Who cycles the most?

A segmentation approach to determine cycling frequency in Montréal, Canada.

Prepared by

Gabriel Damant-Sirois

In partial fulfillment of the requirements for the degree of a Master's of Urban Planning

McGill School of Urban Planning
Supervisor: Ahmed El-Geneidy
May 2014

Acknowledgements

I would like to thank first my supervisor Ahmed El-Geneidy for his guidance throughout my research and my Master. I would also like to thank Richard Shearmur who acted as my second reader and who also gave me nice support on the statistical approach I developed in the second chapter of my Supervised Research Project.

I would also like to thank my colleague at TRAM who helped me develop the ideas and the conceptual framework of the first chapter and my fellow master's student at the School of Urban Planning that make the 2 years program not only rich as an academic and professional formation, but also as a human being. Special thanks to Ted Horton, our beloved class president, for editing my English that is still not perfect even after these 2 years of immersion.

Finalement, un merci spécial à Marie Valade pour son soutien, son encouragement constant, et sa forte croyance en moi et mes capacités ce qui m'a donné la confiance dont j'avais besoin pour continuer d'aller de l'avant dans cette aventure très intense qu'est la Maîtrise en urbanisme de l'Université McGill.

PREFACE

The attention given to bicycle is growing, but it remains marginal as a mode of transportation. Researches have demonstrated the individual and social benefits of cycling. However, this has not convinced the population to start commuting using a bicycle as the modal share remains very low in North America.

Bicycle is a solid alternative to car usage. Indeed, it offers the flexibility, convenience of a car, without the negative environmental impact or the effect of congesting the transportation network of a city. Also, investment aimed at increasing bicycle usage can be seen as equitable, as it is the cheapest mode of transportation after walking.

So, why is cycling up only slowly in North America. Do planners have the good strategies? This study tries to understand better the process that would make someone contemplate the idea of cycling for transportation and doing it. The ultimate goal is to develop a series of recommendations that would guide planners, policy makers and engineers in implementing interventions aimed at increasing bicycle usage. The study is divided into two chapters.

The first chapter of this Student Research Project tries to better understand the heterogeneous cyclist' population by exploring the idea of segmenting this group. Montreal cyclists are divided into four groups based on their motivations and deterrents to cycle, childhood and adulthood encouragement, and preferences about route and infrastructure. Four groups are created and used in the second chapter that explored the factors influencing the frequency to cycle for utilitarian trips. The first chapter was presented at the 93rd Transportation Research Board conference and published in *Transportation* as Damant-Sirois, G., Grimsrud, M., & El-Geneidy, A. (2014). What's your type: a multidimensional cyclist typology. *Transportation*, 1-17. doi: 10.1007/s11116-014-9523-8. The second piece is building from the typology developed there and adds a multivariate analysis of determinants of cycling usage.

ABSTRACT 1

Increasing bicycle use for utilitarian trips is a common city objective for health and environmental improvement and congestion reduction, but cyclists react heterogeneously to interventions and infrastructure. Understanding cyclist types helps in comprehending and planning for this diverse population. This study uses data from 2,004 surveyed Montreal cyclists to generate a multidimensional cyclist typology based on seven factors derived from 35 variables, mostly proven determinants of the intensity of bicycle usage. The analysis revealed four distinct cyclist types: *dedicated cyclists*, *path-using cyclists*, *fairweather utilitarians*, and *leisure cyclists*. The cycling frequencies of each group respond differently to potential interventions and vary within commuting rate ranges with apparent minima and maxima. Building a network adapted to different cyclist types and emphasizing its convenience, flexibility and speed, could be an effective strategy to increase cycling mode share and frequency among the various groups. Findings from this study can be of benefit to transportation engineers, planners and policy makers as they help in better understanding the impacts of various interventions on the different groups of cyclists.

RÉSUMÉ 1

Augmenter la quantité de déplacements utilitaires à bicyclette est un objectif commun des villes en raison des bénéfices pour la santé, l'environnement et des réductions en matière de congestion. Toutefois, les cyclistes réagissent de manière hétérogène aux interventions et infrastructure mises en place par les villes et gouvernements. Comprendre les types de cyclistes aide à comprendre et planifier pour cette population diverse. Cette recherche utilise les données provenant de 2004 cyclistes montréalais afin de générer une typologie de cyclistes multidimensionnelle basée sur sept facteurs dérivés de 35 variables qui sont pour la plupart des déterminants de l'intensité de l'utilisation du vélo. L'analyse a révélé quatre types distincts : *cyclistes dévoués*, *cyclistes utilisateurs d'infrastructures*, *utilitaristes de beaux temps*, et les *cyclistes de plaisance*. La fréquence d'utilisation du vélo de chaque groupe varie différemment à des interventions potentielles à l'intérieur d'une étendue de taux de navettage ayant un minimum et maximum apparent. Construire un réseau adapté aux différents types de cyclistes et mettre l'emphase sur la praticabilité, la flexibilité et la vitesse du vélo pourraient être une stratégie efficace pour augmenter la part modale du vélo et la fréquence d'utilisation pour chaque groupe. Les résultats de cette recherche peuvent être utilisés par les ingénieurs en transports, les urbanistes et décideurs publics puisqu'ils aident à mieux comprendre les impacts d'interventions variées sur différents groupes de cyclistes.

ABSTRACT 2

The impact of cycling on health is a valid argument to convince decision makers to invest in interventions aimed at increasing cycling. However, the decision to cycle and cycling frequency in urban setting are a complex issue and is affected by a variety of factors. Cyclists are a heterogeneous population that reacts differently to conditions and circumstances. This study analyses the different factors that influence the decision to cycle, including safety perception on different infrastructures, and shows that different factors affect different types of cyclist, highlighting the difficulty of designing effective pro-cycling policies. To incorporate the heterogeneity of the cycling population a segmentation of about 1700 Montreal cyclists is used to refine the results obtained from an ordinal logistic regression model. Results show that factors are correlated differently to each type of cyclists. Making cyclists feel safe everywhere in the city and not only on bicycle specific infrastructure, emphasizing on the low cost, convenience and improving the perception of the population towards cycling are good interventions to increase bicycle usage. Finally, even when controlling for safety perception, the behavior between male and female vary. Specific interventions to increase commuting bicycle usage for female should be put in place at work places. Although the findings from this study are specific for Montreal, several of them can be of interest to transportation planners and engineers working towards increasing the frequency of cycling in their regions.

RÉSUMÉ 2

Les impacts positifs du vélo sur la santé sont des arguments valides pour comprendre les décideurs publics d'investir en des politiques ayant comme objectif d'augmenter l'utilisation du vélo. Toutefois, la décision de faire du vélo et sa fréquence d'utilisation dans un environnement urbain sont des enjeux complexes affectés par une grande variété de facteurs. Les cyclistes sont une population hétérogène réagissant de manière variée à différentes conditions et circonstances. Cette recherche analyse les facteurs influençant la décision de faire du vélo, en incluant la perception de sécurité sur une variété de types d'infrastructure, et démontre que différents facteurs affectent différents types de cyclistes, ce qui indique la difficulté de designer des politiques pro-cyclismes efficacement. Pour incorporer l'hétérogénéité de la population cycliste, une segmentation d'environ 1700 cyclistes montréalais est utilisée pour améliorer les résultats obtenus d'un modèle de régression logistique ordinale. Les résultats montrent que les facteurs sont corrélés différemment avec chaque type de cyclistes. Faire que les cyclistes se sentent en sécurité partout en ville et pas seulement sur les infrastructures dédiées aux cyclistes, mettre l'emphase sur le faible coût du vélo, sa praticabilité et améliorer la perception de la population envers le cyclisme, sont de bonnes interventions pour augmenter la fréquence d'utilisation du vélo. Finalement, même en contrôlant pour la perception de sécurité, le comportement des hommes et

des femmes varient. Des interventions visant spécifiquement l'augmentation de l'utilisation du vélo pour le navettage par les femmes devraient être mises en place. Bien que les résultats de cette recherche soient spécifiques à Montréal, la plupart peuvent être d'intérêt pour les individus travaillant dans le but d'augmenter la fréquence d'utilisation du vélo.

Table of Contents

List of Tables

List of figures

CHAPTER 1

What's your type? A multidimensional cyclist typology

INTRODUCTION

Cycling as a means of transportation has increased in many European and North American metropolitan areas. From what was seen by many as a recreational or physical activity, cycling has also become a mode of transportation to commute in urban areas. Positive impacts of increased bicycle modal share are widely argued, including improved health in the cycling individuals (Gordon-Larsen, Nelson, & Beam, 2005; Landsberg, Plachta-Danielzik, Much, Johannsen, & Lange, 2008; Reynolds, Winters, Ries, & Gouge, 2010), as well as reduced air pollution (Woodcock et al., 2009) and congestion (Banister, Pucher, & Lee-Gosselin, 2007; Guttenplan, Davis, Steiner, & Miller, 2007; Woodcock et al., 2009) in the city.

Some research shows that building bicycle infrastructure is expected to increase cycling modal share (Dill & Carr, 2003). While it is known that safety concerns prevent many people from cycling (Handy & Xing, 2010), well-designed infrastructure and resulting increased numbers of cyclists both have positive impacts on cyclist safety (Jacobsen, 2003; Wegman, Zhand, & Dijkstrat, 2012). However, not all cyclists react similarly to the various kinds of infrastructure (Larsen & El-Geneidy, 2011) or changing conditions (Bergstrom & Magnusson, 2003; Nankervis, 1999). This fostered a literature of cyclist typologies, based on one or two factors proven to affect cycling behavior like weather conditions (Bergstrom & Magnusson, 2003), presence of infrastructure (Larsen & El-Geneidy, 2011), or cycling dedication (Geller, 2006). Furthermore, dividing cyclists into groups rather than analyzing them as a whole population has been proven to give better, more nuanced results (Kroesen & Handy, 2013).

This study proposes a multidimensional typology drawing from cycling motivations and deterrents, childhood and adulthood encouragement, and preferences about route and infrastructure. These factors represents the proven determinants of bicycle usage such as personal attitudes, social environment and built environment. The typology developed can be used by planners when selecting the types of new infrastructure and by policy makers who are trying to develop policies to encourage cycling in a region. Sections 2 and 3 review of this paper concentrates on the cyclist typology literature and discusses the study context and the data used in our analysis, respectively. Section 4 details our methodology. While section 5 includes the resulting

cyclist typology. Section 6 concentrates on the policy implications of the study and presents a new framework for understanding the impact of different interventions on the frequency of cycling among the four groups. The article ends with section 7 which includes the conclusions and recommendations.

CYCLISTS TYPOLOGY AND CYCLING DETERMINANTS LITERATURE

The goal of this study is to propose a new cyclists' typology built on proven cycling determinants that can be used to guide practitioners in the decision making process. The new typology will provide planners with a better understanding of the impacts of different intervention policies in order to reach cities' objectives of increasing frequency of using a bicycle among existing users. This section presents previous attempts of categorizing cyclists, their approach or methodology, and then, the literature on proven cycling determinants to support the variables chosen to differentiate the sampled population.

Cyclists' typology

Previous cyclist typologies or types discriminate based on various factors. One of the first authors to discuss cyclist types is Jensen (1999a). He distinguishes three categories each of cyclists and car drivers. Jensen combined cyclists and public transit users, but the types apply logically for bicycle users alone. *The cyclists/public transport users of heart* cycle for the experience and decide to not own a car. *The cyclists/public transport users of convenience* cycle because it is the most convenient mode. *The cyclists/public transport users of necessity* cycle because they cannot afford a car. These categories are useful in order to structure mode selection as a function of choice, whether from principle or utility, or of mode captivity. However, preferences, utility, and constraints likely all influence most cyclists to some degree.

One popular cyclist typology approach uses seasonal criteria. Bergstrom and Magnusson (2003) divided cyclists by frequency and winter usage. Four types were created: winter cyclists, summer-only cyclists, infrequent cyclists and never cyclists. They found that all-year cyclists were more motivated by exercise, summer-only cyclists

were negatively impacted by road and weather conditions, and the other two were mainly influenced by travel time.

Gatersleben and Haddad (2010) analyzed the perception of cyclist types among both non-cyclists and cyclists. With factor-cluster analysis, they found that individuals' perceptions of cyclists could be categorized into four stereotypes of cyclists. The *responsible bicyclist* follows traffic rules and is courteous; the *lifestyle bicyclist* likes cycling and spends a lot of time and money on it; the *commuter* is a young, well-educated professional who cycles to work regardless of weather conditions; and the *hippy-go-lucky* is considerate and usually female, cycles for all trips purpose, and does not wear bicycle-specific clothes. While this is not a cyclists typology per se but rather a typology of perceived cyclists types, the methodology used in this paper has given good results for this kind of exercise. Unsurprisingly, Gatersleben and Haddad found differences in the identified stereotypes of cyclists between non-cyclist and cyclist respondents. It is well known that attitudes toward cycling impact mode choice (Handy, Cao, & Mokhtarian, 2005), and such attitudes are likely influenced by perceptions of what cyclists are and how they behave (Daley & Rissel, 2011), so this stereotype diversity is an interesting finding, but does not address actual cyclist diversity.

A cyclist typology by Larsen and El-Geneidy (2011) might be more useful policy-wise, with findings that frequent cyclists travel farther on average than other groups and that cycling frequency is negatively associated with preference for facilities segregated from street. Their data, however, lacked detail on variables such as peers and institutional encouragement, proven factors of cycling behavior (Cleary & McClintock, 2000), frequency of utilitarian trips (commute, grocery shopping, other shopping, and restaurant, café and bar) other than commutes, cycling deterrents, and residential location environment.

A now famous cyclists typology has been developed for the city of Portland (Geller, 2006) and has been analyzed recently in another study (Dill & McNeil, 2013). The typology divides the entire commuting population into four types: *No way no how*, *Interested but concerned*, *Enthused and confident*, and *Strong and fearless*. The typology divided commuters based primarily on their level of comfort cycling on different infrastructure and street types. Dill and McNeil (2013) tested the typology with the

Portland population. Their research shows that it is possible to base bicycle infrastructure recommendations on this kind of exercise, but also shows several limitations to Geller's typology. First, no other type of potential interventions can be recommended using this typology besides bicycle paths, since the typology is based on the comfort of using different infrastructure. Second, the analysis from the survey used in their study gave some strange results when trying to apply the typology. For example, 34% of the *Strong and Fearless* end up being classified as non-cyclists, compared to only 23% and 28% for *Enthused and confident* and *Interested but concerned,* respectively. Also, 10% of the *Interested but concerned* group cycle 20-31 days in winter months compared to 0% of the *Strong and fearless* group. Planners have used this typology to justify interventions by saying that the interested and concerned should be convinced to cycle more, but Dill and McNeil's study (2013) indicates that this group do cycle more than the *Strong and fearless*. This issue might have arisen because the boxes into which cyclists are supposed to fit have been developed subjectively rather than on an empirical basis: "These numbers, when originally assigned, were not based upon any survey or polling data, or on any study. Rather, they were developed based on the professional experience of one bicycle planner"(Geller, 2006). Such a typology could be refined by increasing the number of factors defining the cyclists and not limiting the study to a predefined framework to allow recommendations on different types of interventions and by building the boxes into which cyclists would fall based on empirical methods rather than a subjective one.

Kroesen and Handy (2013) used two different approaches to test the relation between non-work related trips and commutes. The first approach uses a latent transition model, grouping cyclists into four different clusters: *non-cyclists, non-work cyclists, all-around cyclists* and *commuter cyclists*. The other approach was to test the same relation, but keeping cyclists in one group rather than clustering them into four distinct groups. The results from the latent transition model and the conditional change model, which does not differentiate cyclists into clusters, were similar. However, the parameter estimates of each variable varied significantly between the two models and between each group, indicating the importance of a clustering of cyclists approach.

Proven determinants of bicycle usage

The aim of this paper is to develop a new cyclist typology that incorporates proven cycling determinants, such as cyclists' stated preferences, backgrounds, motivations and deterrents, rather than only behavior or external perceptions. Such determinants and corresponding literature are introduced below.

Weather conditions and effort have been proven to influence bicycle usage significantly (Cleary & McClintock, 2000; Richardson, 2006). Stinston and Bhat (2004) showed that cyclists who considered cycling as fast and flexible with predictable travel time were more likely to use that mode of transportation, especially for commuting to work. Street design influences travel behavior, especially non-motorized vehicle usage, as car traffic volume and speed, and the proximity to parked cars impact safety perception (Cervero & Kockelman, 1997). Bicycle facilities and their characteristics such as continuity, physical separation from traffic and signage, have also been shown to influence bicycle usage (Bhat, Sen, & Eluru, 2009; Handy et al., 2005; Kitamura, Mokhtarian, & Laidet, 1997a).

The influence of peers, either at school or at work, as well as employers or institutional interventions aimed at increasing cycling commutes has been shown to have a positive impact on bicycle commuting frequencies (Cleary & McClintock, 2000). In a study that controlled for self-selection (Handy et al., 2005), it was shown that the intensity of bicycle usage was correlated with self-identity as a cyclist and enjoyment while cycling. While the impact of peer pressure and cycling perception during childhood (Underwood & Handy, 2012) and parental encouragement and bicycle usage for adolescents were recently studied (Emond & Handy, 2012), in our review we did not find any article generating a link between youth parental encouragement and adult cycling. However studies showed that parental encouragement and parental perception of cycling affect children's travel behavior (Johansson, 2006; Panter, Jones, van Sluijs, & Griffin, 2010; Tal & Handy, 2008) and that pre-adult travel behavior affects general behavior such as healthy life habits (Landsberg et al., 2008). In this current study, it is hypothesized that if experience during childhood influences adulthood habits, such as smoking and time spent watching television, it could also affect travel behavior once people become adults.

