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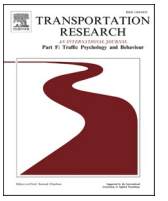

# Why do cyclists violate traffic rules? Evidence for situationally and personally motivated violations, slips, and mistakes from a crowdsourcing project

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ABSTRACT

Almost all cyclists violate some traffic rules with varying frequencies; however, there are few direct assessments of their reasons and motivations for these infringements. If we want to tackle traffic rule violations by cyclists as a source of conflict and contra-cycling attitudes, a more complete understanding of the reasons underlying these violations is required.

This research is based on a non-representative, web-based inquiry consisting of about 5,800 contributions from road users about traffic situations described as dangerous, confusing, or a nuisance. Contributions were manually coded for the transportation modes of perpetrator(s), victim(s), and the violated rule. Regarding the described or assumed reasons, the classification system of human errors by Reasons was used to differentiate between mistakes, slips and lapses, and routine as well as situational violations.

A total of 717 violations committed by cyclists and 1,795 violations committed against cyclists were identified. About half of the contributions expressed or assumed reasons for the described rule violation, only a fraction of which was attributed to recklessness. A noticeable proportion of rule violations by cyclists were attributed to situational factors, suggesting that rule infringements occur because cyclists feel that (i) they have no other choice, (ii) observing the rule is too dangerous, or (iii) traffic regulations are unclear or absent. In order to reduce the rule violations by cyclists as well as their conflicts with other road users, the traffic systems need to be designed such that cyclists do not feel that their most reasonable option is to commit these rule violations.

## 1. Introduction

A rich body of research indicates that almost all cyclists violate some traffic rules on a more or less frequent basis, such as running red lights (e.g. Fraboni et al., 2018; Johnson et al., 2013; Schleinitz et al., 2019), riding on the sidewalk (e.g. Lavetti & McComb, 2014; Lind et al., 2021), or riding in contraflow direction (e.g. Kummeneje & Rundmo, 2020; Langford et al., 2015). Although cyclists' rule

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knowledge can be incomplete (Huemer & Eckhardt-Lieberam, 2016; Johnson et al., 2014), many cyclists are fully aware of their infringements (Alrutz, 2009). These violations contribute to dangerous situations and conflicts between cyclists and other road user groups, as can be derived from the noticeable proportion of crashes involving rule violations by cyclists (Lardelli-Claret et al., 2003; Prati et al., 2017). Therefore, identifying the factors that cause cyclists to violate traffic rules and finding ways to reduce these violations is highly relevant for the safety of cyclists and other road users, as well as for promoting cycling as a transportation mode.

One core issue concerns the question of *why* cyclists commit rule violations on such a frequent basis. A common notion among pedestrians and drivers appears to be that cyclists either lack the necessary rule knowledge or that they are reckless and unconcerned with the safety of others. This focus on the responsibility of the individual cyclist can be understood as an instance of the fundamental attribution error (Ross, 1977), which assumes that people overemphasize dispositional factors while underestimating situational factors when judging the behavior of others. As an example for the fundamental attribution error, Reason (1990) argued that accidents must be seen as multi-causal processes, but also that several psychological phenomena lead to a focus on the person as a causal contributor. Thus, it can be assumed that the general public is inherently biased toward attributing traffic rule violations to the immediate responsibility and fault of the individual cyclist, while neglecting the situational circumstances in which the rule violation takes place. Anke et al. (2024) reported a bias toward making dispositional attributions for out-group members rather than situational attributions for in-group members. Given this bias, it is worthwhile to examine why cyclists and other road users infringe on each other's rights. This comparison could reveal important differences in how these infractions are perceived and attributed. The concept of the self-serving bias (as an extension of the fundamental attribution error, Campbell & Sedikides, 1999) would suggest that one's own violations are more likely to be attributed to external (i.e. situational) factors, whereas the experience of violations by other road users should be attributed to internal (i.e. dispositional) factors.

### *1.1. Research on dispositional and situational factors contributing to cyclists' rule violating behavior*

This research makes the argument that it is not only the general public that is biased in its perception of cyclists' rule violation, but also that the investigation and understanding of traffic rule violations by cyclists in the scientific community may be impeded by the equivalent of a fundamental attribution error as well. Many researchers do consider the role of situational factors in cyclists' rule violations, primarily linked to infrastructural attributes (e.g. Brezina & Hildebrandt, 2016; Lind et al., 2021), but also with regard to the greater geographical context (e.g. city size, with more rule violations by cyclists occurring in larger cities, Useche et al., 2024). However, there are also a lot of studies focused almost entirely on identifying demographic and psychometric variables as predictors of rule-violating behavior (e.g. O'Hern et al., 2020). Furthermore, the respective studies converge on male (as compared to female) and younger (as compared to older) cyclists being more likely to commit rule violations (e.g. Huemer et al., 2022; Marshall et al., 2017; Useche et al., 2018). Similarly, traffic violations are aligned with the individual level of risk acceptance (Kummeneje & Rundmo, 2020). Other authors conclude that cyclists claim that their unlawful behavior is thought to increase their safety or to save energy (Chaloux & El-Geneidy, 2019; Huemer, 2018; Schleinitz et al., 2016). In line with the focus on individual factors determining rule-violating behavior, recommendations towards higher compliance with traffic rules are frequently geared towards measures targeting the individual, such as traffic education programs or information campaigns (e.g. Anke et al., 2024; Fraboni et al., 2018). The effectiveness of such attempts appears doubtful, considering that many cyclists are fully aware of their infringements (Alrutz, 2009; despite sometimes incomplete rule knowledge, Huemer & Eckhardt-Lieberam, 2016; Johnson et al., 2014).

However, the conclusions of most studies are ultimately limited to assumptions and speculations, regardless of whether they concern dispositional or situational factors, as they do not directly assess cyclists' reasons for the infringing behavior. At least two studies approach the issue of cyclists' reasons for rule violations in greater detail: One seminal paper on this matter showed images of different traffic situations to a large sample of participants, and asked them which option of varying legality they would choose (Marshall et al., 2017). Additionally, the authors investigated the reasons participants provided for their rule infringements in open descriptions. The authors conclude that rule-violating behavior by cyclists may be illegal, but rational from the cyclists' point of view, as it appears justified and rational to them within the constraints of the situation. Unfortunately, the paper provides only a few details about the rationalizations indicated by the participants. Secondly, a study by Lavetti and McComb (2014) lists reasons participants provided for "unsafe" (i.e. rule-infringing) cycling maneuvers. The authors find that a very high proportion of their participants indicates disagreement or disregard of the rules, but also convenience or urgency as reasons for the infringing behavior. In addition to these rather dispositional factors, there is also a noticeable proportion referring to more situational factors such as insufficient or inconsistent infrastructure. However, participants reported about violations they either engaged in or observed in others, and, therefore, it is not clear whether the responses represent the participants' own reasons, or their speculation about other the behavior of other road users. Both studies do not differentiate between the transportation modes of the road user groups potentially affected from the rule violations.

In order to tackle traffic rule violations by cyclists as a source of conflict and contra-cycling attitudes, a more complete understanding of the underlying reasons behind these violations is needed, while acknowledging situational as well as individual factors as underlying reasons. Suitable frameworks for this endeavor come from the field of organizational safety, which asks for a systemic perspective on human error and failures. This systemic perspective aims to assess not only which action was wrong and why, but also why exactly this action made sense from the perspective of the person executing it at that time (Dekker, 2004, 2017). Several models of this field are also applied to questions of traffic safety, for example, the Swiss cheese model of accident causation by Reason (1990).

### 1.2. Reason's classification of violations as a form of human errors

One of Reason's accounts of erroneous behavior differentiates between mistakes, slips, lapses, and violations (Reason, 1990). A mistake results from an intended but inadequate action, misguided by insufficient knowledge about the correct response. Detecting one's own mistake can be difficult, as the person making the mistake is frequently unaware of this fact. In contrast, slips and lapses are unintended actions (or the omission of actions) in an otherwise correct understanding of the situation and the appropriate action. Consequently, slips and lapses are normally easily identified once the action leads to an erroneous result. Finally, violations are incorrect actions performed with "some degree of intentionality, but without the goal of causing injury or damage" (Reason et al., 1990, p. 1316). They are not considered an error by the person at the time the action is committed.

