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POLYTECHNIQUE MONTRÉAL

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Information and Perceptions of Safety on Mode Choice: Case Study of Urban Trips in Montreal

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Mémoire présenté en vue de l'obtention du diplôme de *Maîtrise ès sciences appliquées*

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Ce mémoire intitulé :

Information and Perceptions of Safety on Mode Choice: Case Study of Urban Trips in Montreal

présenté par **Jeremy DE SOUSA**

en vue de l'obtention du diplôme de *Maîtrise ès sciences appliquées*

a été dûment accepté par le jury d'examen constitué de :

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RÉSUMÉ

À mesure que les centres urbains se densifient et attirent davantage de population, il est essentiel de repenser les systèmes de transport afin de garantir la prise en compte de tous les aspects du développement durable. Plusieurs stratégies ont été mises en place pour favoriser un transfert modal, des véhicules privés vers des modes de transport partagés et durables. Ces stratégies comprennent la construction de nouvelles infrastructures, ce qui est très coûteux, ainsi que des mesures réglementaires et tarifaires, qui sont politiquement mal perçues. Par conséquent, des interventions moins coûteuses et politiquement acceptables seraient plus faciles à mettre en œuvre et pourraient permettre de réaliser le changement de mode de transport nécessaire dans les villes.

Le choix du mode de transport est complexe et dépend de nombreuses variables. La sécurité, la commodité, le coût et des facteurs extrinsèques tels que le bien-être physique et les préoccupations environnementales comptent parmi les éléments qui influencent ce choix. De plus, des outils de planification de trajet comme Google Maps sont utilisés quotidiennement par des millions de personnes avant de se déplacer. Aborder les facteurs qui influencent le choix du mode de transport par le biais de « nudges » dans un outil de planification de trajet pourrait donc orienter les choix vers des modes plus durables.

Le temps de trajet est un facteur important dans le choix du mode de transport et constitue souvent un indicateur clé de la performance en ingénierie du trafic, notamment à travers des mesures telles que le « niveau de service ». Le temps de trajet est fondamentalement lié à la vitesse de déplacement, qui est directement liée aux risques routiers. Les vitesses élevées des véhicules sont souvent considérées comme un facteur limitant pour les modes de déplacement actifs, tels que la marche. Comme l'accès aux transports en commun se fait généralement à pied, la limitation des dangers liés à la circulation dus à la vitesse est une considération importante. Ces deux aspects étant en tension, il est important de comprendre lequel des deux doit être privilégié du point de vue de la société. Compte tenu de la prédominance de la voiture dans les transports, le terme «motonormativity» ou motonormativité a été créé pour désigner le préjugé favorable aux voitures dont les gens font preuve en raison de leur présence dans la vie quotidienne. Ce phénomène peut donc influencer le choix de modes de transport que les citoyens estiment devoir être limités.

Dans ce contexte, ce mémoire vise à répondre à deux questions de recherche principales. La première consiste à étudier l'effet de l'affichage d'informations dans un outil de planification de trajet sur les modes de déplacement. La deuxième question de recherche visait à examiner l'importance relative du temps de déplacement par rapport à la sécurité routière à partir des limites de vitesse proposées. Pour répondre à ces questions de recherche, une enquête a été créée et distribuée aux habitants de la région métropolitaine de Montréal. Le questionnaire comprenait deux expériences : une expérience de choix discret comportant huit traitements d'information et une expérience sur les opinions relatives aux limites de vitesse et à la motonormativité.

À l'aide de modèles logit mixtes, nous avons évalué sept « nudges » d'information et les avons examinés par rapport à un scénario de référence qui indiquait simplement la durée du trajet, à la manière des outils de planification de trajet actuels. Nous avons testé des incitations quantitatives telles que le coût du trajet et le coût du stationnement, ainsi que des incitations qualitatives incluant la qualité de l'air et des emojis. Les résultats ont montré que la présence de certaines informations peut augmenter la probabilité de se déplacer en voiture, même si l'effet marginal des traitements tend à réduire cette probabilité. Nous avons également constaté que les personnes multimodales réagissent mieux aux informations supplémentaires que celles qui se déplacent uniquement en voiture.

Deuxièmement, les réponses à notre enquête montrent que la grande majorité des personnes interrogées estime que la vitesse des véhicules motorisés (voitures et micro-mobilité électrique) devrait être limitée en présence de piétons. De plus, la grande majorité a indiqué que la sécurité était plus importante que le temps de trajet. Cependant, dans le cadre de la recherche sur la motonormativité, il a été observé que les personnes proposaient une vitesse plus faible pour les véhicules plus petits (micromobilité électrique), plus de 80 % d'entre elles expliquant que c'était en raison du danger que cela représentait pour les autres. Pour les voitures, une limite de vitesse moyenne plus élevée a été constatée. Parmi les personnes ayant répondu au sujet des voitures, même si elles constituent la majorité, seules 60 % ont déclaré que cette limitation était due au danger représenté pour les autres. Du point de vue d'un système sûr, cela pose problème car, compte tenu de ces vitesses moyennes et du poids typique des véhicules, l'énergie associée à la voiture est environ 24 fois supérieure à celle du véhicule de micromobilité électrique. Nous en concluons que les attitudes envers les limitations de vitesse sont davantage influencées par les normes sociales que par le risque réel.

Cette thèse comble une lacune dans la littérature en testant les effets des incitations dans un outil de planification de trajet, en tant que solution peu coûteuse et facile à mettre en œuvre pour favoriser un transfert modal vers des modes de transport plus durables. Elle démontre également que la grande majorité des personnes privilégient la sécurité par rapport au temps de trajet (un indicateur de la vitesse), mais du point de vue d'un système sûr, il existe une incohérence dans les limites proposées pour des véhicules beaucoup plus petits.

ABSTRACT

As urban centers grow and attract many people, it is essential to ensure all pillars of sustainability are considered. Several strategies have been adopted to produce a mode shift away from private vehicles towards sustainable modes of transport. These strategies include building new infrastructure, implementing regulations, and pricing. However, new infrastructure is costly, while the latter two are very difficult politically. Therefore, cheaper and politically neutral interventions would be easy to implement and have the potential to influence more sustainable choices.

Mode choices are complex and consider many variables. Safety, convenience, cost and extrinsic factors such as physical wellbeing and environmental concerns make up some of the factors that influence mode choice. Furthermore, trip planning tools such as Google Maps are used daily by millions before trips are made. Addressing the factors that influence mode choice through information nudges in a trip planning tool could therefore influence mode choice towards more sustainable modes.

Travel time is an important factor in transport mode decisions and is often a key metric of success in traffic engineering through metrics such as "level of service". Travel time is fundamentally linked to the speed of travel, which is directly linked to traffic danger. High vehicle speeds are often found to be a limiting factor for choices around active travel, such as walking. As public transit is typically accessed on foot, limiting traffic danger created by speeds is an important consideration. As these two are in tension, understanding which of the two should be prioritized from society's point of view is important. Given the dominance of the car in transport, a term motonormativity has been coined that signifies the bias people have towards cars as a result of their presence in daily lives. This phenomenon may therefore affect which modes people believe should be limited.

Considering this context, this thesis aims to address two main research questions. The first is to study the effect of displaying information in a trip planning tool on travel behaviour. The second research question was to examine the public's view of traffic safety in urban contexts, as traffic danger impacts sustainable mode usage. To address these research questions, a survey was created and distributed to inhabitants of the greater Montreal area. The survey contained two experiments: a discrete choice experiment that had eight information treatments and a motonormativity experiment on beliefs around speed limits and modes.

Using mixed logit models, we tested seven information nudges and compared them to a base case that simply contained travel time, similar to the current display in trip planning tools. We tested quantitative nudges such as travel cost and parking cost, along with qualitative nudges including air quality and emojis. The results showed that the presence of some nudges can increase the likelihood of travelling by car, despite the treatments' marginal effect decreasing the likelihood of travelling by car. We also found that multimodal individuals respond better to additional information than individuals who only travel by car.

Secondly, the survey responses show that the vast majority of people believe that motor vehicle speeds (both cars and e-micromobility) should be limited where there are pedestrians. Further, the vast majority indicated that safety is more important than travel time. However, the motonormativity aspect of the research found that people proposed a lower speed for the smaller vehicles (e-micromobility) of which over 80 % said it was because of the danger imposed on others. For cars, a higher average speed limit was found. For car respondents, although a majority, only 60 % of people said that it was because of the danger imposed on others. From a safe system perspective, this is problematic as, given those average speeds and typical weights of the vehicles, there is a difference of roughly 24 times more energy associated with the car than the e-micromobility (EM) vehicle. From this, we find that attitudes towards speed limits are more influenced by social norms than real-life risk.

This thesis fills a gap in the literature by testing the effects of nudges in a trip planning tool as a low-cost, easy-to-implement solution to create a modal shift towards more sustainable modes. It also demonstrates that the vast majority of people prioritize safety over travel time (a proxy for speed), but from a safe system perspective, there is an incoherence in the limits proposed for much smaller vehicles.

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LIST OF SYMBOLS AND ABBREVIATIONS

CO2	Carbon dioxide
DCE	Discrete choice experiment
EM	Electric micromobility
GHG	Greenhouse gas
OD	Origin-destination
TOD	Transit-oriented development

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CHAPTER 1 INTRODUCTION

Transportation plays an integral part in every person's life. Travelling, regardless of mode, has either a positive or negative impact on one's physical and mental health, along with significant impacts on the planet (Barreck, 2023). As a result, offering transport services that account for all pillars of sustainability (environmental, economic, social and cultural) has become a goal for cities given transport's significant impact on many spheres of society (Griggs et al., 2013; UNESCO, 2026). With urban areas expected to keep growing to host 68% of the world's population by 2050, it is more important than ever to have well-planned and well-maintained transport networks (United Nations, n.d.).

Among these sustainability concerns, road safety is a critical topic as it impacts three of the four pillars of sustainability. Therefore, traffic danger has increasingly taken up space in the public discourse in recent years. The World Health Organization has found that traffic-related collisions are the global leading cause of death for people aged 5-29, of which more than half are vulnerable road users such as pedestrians, cyclists, and motorcyclists (World Health Organization, 2023). As a result, advocacy groups around the world have formed to push for safer, more inclusive streets. Research has shown that traffic danger can also severely limit children's accessibility due to high-volume roadways (Tavakoli et al., 2024). This interaction displays the importance of safe roads not only on physical well-being but also on developmental and social spheres.

On the climate front, the transportation sector already accounts for 37% of the world's CO_2 emissions (UN, 2024). Projections show that demand for passenger transport is expected to triple by 2050, displaying a crucial time for new best practices to be established (UN, 2024). In Canada, the transportation sector accounted for 60% of national carbon monoxide emissions and 38% of nitrogen oxides in 2023, accounting for a significant portion of the country's greenhouse gas emissions (Environment and Climate Change Canada, 2025). Nitrogen oxides create a haze, heavily contributing to smog seen in cities, causing severe adverse health effects for populations (US EPA, 2025). Locally, in Quebec, 43% of emissions are due to the transport sector, making it the most polluting sector (Québec, 2026). Therefore, finding solutions such as encouraging people to shift away from private cars and towards other sustainable modes (e.g. bus, metro) is essential in reaching global and local climate goals. Such mode shifts have become an important topic for governments and researchers (Hamidi & Zhao, 2020).

In the context of Montreal, the urban areas offer an array of available modes, including light rail, buses, well-connected cycle paths, a subway and a few pedestrianized areas. In such a context where alternatives to the car are available, creating a mode shift is not as difficult given mode availability. As such, influencing car users to take more sustainable modes of transport while simultaneously reducing traffic danger is important. This influence can take shape in many forms, which vary immensely in cost and effectiveness. These interventions include hard measures such as large investments in urban infrastructure projects, which are heavily studied due to their high costs and news coverage (Balaghi et al., 2026; J. Wang et al., 2023; Zhang et al., 2025). Another option is low-cost marketing and information campaigns, which can also have a significant effect on mode choice (C40 Knowledge Hub, 2024; Esztergár-Kiss et al., 2021; Schechner et al., 2025). As many people use mobile apps for their trip planning, an intervention at this stage could be a desirable time to present trip-related information with the aim of creating a mode shift (Peer et al., 2025).

1.1 Problem to address

Given the current context of urbanization and climate change, research in the field of transportation is essential to ensure safe and environmentally friendly ways to travel. Additionally, local governments and transit agencies look to low-cost, easy-to-implement methods of creating mode change.

Traditionally, planners and governments have tried to change mobility patterns to achieve these goals through three avenues: infrastructure, such as transit expansion and cycling infrastructure expansion, regulation through speed limits and pricing mechanisms and lastly land use development, such as transit-oriented development (TOD). Although these methods have been effective in the past, they are costly, slow to implement and often politically unpopular due to high costs or forcing change in individuals' habits. For that reason, new methods are being researched that address the issues of sustainable mobility through a more holistic view that are low-cost, easy to implement and receive more public approval.

Transport policy has long been based on studies that consider mode choice through a simplified microeconomic lens (Xu et al., 2011). We now know that humans do not always make rational decisions when they are provided with a choice to make (Avineri, 2012; Avineri & Waygood, 2013). Notably, decisions are often made without knowing the full extent of possible options along with their costs and benefits. Therefore, a growing body of literature looks at how choices are made by looking at the interactions of psychology and transport (Daziano et al., 2017; Kinman et al., 2025; Liu et al., 2025; X. Wang et al., 2023). Nudging, a non-invasive technique to change behaviour, has the potential to be a low-cost solution to promote sustainable modes (Steffen et al., 2024). Without needing to directly alter the choice alternatives available to an individual, nudging preserves the freedom of choice that decision makers desire while creating a subtle influence on the choice being made.

Currently, digital trip planners such as Google Maps and other transport apps mostly include the car as the default setting and only show the estimated travel time for the proposed trip. These apps rarely highlight environmental impacts, personal cost, safe routes or societal goals. Trip planning apps currently aim to optimize travel time without regard for what is best at the regional, national, or global scale (Tang et al., 2022). Intentionally displaying certain modes before others, and certain attributes related to each mode, can have a significant impact on which mode is selected for a trip (Schechner et al., 2025).

Nudging strategies have shown promising results in previous research, where they have successfully created a mode shift towards public transit or “greener” routes (Aravind et al., 2024; Schechner et al., 2025). That said, little is known about the impact of nudging within a trip planning tool. Further, the potential discrepancy between qualitative (e.g., emoticons) and quantitative (e.g., travel cost) nudges are not well studied within a trip planning tool. Therefore, to address this gap, nudging practices in a planning tool are used to evaluate the effects of quantitative and qualitative information are tested in this research.

The second avenue of research conducted relates to road safety and perceived traffic danger. Schneider (2013) shows that road safety is an important part of mode choice and the habit-making process. Similar to other traditional costs, such as travel time and monetary costs, road safety is considered as a cost by decision makers and impacts mode selection. As road safety significantly impacts the social and cultural pillars of sustainability, research on mode change must consider how road safety potentially limits mode shifts. Conversely, the impact that safety has on mode choice needs to be considered, as active modes are often used to access public transit. The growing size of vehicles that are being purchased is increasing the traffic danger for all other road users (Claus & Warlop, 2022). Despite this, given cars’ integral role in Canada’s transport habits, the risks cars impose on other road users through size and high speeds are often overlooked. We must therefore decide as a society whether we value time savings for drivers or road safety for other road users.

Recently, the term "motonormativity" has been introduced to explain how society is differential towards cars. The concept suggests that as one travels by car, one will unconsciously continue to do so without reflecting on the externalities (Walker et al., 2023). From a scientific perspective, different modes should be limited at different speeds as their mass significantly influences the amount of energy they contain, directly creating traffic risks. The second part of this research examines whether people believe that motor vehicle speeds should be limited, at what speeds, and for what reasons. Given the current discourse in Montreal on bike lanes (Olson, 2026), we examine whether suggested speed limits and traffic risk are dependent on the vehicle as opposed to the energy and potential to harm others.

1.2 Research objectives, hypotheses and contributions

The objectives of this research are twofold. The studies were both based on data collected in a survey that ran in the fall of 2025 after the discrete choice experiment (DCE) was established. The project lays out the following specific research objectives:

- Objective 1: Determine the effect of displaying information in a trip planning tool on travel behaviour.
- Objective 2: To examine the relative importance of travel time vs. road safety and how suggested speed limits might vary by mode being considered.

Given the research objectives above, we hypothesize that;

- Hypothesis 1: In most cases, displaying additional information in a trip planning tool will increase the usage of sustainable transport.
- Hypothesis 2: Suggested speed limits may not be coherent with real traffic, and people may apply lower speed limits to smaller vehicles such as e-micromobility

The results will contribute to the literature firstly by testing the potential of low-cost interventions, through the display of qualitative and quantitative variables in a digital trip planning tool, and secondly, informing the public and policy makers about subconscious biases one may have regarding the car due to its constant presence.

1.3 Structure of the thesis

This manuscript-based thesis contains eight chapters. The present chapter serves as an introduction and provides the context of the topic. In addition, it presents the research problem, the objectives set for the study, and the structure of the thesis. Chapter 2 contains the conceptual framework that forms the basis of this thesis. This framework presents how mode choices are made, the impact engineering metrics have on the built environment and how safety impacts mode choice. Subsequently, motonormativity is introduced, and its potential impacts are discussed. This section complements the literature cited in the articles in Chapter 4 and Chapter 6. Next, Chapter 3 summarizes the methodologies used in reaching the research objectives. Notably, the creation of the survey that served as our data for both studies will be discussed along with the process that was taken in the second paper to interpret the results we obtained. Chapter 4 is the article on nudging and mode choice. Chapter 5 includes findings on travel perception and behaviour. These findings help understand what is considered in mode choices and identify discrepancies between transport perceptions and realities. Chapter 6 is the article on traffic safety perceptions by mode. Chapter 7 is a discussion of the results obtained in the previous three chapters, along with the limitations. The eighth and final chapter of this thesis presents the overarching conclusions of the research conducted and suggests future research on motonormativity and nudging.

CHAPTER 2 CRITICAL LITERATURE REVIEW

This chapter presents the theoretical framework of the thesis by contextualizing this research in the current literature. The need for a reduction in car use, how mode choices are made, safety theories and motonormativity are discussed in this chapter setting the basis for the articles in this thesis. The article in Chapter 4 contains a literature review which synthesizes the current application of digital nudges along with the difference between qualitative and quantitative nudges. To avoid repeating what is presented in the literature review sections that follow, this section provides a brief overview of the broad current literature, allowing the reader to situate the work presented. This literature review section will focus on the interactions between safety conditions, perceived risk and biased societal norms such as motonormativity addressed in Chapter 6.

2.1 Reducing car use

High levels of car use have many adverse effects on people and the environment. Nieuwenhuijsen & Khreis (2019) show that cars negatively impact daily life by reducing the amount of physical activity a person does in a day, emitting air pollution that harms human health and the environment, increasing noise and heat island effects, and heavily contributing to millions of traffic-related deaths globally. Further, car-oriented developments reduce accessibility and perpetuate inequalities in communities (Cohen et al., 2014). These negative impacts impose large costs on society that can be observed in many different realms. As a result, the United Nations has included objectives within its Sustainable Development Goals that reduce car use and diminish the negative effects on society (UN, 2026). Cities such as Copenhagen have successfully created a mode shift toward more sustainable modes and have therefore reaped the public health benefits (Gössling, 2013). Given these impacts, it is important to understand the ways in which car use can be influenced.