The aforementioned factors were explored in a survey of Montreal's cyclists aiming to develop an improved and comprehensive typology. The goal of developing such typology is to propose better policy interventions that can help increase cycling mode share and frequency. Improved understanding of the impacts of some interventions on the different types of cyclists can help planners more efficiently and effectively allocate resources. With better understanding of cycling motivations, policy makers can educate populations and inspire bicycle use as a transportation mode. As presented earlier, typologies can be useful to analyze cyclists, but have mostly been developed based on behavior or on perception of what a cyclist is and are one- or two-dimensional. This study integrates multiple proven cycling determinants. Furthermore, instead of behavior or external perceptions, this typology is based on cyclists' stated preferences, backgrounds, motivations and deterrents. The behavioral aspects such as frequency of cycling for utilitarian purposes are then compared between the groups to see if there is significant difference that would justify the approach taken.

STUDY CONTEXT AND DATA

Study Context

Montreal is the second largest metropolitan region in Canada, with about 3.9 million inhabitants, the city alone counting about 1.65 million. According to the Canadian census of 2006, Montreal was the Canadian city with the highest combined share of bicycle, walking and public transit commuting (Statistics Canada, 2006). While it is hard to define the bicycle-friendliness of a city, Montreal is considered one of the most convenient North American cities to cycle in with an average Bike Score around 70, ranked 1st among North American cities and 11th in the world in the 2013 Copenhagenize index of bicycle-friendly cities (Copenhagenize Design Co., 2013). Montreal also ranked 3rd in Canada for bicycle commute mode share in 2006 (Statistics Canada, 2006). On the Island of Montreal (the city plus some small municipalities in the region) in 2010, 52% of the population aged between 18 and 74 years old use a bicycle (Vélo Québec, 2010) and 36% cycled at least once a week.

Bicycle mode share for the Island of Montreal increased by 33% between 2003 and 2010 and in 2010, 3.2% of the population use a bicycle as their main mode of

transportation for commuting (Statistics Canada, 2011). Central boroughs have a higher level of usage than the periphery. For example, 8.6% of trips in *Le Plateau-Mont-Royal* use a bicycle compared to 0.5% in *Anjou* (see Figure 1) (Vélo Québec, 2010). The bicycle-sharing system BIXI was introduced in 2009 and has experienced a rapid usage increase; in 2009 there were a little over a million single trips made, rising to over four million trips in 2011.

Montreal's geography brings several challenges for cycling. Many people working in the core must cross automobile-dominated bridges connecting the island to the wider region, which can be a barrier. Second, while the city is relatively flat, the downtown area is at the foot of Mount Royal, and some slopes can be quite steep when commuting, especially for people living on the northern side of the mountain. Finally, and more importantly, the winter in Montreal can be relatively harsh with substantial snowfall and cold weather. Cycling drops dramatically during the cold-weather season, although it has seen an increase recently in part due to the implementation in 2008 of the *Réseau blanc* (white network), a network of bicycle paths receiving snow removal and salting (Figure 1).

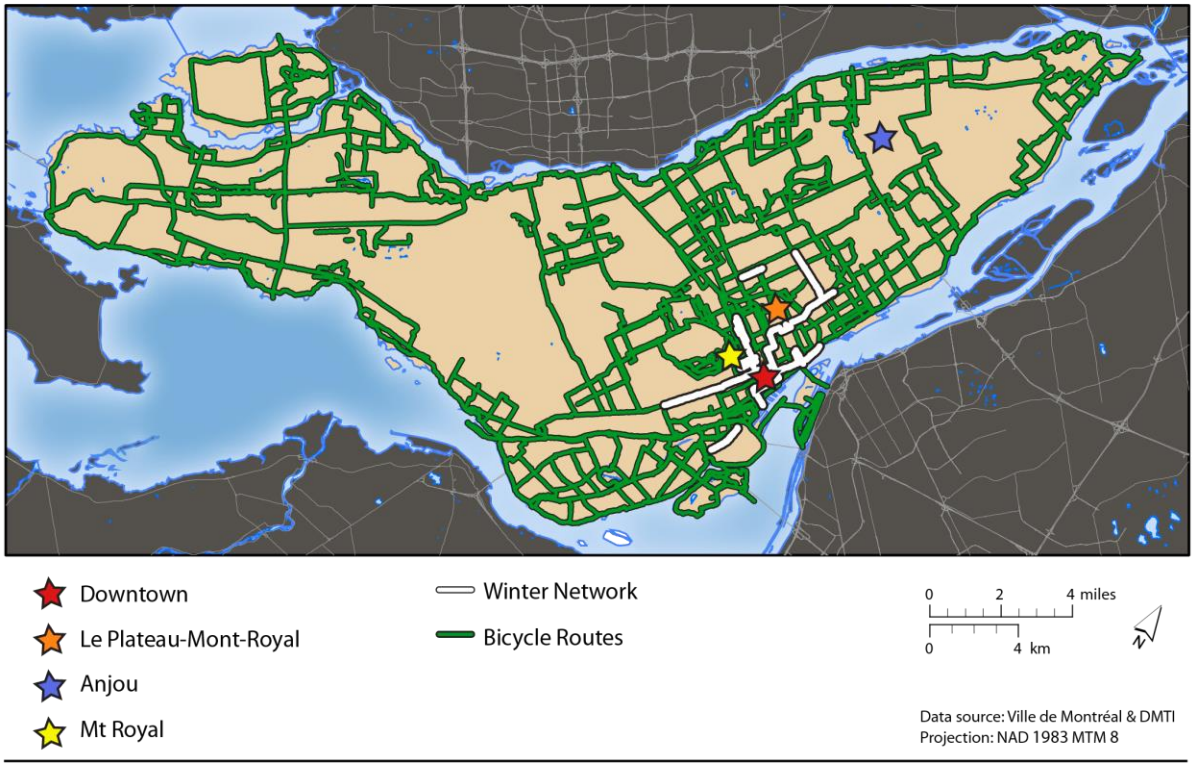

Figure 1 Montreal cycling infrastructure

Data

This study uses data from a bilingual online survey of Montreal cyclists prepared by the authors. The survey was online from the middle of May to the end of June 2013. Following recommendations of Dillman et al. (2009), extensive efforts to publicize the survey and minimize sample bias were employed, including: French and English newspaper articles and advertisements; flyer distribution to individuals, bicycle shops, businesses along major bicycle paths, and around a major bicycle event; a major radio show interview; and survey links emailed throughout the Transportation Research at McGill research group mailing list and to different newsletter groups, as well as in social media.

The survey was aimed only at cyclists, but still allowed non-cyclists to answer some questions about why they do not cycle. The first question in the survey asked whether the person has cycled at least once over the past year. Respondents who answered “no” were excluded from our analysis. The total number of respondents was 2,644, but the final sample used in this research was 2,004 due to some incomplete

responses and errors. This resembles the number of home-based cycling trips recorded in the *Enquête Origine-Destination* (O-D) surveying 5% of the Montreal's region population (Agence Métropolitaine de Transport, 2008), although there are some compositional differences discussed in Section 5.

The survey was divided into seven sections: general information, cycling behavior, cycling history, motivations and habits, infrastructure, route and investment, BIXI (Montreal bicycle-sharing system), and personal profile. Respondents were asked to state their behavior, motivations or deterrents, preferences and personal characteristics in 92 questions with a final open-ended question asking respondents for any further comments. There was no objective measure in the survey of respondents' behavior or observed impact of changing conditions. Survey's participants were asked about general infrastructure preferences like the proximity to traffic and specific infrastructure question like rating types of bike lane and bike path. These two approaches were used to validate the developed clusters' characteristics. The 35 variables used to build the typology along with the survey questions are presented in Table 1 in the following section.

PRELIMINARY ANALYSIS

This study employs a principal component factor analysis followed by a cluster analysis to classify cyclists and examine differences between cyclist types. This method captures overarching concepts (factors) from groups of multiple, but similar variables, and has been used previously to create a typology of cyclists (Gatersleben & Haddad, 2010). The same approach was also used in the public transport field to segment the preferences of transit users and non-users to generate transit market segmentation (Krizek & El-Geneidy, 2007). The factors or components are obtained by grouping variables of interest based on level of correlation. Once the factors are obtained, clusters of respondents are created by maximizing the mean difference between groups and minimizing it within groups. χ^2 tests are then used to compare any significant differences between the groups.

The literature presented earlier about proven cycling determinants is used to choose the variables used in the factor analysis. A total of 35 variables (Table 1) are used to generate seven components. The first component, *weather and effort*, groups variables related to different weather conditions and factors that can impact effort, both of which have been shown to significantly impact bicycle usage (Cleary & McClintock, 2000; Richardson, 2006). The second component, *time efficiency*, is an amalgamation of variables related to speed, flexibility and predictability of travel time (Stinson & Bhat, 2004). The third factor, *dislike cycling near cars*, includes perceived safety impacts based on car volume and speeds as well as proximity to parked cars (Bhat et al., 2009; Cervero & Kockelman, 1997; Handy et al., 2005; Kitamura et al., 1997a). The fourth factor, *bicycle route infrastructure*, captures perceived importance of path continuity, physical separation, and signage (Dill & Carr, 2003). The fifth factor, *peer and institution encouragement*, groups the motivational importance of work or school encouragement and peer cycling behavior (Cleary & McClintock, 2000). The sixth, *cycling identity and enjoyment*, groups cycling impacts of self-identity as a cyclist and perception that cycling is fun (Handy et al., 2005). The last factor, *parental encouragement*, groups separate responses about childhood encouragement from parents to cycle as means of transportation and as a sport or recreational activity (Panter et al., 2010). Table 1 presents the 35 variables and corresponding survey questions used to build the 7 components and their weight in their respective components.

Table 1 Factors, variables, and loadings

Factors	Variables		Loading
Weather and effort	I don't cycle when:	It's too cold	0.791
		There is snow because of the additional effort	0.762
		There is ice or snow because of the risk of slipping	0.712
		It's raining	0.702
		The route I have to take is too steep	0.606
		I have to carry bags or heavy loads	0.535
		It's too hot or humid	0.531
Time efficiency	How important are those factors in your decision to cycle now:	Flexibility of my departure time?	0.879
		Flexibility for multiple trips?	0.872
		It's the fastest way to get from A to B?	0.819
		Predictability of travel time?	0.812
Dislike cycling near cars	How important are the following factors in making a good bicycle route:	Low number of cars driving?	0.871
		Low speed of cars?	0.798
		Low number of parked cars?	0.557
Bicycle route infrastructure	How important are the following factors in making a good bicycle route:	Continuous bicycle route?	0.787
		Presence of a bicycle path with a physical barrier?	0.711
		Bicycle-specific signage?	0.689
Peer and institution encouragement	How important are those factors in your decision to cycle now:	My employer / school encourages cycling?	0.879
		My classmates / coworkers cycle?	0.870
Cycling identity and enjoyment	How important are those factors in your decision to cycle now:	It’s part of my self-identity/culture?	0.803
		Cycling is fun?	0.753
Parental encouragement	To what extent your parent(s) or guardian(s) encouraged you to cycle:	As a way to reach destinations?	0.823
		As a sport or recreational activity?	0.799
	Did you start cycling as a child?	Yes or no	0.435

RESULTS

Cyclist Typology

Previous typologies of cyclists, as presented earlier, were usually one- or two-dimensional: winter cycling or not, frequency and bicycle paths usage, or motivations to cycle. Gatersleben and Haddad (2010) examined stereotypes of what a cyclist is. The typology built here is multidimensional (external conditions, motivations, infrastructure, personal identity toward cycling and past cycling history) and focuses on cyclists' characterizations of themselves rather than largely external attributions like in the Gatersleben and Haddad (2010) article. It analyzes the data initially at the disaggregate level, by making cyclists define themselves, rather than imposing an image of what cyclists are.

Using the factors from the abovementioned principle component analysis, K-means clustering was performed. The clustering was tried with three to eight groups, but the best results were obtained with four clusters, as is common in the literature (Jacques, Manaugh, & El-Geneidy, 2012). The four final clusters are: *dedicated cyclists*, *path-using cyclists*, *fairweather utilitarians* and *leisure cyclists* (**Figure 2**).

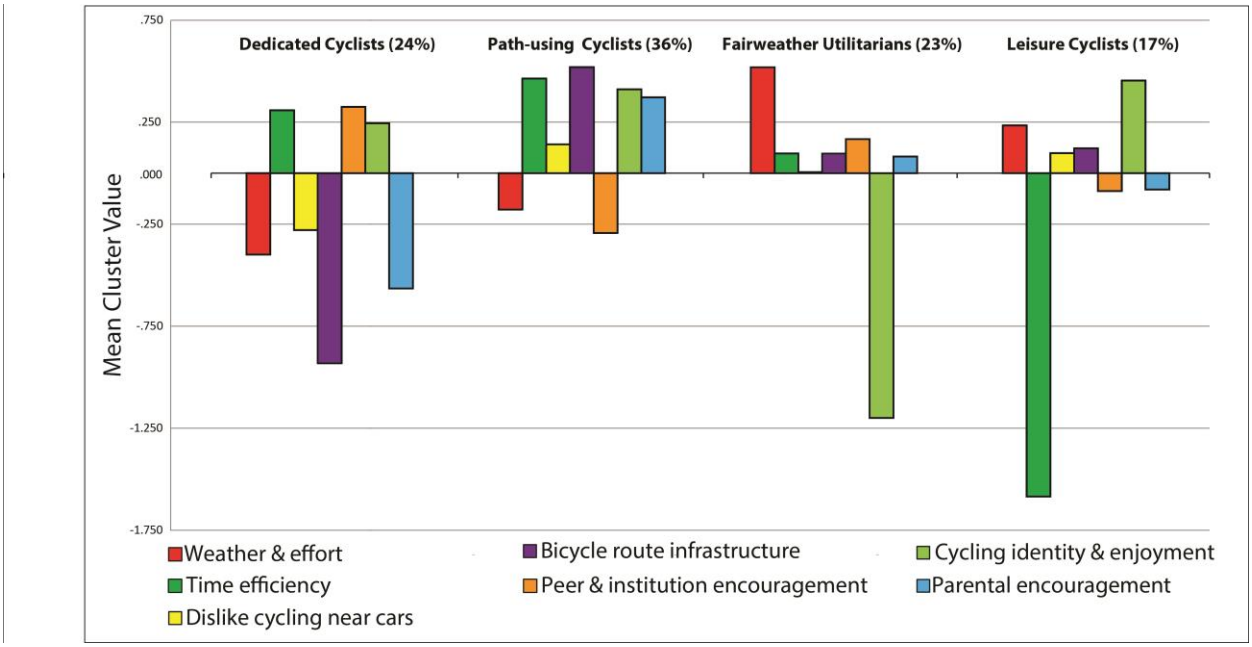

Figure 2 Cyclist types

Dedicated cyclists' (24% of the sample) decision to use a bicycle is not strongly impacted by the weather conditions. The speed, predictability, and flexibility of bicycle trips motivate cyclists in this group to cycle. Peer and employer/school encouragement are also key factors influencing this group. They also see themselves as cyclists and enjoy using a bicycle. They are less keen on bicycle-specific infrastructure than are other groups and do not mind, and sometimes even prefer, riding in car traffic, as shown by a participant's comment answering the open-ended question at the end of the survey: "I find bike paths more dangerous than busy city streets with cars". They are also defined by not having received parental encouragement to cycle as children.

Path-using cyclists (36% of the sample) are only slightly more affected by weather than are *dedicated cyclists*. Their main motivations to cycle are convenience and fun, as well as their identity as a cyclist. They prefer to use a continuous bicycle route that is separated from car traffic by a physical barrier with specific signalization, which is explained by the fact that they dislike cycling near moving and parked cars as shown by this comment in French, followed by the authors' translation: *"Les cyclistes souhaitent-ils circuler dans des rues également utilisées par des véhicules motorisés? Réponse : Non, ils souhaitent circuler dans des rues dédiées aux cyclistes […] »* (Do cyclists wish to circulate in streets used by motorized vehicles? The answer is no, they want to circulate in streets dedicated to cyclists). They were actively encouraged by their parents to use bicycles both to reach destinations and for sport or recreational activity.

Fairweather utilitarians (23% of the sample) are contextual users. They do not cycle in bad weather, and will choose another mode if it is more convenient. They prefer to cycle on bicycle paths and can be motivated by peers or institutional encouragement. This group is uniquely populated, and largely defined, by members who might not consider themselves cyclists, as shown by a comment from a survey respondent: "*Le plus grand obstacle au cyclisme sont les cyclistes eux-même"* (The biggest barrier to cycling is the cyclists themselves).

Leisure cyclists (17% of the sample) do not cycle because it is a fast, convenient mode, but because they enjoy it and identify as cyclists. Their decision to use a bicycle is influenced by weather conditions, and they prefer not to ride close to cars and prefer to use bicycle infrastructure segregated from traffic: "*Pour les enfants et familles, avoir un réseau cyclable développé est très important (pistes cyclable séparée [sic]) car sentiment de sécurité*". (For children and families, a well-developed cycling network is very important [segregated bicycle paths], in order to feel safe). This type groups cyclists that mostly cycle as a hobby or as a family activity.

Further Differentiation

Demographic characteristics of each group help refine definitions, with significant differences between some of them. This sample differs notably from the cyclist population who participated in the 2008 Montreal origin-destination survey (Table 2). The sample has more females (40% vs. 35%), is younger (average age of 37 compared to 42), has a slightly smaller household size, has more full-time employees and students, and is wealthier. However, the O-D survey was done in 2008, and cycling has increased substantially in recent years in Montreal (Vélo Québec, 2010), perhaps in part due to the introduction of Bixi and the importance given to cycling in the 2008 Montreal Transportation Plan (Ville de Montréal, 2008). Furthermore, a 2012 Montreal cycling survey focused on bicycle theft showed demographic characteristics similar to those here (van Lierop, Grimsrud, & El-Geneidy, 2013).

