Rules of the road: Compliance and defiance among the different types of cyclists

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ABSTRACT

While cycling has become a more attractive option to commuters in many North American cities recently, significant apprehension remains around its safety. While risks experienced by cyclists are diverse, the idea that they are due to scofflaw cyclists – cyclists who regularly ignore the rules of the road – remains prevalent. Improving cycling safety requires countering this idea, and therefore an understanding of how different cyclists act under the existing rules. Using a survey of 1,329 cyclists in Montreal, Canada, this study generates a typology of cyclists based on cycling motivations and behaviors and conducts comparisons based on their responses to four cycling rule-breaking scenarios. Our study shows that all cyclist types contravene traffic laws in similar ways, and 0.6% of respondents consistently follow traffic laws. Breaking the law is often considered the safest option by respondents, which reflects a disconnect between the safety goals of traffic laws and the reality on the streets based on the perspectives of different cyclist types. While cyclist types may act similarly in response to existing laws, they still respond uniquely to different policies aimed at increasing rule adherence. Targeted interventions aimed at educating young cyclists, improving dedicated infrastructure, and prioritising cycling traffic can increase rule compliance across all types. Through our study planners, policy makers, and law enforcement can improve cycling safety by better understanding the behaviour and rationale taken by cyclists.

INTRODUCTION

Cycling has grown as a viable commuting option in many North American cities recently, becoming a competitive way to get around urban areas for many users. Collisions with motorists remain common for cyclists, with injuries and fatalities receiving significant media attention recently in cities like Toronto and Montreal (*1; 2*). Despite these collisions often being to no fault of the cyclist, public perception of cyclists remains antagonistic. Cyclists are perceived as rule-breakers, receiving the blame for conflict on the streets in public perception (*3*). Efforts to increase cycling safety often encounter opposition due in part to this characterization.

Countering the rule-breaking perception of cyclists requires an understanding of different cyclists' rule-breaking behaviours. While many typologies of cyclists have been generated, none as of yet have included risk-taking in their classification. Rule-breaking and risk-taking in cycling literature has largely focused on explaining why some cyclists run red lights (*4; 5*), though one major study aims at answering who the rule-breakers are (*6*). Building on the existing literature, this study generates a unique typology that includes risk-taking behaviours, derived from a 2018 survey of 1,329 cyclists in Montreal, Canada. Through comparison of their responses to four different rule-breaking scenarios, we evaluate each cyclist type's responses to better understand why some do not follow the rules. Four targeted approaches are proposed, meant to accompany revisions to existing traffic laws and based on the unique identities of each cyclist type. These interventions affect different types differently, but all serve to increase rule compliance amongst cyclists.

This study commences with a review of the existing literature regarding cyclist typologies is reviewed, then prior research on risk-taking and rule-breaking by cyclists is discussed. The context and structure of the cycling survey are described next. Analysis of the data begins with descriptions of the six cyclist types generated, before their choices in four risk-taking scenarios and their stated rationale are compared. Finally, targeted policies aimed at increasing rule compliance by type are discussed, which are followed by a conclusions section.

LITERATURE REVIEW

Cyclist Typologies

The generation of typologies is an effective research method used to understand variation in populations and target policies towards them. One of the first typologies of cyclists was introduced in a study aiming to understand modern transport behaviour in Norway (*7*). The study categorized cyclists according to why they choose to cycle over using public transport. *Cyclists of heart* choose the bicycle due to their enjoyment of the ride; *Cyclists of convenience* are drawn by the practicality of the mode; *Cyclists of necessity* only choose to cycle in the absence of a better option. While this typology is useful in understanding mode choice, it does not tell much about differences in cyclist behaviour or motivations.

Perhaps the most widespread cyclist typology hails from Portland, Oregon. The Portland typology was developed by a local transport planner, and is constructed from cyclist confidence and comfort (*8*). The measure was used to categorize the entire city's commuting population, thus allowing local planners to attract non-cyclists to the mode with new infrastructure targeted to different cyclist types. The four types include *No way no how*, *Interested but concerned*,

Enthused and confident, and *Strong and fearless.* While Geller's typology has become popular, his arbitrary creation of types that are then applied to the population can lead to incongruent labeling, such as identifying practicing cyclists as *No way no how* cyclists or non-cyclists as *Strong and fearless* cyclists (*9-11*).

Another cyclist typology has been generated by Damant-Sirois, Grimsrud & El-Geneidy (*9*), using multiple factors that lead to bicycle usage. Using data from a survey of Montreal cyclists, questions on cycling background, deterrents, and motivations as well as infrastructure preference and comfort are fed into a principal component analysis and used to generate k-means clusters. Four types are generated from seven factors, being *Dedicated cyclists*, *Path-using cyclists*, *Fairweather utilitarians*, and *Leisure cyclists.* While *dedicated cyclists* are comfortable travelling in almost all conditions, *path-using cyclists* require consistent and dedicated infrastructure. *Fairweather utilitarians* are multimodal and cycle only in ideal conditions, while *leisure cyclists* are looking for safe and fun recreational riding. The authors demonstrated how different policy interventions might be used to increase commuting frequency by bicycle, as each group has unique motivators and deterrents.