Three overarching factors can be modified to alter car usage: infrastructure, social factors and individual factors (Javaid et al., 2020). Cleland et al. (2023) classify these factors into macro, meso and micro levels of car dependence. Similar to Javaid et al. (2020), Cleland et al. (2023) show that the built environment (macro), circumstantial factors such as needing to carry something (meso) and individual elements such as mode access all impact car usage. At the macro level, infrastructure has a significant effect on accessibility and land use, which, if well done, can lead to lower reliance on the automobile. High land-use diversity can lead to higher destination accessibility, reducing the need to travel long distances to get to desired locations (Cervero, 2002). Although changing the built environment can be effective in motivating sustainable travel, doing so requires significant investments in time and money. Therefore, more cost-effective solutions are available through social and individual factors. Perceptions of how others within one's social circle get around have a strong influence on a person's mode choice, often more impactful than the built environment (Javaid et al., 2020). Similarly, Javaid et al. (2020) find that individual habits influence mode choice more than the urban environment. Therefore, avenues other than altering the built environment have proven effective in altering mode choice. Understanding, more broadly, how mode choices are made allows for the creation of better and cheaper interventions to reduce car use.

2.2 Impacts on mode choice

Building on the factors that influence car use, mode choice as a whole is affected by multiple factors such as accessibility, safety and knowledge of alternatives. Five key considerations can be identified in influencing mode choice, which has been coined as the Theory of Routine Mode Choice Decisions (Schneider, 2013). The theory begins with awareness of the mode, followed by basic safety, then by cost and convenience of the mode, which impacts enjoyment and finally creates a habit that repeats itself. Schneider (2013) argues that addressing a single stage of the Theory of Routine Mode Choice Decisions without considering the others is unlikely to lead to a significant change, indicating the importance of holistic planning. Given this framework, the factors influencing mode choice are detailed below.

First, one must be aware of a mode and be able to use it for it to be considered in a choice. For example, owning a bicycle is directly correlated with the usage of a bicycle (Handy et al., 2010). Similarly, owning a car is directly correlated to using a car (Van Acker & Witlox, 2010). Additionally, Rose & Marfurt (2007) show that improving awareness of different modes through campaigns such as ride-to-work days can significantly increase the uptake of the given mode.

Next, feeling safe when travelling using a certain mode has an impact on the selection of that mode (Ibrahim et al., 2024). Vulnerable mode users, such as cyclists, are influenced by road safety when deciding to take that mode (Winters et al., 2011) and choose what they perceive as safer routes (Dill & Gliebe, 2008), displaying a clear consideration for road safety.

In addition to safety, travel cost and convenience significantly impact mode choice. Boarnet et al. (2024) show that increasing the cost of ride-hailing services by 10% diminishes the usage of that mode by 7%, displaying the effect of cost. Utility theory proposes that travellers aim to maximize their utility by choosing a mode that minimizes the costs and effort required (Ewing & Cervero, 2010). In addition to traditional costs (gas, fares, parking) Schneider (2013) found that inconveniences such as time spent looking for parking and trip planning time reduce the utility of the given mode therefore decreasing the odds of selection.

Further, subjective factors such as trip satisfaction also influence behaviour. Satisfaction with a mode has been found to create a desire to use said mode and therefore increase its usage (Gerber et al., 2020). Logically, when someone is deciding which mode to use, they will pick one, if they have it available, that they enjoy the most, given the circumstances.

Additionally, given the repetitive nature of many trips, travel habits have a significant impact on the mode chosen (Loukopoulos & Gärling, 2005; Verplanken & Orbell, 2022). Taking the same mode regularly increases the odds of continuing to use the same mode in the future due to a habit being created. As the share of trips by car in Montreal was unchanged at 67 % from 2018 to 2023 (ARTM, 2023), there is a suggestion of a city-wide habit of car use.

Lastly, the type and quality of information available to an individual before making a decision can significantly shape the outcome of that decision (Hogarth & Soyer, 2015). In transport, research has shown that personal impacts, such as the cost of parking at the destination (Albert & Mahalel, 2006; Fosgerau & de Palma, 2013) or societal impacts such as greenhouse gas emissions (Gaker & Walker, 2013; K. Wang et al., 2025), can influence mode choice. We also know that given travel habits that are formed, travelers consider information once and make a restricted decision every subsequent trip (Liu et al., 2025). As a result, providing high-quality, digestible information at the right time can alter the loop described in the Theory of Routine Mode Choice Decisions and help create desired outcomes.

2.3 Safety considerations

Among all the influences mentioned above, road safety is complex and its impact on choice varies throughout the population with objective and subjective safety. Perceived road danger is an important factor when considering different modes and routes for a given trip (Rothman et al., 2015). Particularly, the perception of road safety for vulnerable road users such as pedestrians and cyclists has a large impact on the number of trips taken using that mode (Kim et al., 2024; von Stülpnagel & Lucas, 2020). As perceived danger is intrinsic to each individual and consists of different characteristics for every person, perceived traffic danger is not always in accordance with objective measures of street danger (Amiour et al., 2022). For example, flashing beacons in school zones have been found to increase the perceived risk of danger of crossing the street despite being effective in reducing vehicle speeds (Rothman et al., 2015). von Stülpnagel & Lucas (2020) find that for cyclists, there can be discrepancies between what is perceived as high risk and locations that are objectively high risk (where crashes are most likely to occur). These instances occurred in places where a bike path went in the opposing direction of car traffic and at intersections with tram lines. These suggest that humans do not always properly interpret safety features, nor do they have a perfect ability to detect risk and danger in the urban realm. As perceived road safety is linked to mode choice, understanding these discrepancies is essential when aiming to create a mode shift.

A systematic review of the literature finds that out of 34 barriers to cycling, road safety is the number one concern (Pearson et al., 2023). Similarly, in Montreal, 69.2 percent of respondents in a survey said that they are or would be concerned about traffic danger if they were to bike (Naseri et al., 2026). Further, given that active modes are often used to access public transit, corridors that are perceived as safe and objectively safe are needed to ensure access to the public transit network (Makahleh et al., 2025).

That said, safety considerations for different modes are not always considered in the same way, nor do they aim at protecting the same group of people. For example, a car's safety features for the person inside the vehicle are a significant selling point when purchasing a vehicle, leading to significant improvements in that realm (Wu et al., 2014). However, driver safety is not correlated with vehicles being safer for other road users outside of the vehicle. On the contrary, the growing average size and weight of new vehicles being purchased in North America creates a larger threat than previously to vulnerable road users, such as pedestrians and cyclists (Claus & Warlop, 2022).

Canada saw a decrease in traffic-related fatalities from 2004 to 2023 (Government of Canada, 2025). Canada and Montreal have adopted the philosophy of Vision Zero (Ville de Montréal, 2025). This means taking a safe systems approach that is composed of Safe Roads, Safe Speeds, Safe Road Users and Safe Vehicles, with the objective of zero road deaths by the year 2040 (Edvardsson Björnberg et al., 2020). This theory addresses what creates the hazard by looking at the built environment and socioeconomic factors, such as rezoning to reduce vehicle miles travelled (Ederer et al., 2023).

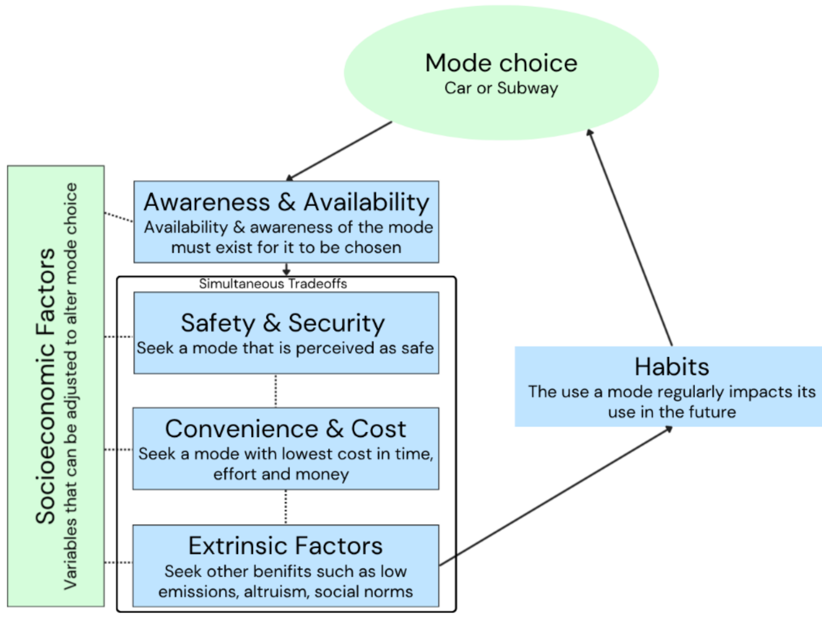
Various policies over recent years have shaped the car-centric infrastructure seen in North America today. The slow and systematic takeover of streets by the car, despite large amounts of pushback since the inception of the automobile, has created a new norm where cars themselves have shaped law (Norton, 2015). Measures such as "level of service" measure driver experience on a road by considering the flow on the road and congestion, leading to the construction of roads that favour high speeds and neglect all other transit modes (Transportation For America, 2023). Infrastructure is designed to facilitate car use, which has resulted in car dominance and left other modes with less investment (Romm et al., 2025). Roads designed for cars lead to higher vehicle speeds and, therefore, greater traffic safety risks than roads designed for integrated multimodal use (Tzouras et al., 2024).

This history helps explain the emergence of motonormativity, a term that is explained as "largely unconscious assumptions about how travel is, and must continue to be, primarily a car-based activity" (Walker et al., 2023). For example, when replacing car fumes with cigarette fumes in a statement, people were more likely to oppose the latter despite having very similar externalities (Walker & Brömmelstroet, 2025). The bias towards cars can be seen systematically distorting policy decisions, leading to the car gaining a larger space than it would if these biases were not present (Walker et al., 2023).

Despite high vehicle speeds, recent debates in Montreal have focused on the "danger" of bicycle lanes (Olson, 2026), but from a safe systems point of view, bicycles carry a lot less energy than larger vehicles, given the immense weight difference. Bicycles, therefore, pose a much smaller traffic risk to other road users than cars. Further, research shows that traffic risk varies immensely by mode, with cars producing a large risk and motorcyclists, cyclists, and pedestrians incurring a lot of risk (Stipdonk & Berends, 2008). Chapter 6**,** therefore, bridges the gap between the effects of motonormativity on road safety through the lens of speed limits and perceived vs objective safety.

Based on Schneider, a mode choice decision-making framework is used to understand how choices are made (see Figure 2.1). The research in this thesis considers how the policy-sensitive variables displayed in Figure 2.1 can alter mode choice.

Figure 2.1 Mode choice framework



CHAPTER 3 METHODS

This chapter discusses the methods used to create the survey that generated the data for both manuscripts in this thesis. Full methods sections are included in the articles in Chapter 4 and Chapter 6. To not repeat information, this chapter consists of an overview of the methods used and the research design. The research was approved by the Polytechnique Montréal research ethics committee (CER-2526-07-D).

3.1 Research design

This thesis uses quantitative research methods to address the research questions. The methodological diagram seen in Figure 3.1 displays the process of the research in this thesis.

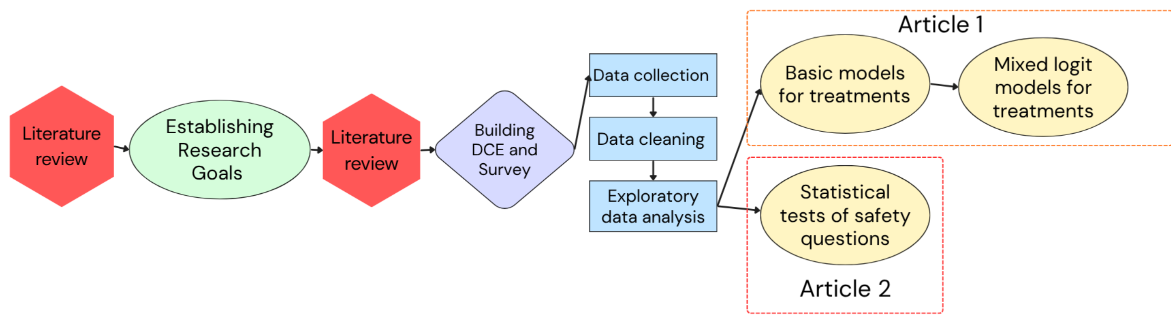


Figure 3.1 General Methods Diagram

An experimental design was employed, consisting of a survey with an integrated discrete choice experiment (DCE). Stated preference and attitudinal questions were asked and used as the main data source for the two manuscripts in this thesis. The DCE allowed us to determine causal effects between information/treatment and choices made by the respondents. The additional survey questions allowed us to capture travel habits that influence mode choice and perceptions of safety and motonormativity. The survey collected data from residents in the greater Montreal region. The discrete choice experiment was the source of data for Chapter 4, while the travel habits and perceptions of speed limit sections were the source of data for Chapter 6.

3.2 Survey structure

The survey was created using PolyOpinion (LimeSurvey), an online survey platform. To obtain a large enough dataset that would be statistically reliable, Leger Opinion was hired to distribute the survey to people around the greater Montreal area. Table 4.1 presents the sociodemographic characteristics of the sample in reference to the population of Montreal. Respondents were given a small point incentive from Leger Opinion to complete the survey. Quotas were used based on age, income, education level and gender to ensure our sample was representative of the island of Montreal for those categories. This thesis focuses on the car versus metro experiment, as the sample was sufficiently large to allow for multivariate analysis. The survey consists of six main sections; the full survey can be found in Appendix A:

1. Introductory questions, including sociodemographic questions such as those described above. This section also included travel behaviour questions, such as having access to a car, the modes one is open to using, the modes that one usually uses, and having a transit (Opus) card.
2. Next, respondents were presented with the DCE. Each respondent was randomly shown one of eight information treatments and responded to between 9 and 15 choice tasks within that treatment. In each choice task, they were asked to select either car or metro for the proposed trip.
3. Respondents' opinions on factors in favour of or against using different modes (car, public transit, bicycle).
4. Descriptive norm questions related to the respondents' perceptions of what percentage of people go downtown by different modes and what proportions of their neighbourhood use modes to get around in general.
5. Questions regarding street safety and speed limits. For this section, respondents were randomly assigned to one of two treatments. One treatment included questions regarding the speed limits for cars, while in the other treatment, questions were about the speed limits for e-micromobility, such as scooters and e-bikes. Respondents were also asked why they think the speeds should or should not be limited.
6. Car use change and climate change stage of change questions. These questions captured the desire to reduce or increase car usage and their desire, or not, to reduce their personal emissions

The survey contained 3 attention questions to remove any inattentive respondents. These attention or "trap" questions were formatted to blend well with the other questions, ensuring high-quality responses. The time of completion was approximately 10 minutes and should not have imposed a significant cognitive load.

3.3 Discrete choice experiment

The discrete choice experiment was set up to capture the effect of different treatments on mode choice. In order not to repeat information, this section only contains a summary of the DCE process; section 4.3 describes it in detail, including the attributes and their levels.

The number of choice tasks that each participant responded to varied between 9 and 15, where respondents were asked to choose a mode of transport (either car or metro) in each trip scenario. The number of choice tasks per respondent was determined using a D-efficient design using Ngene to generate a reasonable number of choice tasks, as all possible attribute combinations would have created a large burden for respondents (*Ngene User Manual*, 2024). In order to minimize the influence of external factors, respondents were presented with a standardized scenario, regardless of treatment, that indicated the proposed trip was to meet a friend for a meal, on a Saturday at 11 am and that both modes (car and metro) were available. This weekend trip was used instead of a commuting to downtown trip, which only some of the adult population usually do. The weather was also established as being pleasant to eliminate the potential influence of weather on choice. Table 3.1 shows all the origins and destinations used in the DCE, along with the base travel time and cost for both modes. The travel times and costs varied by a factor of 0.7 and 1.3 for the car and 0.85 and 1.15 for the subway to account for variability. The variability is larger for cars than for the metro, as Montreal has the highest congestion rates in Canada (INRIX, 2026), while the subway respects its planned intervals 96.9% of the time in the morning peak (STM, 2025). The origins and destinations (OD) were selected to have competitive metro and car times to ensure competitiveness. The travel time was based on the median expected travel time for each OD pair provided on Google Maps. The use of real trips and times in Montreal were used to both increase realism and gain trust from the respondents in the accuracy of the scenario.

Table 3.1 OD pairs with travel times and costs

Origin	Destination	Distance Car (km)	Travel time (min)		Travel cost ($)	
			Car	Subway	Car	Subway
Verdun station	Place des Arts	10.8	23	17	12.04	4
alancette Park	Place des Arts	6.1	21	17	6.81	4

Université de Sherbrooke à Longueuil	Place des Arts	9	22	25	10.04	4
Laurier station	Place des Arts	3.4	15	14	3.79	4
Vendome station	Place des Arts	10	20	20	11.16	4
Champs de Mars	Marché Jean Talon	6.4	28	17	7.14	4
Station St-Laurent	Marché Jean Talon	5.5	25	25	6.14	4
UdeM Roger Gaudry	Marché Jean Talon	6.2	24	22	6.92	4
Ahuntsic Park	Marché Jean Talon	5	18	14	5.58	4
St-Michel station	Marché Jean Talon	3	14	11	3.35	4

3.4 Treatment analysis

Before releasing the survey, we hypothesized that treatments displaying information about the costs, time, and impact of car travel relative to metro travel would have a negative impact on car use (Schechner et al., 2025; X. Wang et al., 2023; Waygood & Avineri, 2016). An initial basic analysis was conducted on the choice outcomes by each treatment. The results showed that the base treatment (a treatment only showing travel time) had a larger preference for the metro than the other treatments. This unexpected result motivated additional analysis, as we expected the treatments to have a negative effect on car use, to ensure that there were no errors in our analysis and that the results were robust. The first step was to ensure that the data collected was indeed clean and free from other confounding variables. The following steps were conducted to gain a maximum understanding of the data and create high-quality and representative models.

3.4.1 Data cleaning

First, the data was recleaned. In addition to removing people who failed in any of the attention trap questions, we also removed the fastest 5% of respondents in each group. All these respondents had completion times that were faster than the anticipated fastest possible response time needed if all the questions were read and instantly answered. We then removed respondents with incoherent answers. For example, if someone stated they used a car for most of their trips but said their current travel modes did not include car as a driver or car as a passenger, they were removed from the data set.

3.4.2 Sample Balance

Imbalances in likely influential personal characteristics were examined (Table 3.2)**.** The table shows the base case having the highest car access, the lowest Opus card possession rate and the second highest driver's licence rate, which should suggest a lower likelihood of choosing the metro option. Further, the base case is similar to other treatments in terms of attitudes towards climate change. As the percentage of trips where the destination was downtown was higher in the base case, this variable is controlled for in the modelling.

Table 3.2 Descriptive statistics by treatment

Treatment	% of choice tasks where metro was chosen	Do not feel affected by climate change (%)	No access to a car (%)	No transit (Opus) card (%)	Has a driver's license (%)	Destination downtown (%)
Base case	61.66	12.2	6.5	64.23	91.87	77.78
Parking cost	55.25	12.3	13.11	56.55	89.34	66.76
Parking time	56.85	16.03	13.74	60.31	83.21	66.76
Travel cost	53.28	16.54	11.81	59.06	92.13	53.34
Climate change	57.36	18.4	16.8	54.4	81.6	53.34
Air quality	53.66	14.53	17.95	58.97	88.03	53.34
Colour	54.7	7.14	9.52	53.17	91.27	53.34
Emoji	52.08	6.77	9.02	65.41	88.72	53.34

Further, Table 3.3 shows all the modes currently used by respondents, segmented by treatments. In the base case, we observe the highest levels of car use, both as a driver and as a passenger. This would suggest a continuation in that trend by selecting car more frequently. Nonetheless the overall variation in current mode use is relatively stable between treatments.