Table 2 Demographic characteristics

	All survey respondents	Path-using Cyclists	Dedicated Cyclists	Fairweather Utilitarians	Leisure Cyclists	2008 Origin-Destination Survey	
						Cyclists	All
Gender							
Female	40%	42%	42%	41%	31%	35%	53%
Male	59%	57%	56%	57%	68%	65%	47%
Age							
Average	37.32	36.15	36.33	35.84	43.46	42	48
18-30	34%	38%	35%	38%	16%	24%	16%
31-40	34%	33%	38%	35%	28%	22%	16%
41-50	17%	16%	14%	15%	26%	25%	21%
51-60	11%	9%	9%	9%	20%	24%	28%
61+	4%	3%	4%	3%	9%	6%	19%
Household size							
1	20%	24%	20%	22%	17%	22%	15%
2	41%	40%	42%	41%	46%	34%	38%
3	18%	15%	17%	18%	18%	20%	19%
4	15%	14%	14%	14%	14%	17%	19%
5+	6%	6%	4%	5%	7%	7%	9%
Occupation							
Employed Full-time	64%	60%	63%	64%	73%	59%	52%
Employed Part-time	8%	9%	15%	7%	6%	9%	6%
Student	17%	20%	18%	21%	8%	13%	8%
Retired	3%	2%	2%	2%	1%	11%	25%
Unemployed	1%	2%	2%	1%	1%	8%	10%
Household Income							
<$20,000	13%	18%	13%	11%	6%	15%	12%
$20,000 - $40,000	16%	17%	19%	15%	8%	24%	22%
$40,000 - $60,000	16%	17%	17%	16%	10%	22%	21%
$60,000 - $80,000	11%	10%	11%	13%	13%	16%	16%
$80,000 - $100,000	11%	11%	8%	11%	13%	10%	11%
>$100,000	24%	18%	22%	23%	40%	13%	17%

Leisure cyclists stand apart from the rest, with a male proportion nine percentage points higher than the sample. They are six years older on average and have much

higher incomes, possibly explained by the proportion of students being less than half that of the other groups. *Leisure cyclists* also own one or more cars 44% more frequently than average and car ownership has been proven to be an important factor in modal choice (Lee, Nam, & Lee, 2012). The general demographic characteristic similarity between the other three groups is supporting the exclusion of these variables in the principal component analysis.

Motivations to cycle, transportation behavior and preferences not included in the factor cluster analysis do differ significantly between groups, and these contrasts are important because convincing people to cycle or cycle more requires understanding their motivations, and locating and building adequate infrastructure requires understanding behavior and preferences. **Figure 3** (a) illustrates the proportion of cyclists of each type who indicated a factor is important or very important to their decision to cycle. Environmental reasons motivate almost universally, especially among *path-using cyclists* but less so for *leisure cyclists*. Health also motivates all cyclist groups, especially *leisure cyclists* and *path-using cyclists*. The importance that is placed on the low cost of cycling varies substantially between groups, and was found to be far more important for *path-using cyclists* (79%) than *leisure cyclists* (46%), corresponding inversely and unsurprisingly to the groups' household incomes. Directness to destination, as expected, is more important for the groups that were also positively correlated to the time efficiency factor.

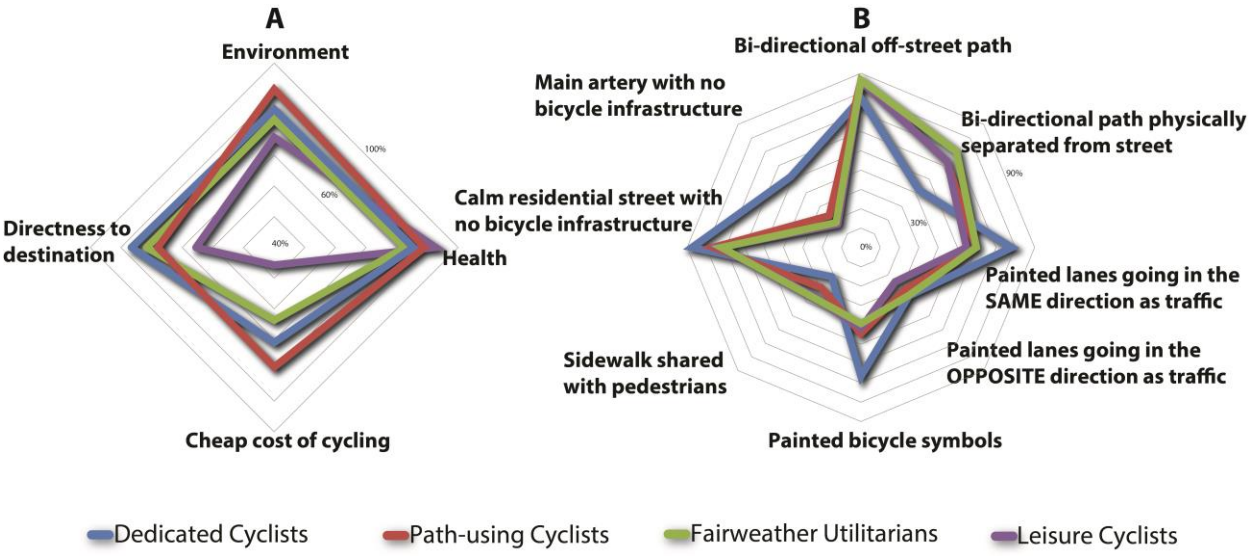

Figure 3 Cycling motivations and infrastructure preferences

Preferences for different bicycle facilities (**Figure 3** b) differ significantly between the groups ($p<0.01$), except for a general dislike for painted lanes going in the opposite direction of traffic. The differences come mostly from the *dedicated cyclists* who, compared to the other groups, enjoy unsegregated route types like residential streets, painted lanes, markings on the pavement, or even riding mixed with traffic on main arteries. This is not surprising as the *dedicated cyclists* were defined largely by their relative indifference to nearby cars and physical separation from traffic.

Substantial inter-group difference is seen in the distances between home and job/school location: 71% of the *leisure cyclists* live farther from work/school than the sample median distance. Some evidence suggests behaviors or preferences influence the choice of home location, rather than the reverse. Answering why they moved to their current home location, the share of *Leisure cyclists* for whom having a “spacious home” was very important was about 1.5 times more than that of the sample average, living in a “calm neighborhood” was 1.42 times more, and “proximity to shopping and services” was 1.29 times lower. Interestingly, “proximity to bicycle infrastructure” was about 1.40 times less important for *dedicated cyclists* and *fairweather utilitarians* than for the sample average, perhaps due to traffic indifference in the first case and to perceived infrequent cycling in the second.

The stated frequency of cycling for utilitarian purposes of each group presents an interesting pattern (**Figure 4**). *Leisure cyclists* peak at “rarely”, *fairweather utilitarians* at “sometimes”, and *path-using cyclists* and *dedicated cyclists* at “often”, the latter two groups with over 20% of members “always” cycling. The least cycled trip purpose for all groups is grocery shopping, followed by other shopping. Many respondents, especially outside of *dedicated cyclists*, seem as though they might have answered “always” if not for winter conditions. Indeed, 82% of respondents agreed or strongly agreed that they do not cycle when there is ice on the pavement (even 69% for *dedicated cyclists*), which is by far the most commonly reported factor preventing all cyclists from cycling in Montreal, (48% snow, 46% cold, 36% rain, and 9% heat and humidity).

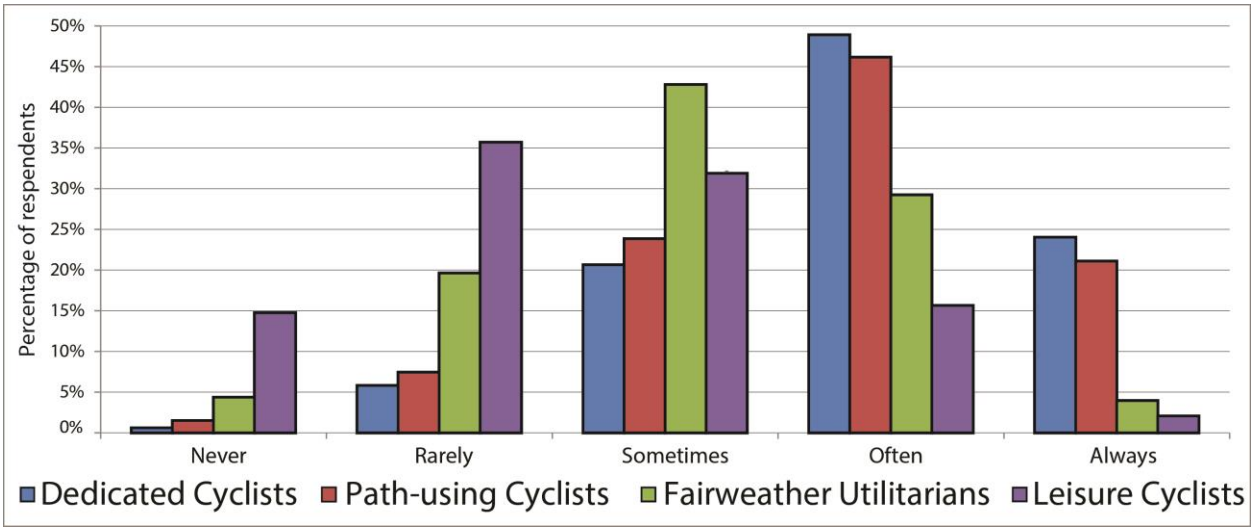

Figure 4 Frequency of cycling for utilitarian purpose

Impact of motivators on frequency of cycling for utilitarian purposes

Analyzing other variables allows examination of the potential effectiveness of bicycle promotion based on different motivators. As shown by looking at the literature on active transportation, one of the most promoted positive impacts of cycling is health through exercise. The data collected shows health benefits motivate all cyclist groups, and many comments note having picked up cycling for health reasons. However, a χ^2 test on the relation between frequency of utilitarian trips and health motivation shows no significance, except a negative one with frequency of trips to restaurant, café and bar ($p<0.01$). Also, the group that is motivated the most by health, the *leisure cyclists*, cycles the least often for utilitarian purposes and commuting. Therefore, promoting health as a reason to cycle can inspire people to try cycling, but does not seem likely to increase frequency among current cyclists.

Speed motivation strongly correlates with use frequency, 68% of people who always cycle to work or school indicating that speed is a very important cycling motivator. Health is a very important reason to cycle for 44% of those who always cycle to work or school, but also for 43% of those who never do so. Speed was unimportant or very unimportant for only 1.5% of people who always commute by bicycle. Of those for whom health was a very unimportant motivator, 77% often or always cycle to work or school. Measures of convenience such as flexibility for multiple trips, predictability of

travel time and flexibility of departure time relate to cycling frequency largely the same as does speed. Therefore, if a city or government intends to increase bicycle modal share, promoting the convenience of cycling might be more effective, especially considering that travel time is a major mode choice determinant (van Exel & Rietveld, 2010). This is particularly true in cities where populations are already aware of cycling and many individuals do it occasionally, such as Montreal where 52% of adults in the city cycled at least once in 2010 (Vélo Québec, 2010). Promoting cycling as an exercise activity could even possibly deter some people from commuting as it may encourage a perception that high levels of effort are required. The data shows that to increase the frequency of cycle commutes, emphasizing the convenience and speed of cycling should be more effective.

In this study, the parental encouragement of childhood cycling did not show an impact on adulthood utilitarian cycling frequency ($p=0.140$). It contrasts, but not contradicts findings from Emond and Handy (2012) that found a positive correlation between parental encouragement and usage of bicycle to commute to school for teens. However, it helps distinguish the two groups that cycle the most, *path-using cyclists* and *dedicated cyclists*. The data and analysis in this study do not allow definitive conclusions on impacts of childhood parental encouragement to be drawn, but note a possible direction for future research. Interestingly, the most parentally-encouraged group uses segregated bicycle infrastructure the most, while the least parentally-encouraged uses it the least. It might come from parents who encouraged their children to cycle also asking them to use certain route types or cycling with them on paths and creating habits. There is a significant positive relationship ($p<0.05$) between frequency of parents' utilitarian trips and encouraging their children to cycle. Also, those in the two groups that cycle the most for utilitarian purposes encourage their children significantly ($p<0.01$) more than other group members, especially to reach destinations (not as a sport or recreational activity). This might suggest that a virtuous circle could start, or already exists, with increased adult cycling.

DISCUSSION

Different strategies are needed to facilitate increases in cycling among different groups of people (Panter et al., 2010). Cyclists are heterogeneous, but with some similar characteristics that allow clustering. This study generated a typology based on stated cycling motivations and deterrents, childhood and adulthood encouragement, and general infrastructure preferences. It shows meaningful differences between groups in demographic characteristics, behavior, and specific infrastructure preferences. Analyzing answers about motivators, deterrents, and infrastructure preferences given by respondents of each cyclist type allows understanding which type of cyclists will likely be affected by certain interventions. Also, looking at commuting frequency per type of cyclist allows determination of approximate bicycle commute frequency minima and maxima for each group. Figure 5 shows in a simplified way each group's relevant intervention areas and range of frequently observed commuting frequencies.

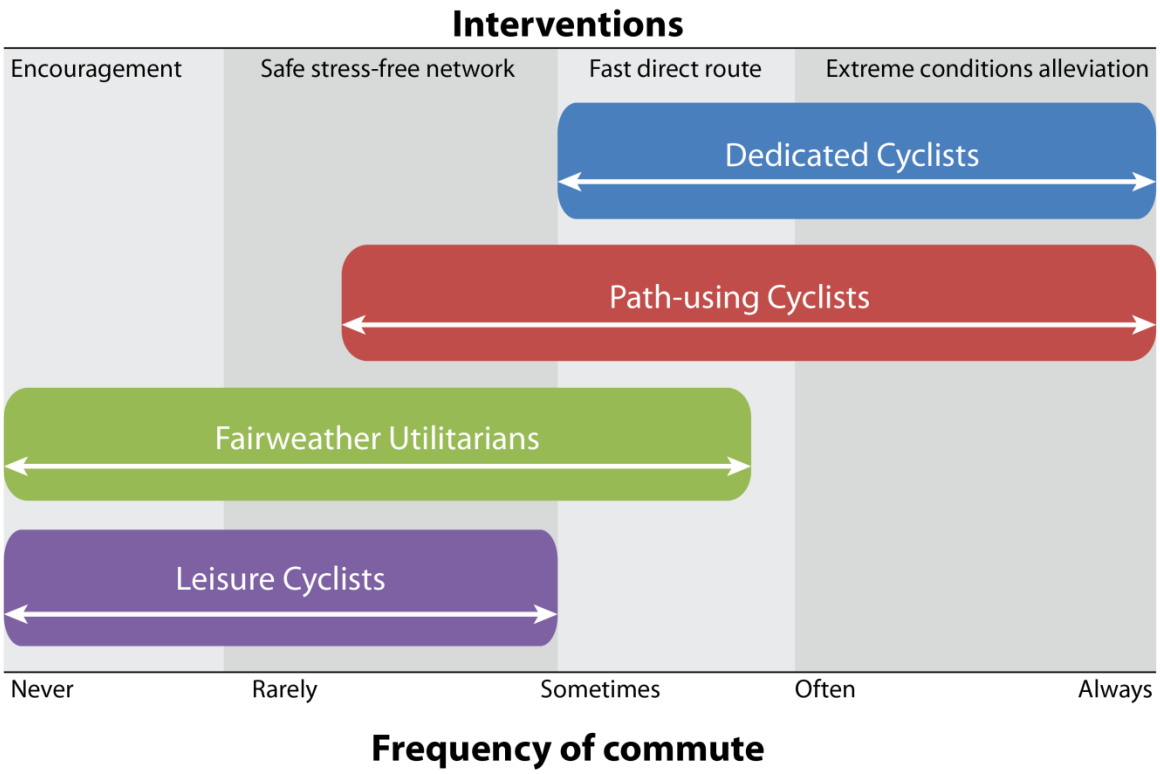

Figure 5 Cyclist types, commute frequencies, and relevant intervention areas

In the survey, encouragement could come from initiatives by school or work to incite students or workers to use their bicycle to commute, or from an educational campaign aimed at cyclists or other road users. For example, encouragement can come from an employer installing shower facilities or providing employees with free bicycle-sharing memberships, and can also be the result of public awareness campaigns on cycling safety, convenience and benefits. Encouragement is an important step to convince people who are contemplating bicycle commuting to make them aware that getting on a bicycle is a viable option (Nkurunziza, Zuidgeest, & Van Maarseveen, 2012). It could also push a non-cyclist or non-commuting cyclist to try using a bicycle to commute to work or school. *Leisure cyclists* and *fairweather utilitarians* are the two groups that could be the most influenced by encouragement. The safe stress-free network might feature segregated facilities along important commute routes accompanied by safe and potentially secure bicycle parking. This would help a person that already cycles sporadically to feel more comfortable and incite them to use a bicycle more frequently than they currently do. Recreational cyclists with expensive bicycles might also cycle to work if not worried about bicycle theft. Bicycle usage frequencies of *leisure cyclists, fairweather utilitarians* and *path-using cyclists* are likely to be positively impacted by enhancing the safe stress-free network. This is especially true for the *path-using cyclists*, who value segregated infrastructure the most.

Numerous streets with bicycle lanes, bicycle markings and signage aimed at increasing the awareness of the presence of cyclists can contribute to fast direct routes complementary to segregated routes. These infrastructure changes require smaller investment than segregated paths, often require only a small amount of space, and are easy to build on most streets. Fast direct routes reduce travel time and increase convenience for cyclists who are already comfortable cycling in urban environments, thereby improving the attractiveness of cycling in comparison to other modes. *Fairweather utilitarians, path-using cyclists* and *dedicated cyclists* could increase their bicycle commuting if such measures would be put in place, as time efficiency motivates them the most. Alleviating extreme conditions that at times substantially interfere with cycling, like plowing away Montreal winter snow, can keep some cyclists choosing to ride through conditions that would otherwise dissuade them. . Only *path-using cyclists*

and *dedicated cyclists* could be significantly affected by such measures. The other two types already refrain from cycling in even less severe weather conditions.

