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Transferring Matters: Analysis of the Influence of Transfers on Trip Satisfaction

Emily Grisé[1] and Ahmed El-Geneidy[1]

Abstract

Conventional wisdom in public transport planning suggests that transfers should be minimized because of the negative perceptions associated with them. However, little is known about how transferring affects overall satisfaction levels. This study aims to answer the following three research questions: (1) Are people that require transfers on their daily commute less satisfied with their trips compared with their non-transferring counterparts? (2) How many transfers appear to be too many transfers to remain satisfied with a trip? (3) Do mode-specific transfers have different impacts on overall satisfaction levels? Using data from a 2017/18 commuting survey of students, faculty, and staff at McGill University, Montreal, Canada, this study tries to answer the above questions through two statistical models, general and mode-specific. The general model showed that compared with trips involving zero transfers, no statistical difference in trip satisfaction was observed for one-transfer trips, whereas trip satisfaction declines by 32% when a rider must transfer at least two times. The mode-specific transfers showed that transferring between bus routes, and between a bus and subway, negatively affects trip satisfaction. However, transferring between subway lines did not show an impact in the models. These results show that transferring between high-frequency routes does not affect total trip satisfaction levels in the same way as transfers involving low-frequency services. Findings from this study are expected to contribute to both scholarly and practical discussions of the relationship between transferring and customer satisfaction.

As cities have grown more dispersed and auto-oriented, the demand for travel has become increasingly difficult to meet via public transport. In large metropolitan areas public transport providers have been trying to deliver reliable, integrated, and multi-modal systems. In doing so, carefully designing a seamless integration between different public transport modes is critical to minimize the burden that transferring potentially imposes on passengers. A transfer can be a burden because of a potential increase in overall travel time, imposed by walking between stops, and waiting times for next vehicle. Furthermore, unreliable service can cause missed connections or extend waiting times (*1*), both which can have negative implications on the users' experience with public transport. In response to an unreliable service, a commuter might adjust their departure time to leave early in light of an uncertainty in service (*2*, *3*), and the additional time budgeted for delays has been shown to significantly lower trip satisfaction (*4*). For commuters who are unfamiliar with a public transport system, poor information and/or signage at transfer points can lead to wandering, stress, and uncertainty (*5*), which can compound the existing stress that some public transport users experience compared with other modes (*6*). Difficulty in wayfinding can invoke anxious feelings in passengers (*7*), and these impressions of unfamiliar travel can influence overall attitudes toward public transport services (*8*) and can have an impact on people's intention to use the service in the future (*7*).

Conventional wisdom in public transport planning suggests that transfers should be minimized because of the negative perceptions associated with them (*9*). Despite the seeming consensus in the literature regarding public transport users' aversion to transferring, little scholarly attention has been paid to the association between number and type of transfers and overall satisfaction with public transport services. Therefore, the aim of this study is to answer the following three research questions: (1) Are people that require transfers on their daily commute less satisfied with their trips compared with their non-transferring counterparts? (2) How many transfers appear to be too many transfers to remain

[1]School of Urban Planning, McGill University, Montreal, QC, Canada

Corresponding Author:
Address correspondence to Ahmed El-Geneidy:
ahmed.elgeneidy@mcgill.ca

satisfied with a trip? (3) Do mode-specific transfers have different impacts on overall satisfaction levels? Results of this study aim to provide public transport agencies with a clear understanding of the role of transferring in daily trip satisfaction among existing riders. Ensuring riders' satisfaction in today's competitive transport market presents many benefits for a public transport agency, most notably the cost-efficiency of customer retention (*10*).