A final typology of note considers social perceptions and stereotypes of cyclists in generating a typology and compares the results between bicycle users and non-users (*12*). In this case, a principal components analysis was used to generate factors that themselves are considered types of cyclists. These types are *Responsible bicyclists*, *Lifestyle bicyclists*, *Commuter bicyclists*, and *Hippy-go-lucky bicyclists.* Non-cyclists were more likely to consider the *lifestyle bicyclist* as less responsible bicyclists when compared to their cycling counterparts. The authors note that overcoming the stereotypes of cyclists as a lifestyle group of extreme riders will be key in attracting non-cyclists to the mode and may help political efforts to improve safety conditions for cyclists. While this study does not consider actual cyclist behaviour, it demonstrates the importance of including cyclist risk-taking behaviours into account when generating a typology to better counter negative public perceptions or stereotypes. All the above studies have shown the importance of generating cyclist typologies in order to develop public policy. It is also important to note that the differences in the cyclist typologies generated above mostly return to the type of questions posed to respondents.

Cyclist Safety & Rule-breaking

Rule-breaking in the cycling literature has generally revolved around red-light running, perhaps due to the violation being among the most infuriating to motorists. Finchham (*13*) suggests that negative opinions of cyclists can be sourced to the motorists frustrated with cyclists breaking laws that motorists cannot break themselves, rather than cyclists' behaviours being a real safety danger to themselves or others. Understanding the different reasons why cyclists run red lights has thus become a popular research direction in that it may diffuse tensions around the violation while also identifying ways to reduce the practice.

Traffic camera observation is a popular method used to study red light running behaviour, allowing for a categorisation of cyclists by appearance and action. Pai & Jou (*4*) used the method in Taiwan, labeling the cyclists observed as *Risk-taking*, *Opportunistic*, and *Law-obeying*. While their estimation of demographic variables such as gender via traffic camera may be somewhat inaccurate, other significant findings concerning infrastructure type suggest that cyclists are more likely to run a red light on T or Y intersections, intersections with long light timers, and intersections of low traffic volume. A similar method undertaken by Wu et al. (*14*) in China

found 44% of observed cyclists were law-obeying, 31% risk-taking, and 25% opportunistic This study concluded that as age and number of cyclists waiting for the light increased, the likelihood of running a red light decreased. Nevertheless, neither study can accurately discuss the demographic identities of their rule-breaking cyclist types based on traffic camera observation alone.

While Johnson et al. (*5*) also used the above method to track red light running behavior in Australia, a second study by the same authors uses a national online survey to better understand the practice (*5; 15*). Two questions regarding red light running were asked and six demographic variables were extracted. Around 37.3% of respondents who identified as cyclists reported running a red light previously, with gender, age, past collision involvement, and similar behaviour while driving variables being significant in affecting the likelihood of running a red light in a binary logistic regression model. The most common reason for violation was to turn left on a red (Australia drives on the left), with the authors concluding that changes to local traffic rule should permit this maneuver for cyclists in order to minimise heavy truck collisions and increase cycling attractiveness.

Stated-preference surveys have also been used in Germany to understand cyclist rule violation and to increase rule compliance. Using two online surveys, Huemer (*16*) examined the practice of riding the wrong way on cycling infrastructure and cycling without lights. A low perceived risk of detection, high rationalization of the action, and young age increased intention of cycling in the wrong direction, with every respondent having done so at least once. Most cyclists who violated the rule cited poor infrastructure for their action - being forced to take the wrong direction in order to reach their destination - while claiming to be disadvantaged in current traffic law and more comfortable because of their choice. She argues for increasing cycling compliance through increased rule education and explanation of motorist expectations, matched with enforcement.

What most of the above studies have not included is an understanding of the rationalization of rule-breaking. While Johnson et al. (*15*) use rationale to recommend some policy changes, Huemer (*16*) on the other hand disregards the rationale to argue for increased compliance. A final study aims to contextualise rule-breaking through comparisons with motorists, suggesting that cyclists make rational decisions to contravene the law and are not reckless in doing so in the vast majority of cases (*6*). Cyclists are grouped by the level of risk taken in their responses to a set of scenarios, with relatively few cyclists categorised as law abiders or undertaking reckless endangerment. The number one reason for cyclists to break a law was personal safety, whereas saving time was chosen first by drivers and pedestrians. The rationalization of rule-breaking continues to be assigned to cyclists at large, meaning that any proposed response to violation (be it enforcement, infrastructure provision, or policy change) may continue to miss the mark in addressing specific behaviours present in specific cycling types. The introduction of cyclist typologies to the rule-breaking literature will allow for more fine-grained analysis based on the responses of cyclists themselves, rather than on passive observations or arbitrary categorization.

STUDY CONTEXT

Montreal is Canada's second-largest urban region, with a population of almost 4.1 million as of the 2016 Canadian Census (*17*). Around 29.5% of the region commutes to work using a sustainable mode – public transport, walking or cycling. These numbers rise to 49% in the city

itself, where public transport and cycling networks are more established. Considered among North America's most bikeable cities, Montreal's reputation has been sliding in one popular ranking. The Copenhagenize Index, which had ranked Montreal 8th in 2011, has listed the city as 20th in 2017 and noted that many areas remain too unsafe while infrastructure growth has been stagnant (*18*).

A notable change in the Montreal cycling environment was a revision of the local traffic laws, which has notably allowed for the implementation of *vélorues* (dedicated cycling streets), the elimination of demerit points for cyclists, and allowing for cyclists to advance through pedestrian lights (*19*). The changes also dramatically increased fines to cyclists and continue to enforce full stops at stop signs and before advancing through pedestrian signals. Overall, the rules of the road applying to cyclists remain generally identical to those that apply to motorists in Montreal, similar to many North American cities.

