cyclists. On
367 the one hand, these cyclists almost never engage in any secondary tasks, and have a higher
368 equipment with headlights than the general population observed (64.69% of class 3 cyclists have a
369 headlight; compared to 43.81% in the general population). On the other hand, two indicators -
370 although close to the average of observations - show that these older cyclists rarely wear a helmet
371 (e.g. 63.43% of class 3 cyclists do not wear a helmet) and sometimes do not comply with traffic
372 regulations (infringements are observed in almost 8.59% of the situations involving these cyclists).

373 Considering these results, associated with the frailty bias (Hakamies-Blomqvist, 1998) and the
374 natural decline in concentration, attention, hearing and sight (Schmitz et al., 2010) affecting older
375 people in general, elderly could become a new target for safety policies. In addition to the provision
376 of more dedicated infrastructure, targeted responses could be provided – whether focused more
377 on the use of helmets and compliance with the traffic regulations for elderly cyclists, or on
378 secondary tasks for younger male cyclists – to reduce the number of cyclist injuries and fatalities in
379 cities in France and elsewhere.

380 An analysis that combines the different facets of cycling behavior, as we have attempted to do in
381 this study, allows for a better understanding of the diversity of cycling practices with respect to
382 safety, and perhaps helps identifying more effective measures to improve it.

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