Table 3.3 Modes currently used by respondents, segmented by treatment

Treatment	Car as a driver	Car as passenger	Rail	Bus	Walking
Base case	82.11	43.9	26.83	22.76	34.96
Parking cost	77.05	40.98	28.69	28.69	31.97
Parking time	71.76	32.06	29.01	23.66	42.75
Travel cost	74.8	31.5	32.28	28.35	37.8
Climate change	69.6	33.6	32.8	30.4	36.8
Air quality	75.21	37.61	31.62	29.91	42.74
Colour	78.57	38.89	32.54	24.6	32.54
Emoji	81.2	40.6	26.32	25.56	36.84

3.4.3 Modelling approaches

Different techniques were tested to ensure the robustness of the results. First, simple multinomial logit models were made that showed the treatments had a negative effect on metro selection, which was an unexpected result, yet is coherent with the metro section share seen in Table 6.2. This model set the baseline for the rest of the analysis. The simple logit model using equation 3.1 allows for the estimation of choosing an alternative based on the observed utility of each treatment. P_i is the probability of choosing alternative i over the sum of all choice tasks j.

Logit equation (Páez & Boisjoly, 2023)

$$P_i = \frac{e^{V_i}}{\sum_j^J e^{V_j}} \tag{3.1}$$

Interaction terms were then tested in the baseline logit model that would account for the slight over-representation of trips with a downtown destination in the base case. Socio-demographic characteristics were also added to improve model performance and consider differences in respondents. Next, we tested mixed logit models that account for unobserved preferences from individuals. The mixed logit model allows parameters specific to the individual to vary across a symmetric uniform distribution, in our case, allowing the capture of heterogeneity between individuals. Two utility functions are used to describe the probability of choosing one option over another. As the options are unique and the absence of one does not ensure the selection of the other, two utilities must be used to determine a probability.

Mixed logit equation (Páez & Boisjoly, 2023)

$$P_{ij} = \int \frac{e^{\beta(\sigma)' x_{ni}}}{\sum_k e^{\beta(\sigma)' x_{nk}}} \cdot \varphi(\beta \mid \sigma) \, d\beta$$

Where P_{ij} is the probability of choosing alternative j, while β is a random variable that follows the distribution of σ. The integral provides the weighted average given a mixing distribution φ. A mixed logit model, being more complex, can account for unobserved differences between respondents and therefore provides a better fit than a simple multinomial logit model. The results of the mixed logit models are presented in Chapter 4. To investigate further, mixed logit models with a panel effect were also tested to see the impact of the variation in the number of choice tasks between treatments, yet no improvement was found. Additionally, in panel models, the number of variables tested had to be reduced in order to ensure model convergence, given the sample size. The models were also retested with a manipulated dataset that had every treatment have the same number of choice tasks and number of downtown OD pairs. This was done by randomly duplicating lines in treatments that had inferior amounts of choice tasks. Despite this dataset controlling for the number of choice tasks, the same results occurred. The data was then reimported from the survey platform and displayed the same results. We therefore conclude that the data we obtained is correct. The analysis that follows and its interpretation are detailed in Chapter 4**.**

3.5 Safety analysis.

To fulfill the second research objective of this thesis, an analysis was conducted focusing on the latter half of the survey. The respondents were randomly assigned to one of two groups for this part of the survey. They were then asked questions about their support for more or less infrastructure for all various modes of travel (rail, bus, car, pedestrian, cycling). These results were used to confirm homogeneity in terms of general attitudes towards the modes between the two treatments. Respondents were then asked if they believe the speed of X vehicle should be limited in areas of Montreal where pedestrians are present, where X was either e-scooter/e-bicycle or car depending on the treatment they were assigned to. Respondents were then asked why they did or did not support limiting speed limits. Simple statistical measures such as chi-squared tests of independence (reasons for (not) limiting speed) and Welch t-tests (speed limit to be applied) allowed us to identify any significant variation in responses between treatments.

CHAPTER 4 ARTICLE 1: NUDGING FOR MODE CHOICE IN A MOBILE TRIP PLANNING TOOL

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ABSTRACT

The objective of this study is to determine the effects of nudges in a mobile trip planning application on mode choice. Seven different nudging techniques were developed and tested relative to the common layout for route choice apps. Both qualitative and quantitative nudges were tested to test their relative effectiveness. Previous mode choice experiments typically present information in detailed text format, but many individuals use mobile apps to plan trips. A discrete choice experiment with 903 respondents from the greater Montreal, Canada, was used to run mixed logit models that tested the effectiveness of the treatments. The results find that treatment levels are more important than the presence of a treatment to ensure desired effects. Various socio-demographic and attitudinal variables were found to influence the impact of mode choice. This research helps policymakers understand the importance of well-calibrated nudges to avoid unwanted effects.

KEYWORDS

Nudging, Mode choice, Trip planning tool, Information display, Mobile application, public transport

4.1 Introduction

Traditional policies set in place to reduce negative impacts related to transport (emissions, congestion, public health costs) often consist of costly or politically unpopular tools such as pricing, regulations and infrastructure projects. A less explored alternative is information-based interventions and behavioural nudges that are low cost, easy to implement and influence travel behaviour. Studies have shown that information shown to individuals when making a transport-related choice can have an impact on the choice being made (R. Daziano et al., 2021; B. Wang et al., 2021). Providing people with information such as fuel cost for trips and the amount of emissions produced has proven to influence one's route choice when travelling by car (Schechner et al., 2025). Additional information given to individuals when making decisions has been tested in car purchasing and mode choice (Gaker et al., 2011; B. Wang et al., 2021). Further, it has been proven that different kinds of framing can affect different groups in different ways (Kinman et al., 2025; B. Wang et al., 2023). While previous studies consider the addition of environmental information or costs in route choice or vehicle purchasing, the impact of different framing on mode choice is less studied. As such, this paper tests different framings, such as pollution, parking information, and injunctive norms, on mode choice in a trip planning app.

The proposed methods are low-cost interventions that could potentially nudge travelers towards more sustainable transport choices. In October 2021, Google Maps began showing an eco-route option that was deemed to emit fewer emissions by considering stop-and-go traffic patterns, the steepness of hills on one's route, and the type of road used, e.g., local roads or highways. However, research has shown that the routes suggested by Google are not always indeed lower emission routes than the alternative, raising questions about the effectiveness of this intervention in terms of reducing emissions (Jovanovic et al., 2024). Within the current usage of Google Maps, mode choice alternatives are not given unless one intentionally shuffles through the tabs at the top of their screen. Further, many different types of additional information could be given that might influence mode choice. This study examines how different information might impact the choice between public transport and private car.

This paper adds to the existing body of literature in a number of ways. Through discrete choice experiments, it examines the relative effectiveness of numerous different framings of travel-related information on mode choice. The experiment goes beyond standard measures such as trip time and trip cost. It tests diverse types of information such as personal impacts (mode costs, parking cost, parking search time), local impacts (air quality), global impacts (climate change emissions), injunctive norms (emoticons), and subtle nudges (colour). The remainder of the paper is structured as follows. Section two reviews the current literature, focusing on mode choice selection and information nudges. Data collection, the experiment and modelling approaches are introduced in section three. Sections four and five present the results and implications they may have. Lastly, section six discussed the limitations of this research.

4.2 Background and Literature Review

Transport has numerous impacts on society (Abdollahi et al., 2023; Glazener et al., 2021; Miner et al., 2024), of which emissions is one. In Canada, the transportation sector accounted for 60% of national carbon monoxide emissions and 38% of nitrogen oxides in 2023, accounting for a significant portion of the country's greenhouse gas emissions (Environment and Climate Change Canada, 2025). Nitrogen oxides make the air hazy, contributing heavily to smog and having severe adverse health effects for populations (US EPA, 2025). Globally, the transport sector accounts for just under a quarter of GHG emissions, with road vehicles accounting for 70% of that (IPCC, 2022). It is therefore essential to support a shift to less polluting modes for Canada to reduce smog in cities and reach its climate goals. In urban contexts, there are often realistic options to travel other than by automobile. However, transportation applications (or "apps") typically only display travel time, which often favours private motor vehicles (e.g., cars). The widespread adoption of mobile devices that are equipped with trip planning tools is an important source of information for many travelers. These apps give route options, show travel time and estimate congestion, all of which influence travel departure times and reduce uncertainty for travelers using the apps (Tang et al., 2022). Therefore, harnessing the power of the trip planning app, one could influence travel choices.

Mode choice has long been studied through a lens of microeconomics, where a traveler would pick the mode that maximizes their utility based on time and cost (Xu et al., 2011). Rather than considering all travel options rationally, we know that travelers consider information once and make a restricted decision (Liu et al., 2025). For that reason, providing simple and digestible information at the right time (when the decision is being made) is crucial in evoking change. Various studies have applied social psychology to help understand transportation choices. Such approaches allow for a better understanding of how choices are made and who responds best to different kinds of information (R. Daziano et al., 2021; Kinman et al., 2025; B. Wang et al., 2021). Understanding what information could shift individuals towards more sustainable choices would be a valuable addition to the toolkit of sustainable transport promotion.

Using trip planning tools before trips are made has become more and more common, with a study in Vienna finding that approximately 80% of adults regularly use Google Maps to plan their trips (Peer et al., 2025). To harness the power of mobile applications such as Google Maps, this study examines how different information could influence mode choice. Some travel apps show the crowdedness of public transport (Pan et al., 2022, 2023) or the congestion on the road (Ding & Zhang, 2016; Nichols et al., 2024) to provide further information about the mode and route choice, but such studies do not currently display extrinsic information that is pertinent to the trip. Previous research has shown that personal impacts, such as the cost of parking at the destination (Albert & Mahalel, 2006; Fosgerau & de Palma, 2013) or societal impacts such as greenhouse gas emissions (Gaker & Walker, 2013; K. Wang et al., 2025), can influence mode choice. In other experiments, injunctive norms (e.g., what society approves of) displayed through emoticons or subtle influences such as colour have been shown to influence transport choices (Wang et al., 2021). Further, research has shown that people with different political associations are influenced by different information such as air quality rather than global climate change emissions (B. Wang et al., 2023). However, most research on mode choice to date has studied creating more efficient, less congested networks as opposed to pushing for sustainable transport options and mode shifts (Tang et al., 2022).

Nudging is a strategy used to influence a decision made by someone without changing their direct gain or loss (Thaler & Sunstein, 2019). Nudging can therefore be harnessed in many ways, allowing for implications in many fields, including transport. Anagnostopoulou et al., (2020) use this approach in a deliberate way, having respondents interact with the given information by ranking routes. In doing so, the researchers were able to significantly alter the travel patterns of the respondents. In a less intrusive way, providing additional information (nudging) to someone when making a transport choice has been shown to encourage the use of public transit (Aravind et al., 2024) and increase willingness to pay for GHG reductions (K. Wang et al., 2025). This study aims to identify which types of nudging are most effective and which groups of people they influence most.

4.2.1 Quantitative nudges

Quantitative nudges include displaying information such as time or cost that the user would have incurred, whether the nudge was present or not. Showing the cost savings has proven to be an effective way of incentivizing users to take a more sustainable mode of transport, such as car sharing (Steffen et al., 2024). Showing individuals the full cost of parking before a trip was found to reduce car use . In many cases, a trip by car will incur a parking cost; displaying that information is a nudge. Although parking costs have been studied in terms of impacts on mode choice, parking also requires additional time, which is a personal resource, but is rarely tested for impacts on choice, though individuals state it as an inconvenience of using cars (Schneider,). Quantitative nudges shed light on added disadvantages, such as parking time or "forgotten" costs of parking or gasoline. Therefore, presenting this information at the trip planning stage in a mobile app can alter the perceived costs of driving that would be overlooked. These numerical attributes are often easy to interpret, given that users often interact with time and cost variables when making decisions in daily life.

4.2.2 Qualitative nudges

Qualitative nudges often rely on visual or symbolic cues that convey emotion rather than raw information. These cues can highlight desirable information or feelings that motivate desired behaviours. Hedonic qualitative, non-verbal nudges, such as emojis, touch on affective (emotional) information have proven to influence attitudes and behaviours (Yan et al., 2026). Qualitative visual cues activate an emotional response that can increase engagement and cause more empathy and trust, allowing for desirable outcomes to be picked at a higher rate (Qiu et al., 2023; X. Wang et al., 2023). Colour and emoticons have been tested and used in the context of framing vehicle greenhouse gas emissions (Naseri et al., 2024; B. Wang et al., 2021, 2023). Both emoticons and colour had a significant effect on increasing the willingness to pay for emissions. Emojis also have the ability to convey an injunctive norm that either approves or disapproves of a statement (Schultz et al., 2007). Normative signals can communicate a behaviour that is socially acceptable. These nudges can make respondents lean towards the socially responsible thing to do. Norm-framing of societal goals when contextualized in reference to climate change and or local air quality has an effect on choices (R. A. Daziano et al., 2017). This study finds that 'doing the right thing' when information is framed with a societal goal has a significant impact on the choice being made. In transportation contexts, framing travel choices in relation to collective environmental outcomes such as improved air quality or reduced emissions may therefore increase the likelihood that individuals choose more sustainable travel options.

Overall, mode choice experiments typically examine quantitative personal resource information such as travel time and travel costs. Some experiments have shown how travel costs (e.g. parking) influence choices, but rarely is the hassle of parking tested. Further, some experiments have shown that societal impacts such as climate change emissions can influence mode choice, but distinctions exist between which populations are impacted by GHG emissions versus air quality. Finally, injunctive norms and emotions have been shown to influence transport choices, but they have not been tested on mode choice. Overall, this research is unique as it will test each of these in parallel discrete choice experiments to examine how they influence mode choice.

4.3 Methodology

4.3.1 Survey design

Data collection took place in November and December of 2025 with respondents from the greater Montreal area, a Canadian city with 4.2 million inhabitants (Government of Canada, 2022). As Montreal is situated in a predominantly French-speaking part of Canada, the survey was distributed in both English and French. The participants were recruited by Leger Opinion (a survey company). Participants received points from Leger Opinion as an incentive for having completed the survey. Three attention-check questions were inserted into different sections of the survey to exclude inattentive respondents and improve data quality. Quotas were established based on gender, age, income, and education to obtain a sample that is representative of the population of the greater Montreal area. Ethics approval was received from Polytechnique's ethics board (CER-2526-07-D).

The survey first collected some socio-demographic information for the quotas, along with questions on usual mode use and whether or not the respondents were open to using other modes. Respondents were then randomly assigned to one of the information treatments (participants were not aware of this) and completed a number of choice tasks for trips in central areas of Montreal, where the travel times for car and public transit are often similar. They then completed some further socio-demographic and attitude questions towards modes.

4.3.2 Survey respondents

The final sample, after data cleaning, was 903 valid responses. The sample representativeness in relation to the Montreal population can be found in Table 4.1. Given the hard-to-reach nature of people with education below high school, the sample is missing respondents from this group.

Table 4.1 Socio-demographic characteristics of the survey sample relative to the Montreal population (%)

	Survey Sample (%)	**Montréal Population (%)**
Education		
Primary / no degree	0.78	15.71
Secondary or equivalent	19.78	19.37
Vocational training (DEP or equivalent)	16.19	18.62
College (CEGEP)	22.72	19.63
University – Bachelor's degree	26.63	23.78
University – Master's / DESS	11.49	9.56
University – Doctorate	1.89	1.74
Prefer not to answer	0.13	---
Other	0.39	---
Household Income, Before Tax		
$0--9,999	1.11	3.3
$10,000--19,999	3.72	5.1
$20,000--39,999	12.47	11.3
$40,000--59,999	18.21	14.1
$60,000--79,999	15.8	20.8
$80,000--99,999	12.73	12.8
$100,000--124,999	10.18	9.3
$125,000--149,999	7.25	6
$150,000--199,999	8.42	6.4
$200,000 or more	6.85	5.9
Do not know	0.33	---
Prefer not to answer	2.94	---
Age (Years)		
18--19	1.5	1.16
20--24	6.14	8.78
25--29	9.2	10.8
30--34	8.81	10.29
35--39	9.92	9.53

40--44	10.05	8.91
45--49	8.68	7.72
50--54	7.77	7.4
55--59	7.05	7.57
60--65	7.7	7.13
65--69	6.53	5.96
70 and over	16.64	14.75
Gender		
Female	56.33	51.18
Male	43.02	48.82
Other	0.65	---

Statistical analysis confirmed that the samples in each treatment were not different in terms of income, age, education, and gender. A question on their support for increased bike, rail, bus, walking or car infrastructure further ensured that the general opinions on travel modes were similar between treatments. Discrepancies in car access, transit card rates, and licenses were also tested for. Table 4.2 summarizes the treatment sample size, observations and mode chosen outcomes.

Table 4.2 Treatment characteristics

Treatment	Sample size (n)	Percentage of total responses (%)	Number of choice tasks	Number of observations	Percent subway choice (%)
Base case	111	12.29	9	999	62
Parking Cost	108	11.96	12	1296	55
Parking Time	118	13.07	12	1416	57
Travel Cost	119	13.18	15	1785	53
Climate Change	111	12.29	15	1665	57
Air Quality	102	11.3	15	1530	54
Emoji	112	12.4	15	1680	55
Colour	122	13.51	15	1830	52

4.3.3 Design of choice experiments with treatments

In this study, choice tasks were limited to subway versus car trips. In each information treatment, respondents were shown the travel time and, if they were not in the base case, one piece of additional information (Table 4.3, Figure 2.1). In order to study a realistic trip for nearly any respondent, respondents were asked to imagine they were meeting a friend for a meal on a Saturday at 11 am with pleasant weather (to eliminate the potential influence of weather). They were also told to imagine they had access to both modes.

Ten different origin-destination pairs (OD) were selected across the city of Montreal that offer variety and similar "real world" travel times for car and subway to ensure competitiveness and trust from respondents. Each treatment contained between 9 and 15 choice tasks in which the respondent would have to choose between the two modes available for each OD pair given. Table 4.3 describes the treatments and the anticipated influence of the information on choice. The attributes and respective levels are shown in Table 4.4.

Table 4.3 Description and hypothesis of the different treatments used

Treatment	Description	Anticipated influence
Base case	Only the travel times for car and subway are shown	People will principally default to their usual mode if travel times are close.
Parking Cost	Base case + Parking cost	As the parking cost increases, preference should shift towards the subway
Parking Time	Base case + Time spent looking for parking at destination	As the time spent looking for parking increases, preference should shift towards the subway.
Travel Cost	Base case + Total travel cost. For the car, this was based on ownership and operational costs (estimated for 16 000 annual KMs driven) (Gauthier, 2024). Although ticket prices for the subways are stable, a variation in price was shown for the experimental purposes.	As the relative cost of driving goes up, preference should shift towards the subway.
Climate Change	A tree symbolizing forest fires (based on Naseri et al., (2024)) with three levels of environmental impact representing low, medium and high levels of emissions	GHG is a global emissions problem that is not always evident at the local level, which could diminish its influence. The link to the forest fires is a relevant climate disaster in Canada and addresses the problem of psychological distancing (Naseri et al., 2025). Higher levels of GHG emissions will decrease the attractiveness of the car (the carbon content of electricity for the subway in Quebec is extremely low as it is hydropower).
Air Quality	Three levels of haze in front of a sun symbolizing local air quality impacts with three levels representing; low, medium and high levels of smog	Linking to local problems such as air quality could make the impact of such an emission for salient. Showing a smog cloud will negatively impact the use of automobiles.
Emoji	Using emojis to frame social acceptance of a mode: red angry, yellow indifferent, green happy	Showing emojis as a means of communicating injunctive norms can influence transport choices (B. Wang et al., 2023). Showing the disapproval of

		a red emoji will negatively impact the use of automobiles
Colour	Routes highlighted on the map in either red, blue or both. The car route colour is red, the alternative is blue.	Red is associated with avoiding, blue is associated with calm and clear (B. Wang et al., 2021). Highlighting car's route in red will have a negative impact on car use. Highlighting the subway route in blue will increase subway usage

Table 4.4 Attributes and levels

Variable	**Car**	**Subway**
Travel time	car factor * travel time car	subway factor * travel time subway
Travel cost	car factor *$0.98 * vehicle km travelled	$2, $4, $6
Parking time	2 min, 8 min, 14 min	N/A
Parking cost	$0, $10, $20	N/A
Color	Positive, neutral, negative	Positive
Emoji	Positive, neutral, negative	Positive
GHG	High, medium, low	Low
Air quality	High, medium, low	Low

Travel time, for subway and car, was calculated by taking the median value of the estimated travel time for each OD pair provided on Google Maps. The multiplication factors (car factor and subway factor) vary between the car and the subway due to the risk of potential delays. The variability in travel time by car (0.7, 1, 1.3) is greater than by subway (0.85, 1, 1.15) due to road traffic the subway does not encounter. The large variability for cars was selected due to Montreal having the highest congestion rates in Canada (INRIX, 2026). That said, variability in subway time is still provided to account for potential delays that do still occur in the subway despite respecting their planned intervals 96.9% of the time in the morning peak (STM, 2025).