The questions in the survey were purposefully aimed at being generalizable to other regions and not only to the particular bicycle culture of Montreal. While Montreal has a strong bicycle culture compared most North American cities, the variables used in the clustering of cyclists have been found to be determinants of bicycle usage around the world. The percentage of each group among the cyclist population will differ in other regions, but similar groups of cyclists are expected to be present.

CONCLUSION

The main goal of this research was to build a useful multidimensional cyclist typology. The four resulting groups are strongly distinct from each other and are likely to react differently to efforts to increase cycling in a city. This last point is important because with limited funds and polarized political positions on public investment in cycling infrastructure, every dollar spent should produce results. The four clusters were defined by the motivations and deterrents to cycle, childhood and adulthood encouragement, and route and infrastructure preferences. Each factor has been shown to affect bicycle usage intensity in previous research except childhood encouragement, which was apparently untested before now. While not proven to relate to utilitarian trip frequency, it seems to relate to cycling behavior or preferences, and further studies might explore this theme.

Finally, different strategies apply to different types of cyclists. Some interventions such as segregated paths and regular de-icing would likely increase cycling substantially for some groups but not all, and some groups are unlikely to cycle beyond a certain frequency threshold regardless of investments. Health benefits have been promoted to increase cycling. This seems to be effective to encourage first-time or resuming cyclists, but there is no significant relationship between health motivation and cycling frequency for utilitarian trips. Speed and convenience strongly and positively relate to cycling frequency and have been proven to influence modal choice in other studies. To increase bicycle modal share, the attractiveness of cycling should be

increased relative to other modes. This paper helps do so, showing to planners and decision makers a useful portrayal of a heterogeneous cyclist population by dividing it into types and showing interventions that would motivate each type to commute by bicycle more often.

CHAPTER 2:

Why are they cycling the most? An analysis of determinants of cycling frequency

INTRODUCTION

Policy makers and officials promoting cycling often use health, congestion reduction, and environmental benefits as a way to convince people to use a bicycle more. While these benefits make an increase in cycling a logical goal for decision makers, they might not be the most effective argument in a promotional campaign or good guides for planning interventions. Focusing on the convenience and flexibility of cycling might be a better strategy to increase cycling for utilitarian purposes (Damant-Sirois, Grimsrud, & El-Geneidy, 2014). Indeed, Börjesson and Eliasson (2012) found that it is better to present cycling as a mode that can compete with others rather than focusing on the environmental and health benefits.

There is a vast amount of literature on cycling usage and frequency determinants, but ambiguity remains on many factors as conclusions have not been consistent (Heinen, van Wee, & Maat, 2010). For example, several researches found that men cycle more than women (Dill & Voros, 2007; Stinson & Bhat, 2004), while some studies suggest otherwise (de Geus, De Bourdeaudhuij, Jannes, & Meeusen, 2008; Wardman, Tight, & Page, 2007). Many other variables did not reach consensus, like age, built environment and income. This study builds on past findings to test the importance of determinants of cycling, yet using a segmentation approach and adding new variables that were not tested before in previous research. Segmenting population has been shown to nuance results and to be useful in informing decision makers about interventions (Dill & McNeil, 2013; Kroesen & Handy, 2013), because different types of cyclists react differently to different types of infrastructure (Larsen & El-Geneidy, 2011) or to varying conditions (Bergström & Magnusson, 2003; Nankervis, 1999). This study uses a sample of 1,707 Montreal cyclists and a segmentation that has been developed in a previous research (Damant-Sirois et al., 2014) to understand the determinants of increasing cycling frequencies among different types of cyclists.

Determinants of cycling can be grouped in four main categories: individual characteristics (e.g. gender or household size), individual attitudes, and social and built environment. It was also showed that it is important to control for self-selection to test the impact of the social and built environment (Handy et al., 2005). This paper is

exploring the impact of these four categories on frequency to commute by bicycle and frequency of using the bicycle as a mode of transportation for other utilitarian trips. In addition to these four categories, the impact of the perception of safety of different kinds of infrastructure is added in the equation. This distinguishes this study from previous ones as infrastructure was often present in the models, but this study considers what might be the most important, the safety *perception* of these types of infrastructure. Indeed, many studies showed that infrastructure was not a determinant of cycling, but safety is often mentioned as the most important factor in the decision to cycle or not. For example, Krizek et al. (2007) showed that cyclists would make a detour to reach certain facilities. However, if what make individuals choose such a detour is their perception of safety rather than the actual enjoyment of the facilities, policy recommendations would be quite different.

The findings of this research can be useful to inform transportation planners, engineers and policy makers trying to adopt interventions or promotional campaigns that can increase bicycle usage in cities. The following section of this manuscript presents the relevant literature on determinants of bicycle usage and frequency, and segmentation of cyclists. This is followed by an explanation of the context of the study and the data used in the analysis. Later we present the methodology used and analysis. Finally, we present the results and discussion followed by a conclusion.

BACKGROUND

Literature on Bicycle Usage and Frequency Determinants

The goal of this section is to present the variables that have been shown to impact bicycle usage and cycling frequency. In addition, we will discuss factors affecting route choices and safety perception.

Individual characteristics: This category regroups demographic information and household composition of the individual. While some studies found that age has no clear impact on cycling (Kitamura, Mokhtarian, & Laidet, 1997b; Wardman et al., 2007), most studies observed a variation in cycling usage with age (Dill & Voros, 2007; O'Connor & Brown, 2010). When drawing general portrait of the cyclist population, the

share of women cycling compared to man has shown to be relatively lower. This variable has been explored as a determinant of cycling usage and has been shown to be significant (Krizek, Johnson, & Tilahun, 2005; Landis, Vattikuti, & Brannick, 1997) and was often explained by saying that women are more risk averse than men or that women might still be more involved in household responsibilities (Garrard, 2003; Heinen et al., 2010). Household characteristics have also been proven to influence the bicycle usage. The structure of the household has been shown to be significant (Moudon et al., 2005; Ryley, 2006) as has the number of cars in the household (Dill & Voros, 2007; Kitamura et al., 1997b; Parkin, Wardman, & Page, 2008; Stinson & Bhat, 2004).

Individual attitudes: This group of variables has been shown to be quite important in previous studies (Heinen et al., 2010). Fernández-Heredia et al. (2014) showed that attitudes can directly affects the intention of cycling, but also perception of benefits and barriers of cycling. Pro-bicycle attitudes and pro-car attitudes have both a strong and opposite impacts on cycling frequency and behavior (Dill & Carr, 2003; Fernández-Heredia et al., 2014; Handy & Xing, 2010; Vredin Johansson, Heldt, & Johansson, 2006). Safety perception, which is considered one of the most important determinants of cycling, (Heinen, Maat, & van Wee, 2011; Rietveld & Daniel, 2004; Titze, Stronegger, Janschitz, & Oja, 2007; Xing, Handy, & Mokhtarian, 2010) is also affected by individual attitudes (Fernández-Heredia et al., 2014). The pro-environment attitude has also been shown to be positively correlated to cycling usage frequency (Li, Wang, Yang, & Ragland, 2013; Vredin Johansson et al., 2006). Finally, Fernández-Heredia et al. show that people who see bicycles as a way to exercise are more likely to cycle more.

Social environment: This category refers to perception of society and relatives on bicycles and transportation in general. Xing and Handy (2008) found that social environment was more determinant in bicycle ownership and usage than built environment and that it has a strong impact in the decision to use bicycle for recreational purpose over transportation purpose (Xing et al., 2010). Titze et al. (2007) found that social and peer support have a strong and positive impact on the decision to commute by bicycle. De Geus et al. (2008) had a similar conclusion and obtained

results that showed that augmenting social support through promotional campaigns would be an efficient way of increasing cycling frequency.

Built environment: This category has been extensively studied and while earlier research found a strong positive correlation with bicycle usage (Cervero & Kockelman, 1997; Dill & Carr, 2003), results have been nuanced with the introduction of self-selection as a control variable (Handy et al., 2005). Self-selection represents the idea that people who already have the intention of cycling will locate themselves in area that offers substantial bicycle infrastructure. This gives the impression that these infrastructures incite people to cycle more. However, even when controlling for self-selection and individual attitudes, some studies still found some correlation between cycling usage and the built environment (Pinjari, Bhat, & Hensher, 2009; Xing et al., 2010). Some studies also show an important impact of infrastructure (Carver, Timperio, Hesketh, & Crawford, 2010; Fraser & Lock, 2011) on bicycle safety perception of individuals. Others have demonstrated that infrastructure influences the behavior of cyclists (Krizek et al., 2007; Menghini, Carrasco, Schüssler, & Axhausen, 2010; Tilahun, Levinson, & Krizek, 2007).

Following this survey of the literature, it was decided to include different variables from each of these four categories, while controlling for self-selection. Due to the importance of safety perception on bicycle frequency, usage, and behavior, different safety perception measures are included in the analysis, although they were not tested extensively in previous research. This study takes a different approach on safety perception. Instead of studying general safety perception of cycling separately from infrastructure usage or proximity, this research incorporates safety perception of specific infrastructure impact on cycling frequency.

Literature on Cyclists Segmentation

The approach we will be following in this study is using predefined segments to understand the impacts of the abovementioned variables on each cycling segment. This section of the literature review will briefly present methods of segmentation and the different definitions of segments that can be used for cyclists, and then concentrate on

the one used in this study. Segmentation of cyclists have been mostly used to describe the cyclist population (Jensen, 1999b; Larsen & El-Geneidy, 2011), what affects them (Bergström & Magnusson, 2003), how they are perceived (Gatersleben & Haddad, 2010), or on their intention of cycling and their safety perception (Geller, 2006). Damant-Sirois et al. (2014) developed a multi-dimensional typology that included the motivations and deterrents to cycle, childhood and adulthood encouragement, and route and infrastructure preferences. Most of these typologies have been used to prescribe policy recommendations, but most typologies were not supported by empirical evidences. For example, Dill and McNeil (2013) used the Portland cyclist' typology developed by Geller' (2006) to inform a set of recommendations. Segmentation can also be used to nuance results from regression analysis. Kroesen and Handy (2013) segmented cyclists into four groups to study the relation between non-work related trips and commutes . The two models, one using segmentation and the other not, gave similar results, but the size of the factors affecting cycling frequency varied and the level of significance for each variable changed from one group to the other. This shows the usefulness of segmenting populations in order to better understand the factors affecting the different groups of cyclists and to recommend policies depending on the target audience.

This study will examine the impact of proven determinants of bicycle usage by using the typology developed by Damant-Sirois et al. (2014), both on frequency of commute and of other utilitarian cycling trips. This typology is developed using a factor cluster analysis followed by a k-means cluster. It divided the cycling population to four distinct groups.

The *dedicated cyclists* are motivated to cycle by the speed, predictability and flexibility of bicycle. Peer and employer/school incite this group to use their bicycle. They strongly identify themselves as cyclists and enjoy riding their bicycle. They are less keen on using separated infrastructures than the other groups and are not deterred from cycling by weather conditions.

Path-using cyclists are also not strongly influenced by weather conditions. They have a strong cyclist identity which motivates them to cycle and enjoy riding a bicycle. The main difference they have with the *dedicated cyclists* is that they strongly dislike

cycling near cars and prefer infrastructure that separates bicycles from traffic. Contrary to *dedicated cyclists*, they were actively encouraged by their parents to cycle both as a sport or a recreational activity and to reach various destinations.

Fairweather utilitarians are best defined as contextual users, since they would choose another mode if they perceive it as more convenient and are unlikely to cycle in bad weather. Like *path-using cyclists*, they prefer to use bicycle paths and are influenced by peers and institutional encouragement. They distinguish themselves from the other clusters and are defined by members that do not identify themselves as cyclists.

Leisure cyclists prefer to use infrastructure segregated from traffic and prefer to not ride close to cars, whether parked or driving. They do not cycle because it's a convenient mode, but because they enjoy cycling and because they identify themselves strongly as cyclists. They are the type of cyclists that cycle mostly as a hobby or as a family activity rather than for transportation.

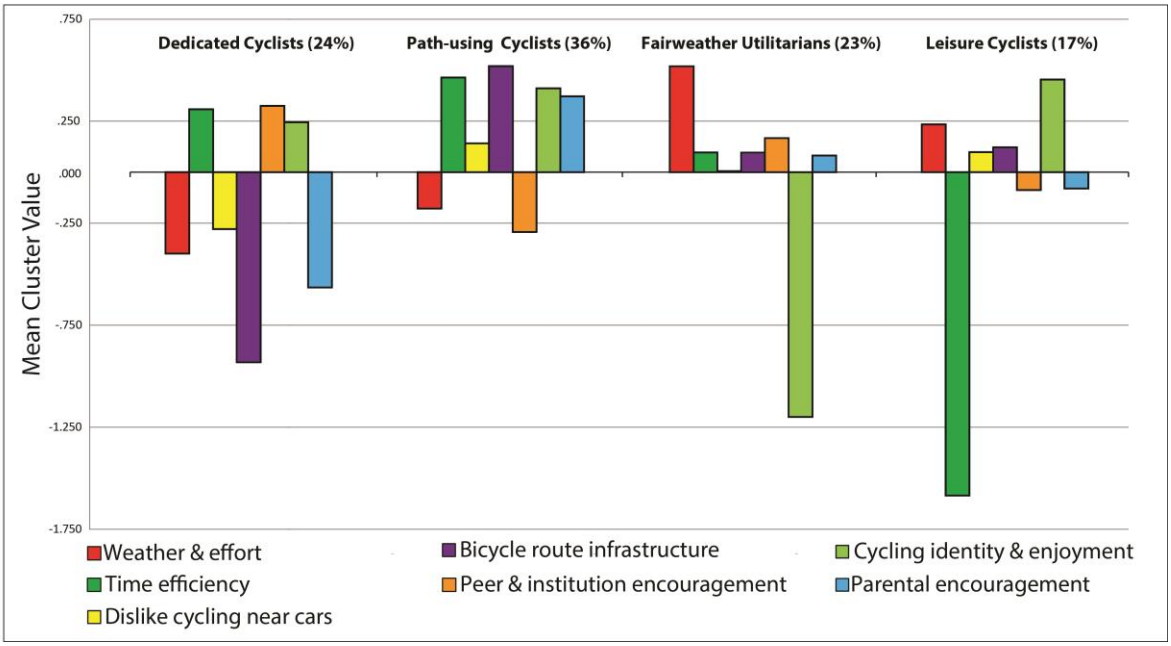

Figure 6 Cyclist' types and components defining them

One major advantage of this typology compared to others developed previously is that it is based on empirical evidence coming from a large sample of cyclists rather than from

individual perceptions of what a cyclist is. The variables chosen to define the segments come from the literature on cycling determinants. The results made sense when tested with other variables from the same survey like the commuting frequency or the safety perceptions of different infrastructure. Every cyclist, whether cycling every day or only once a year, can be represented in this typology. Finally, because the variables used to segment the cyclists are generalizable to different context, other regions than the one in which the survey took place could use it.

While some policy recommendations were drawn from the findings, the goal of that paper was to develop the typology and test its consistency rather than use it for policy recommendations. Therefore, the recommendations were coming from descriptive statistics and simple analysis of the survey responses. Furthermore, no multivariate analysis and only chi-square test were run to test the similarities and differences of the groups. The goal of this research is to use that typology in a rigorous setting and test the differences between the groups into multivariate analysis. From this typology and other data gathered from an online survey, Damant-Sirois et al. (2014) developed recommendations on how to increase the frequency of cycling for each type. The data showed that each type had an apparent maxima and minima of commuting, that certain interventions would impact certain types, but not others, and that these interventions can help move a cyclists from one frequency of commuting category to another (as shown on figure 2). For example, building a network of fast direct route can convince *dedicated cyclists, path-using cyclists* and *fairweather utilitarians* that cycle sometimes to work to cycle often. However, *Leisure cyclists* would not be as affected by this intervention as the other groups, because they do not cycle for the convenience aspect of cycling and the members of this group rarely commute using a bicycle. The sample seems to have been leaning more towards *dedicated cyclists* (24%) and *path-using cyclists* (36%). Even then, the same types with different weights could be found in other cities. This set of conclusions and recommendations were developed from the definition of each cyclist's types and backed up only by summary and descriptive statistics. This paper, in addition to the analysis of the determinants of cycling frequency, will try to test these conclusions and validate the usefulness of the typology.