There are several further differentiations of violations, the most frequent being "routine" violations (i.e. a behavior becoming routine due to the absence of harm resulting from it, a lack of enforcement of the rule, or individual gains from violating it) and situational violations (i.e. external pressure, missing the tools or abilities to act correctly, or believing that following the rule is unsafe under the circumstances). Furthermore, there are exceptional violations (defined by the perceived necessity to violate a rule despite taking a risk) and "sabotage" violations (defined by a deliberate intention to harm the system, oneself, or others).

In an early work, Reason et al. (1990) applied this categorization to drivers' behavior, and confirmed the differentiation between severe errors on the one hand, and rather harmless errors as well as violations on the other hand. They conclude that the former might be addressed through additional training and information campaigns, whereas the latter should be analyzed concerning the social and individual motivations. Somewhat surprisingly, the authors do not consider situational reasons for traffic rule violations.

It is important to distinguish between the legal violation of a traffic rule and a rule violation according to Reason's classification. By definition, every infringement of a legally binding traffic rule constitutes a violation of this rule, regardless of the perpetrator's knowledge of this rule or the degree of intention to violate it. For example, a collision resulting from a car driver initiating a turn but failing to look for cyclists travelling straight constitutes a violation of the cyclist's right of way. However, depending on whether the driver possesses the general knowledge that this rule applies to this situation at all, forgets to apply this knowledge and thus to check for cyclists, or notices the cyclist but decides to risk a narrow turning maneuver anyways, the same legal violation constitutes a mistake, a slip, or a violation according to Reason's classification.

It is generally not possible to apply this classification on real-world traffic violations and crashes in a reliable and valid way, as such application would require constant monitoring of a road user's state of mind. However, the open-format contributions investigated in this research can be assessed post-hoc concerning the assumed or ascribed state of mind of a perpetrator. This assumption is likely to deviate from the (unknown) ground-truth, but can still provide valuable insights into whether a deviant behavior is primarily perceived as intentional or not.

### 1.3. Study aims

This research aims to explore the reasons cyclists report for the violation of various traffic rules against other road users, and contrast these reports to the violations committed by other road user groups against cyclists. It is assumed that the reported traffic rule violations are not primarily attributed to dispositional factors (e.g. recklessness or a lack of knowledge), but that a noteworthy proportion is considered a result of situational factors (e.g. responses to the traffic system or other road users). In other words, this research's aims to extend the perspective of why cyclists violate traffic rules from a focus on the role of the individual cyclist to the situational context in which this cyclist decides to commit a rule violation. The type of violation as well as the assumed reason is likely dependent on the transportation mode of both perpetrator and victim.

This goal is addressed by investigating a dataset from a large-scale crowdsourcing project concerned with the subjective safety (but not immediately with rule violations) of cyclists (as well as other road user groups) in a large German city. The focus lies on those contributions that include descriptions of a traffic rule violation by or against cyclists. These contributions are further analyzed for the (assumed) reasons of the described violations provided by the road user.

It should be stressed that this study does not focus on the question of whether a reported traffic violation is valid (i.e. whether it did occur or could have occurred as described), and whether a victim's assumption about the perpetrator's reason for the violation is true. It is only focused on events individual road users perceived as a rule violation, and their assumptions about the reasons underlying the reported behavior.

## 2. Data collection and methods

### 2.1. Description of the survey's general design and procedure

Information about traffic rule violations and described or implied reasons was sourced from a dataset collected in a web-based inquiry of the major Munich-based German newspaper 'Süddeutsche Zeitung'. In July 2014, the newspaper created an interactive map (the so-called 'Gefahrenatlas' or 'Hazard Atlas') and invited their readers to mark locations in the greater area of Munich they considered (based on their personal experiences and observations) to be dangerous, confusing, or a nuisance. The project was primarily geared towards cyclists, but allowed contributions of other vulnerable road user groups as well. The primary involved road user group could be indicated (cyclists: N = 4,736, pedestrians: N = 962, Moped: N = 51, or skaters: N = 9), followed by an open-format description of the problem. Existing reports from other contributors could be endorsed with a "Like" function. Within several weeks, the inquiry generated about 5,800 unique contributions featuring open-text descriptions, their geolocations, and 17,000+

'Likes' (i.e. support for existing contributions). The representativeness of individual contributions for a larger public in this dataset has been tested and confirmed in a previous research (von Stülpnagel & Krukar, 2018).

The large number of contributions within a geographically limited area, in combination with the frequently detailed descriptions, make this dataset uniquely suitable for the present research. Contributors using different traffic modes reported about their perspective concerning traffic safety and conflicts with other road user groups, but were not biased in any way to speculate about the reasons underlying the reported behavior. Thus, any mention of a traffic rule violation and any indication of a supposed reason are unprompted.

### 2.2. Classification of reasons for traffic rule violations

The coding of the described or assumed reasons for the reported traffic violations was informed by the framework of human errors by Reason (1990). More specifically, the following categories were distinguished:

(1) *Mistakes* are intentionally performed, but inappropriate actions resulting from a conceptual misrepresentation of what constitutes the correct action in a situation. Applied to the contributions analyzed in this research, a traffic rule violation is categorized as a mistake if the description implies the assumption that the perpetrator did not know the corresponding traffic rule or the correct behavior, for example, that cycling on a certain road was prohibited.
(2) *Slips/Lapses* are errors that result not from a lack of knowledge, but a failure to apply this knowledge appropriately.[1] Applied to the contributions analyzed in this research, a traffic rule violation is categorized as a slip/lapse if the description implies that a road user knows the traffic rule and the correct behavior but misses or forgets to apply this knowledge to the current situation. This includes, for example, drivers intending to turn at an intersection but forgetting to watch out and yield to cyclists travelling straight.
(3) *Violations* encompass several possible reasons for a conscious decision not to comply with a rule that is known to apply to a given situation. *Routine violations* include those committed for personal comfort, if rules are perceived as too restrictive or not enforced. In the context of the present research, descriptions of rule violations primarily committed to cut time or travel distance, to avoid braking, and similar personal gains were labeled as *routine violations (comfort)*. Descriptions of violations committed as a result of traffic rules perceived as illogical or pointless were labeled as *routine violations (traffic regulation)*. The underlying rationale is that these violations are not primarily motivated by the assumed immediate gains of violating a traffic rule in a specific situation, but by the perceived inadequacy of the traffic rule in this situation in general. Furthermore, contributions were labeled as *routine violations (recklessness)* if the descriptions included a connotation that the traffic rule violation occurred while deliberately accepting risks of harming oneself or others.

In contrast, *situational violations* are defined by responses to external forces. People know the correct action in general as well as its applicability to the current situation. They may even have the intention to adhere to them, but decide that this is impossible due to situational factors. In light of the current research, three subtypes of situational violations were differentiated. If contributions described a situation where a road user assumed that the only available option was a traffic rule violation, then it was labeled as *situational violations (inevitable)*. Such violations include, for example, a cycling lane blocked by a parked vehicle, requiring a cyclist to evade on either the road or the sidewalk to continue. Contributions describing rule violations resulting from inadequate, confusing, or missing traffic regulations were labeled *violations (traffic regulation)*. Finally, situational violations resulting from safety considerations for oneself were defined as *violations (safety)*: If a cyclist experiences riding on the road as too dangerous due to the traffic speed and volume, evading illegally to the sidewalk is not inevitable, but primarily motivated by the situation.

All error types, subtypes, defining elements, and exemplary segments from contributions to the crowdsourcing project are provided in Table 1.

### 2.3. Annotation of the contributions

Due to the open text format, the diverse descriptions, and the explorative nature of this research, a manual annotation process was used. Two annotators (the first author and a student assistant) worked on the complete dataset in MAXQDA24, initially annotating approximately 1/4 and 3/4 of all contributions, respectively. The student assistant was trained on a small sample of contributions under supervision. A first batch of unsupervised annotations was discussed with the first author.

Each contribution was initially inspected for any reference to a traffic rule violation BY cyclists or AGAINST cyclists. If references to a respective traffic rule violation were identified, a coding scheme was used to annotate the perpetrator(s), the victim(s), the reported traffic violation(s), and the indicated reasons. The applied coding scheme is presented in Table 2. Fig. 1 provides four exemplary contributions from the dataset, with annotations based on this coding scheme.

The transportation modes of perpetrators and victims were labeled as cyclists, pedestrians, or drivers of motorized vehicles. No distinction was made between different motorized vehicles (i.e. cars, heavy vehicles, and motorcycles), because they are (with minor exceptions) subject to the same traffic legislation. The transportation modes of perpetrators and victims were explicitly mentioned and

[1] The authors refrained from an attempt to distinguish between slips and lapses as it would cause a high level of ambiguity.