DATA

Data from the 2018 Montreal Cycling Survey is used in this study to generate a typology of cyclists. The Survey was available online from May 15th to June 15th, 2018 in both French and English. The Survey was shared with the Transportation Research at McGill research group mailing list (roughly three thousand emails) as well as the group's social media. Links to the Survey were shared by McGill University and several local cycling advocacy organizations, as well as Montreal's local sustainable commuting institute, *Centre de gestion des déplacements de la région de Montréal*. The Survey was shared during a live television interview with CTV News Montreal, and several other local media outlets were contacted. Lastly, flyers were distributed to cyclists along bicycle lanes and on parking stands in downtown Montreal to ensure diversity in the recruitment process. While these strategies improve the range of the convenience sampling approach, our final sample is not fully representative of the Montreal cycling population.

At the end of the survey, 1,391 complete responses were collected, including current, lapsed, and non-cyclists. Lapsed and non-cyclists were asked several questions as to why they chose not to cycle, as well as preferences for infrastructure that would attract them to riding. For this study, only active cyclists are included, resulting in a total of 1,329 respondents.

For active cyclists, the survey consisted of ten sections: general information, cycling behaviour, mobility spending, BIXI (Montreal's bicycle sharing system) usage, winter riding, cycling risk, cycling scenarios, local Montreal infrastructure, cycling history, and personal profile. These sections ask respondents to share their experiences cycling, including their frequency, motivations, deterrents, history, and demographic characteristics.

The cycling risk and cycling scenario sections are modeled after Marshall et al.'s (*6*) survey design, with the first section asking respondents to rate their level of confidence with several aspects of cycling and their attitude towards risk. While this approach relies on respondents' self-reporting their attitudes and behaviours, it allows for the capturing of their perceptions towards safety and risk. The cycling scenario section consists of four unique multiple-choice questions, all with a brief description and accompanying picture. The respondent is asked to choose between four reactions, one of which follows the Highway Safety Code and three of which do not in increasing levels of riskiness. Respondents who choose an illegal option must provide

their rationale for doing so, with potential answers again reflecting Marshall et al.'s (*6*) design. All four scenarios and their accompanying reaction choices can be seen in Table 1.

TABLE 1: Scenario design and responses, from Montreal Cycling Survey 2018

Scenario Question	Scenario Picture
You are biking along the above street and are approaching an intersection with four-way stop signs. You wish to continue straight. How do you proceed? 1. Come to a full stop to check for traffic in all directions before proceeding through the intersection. 2. Slow down - but not stop - to check for traffic in all directions before proceeding through the intersection. 3. Slow down - but not stop - before proceeding through the intersection. 4. Proceed through the intersection at full speed.	
You are travelling along the above road and are stuck in traffic due to a red light ahead. How do you proceed? 1. Maintain your place in traffic and wait for the intersection to clear. 2. Dismount your bike and walk it along the sidewalk. 3. Continue cycling towards the light by riding between the waiting cars. 4. Continue cycling ahead by switching to the sidewalk.	
While cycling, you receive a phone call. How do you proceed? 1. Ignore the call - you can check when you finish your ride. 2. Come to a complete stop and immediately answer the call. 3. Slow down - but not stop - to answer the call just to say you will call back. 4. Continue cycling while you answer the call.	
You are approaching your destination, which is at the end of the road on the right. The road is a one-way street going in the opposite direction you need to travel. How do you proceed? 1. Continue cycling until you find another route to get to your destination. 2. Turn right, dismount your bicycle, and walk it along the sidewalk until you reach your destination.	

3. Turn right and cycle on the sidewalk until you reach your destination.
4. Turn right and stick to the right-hand side of the street until you reach your destination.

ANALYSIS

Factor analysis

Several variables representing cycling deterrents, motivations, history, risk, and frequency were loaded into a factor analysis. The analysis was run several times as variables with low correlation to any factors (between -0.4 and 0.4) were removed. Scree plots were consulted to select the most appropriate number of factors for analysis, while being guided with the Eigen values. The resulting factors draw from questions on cycling motivations and cycling risk, see Table 2 for details.

The first factor, *fearfulness,* captures respondents' worry of being involved and injured in a cycling collision. The second factor, *efficiency-seeking,* groups motivational variables concerning the speed and efficiency of cycling. The third, *confidence*, captures cycling ability in terms of both practical and theoretical skill. The fourth factor, *lawfulness*, includes past behaviour towards the Safety Code and the use of signals, with signals being included despite a lower correlation value because of its high topical relation. Lastly, *health-seeking* describes motivational variables for cycling that revolve around personal and social wellness.