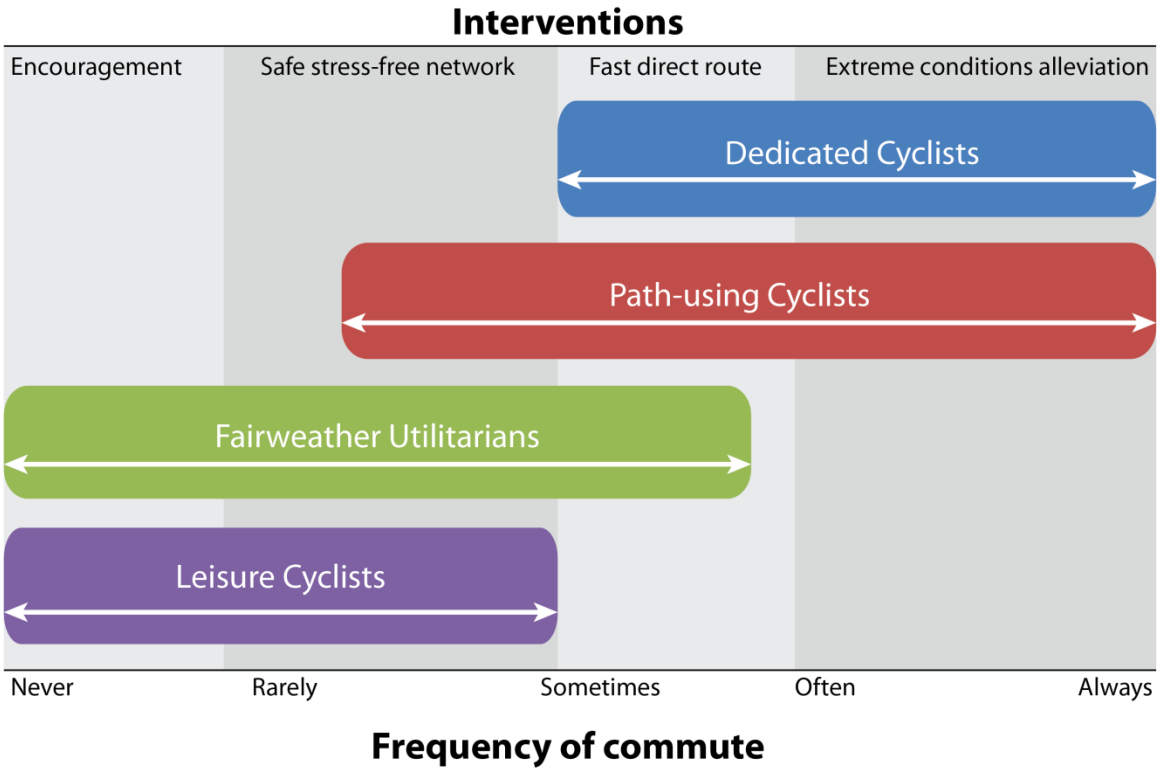

Figure 7 Cyclist' types, commute frequencies, and relevant intervention areas

STUDY CONTEXT AND DATA

Study Context

The study has surveyed Greater Montreal region cyclists. There are about 1.8 million people living in the city and about 3.8 million in the region, making Montreal the second largest city of Canada. Recognized as being a bicycle-friendly city, Montreal has the highest combined share of public transit, walking and bicycling in Canada (Statistics Canada, 2011). In the city of Montreal, 36% of the population aged between 18 and 74 years old cycle at least once a week and 52% at least once a year (Vélo Québec, 2010).The bicycle mode share for commuting of the region is 1.6% and of 3.2% for the city (Statistics Canada, 2011). This gap between cycling for commute on a regular basis and cycled at least once a year or over the past week needs to shrink if the Montreal region is interested in increasing the number of cyclists on the road for various reasons. This goal is not limited to Montreal but of interest to other regions as well, which makes this paper of value to other regions.

Data

The data used in this study come from an online bilingual survey that was online for a month at the end of spring 2013. Dillman et al. (2009) provide guidelines to reduce sample bias in online surveys. Following these recommendations, an extensive advertising campaign was conducted, including: survey links throughout the Transportation Research at McGill group mailing list and different newsletter groups as well as in social media; French and English newspaper advertisements and articles; flyer distribution to individuals, bicycle shops, businesses along major bicycle paths, and around a major bicycle event; and a major radio show interview.

The survey was aimed only at cyclists. A cyclist is defined as a person who cycled at least once for any purpose in the past year. The number of respondents was 2,644 with a final sample size of 2,004 of data with complete records. However, the sample size for this particular study is 1,524 for the models analyzing the commute trips and 1,707 for the models studying other utilitarian trips. The differences come from the fact that respondents who worked from home were removed from the sample for the commute model. Coding errors for home and work location and other variables like age and income also led to a decline in the sample used in the study.

The survey itself was divided in 7 main sections presented in the following order: general information, cycling behavior, cycling history, motivations and habits, infrastructure, route and investment, BIXI (bicycle sharing), and personal profile. Respondents were asked to state their behavior, home and job location, motivations and deterrents to cycling, many preferences on different subjects like infrastructure, route and intersection, and on their safety perception of specific infrastructure types. The variables used in the models come mainly from the survey, but others were obtained through the analysis of geographic characteristics of home and job location of the cyclist. The following section details the methodology used to conduct the analysis.

METHODOLOGY

The nature of the data gathered in the survey on cycling frequency made the choice of the appropriate analysis tool easy. The respondents were asked to answer the following

question for different trip purposes: “When you travel for these purposes, how often do you travel by bicycle (including BIXI)?” The possible answers were: Never, Rarely, Sometimes, Often, Always and Not applicable. Participants who answered *Not applicable* were removed from the study. There are pros and cons of asking frequency this way instead of a direct number like the number of days per week. The main advantage for using the former is that it was better at answering the main question of the research without asking the respondents to answer many similar questions. In this case, the fundamental research question was what makes individuals choose to use a bicycle for a trip when they make this trip rather than what makes an individual make a certain amount of trips. This way, the question controls for differences in life habits (e.g. number of times a week doing grocery shopping) or work status (e.g. part-time or full-time worker). It allows to differentiate someone who cycles only once a month to get to work because he or she only works once a month from someone who cycles twice a week to work, but takes a car three times. The goal here is to identify the determinants that make people choose bicycle over another modes. This is in line with city objective of shifting people from cars to bicycles for the trips they already do, rather than increasing the number of trips *per se*. Finally, it also prevents people from putting bigger or smaller numbers because of perception flaws.

Because the dependent variables were ordinal, an ordered logit regression model is used to analyze the factor affecting the frequency of cycling. Two models were developed; one for the commute frequency, and one for the other utilitarian trips. The models are applied to the full sample and on the four different types of cyclists developed in a previous study by the authors (Damant-Sirois et al., 2014), which was presented earlier in the article. A total of 10 regression models were done. The variable choice is inspired from the literature presented in the literature review section. The rationale behind the model is similar to the one developed by Fernández-Heredia et al. (2014), except that the physical determinants factor is replaced by a social environment one as it was shown to be more significant in the literature and that physical determinants was not a strong factor in their study.

Table 1 presents the average and standard deviation for every variable used in the study. A chi-square, reported in the table, is used to test if the differences between the four types of cyclists are significant. It is important to note that all the variables used in the models are not used in defining the types of cyclists to avoid any violations in the assumptions of the statistical technique used.

Commute and utilitarian trips frequency represent the average answer on a 5-likert scale ranging from never to always. The utilitarian trips include grocery shopping, shopping and going to social activities (e.g. restaurant, bar, etc.). The motivation variables come from a question where respondents were asked to give the importance, on a 5-likert scale, of different source of motivation for them to use a bicycle for such a commute. Health motivation is important for all groups, but was not significantly different between them, while environmental and cost motivation are significantly different between the groups.

A series of questions are asked about the importance of different strategies to improve cycling in Montreal. Two of them asked the respondents to rank the importance of increasing bicycle safety awareness for two street users, cyclists and drivers. The variable *moved for bicycle infrastructure* comes from a question that asked the importance of different factors in their last home location decision on a 5-likert scale. This variable will help in controlling for self-selection in the models.

The Walkscore, commute distance and density variables are derived in a Geographic Information System (GIS) based on the self-reported home and work location for every cyclist. Commute distance is obtained through a network analysis tool in GIS using the shortest possible route using a network of streets and bicycle facilities. We can see that the commuting distance is relatively small for each group and that the average Walkscore is quite high. This means that most cyclists are living in central area of Montreal.

Table 3 Variables used in the models

	All		Path-Using Cyclists		Leisure Cyclists		Fairweather Utilitarians		Dedicated Cyclists	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Dependent variables										
#Commute frequency* **	3.91	1.25	4.25	1.11	3.23	1.40	3.47	1.23	4.27	1.03
#Utilitarian trips frequency* **	3.16	1.16	3.52	1.04	2.19	1.06	2.80	1.00	3.62	1.02
Attitudes										
#Health Motivation	4.22	0.86	4.35	0.83	4.42	0.75	3.99	0.83	4.07	0.92
#Environmental motivation* **	4.20	0.89	4.45	0.78	3.93	1.06	4.02	0.82	4.16	0.90
#Cost motivation* **	3.80	1.15	4.12	1.04	3.13	1.22	3.64	1.10	3.90	1.06
#Cyclists should be more aware of their own safety	4.04	1.02	4.08	0.99	4.08	1.02	4.04	1.00	3.96	1.09
#Drivers should be more aware of cyclists safety**	4.60	0.74	4.68	0.62	4.54	0.81	4.50	0.84	4.61	0.73
Self-Selection control										
#Moved for bike infrastructure* **	3.02	1.17	3.26	1.13	2.88	1.18	2.87	1.14	2.89	1.19
Built environment										
Walkscore	82.26	14.03	84.20	12.31	74.66	17.47	83.26	12.85	83.80	13.03
Commute distance (km)	4.64	4.13	4.38	3.52	5.68	5.72	4.19	3.57	4.76	4.05
Density (1000pop/km2	11.31	7.04	12.52	8.50	8.55	5.70	11.22	5.78	11.42	5.61
Social environment										
Children cycle (%)	0.48	0.50	0.48	0.50	0.51	0.50	0.46	0.50	0.47	0.50
Adult cycle* (%)**	0.68	0.46	0.72	0.45	0.52	0.50	0.71	0.45	0.72	0.45
Getting a car is a normal step to become an adult* (%)**	0.38	0.49	0.37	0.48	0.50	0.50	0.35	0.48	0.34	0.48
Car is a symbol of social status (%)	0.37	0.48	0.36	0.48	0.43	0.50	0.35	0.48	0.36	0.48
It is a normal to take public transit* (%)	0.63	0.48	0.63	0.48	0.56	0.50	0.66	0.47	0.66	0.48
Individual characteristics										
Number of people in household	2.42	1.21	2.48	1.26	2.38	1.19	2.45	1.17	2.33	1.17
Number of cars in household* **	0.69	0.78	0.54	0.69	1.10	0.87	0.73	0.73	0.58	0.76
Female* (%)	0.40	0.49	0.41	0.49	0.31	0.46	0.42	0.49	0.41	0.49
AGE	37.34	11.54	36.06	11.00	43.25	11.92	35.61	10.77	36.73	11.48
	N=1707		N=658		N=293		N=378		N=378	

*Significant at 10%, **Significant 5%, ***Significant at 1%, #5-likert scale

Five variables describing the social environment are obtained through a series of question where participants are asked to check box if the statement was applying to: “How would you characterize the cycling culture where you live in now?” The percentage represents the share of people who considered the statement to be true. For example, 68% of the respondents said that it is common for adult to cycle where they live, which is surprisingly higher than for children at 48%. Standard deviations were relatively important so there is some variance on these variables within group even if they all live in the same city. The last variables represent demographic information. There was statistically significant variation between groups for the number of cars and the share of females within each group.

To reduce the number of variables in the statistical models and to account for colinearity, a factor cluster analysis is done to merge similar questions concentrating on safety perception and social environment. The factor analysis type used is principal components and the total variance explained for the safety perceptions component is 68% and 60% for the social environment one. Table 2 shows the grouping results, the weights of each variable into the component and the name of the new component.

Two distinct social environments appeared. In the first one, cars have a preponderant social importance. In the second, alternative modes, bicycling and transit, are social norms and are well accepted. It is interesting to note that the variable *adult cycle* is negatively correlated for the “car-oriented” social environment.

The three other components represent safety perception on different groups of infrastructure. Respondents are asked to rate the safety of specific infrastructure between and at intersections. The results gave three distinct groups of infrastructure. The first one is the safety perception of on-street painting, the second is streets without any infrastructure or indication, but with more weight to residential street than main streets, and the last one is infrastructure that separates cyclists from car traffic.

Table 4 Results from the factor cluster analysis

Component	Variables	Loadings
Car-oriented environment	**Getting a car is a normal step to become an adult**	.799
	Car is a symbol of social status	.743
	Adult cycle	-.563
Active-oriented environment	**It is normal to take public transit**	.525
	Children cycle	.767
		.665
Safety perception on-street infrastructure	**Painted symbol Inter.**	.874
	Painted symbol Between	.873
	Painted lane Intersection	.694
	Painted lane between	.662
Safety perception street	**Residential between**	.889
	Residential intersection	.871
	Main Intersection	.585
	Main between	.528
Safety perception, separated infrastructure	**Bi-directional intersec.**	.849
	Bi-directional between	.846

The dependent variables used in the study are the frequency for commute and for other utilitarian trips. As expected by conducting preliminary analysis and supporting the findings on the types developed previously (Damant-Sirois et al., 2014), some groups were either not represented at all in the *never* or the *always* category (see figure 2). Therefore, to meet the *proportionality assumption* of equivalent distance between each category for an ordered logit regression (tested through a test of parallel lines) some categories were merged. The *never* category was merged with the *rarely* category for the commute to work or school as it was almost non-existent for the entire sample. For the *dedicated cyclists*, the new *rarely* category had to be merged with the *sometimes* category as there was almost no member of this group in that category. The *never* category was merged with *rarely* for both the *dedicated cyclists* and *path-using cyclists*, and the *always* was merged with the *often* category for the *fairweather utilitarians* and the *leisure cyclists* for the utilitarian trips. Also, to test for co-linearity

between the variables, a variance inflation factor test is conducted in addition to regular correlation matrix.

Using the variables presented in table 1 and the components presented in table 2, an ordered logit regression is run with the commute and utilitarian trips frequency as dependent variables for the entire sample and for each cyclist's type. The next section presents the results of these regression models.

ANALYSIS AND RESULTS

A total of ten regressions were done; the entire sample and four cyclists types for both the commute and utilitarian trips frequency. The results of these regressions will show if it is useful policy-and research-wise to segment population in groups, the adequacy of the typology developed previously and, most importantly, if they can be used to inform recommendations made to policy makers on how to increase cycling frequency for different purposes. Table 3 presents the results for the commuting frequency regression. The number adjacent to the dependent variable represents the categories of frequency: 2 represents Never and Rarely, 3 Sometimes, 4 Often and 5 Always.

The variables are presented by categories in this order: Built environment, social environment, self-selection (control for the previous two), safety perception, attitudes and individual characteristics. Similar to other research, built environment variables are not significant when controlling for self-selection, except for the commuting distance which shows that every additional kilometer of commuting distance decreases the chance of being one frequency category higher by about 4% and by about 8% for *fairweather utilitarians* and *dedicated cyclists*. Even infrastructure distance, representing the home distance to the closest facility that was initially placed in the models had to be removed due to its high correlation with the self-selection variable. The commute distance is significant for the entire sample, but has to be nuanced when looking at the different types of cyclists. Interestingly, it is not significant for *leisure cyclists* even though they have the highest commuting distance and the biggest standard deviation (over 1 time the mean). None of the social environment variables are significant in this model, except for a surprisingly negative correlation between positive social perception

of cycling and transit, and cycling commuting frequency for *fairweather utilitarians*. This could be explained by the fact that the members of this group can easily shift from bicycle to public transit as was explained in Damant-Sirois et al. (2014).

Self-selection is slightly significant ($p<0.10$) and positively correlated with commuting frequency. However, when segmenting the sample, this variable is not significant for any group and far from it for some ($p=0.430$ for *leisure cyclists* is the smallest). The safety perception variables are all significant for the entire sample. Safety perception for on-street infrastructure (e.g. painted lanes) and safety perception on street without infrastructure are positively correlated with the frequency of commute by bicycle. Interestingly, safety perception for facilities that separate cyclists from traffic has negative correlation with commuting frequency. Safety perception on residential and main streets shows a statistically significant and positive impact on frequency of cycling among three of the cyclist' types, but not a significant one for the other street or infrastructure types.

Two sub-categories of individual attitudes are included in the models: motivations, and perception of behavior towards other cyclists and drivers. No statistical significance was found between health and environmental motivation, and commuting frequency by bicycle. Individuals are aware of these benefits (see table1), but what drives them to cycle more is the cost benefit. Indeed, this motivation is strongly significant ($p<0,01$ or $p<0,05$ depending on types) and has an important impact on frequency. An increase in 1 point on a 5-likert scale of the importance of cost as a motivation to cycle has a probability between 25% and 62% depending on types of cyclists or 42% for the entire sample to be in a higher category of cycling frequency.

Table 5 Cycling commuting frequency regression results

	ALL			Path-Using Cyclists			Leisure Cyclists			Fairweather Utilitarians			Dedicated Cyclists		
	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound
[OftBkWS = 2]	0.199	0.036	1.118	0.403	0.019	8.346	3.319	0.028	389.051	0.021	0.000	0.986			
[OftBkWS = 3]	0.914	0.165	5.075	1.764	0.089	34.924	18.664	0.159	2194.253	0.120	0.003	5.553	0.005	0.000	0.262
[OftBkWS = 4]	8.842	1.585	49.331	19.853	0.998	395.115	405.783	3.272	50319.728	1.334	0.029	61.121	0.061	0.001	2.890
Commute Distance	***0.956	0.931	0.983	0.974	0.927	1.023	0.965	0.912	1.022	**0.916	0.856	0.981	***0.919	0.865	0.976
Walkscore	1.005	0.997	1.014	1.012	0.996	1.027	0.999	0.979	1.019	0.997	0.979	1.017	0.994	0.975	1.014
Density (1000/km2)	1.004	0.989	1.020	0.993	0.974	1.012	1.029	0.968	1.093	1.024	0.984	1.064	0.988	0.948	1.030
Car-oriented envir.	1.026	0.925	1.137	0.967	0.816	1.147	1.236	0.934	1.635	0.983	0.787	1.228	1.049	0.832	1.323
Active-oriented envir.	0.922	0.832	1.022	1.044	0.876	1.243	0.959	0.730	1.260	*0.832	0.670	1.033	0.838	0.666	1.054
Self-Selection	*1.0840	0.993	1.183	1.049	0.904	1.216	1.107	0.860	1.424	1.008	0.832	1.220	0.999	0.829	1.203
SP on-street	**1.128	1.021	1.247	1.037	0.872	1.233	1.210	0.905	1.618	0.863	0.684	1.090	1.142	0.917	1.422
SP separated	**0.883	0.798	0.978	0.961	0.804	1.149	0.857	0.651	1.127	1.032	0.828	1.286	0.836	0.668	1.045
SP Street	***1.244	1.127	1.373	*1.139	0.974	1.331	**1.411	1.046	1.904	1.150	0.927	1.425	**1.317	1.042	1.664
Enviro motiva.	1.075	0.943	1.227	1.111	0.874	1.411	1.037	0.751	1.432	0.889	0.669	1.180	0.959	0.716	1.284
Cost motiva.	***1.417	1.285	1.563	**1.249	1.051	1.487	***1.621	1.254	2.095	***1.325	1.080	1.626	**1.353	1.066	1.718
Health motiva.	1.030	0.907	1.170	1.018	0.822	1.260	1.208	0.809	1.806	1.047	0.800	1.369	1.071	0.800	1.435
Cyclists awareness	***0.857	0.766	0.959	**0.785	0.644	0.959	1.047	0.777	1.409	*0.788	0.606	1.024	0.919	0.730	1.157
Drivers awareness	***1.382	1.182	1.616	**1.459	1.087	1.960	1.087	0.712	1.660	***1.599	1.173	2.180	1.239	0.887	1.731
AGE	**0.925	0.869	0.985	0.993	0.894	1.103	1.068	0.889	1.284	**0.862	0.749	0.992	***0.820	0.712	0.945
Age2	**1.001	1.000	1.002	1.000	0.999	1.001	0.999	0.997	1.001	**1.002	1.000	1.004	**1.002	1.001	1.004
HHPeople	**1.097	1.005	1.196	1.102	0.956	1.272	0.923	0.707	1.204	0.995	0.820	1.206	1.122	0.917	1.372
HHCars	***0.780	0.671	0.908	*0.774	0.595	1.008	0.968	0.658	1.423	*0.730	0.530	1.007	0.924	0.650	1.312
Male	***1.507	1.222	1.857	*1.394	0.985	1.974	*1.916	1.047	3.504	**1.700	1.093	2.644	1.312	0.830	2.074
Sample size	N=1524			N=609			N=225			N=331			N=359		
Model fitting sig.	p<0.01			p<0.01			p<0.01			p<0.01			p<0.01		

*Significant at 10%, **Significant 5%, ***Significant at 1%

Attitudes towards cyclists and drivers are statistically significant for the entire sample, *path-using cyclists* and *fairweather utilitarians*, but not for the other two types. Individuals who think that cyclists should be targeted in a safety awareness campaign are less likely to commute by bicycle, while those who think that drivers should be targeted by such policy are more likely to cycle. One way to interpret this variable is that people who think cyclists behave dangerously and should change the way they use the public right of way are both less likely to be a cyclist and less likely to be seen as one. Therefore, their frequency of usage will likely be lower. On the other hand, people who already cycle more frequently do not want to be blamed for conflict between users and prefer to blame drivers, because of their bad behavior.