Travel cost for cars was estimated using a $/km ratio ($0.98). The ratio was then multiplied by the multiplication factor (car factor) and the trip length in kilometres (vehicle km travelled which ranged from 3 to 11 km). The value found for this ratio of the full cost, including registration, insurance, maintenance, and fuel, is estimated at $0.98/km for an average car in Montreal (Gauthier, 2024). A factor represented as "car factor" equal to (0.7, 1, 1.3) is introduced to account for variability in the cost depending on the size and price of the vehicle, which will alter the cost per km. For experimental purposes, the subway trip costs varied above the standard trip costs of

$C 3.50. This could be the case if someone bought a 24-hour pass ($C 11.25) but only did two or three trips (STM, 2026).

Parking time was determined by conducting a small focus group. Respondents were asked about the time it took them to park in the downtown core, in the city and in the periphery. As such, the three levels of 2, 8 and 14 minutes were established.

Parking cost levels were identified as $0, $10 and $20 for what would be a 2-3 hour stay as described in the preamble. These roughly account for free parking (more present on the OD pairs further from the city center), street parking and indoor parking (Agence de mobilité durable de Montréal, 2026; Parkopedia, 2026). The parking cost for the subway is fixed at zero, as there is no need to park.

Colours were established using North American colour norms. These show that red is associated with danger, aggressiveness and typically negative emotions, while blue is a safe colour that lacks negative undertones (Murphy, 2020). As such, the subway route was either highlighted in blue for positive framing or not highlighted (in black). The car route would be highlighted in red for a negative framing or not highlighted (in black). Therefore, the three levels were negative framing (red only), positive framing (blue only) and positive and negative framing (red and blue).

Lastly, the qualitative variables (air quality, GHG emissions, and social approval) all contain three levels – low, medium and high impact. These levels are based on the potential impact of different kinds of cars, notably large SUVs and trucks, compared to hybrid and EVs. Low level was kept for the car to account for the possibility of low-emitting vehicles such as EVs. The subway was always framed as low-impact, as the electricity used is hydropower with extremely low carbon content in Quebec (Levasseur et al., 2021).

These attributes and associated levels would generate a large number of combinations, which could impose a burden on respondents. To reduce this burden, a D-efficient design method is applied using Ngene to generate a subset of combinations (Ngene User Manual, 2024). A multinomial logit model is assumed for the design generation, and the prior coefficients for each variable are drawn from Loa et al. (2023). Based on the number of parameters, 9 choice tasks are generated for the base treatment, 12 choice tasks for the parking cost and time treatment, and 15 choice tasks for the other treatments. There is a variation in the number of choice tasks by treatment, as the base case has no levels, the quantitative only has levels for the car choice, while the qualitative treatments have levels for both the car and subway choice. An example of a choice task for each treatment is presented in Figure 4.1. In the experiment, the icons for each treatment were explained at the start of the choice tasks.

Figure 4.1 Example of choice task for each treatment

1. Base case 2. Parking cost 3. Parking time 4. Travel cost

5. Climate change 6. Air Quality 7. Emoji 8. Colour

4.3.4 Mixed logit model

Mixed logit models are used in the analysis for this study in order to capture discrepancies between individuals (Páez & Boisjoly, 2023). This allows for varying coefficients between individuals using a random parameter. Mixed logit models also allow for the relaxing of assumptions of independence of irrelevant alternatives, which states that the relative odds of choosing one option are unaffected by the presence of other options. The most basic form of utility function is:

$$U_{ij} = V_{ij} + \varepsilon_{ij}$$

Where V_{ij} is the observed utility

ε_{ij} is an error term

Subscript i is for every individual

Subscript j is for every option

From this, we derive the utility functions used in the mixed logit models presented in Table 4.5. The utility functions are as follows:

$$U_{i\_metro} = ASC_{metro} + \alpha_{dif} Dif + \left[\sum_{k=1}^{7} \beta_k \, TREAT_k + \gamma_{metro} SOCIO_i + \delta_{metro} ATT_i \right] + \varepsilon_{i\_metro}$$

$$U_{i\_car} = \alpha_{ttcar} TTcar + \left[\sum_{k=1}^{7} \beta_k \, TREAT_k \times LEV \right] + \varepsilon_{i\_car}$$

Where all variables have their own constant, as seen in the utility function

ASC_{metro} is the subway alternative specific constant

Dif is the difference in travel time between car and subway

$TREAT_k$ is the dummy variable for treatment k

TTcar is the travel time of the car

LEV is the marginal effect of the treatment (level)

SOCIO is a socio-demographic characteristic

ATT is attitude variables, such as having an Opus car and openness to modes

ε_{i_x} is an error term

Mixed logit models are based on simulation techniques that aim to simulate maximum likelihood (Páez & Boisjoly, 2023). It does so by integrating the properties from the theoretical formula below, where P_{ij} is the probability of choosing mode j. β is the random variable that differentiates mixed logit from a multinomial logit model and σ describing its distribution. $x_{ni}$is the observed variable for person i in choice j. The integral provides the weighted average given a mixing distribution j.

$$P_{ij} \; = \int \frac{e^{\beta(\sigma)\prime x_{ni}}}{\sum_k e^{\beta(\sigma)\prime x_{nk}}} \cdot \varphi(\beta \mid \sigma)\, d\beta$$

In order to achieve this in practice, β must be obtained using random draws of σ. In doing so, we obtain:

$$P_{ij} \; = \frac{1}{R} \sum_{r=1}^{R} \frac{e^{(\beta^r)\prime x_{ni}}}{\sum_k e^{(\beta^r)\prime x_{nk}}}$$

Using the Montecarlo simulated approximation, we randomly draw R number of times to find the average of all possible values. This needs to be done as the integral above has no closed form and therefore must be estimated with a significantly high number of draws, 1000 in our case. The draws are uniform symmetric in our model, meaning they draw above and below the mean.

4.3.5 Modeling procedure

First, treatments were introduced as explanatory variables in logit models. Biogeme was used to create the models shown in this study (Bierlaire, 2020). The model was run for two different samples: those who strictly use cars as their mode of transport and those who are multimodal (use cars and other modes of transportation). Initially, simple logit models were created to include treatments and a mode choice. To increase model fit, socio-demographic characteristics were added one at a time to test their significance and whether they increase the model's performance. The performance indicators used were the log likelihood and rho square. Finally, mixed logit models are presented in Table 4.5 that display the final results of this study.

4.4 Results and analysis

4.4.1 Model fit and comparison

Table 4.5 presents the results of the three mixed logit models. The global model contains all responses; the sample is then divided into two groups for segment analysis as the impact of different information on people who solely drive is likely to be different than those who do not only get around by car. One such factor is that people who typically get around by car would have a stronger car habit and may be less influenced by information (Verplanken et al., 1997). The car-only model contains respondents who strictly use the car as their only transport mode, while the multimodal model contains those who take more than one mode of transport (this can include using a car for some trips). The travel time difference between the car and the subway was selected as the random parameter, where the draws create a symmetric uniform distribution (Hess et al., 2005). The logic behind this is that the time savings relative to the other mode are more important than the trip duration by each mode. Both the independent variable and the time difference were tested in simple logit models, and the time difference had a consistently strong and significant effect on mode choice. The random parameter, being the travel time difference, allows us to capture how different people react to the time difference. The mean is significant and negative in all models, indicating its importance. The standard deviation is not significant in the car-only model. This demonstrates that there is more heterogeneity in responses within the multimodal group than within the car-only group, which could point to a stronger habit in the car-only group.

Table 4.5 Mixed logit model results segmented by multimodal users and car-only users

	Global model		**Multimodal model**		**Car only model**	
Variable	Value	**rob. P-value**	Value	**rob. P-value**	Value	**rob. P-value**
ASC Car (REF)	--		--			--
ASC subway	**-1.41**	0 (***)	**-0.222**	0.316	**-1.59**	0 (***)
Car travel time	**-0.005**	0.119	-0.010	**0.032 (**)**	0.00041	0.92
Time difference between option	**-0.04**	0 (***)	**-0.0452**	3.11E-15 (***)	**-0.0377**	0 (***)
SD of Time difference between option	**0.046**	0.0668 (*)	**0.066**	0.017 (**)	**0.00238**	0.803
Desire to reduce GHG emissions	**0.147**	0 (***)	**0.183**	1.11E-13 (***)	**0.129**	4.46E-10 (***)

Parking cost treatment	**0.576**	7.00E-06 (***)	**0.786**	0.000325 (***)	**0.363**	0.0156 (**)
Parking cost ($)	**-0.0147**	0.0734 (*)	**-0.016**	0.251	**-0.0127**	0.193
Parking time treatment	**0.534**	0.000126 (***)	**0.398**	0.0694 (*)	**0.582**	0.00143 (***)
Parking time (min.)	**-0.0221**	0.0827 (*)	**-0.0251**	0.206	**-0.0208**	0.221
Total travel cost treatment	**0.979**	1.11E-05 (***)	**0.558**	0.0879 (*)	**1.36**	4.54E-05 (***)
Total cost car	**-0.106**	1.23E-07 (***)	**-0.101**	0.0011 (***)	**-0.129**	1.58E-05 (***)
Total cost subway	**-0.113**	0.000681 (***)	**-0.156**	0.00146 (***)	**-0.0796**	0.0998(*)
Climate change treatment	**0.538**	1.91E-05 (***)	**0.433**	0.0327 (**)	**0.453**	0.00456 (***)
Burning tree	**-0.149**	0.297	**-0.191**	0.41	**-0.163**	0.381
Brown tree	**-0.0857**	0.538	**-0.019**	0.929	**-0.156**	0.39
Air quality treatment	**0.503**	9.05E-05 (***)	**0.565**	0.00635 (***)	**0.305**	0.055 (*)
Black cloud over sun	**-0.0948**	0.521	**-0.216**	0.362	**-0.0342**	0.855
Hazy sun	**0.0364**	0.8	**-0.014**	0.95	**0.057**	0.755
Emoji treatment	**0.729**	1.09E-08 (***)	**0.74**	0.000287 (***)	**0.585**	0.00016 (***)
Red angry emoji	**-0.258**	0.0796 (*)	**-0.49**	0.0407 (**)	**-0.137**	0.456
Yellow neutral emoji	**-0.177**	0.219	**-0.242**	0.284	**-0.148**	0.404
Colour treatment	**0.501**	2.20E-05 (***)	**0.174**	0.375	**0.632**	2.22E-05 (***)
Subway highlighted in blue	**0.0961**	0.46	**0.116**	0.577	**0.0935**	0.586
Subway in blue, car in red	**-0.132**	0.31	**-0.115**	0.576	**-0.147**	0.392
Aged 31-65	**0.123**	0.0151 (***)	**-0.389**	2.65E-06 (***)	**0.646**	0 (***)
Below the age of 30	**0.25**	0.000381 (***)	**-0.156**	0.129	**0.646**	2.52E-10 (***)
Currently is multimodal	**0.875**	0 (***)				
Currently does not use car	**1.72**	0 (***)				
Destination is downtown	**0.147**	0.00592 (***)	**0.244**	0.00324 (***)	**0.0708**	0.317
University education, all levels	**0.514**	2.22E-16 (***)	**0.779**	4.64E-14 (***)	**0.291**	0.000307 (***)

College (Cegep in Qc) and professional education	**0.429**	4.95E-14 (***)	**0.317**	0.000918 (***)	**0.469**	3.76E-11 (***)
Income 125 000k+	**0.165**	0.0256 (**)	**-0.24**	0.0425 (**)	**0.0941**	0.3
Income 40-125k	**0.0866**	0.128	**0.0346**	0.7	**-0.109**	0.148
Having a transit card (Opus)	**0.983**	0 (***)	**1.2**	0 (***)	**0.982**	0 (***)
Considering street safety	**0.0709**	0.00383 (***)	**0.0842**	0.0373 (**)	**0.0384**	0.212
Model fit						
Sample size:	**12201**		**5763**		**6438**	
Init log likelihood:	**-8458.434**		**-3996.907**		**-4466.82**	
Final log likelihood:	**-6985.46**		**-2972.617**		**-3953.671**	
Likelihood ratio test for the init. model:	**2945.947**		**2048.58**		**1026.298**	
Rho-square for the init. model:	**0.174**		**0.256**		**0.115**	
Rho-square-bar for the init. model:	**0.17**		**0.248**		**0.107**	
Number of draws:	**1000**		**1000**		**1000**	
Number of iterations:	**241**		**207**		**194**	
Optimization time (10-core M4 chip):	**9h 13 min**		**7h 41min**		**7h 30min**	

****: p-value < 0.01, **: p-value < 0.05, *: p-value < 0.1*

The results of the models are presented in Table 4.5 use the utility functions described above. For ease of interpretation, Table 4.5 displays all values with respect to the subway utility function. Therefore, a negative sign negatively impacts the subway's utility while a positive sign improves the utility of the subway. The multimodal model performs the best with a rho squared of 0.26, which is very high for a binary mixed logit model. Next, the global model containing all respondents (0.17) and finally the model with people who only use a car as a mode of transport (0.12). From this, we conclude that taking different modes of transport allows better estimation of behaviour through models with more explanatory power. This is also likely due to the lack of variation in behaviour for people who strictly use the car to get around. These findings highlight the impact that accounting for multimodality has on model fit.

4.4.2 Attributes affecting mode choice

The difference in travel time between the two options is more important than the mode-specific travel time. This variable was calculated in the analysis step, as respondents were asked to make a choice between two modes. The relative time to the other option was found to have a larger effect than the mode-specific value of time. The time difference is highly significant in all three models. Having a larger travel time in the subway than by car will significantly reduce the utility of the subway and vice versa. The desire to reduce GHG emissions in one's daily life in the multimodal group had a larger impact than the car-only group. Nonetheless, in all three models, wanting to reduce GHG emissions had a positive impact on subway usage. Having a transit card (Opus) had a significant and positive effect on subway usage, which is logical as it likely relates both to experience using transit and intention to use transit. Not having a transit card is a significant barrier to transit in Montreal due to the lack of tap-to-pay infrastructure, typically requiring individuals to queue to buy a ticket (and only in the past few years has it become possible to so by card rather than by cash). For buses, it is still necessary to pay in cash.

Various socio-demographic variables were found to influence choice. In the car-only model, being under 65 increases the probability of selecting the subway in the choice tasks. In contrast to the other models, in the multimodal model, being an adult (aged 30-65) has a negative impact on subway usage relative to being younger than 30. Additionally, having gone to post-secondary education (trade, college, or university) showed a significant and positive effect on subway selection relative to having a high school degree in all models. Further, we found that income has no impact on mode selection in the car-only model, but in the multimodal model, having an income of $125 000 or more before taxes has a significant negative impact on the selection of the subway.

Lastly, the models show that road safety was a factor in most choices, except for car-only respondents. Considering street safety when making choices positively impacts the use of the subway for the multimodal and global model.

4.4.3 Overall treatment effect

Somewhat counterintuitively, the treatments have an overall negative effect on subway usage. Or put another way, showing information (nudging people) made them more likely to choose the car over the people who were not nudged (the base case). We hypothesize this is due to the magnitude of the lowest level of attributes presented. As all of the origins and destinations were in the central areas of Montreal, and the respondents were from the Greater Montreal Area, we believe showing, for example, zero-dollar parking cost when someone was expecting to pay for parking when they come to the city would be an incentive to drive. This effect could be extrapolated to all treatments, as the lowest level would motivate driving, as the costs/externalities are smaller than anticipated by the respondent.

We hypothesize this outcome is due to the fact that choices are made in reference to the preconceived idea someone already has in their head about the option, not purely based on the values presented in the choice moment. This stems from the psychological theory of anchoring effect. This theory suggests that the idea one has in their head about the price or effect of an item being more or less than what is shown in the choice moment heavily influences the choice that is being made (Tversky & Kahneman, 1974). This theory, linked with the low levels in the choice tasks, can be used to explain the discrepancy between the marginal effect of treatments and the overall effect of treatments as seen in Table 4.5. In the case of parking costs, if someone's experience of parking downtown related to events such as the professional hockey games, parking would typically start at $20 (our highest amount) and go to close to $50. As such, their reference point (anchor) might be quite high, and the presented amounts appeared cheaper, thus stimulating car selection. Similarly, given the short distances between the provided OD pairs, the cost of car and metro can be very similar for the shortest trips. At $0.98/km, a car trip that is 4 km will be $3.92 multiplied by a car factor of 0.7, 1 or 1.3. As the cost of the subway varies between $2, $4, and $6, the cost difference between the modes on trips less than 5 km is not significantly different, leading to potentially ineffective treatments.

The impact of habit was shown to potentially influence results. As travel patterns are often repeated, conscious choices are rarely made for frequently repeated trips. As such, the fact that a lot of travel is habitual can slow the adaptation of new modes or new travel patterns, as users typically resort to their normal mode without considering all the options that are available (Verplanken & Orbell, 2022). Consistent, habitual behaviours might motivate the low levels of effectiveness in overall treatments. More established travel habits should reduce the influences of supplemental information on choice.

A few notable differences exist between the influence of the information by typical mode use. Car-only individuals were less influenced by no parking cost than the multimodal users. This could suggest that multimodal users would be more likely to switch to a car if parking were free than the car-only users. For the qualitative treatments, air quality had a smaller impact on the car-only group, as did the injunctive norm (emoji). This could indicate that the car-only individuals are not as concerned about such considerations.

One treatment that did not follow that trend was the cost of travel. Presenting the cost of using the mode (but not including parking costs) had a much larger influence on car-only participants choosing the car than on the multimodal group. This can be explained in a similar manner to the parking costs. The distances were not large (around 5 km), and the cost per kilometer was roughly $1/km. Individuals might have also assumed that the parking cost was included. That means that the car costs would be similar to the subway costs. If people thought that it included the parking cost, this might seem cheaper than their reference point.

4.4.4 Marginal treatment effects

The results show that multimodal people respond more consistently to qualitative treatments than the car-only group. The significance levels of the environmental treatments, such as climate change and air quality, are more consistent for the multimodal group than the car-only group. This is congruent with the literature, given that they have already broken the barrier to trying different modes (Lowry, 2024; Verplanken et al., 1997). As they are open to currently using more than one mode, they may also be less hard to persuade than car-only users. Further, in the global model, as hypothesized, the higher the treatment level, the more probable it is to choose subway (which does not have as many negative nudges). This is also reflected in other literature where displaying negative information sways respondents away from that choice (Schechner et al., 2025; B. Wang et al., 2021; X. Wang et al., 2023).

Travel cost, a quantitative treatment, is the most significant marginal treatment variable, being very significant and consistently negative in all models. This indicates that cost has a large effect on mode choice, and the more expensive the car is displayed, the higher the probability of choosing the subway becomes, though the inverse is true as well. For the emoji treatment, having a red angry face was found to be the only significant level. That said, even the high level of emoji only had an impact on multimodal users. The colour that was shown in the colour treatment did not have a significant impact on mode choice. Overall, the models show that the marginal impact of the treatments has a push effect toward the subway.