TABLE 2: Factors, variables, and loadings

Question/Variable	Factor Loading
Fearfulness	
How worried are you of potentially being injured in a cycling collision?	**0.897**
How worried are you of potentially being involved in a cycling collision?	**0.891**
Efficiency-Seeking	
How important is taking the fastest way from A to B in your decision to cycle now?	**0.804**
How important is predictability of travel time in your decision to cycle now?	**0.761**
How important is the low cost of cycling in your decision to cycle now?	**0.527**
Confidence	
How confident are you in your cycling ability?	**0.644**
How confident are you in your knowledge of cycling rules, according to the Quebec Highway Safety Code?	**0.613**

Lawfulness	
Thinking of my typical behavior in the past year, I always follow the Quebec Highway Safety Code while cycling.	**0.823**
Thinking of my typical behavior in the past year, I use signals for all of my movements while cycling.	**0.435**
Health-Seeking	
How important are environmental reasons in your decision to cycle now?	**0.74**
How important are health reasons in your decision to cycle now?	**0.513**

Cyclist typology

Similarly to Damant-Sirois (9), the typology built here considers multiple dimensions and allows the responses of cyclists to characterize themselves. Each cyclist is defined individually, rather than creating a label to assign cyclist by cyclist. The results of the principal component factor analysis are used in a k-means cluster analysis, with the analysis tried for three to seven groups. In our case, six clusters gave the best results; these six clusters are *Safety-first cyclists*, *Unfamiliar cyclists*, *Recreational cyclists*, *Radical cyclists*, *Risk-taking cyclists*, and *Shortcut cyclists.* The characteristics of each can be seen in Figure 1, with additional comparisons visible in group means of selected variables in Table 3.

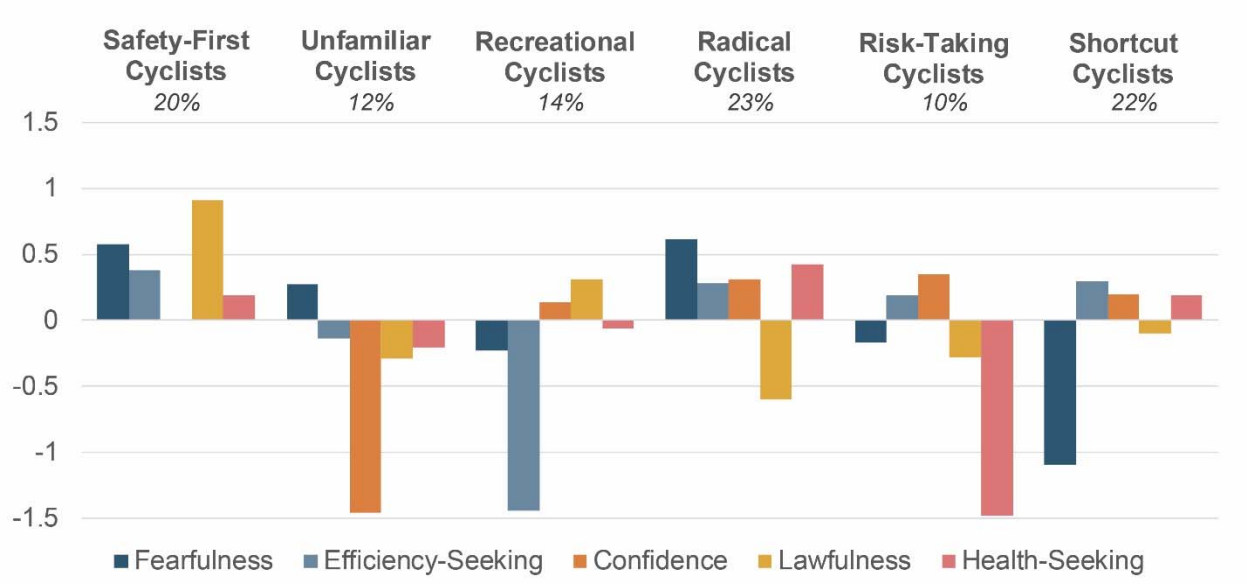

FIGURE 1: Cyclist types

Safety First Cyclists

Safety-first cyclists (20% of sample) are strongly defined by their following of existing road rules and signals. They are among the most fearful while cycling, with neutral confidence in their abilities. Motivated more by efficiency than health, this type puts the law first when cycling.

Unfamiliar Cyclists

Unfamiliar cyclists (12% of sample) are the newest cyclists with the least amount of experience. They have the largest proportion of students of any group. With very little confidence in their abilities and some fear, these cyclists also show low levels of lawfulness. Not motivated by efficiency or health, *unfamiliar cyclists* are most likely to not to cycle and walk or transit instead.

Recreational Cyclists

Recreational cyclists (14% of sample) are here to enjoy the ride; they could not care less about efficiency and are less fearful on their rides. This group uses their bicycles the least, preferring to drive for utilitarian trips. They are the oldest group and have the highest proportion of retirees.

Radical Cyclists

Radical cyclists (23% of sample) are the cycling devout; they complete the most utilitarian trips by bike of all groups, including through winter, and are least likely to find a reason not to cycle. They are the youngest, most fearful, and least lawful group *Radical cyclists* are sold on the health and efficiency benefits of cycling, having rejected car usage and taken a hard line in claiming right-of-way against the car.

Risk-taking Cyclists

Risk-taking cyclists (10% of sample) do not worry for their health; confident in their abilities, they do not consider themselves lawful. *Risk-taking cyclists* are most likely to use a BIXI.

Shortcut Cyclists

Shortcut cyclists (22% of sample) are the last group, defined by their complete lack of fearfulness. They are more confident and less lawful than average. *Shortcut cyclists* have the shortest commutes of all and the most cycling experience. Familiar and at ease on their routes, shortcut cyclists are somewhat motivated by health and efficiency considerations.