Literature Review

Transfers play a significant role in the daily operations of public transport service, with respect to ridership, cost-effectiveness, and customer perceptions of service quality (*11*). Much scholarly attention has been paid to attributing a penalty to represent the perceived inconvenience that public transport riders experience when transferring (*11–13*). Knowledge of transfer penalties has important implications for public transport planning, including ridership forecasting, network design, station design, and marketing strategies. The impedance of transferring has several components, including transfer time, walking distance, inconvenience, fare, and labor (*11*, *12*, *14*). One way of estimating the transfer penalty is through revealed choices of routes when passengers have route alternatives; in other words, comparing choices that passengers make between a route with and without transfers. For example, Guo and Wilson conducted an on-board travel survey to examine riders' path selection from a subway line to their final destination, to evaluate the choice of riders' between a path that either includes or excludes a transfer (*11*). Interestingly, the authors observed different transfer penalties depending on the transfer station and time of day, and also found that the pedestrian environment affects how far people are willing to walk to avoid transferring, thus affecting the transfer penalty.

In response to conventional knowledge of the perceived inconvenience of transferring, public transport planning design strategies have aimed to minimize or constrain transferring. As described by Vuchic (*15*), there are two bus network design strategies that are generally considered by public transport planners. The first is a direct-service model, which encourages direct trips so that users can reach their destination with one route. In this bus network design, each route in the network works independently of other routes. The second model is a transfer-based model, which for the most part is designed in a grid-like fashion where transfers are essential. To maximize the appeal of a transfer-based network, potential interruptions to passengers must be minimized. As transferring does impose a time delay for passengers, Vuchic (*15*) classifies "convenient" transfers based on the headway of the destination line, as transferring from any line to a line with a short headway (less than 10 min) involves short transfer times, and in this case no need for schedule coordination at transfer points is needed. However, transferring from any line to a long-headway line (10 min or more) can involve short or long waiting times, thus affecting the convenience of this transfer. When transfers are planned effectively and disruption to customers is minimized through good network design (i.e., schedule coordination, frequent service, pedestrian connections, and wayfinding), transfers can be beneficial by offering passengers a much greater selection of travel paths compared with direct-service networks (*15*). Badia et al. presented a case study of a reshaped bus network in Barcelona that transitioned from a direct-service network to a transfer-based network, which increased demand for service (*9*). This experiment suggests that bus users are less averse to transfers than previous literature found, as a result of higher demand. However, what is missing from the above literature on transferring is the stated preference or perception of customers while transferring.

Within the literature on public transport customer satisfaction, the research on transfers has largely focused on details related to the quality of the transfer experience. For example, Tyrinopoulos and Antoniou evaluated the importance of service attributes related to overall satisfaction in Greece, and observed that factors related to transfer coordination, including distance, waiting time, and information are of high priority to customers (*16*). Similarly, Susilo and Cats found that the ease of transferring affects overall satisfaction (*17*). de Abreu e Silva and Bazrafshan evaluated passengers' satisfaction of intermodal transfer facilities, to understand which characteristics of these infrastructures have the greatest influence on passenger satisfaction (*18*). The authors concluded that investments in station maintenance, signage, and security are important for increasing satisfaction levels. Similarly, Hernandez et al. studied the discrepancies between performance ratings and the relative importance of features in a transport interchange in Spain, observing that improvements in comfort inside the interchange, number and variety of shops, and aspects related to emergency situations should be high-priority areas of improvement because of their low performance ratings yet high importance (*19*). Lastly, Guo and Wilson showed that the presence of escalators increases the willingness of passengers to transfer, and the perception of the pedestrian environment can influence the decision to transfer or not, whereby a positive perception of the walking environment influences passengers to walk further distances to avoid transferring (*11*).

Despite the knowledge that can be garnered from the above discussion on how transfer stations and stops can be designed to improve the transfer experience for passengers, Iseki and Taylor found that the influence of the physical characteristics of the facility was minor compared with factors related to the frequency and reliability of service and personal safety (*20*). In a study specifically focusing on the experience of bus transfers, Stradling et al. similarly found that the previously mentioned service characteristics were most important to passengers, with the addition of protection against the weather (*21*). Although the customer satisfaction literature discussed above focused closely on satisfaction with transferring, transferring facilities, or both, surprisingly little is known about how transferring affects overall satisfaction levels.