4.4.5 Limitations

The research has several limitations. The trips examined were only for those linked to the downtown area and thus cannot be applied to more general trips. Quotas were used to make the sample to be as representative as possible, but people with low educational attainment were essentially not represented, and households of low income were underrepresented. As mentioned, the levels tested were potentially too small in terms of costs (financial or time) to motivate a shift. The icons used to present air quality and greenhouse gas emissions could be tested for comprehension and improved.

4.5 Conclusions and future directions

Nudging can have a significant impact on mode choice both in qualitative and quantitative manners. In this study, it was shown that the marginal effects of quantitative nudges, such as time and money (attributes respondents are used to dealing with), significantly reduce the utility of the car relative to the subway, leading to more sustainable choices. However, we find the overall treatments to have a negative impact on subway choice relative to the base case. This shows that the effectiveness of nudges is not only reliant on the information shown and how it is shown, but also on the levels of the attributes in the nudge. Framing the car with the same costs as the subway will encourage car use for those who already use the car. As such, we find it is important to know when to nudge and how to do so to not incur adverse effects such as more car use. This highlights the effects of anchoring, where individuals make decisions based on their relative expected value and what is shown.

The results show that multimodal users have more openness to nudges and have a higher probability of changing modes than car-only respondents. This is in line with research on habits in travel behaviour. Hence, breaking habits is essential in achieving desired mode changes as they dictate a large part of the mode decision-making process (Verplanken & Orbell, 2022). We also find that having an Opus card is a significant determinant of mode usage as it likely serves as a proxy for individuals' multi-modality, experience with the system, and general intention to use public transport.

This research finds that both qualitative and quantitative nudges in a trip-planning app can influence choice behaviour, but must be carefully designed. Nudges indicating lower costs (personal or environmental) than those perceived can have unintended and opposing effects. Therefore, if the intention is to support sustainable mode choice, careful attention must be made to understand reference points.

CHAPTER 5 ADDITIONAL FINDINGS ON TRAVEL PERCEPTION AND BEHAVIOUR

In addition to the experiments, the survey asked participants about a number of additional potential influences on their choices. The questions asked aimed to gather information on instrumental factors (e.g., reliability, ease of carrying things), comfort (e.g., personal safety, cleanliness), and externalities (e.g., air quality, environment). It also asked about perceptions of social norms around going downtown. Finally, as traffic danger can influence choices to walk or cycle (which are means of accessing public transit), whether people considered traffic danger in the DCE and what people said they considered when thinking about traffic danger were also captured. The findings presented here allowed for a better understanding of people's opinions related to mode choice and include valuable insights into mode choices and perception of travel behaviour.

5.1 Advantages and disadvantages of cars and public transit

Participants were asked to indicate whether different considerations about cars and public transit impact their choices and in what direction (for or against). Figure 5.1 displays how respondents said various statements influence their use of a car. We can observe that difficulties finding parking have the largest impact against car use, while the need to carry things has the greatest positive impact on car use.

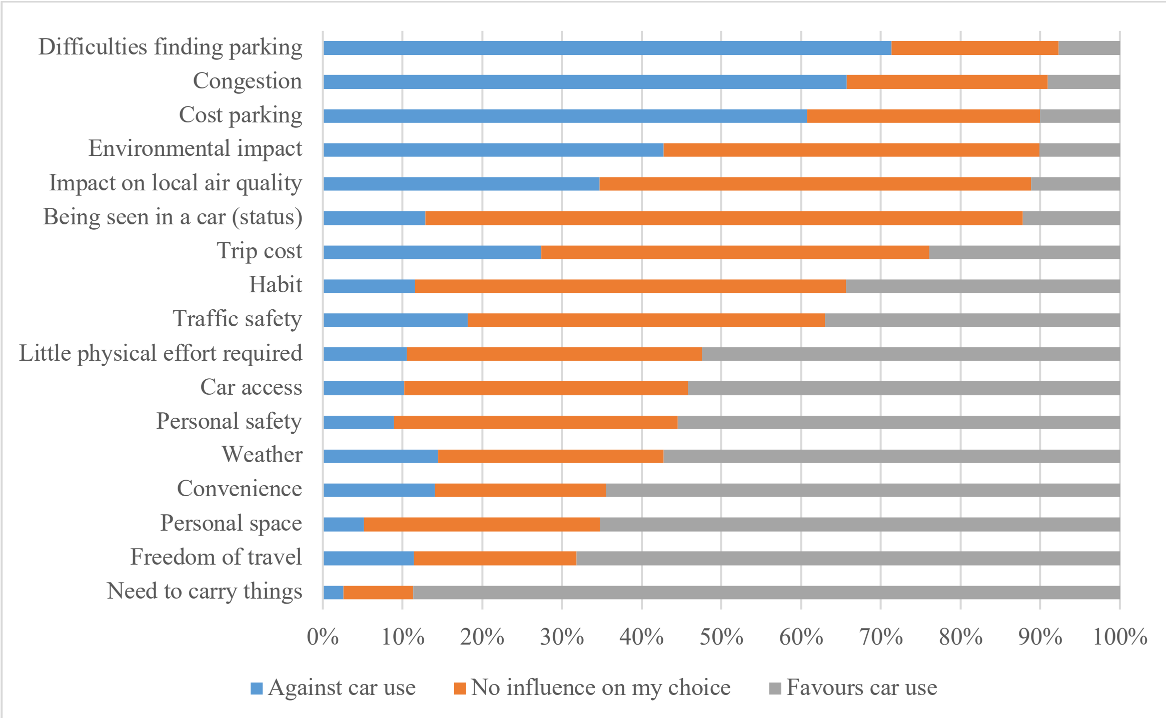

Figure 5.1 Factors influencing car use

The advantages and disadvantages for public transit are shown in Figure 5.2. The need to carry things had the largest influence against transit use, while traffic congestion and environmental impacts have the largest positive impact on transit usage. Notably, cleanliness, crowdedness and the presence of homelessness in the metro were concerns for large amounts of respondents (48%, 47% and 45% respectively) and negatively influenced their choice to take public transit. Addressing these concerns could therefore improve the likelihood of people taking public transit. Of our respondents, 42% of people do not think that using public transit as their usual mode of transportation influences their use of public transit.

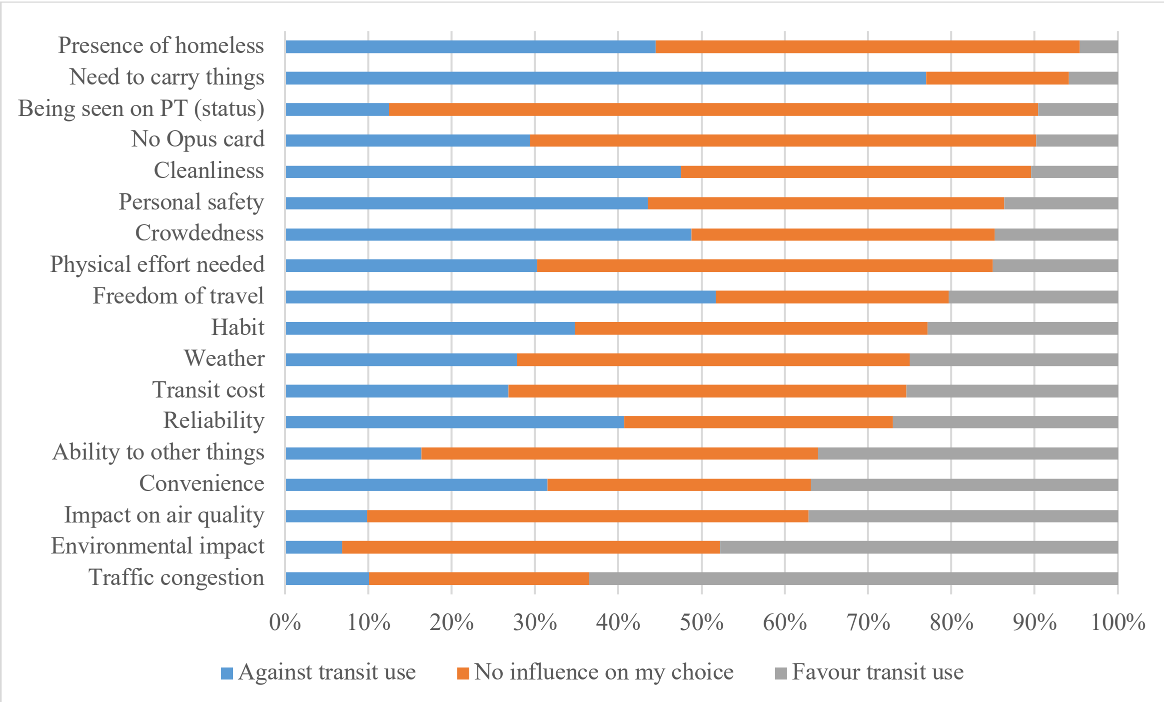

Figure 5.2 Factors influencing transit use

5.2 Perceptions on the usual mode of travel to the downtown

Interestingly, respondents underestimate the number of trips made using public transit. Table 5.1 displays the mean of respondent's estimated mode share for trip made to downtown. We see that respondent estimates that 38% of trips that are made where the destination is downtown are by public transit. The ARTM found in the 2018 origin-destination survey that 57% of trips to downtown are by public transit (ARTM, 2020), a substantial difference from the general public's perceptions. Another large discrepancy between perceived and actual mode split is with walking. Respondents estimated that 6.6% of trips made to downtown were made via active modes. Actually, 14% of trips made in the city center were completed by active modes (ARTM, 2020), approximately double that of the public's perception.

Table 5.1 Respondents estimated mode share for trips to downtown

	Mean estimated mode share (% of total trips)	Mode share from 2018 Origin destination data (% of total trips)
Car	43	38.1
Public Transport	38.7	57.4
Bike	9.3	14.1 (bike and walk)
Walk	6.6	NA
Other	2.4	2.2

5.3 Traffic safety considerations

Table 5.2 presents the factors considered when thinking about road safety. First, we find that 58% of respondents said they considered road safety when making their choices in the discrete choice experiment. Street safety had a significant impact on mode choice in the global and multimodal mixed logit models (see Table 4.5). Among the group that considers road safety, the amount of traffic on the road was the most frequently selected factor when asked what they consider when thinking about road safety (76% of respondents who consider traffic safety). The next most considered factors (60 %) when thinking about road safety were 1) time of day and 2) whether or not the trip took place downtown. The presence of large vehicles, despite carrying more energy and therefore a greater risk, was the least considered statement when asked what they considered when thinking about road safety. This result is aligned with the theories discussed in Chapter 6 as vehicle size is rarely considered in traffic risk (Y. Wang et al., 2022).

Table 5.2 Factors considered when evaluating road safety (%)

	Amount of traffic on the road	Where the trip takes place (downtown or other)	Time of day (day or night)	Condition of the infrastucture	Number of intersections one must cross	Lack of protected infrastuture or sidewalks	Presence of large vehicles
Not considered	24.37	40.16	40.85	70.14	73	75.63	78.49
Considered	75.63	59.84	59.15	29.86	27	24.37	21.51

CHAPTER 6 ARTICLE 2: MOTONORMATIVITY AND SPEED LIMITS

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ABSTRACT

The safe system approach to traffic danger proposes kinetic energy as the primary hazard. However, speed limitations are imposed on new travel options like e-bicycles that do not pose the same hazard as cars. This uneven application of rules to cars has been termed motonormativity. This research examined whether the general population would apply the same speed limits to the two vehicle types and asked why those limits should exist (or not). Individuals were randomly assigned to questions related to one mode. In conflict with the hazard approach, greater restrictions were proposed for e-micromobility modes.

KEYWORDS

Traffic hazard; Traffic danger; Speed limit; Motonormativity; E-bicycle; E-scooter; Micromobility; Kinetic energy

6.1 Questions

With the recent growth in the adoption of electric bicycles and electric scooters (e-micromobility), safety concerns have emerged. As a result, speed limits, often around 25 to 30 km/h, have been imposed on these types of vehicles. This limit is 32 km/h in Quebec, Canada (SAAQ, n.d.). Our study was conducted in Montreal, Canada, where the speed limit for cars is 30 km/h on residential streets, 40 km/h on secondary arterials, and 50 km/h on primary arterials. In some locations, geofencing has been used to limit the speeds of the smaller electric vehicles due to the danger imposed on others (pedestrians principally; (Caggiani et al. 2025)), yet we are unaware of similar applications to cars. From a safe system perspective on traffic danger, it is important to assess the hazard a vehicle creates in terms of kinetic energy (Ederer et al., 2023). Kinetic energy is calculated using the following formula.

$$E_k = \frac{1}{2} \times m \times v^2 \qquad [1]$$

Where:

E_k = Kinetic energy (J)

m = mass (kg)

v = velocity (m/s)

The calculations below are intentionally conservative, using values for mass on the higher end (e.g., 100 kg for the user and 40 kg for the e-micromobility vehicle). Using equation [1], someone on an e-micromobility vehicle at 25 km/h would create approximately 3,375 joules of kinetic energy. For an average adult (62kg) and an average urban e-bicycle (roughly 20kg), the energy would be 1,977 joules (Walpole et al., 2012).

$$E_k = \frac{1}{2} \times 140 \times (25 \div 3.6)^2 = 3{,}375.77\,J$$

By contrast, if we consider a compact SUV, the most popular car for purchase in North America (Brazeau, 2021), weighing approximately 1,500 kg (Axsen & Bhardwaj, 2024) with an average of 1.2 passengers (*EOD23 - Enquête Origine-Destination*, n.d.) weighing 100 kg each (same assumption as e-micromobility), the maximum speed of the car would need to be 7.3 km/h to match the same 3,375 joules considered for the e-micromobility. For a full-size SUV (approximately 2560 kg), the maximum speed would be 5.7 km/h (Hawley, 2021).

$$3{,}375\,J = \frac{1}{2} \times \big((100 \times 1.2) + 1{,}500\big) \times v^2 \rightarrow v = 2.04\,\frac{m}{s} \approx 7.3\,\frac{km}{h}$$

Therefore, in terms of the hazard imposed on the public, cars pose a bigger threat to pedestrians than e-micromobility. However, anecdotally, the same logic is not applied to both vehicle types when considering the risk to others. This phenomenon, where people are biased toward cars, is referred to as motonormativity (Walker, Tapp, and Davis 2023). In this research, we examine whether people apply the same restrictions and justifications to cars and e-micromobility (EM) options.

6.2 Methods

This study was conducted using data collected from a survey with respondents from the greater Montreal area, a Canadian city with 4.2 million inhabitants (Government of Canada, 2022). Montreal has seen significant growth in the number of cyclists, along with an expansion of cycling infrastructure that is often used by EM users (Ville de Montréal, n.d.).

The survey was distributed by Leger Opinion. Three trap questions were used to eliminate inattentive respondents; the final sample had 1,532 valid responses. The sample's representativeness in relation to the Montreal population can be found in Table 6.1. Given the hard-to-reach nature of people with education below high school, the sample is missing respondents from this group.

Respondents were randomly assigned to one of two treatments: (i) EM or (ii) car. Statistical analysis confirmed that the samples were not different in terms of income, age, education, and gender. A question on their support for increased bike, rail, bus, walking or car infrastructure further ensured that the general opinions on travel modes were similar between treatments. Respondents from both treatments were then asked whether the speed of (i) e-scooters/e-bikes or (ii) cars should be limited in areas where there are pedestrians. Respondents then chose from a multiple choice list the reason(s) they believe the speed of the relevant mode should or should not be limited. The two treatments' responses were then compared using Welch Two-Sample T-tests and Chi-squared tests.

Table 6.1 Socio-demographic characteristics of the treatment samples relative to the Montreal population (%)

	Car Sample (n= 767)	**EM Sample (n= 765)**	**Montreal Population**
Education			
Primary / no degree	0.65	0.92	15.71
Secondary or equivalent	20.21	19.35	19.37
Vocational training (DEP or equivalent)	15.38	16.99	18.62
College (CEGEP)	22.03	23.4	19.63
University – Bachelor's degree	26.6	26.67	23.78
University – Master's / DESS	12.39	10.59	9.56
University – Doctorate	2.22	1.57	1.74
Prefer not to answer	0.13	0.13	---
Other	0.39	0.39	---
Household Income, Before Tax			
$0--9,999	0.91	1.31	3.3
$10,000--19,999	3.78	3.66	5.1
$20,000--39,999	10.56	14.38	11.3
$40,000--59,999	18.12	18.3	14.1
$60,000--79,999	15.78	15.82	20.8
$80,000--99,999	12.65	12.81	12.8
$100,000--124,999	11.6	8.76	9.3
$125,000--149,999	7.17	7.32	6
$150,000--199,999	9	7.84	6.4
$200,000 or more	6.52	7.19	5.9
Do not know	0.13	0.52	---
Prefer not to answer	3.78	2.09	---
Age (Years)			
18--19	1.43	1.57	1.16

20--24	5.35	6.93	8.78
25--29	9.78	8.63	10.8
30--34	10.17	7.45	10.29
35--39	9.39	10.46	9.53
40--44	10.04	10.07	8.91
45--49	8.34	9.02	7.72
50--54	6.91	8.63	7.4
55--59	7.04	7.06	7.57
60--65	7.43	7.97	7.13
65--69	6.78	6.27	5.96
70 and over	17.34	15.95	14.75
Gender			
Female	53.98	58.69	51.18
Male	45.37	40.65	48.82
Other	0.65	0.65	---

6.3 Findings

The results, as well as their statistical significance, are shown in Table 6.2. First, in both groups, the vast majority said that speed limits were required (82% EM, 80% car), highlighting that a super majority of the population supports limiting speeds where there are pedestrians. However, the participants were statistically more likely to support no speed limits for cars (12.4%) than for EM (6.7%). For both the "yes, limit" and the "no limit" groups in either experimental group, the majority do not believe that travel time is more important than safety. These findings suggest that this population supports limiting the hazard even if speeds would need to be limited."

Further, the average speed limit suggested by respondents differed significantly ($p<0.001$) between EM (26.0 km/h) and cars (37.6 km/h). At these speeds, 3,650 J of kinetic energy is produced by EM and 88,720 J for the car, indicating that cars would produce ~24 times more kinetic energy than the EM alternative. Figure 6.1 shows the distribution of suggested speed limits across the two treatments, with responses in the car condition clustered around the current Montreal speed limits of 30, 40 and 50 km/h. We conclude that speeds allowed for different transportation modes are more in line with norms, rather than the hazards they impose. We also find a statistically significant difference, where more respondents are unsure whether the speed of EM (11.2%) should be limited compared to cars (8%).