**Table 1**
Error types according to Reason. Level II subtypes of violations are based on the authors' consideration (with the vertical lines being color-coded consistent with the presentation of the respective error types in the figures further below). 'Description' indicates core elements of the respective error type. 'Exemplary keywords' provides phrases from the dataset that were labeled accordingly.

| Error type | Subtype Lvl I | Subtype Lvl II | Description | Exemplary keywords |
|---|---|---|---|---|
| Mistake | | | • Missing knowledge about correct action<br>• (Inappropriate) action is consciously chosen<br>• Missing awareness that action is inappropriate<br>• Rule violation is unintentional | • "…do not know…"<br>• "Nobody gets that…"<br>• "out of ignorance…"<br>• "…unaware of…"<br>• "…due to missing traffic education" |
| Slip | | | • General knowledge about the appropriate action available<br>• Failure to apply action in current situation<br>• Rule violation is unintentional | • "…do not pay attention…" "…overlook…"<br>• "…underestimate…"<br>• "…do not expect…" |
| Violation | | | • General knowledge about the appropriate action available<br>• Rule violation is intentional | |
| | Routine | Comfort | • Driven by personal gains such as saving time and energy<br>• No detectable intention or acceptance of harming others | • "…too lazy…"<br>• "…use as a shortcut…"<br>• "…a detour…"<br>• "…unreasonable waiting time…" |
| | Routine | Traffic regulation | • Rule is perceived as too restrictive, inadequate, or pointless | • "…a joke…"<br>• "…pointless…"<br>• "…no detectable reason…" |
| | Routine | Recklessness | • Driven by personal gains<br>• Acceptance of potentially harming self or others | • "…ignored…"<br>• "…purposefully disregarded"<br>• "…do not respect…" |
| | Situational | Inevitable | • Correct action is constrained by external factors<br>• Rule violation is considered the only remaining option | • "…it is necessary…"<br>• "…the only option is…"<br>• "…forced…" |
| | Situational | Traffic regulation | • Correct action is impossible due to inconsistent, unclear, or missing traffic regulation | • "…confusing / contradicting / ambiguous traffic signs…"<br>• "…missing sign…" |
| | Situational | Safety | • Following the traffic rule is considered unsafe under the circumstances | • "…for self-protection…"<br>• "…it is safer…" |

**Table 2**
Coding scheme used for annotation of the contributions.

| | Categories | Explanation |
|---|---|---|
| Perpetrator | Cyclist | |
| | Pedestrians | |
| | Driver of motorized vehicle | |
| | Unspecified road user group | |
| Victim | Cyclist | |
| | Pedestrians | |
| | Driver of motorized vehicle | |
| | Unspecified road user group | |
| Traffic rule violation | Hard breaking without reason | e.g. stop signs |
| | Illegal behavior at junction | referring to illegal walking/driving |
| | Failure to observe "right before left" | referring to illegal riding/driving |
| | Failure to observe traffic sign | referring to illegal walking/riding |
| | Failure to yield | on pedestrian path, bike lane/path |
| | Incorrect positioning | incl. riding on left-hand bike lane/path |
| | Turning not indicated | |
| | Red light running | |
| | Illegal use of bike lane/track | |
| | Illegal use of pedestrian path | |
| | Illegal use of vehicle lane | |
| | Lacking lateral overtaking distance | |
| | Parking/stopping | |
| | Dooring | |
| | Careless parking maneuver | |
| | Illegal parking/stopping | |
| | Pushy behavior/Tailgating | |
| | Riding/driving in contraflow direction | |
| | Speeding | |
| | Smartphone use | |
| | Other | |

**Note.** Reasons for the rule-violating behavior (if identifiable) were coded as described in Table 1.

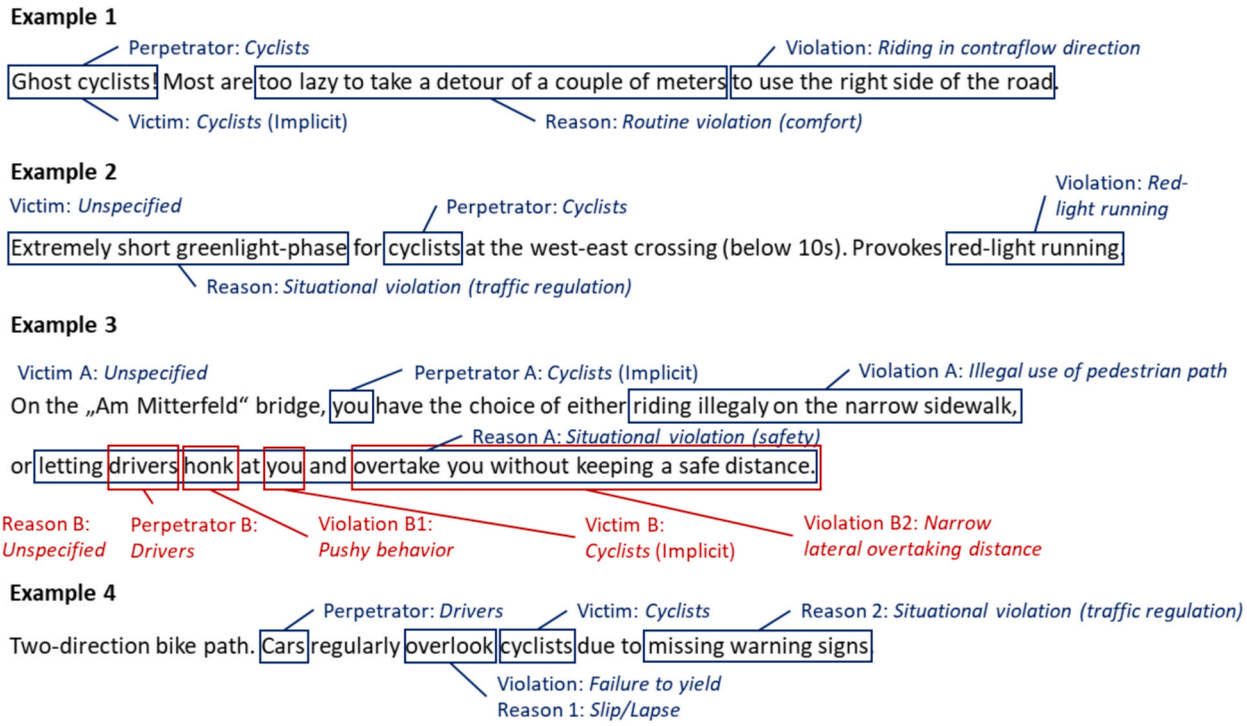


**Fig. 1.** Examples of verbatim, annotated contributions (translation by authors).

thus self-evident in almost all contributions. In some contributions, the victim's transportation mode was not explicitly stated, but was identifiable through the context (see Fig. 1, Example 3A) or the category of the primarily involved road user group selected on the website by the contributor. If a contribution indicated more than one road user group as perpetrator or victim of the violation, all respective groups were labeled accordingly. If a contribution reported about a violation BY a cyclist AGAINST a cyclist (see Fig. 1, Example 1), cyclists were labeled both as perpetrator and victim.

Although most contributions did specify the perpetrating road user group, some contained no indication about who was affected by the rule violation. In these cases, the victim label was classified as "unspecified"[2] (see Fig. 1, Examples 2 and 3A). This approach ensured that these cases were retained in the analysis.

There were also contributions consisting of different violations by different road user groups. Among these cases were 167 instances where one violation represents an immediate response to another violation. To avoid confusion, all contributions reporting multiple violations were manually split and treated as separate cases, each labeled for only one violation (see Fig. 1, Example 3).

The type of traffic rule violation was annotated as reported, without any background check about its correctness or applicability. The initial coding scheme included the most frequent traffic rule violations by and against cyclists investigated in the literature, but was extended to include violations that were mentioned repeatedly in the dataset.

Reported or assumed reasons and justifications for the rule-violating behavior (if identifiable) were coded as described in Section 2.2. If a contribution included hints of more than one reason, it was labeled for all respective categories (see Fig. 1, Example 4). If no reason within the coding scheme was identified, it was labeled as 'not reported'. The classification of the violated rule as well as the reported or assumed reason were double-checked in a second annotation round by the first author.[3]

Unfortunately, it was not possible to classify the role of the contributor (i.e. whether the contributor committed, observed, or suffered from the described violation) with a sufficient level of certainty in the majority of the cases. The contributor's role appears to

[2] Two contributions explicitly stating that nobody was affected by the rule violation were subsumed in the "unspecified" category as well.