TABLE 3: Selected demographic characteristics of cyclist types

Demographic	Safety-first Cyclists	Unfamiliar Cyclists	Recreational Cyclists	Radical Cyclists	Risk-taking Cyclists	Shortcut Cyclists
Age (years)	42.4	41.0	50.2	40.3	43.4	43.1
Cycling experience (years)	16.3	13.0	17.5	17.2	18.0	20.2
% female, non-binary, or other	0.51	0.73	0.30	0.35	0.27	0.37
% student	0.08	0.25	0.05	0.12	0.10	0.11
% retired	0.07	0.06	0.22	0.04	0.06	0.07
Trip Behaviour						
Commute distance (km)	6.71	7.02	6.80	6.07	6.72	5.67
# of weekly work trips by bicycle	4.77	2.83	2.65	4.88	4.06	3.93
# of weekly grocery trips by bicycle	1.00	1.01	0.56	1.36	1.10	1.07
# of weekly leisure trips by bicycle	2.42	2.28	1.60	2.87	2.61	2.29
% who cycle in winter	0.27	0.14	0.14	0.43	0.36	0.37

Mode Behaviour						
% who when not cycling, drive	0.25	0.23	0.43	0.23	0.26	0.25
% who when not cycling, take public transport	0.76	0.82	0.61	0.73	0.74	0.73
% who when not cycling, walk	0.42	0.56	0.34	0.39	0.42	0.41
% who use BIXI	0.40	0.46	0.22	0.44	0.55	0.38
% agree, cyclists should always have the right-of-way	0.54	0.58	0.49	0.69	0.51	0.55

Scenario Responses

Having generated a cyclist typology, responses to the four scenarios can be compared. Figure 2 shows each cyclist type according to the percentage of responses that follow the Quebec Highway Safety Code (option 1 for each scenario in Table 1). Very few respondents followed the Code in all scenarios; less than 2% of *safety-first cyclists*, *unfamiliar cyclists*, and *recreational cyclists* chose rule-abiding answers (see Figure 2). On the other end of the scale are those who did not choose a single response following the Code, ranging from 16.5% to 25.3% of each type. In order of most to least rule-breaking, the types are *radical cyclists* (who all broke the Code at least twice), *risk-taking cyclists*, *shortcut cyclists*, *safety-first cyclists*, and *recreational cyclists*.

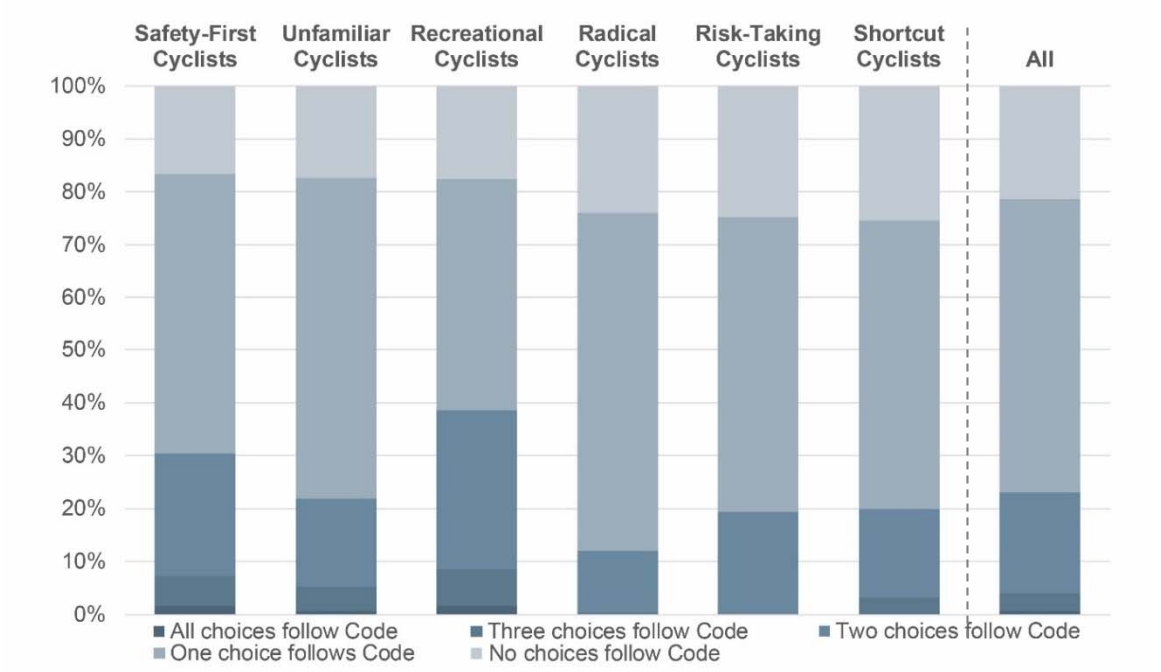

FIGURE 2: Scenario response by cyclist type

Breaking the responses down by scenario, the picture of rule-breaking shifts away from universal disregard for the Highway Safety Code. It becomes clear that all types commonly break certain rules and consistently follow others. Table 4 provides statistics for each scenario by cyclist type.

A high level of consensus between types suggests a unique approach to rules shared by all cyclists. The consensus against following the Code in scenarios 1 and 2, and 4 suggest that some rules shared with motorists are not considered rational by even the most law-abiding cycling types. Similarly, the consensus for following the Code in reference to phone use across all types suggests that the rationale for this rule is accepted by even the least law-abiding cycling types. Within this consensus remains room for variation: for example, while most cyclists in each type choose Option 2 in Scenario 1 (choosing to slow, but not stop, before passing through a stop sign), *safety-first cyclists* and *recreational cyclists* show a high level of variation from the majority. These variations may be attributed to the unique characteristics of each cyclist type (fearfulness, confidence, lawfulness, efficiency motivations, and health motivations).