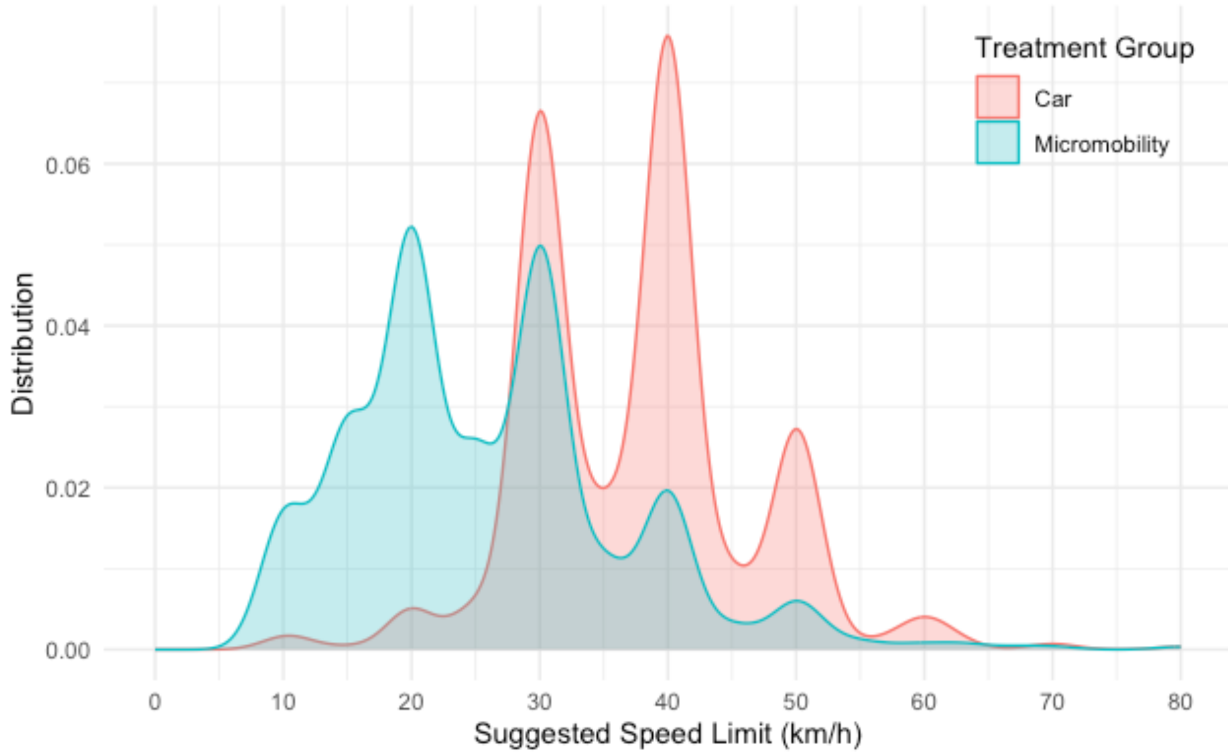

Figure 6.1 Distribution of suggested speed limit by treatment (Density Estimation)

Among respondents who supported speed limits, nearly all the EM sample (88.2%) indicated that danger to others was important to consider, compared to 61.4% in the car sample. Additionally, more than half (53.3%) of the EM sample indicated danger to self as being relevant, compared to a quarter (24.4%) of the sample for cars. Consequently, EM is viewed as more dangerous than cars for oneself in a collision, a legitimate perception considering the numerous safety features of cars designed to protect the people inside the cabin. From a public health point of view, limiting the speed of cars because of their impact on others would be more coherent, considering the kinetic energy, while limiting EM speed because of the danger faced by its users is reasonable.

Among respondents indicating speeds should not be limited, the vast majority in both samples (82.4% EM; 89.5% car; not statistically different) indicated that the users only need to follow the current speed limit. For personal safety-related restrictions, statistically, more people (21.6%) of the EM group, compared to the car group (8.4%), justify this by saying that it is the user's choice, even if they are endangering themselves. For travel time being more important than safety, only 2% of the EM and 4.2% of the car sample agreed with this. The key takeaways are thus: a) these individuals are more about following the rules regardless of safety considerations; b) a minority believe that it is an individual's choice to take personal risks; c) even for this group, convenience (e.g., not limiting speeds, saving time) was not seen as a justification.

Finally, those who answered that they do not know if the speed should be limited had no significant differences between the EM group and the car group. Nevertheless, when asked what should be considered when deciding whether to limit speeds, the majority in both groups (66.3% EM; 52.5% car; not statistically significant) indicated that the danger it creates for others should be considered.

Table 6.2 Results summary of statement support with statistical significance. Values (n) and percentages calculated within each response category (Yes/No/Don't know).

Should speeds be limited?	**EM (n = 765)**	**Cars (n = 767)**	**Post-hoc p-value**
Yes	628 (82.1%)	611 (79.7%)	0.2265
No	51 (6.7%)	95 (12.4%)	0.0001 (***)
I don't know	86 (11.2%)	61 (8%)	0.0289 (**)
If yes, what should the limit be			**T-test p-value**
Mean in km/h	26	37.6	2.2e-16 (***)
Why speed should be limited?	**n = 628**	**n = 611**	**Chi-squared p-value**
Danger to others	554 (88.2%)	375 (61.4%)	2.2e-16 (***)
Danger to self	335 (53.3%)	149 (24.4%)	2.2e-16 (***)
Road safety is more important than shorter travel time	403 (64.2%)	469 (76.8%)	1.7e-6 (***)
Why speeds should NOT be limited	**n = 51**	**n = 95**	**Chi- squared p-value**
Same rules for all vehicles - Just follow the speed limit	42 (82.4%)	85 (89.5%)	0.336
It is their choice even if they are endangering themselves	11 (21.6%)	8 (8.4%)	0.046 (**)
Travel time is more important than road safety	1 (2%)	4 (4.2%)	0.814
Not sure if speeds should be limited	**n = 86**	**n = 61**	**Chi- squared p-value**
Danger to others	57 (66.3%)	32 (52.5%)	0.129
Danger to self	34 (39.5%)	20 (32.8%)	0.508
Freedom	17 (19.8%)	10 (16.4%)	0.701
I don't know	19 (22.1%)	20 (36.1%)	0.094 (*)
* p-value <0.1, **p-value<0.05, *** p value < 0.01			

CHAPTER 7 DISCUSSION

This research examined the factors that influence mode choice and collected information on which factors work best at reducing car use and which work best at promoting public transit usage. With that data, we examined how different types of information influence mode choice in a trip planning tool and looked at how traffic safety is considered. Lastly, we examined how people think about speed and danger. The need for a low-cost, easy-to-implement solution to the current issues in transport is presented. Two experiments examined these issues: information displays in a planning tool and understanding public perceptions related to traffic danger.

Through Chapter 4, seven different ways of framing information related to a trip were tested in a discrete choice experiment (DCE). We find that the levels shown in the attributes have the largest impact on the effectiveness of the treatment. When displaying a cost that is potentially smaller than the one expected by the respondent, we observe an effect that opposes the one we hypothesized. For example, displaying a parking cost of $0 when driving into the city, when the respondent may have assumed a non-zero parking cost, incentivizes car usage relative to not showing any additional information. This explanation is supported by the marginal effects of treatments, where displaying increasing costs proved significant and reduced car utility. As such, the discrepancy between the two indicates that the participants likely responded not only to the absolute values but also to the discrepancies from what they expected. In addition, we find that multimodal users are more susceptible to mode change than car-only users. This is likely due to entry barriers to sustainable modes being broken and weaker habits due to more mode variation. Lastly, subjective factors such as trip satisfaction also influence behaviour (Schneider, 2013). These subjective factors were not included in our models due to their complexity in capturing them, yet they likely influence mode choice.

Chapter 6 shows that norms likely impact the public perception of traffic danger created by motorized vehicles. We found that people suggested lower speeds for e-micromobility than for cars, likely reflecting social norms where cars are the dominant mode. Using the average proposed speed limit and vehicle (and user) mass, we find that the proposed speed limits would result in a situation where a car would produce roughly 24 times more kinetic energy than e-micromobility. Such outcomes are illogical from a street safety perspective, where the larger hazard should be limited. It must be noted that in addition to vehicle speed, shape also has a large impact on traffic hazard. For example, vehicles with tall bumpers do not allow pedestrians or other road users to go over the vehicle on impact; instead, they push them under the vehicle, which is a larger risk (Monfort et al., 2024). These results are linked to the concept of motonormativity, a phenomenon where people are biased towards cars (Walker et al., 2023). This study confirms the presence of motonormativity in Montreal.

The suggested speed limits are likely a reflection of social norms rather than actual hazards. As seen in Figure 6.1, the suggested speed limits for cars all cluster around the existing limits of 30, 40 and 50 km/h. The desire to limit the speeds of e-micromobility vehicles could be due to the lack of familiarity with e-micromobility or a perception that they follow road rules less than cars. Research focusing on micromobility suggests that speed should be limited due to e-micromobility being used in crowded pathways and reckless driving styles, though rarely are these reasons mentioned when considering car restrictions (Pande & Taeihagh, 2021). Current policies likely reflect these biases as they limit the maximum speed of e-micromobility to 32km/h in Quebec. These limits on e-micromobility could be aimed at limiting the risk for the user, as these vehicles contain fewer safety features for the user than a car. Speed limits should consider kinetic energy, as it is directly correlated with injury severity for other road users, which we argue is as important as the safety of the driver. Valuing travel time over safety or vice versa has been found to depend on who you are responding as: a consumer or a citizen (Mouter et al., 2017, 2018). These studies find that, as citizens, there is a preference for safety over speed, but when asked the same questions from the consumer's point of view, speed is preferred, as personal risk is perceived as lower than average. These considerations could affect how speed answers were given if they were responding as citizens or consumers. Given the response of limiting speeds on new modes such as e-micromobility as a measure to increase road safety, laws for cars, where there are other people, should also be revised to account for the real safety threat they impose without a biased perspective.

In response to the second research objective, Chapter 6 allows us to understand that perceptions of danger are mode-dependent and are heavily based on social norms. Given that safety perceptions are heavily influenced by extrinsic factors, adding safety information to a trip planning tool may not be effective in changing behaviour, as respondents are likely not to respond to absolute hazards such as kinetic energy. Further, removing a bias towards the car is difficult due to the nature of biases. A shift towards a more holistic understanding of traffic hazards will take time and education at all stages of life to have the population look at traffic danger in an unbiased way. More immediately, the research has found that people do not suggest the same speed limits for different vehicles. Given that, engineers should employ the engineering approach when making judgments on infrastructure and limits towards different modes of transport, which have historically favoured larger vehicles.

Together, the two articles portray various nuances in the study of transport. Our findings in Chapter 4 show that treatment levels, notably for multimodal users, have a significant effect on mode choice. Meanwhile, in Chapter 6**,** we find that social norms influence the perceived danger that certain modes exert on road users. The results support arguments that choices in transport are not always made rationally and/or with complete information. While nudges aim to influence decision-making through information framing, their effectiveness is constrained by beliefs, habits and biases such as seen in motonormativity. Considering the effects of motonormativity on nudges in route planning tools could allow for better predictive power and more precise nudges that could have a larger impact.

Referring back to Figure 2.1, this thesis successfully addresses and tests the application of the policy-sensitive variables through the research. Building on work from Schneider (2013), we found that safety, costs and extrinsic variables all affect mode choice in a trip planning tool. We also learned that safety is more complex than anticipated by Schneider (2013) as the perception of danger varies by mode rather than absolute risk.

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

In this chapter, I summarize the research, highlight the contributions made to the field of study and make future study recommendations.

8.1 Summary of research and contributions

This thesis considered variables affecting mode choice. The literature review highlights the factors that commonly impact mode choice, along with the importance of considering safety as a factor that impacts mode selection. The research questions were examined through a survey with 1532 respondents from the greater Montreal area. Along with gathering some general descriptive information on people's beliefs around advantages and disadvantages of cars and public transport, the survey contained two experiments: a discrete choice experiment that had eight information treatments and an experiment on beliefs around speed limits and motonormativity.

In Chapter 4, using mixed logit models, we found differences in the marginal and overall effectiveness of nudges. The results showed that the presence of nudges can increase the likelihood of travelling by car, despite the treatments' marginal effect decreasing the likelihood of travelling by car. We hypothesized that this is due to a combination of the anchoring effect and the attribute levels presented in the DCE. Displaying costs (economic or societal) that are negligible or zero could increase the likelihood of travelling by car. Further, we found discrepancies in effects by segmenting the model into two groups: multimodal respondents (people who use at least 2 modes of transport) and car-only users. By doing so, we found that multimodal individuals respond better to additional information than the car-only group, which was likely due to barriers to entry that had already been broken. Lastly, we found that having an Opus card has a significant and positive influence on subway usage. The possession of an Opus card displays an intention to use transit and experience with the system.

The first experiment made numerous contributions to the current body of literature. First, by providing different information, it applied behavioural nudges to mobile trip planning tools, which are increasingly relevant for trip planning yet have little literature concerning them. Second, it highlighted the importance of attribute levels within a nudge that are large enough relative to the anticipated cost to ensure desired effects are achieved. Lastly, the study identified sociodemographic and attitudinal variables that influence nudge receptiveness. Overall, this research can help policymakers understand the complexities associated with nudging within a trip planning tool while providing a framework for which kinds of people are most susceptible to mode change.

In the second experiment (Chapter 6), several other contributions are evident. Through a survey in which respondents were randomly assigned to either a e-micromobility treatment or a car treatment, we asked their opinions on speed limits for the mode. Using a safe systems approach, we used kinetic energy as the primary determinant of traffic danger when comparing cars against e-micromobility. The results show that people desire to limit e-micromobility to lower speeds than cars. Additionally, most respondents said limiting the speed of e-mircomobility is about protecting others, but fewer gave this same reason for cars. The same logic of why speeds should be limited and whose safety is being considered changes between the modes, suggesting motonormativity. This coincided with the literature that indicates that driving has become such a social norm and that the real risks associated with it are often diminished. The proposed speeds suggest that they are more influenced by social norms than their potential harm.

The study adds to the evidence of motonormativity in a few ways. First, it displays the difference in perceptions of safety between cars and e-micromobility. Despite carrying more kinetic energy, car speed limits were suggested at higher speeds than those of e-micromobility. Secondly, the results highlight the misalignment between policies and actual risk. Therefore, this research is useful for policymakers to understand the biases that are present in the way of thinking that systematically benefit the automobile over other modes of transport.

8.2 Limits of study

Despite the contributions made in this thesis, the studies presented have some limitations. First, given the nature of a DCE, the respondents were asked to imagine their behaviour given a certain set of circumstances and declare what they would do. This form of data collection does not always reveal what would have been the observed choice if the experiment were to actually take place.

The variability in the time, origins, and destinations between treatments created a more complicated comparison to find treatment effectiveness, making it a limitation of the study. Using the same choice set across all treatments would be recommended to reduce the complexity of the analysis. Further, focus groups or a pilot test before the DCE experiment could have helped determine the perceived costs or impacts (e.g., GHG emissions, air quality) and where the tipping points would be when considering such information. This would ensure the levels shown in the DCE are not too small in terms of costs or impact to motivate a shift.

Lastly, the sample from our survey only targets people aged 18 and over. As such, the results in this study cannot be generalized to the whole population, as people aged under the age of 18 were not considered, yet still often travel daily for various activities.

8.3 Future research

Many avenues can be taken when using this research for future studies. First, future research could look at how information is presented in a trip planning tool. For example, the icons used to present air quality and greenhouse gas emissions could be tested for comprehension and improved. This could lead to them having a larger impact on choices. Understanding how people interact with icons will help adjust the display of information and could lead to more impactful qualitative nudges in the future.

Second, similar research could be conducted to study attribute levels at a greater depth. As this thesis has shown, the anchoring effect of people's beliefs (e.g., around parking costs, parking search times) and low attribute levels can lead to undesired effects. This could help establish at which level the marginal benefits we found in Chapter 4 consistently create a shift to sustainable modes.

Expanding the sample size to include people below the age of 18 would help gain a more holistic understanding of transport patterns. Younger people could respond differently to information, given their context, potentially requiring a personalized nudge for the group.

Finally, exploring the policy implications of the motonormativity findings could help design regulations that offer non-biased limits to different travel modes, therefore creating a more sustainable and equitable transport system.

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APPENDIX A SURVEY

This appendix contains the full survey distributed with Leger Opinion.

Travel to downtown

This survey will ask you about travel choices between central locations in Montréal. In order to conduct statistical analysis, socio-demographic information including your postal code will be requested in order to better understand your living context. The survey will take roughly 10 minutes to complete. Thank you for your time.
There are 261 questions in this survey.

Ethics

This survey will ask you about travel choices between central locations in Montréal. In order to conduct statistical analysis, socio-demographic information, including your postal code, will be requested in order to better understand your living context. The survey will take roughly 10 minutes to complete. Thank you for your time.

POLYTECHNIQUE MONTRÉAL

Your data will remain confidential.

This survey has been approved by Polytechnique's Research Ethics Committee (Projet CER-2526-07-D).

Thank you for your time!

Consent form page:

Prior to completing this survey, thank you for taking the time to fully read and accept all the information provided:

Title of the research project
Transportation mode choice for residents of the Greater Montreal area travelling to downtown Montreal.

Purpose of the project
To better understand the mobility patterns of Montrealers.

Research project supervisor
Owen Waygood, Professor, Polytechnique Montréal
owen.waygood@polymtl.ca

Researchers
Jeremy de Sousa, Master's student, Polytechnique Montréal

Frédérick Chabot, PhD student, Concordia University

Xiaoyu Zhang, Postdoctoral Researcher, Polytechnique Montréal

Research project funding
This research project is funded by the Natural Sciences and Engineering Research Council of Canada.

Conflicts of interest
The research team does not have a conflict of interest in terms of the present research project.

Overall presentation of the research project
The main objective of this research is to examine how different information influences people's choices on how to travel to downtown Montreal.

For this research project, we are seeking participants aged 18 and older who frequently or occasionally visit downtown Montreal.

Risks and inconveniences
The present activity should not present greater risks than those encountered in everyday life.

Advantages and benefits
No personal advantage is associated with this research.However, because the recruitment happens through LÉO's web panel, it is possible that you will receive rewards offered by Léger Opinion for completing this survey.

Voluntary participation and possibility of ceasing participation
Your participation in this research project is voluntary. Thus, you are free to cease participating at any time and can decide to cease participation in the activity – simply stop completing the survey.
Note that it will be impossible to delete your data after you have completed the survey, as it is not possible to identify individuals with the information gathered.

Confidentiality and protection of personal information
The research team will collect and store all personal data in a secure manner, and will respect and protect its confidential nature.

The following is how we will protect your personal information:

- **During data collection:** Data will be anonymized.
- **During data analysis and transfer between team members:** Your responses will be anonymous, and all transfers of data will require a secret code.
- **During result publication:** As the results are anonymous, it will not be possible to associate results to any one individual.
- **After the end of the research project:** Your data will be stored by the Research Team on Polytechnique Montréal's server, for a period of 7 years after the research project has come to an end. After this period, the data will be destroyed.

It will not be possible to view your research data profile to verify the accuracy of information gathered, as the data will be anonymous, and it will not be possible to link it with any individual.

Dissemination of research results
If you would like to be kept informed of research results, you can provide your email to the principal

researcher at owen.waygood@polymtl.ca. The data will be used to publish papers for academic journals and/or conference papers.

Compensation in the event of participant injury / damages
If your participation in the research project results in any injury whatsoever, you in no way wave your legal rights, nor relieve researchers, funding organizations, and Polytechnique Montréal of their professional and legal responsibilities.

Reference and resource people
If you have questions about scientific aspects of the research project, or to cease participation in the study, please contact: Owen WAYGOOD at (514) 340-4711, ext. 2738 or via email at owen.waygood@polymtl.ca.

For all concerns regarding your rights or the responsibilities of the research team in regards to your participation in this project, you can contact the Comité d'éthique de la recherche at Polytechnique Montréal at 514-340-4711, ext. 4420 or via email at: ethique@polymtl.ca

Consent

1. I have read and understood the attached documentation, which describes the nature and the process of the research project, as well as the risks and inconveniences that this project may incur.
2. I understand that as a participant in this research project, I do not renounce any of my rights, nor do I waive researcher's legal responsibilities.

*

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

◯ Yes, I accept the privacy policy
◯ No, I do not accept the privacy policy

Introductory Questions

How old are you?

*

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

◯ 17 years old or younger
◯ 18-19 years old
◯ 20-24 years old
◯ 25-29 years old
◯ 30-34 years old
◯ 35-39 years old
◯ 40-44 years old
◯ 45-49 years old
◯ 50-54 years old
◯ 55-59 years old
◯ 60-64 years old
◯ 65-69 years old
◯ 70 years old or more

What gender do you identify as?