Background and Data

The data used in this study were obtained from the 2017/18 McGill University Travel Survey. The majority of McGill University students, faculty, and staff commute to the downtown campus in the heart of Montreal, Canada with an average mode of share of 56% using public transport for their daily commute. However, McGill does have a second campus, Macdonald campus, located in the suburbs of the Island of Montreal (approximately 35 km from the downtown), as well as several teaching hospitals located throughout the city. Figure 1 shows the location of McGill's downtown campus and Macdonald campus in relation to the public transport network. Montreal's public transport network comprises buses, subways, and commuter train lines; however, the subway and bus network are operated by the Société de transport de Montreal (STM), whereas the commuter train network is operated by Exo. This means that passengers transferring from the train to the subway pay two fares or a more expensive monthly fare compared with riding one of the two networks. Presently, transfers across the network are not synchronized.

The public transport system in Montreal was designed with a direct-service model to downtown complemented with a transfer-based model feeding into the direct-service network. With regard to the stop and station design of Montreal's public transport network, all subway stations are located underground. All of Montreal's subway stations have an indoor heated space for passengers to wait when connecting to a bus, yet in many cases bus stops are located within a walking distance from this waiting area. Many passengers do wait outdoors for their bus connection in front of subway stations. Some of Montreal's bus stops have a shelter; however, these shelters are rarely heated. Commuter trains operate above ground, except for a small portion of track that is operated underground in downtown Montreal. Above-ground train stations are equipped with shelters for passengers to wait. All trains and most subway platforms provide customers with real-time information; however, few bus stops are equipped with next-bus information. Next-arrival information for buses is present only for smart phone users with internet connections through two applications.

The survey was distributed to all McGill staff and faculty, and a random sample of one-third of the student population was selected to complete the survey. All selected participants received an invitation via email to complete the survey online, and various prizes were offered to encourage participants to complete the survey. One reminder email was sent to each participant who had not completed the survey within 2 weeks of receiving the initial invitation. Half of the selected participants were invited to participate in the survey in fall 2017, and the other half were invited to complete the survey in winter 2018. This allowed the authors to obtain a representative sample of commutes under different weather trends. A total of 16,930 invitations were sent in the two seasons, and 4,859 completed responses were obtained, representing a 33.4% response rate. The final sample consisted of 1,342 responses who commuted to either McGill University campus by public transport and answered questions related to their home address or postal code, satisfaction with commute, travel time, and whom stated the number of distinct bus, subway, and train lines that they used on their last commute, representing 27.6% of the collected sample. Respondents were asked to state the time they departed home and arrived at McGill. Of those respondents whose reported travel time was approximately 12 h, we adjusted for mistakes in the reporting of either the AM or PM time by determining which arrival and departure time made sense with their reported time of departure from McGill at the end of the day. Lastly, respondents who drove or bicycled to a public transport station were not removed from the sample.

Methodology

Statistical Analysis

The analysis begins by presenting descriptive statistics of the relationship between satisfaction levels of each respondent's most recent trip to McGill University and transferring. In this study a transfer is present any time the public transport user switches routes or modes on her way to school or work. For example, a trip that began on a bus and then involved two subway lines would be a two-transfer trip. The relationship between transferring and satisfaction was further disaggregated by segmenting the study sample first by number of transfers and second by public transport modes involved in each transfer. Chi-square tests were then conducted to test for statistically significant differences between satisfaction levels between the different groups. Following the descriptive statistics, two binary logistic regression