[3] The level of congruency between the original annotations by the student assistant and annotations adjusted by the first author was checked with Cohen's kappa for all contributions reporting about violations BY or AGAINST cyclists. Concerning the identification or reasons, Kappa was generally high (all $k > 0.86$, all $p < 0.001$), with two exceptions. For the category 'situational violations (inevitable)', the level of congruency was acceptable ($k = 0.73$, $p < 0.001$), but rather poor for the category 'mistakes' ($k = 0.46$, $p < 0.001$). The level of congruency for the type of rule violation was checked for all violations listed in Fig. 4. Kappa was generally high (all $k > 0.89$, all $p < 0.001$), with the following exceptions. For the rule violations 'illegal use of bike lane/path' and 'failure to observe traffic sign', kappa was acceptable ($k = 0.74$, $p < 0.001$, and $k = 0.68$, $p < 0.001$). Kappa was poor for the violations 'illegal use of vehicle lane' ($k = 0.48$, $p = 0.001$) and 'pushy behavior' ($k = 0.37$, $p = 0.001$). A closer inspection revealed that the poor consistency for 'mistakes' and 'illegal use of vehicle lane' resulted from conceptual misunderstandings of these categories by the student assistant, with multiple false positives. In the case of 'pushy behavior', the initial definition was quite narrow and later extended by the first author. The first author's evaluation superseded that of the student assistant in conflicting assessments.

be a significant factor in determining the reasons behind rule violations. The Discussion section explores the broader implications as well as the limitations of this observation.

## 3. Results

Due to the nominal data level and the open-format structure of a non-representative dataset, any inferential statistical approach would be severely limited. Therefore, a descriptive analysis and interpretation of the extracted information is deemed more appropriate.

### 3.1. Prevalence of traffic rule violations in open-format descriptions of traffic safety issues

From the complete set of contributions, 717 violations were identified as being committed BY cyclists and 1,795 violations as being committed AGAINST cyclists. In other words, there were more than twice as many contributions concerned with cyclists suffering from rule violations of other road user groups compared with those concerned with other road user groups suffering from rule violations by cyclists. On the one hand, this distribution supports the notion that cyclists are indeed a vulnerable road user group frequently suffering from traffic rule violations of other road users. On the other hand, it must be kept in mind that the crowdsourcing project was primarily initiated to assess safety and comfort issues of cyclists, and that the perspective of cyclists may thus be overrepresented in this dataset.

Table 3 provides an overview of the road user groups affected by violations committed BY cyclists, as well as of road user groups committing violations AGAINST cyclists. The largest proportion of violations BY cyclists is committed against pedestrians as well as against other cyclists. For about a quarter of the violations, it remains unclear whether another road user group suffered from the cyclists' behavior. In contrast, the overwhelming majority of violations AGAINST cyclists were committed by drivers of motorized vehicles.

### 3.2. Prevalence of reasons for traffic rule violations in open-format descriptions

The next question was whether contributions concerned with traffic rule violations also included assumptions about the reasons for the mentioned rule violations. As shown in Fig. 2, this was indeed the case for more than half of all contributions concerned with traffic violations BY or AGAINST cyclists.

Upon initial observation, missing rule knowledge is cited in few of the reported violation. Furthermore, recklessness is attributed to the perpetrator in roughly 10 % of all cases, irrespective of the road-user combination.

In line with the assumptions of this research, situational factors dominate the explanations for rule violations BY cyclists: these contributions link a cyclist's infringement to situational constraints, such as ambiguous traffic regulations, inevitable circumstances, or safety concerns, regardless of who is affected by the violation. Situational factors are also prevalent in violations AGAINST cyclists, though to a lesser extent.

Routine violations form another sizeable share of the attributions BY cyclists, and are often attributed to comfort-related considerations or the perception that certain traffic regulations are illogical or pointless. In contrast, routine violations other than recklessness are almost missing from contributions concerned with violations AGAINST cyclists. Conversely, slips/lapses are cited to be the reason for a moderate proportion of violations AGAINST cyclists, yet they are rarely mentioned in contributions about violations BY cyclists.

Interestingly, and in contrast to all other road-user combination, contributions concerning violations BY cyclists with an unspecified victim almost always include a stated reason. This pattern suggests that many unspecified-victim contributions were likely made by perpetrating cyclists, who felt compelled to justify their behavior.

Taken together, the results reveal a clear asymmetry. Contributions concerned with violations BY cyclists emphasized situational circumstances and, to a lesser extent, routine motives. In contrast, violations AGAINST cyclists were more often described as slips or laps than as deliberate recklessness.

### 3.3. Which traffic rules violations are committed BY and AGAINST cyclists?

This section deals with the question of what the violated traffic rules are, according to the contributions. Fig. 3 provides an overview of all specific traffic rule violations reported in the contributions committed BY cyclists, grouped by the victim's mode of transport. Fig. 4 presents the opposite perspective, traffic rule violations AGAINST cyclists, grouped by the perpetrator's mode of transport.[4]

In many contributions reporting about specific perpetrator-victim combinations, a single type of rule violation is dominant. A closer inspection of Fig. 3 and Fig. 4 reveals two main clusters of rule violations. The first cluster of violations BY and AGAINST cyclists is defined by a spatial aspect, namely the illegal use of infrastructure designated for other road users. Pedestrians and vehicle drivers are inconvenienced by cyclists riding illegally on the sidewalk or on the vehicle lane, respectively. Meanwhile, cyclists are inconvenienced

[4] We decided to exclude 16 contributions consisting of violations AGAINST cyclists by unspecified perpetrators due to the low number of incidents.

**Table 3**
Absolute number (and proportion) of rule violations BY and AGAINST cyclists, grouped by the other involved road user group. (Proportions exceeding 100% result from contributions including several road user groups as victims or perpetrators, respectively.).

| | Violations committed BY cyclists (N = 717) against… | Violations committed AGAINST cyclists (N = 1,795) by… |
|---|---|---|
| …pedestrians | 311 (43.4 %) | 257 (14.3 %) |
| …drivers of motorized vehicles | 70 (9.8 %) | 1,340 (74.7 %) |
| …cyclists | 186 (25.9 %) | 186 (10.4 %) |
| …unspecified road user groups | 186 (25.9 %) | 16 (0.9 %) |

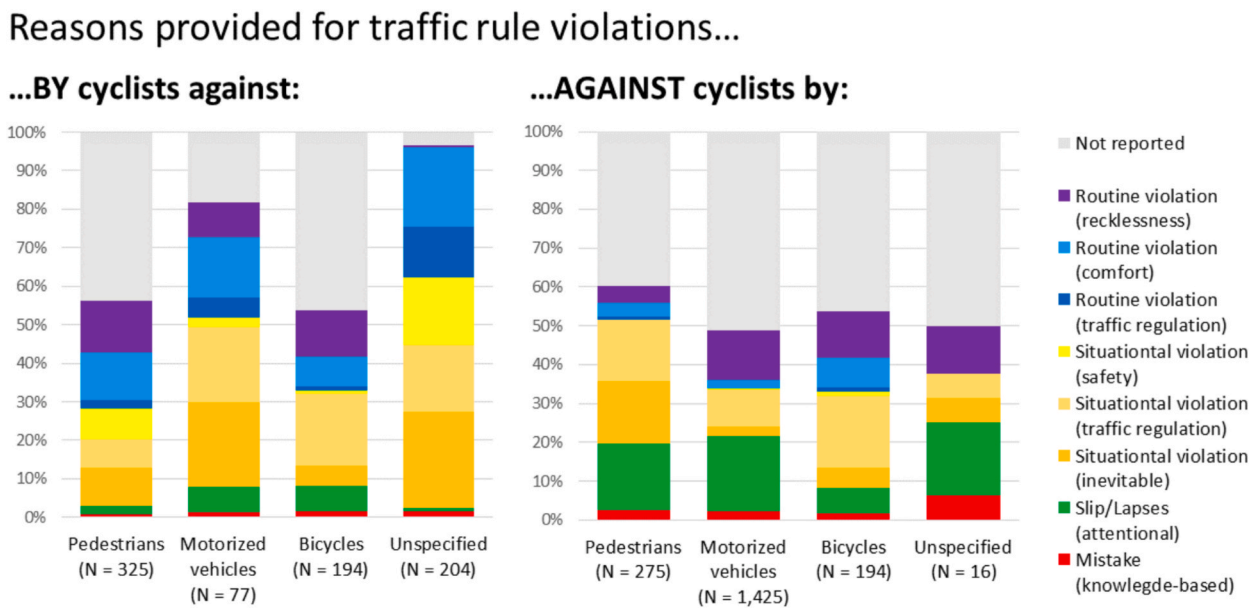


**Fig. 2.** Reasons provided BY cyclists (left panel) and AGAINST cyclists (right panel), grouped by the affected or the committing road user group, respectively. Bars indicate the proportion of each reason. The total number of contributions per road user group is reported below each bar. Please note that each contribution may contain several reasons for the reported rule violation.