*

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

◯ Male
◯ Female
◯ Other
◯ Prefer not to answer

What is the highest level of education you have completed?

*

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

- Primary school
- Secondary school
- College / CÉGEP
- Technical school / professional school
- University: Undergraduate
- University: Master's
- University: Doctorate
- Prefer not to answer.
- Other

What is the total annual income (before taxes) of your entire household?

Please include all sources of income, such as employment, investments, real estate, and any other sources.

*

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

- $0 to $9,999
- $10,000 to $19,999
- $20,000 to $39,999
- $40,000 to $59,999
- $60,000 to $79,999
- $80,000 to $99,999
- $100,000 to $124,999
- $125,000 to $149,999
- $150,000 to $199,999
- $200,000 or more
- I don't know
- Prefer not to answer

Do you have access to a car? *

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

- Yes, I own one
- Yes, most of the time
- Yes, sometimes
- Yes, through car sharing (ie. communoauto)
- No

Please select all of the modes that you would be open to using (whether you are currently using them or not). *

Select all that apply
Please choose **all** that apply:

- Car as driver
- Car as passenger
- Rail (Train, Metro, Tram Etc.)
- Bus
- Biking (including bike share)
- Walking
- Other

Which of the following does not have wheels? *

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

- Bike
- Car
- Boat
- Bus

What is your postal code?

If you have more than one place of residence, indicate the one where you spend most of your time.

*

Please check the format of your answer.
Please write your answer here:

Format = H3A 0G4 or H3A0G4

{if(is_empty(rand2.NAOK),rand(1,2),rand2.NAOK)} *

Travel patterns

Do you have a valid Canadian driver's license? *

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

- ◯ Yes
- ◯ No

Do you own a functional bike? *

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

- ◯ Yes
- ◯ No

Have you used BIXI (Montreal's bikesharing service) in the last 12 months? *

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

- ◯ No and I am not interested
- ◯ No, but I am interested
- ◯ Yes, but I don't have a membership
- ◯ Yes, I have a membership

What is (are) your main mode(s) of transportation? *

Select all that apply
Please choose **all** that apply:

- ☐ Car as driver
- ☐ Car as passenger
- ☐ Rail (Train, Metro, Tram, etc.)
- ☐ Bus
- ☐ Biking (including bike share)
- ☐ Walking
- ☐ Other

At what time are most of your trips? *

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

- ◯ During peak periods (weekdays from 6am to 9am and from 3pm to 6pm)
- ◯ Outside peak periods
- ◯ Combination of both periods

When was the last time you used each transport option listed below? *

Please choose the appropriate response for each item:

	The past 7 days	The past 30 days	The past year	Over a year ago	Over 5 years ago/Never	I cannot use this mode
Car as driver	◯	◯	◯	◯	◯	◯
Car as passenger	◯	◯	◯	◯	◯	◯
Bike	◯	◯	◯	◯	◯	◯
Bus	◯	◯	◯	◯	◯	◯
Metro	◯	◯	◯	◯	◯	◯
Walking	◯	◯	◯	◯	◯	◯
Scooter/Motorcycle	◯	◯	◯	◯	◯	◯

Do you have an Opus card? *

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

◯ Yes, with a monthly pass
◯ Yes, without a monthly pass
◯ No

group placement

{if(is_empty(randMETRO.NAOK), substr("12345678", rand(0,7), 1), randMETRO.NAOK)} *

Only answer this question if the following conditions are met:
! (openModes_bike == "Y" OR currentMode_bike == "Y")

{if(is_empty(randBIKE.NAOK), substr("ABCDEFG", rand(0,6), 1), randBIKE.NAOK)} *

Only answer this question if the following conditions are met:
(openModes_bike == "Y" OR currentMode_bike == "Y")

Parking cost metro - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, metro), and that the weather was pleasant, please select which option you would choose to use.

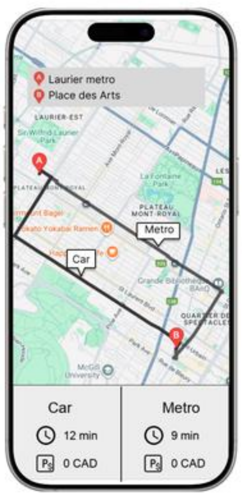
Represents the travel time for the trip.

P$ Represents parking cost for a trip.

*

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

- Car
- Metro



*

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

- Car
- Metro

*

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

- Car
- Metro

*

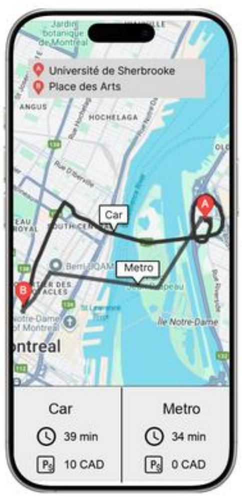
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

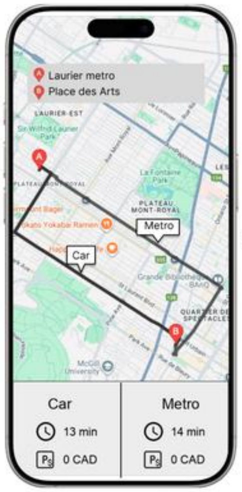
◯ Car
◯ Metro



*

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

◯ Car
◯ Metro



*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

Parking cost bike - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, bike), and that the weather was pleasant, please select which option you would choose to use.

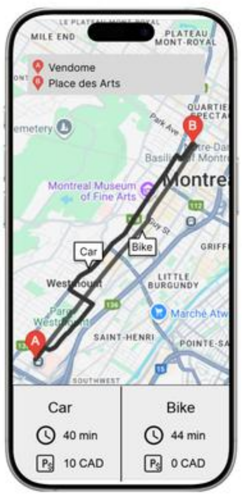
Represents the travel time for the trip.

Represents parking cost for a trip.

*

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

- ◯ Car
- ◯ Bike



*

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

- ◯ Car
- ◯ Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

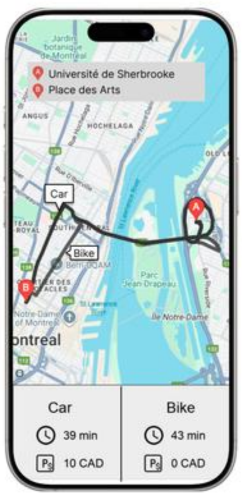
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

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

- Car
- Bike

Parking time metro - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, metro), and that the weather was pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents time spent looking for parking at the destination.

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

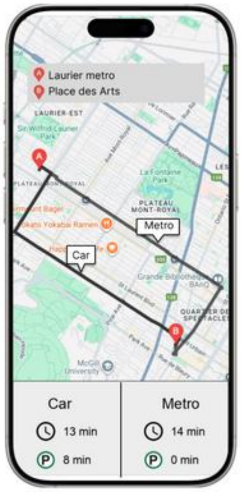
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

- Car
- Metro



*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

Parking time bike - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, bike), and that the weather was pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents the time spent looking for parking at the destination.

*

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

- Car
- Bike

*

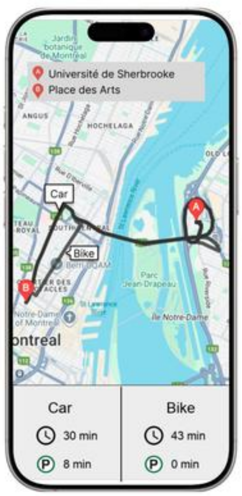
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

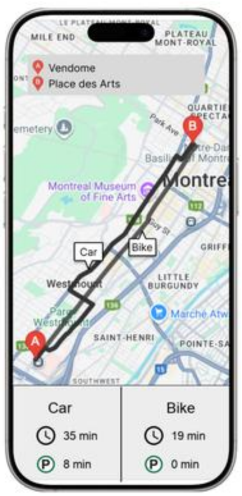
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



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

- Car
- Bike

*

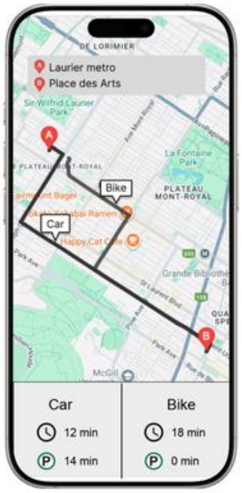
Choose one of the following answers
Please choose **only one** of the following:

◯ Car
◯ Bike

*

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

◯ Car
◯ Bike



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

◯ Car
◯ Bike

*

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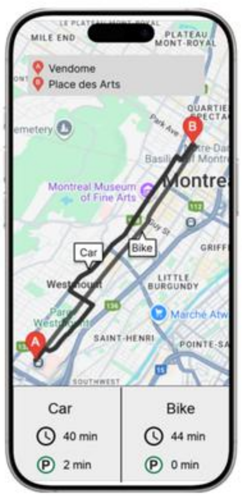
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike



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

- ◯ Car
- ◯ Bike

Travel cost metro - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, metro), and that the weather was pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

$ Represents the total travel cost for the trip.

*

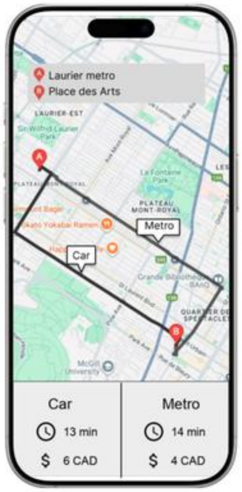
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro



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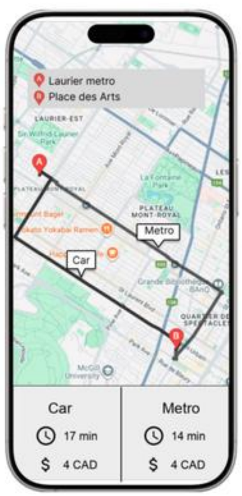
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro



*

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

- Car
- Metro

*

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

◯ Car
◯ Metro

*

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

◯ Car
◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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- ◯ Car
- ◯ Metro

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Choose one of the following answers
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◯ Car
◯ Metro

*

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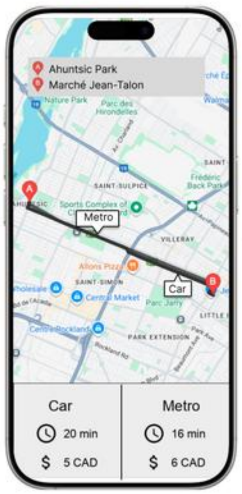

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Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- Car
- Metro

Travel cost bike - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, bike), and that the weather was pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

$ Represents the total travel cost for the trip.

*

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

- Car
- Bike

*

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

- ◯ Car
- ◯ Bike

*

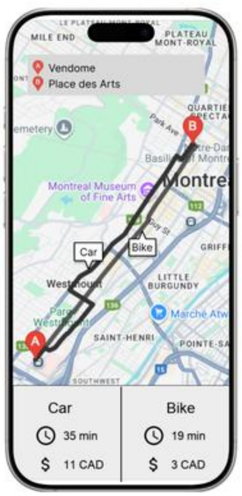
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike



*

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

- ◯ Car
- ◯ Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- Car
- Bike

*

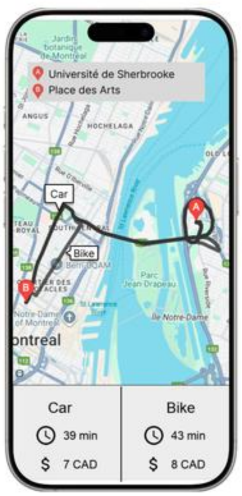
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- ◯ Car
- ◯ Bike



*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

GHG emission (national framing) metro - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, metro), and that the weather was pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents a trip that emits small amounts of CO2, reducing the impact of climate change and natural disasters (e.g., forest fires, and floods).

Represents a trip that emits average amounts of CO2 not significantly contributing to climate change and natural disasters (e.g., forest fires, and floods).

Represents a trip that emits large amounts of CO2, which contribute significantly to climate change and natural disasters (e.g., forest fires, and floods).

*

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

- Car
- Metro

*

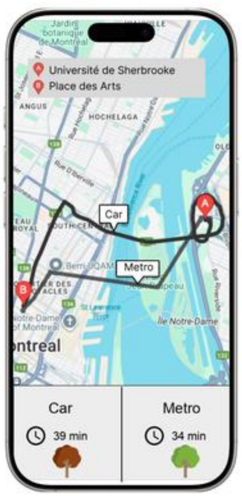
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

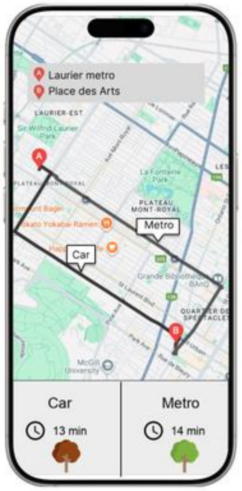
- ◯ Car
- ◯ Metro



*

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

- ◯ Car
- ◯ Metro



*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

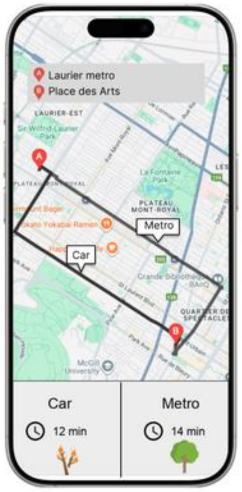
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro



*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- Car
- Metro

GHG emission (national framing) bike - car

It is Saturday at 11 AM and you are meeting a friend for a meal.

Assuming that you had access to both options (car, bike), and that the weather was pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents a trip that emits small amounts of CO2, reducing the impact of climate change and natural disasters (e.g., forest fires, and floods).

Represents a trip that emits average amounts of CO2 not significantly contributing to climate change and natural disasters (e.g., forest fires, and floods).

Represents a trip that emits large amounts of CO2, which contribute significantly to climate change and natural disasters (e.g., forest fires, and floods).

*

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

- Car
- Bike

*

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

- ◯ Car
- ◯ Bike

*

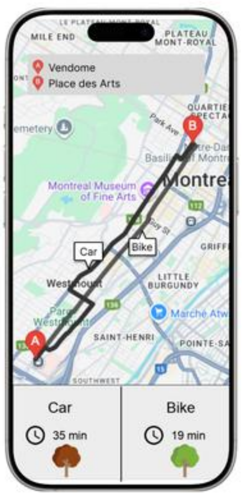
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

◯ Car
◯ Bike



*

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

◯ Car
◯ Bike

*

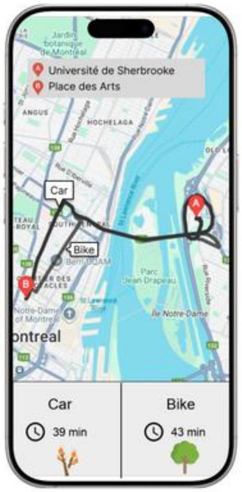
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

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

- ◯ Car
- ◯ Bike

*

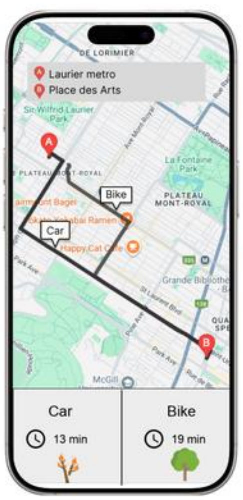
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

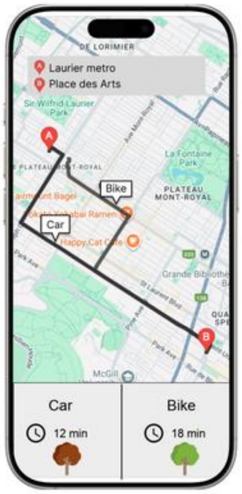
- ◯ Car
- ◯ Bike



*

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

- ◯ Car
- ◯ Bike



*

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

- Car
- Bike

*

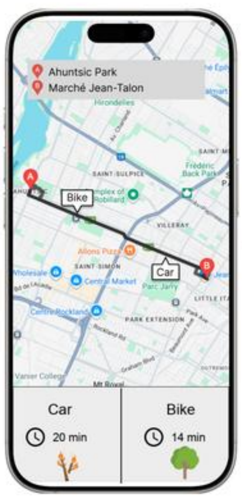
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

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

- Car
- Bike

Air Quality (local framing) metro - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, metro) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents a trip that emits a small amount of pollutants that do not contribute to local air quality issues and smog.

Represents a trip that emits an average amount of pollutants that contribute slightly to bad local air quality and smog.

Represents a trip that emits a large amount of pollutants, which has a negative impact on local air quality and causes a significant amount of smog.

Large amounts of smog have a negative impact on one's health, with symptoms including headaches, coughing, and eye irritation.

*

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

◯ Car
◯ Metro

*

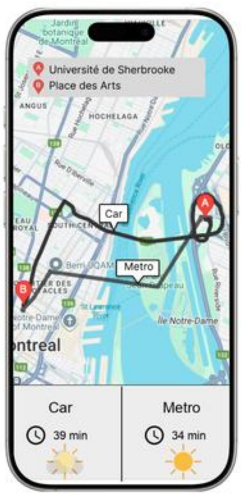
Choose one of the following answers
Please choose **only one** of the following:

◯ Car
◯ Metro

*

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

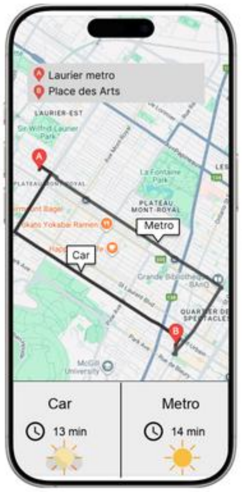
- Car
- Metro



*

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

- Car
- Metro



*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

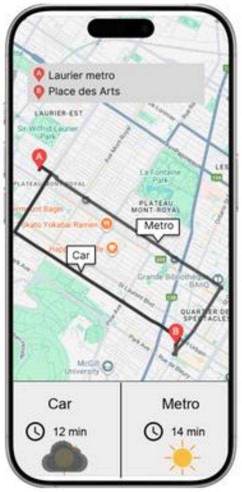
Choose one of the following answers
Please choose **only one** of the following:

◯ Car
◯ Metro

*

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

◯ Car
◯ Metro



*

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

◯ Car
◯ Metro

*

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

◯ Car
◯ Metro

*

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

◯ Car
◯ Metro

Air Quality (local framing) bike - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, bike) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents a trip that emits a small amount of pollutants that do not contribute to local air quality issues and smog.

Represents a trip that emits an average amount of pollutants that contribute slightly to bad local air quality and smog.

Represents a trip that emits a large amount of pollutants, which has a negative impact on local air quality and causes a significant amount of smog.

Large amounts of smog have a negative impact on one's health, with symptoms including headaches, coughing, and eye irritation.

*

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

◯ Car
◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

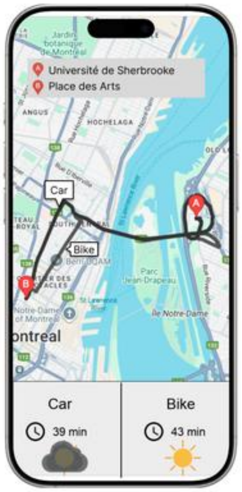
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

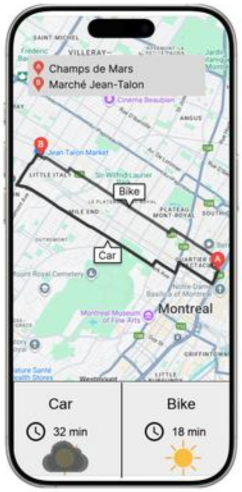
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

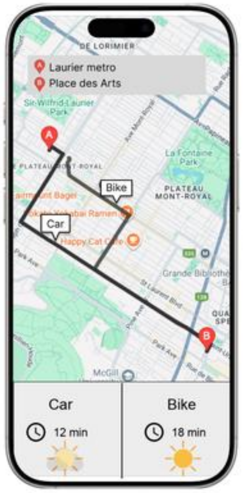
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike



*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

Societal alignment (emoji) metro - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, metro) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents a trip that is aligned with societal mobility goals.