TABLE 4: Scenario response by cyclist type

	Level of Risk	Safety-First Cyclists	Unfamiliar Cyclists	Recreational Cyclists	Radical Cyclists	Risk-Taking Cyclists	Shortcut Cyclists
Scenario 1	*1*	16%	10%	15%	1%	4%	9%
	2	82%	85%	79%	95%	91%	86%
	3	2%	3%	5%	3%	4%	4%
	4	0%	1%	1%	1%	1%	1%
Scenario 2	*1*	11%	7%	13%	4%	8%	6%
	2	9%	8%	8%	3%	4%	3%
	3	78%	81%	78%	92%	87%	90%
	4	2%	4%	0%	2%	2%	1%
Scenario 3	*1*	75%	79%	75%	71%	68%	69%
	2	25%	17%	23%	25%	29%	27%
	3	0%	1%	1%	1%	2%	1%
	4	1%	3%	1%	2%	1%	2%
Scenario 4	*1*	21%	14%	28%	12%	15%	13%
	2	53%	41%	40%	34%	38%	37%
	3	10%	15%	10%	16%	9%	13%
	4	16%	30%	22%	39%	38%	37%

Scenario Rationale

For those who did not follow the highway safety code in their responses, a follow up question appeared asking them to state the rationale for not following the rule. Respondents could select only one rationale, with most of the "other' open text option being used to select multiple responses. Unsurprisingly, *safety-first cyclists* were most concerned with their safety when choosing to break the law, with 43.3% choosing "it was the safest option" or "it made sure I was visible to cars". Similarly, *radical cyclists* were most concerned with saving time or energy, reflecting the high efficiency motivation they have to cycle. *Risk-taking* and *radical cyclists* are

most likely to have a respondent choose rule-breaking for fun or for protest, but these numbers are very low at 3.2% and 2.7% respectively.

When observing the rationales given, what is most evident is the relative similarity between all cyclist types despite the discrepancies in their cycling attitude and behavior. Efficiency concerns are more important than safety concerns for all types except *safety-first cyclists* but are not significantly more often chosen amongst other types. No single cyclist type is claiming one rationale more than another in rule-breaking; rather, rule-breaking is a decision that is similarly rationalized by all different types of cyclists.