All of the individual characteristics are significant for the entire sample and follow the expected sign as defined in the literature. Even when controlling for safety perception, males are between 39% and 91% more likely to be in a higher category of cycling frequency compared to females, depending on the cyclist' types. This variable is not significant for *dedicated cyclists*. In fact, only age is significant for this group.

To verify if there is different determinant depending on the purpose of the trips, the same variables, minus commuting distance, are used in the second model that analyzes the factors influencing frequency for utilitarian purposes. Table 4 presents the results of these regression models.

Since most of the results are similar to the ones obtained in the commuting frequency models, the presentation of the results for the utilitarian trips models will concentrate on the differences between the two sets of models. Not surprisingly, the *Walkscore* variable becomes statistically significant with a positive sign for this model while the density stays not significant. As *Walkscore* represents the local accessibility (Manaugh & El-Geneidy, 2011, 2012) to different kinds of services, it is normal that an increase of one point in *Walkscore* increases the odds of being one category higher in the utilitarian trips frequency by about 2% for the whole sample, the *path-using cyclists* and the *fairweather utilitarians.*

Table 6 Cycling for utilitarian trips frequency regression results

	ALL			Path-Using Cyclists			Leisure Cyclists			Fairweather Utilitarians			Dedicated Cyclists		
	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound	Odds ratio	Lower Bound	Upper Bound
[FreqUt = 1.00]	0.337	0.082	1.395				2.267	0.057	90.943	0.375	0.014	10.208			
[FreqUt = 2.00]	1.293	0.313	5.348	0.918	0.078	10.781	10.991	0.272	444.496	1.919	0.070	52.420	0.006	0.000	0.147
[FreqUt = 3.00]	6.282	1.515	26.052	4.568	0.387	53.861	62.217	1.517	2551.165	14.367	0.523	394.730	0.031	0.001	0.756
[FreqUt = 4.00]	50.890	12.208	212.142	39.361	3.302	469.152							0.252	0.011	5.995
Walkscore	***1.020	1.013	1.027	***1.019	1.006	1.032	1.010	0.993	1.026	**1.019	1.003	1.036	1.007	0.990	1.023
Density (1000/km2)	1.003	0.990	1.017	0.996	0.978	1.013	1.009	0.964	1.055	1.012	0.976	1.050	1.001	0.965	1.038
Self-Selection	**1.093	1.013	1.180	1.064	0.935	1.211	0.952	0.777	1.167	*1.177	0.994	1.394	0.978	0.832	1.150
SP on-street	***1.165	1.066	1.273	0.995	0.856	1.156	1.207	0.953	1.529	**1.251	1.010	1.550	1.070	0.880	1.303
SP separated	**0.909	0.832	0.993	1.022	0.879	1.190	0.996	0.790	1.255	0.901	0.740	1.097	0.988	0.813	1.201
SP Street	***1.301	1.191	1.422	***1.290	1.121	1.485	**1.365	1.065	1.750	1.114	0.918	1.353	1.013	0.822	1.248
Car-oriented envir.	0.931	0.850	1.019	0.920	0.793	1.067	0.855	0.679	1.077	0.955	0.778	1.171	1.009	0.824	1.236
Active-oriented envir.	0.927	0.847	1.016	0.947	0.814	1.102	1.001	0.798	1.256	0.893	0.734	1.087	0.983	0.804	1.204
Enviro motiva.	***1.289	1.147	1.448	1.158	0.937	1.431	**1.376	1.053	1.799	***1.403	1.084	1.816	1.057	0.820	1.362
Cost motiva.	***1.417	1.298	1.547	***1.307	1.121	1.525	**1.483	1.201	1.831	*1.185	0.982	1.429	**1.253	1.013	1.551
Health motiva.	***0.786	0.701	0.881	0.859	0.711	1.036	0.887	0.628	1.254	*0.785	0.613	1.005	**0.737	0.571	0.951
Cyclists awareness	***0.849	0.769	0.938	***0.783	0.663	0.924	**0.758	0.578	0.996	1.013	0.808	1.271	0.955	0.782	1.166
Drivers awareness	***1.301	1.134	1.494	***1.315	1.017	1.700	***1.983	1.383	2.845	1.129	0.860	1.482	1.043	0.775	1.402
AGE	***0.919	0.875	0.966	0.977	0.899	1.062	0.928	0.822	1.049	0.913	0.814	1.026	**0.872	0.781	0.975
Age2	***1.001	1.000	1.001	1.000	0.999	1.001	1.001	1.000	1.002	1.001	0.999	1.002	**1.001	1.000	1.003
HHPeople	0.977	0.904	1.056	0.880	0.779	0.994	0.857	0.686	1.071	1.082	0.903	1.296	0.902	0.757	1.075
HHCars	***0.514	0.448	0.589	***0.596	0.472	0.752	***0.508	0.357	0.723	***0.520	0.386	0.702	***0.554	0.409	0.751
Male	*0.848	0.702	1.024	*0.751	0.553	1.021	0.700	0.416	1.177	1.015	0.679	1.518	1.054	0.701	1.585
Sample size	N=1707			N=658			N=293			N=378			N=378		
Model fitting sig.	p<0.01			p<0.01			p<0.01			p<0.01			p<0.01		

*Significant at 10%, **Significant 5%, ***Significant at 1%

There are important changes in the results in terms of individual attitudes. Cost motivation remains strong for each cyclist type, but environmental and health motivations become statistically significant also. A one point increase in environmental motivations on a 5-likert scale increase the odds of being in an higher category of frequency of cycling for utilitarian's trips by 29%, 38% and 40% for the entire sample, the *leisure cyclists* and the *fairweather utilitarians* respectively. The cyclists that are the influenced by this variable are the ones that cycled the least often. One really interesting finding here is the strong and negative correlation between health as a motivation to cycle and the frequency of utilitarian trips. It is especially true for *fairweather utilitarians* that might be deter from cycling if they see it as an exercise and for some *dedicated cyclists* that, while defined as cyclists who would cycle in any situation, do it mostly as a sport or recreational activity.

The impact of number of cars is quite stronger for this kind of trips compared to commuting ones; having one additional car decreases by half the odds of being one category higher in the utilitarian trips frequency categories. A very interesting finding here is that contrary to frequency for commuting trips, male are less likely to cycle for other utilitarian purposes all things being equal than female. It is only significant ($p<0.10$) for the entire sample and the *path-using cyclists*, but the result is quite contrasting with the other regressions results that gave stronger and opposite sign.

The results of the two main models give interesting differences between them and between each cyclist' type, give important information in terms of policy recommendations and point at future research implication directions that are going to be discussed in the following section.

DISCUSSION

The results presented in the previous section confirm both the importance of segmenting the cyclists' instead of treating them as a homogeneous population, and the usability of the typology used in this study. Indeed, while the direction of the relation of the statistically significant variables do not change between types, the significance and size of the odds ratio differ between each type, and between the entire sample and the

types as it was the case in studies that segmented the sample (Dill & McNeil, 2013; Kroesen & Handy, 2013). Those differences follow the rationale that was used in the development of this typology (Damant-Sirois et al., 2014). This is an important finding as it shows that, while it is possible to develop through general research sets of efficient tools to increase bicycle usage, cities need to consult their population before drafting active transportation plans as cyclists' preferences and behavior would affect the reactions towards the different types of interventions.

Many recommendations on interventions aimed at increasing cycling frequency can be extracted from the regression results. As shown in other research (Pucher & Buehler, 2008), land use policy could have an impact on the frequency of commuting and utilitarian trips. Increasing the mix of land uses could reduce the distance between home location and job location and increase the diversity of commerce at proximity. Both of these variables impact positively bicycle usage frequency, except for *leisure cyclists* that were not correlated with these variables. Distance was significant even if the sample was centered in the core of Montreal. This means that distance is important even at a small scale as it was a deterrent also for *dedicated cyclists* even if they had an average commuting distance of 4.76km. This indicates that accessibility to services for bicycle should be considered at a relatively small scale as respondents seemed to find bicycle convenient and flexible only within a relatively small zone.

While density was not found significant in any model, a certain threshold of density is required to sustain commercial diversity. Therefore, zoning that requires minimum housing density mixed with commercial activities could be a useful tool to reach this objective. This kind of intervention would affect all types of cyclists, except the *leisure cyclists*, maybe because they tend to cycle mostly for recreation purposes which is not really affected by land usage.

A really important finding in this study is the varying impact of different infrastructure types' safety perception on cycling frequency. This differentiates this study from previous one by combining the safety perception on certain infrastructures and its impact on frequency. Previous studies showed that cyclists value facilities and go out of their way to use them (Larsen & El-Geneidy, 2011), and more so for segregated ones

over simple painted lanes (Broach, Dill, & Gliebe, 2012). The conclusion found by Broach, Dill and Gliebe (2012) that lanes offset the effect of adjacent traffic can be confirmed with the results here. Safety is more important for cyclists than the infrastructure itself. What seems to have the strongest positive correlation with cycling frequency is if cyclists feel safe when they are not on a separated facility as this even has an impact on frequency of *dedicated cyclists*. This means that what is really important for increasing bicycle usage is to make people feel safe everywhere in the city, not only when someone reaches a specific types of infrastructure. While this can seem a huge task compared to deciding on which street to build segregated infrastructure, it also means that small broad interventions can have a very important impact. What affects cyclists' safety on streets are mainly the volume and speed of car traffic. Most of the interventions that would have such effect would also increase safety for pedestrian.

There are plenty of traffic calming measures that can be applied to increase the safety perception of cyclists. Painted bicycle lanes have two positive impacts. They increase the perception of legitimacy of cyclists on the street and give the impression of narrowing down the roadway which has the effect of slowing down vehicle. Results from the survey also show that cyclists prefer not to ride close to fast cars; reducing speed limits might be a solution if complemented with street design elements.

This conclusion does not mean segregated facilities should not be built. Such a continuous network can be developed to link main employment and shopping poles to population pool. However, this is not sufficient to reach important modal share for cycling. The streets that feed such network have also to be stress-free for cyclists. This pattern is very similar to the analysis of German, Dutch and Danish cycling network made by Pucher and Buehler (2008).

Another important finding policy-wise is the impact of different motivation to cycle and the perceptions towards cyclists on frequency for utilitarian and commuting trips. The benefits that are put forward in cycling promotional campaign are mostly the individual health and environmental benefits. While positive environmental impact of cycling is a motivation that can increase the odds of cycling for other utilitarian trips

especially for the *fairweather utilitarians*, it does not have a significant impact on commuting. Seeing bicycle as a healthy activity is negatively correlated with frequency for utilitarian trips other than commute. People who sees bicycle as a cheap mode of transportation are more likely to use it as a mode of transportation more frequently. This is true for all the segments of the sample. As suggested by (Börjesson & Eliasson, 2012), promoting cycling using this argument might have a stronger positive impact than promoting it using health benefits. The fact that the members of the group that cycled the most are the ones that were the most motivated by the convenience of cycling points at other arguments that should be mentioned in a cycling promotional campaign. The speed, flexibility for departure time and for multiple trips, and the predictability of travel time are bicycle's advantages that should be brought up in such campaign. Also, campaigns aimed at improving the perception of the population towards cyclists would be a very efficient way to increase the usage of bicycle as a mode of transportation.

Other interventions could be developed to promote the cost benefits of the bicycle. Increasing the cost of other mode would make the cost of using bicycle even more appealing. In Montreal, transit passes are tax deductible, similar tax incentives could be put in place. France is considering putting in place programs to encourage employers to pay workers that use a bicycle to commute. The growing number of cities with bicycle-sharing system makes it easier than before to plan for ways to include a financial incentive on interventions aiming to increase bicycle usage. The biggest cost to use a personal bicycle is the purchase of the bicycle, and providing safe bicycle parking that prevents bicycle theft is another strategy to reduce the cost of cycling.

Finally, even when controlling for safety perception, important differences have been found between male and female on their respective behavior, except within the *dedicated cyclists* group. This shows that, while this might be the case, the explanation that female are more risk averse than male is not sufficient. Indeed, they tend to cycle more than male for utilitarian trips other than commutes. This might be explained by the dress code in work place and that, still today, women are more often than men taking care of family-related responsibilities. Future research should explore the barriers that prevent women from cycling to work.

CONCLUSION

This paper studied the relationship between different factors and the frequency of cycling for utilitarian purposes by segmenting a sample of cyclists into four different types following a typology developed in previous research. The points that differentiate this study from previous work are the segmentation approach and the usage of variables that combined safety perception on different infrastructure types. This allowed a better understanding of the mechanism linking infrastructure, safety and bicycle usage. The results can help by informing decision makers on interventions that can be implemented in order to increase bicycle usage among the different groups.

The results confirm the importance of segmenting the cycling population in order to account for the group's heterogeneity. Also, it showed that the typology used in this article gives logically sound results in both an academic and policy-wise perspective as it nuances the results and show which group would be more affected by different interventions. Depending on the size of each group in a city, some interventions would have a stronger impact compared to another city.

Land use can have an impact on bicycle usage. Using zoning to promote mixed-use development or redevelopment of areas is expected to have a positive impact on bicycle usage. The fact that people that felt safe on segregated infrastructure were cycling less and that those that were feeling safe with on-street facilities and no facility at all were cycling more gives indications for policies. While building a separated bicycle network could increase usage, it could also give the impression to people that these types of facilities are the only places cyclists should be, and the only place cyclists should feel safe, which could lead to a lower modal share for the bicycle. City planners and engineers should do specific interventions that help cyclists feel safe on residential streets.

Previous studies found that male were cycling more than women because female were more risk averse. This study showed that when controlling for safety perception, women do cycle less than men for commuting, but cycle more for other utilitarian trips. Interventions at workplaces like installing a day care, showers, changing rooms or

having flexible dress codes can be solutions that will promote cycling more among females.

Environmental and health benefits of cycling are important. Policy makers have to consider their benefits while allocating money in a budget. However, these benefits do not seem to help in increasing the frequency of cycling. Promoting cycling as a convenient, cheap and safe mode of transportation seems to be strategies that would be more efficient to reach the goal of increasing bicycle usage among the different groups.

AFTERWORD

The two chapters presented here have developed tools that can be useful both for the academic and professional world. The typology presented in chapter 1 can be useful in understanding a local cyclist population and provides a set of policy recommendations aimed at increasing bicycle usage. Already, the City of Saint Paul, MN, incorporated the groups built here to develop the *The Saint Paul Bikeway Plan*. The results from chapter 2 can be of great use for any city, and particularly for Montreal, when trying to increase the modal share and the usage of bicycle as a mode of transportation. Indeed, the importance of safety perception has been shown again, but nuanced in an important way by indicating that the perception of safety can vary from one infrastructure type to the other and that it is important to make cyclists feel safe on every street, not only on dedicated bicycle paths. Also, currently, more male are using a bicycle to get to work, which previous studies have explained by citing risk aversion of female. However, this study showed that there was still a difference between male and female when controlling for safety and that female were cycling more for utilitarian trips other than commutes. This means that there are targeted interventions that could easily be put in place to encourage female to cycle more often to work.

If city wants to encourage bicycle usage, they should do it in a methodical and calculated way. Budgets are tight, cycling is still a very polarized issue, and every dollar spent should have the biggest possible impact. Different stakeholders can participate in this effort. As the low cost of cycling is a major motivator for people to cycle, governments and employers should put monetary incentives on bicycle usage. Workplaces should have facilities that allow people to change, shower and prepare for their day of work after a bicycle ride.

Finally, a very important point in order to both increase the frequency of usage and the safety for cyclists is to create campaigns to change the perception of cycling and cyclists in general to make it be seen as a legitimate mode of transportation.

REFERENCES

Agence Métropolitaine de Transport. (2008). *Enquête Origine-Destination. Région Métropolitaine de Montréal*.