Represents a trip that is partially aligned with societal mobility goals.

Represents a trip that is opposed with societal mobility goals.

*

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

- Car
- Metro

*

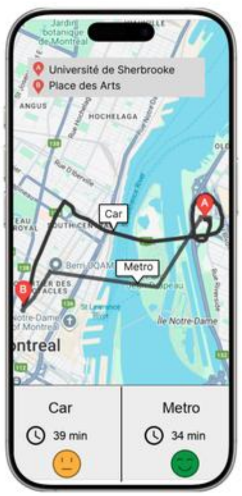
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

- Car
- Metro



*

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

- Car
- Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- Car
- Metro

*

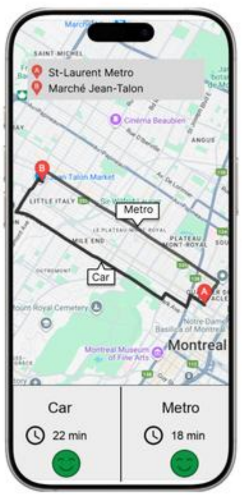
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

- ◯ Car
- ◯ Metro



*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- Car
- Metro

Societal alignment (emoji) bike - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, bike) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

Represents a trip that is aligned with societal mobility goals.

Represents a trip that is partially aligned with societal mobility goals.

Represents a trip that is opposed with societal mobility goals.

*

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

- Car
- Bike

*

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

- ◯ Car
- ◯ Bike

*

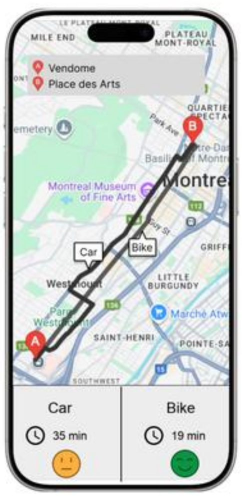
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

- Car
- Bike



*

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

- Car
- Bike

*

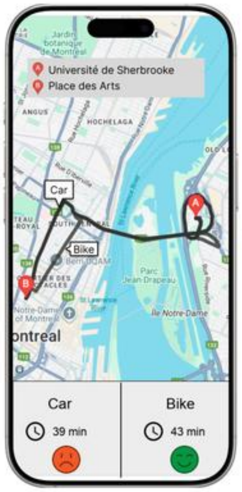
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike



*

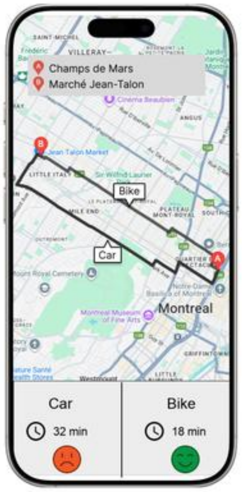
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike



*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

*

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

- Car
- Bike

Societal alignment (color) metro - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, metro) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

*

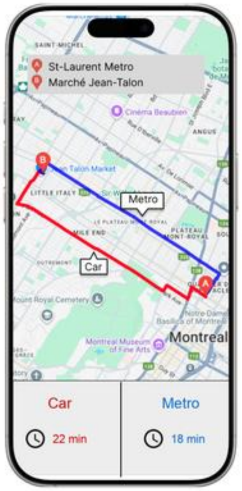
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro



*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

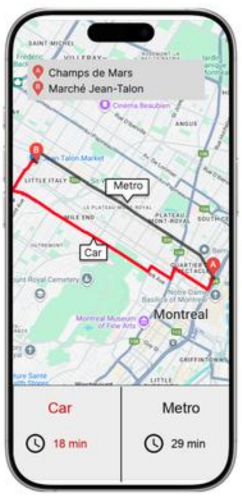
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Metro

*

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

- Car
- Metro



*

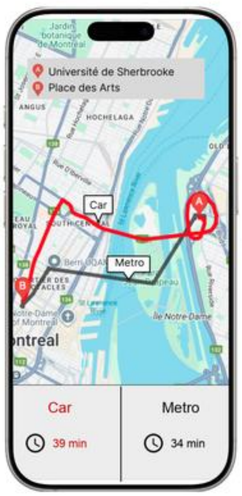
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

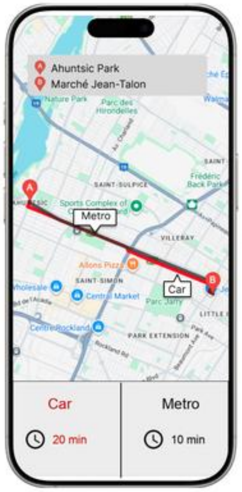
◯ Car
◯ Metro



*

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

◯ Car
◯ Metro



*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

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

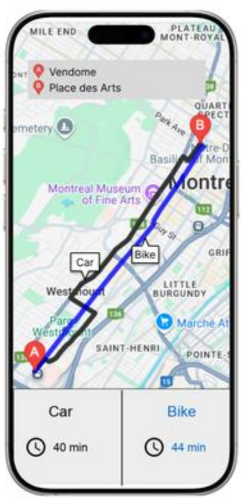
- Car
- Metro

Societal alignment (color) bike - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, bike) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.



*

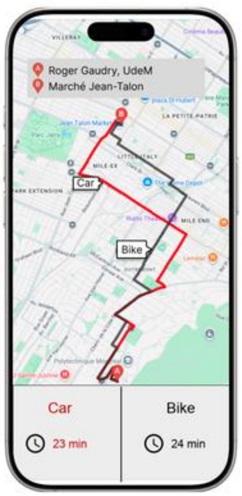
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

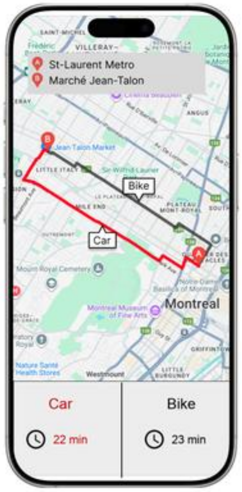
- ◯ Car
- ◯ Bike



*

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

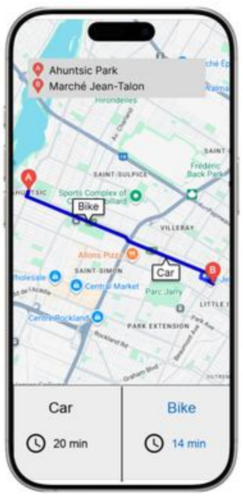
- ◯ Car
- ◯ Bike



*

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

- Car
- Bike



*

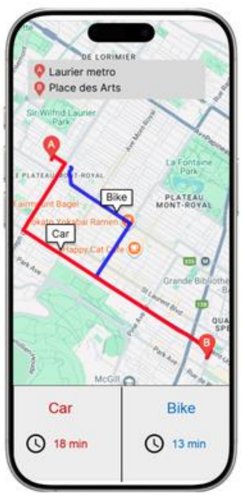
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

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

- Car
- Bike

*

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

- Car
- Bike

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

- Car
- Bike

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

- Car
- Bike

*

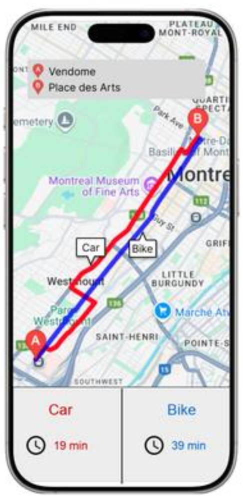
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- ◯ Car
- ◯ Bike



*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

*

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

- ◯ Car
- ◯ Bike

Base metro - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

Assuming that you have access to both options (car, metro) and that the weather is pleasant, please select which option you would choose to use.

🕓 Represents the travel time for the trip.

*

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

- Car
- Metro

*

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

- Car
- Metro

*

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

- ◯ Car
- ◯ Metro

*

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

- ◯ Car
- ◯ Metro

*

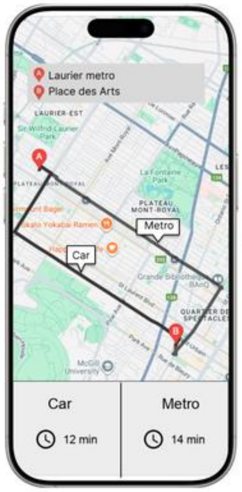
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Metro

*

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

- Car
- Metro



*

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

◯ Car
◯ Metro

*

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

◯ Car
◯ Metro

*

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

- Car
- Metro

Base bike - car

It is Saturday at 11 a.m. and you are meeting a friend for a meal.

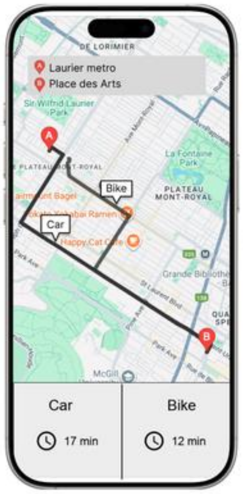
Assuming that you have access to both options (car, bike) and that the weather is pleasant, please select which option you would choose to use.

Represents the travel time for the trip.

*

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

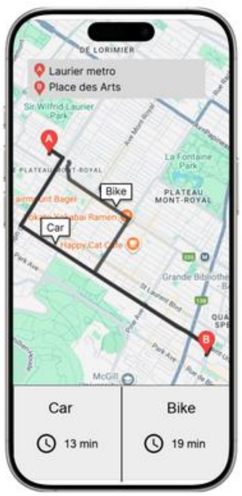
- Car
- Bike



*

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

◯ Car
◯ Bike



*

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

◯ Car
◯ Bike

*

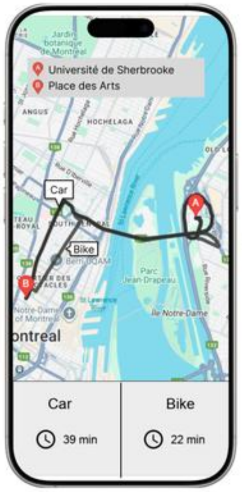
Choose one of the following answers
Please choose **only one** of the following:

- Car
- Bike

*

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

- Car
- Bike



*

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

- ◯ Car
- ◯ Bike

*

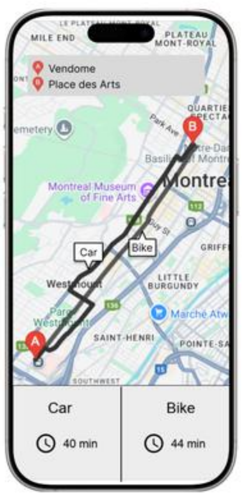
Choose one of the following answers
Please choose **only one** of the following:

- ◯ Car
- ◯ Bike

*

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

◯ Car
◯ Bike



*

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

◯ Car
◯ Bike

Travel choice considerations

The following questions relate to the travel choices you just made.

Did you consider road safety when making your choices? *

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

◯ Yes
◯ Somewhat
◯ No

What do you consider when thinking about road safety? *

Only answer this question if the following conditions are met:
(streetdesign == "A1") OR (streetdesign == "A3")

Select all that apply
Please choose **all** that apply:

- ☐ The amount of traffic on the road
- ☐ The amount of intersections I need to cross
- ☐ The condition of the infrastrcture
- ☐ Where the trip takes place (ie. downtown or further away)
- ☐ Presence of large vehicles
- ☐ Lack of protected bicycle infrastructure or sidewalks
- ☐ Time of day (ie. day or night)
- ☐ Other: ____________

Which of the following statements influences your choice to use the car? *

Please choose the appropriate response for each item:

	Against car use	No influence on my choice	In favour of car use
I use this mode by habit	○	○	○
Having access to a car	○	○	○
The weather	○	○	○
Convenience	○	○	○
Environmental impact	○	○	○
Little physical effort needed	○	○	○
Impact on local air quality	○	○	○
The need to carry things	○	○	○
Traffic congestion	○	○	○
I like being seen in my car (ex. status)	○	○	○
Freedom of travel	○	○	○
Choose 'In favour of car use' here	○	○	○
Personal safety	○	○	○
Difficult to find parking	○	○	○
Cost of parking	○	○	○
Cost of trip	○	○	○
Having my own space	○	○	○
Traffic safety	○	○	○

Which of the following statements influences your choice to use public transport? *

Only answer this question if the following conditions are met:
! (openModes_bike == "Y" OR currentMode_bike == "Y")

Please choose the appropriate response for each item:

	Against taking transit	No influence on my choice	In favour of taking transit
It's my normal choice	○	○	○
I don't have an OPUS card	○	○	○
The weather	○	○	○
Convenience	○	○	○
Crowdedness	○	○	○
Environmental impact	○	○	○
Cleanliness	○	○	○
Presence of homeless	○	○	○
Cost of public transit	○	○	○
Some physical effort needed	○	○	○
Reliability of public transport	○	○	○
Impact on local air quality	○	○	○
The need to carry things	○	○	○
Traffic congestion	○	○	○
I can do other things during the travel	○	○	○
I like being seen using trasnit	○	○	○
Freedom of travel	○	○	○
Personal safety	○	○	○

Which of the following statements influences your choice to use a bike? *

Only answer this question if the following conditions are met:
(openModes_bike == "Y" OR currentMode_bike == "Y")

Please choose the appropriate response for each item:

	Against going by bicycle	No influence on my choice	In favour of going by bicycle
It's my normal choice	○	○	○
The weather	○	○	○
Convenience	○	○	○
Environmental impact	○	○	○
Cost	○	○	○
Physical effort needed	○	○	○
Impact on local air quality	○	○	○
The need to carry things	○	○	○
I like being seen using a bike	○	○	○
Freedom of travel	○	○	○
Personal safety	○	○	○
I don't have access to a bicycle	○	○	○
Self appearance	○	○	○

Human envr questions

How many people, out of 100, do you think use each of these ways to get DOWNTOWN? *

Please fill in at most 100 answers
The sum of the responses must equal 100.

	Percentage
Car	
Public transit	
Bike	
Walking	
Other	

The current sum of the above question is: {TravelNorms_SQ001_NrmPrc + TravelNorms_SQ002_NrmPrc+ TravelNorms_SQ003_NrmPrc + TravelNorms_SQ004_NrmPrc + TravelNorms_SQ005_NrmPrc}

To the best of your knowledge, how many people in YOUR NEIGHBOURHOOD use these modes of transportation to GET AROUND? (One individual can use more than one mode) *

Please choose the appropriate response for each item:

	Nearly all (80% or more)	Most (60-79%)	About half (40-59%)	some (20-39%)	A few (below 20%)	None (0%)
Car	◯	◯	◯	◯	◯	◯
Public transit	◯	◯	◯	◯	◯	◯
Bike	◯	◯	◯	◯	◯	◯
Walk	◯	◯	◯	◯	◯	◯

CarBrain Ebike

Should there be more or less in infrastructure for these transport choices on the island of Montreal?

-100 = Much less infrastructure

0 = Unchanged

100 = Much more infrastructure

*

Your answer must be between -100 and 100
Please write your answer(s) here:

B	
W	
R	
B	
P	

In areas of Montreal where there are usually pedestrians, should the speed of electric scooters and bicycles be limited? *

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

◯ Yes
◯ No
◯ I don't know

What speed should they be limited to?

*

Only answer this question if the following conditions are met:
(G19Q242 == "A1")

Your answer must be between 10 and 80
Please write your answer(s) here:

S

Why should the speed be limited? *

Only answer this question if the following conditions are met:
(G19Q242 == "A1")

Select all that apply
Please choose **all** that apply:

- [ ] They create danger to others
- [ ] They are dangerous for the user
- [ ] Road safety is more important than travel time
- [ ] Other:

Why should the speed not be limited? *

Only answer this question if the following conditions are met:
(G19Q242 == "A2")

Select all that apply
Please choose **all** that apply:

- [ ] They only need to respect the street's speed limit like any other motorized vehicle.
- [ ] Even if it is more dangerous to themselves, it is their own choice.
- [ ] Even if it is more dangerous for others, travel time is more important
- [ ] Other:

What should be considered when making this decision? *

Only answer this question if the following conditions are met:
(G19Q242 == "A3")

Select all that apply
Please choose **all** that apply:

- [ ] The danger created for others
- [ ] The danger created for the user
- [ ] The user's freedom
- [ ] I am not sure
- [ ] Other:

CarBrain car

Should there be more or less in infrastructure for these transport choices on the island of Montreal?

-100 = Much less infrastructure

0 = Unchanged

100 = Much more infrastructure

*

Your answer must be between -100 and 100
Please write your answer(s) here:

B

W

R

B

P

In areas of Montreal where there are usually pedestrians, should the speed of cars be limited? *

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

- Yes
- No
- I don't know

What speed should they be limited to?

*

Only answer this question if the following conditions are met:
(r991q0 == "A1")

Your answer must be between 10 and 80
Please write your answer(s) here:

S

Why should the speed be limited? *

Only answer this question if the following conditions are met:
(r991q0 == "A1")

Select all that apply
Please choose **all** that apply:

- They create danger to others
- They are dangerous for the user
- Road safety is more important than travel time
- Other:

Why should the speed not be limited? *

Only answer this question if the following conditions are met:
(r991q0 == "A2")

Select all that apply
Please choose **all** that apply:

- They only need to respect the street's speed limit like any other motorized vehicle.
- Even if it is more dangerous to themselves, it is their own choice.
- Even if it is more dangerous for others, travel time is more important
- Other:

What should be considered when making this decision? *

Only answer this question if the following conditions are met:
(r991q0 == "A3")

Select all that apply
Please choose **all** that apply:

- The danger created for others
- The danger created for the user
- The user's freedom
- I am not sure
- Other:

Closing Questions

Closing Questions

Finally, we need to know a little bit about you and your household to better understand the context of your transport choices and preferences.

How frequently do you use a car for your trips? *

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

- ◯ Nearly all (80-100%)
- ◯ Most (60-79%)
- ◯ About half (40-59%)
- ◯ Some (20-39%)
- ◯ Few (below 20%)
- ◯ Never

Would you like to decrease or increase your current car use? *

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

- ◯ Decrease a lot
- ◯ Decrease some
- ◯ No change
- ◯ Increase some
- ◯ Increase a lot

When will you make this change? *

Only answer this question if the following conditions are met:
CarSoc2 == "A1" OR CarSoc2 == "A2" OR CarSoc2 == "A4" OR CarSoc2 == "A5"

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

- ◯ I am not sure
- ◯ Within a year
- ◯ More than a year from now

Thinking about your life in general (not just transport), please choose the phrase that most corresponds to you for reducing greenhouse gas emissions:

*

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

- ◯ I am not concerned about climate change.
- ◯ I am concerned about climate change, but I do not plan to reduce my emissions.
- ◯ I would like to reduce my emissions, but I don't know how.
- ◯ I would like to reduce my emissions, and will do so in the near future.
- ◯ I intentionally make choices to significantly limit the climate change emissions I produce.

Which of these is not a trip? *

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

- ◯ Going to the store
- ◯ Working from home
- ◯ Going to an doctor's appointment
- ◯ Going to the restaurant

What is your current occupation status?

*

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

- ◯ Full time employed/self-employed (30 hours or more per week)
- ◯ Part time employed/self-employed (less than 30 hours per week)
- ◯ Student only
- ◯ Student and employed/self-employed
- ◯ At home / unemployed / looking for work
- ◯ Retired
- ◯ Prefer not to answer
- ◯ Other ______

Your responses have been saved. Thank you for taking the time to complete this survey!
06-10-2026 – 12:18
Submit your survey.
Thank you for completing this survey.