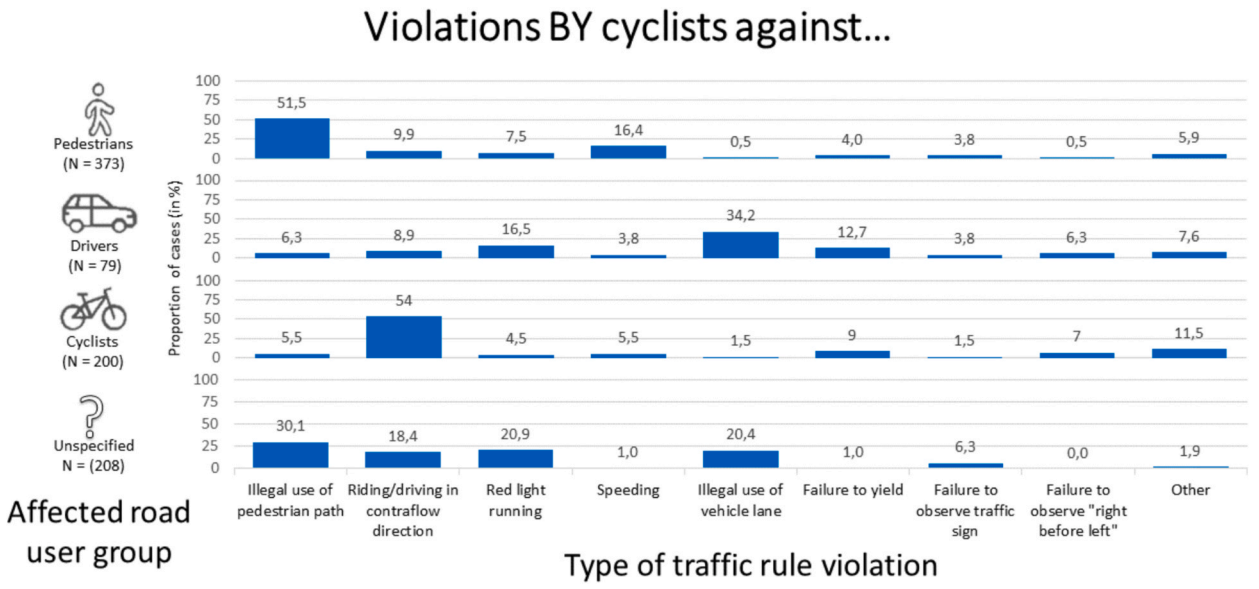


**Fig. 3.** Proportion of specific traffic rule violations committed BY cyclists as identified in the contributions, grouped by the affected road user group, mentioned at least 20 times across all transportation modes, and in descending order of the total number of rule violations.

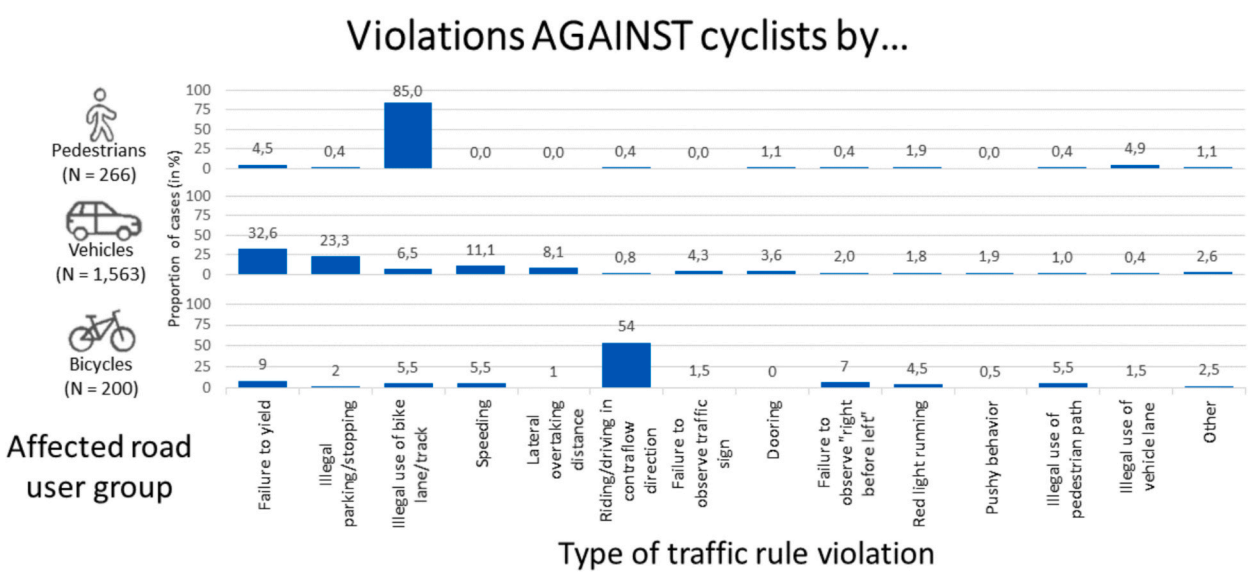


**Fig. 4.** Proportion of specific traffic rule violations committed AGAINST cyclists as identified in the contributions, grouped by the perpetrating road user group, mentioned at least twenty times across all transportation modes, and in descending order of the total number of rule violations.

by other cyclists riding in the contraflow direction or by pedestrians walking on bike lanes/tracks.

A second cluster of violations is defined by a temporal aspect, namely the use of infrastructure at an inadequate time. This cluster includes failures to yield at intersections, such as red-light violations, failure to observe a stop sign, and failure to yield to traffic approaching from the right at uncontrolled intersections, as required by the "right before left" rule common in Germany and parts of Europe. Drivers' failure to yield when turning right to cyclists travelling straight is by far the most prominent category. Although the literature often highlights cyclists' red-light running (e.g. Brezina & Hildebrandt, 2016; Fraboni et al., 2018; Johnson et al., 2013), this offense appears comparatively less frequently here; nevertheless, it ranks third among all reported violations BY cyclists and deserves separate investigation.

Some other frequently mentioned violations (e.g. speeding, narrow overtaking) may be often perceived by drivers as less serious, "trivial" offenses, which does not imply that they are indeed less uncomfortable or less dangerous. In particular, cyclists are affected by

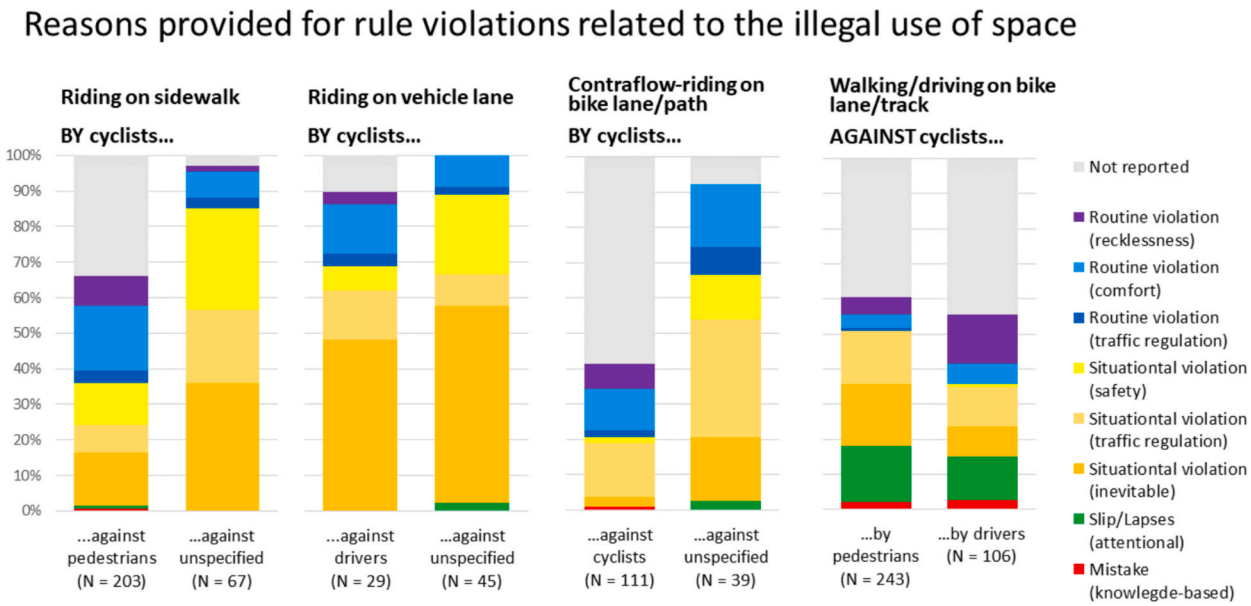


**Fig. 5.** Reasons for traffic rule violations related to the illegal use of space, by perpetrator and victim mode. Bars indicate the proportion of each reason. The total number of contributions for each perpetrator/victim combination is indicated below each bar. Please note that each contribution may contain several reasons for the reported rule violation.

vehicles parked or stopped on bike lanes/tracks. These violations represent a third cluster.