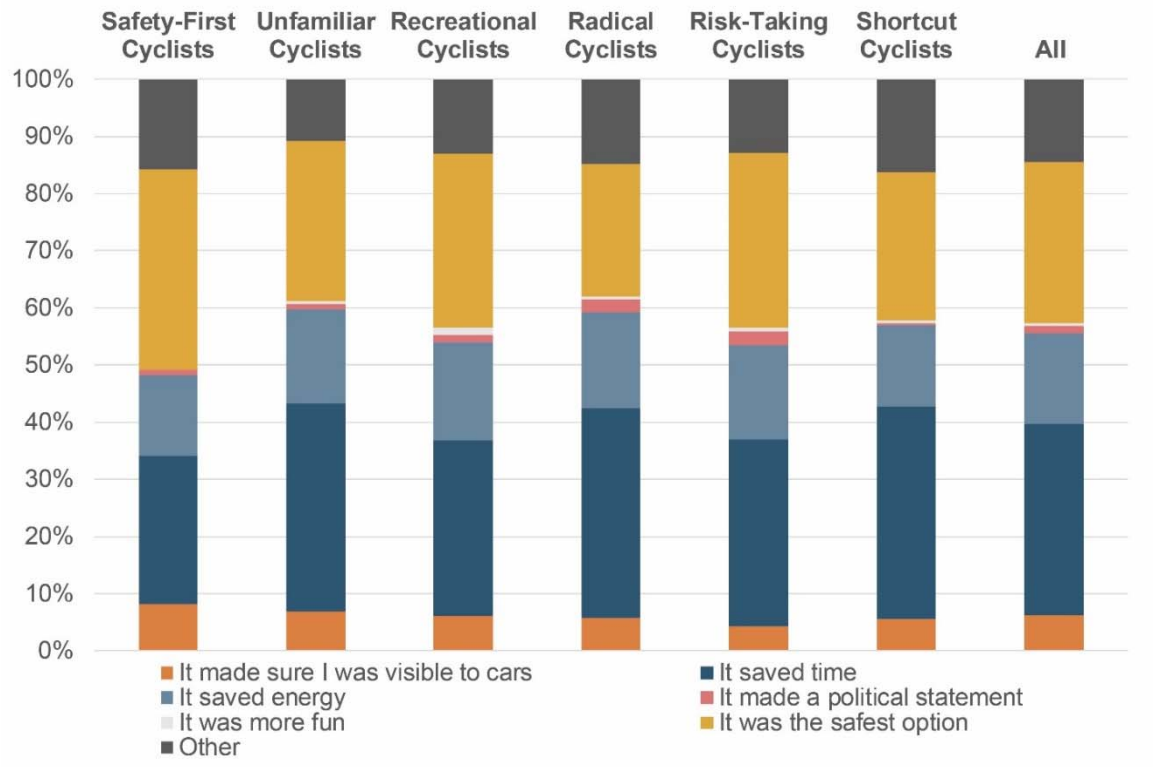

FIGURE 3: Rationale for not following the Safety Code by cyclist type

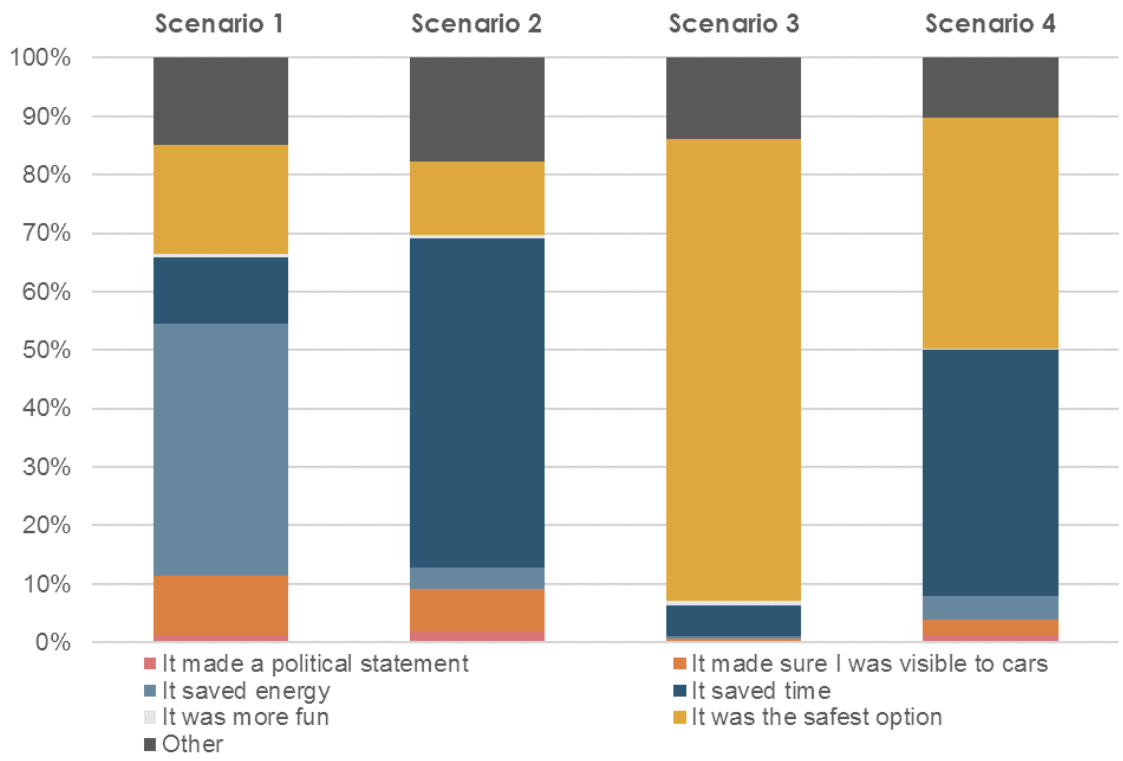

FIGURE 4: Rationale for not following the Safety Code by scenario

When considering the given rationale by rule-breakers of all cyclist types by scenario, it is clear that each scenario has a predominant concern. Figure 4 shows the percentage of all cyclists selecting a given rationale for each scenario. In Scenario 1, cyclists choose to break the rules and not come to a complete stop in order to save energy, while in Scenario 2 cyclists choose not to wait with traffic in order to save time. In Scenario 3, cyclists who chose to stop immediately to answer a call perceive this as the safest option. Only Scenario 4 sees a roughly equal split in the dominant rationale, with cyclists divided on saving time and seeking safety. This reflects the division in the 'appropriate' choice of rule-breaking, with respondents split between walking the bike up the sidewalk and continuing to ride their bike against traffic

DISCUSSION

With most cyclists choosing not to follow traffic laws to some extent, it is clear that frequent revision of the rules must be a key plank of cycling policy. These revisions should take into consideration the primary rationale for rule-breaking in each scenario; for example, the desire to save energy should factor into stop sign rules for cyclists. With or without revisions, however, there will always be a percentage of cyclists who choose not to follow the law. These riders require unique and targeted policies based on their cyclist type if they are to make a sustainable change to rule-abiding behaviour.

Our cyclist typology identifies unique characteristics between groups that may be used to develop targeted policies for increasing rule compliance. By addressing these characteristics, rule-breaking behaviour can be reduced. Figure 5 displays the orientation of cycling types to four recommended policy interventions, in the aim of achieving the highest level of compliance

possible by all cyclists. Each policy recommendation corresponds to a shared characteristic of the present cyclist types; training and practice targets low confidence, infrastructure targets high fearfulness, and prioritisation targets high efficiency-seeking.Please note that the size of each bar does not correspond to the percentage of rule-breakers present in each type; for example, *unfamiliar cyclists* are not most in need of intervention to assure rule compliance. Rather, the size of the bar only corresponds to which policies can affect members of a cyclist type.