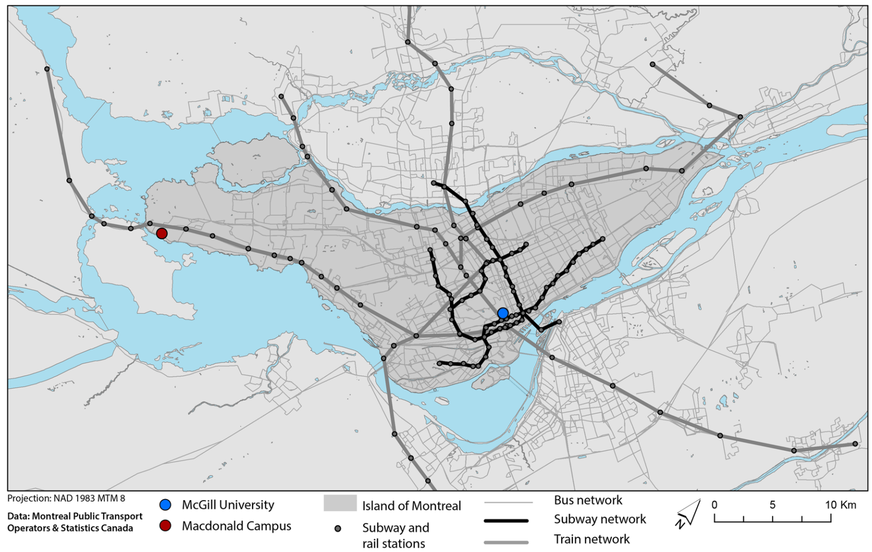

Figure 1. Map of the location of McGill University relative to the Montreal public transport network.

models were constructed to assess the determinants of overall satisfaction, with the goal of disentangling the effects of transferring on overall satisfaction. The dependent variable for both models was derived from the following question: "Overall, how satisfied are you with your most recent trip?" This question was asked on a five-point Likert scale. As a result of the failure of the parallel assumption test and for the ease of communicating the model findings, this satisfaction variable was recoded as a binary variable, satisfied or unsatisfied. Values 4 and 5 were considered satisfied (coded as 1) and values of 3 and lower were unsatisfied (coded as 1).

Model 1 controls for the number of transfers involved in each respondent's trip. Model 2 controls for the mode-specific transfers that were observed, which include: bus–bus, subway–subway, bus–subway, subway–train, and bus–train transfers. It is important to note that these categories are not mutually exclusive; rather, a trip may have involved more than one mode-specific transfer, for example in the case of a trip that involved transferring between bus routes and a transfer to the subway. A variable to capture number of modes used was tested in the model, however, was removed because of multicollinearity. For intermodal transfers, the order in which the transfer occurred is not known. Also, it was not possible to study satisfaction when transferring between train lines, as no responses in the study sample reported using more than one train line. It is a rare occasion in the Montreal train system to transfer between train lines because of the structure of the train network, as all train lines converge in downtown Montreal.

All independent variables explored within this study are presented in Table 1. Travel time was obtained by subtracting the respondent's reported arrival and departure time (reported in 15-min increments) of their morning commute to McGill. The decision to control for travel time rather than trip distance reflects the relationship between travel time and satisfaction as noted in previous literature (*17*, *22*, *23*). Furthermore, there is a potential waiting time associated with each transfer, and therefore holding travel time constant in the model allows the relationship between transferring and satisfaction to be isolated, to determine how significantly other factors associated with transferring affect overall trip satisfaction. Lastly, to capture non-linear effects of travel time, the square of travel time was included in the models.

Additional trip characteristics were included in the models, such as the season in which the survey was completed (fall or winter), a dummy variable to differentiate a trip to the downtown campus compared with another affiliated McGill University campus, and a dummy variable to identify trips that occurred or partially occurred during the peak morning commute. Other variables, such as a travel time ratio between public transport and walking as well as a ratio of travel time by public transport to congested driving time, were tested but did not show an effect on trip satisfaction so they were excluded from the models. Lastly, the authors tested whether individuals' responses were spatially nested in their neighborhoods, requiring a multilevel modeling approach to reduce potential spatial estimation bias. However, the test