The following sections examine the reasons extracted from the various contributions, separately for the three clusters outlined above.

### 3.4. What are the reasons for space-related violations committed BY or AGAINST cyclists?

Fig. 5 provides an overview of the reasons derived from the contributions concerning the illegal use of space BY and AGAINST cyclists.

Contributions reporting illegal use of space BY cyclists (riding on the sidewalk, on vehicle lanes, or contraflow-riding on bike lanes/tracks) predominantly attribute these violations to situational reasons (mostly with circumstances perceived as making the violation inevitable; for example, due to the bike lane or path being blocked by parked cars or crossed by pedestrians). This attribution is noticeably reduced in contributions affecting pedestrians or other cyclists. Safety issues occur more frequently in contributions reporting violation BY cyclists against unspecified road users. Contra-flow riding on bike lanes/paths is relatively often attributed to poor traffic regulation.

In contrast, situational reasons are less prominent in reported contributions of violations AGAINST cyclists when pedestrians or drivers walk or drive on bike lanes/tracks, whereas slips/lapses are cited more frequently. Across all combinations, references to routine motives remain limited overall, and references to knowledge-based mistakes are basically absent.

Under the assumption that the majority of the contributions were provided by cyclists, this could indicate that cyclists rationalize their own offending behavior more than that of other road users infringing on their rights. However, even if this assumption holds, it is noteworthy that, overall, references to routine violations (i.e. comfort-related issues arising from poorly maintained cycling infrastructure such as potholes or bumps created by roots, or from traffic regulations perceived as inadequate or pointless) remain limited across all offenses and involved road user groups, regardless of whether cyclists are affected. Violations AGAINST cyclists are more often linked to slips/lapses by drivers and pedestrians than to deliberate intent, suggesting no general insinuation of malicious intent.

### 3.5. What are the reasons for temporal-related violations committed BY or AGAINST cyclists?

Fig. 6 shows reported reasons for temporal-related violations (excluding red-light running). Compared with the space-related violations in Fig. 5, situational attributions for temporal-related violations are less prominent overall. The pattern varies primarily by the perpetrator-victim pairing rather than by the specific type of yielding offense, and the following paragraphs are therefore primarily focused on the perpetrator-victim pairing.

For drivers' failure to yield, to observed a traffic sign, or to observe "right before left" AGAINST cyclists, slips/lapses are most frequently cited, followed by recklessness. In contrast, for cyclists' failures to yield or to observe a traffic sign against pedestrians,

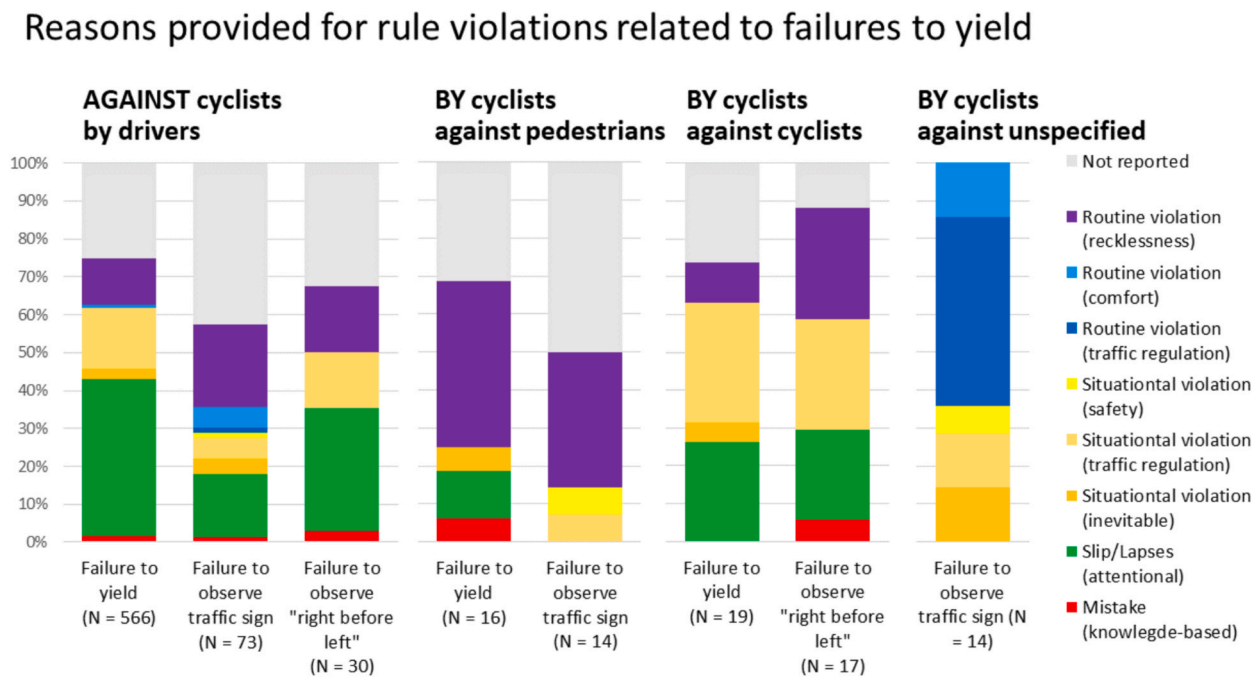


**Fig. 6.** Reasons for traffic rule violations related to failures to yield (excluding red-light violations), by perpetrator and victim mode. Bars indicate the proportion of each reason. The total number of contributions for each perpetrator-victim combination is indicated below each bar. Please note that each contribution may contain several reasons for the reported rule violation.

recklessness is the dominant reason. For cyclists' failures to yield to cyclists or to observe "right before left", traffic-regulations related reasons dominate, followed by slips/lapses. However, recklessness is also cited for cyclists' failures to observe "right before left" to other cyclists. Finally, cyclists report to fail to observe traffic signs in the absence of other road users because they feel that the regulation is pointless and inadequate for them.

Overall, the distribution of reasons for failures to yield depends mainly on the perpetrator-victim pairing, that is, who acts against whom, rather than on the specific legal provision. From a pedestrian perspective, violations BY cyclists appear to be predominantly attributed to recklessness. As already stated in Section 3.2, no corresponding pattern is observed for violations AGAINST cyclists; these are more often attributed to slips/lapses.

After the analysis of failures to yield without red-light running, the focus now turns to red-light violations. Red-light violations at signalized intersections are mentioned across several perpetrator-victim combinations, but their numbers, both in absolute and relative terms, are lower than might be expected from the body of research on this matter. Fig. 7 indicates that, unlike other failures to yield, red-light running is most often considered a routine violation rather than attributed to recklessness or slips/lapses, with notable differences by the affected road user group. When pedestrians are affected, cyclists' behavior is about equally more likely to be attributed to recklessness. When drivers are affected, cyclists' behavior is reported to result primarily from comfort issues. This reason is even more prominent when no specific victim is identified (similar to the reasons of cyclists' failure to observe traffic signs). When cyclists are affected by drivers' red-light violations, the most frequently mentioned reason is a slip/lapse of the driver, consistent with the pattern for other failures to yield by drivers.

### 3.6. *What are the reasons for "trivial" violations committed BY or AGAINST cyclists?*

Fig. 8 summarizes reasons for "trivial offense" violations (e.g. illegal parking/stopping, speeding, close/unsafe lateral overtaking, and dooring) committed by drivers AGAINST cyclists. Across these offences, a large share of reported contributions does not state a reason. In particular, a very high number of contributions report drivers parking or stopping on bike lanes/tracks, underscoring how common this nuisance is for cyclists. Despite its frequency, very few of these contributions include any information or speculation about underlying reasons. For drivers speeding against cyclists, among entries that state a reason, recklessness is most frequently cited reason. Speeding and dooring are attributed to slips/lapses in a lower, but noteworthy, proportion of these cases.