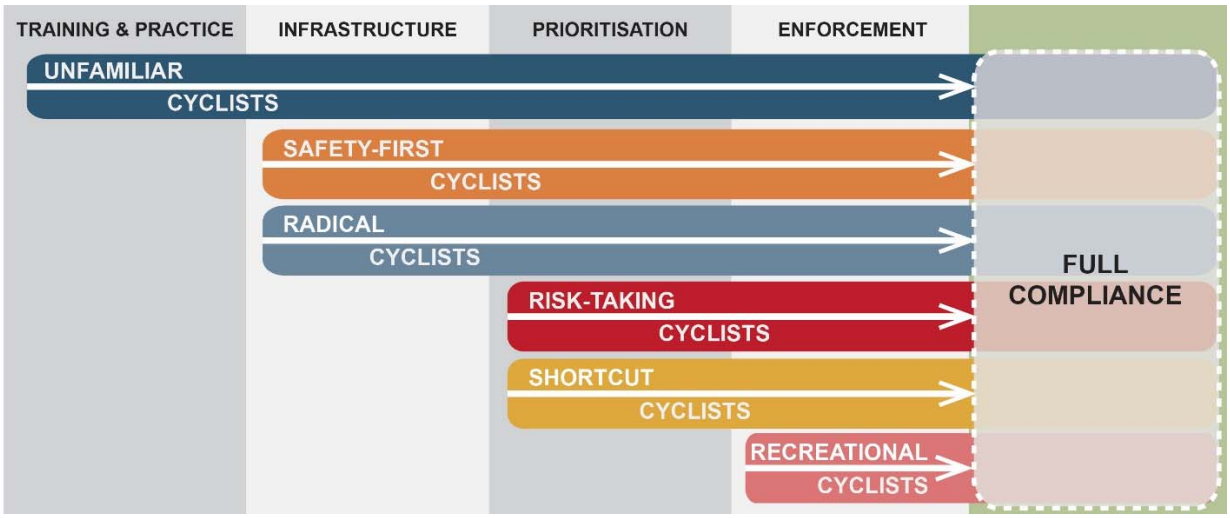

FIGURE 5: Targeting cycling policies for increasing rule compliance by cyclist type

Increasing cycling rule compliance begins with establishing confidence, namely impacting *unfamiliar cyclists*. This begins with childhood education, a policy that has been piloted in Montreal (*20*) and other parts around the world (*21; 22*). Such education may include practical training and education of cycling rules, both lacking amongst unfamiliar cyclists.

Providing clear and legible infrastructure is key in countering fearfulness, impacting *unfamiliar cyclists*, *safety-first cyclists*, and *radical cyclists*. These types share a high level of fear of being involved in a collision while cycling. Reducing this fear necessitates a comprehensive grid of dedicated cycling infrastructure, making it easy to follow the rules in an environment with minimal exposure to other modes. Particular attention should be paid to intersections, with clear communication of expected cyclist behaviour through their design.

Emphasizing the efficiency benefits of cycling affects most cycling types and can be done through cycling prioritisation in planning and policy. Providing synchronised signal corridors is one example of formalising the efficiency of cyclists and minimising the need to break a rule. *Unfamiliar cyclicsts, Safety-first cyclists, radical cyclists, risk-taking cyclists* and *shortcut cyclists* will most appreciate improvements to their trip efficiency and may no longer need to break a rule as a result.

There will always be some need for continued enforcement, as *radical cyclists*, *risk-taking cyclists*, and *shortcut cyclists* will not necessarily conform to rules as easily as *recreational cycists* and *safety-first cyclists* do. The proposed policies should be paired with regular revision to traffic laws to accommodate cyclists if they are to be of maximum effectiveness.

These policies may also be applied in other regions with similar cycling experiences as Montreal. While the cycling cultures of different regions may have different approaches to rule-breaking, the same cyclist types are expected to be present with different proportions.

CONCLUSION

This study has generated a unique cycling typology that includes rule-breaking in its categorization, allowing for a cyclist-by-cyclist understanding of how and why rules are broken. Uniquely defined by their motivations to cycle, fearfulness, confidence, and lawfulness, all six cyclist types were in agreement when breaking the rules. The similar approach to rule-breaking taken by all cyclist types reveals the impracticality of traffic laws that do not consider the unique mode of cycling in enforcing safety. Actions labeled as careless and dangerous by other road users are in fact considered the safest and most rational by cyclists themselves, across all types, yet infrastructure and policy remain disconnected from this reality.

Addressing this disconnect requires a reconsideration of traffic law and the potential creation of bicycle-specific rules for the road. Bicycle-specific rules may be a worthwhile option for regions with high levels of rule-breaking, as they can consider the rationale and safety of the mode specifically. Even with traffic law changes, however, some cyclists will continue to break the rules. Increasing rule compliance requires a targeted approach to enforcement, as no one-size-fits-all approach exists for all cyclist types. While a change in the law is enough for some cyclists to change their behaviour, others may only respond to infrastructure changes, further training and education, or cycling prioritisation.

Our findings are limited by the convenience sampling approach and self-reported nature of the survey design. Future research could adopt a more representative sample approach to verify the cyclist types generated here. Addressing the self-reported nature of respondents' behaviours and rationales could involve using direct observation, though participants may change their behaviours in this environment.

Transport planners, policy makers, and law enforcement should note the diversity of cycling types when rethinking cycling strategies and laws for their region. Any reconsideration of cycling policy, infrastructure, or laws must consider the actions and behaviours of the cyclists on the street as rational choices aimed at maximising safety and efficiency, rather than the actions of a reckless few.

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AUTHOR CONTRIBUTION

The authors confirm contribution to the paper as follows: study conception and design: Chaloux & El-Geneidy; data collection: Chaloux & El-Geneidy; analysis and interpretation of results:

Chaloux & El-Geneidy; draft manuscript preparation: Chaloux & El-Geneidy. All authors reviewed the results and approved the final version of the manuscript.

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