Banister, D., Pucher, J., & Lee-Gosselin, M. (2007). Making sustainable transport politically and publicly acceptableL Lessons from the EU, USA and Canada. In P. Rietveld & R. Stough (Eds.), *Institutions and Sustainable Transport: Regulatory Reform in Advanced Economies* (pp. 17-50). Cheltenham: Edward Edgar Publishing.

Bergstrom, A., & Magnusson, R. (2003). Potential of transferring car trips to bicycle during winter. *Transportation Research Part A: Policy and Practice, 37*(8), 649-666.

Bergström, A., & Magnusson, R. (2003). Potential of transferring car trips to bicycle during winter. *Transportation Research Part A: Policy and Practice, 37*(8), 649-666.

Bhat, C., Sen, S., & Eluru, N. (2009). The impact of demographics, built environement attributes vehicle characteristics, and gasoline prices on household vehicle holding and use. *Transportation Research Part B: Methodological, 43*(1), 1-18.

Börjesson, M., & Eliasson, J. (2012). The value of time and external benefits in bicycle appraisal. *Transportation Research Part A: Policy and Practice, 46*(4), 673-683.

Broach, J., Dill, J., & Gliebe, J. (2012). Where do cyclists ride? A route choice model developed with revealed preference GPS data. *Transportation Research Part A: Policy and Practice, 46*(10), 1730-1740.

Carver, A., Timperio, A., Hesketh, K., & Crawford, D. (2010). Are children and adolescents less active if parents restrict their physical activity and active transport due to perceived risk? *Social science & medicine, 70*(11), 1799-1805.

Cervero, R., & Kockelman, K. (1997). Travel demand and the 3Ds: Density, diversity, and design. *Transportation Research Part D: Transport and Environment, 2*(3), 199-219. doi: http://dx.doi.org/10.1016/S1361-9209(97)00009-6

Cleary, J., & McClintock, H. (2000). The Nottingham cycle-friendly employers project: Lessons for encouraging cycle commuting. *Local Environment, 5*(2), 217-222. doi: 10.1080/13549830050009364

Copenhagenize Design Co. (Producer). (2013). The Copenhagenize index 2013: Bicycle friendly cities.

Daley, M., & Rissel, C. (2011). Perspectives and images of cycling as a barrier or facilitator of cycling. *Transport Policy, 18*(1), 211-216. doi: http://dx.doi.org/10.1016/j.tranpol.2010.08.004

Damant-Sirois, G., Grimsrud, M., & El-Geneidy, A. (2014). What's your type: a multidimensional cyclist typology. *Transportation*, 1-17. doi: 10.1007/s11116-014-9523-8

de Geus, B., De Bourdeaudhuij, I., Jannes, C., & Meeusen, R. (2008). Psychosocial and environmental factors associated with cycling for transport among a working population. *Health Education Research, 23*(4), 697-708.

Dill, J., & Carr, T. (2003). Bicycle commuting and facilities in major U.S. cities: If you build them, commuters will use them. *Transportation Research Record, 1828*, 116-123.

Dill, J., & McNeil, N. (2013). *Four types of cyclists? Examining a typology to better understand bicycling behavior and potential*. Paper presented at the Transportation Research Board Annual Meeting, Washington DC.

Dill, J., & Voros, K. (2007). Factors affecting bicycling demand: initial survey findings from the Portland, Oregon, region. *Transportation Research Record: Journal of the Transportation Research Board*(2031), 9-17.

Dillman, D., Smyth, J., & Christian, L. (2009). *Internet, mail and mixed-mode surveys: The tailored design method, third edition*. Hoboken, NJ: John Wiley and Sons, Inc.

Emond, C. R., & Handy, S. L. (2012). Factors associated with bicycling to high school: insights from Davis, CA. *Journal of Transport Geography, 20*(1), 71-79.
Fernández-Heredia, Á., Monzón, A., & Jara-Díaz, S. (2014). Understanding cyclists' perceptions, keys for a successful bicycle promotion. *Transportation Research Part A: Policy and Practice, 63*, 1-11.
Fraser, S., & Lock, K. (2011). Cycling for transport and public health: A systematic review of the effect of the environment on cycling. *The European Journal of Public Health, 21*(6), 738-743.
Garrard, J. (2003). Healthy revolutions: Promoting cycling among women. *Health Promotion Journal of Australia, 14*(3), 213-215.
Gatersleben, B., & Haddad, H. (2010). Who is the typical bicyclist? *Transportation Research Part F: Traffic Psychology and Behaviour, 13*(1), 41-48.
Geller, R. (2006). *Four types of cyclists*. Portland, OR: Retrieved from http://www.portlandoregon.gov/transportation/article/264746.
Gordon-Larsen, P., Nelson, M., & Beam, K. (2005). Associations among active transportation, physical activity, and weights status in young adults. *Diet and Physical Activity, 13*(5), 868-875.
Guttenplan, M., Davis, B., Steiner, R., & Miller, D. (2007). Planning-level areawide multimodal level-of-service analysis: Performance measures for congestion management. *Transportation Research Record, 1858*(2003), 61-68.
Handy, S., Cao, X., & Mokhtarian, P. (2005). Correlation or causality between the built environment and travel Behavior? Evidence from Northern California. *Transportation Research Part D: Transport and Environment, 10*(6), 427-444.
Handy, S., & Xing, Y. (2010). Factors correlated with bicycle commuting: A study in six small U.S. cities. *International Journal of Sustainable Transportation, 5*(2), 91-110. doi: 10.1080/15568310903514789
Heinen, E., Maat, K., & van Wee, B. (2011). The role of attitudes toward characteristics of bicycle commuting on the choice to cycle to work over various distances. *Transportation Research Part D: Transport and Environment, 16*(2), 102-109.
Heinen, E., van Wee, B., & Maat, K. (2010). Commuting by bicycle: An overview of the literature. *Transport reviews, 30*(1), 59-96.
Jacobsen, P. (2003). Safety in numbers: More walkers and bicyclists, safer walking and bicycling. *Injury Prevention, 9*(3), 205-209. doi: 10.1136/ip.9.3.205
Jacques, C., Manaugh, K., & El-Geneidy, A. (2012). Rescuing the captive [mode] user: An alternative approach to transport market segragation. *Transportation, 40*(3), 625-645.
Jensen, M. (1999a). Passion and hearth in transport - a Sociological analysis on transport behaviour. *Transport Policy, 6*, 19-33.
Jensen, M. (1999b). Passion and hearth in transport: A Sociological analysis on transport behaviour. *Transport Policy, 6*, 19-33.
Johansson, M. (2006). Environment and parental factors as determinants of mode for children's leisure travel. *Journal of Environmental Psychology, 26*(2), 156-169. doi: http://dx.doi.org/10.1016/j.jenvp.2006.05.005
Kitamura, R., Mokhtarian, P., & Laidet, L. (1997a). A micro-analysis of land use and travel in five neighborhoods in San Francisco Bay area. *Transportation, 24*(2), 125-158.
Kitamura, R., Mokhtarian, P., & Laidet, L. (1997b). A micro-analysis of land use and travel in five neighborhoods in the San Francisco Bay Area. *Transportation, 24*(2), 125-158.
Krizek, K., & El-Geneidy, A. (2007). Segmenting preferences and habits of transit users and non-users. *Journal of Public Transportation, 10*(3), 71-94.
Krizek, K., El-Geneidy, A., & Thompson, K. (2007). A detailed analysis of how an urban trail system affects cyclists' travel. *Transportation, 34*(5), 611-624.

Krizek, K., Johnson, P., & Tilahun, N. (2005). Gender differences in bicycling behavior and facility preferences. *Research on Women's Issues in Transportation Ed. S Rosenbloom (Transportation Research Board, Washington, DC) pp*, 31-40.

Kroesen, M., & Handy, S. (2013). The relation between bicycle commuting and non-work cycling: results from a mobility panel. *Transportation*, 1-21. doi: 10.1007/s11116-013-9491-4

Landis, B., Vattikuti, V., & Brannick, M. (1997). Real-time human perceptions: Toward a bicycle level of service. *Transportation Research Record*(1578), 119-126.

Landsberg, B., Plachta-Danielzik, S., Much, D., Johannsen, M., & Lange, D. (2008). Association between active commuting to school, fat mass and lifestyle factors in adolescents: the Kiel Obesity Prevention Study (KOPS). *European Journal of Clinical Nutrition, 62*, 739-747.

Larsen, J., & El-Geneidy, A. (2011). A travel behavior analysis of urban cycling facilities in Montreal Canada. *Transportation Research Part D: Transport and Environment, 16*(2), 172-177.

Lee, J., Nam, J., & Lee, S. (2012). Built environment impacts on individual mode choice: An empirical study of the Houston-Galveston metropolitan area. *International Journal of Sustainable Transportation*, null-null. doi: 10.1080/15568318.2012.716142

Li, Z., Wang, W., Yang, C., & Ragland, D. (2013). Bicycle commuting market analysis using attitudinal market segmentation approach. *Transportation Research Part A: Policy and Practice, 47*, 56-68.

Manaugh, K., & El-Geneidy, A. (2011). Validating walkability indices: How do different households respond to the walkability of their neighbourhood? *Transportation Research Part D: Transport and Environment, 16*(4), 309-315.

Manaugh, K., & El-Geneidy, A. (2012). What makes travel “local”: Defining and understanding local travel behavior. *The Journal of Transport and Land Use, 5*(3), 15-27.

Menghini, G., Carrasco, N., Schüssler, N., & Axhausen, K. (2010). Route choice of cyclists in Zurich. *Transportation Research Part A: Policy and Practice, 44*(9), 754-765.

Moudon, A., Lee, C., Cheadle, A., Collier, C., Johnson, D., Schmid, T., & Weather, R. (2005). Cycling and the built environment, a US perspective. *Transportation Research Part D: Transport and Environment, 10*(3), 245-261.

Nankervis, M. (1999). The effect of weather and climate on bicycle commuting. *Transportation Research Part A: Policy and Practice, 33*(6), 417-431. doi: http://dx.doi.org/10.1016/S0965-8564(98)00022-6

Nkurunziza, A., Zuidgeest, M., & Van Maarseveen, M. (2012). Identifying potential cycling market segments in Dar-es-Salaam, Tanzania. *Habitat International, 36*(1), 78-84. doi: http://dx.doi.org/10.1016/j.habitatint.2011.06.002

O’Connor, J., & Brown, T. (2010). Riding with the sharks: serious leisure cyclist's perceptions of sharing the road with motorists. *Journal of Science and Medicine in Sport, 13*(1), 53-58.

Panter, J., Jones, A., van Sluijs, E., & Griffin, S. (2010). Attitudes, social support and environmental perceptions as predictors of active commuting behaviour in school children. *Journal of epidemiology and community health, 64*(1), 41-48. doi: 10.1136/jech.2009.086918

Parkin, J., Wardman, M., & Page, M. (2008). Estimation of the determinants of bicycle mode share for the journey to work using census data. *Transportation, 35*(1), 93-109.

Pinjari, A., Bhat, C., & Hensher, D. (2009). Residential self-selection effects in an activity time-use behavior model. *Transportation Research Part B: Methodological, 43*(7), 729-748.

Pucher, J., & Buehler, R. (2008). Making cycling irresistible: lessons from the Netherlands, Denmark and Germany. *Transport Reviews, 28*(4), 495-528.

Reynolds, C., Winters, M., Ries, F., & Gouge, B. (2010). Active transportation in urban areas: Exploring health benefits and risks. *National Collaboration Centre for Environmental Health*, 1-15.

Richardson, A. (2006). Estimating Bicycle Usage on a National Cycle Network. *Transportation Research Record: Journal of the Transportation Research Board*(1982), 166-173. doi: 10.3141/1982-22

Rietveld, P., & Daniel, V. (2004). Determinants of bicycle use: do municipal policies matter? *Transportation Research Part A: Policy and Practice, 38*(7), 531-550.
Ryley, T. (2006). Use of non-motorised modes and life stage in Edinburgh. *Journal of Transport Geography, 14*(5), 367-375.
Statistics Canada. (2006). *Canadian Census*.
Statistics Canada. (2011). *Canadian Census*.
Stinson, M., & Bhat, C. (2004). Frequency of bicycle commuting: Internet-based survey analysis. *Transportation Research Record*(1878), 122-130. doi: 10.3141/1878-15
Tal, G., & Handy, S. (2008). Children's biking for non-school purposes: Getting to soccer games in Davis, CA. *Transportation Research Record*(2074), 40-45.
Tilahun, N., Levinson, D., & Krizek, K. (2007). Trails, lanes, or traffic: Valuing bicycle facilities with an adaptive stated preference survey. *Transportation Research Part A: Policy and Practice, 41*(4), 287-301.
Titze, S., Stronegger, W., Janschitz, S., & Oja, P. (2007). Environmental, social, and personal correlates of cycling for transportation in a student population. *Journal of physical activity & health, 4*(1).
Underwood, S., & Handy, S. (2012). Adolescent attitudes toward active transportation: Bicycling in youth in retrospect from adulthood: University of California, California.
van Exel, N., & Rietveld, P. (2010). Perceptions of public transport travel time and their effect on choice-sets among car drivers. *Journal of Transport and Land Use, 2*(3), 75-86.
van Lierop, D., Grimsrud, M., & El-Geneidy, A. (2013). Breaking into bicycle theft: Insights from Montreal, Canada. *Internation Journal of Sustainable Transportation*(Accepted).
Vélo Québec. (2010). L'état du vélo au Québec en 2010: zoom sur Montréal. In V. Québec (Ed.), *L'état du vélo au Québec* (pp. 28). Montréal: Vélo Québec.
Ville de Montréal. (2008). *Réinventer Montréal: Plan de transport 2008*. Montréal.
Vredin Johansson, M., Heldt, T., & Johansson, P. (2006). The effects of attitudes and personality traits on mode choice. *Transportation Research Part A: Policy and Practice, 40*(6), 507-525.
Wardman, M., Tight, M., & Page, M. (2007). Factors influencing the propensity to cycle to work. *Transportation Research Part A: Policy and Practice, 41*(4), 339-350.
Wegman, F., Zhand, F., & Dijkstrat, A. (2012). How to make more cycling good for road safety. *Accident Analysis and Prevention, 44*(1), 19-29.
Woodcock, J., Edwards, P., Tonne, C., Armstrong, B., Ashiru, O., Banister, D., . . . Roberts, I. (2009). Public health benefits of strategies to reduce greenhouse-gas emissions: Urban land transport. *www.thelancet.com, 374*(9705), 1930-1943.
Xing, Y., Handy, S., & Buehler, T. (2008). *Factors associated with bicycle ownership and use: A study of 6 small US cities.* Paper presented at the Annual Meeting of the Transportation Research Board, Washington, DC.
Xing, Y., Handy, S., & Mokhtarian, P. (2010). Factors associated with proportions and miles of bicycling for transportation and recreation in six small US cities. *Transportation Research Part D: Transport and Environment, 15*(2), 73-81.

Montreal Cycling Survey

The inter-disciplinary research group Transportation Research at McGill (TRAM) is currently undertaking research aiming to understand **the needs and behavior of cyclists** in Montreal. The previous surveys conducted by our group were successful in capturing the concerns of cyclists and in the establishment of several campaigns across Montreal as well as raising the collective points of views of cyclists to various groups in Montreal.

Some sections of the survey are not compatible with tablets and smart phones. Please use a personal computer to fill out the survey.

This survey builds on our previous studies trying to gather information regarding **safety, bicycling culture, infrastructure needs, seasonality, and Bixi use**. Since the City of Montreal has heavily invested in cycling infrastructure and campaigns since our last behavior survey in 2010, your participation is greatly appreciated, as it will help develop recommendations on how to further encourage and improve bicycling in Montreal. The project is led by Gabriel Damant-Sirois and Michael Grimsrud, Master of Urban Planning candidates, under the supervision of Ahmed El-Geneidy, Associate Professor with the School of Urban Planning.

This short survey will take approximately **15 minutes** to complete. Participation is voluntary, and you may exit the survey at any time. The findings of the survey may be presented to different stakeholders in Montreal to help in raising the concerns of cyclists and indicating their preferences. Other research resulting from the survey may be published in various academic journals and at conferences. All survey responses will remain confidential, stored on password-protected computers, and participants will not be identified in any publications or reports. The data may be kept for future research purposes. You might notice some repetition from previous surveys because we are not linking respondents between surveys and thus cannot automatically enter information.

Consent to be included in the study

By submitting the survey responses, you indicate consent for inclusion in this study. If you provide your email address at the end of the survey, the data will be immediately anonymized upon the receipt of the data. Because the data will be anonymous, once you have submitted your responses, it is no longer possible to withdraw from the study. Participants are encouraged to print a copy of this form for future reference.

If you have any questions or concerns regarding this research project, please send an email to

tram@mcgill.ca. If you need urgent assistance, you may call TRAM at 514-398-4058.

There are 92 questions in this survey

General information

1 During the past year have you made at least one trip using a bicycle (including Bixi) in Montreal? *

Please choose **only one** of the following:

- ○ Yes
- ○ No, but I have in other years
- ○ No, I never used a bicycle

2 Why do you choose not to cycle? *

Please choose **all** that apply:

- ☐ I don’t feel safe cycling
- ☐ I don’t know how to cycle
- ☐ I don’t feel comfortable cycling
- ☐ The infrastructure is not adequate
- ☐ There are too many cars around
- ☐ There are too many cyclists around
- ☐ The distance is too long to reach my desired destination
- ☐ My culture restricts me from cycling
- ☐ I don’t like the clothes required to cycle
- ☐ I am out of shape
- ☐ It requires too much effort
- ☐ I can't afford to buy a bicycle
- ☐ I can’t take my children with me on trips
- ☐ Other

3 If other, please specify

Please write your answer here:

4 Have you ever used a Bixi? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

5 For us to better understand your travel behaviour please identify your approximate home location by: *

Please choose **only one** of the following:

- ○ Placing a pin on a map
- ○ Entering your home postal code

6 Please adjust the zoom and place the pin by right-clicking on your current home location or by dragging it to this location: *

Please write your answer here:

7 Please enter your current home postal code: (Example: H3A 0C2) *

Please write your answer here:

Cycling behavior

The following section will help us to better understand the travel behavior of Montreal's cyclists. Information about actual bicycle use, such as cycling trip frequencies, purposes and conditions that affect use, can support recommendations for bicycle infrastructure improvement.