The only comparable violation committed BY cyclists in this group is speeding near pedestrians, for which recklessness is the most cited reason.

Unfortunately, reliable information on the role of the person providing each contribution is not available. However, the increased prominence of recklessness makes it plausible to assume that these contributions were primarily provided by road users suffering from the reported violations.

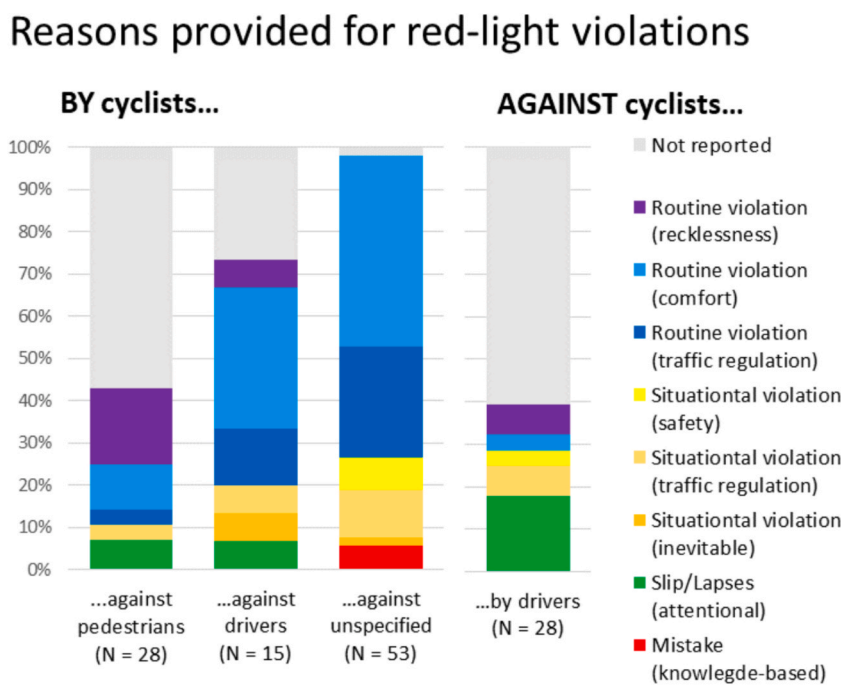


**Fig. 7.** Reasons for red-light violations, depending on the transportation mode of perpetrator and victim. Bars indicate the proportion of each reason. The total number of contributions for each perpetrator-victim combination is indicated below each bar. Please note that each contribution may contain several reasons for the reported rule violation.

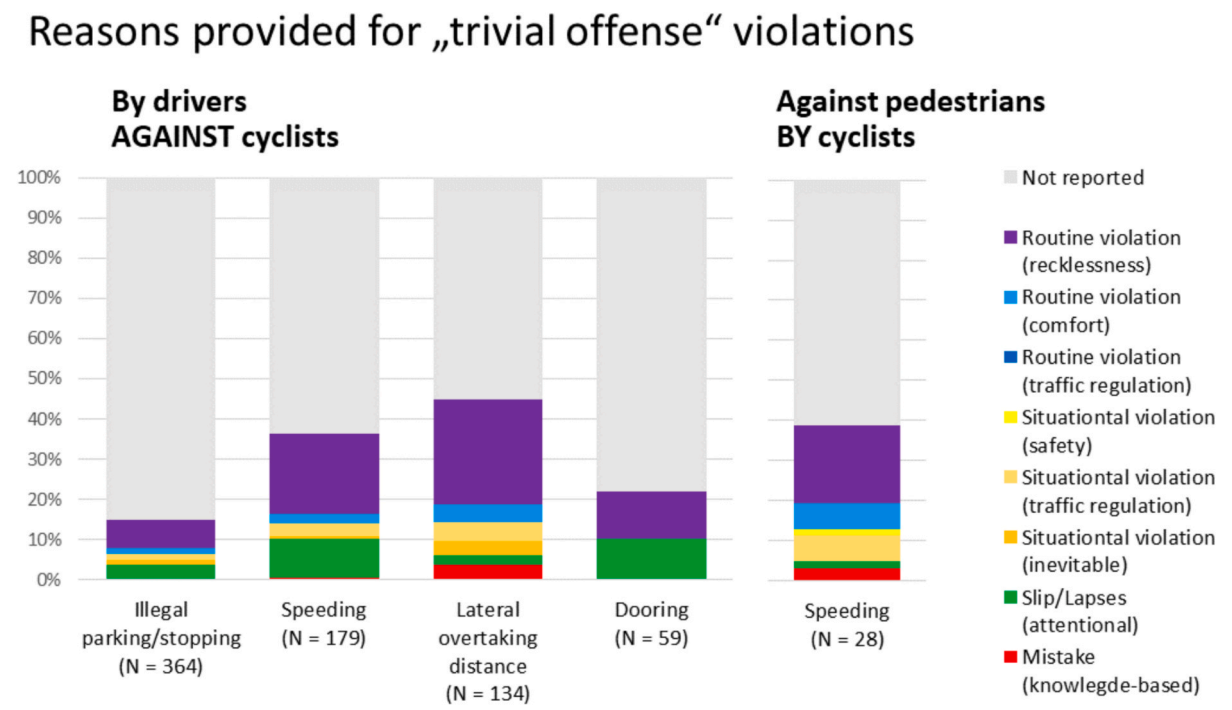


**Fig. 8.** Reasons for "trivial offense" violations, by perpetrator and victim mode. Bars indicate the proportion of each reason. The total number of contributions for each perpetrator/victim-combination is indicated below each bar. Please note that each contribution may contain several reasons for the reported rule violation.

## 4. Discussion

Cyclists are frequently reprimanded for perceived non-compliance with traffic rules. Undeniably, their infringements are violations of the law, irrespective of the individual cyclist's reasons underlying this behavior. Nonetheless, understanding why a given behavior occurs may provide insights into how to change it. This study therefore examined stated reasons for traffic-rule violations in cycling traffic. A large crowdsourcing dataset concerned with traffic situations cyclists (and other road users) reported as dangerous, confusing, or a nuisance was investigated for references to traffic rule violations. Next to the transportation mode of perpetrator and victim, contributions were examined for statements referring to reasons for these traffic rule violations, which were labeled according to Reason's classification of human error (Reason, 1990). The investigation of this dataset reveals several clusters consisting of specific types of rule violations, each predominantly attributed to specific error types. Before discussing these findings in detail, it is prudent to acknowledge the nature of the underlying data.

### *4.1. Acknowledging the nature of the investigated crowdsourcing data*

It can be assumed that the investigated crowdsourcing project is affected by selection bias, over-representing the perspective of cyclists committing (or suffering from) rule violations, over-representing some rule violations types, as well as potentially over-representing safety-conscious but motivated vulnerable road users. Nevertheless, even without a representative ground-truth, these contributions offer valuable insight into road users' perceived problems and attributions that have been found representative of a larger population (von Stülpnagel & Krukar, 2018). From a policy perspective, addressing norm violations that generate conflict may also be as important to address as addressing strictly legal traffic violations. Similarly, using concerns voiced by safety-conscious cyclists as a benchmark for countermeasures may also be a conservative yet effective approach.

However, given the nature of crowdsourced data, it cannot be ruled out that the observed tendency to justify some violation types with situational reasons reflects a conscious or unconscious effort by presumed cyclist contributors to rationalize their behavior through moral disengagement (Bandura et al., 1996; Schaefer & Bouwmeester, 2021), while their primary motivations may be more self-serving (Campbell & Sedikides, 1999). In other words, a cyclist riding on the sidewalk may describe this behavior as inevitable given the traffic situation, whereas an affected pedestrian may view it as reckless. Unfortunately, the most informative datapoint on this matter – the role of the contributor – could not be included in the present research because a clear classification was not possible for a large proportion of the contributions. Within these constraints, the extent to which fundamental attribution errors and self-serving attributions are present in the perception of traffic rule violations cannot be determined. A more controlled setup would allow comparisons of how identical behaviors are perceived across different road-user groups, which could inform conflict mitigation strategies.