8 When you travel for these purposes, how often do you travel by bicycle (including Bixi)? *

Please choose the appropriate response for each item:

	Never	Rarely	Sometimes	Often	Always	Not applicable
To go to work or school	○	○	○	○	○	○
To go grocery shopping	○	○	○	○	○	○
To go shopping (non-grocery)	○	○	○	○	○	○
To go to a restaurant, café, or bar	○	○	○	○	○	○

9 Please adjust the zoom and place the pin (by dragging it or by right-clicking) on the place that you most often go to work or school by bicycle:

Please write your answer here:

10 Please adjust the zoom and place the pin (by dragging it or by right-clicking) on the place that you most often go to do grocery shopping by bicycle or by dragging it to this location: *

Please write your answer here:

11 Approximately how much money did you spend the last time you went to a grocery store by bicycle? (round to the nearest dollar) (optional)

Please write your answer here:

12 Please adjust the zoom and place the pin (by dragging it or by right-clicking) on the general area in which you most often go shopping (non-grocery) by bicycle: *

Please write your answer here:

13 Approximately how much money did you spend the last time you went shopping (non-grocery) by bicycle? (round to the nearest dollar) (optional)

Please write your answer here:

14 Approximately how much money did you spend the last time you went to a restaurant, café or bar by bicycle? (round to the nearest dollar) (optional)

Please write your answer here:

15 When you travel without using a bicycle (including Bixi), what are the other mode(s) of transportation that you sometimes use?

Please choose **all** that apply:

- ☐ Walking
- ☐ Public transit
- ☐ Private motor vehicle
- ☐ Taxi
- ☐ Carshare (example: Communauto)
- ☐ Carpool
- ☐ Other:

16 To what extent do you agree with the following statements? I don't cycle when: *

Please choose the appropriate response for each item:

	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
It's too hot or humid	○	○	○	○	○
It's too cold	○	○	○	○	○
There is snow because of the additional effort	○	○	○	○	○
There is ice or snow because of the danger of slipping	○	○	○	○	○
Bixis are unavailable	○	○	○	○	○
It's raining	○	○	○	○	○
I think it will be difficult to find parking near my destination	○	○	○	○	○
I have to carry bags or heavy loads	○	○	○	○	○
The route I have to take is too steep	○	○	○	○	○

Cycling history, motivations and habits

The following section will allow us to study the impacts of cyclists' history and motivations to cycle. Information from this section can influence policies to encourage and facilitate future cycling campaigns in Montreal.

17 Did you start cycling as a child? *

Please choose **only one** of the following:

- ○ Yes

- ○ No

18 To what extent your parent(s) or guardian(s) actively encouraged or discouraged you to cycle: *

Please choose the appropriate response for each item:

	Actively discouraged	Somewhat discouraged	Neither encouraged nor discouraged	Somewhat encouraged	Actively encouraged
As a way to reach destinations (eg. School, library, friend's house, etc.)?	○	○	○	○	○
As a sport or recreational activity?	○	○	○	○	○

19 How would you characterize the environment where you grew up? *

Please choose **only one** of the following:

- ○ Urban
- ○ Suburban
- ○ Rural

20 How would you characterize the cycling culture where you grew up? *

Please choose **all** that apply:

- ☐ Most children cycled sometimes
- ☐ Bicycles were seen as a common mode of transportation for adults
- ☐ Driving a car was a normal and important part of becoming an adult
- ☐ Cars were important symbols of social status
- ☐ Transit was seen as a common mode of transportation for most people

21 Where did you learn about bicycle safety? *

Please choose **all** that apply:

- ☐ Parents
- ☐ Friends
- ☐ School

- ☐ On my own
- ☐ Popular media
- ☐ Government media
- ☐ Bicycle or sports shop
- ☐ Other

22 If other, please specify

Please write your answer here:

23 For how long have you been cycling regularly? *

Please choose **only one** of the following:

- ○ I don’t use my bicycle regularly
- ○ Less than a year
- ○ 1 year
- ○ 2 years
- …

24 How many times have you: (please enter a whole number) *

	Number of accident(s)
Been hit by an opening car door	
Had a collision with a car	
Had a collision with a pedestrian or an accident due to avoiding a pedestrian	
Had a collision with a cyclist or an accident due to avoiding a cyclist	
Fallen due to poor condition of pavement	

25 Was the accident(s) reported? *

Please choose **only one** of the following:

- ○ No, none of them
- ○ Few of them
- ○ Some of them
- ○ Most of them
- Yes, all of them

26 Have you ever received a ticket when riding your bicycle? *

Please choose **only one** of the following:

- ○ Yes
- ○ No
- ○ I prefer not to answer

27 How important are these factors in your decision to cycle now? *

Please choose the appropriate response for each item:

	Very unimportant	Unimportant	Neither important nor unimportant	Important	Very important
Health reasons	○	○	○	○	○
Environmental reasons	○	○	○	○	○
Cost of cycling	○	○	○	○	○
It's the fastest way to get from A to B	○	○	○	○	○
Flexibility for multiple trips	○	○	○	○	○
Flexibility of my departure time	○	○	○	○	○
Predictability of travel time	○	○	○	○	○
My employer / school encourages cycling	○	○	○	○	○
My classmates / coworkers cycle	○	○	○	○	○
It's part of my self-identity/culture	○	○	○	○	○
Cycling is fun	○	○	○	○	○

28 Did you stop cycling for at least 2 years as an adult and resume? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

29 Did you stop cycling when you were a child and resume as an adult? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

30 Which factors contributed to you resuming cycling as an adult? *

Please choose **all** that apply:

- ☐ Improvement of bicycle network
- ☐ Improvement of bicycle facilities at main destinations
- ☐ Introduction of Bixi system
- ☐ Change home location
- ☐ Change of family / household composition
- ☐ Change job type or location
- ☐ Change of attitude about cycling
- ☐ Influence of friends or colleagues
- ☐ Other

31 If other, please specify:

Please write your answer here:

32 How often do you wear a helmet when using a Bixi? *

Please choose **only one** of the following:

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Most of the time
- ○ All the time

33 How often do you wear a helmet when cycling (not Bixi)? *

Please choose **only one** of the following:

- ○ Never
- ○ Rarely
- ○ Sometimes
- ○ Most of the time
- ○ All the time

Infrastructure

The following section asks which kinds of infrastructure cyclists currently use in Montreal and which ones are seen as the safest and most convenient. This section also directly asks cyclists which types of investments and improvements are the most important and which locations are in most need of attention.

34 The city of Montreal has many types of bicycle paths and lanes. How would you rate each bicycle path or lane type?

Bi-directional off-street path:

*

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

35 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

36 Bi-directional path physically separated from street by curb, post, or wide space:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

37 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

38 Painted lanes going in the SAME direction as traffic:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

39 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

40 Painted lanes going in the OPPOSITE direction as traffic:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

41 When you travel to work / school by bicycle do you usually use the type of facility shown above?

Please choose **only one** of the following:

- ○Yes
- ○No

42 Painted bicycle symbols indicating presence of bicycles:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

43 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

44 Sidewalk shared with pedestrians separated by paint:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

45 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

46 Calm residential street with no bicycle infrastructure:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

47 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

48 Main artery without bicycle infrastructure:

Please choose the appropriate response for each item:

	Very bad	Bad	Neither good nor bad	Good	Very good	No opinion
Speed	○	○	○	○	○	○
Safety at intersections	○	○	○	○	○	○
Safety while riding between intersections	○	○	○	○	○	○

49 When you travel to work / school by bicycle do you usually use the type of facility shown above? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

Route and investment

50 How important are the following factors in making a good bicycle route? *

Please choose the appropriate response for each item:

	Very unimportant	Unimportant	Neither important nor unimportant	Important	Very important
Low number of parked cars	○	○	○	○	○
Low number of cars driving	○	○	○	○	○
Low speed of cars	○	○	○	○	○
Presence of a bicycle path with a physical barrier	○	○	○	○	○
Continuous bicycle route	○	○	○	○	○
Directness to my destination	○	○	○	○	○
Attractive or interesting surrounding environment	○	○	○	○	○
Bicycle-specific signage	○	○	○	○	○
Low number of crossing streets	○	○	○	○	○
Flat route	○	○	○	○	○

51 Is there a street in Montreal that is in most need of a bicycle path or lane? *

Please choose **only one** of the following:

- ○ Yes
- ○ No

52 What street in Montreal is in most need of a bicycle path or lane?

Please write your answer here:

53 From (cross-street):

Please write your answer here:

54 To (cross-street):

Please write your answer here:

55 Do you know how to use a bicycle box?

Please choose **only one** of the following:

- ○ Yes
- ○ No

56 How important are the following factors in making an intersection good for cyclists? *

Please choose the appropriate response for each item:

	Very unimportant	Unimportant	Neither important nor unimportant	Important	Very important
Signage at intersections to make drivers aware of the presence of cyclists	○	○	○	○	○

Markings on the pavement indicating the presence of cyclists	○	○	○	○	○
Presence of a bicycle box	○	○	○	○	○
Long distance between the nearest parked car and the intersection	○	○	○	○	○
Separated crossing lights for cars and bicycles	○	○	○	○	○

57 What intersection in Montreal is in most need of improvements for cyclists? (optional) On the following map, please adjust the zoom and place the pin by right-clicking on this intersection or by dragging it to this location:. (Be as precise as possible please)

Please write your answer here:

58 How important are the following general strategies for improving cycling in Montreal? *

Please choose the appropriate response for each item:

	Very unimportant	**Unimportant**	**Neither important nor unimportant**	**Important**	**Very important**	**No opinion**
Expanding the reach of the bicycle infrastructure network	○	○	○	○	○	○
Improving connection between existing bicycle paths and lanes	○	○	○	○	○	○

Making the intersections safer	○	○	○	○	○	○
Increasing the quantity and quality of dedicated bicycle parking	○	○	○	○	○	○
Improving / expanding the Bixi system	○	○	○	○	○	○
Increasing bicycle safety awareness among cyclists	○	○	○	○	○	○
Increasing bicycle safety awareness among other street users	○	○	○	○	○	○

59 How satisfied are you with the current investment in cycling infrastructure taking place in Montreal? *

Please choose **only one** of the following:

- ○ Very dissatisfied
- ○ Somewhat dissatisfied
- ○ Neither satisfied nor dissatisfied
- ○ Somewhat satisfied
- ○ Very satisfied
- ○ No opinion

60 How effective are the current cycling awareness campaigns taking place now in Montreal? *

Please choose **only one** of the following:

- ○ Very ineffective
- ○ Ineffective
- ○ Neither effective or ineffective
- ○ Effective
- ○ Very effective

- ○ No opinion

61 To what extent do you agree with that sentence: "decision makers (eg. City of Montreal, STM, Ministère des transports du Québec, etc.) consult cyclists enough about relevant transportation issues"? *

Please choose **only one** of the following:

- ○ Completely disagree
- ○ Somewhat disagree
- ○ Neither agree nor disagree
- ○ Somewhat agree
- ○ Completely agree
- ○ No opinion

62 How could consultation about relevant transportation issues best be improved? *

Please choose **only one** of the following:

- ○ Public meetings
- ○ Internet forums
- ○ Surveys
- ○ Government consultation with bicycle advocacy groups
- ○ Other

63 If other, please specify:

Please write your answer here:

Bixi

64 How often do you usually use a Bixi ? *

Please choose **only one** of the following:

- ○ I don’t use Bixi now
- ○ Once or twice a month
- ○ 1 day per week
- ○ 2 days per week
- ○ 3 days per week
- ○ 4 days per week
- ○ 5 days per week
- ○ 6 days per week
- ○ 7 days per week

65 When you use Bixi, what type of Bixi membership do you usually use? *

Please choose **only one** of the following:

- ○Pay-per-use 24 hours
- ○Pay-per-use 72 hours
- ○30 days
- ○Annual

66 If there was no Bixi system which other mode would you use most for trips currently made by Bixi? *

Please choose **only one** of the following:

- ○Walking
- ○Bicycle
- ○Public transit
- ○Car, truck, motorcycle, etc.
- ○Taxi

67 When you use Bixi, why do you use it instead of a personal bicycle? *

Please choose **all** that apply:

☐Avoid hassle of maintaining a bicycle
☐I don't own a bicycle
☐I don't have space to store a bicycle when not in use
☐It's convenient to use in conjunction with public transportation
☐Attractive design of Bixis
☐It's practical to use a Bixi for a one-way trip
☐Avoid the risk of theft
☐Other

68 If other, please specify:

Please write your answer here:

69 How satisfied are you with the Bixi system? *

Please choose **only one** of the following:

- ○Very dissatisfied
- ○Somewhat dissatisfied
- ○Neither satisfied nor dissatisfied
- ○Somewhat satisfied
- ○Very satisfied

- No opinion

70 What would improve the Bixi system the most? *

Please choose **only one** of the following:

- ○ More stations
- ○ More bicycles
- ○ More parking slots
- ○ Lower cost
- ○ Better bicycle design
- ○ Other
- ○ No opinion

71 If other, please specify:

Please write your answer here:

72 How often do you use Bixi location apps? *

Please choose **only one** of the following:

- ○ Every time I use Bixi
- ○ Most of the time I use Bixi
- ○ Sometimes when I use Bixi
- ○ Rarely when I use Bixi
- ○ Never

Personal Profile

The following section will help us to better understand social and demographic characteristics of Montreal's cyclist population. This information can enable us to give recommendations on new cycling investment adapted to the people it will most affect.

73 Where were you born? Please select the country: *

Please choose **only one** of the following:

74 If other, please specify:

Please write your answer here:

75 Please specify the province or territory: *

Please choose **only one** of the following:

76 Please specify the state, district or territory: *

Please choose **only one** of the following:

77 How would you characterize the cycling culture where you live now? *

Please choose **all** that apply:

- ☐ Most children cycle sometimes
- ☐ Bicycles are seen as a common mode of transportation for adults
- ☐ Driving a car is a normal and important part of becoming an adult
- ☐ Cars are important symbols of social status
- Public transit is seen as a common mode of transportation for most people

78 How cycle-friendly is your current neighborhood in terms of infrastructure? *

Please choose **only one** of the following:

- ○ Not at all cycle-friendly
- ○ Slightly cycle-friendly
- ○ Moderately cycle-friendly
- ○ Very cycle-friendly
- Extremely cycle-friendly

79 When you moved into your current residence, how important were the following factors in your decision? *

Please choose the appropriate response for each item:

	Very unimportant	**Unimportant**	**Neither important nor unimportant**	**Important**	**Very important**	**No opinion**
Proximity to work / school	○	○	○	○	○	○
Bicycle infrastructure in this area	○	○	○	○	○	○
Proximity to shopping and services	○	○	○	○	○	○
Proximity to public transportatio	○	○	○	○	○	○

n						
Calm neighborhood	○	○	○	○	○	○
Vibrant neighborhood	○	○	○	○	○	○
Close to family or friends	○	○	○	○	○	○
Spacious home	○	○	○	○	○	○

80 For how long have you been living in your current residence? *

Please choose **only one** of the following:

81 Are you (or someone of your household)? *

Please choose **only one** of the following:

- ○Tenant
- ○Owner

82 How many people are in your household including yourself? *

Please choose **only one** of the following:

- ○1
- ○2
- ○3
- ○4
- ○5
- ○6
- ○7
- ○8
- ○9
- ○10
- ○More than 10

83 How many motor vehicles are owned in your household? *

Please choose **only one** of the following:

- ○0
- ○1
- ○2
- ○3

- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ More than 10

84 To what extent are you actively encouraging or discouraging your children to cycle : *

Please choose the appropriate response for each item:

	I don't have any children	Actively discourage	Somewhat discourage	Neither encourage nor discourage	Somewhat encourage	Actively encourage
As a way to reach destinations (eg. School, library, friend's house, etc.)?	○	○	○	○	○	○
As a sport or recreational activity?	○	○	○	○	○	○

85 How many family members under the age 16 are in your household? *

Please choose **only one** of the following:

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4
- ○ 5
- ○ 6
- ○ 7
- ○ 8
- ○ 9
- ○ 10
- ○ More than 10

86 You are: *

Please choose **only one** of the following:

- ○Male
- ○Female
- ○Prefer not to answer

87 What year were you born? *

Please choose **only one** of the following:

88 You are: *

Please choose **only one** of the following:

- ○Employed full-time
- ○Employed part-time
- ○Unemployed
- ○A student
- ○Retired
- ○Other

89 What was your household income in 2012? *

Please choose **only one** of the following:

- ○$20,000 or less
- ○Between $20,001 - $40,000
- ○Between $40,001 - $60,000
- ○Between $60,001 - $80,000
- ○Between $80,001 - $100,000
- ○Between $100,001 - $120,000
- ○More than $120,000
- ○Prefer not to answer

90 What is the highest level of education that you have completed? *

Please choose **only one** of the following:

- ○No formal education
- ○Elementary school
- ○High school
- ○CEGEP
- ○Diploma
- ○Undergraduate degree
- ○Graduate degree
- ○Other

91 Do you have any other comments or concerns about traveling by bicycle in Montreal?Do you have any other comments or concerns about traveling by bicycle in Montreal?

Please write your answer here:

92

If you would like to be included in further research at Transportation Research at McGill, please provide us with your email address. Your email adress is confidential and will be in no way linked to the survey answers:

Please write your answer here:

Thank You!

Thank you for your participation in the Montreal Cycling Survey!
Transportation Research at McGill (TRAM) will use the results of this survey to build recommendations on how to further encourage the use of bicycle and improve the cycling experience in Montreal.

Findings from the survey will posted at
http://tram.mcgill.ca/cycling.html in fall 2013.

24.06.2013 – 00:00

Submit your survey.
Thank you for completing this survey.