Despite these limitations, the presented findings point to heterogeneous reasons for rule violations in bicycle traffic. First, some contributors explicitly acknowledge comfort-driven rule violations, which runs counter to a pure rationalization account. Second, a high proportion of violation by cyclists affecting pedestrians is perceived as reckless, thus pointing towards a dispositional attribution style. However, although a similar pattern could be expected for violations by drivers affecting pedestrian, the trend is far less evident in the dataset. Finally, focusing primarily on dispositional explanations risks reproducing the bias discussed in the introduction: emphasizing offenders' traits at the expense of situational factors that may prompt rule-violating behavior (i.e. the fundamental attribution error, Ross, 1977). Overall, self-serving attributions are possible, but it appears at least as plausible that many reported violations were perceived by contributors as the least-bad option in the moment (in line with the arguments of Dekker, 2004, 2017; Marshall et al., 2017). Nevertheless, the following discussion of the findings should be understood with the outlined limitations in mind.

### 4.2. Situational factors as reasons for the illegal use of space

One major cluster of rule violations consists of reports about various illegal uses of space. With few exceptions, these infringements are attributed to situational factors. Cyclists are described as (i) having no other choice (e.g. evading to the vehicle lane due to pedestrians walking on the bike lane), (ii) perceiving compliance as unsafe (e.g. due to high car traffic volumes on a road with mixed traffic), or (iii) facing unclear or absent regulation. Similar reasonings are identifiable in contributions about pedestrians or drivers infringing on space dedicated to cyclists. Many such traffic rule violations appear to be responses to other road users infringing on space designated for cycling.

Attributions to situational reasons are particularly prominent where the contribution suggests that a cyclist's rule violation does not have an immediate impact on another road user. It seems plausible that cyclists who feel unsafe in traffic or harassed on a shared sidewalk are more likely to illegally deviate to a space dedicated to another road user group if they assume no one is directly affected. A practical implication is that infrastructure which prevents encroachment on cycling space may, in turn, reduce cyclists' behavior that affect other road-user groups, while improving their comfort and safety.

### 4.3. Attentional slips and recklessness and as reasons for failures to yield

A second cluster of contributions reported about temporal-related violations, i.e. violations resulting from the use of infrastructure at an inadequate time such as failures to yield, red lights violations, or failures to observe traffic signs. The reasons provided in these contributions vary remarkably by perpetrator-victim relation and rule violation.

Failures to yield are among the most frequently mentioned violations in interactions between cyclists and other road user groups. Drivers turning right at an intersection and failing to yield to cyclists riding straight are by far the most frequently cited violation in the entire crowdsourcing project, consistent with a common crash scenario (e.g. Berghoefer et al., 2023). Notably, many descriptions attribute these driver violations to attentional slip (e.g. a driver forgets to look for cyclists properly, or looks but fails to see), rather than to recklessness (e.g. a conscious disregard of cyclists' rights and safety). A similar trend can be observed for contributions of cyclists failing to yield to other cyclists. By contrast, cyclists' failures to yield to pedestrians or to observe traffic signs giving pedestrians the right-of-way are more often attributed to deliberate disregard (i.e. recklessness), whereas the same attribution for drivers' violations against cyclists does not emerge.

### 4.4. Comfort and routine violations as reasons for failures to observe traffic signs and red lights

Although red-light running can be understood as a temporally-related violation, the reasons provided for this violation type differs remarkably from those provided for other failures to yield. More specifically, comfort and routine are mentioned in a much higher proportion of the respective contributions. Many of them suggest that traffic lights are perceived as imposing unreasonably long waiting times (also see Brezina & Hildebrandt, 2016), favoring the flow of vehicle traffic, or plainly ill-suited from the cyclists' perspective. This is particularly prevalent in contributions reporting red-light running affecting no other road users (with a corresponding pattern for cyclists' failures to observe traffic sign affecting no other road users). At the same time, contributions about red-light violations affecting pedestrians (presumably reported by the affected pedestrians) frequently characterize cyclists' red-light running red lights as reckless. Interestingly, contributions reporting about cyclists' being affected by drivers running red lights are more likely to refer to attentional slips rather than recklessness, thus corresponding to the pattern observed for failures to yield.

In general, there appears to be a tendency to attribute "trivial" offenses (such as speeding, narrow overtaking, and stopping/parking on bike lanes/tracks) by the stronger road-user group (i.e. cyclists towards pedestrians, vehicle drivers towards cyclists) to recklessness. At the same time, many reports provide no stated reason, leaving open whether perpetrators are unaware of the discomfort and risk caused, perceive the situation differently, or are simply inconsiderate regarding more vulnerable road user groups.

### 4.5. Limitations and future directions

The investigated dataset was collected more than a decade ago and parts of the context have changed. At the municipal level, Munich's transport network has been undergoing renewal and maintenance. At the legislative level, the Germany road traffic regulation was amended in 2020 to require minimum overtaking distances for motor vehicles passing cyclists (1.5 m in urban areas and 2 m in rural areas). Close overtaking maneuvers, therefore, did not constitute a statutory traffic rule violation at the time of the data

collection. Despite these developments, the vast majority of the described violations remain relevant, and the attributions reported for them are not rendered invalid by the subsequent legal changes.

As previously stated, the analysis relies on contributors' expressed opinions. In other words, it was not validated whether the reported behavior were legal violations under the applicable rules (i.e. the contributor may be mistaken about the traffic legislation and make a false claim) or whether events occurred exactly as reported. For example, pedestrians may complain about cyclists riding on the sidewalk even where such riding is permitted. Such contributions would reflect perceived norm violations and sources of conflicts rather than an actual violation of traffic legislation.

Red-light running appears as one of the more frequently mentioned rule violations by cyclists affecting pedestrians and vehicle drivers. It is also common in reports describing cyclists' violations with no specific victim identified, yet it still accounts for only a fraction of the cases as compared to other types of violations. This may suggest that, in the public eye, cyclists' red-light running is a less salient source of conflict and perceived risk than might be inferred from the volume of research on the topic (e.g. Fraboni et al., 2018; Johnson et al., 2013; Schleinitz et al., 2019). A similar pattern holds for other easily detected and enforceable violations, such as riding without lights, cycling under the influence of alcohol, or using phones during cycling, which are basically absent in the dataset investigated in this research. Contrasting the low reporting rates of these violations with crash data would help assess whether their perceived relevance aligns with actual safety impact. It is possible that cyclists and other road users underestimate the risks associated with these behaviors; alternatively, these violations may attract research attention primarily because they are easy to observe and enforce rather than because they are central to traffic safety or to conflicts in bicycle traffic.

Linking the contributions to the infrastructural context via geolocation was beyond the scope of this research. Future work could examine how local infrastructure, traffic volumes, and crash rates relate to the frequency of traffic rule violations and their attributed reasons, distinguishing actions that are primarily annoying yet legal from those that are illegal and increase crash risk.

## 5. Conclusions

In summary, this research indicates that reported traffic rule violations by and against cyclists contribute substantially to cyclists' discomfort and insecurity, as well as to conflicts between cyclists and other road-user groups. With regard to the initial question of why cyclists violate traffic rules, this research provides substantial evidence that their behavior must be understood from a holistic perspective including not only the cyclist's action, but also the situational context in which this action takes place. More specifically, only a fraction of all traffic rule violations is assumed to be consciously reckless behavior or missing rule knowledge. Depending on the perpetrator's transport mode as well as on the violated traffic rules, violations are more often attributed to attentional slips (especially drivers failing to yield to cyclists when turning right), routine motives, or situational constraints. However, so-called "trivial" offenses that affect a more vulnerable road-user group are frequently attributed to recklessness on the part of the perpetrating group. At the same time, a large proportion of traffic rule violations committed by cyclists (in particular those involving illegal use of space) are attributed to situational factors, that is, a response to a situation perceived as dangerous, unclear, or compelling. Such behavior remains an infringement of traffic rule legislation, but the attribution pattern suggests context matters for how these behaviors arise. To reduce these forms of rule violating behavior and the resulting conflicts, it is important to account for the reasons underlying cyclists' behavior, and to design traffic systems in which cyclists do not perceive rule violation as the most reasonable option in in a given situation.

## 6. Competing interest statement

The authors declare that there are no financial and personal relationships with other people or organizations that could inappropriately influence (bias) our work, including potential competing interests such as employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding.

## 7. Data statement

The annotated dataset can be made available upon request to the first author.

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## CRediT authorship contribution statement

**Rul von Stülpnagel:** Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Fabian Niemann:** Writing – review & editing, Methodology, Conceptualization. **Hiba Nasser-eddine:** Writing – review & editing, Conceptualization. **Anja Huemer:** . **Axel Leonhardt:** Writing – review & editing, Funding acquisition, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2025.103470.

## Data availability

Data will be made available on request.

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