Table 1. Description of Variables and Summary Statistics

Variable	Variable description	Mean	Std.
Personal characteristics			
Car ownership	Dummy variable equal to 1 if the respondent reported that they own a car	46%	na
Household size	Number of people residing in the respondent's primary household	2.80	1.33
Child at home	Dummy variable equal to 1 if the respondent has a child under the age of 16 living at home	27%	na
Male	Dummy variable equal to 1 if respondent is a male	37%	na
Other	Dummy variable equal to 1 if respondent identified as other	1%	na
Age	Age of the respondent	36.43	13.51
High income	Yearly personal income above $80,000	16%	na
Medium income	Yearly personal income between $40,000 and $79,999	37%	na
Trip characteristics			
Fall trip	Dummy variable equal to 1 if the surveyed trip in question occurred in the fall semester (September–December 2017)	48%	na
Travel time	Reported travel time in minutes	51.67	23.02
Travel time squared	A square term of travel time to capture the diminishing return associated with travel time	3200.47	2972.82
Travel during peak hour	Dummy variable equal to 1 if the surveyed trip occurred during or partially during peak hours (7:00 and 9:00 a.m.)	65%	na
Downtown campus	Dummy variable equal to 1 if the individual reported spending the majority of time at McGill's downtown campus	99%	na
Model 1			
Number of transfers			
One transfer	Dummy variable equal to 1 if 1 transfer was needed to complete the respondent's last trip	32%	na
Two transfers	Dummy variable equal to 1 if 2 or more transfers were needed to complete the respondent's last trip	23%	na
Model 2			
Mode-specific types of transfers			
Bus–bus transfer	Dummy variable equal to 1 if a respondent transferred bus routes	11%	na
Subway–subway transfer	Dummy variable equal to 1 if a respondent transferred subway lines	32%	na
Bus–subway transfer	Dummy variable equal to 1 if a respondent transferred from a bus route to a subway or a subway to a bus route[a]	31%	na
Bus–train transfer	Dummy variable equal to 1 if a respondent transferred from a bus route to a commuter train[a]	3%	na
Train–subway transfer	Dummy variable equal to 1 if a respondent transferred from a commuter train route to a subway line[a]	4%	na

Note: na = not applicable; Std. = standard deviation.
[a]For cross-model transfers, order of transfer between modes is unknown.

indicated that a multilevel model was not needed for the data.

Results

Descriptive Statistics

Table 2 presents summary statistics of the study sample, average trip satisfaction, travel time, and trip distance, according to the number and type of transfers taken on each respondent's last trip. Results of the chi-square tests of statistical significance are presented in Table 3, alongside absolute differences between all groups. Looking at trends in average satisfaction according to number of transfers, it can be seen that satisfaction decreases with number of transfers, and each of these differences are statistically significant. Of individuals who did not transfer on their last trip, train and subway commuters are equally the most satisfied, followed by bus users, although this difference is only statistically significant at the 90% level. Looking at average travel times, it is important to note that the commute time for train users is almost twice as large as bus and subway users, yet the satisfaction levels of these riders with zero transfers are all similar.

Comparing satisfaction levels of individuals who completed at least one transfer in their last trip (Table 2), it can be seen that individuals who transferred subway lines were more satisfied (mean of 3.88 out of 5) compared with those who transferred bus routes (mean of 3.5 out of 5). It can also be seen that individuals transferring from a subway to a bus were more satisfied (mean satisfaction of 3.73) compared with people transferring bus

Table 2. Evaluating Satisfaction Levels and Trip Characteristics by Number of Transfers and Mode-Specific Transfers

	N	Average satisfaction	Average travel time (min)	Average trip distance (km)
Comparing trip details by number of transfers				
0 transfer	598	4.13	49.47	12.26
1 transfer	433	3.90	58.61	14.01
2 or more transfers	311	3.20	79.66	17.59
All respondents	1,342	3.44	72.06	16.27
Trips with zero transfers				
Train only	144	4.17	71.77	23.15
Bus only	247	3.96	40.69	7.12
Subway only	207	4.25	35.94	6.53
Mode-specific transfers				
Bus–bus	154	3.48	62.24	11.47
Subway–subway	425	3.88	53.08	11.26
Bus–subway	414	3.73	58.91	12.93
Bus–train	40	3.60	87.00	26.12
Train–subway	51	3.69	77.65	25.32

Table 3. Statistical Significance of Difference in Mean Satisfaction Levels of Trips According to Number of Transfers and Mode-Specific Transfers, Using a Chi-Square Test

Number of transfers	0 transfers	1 transfer	2 or more transfers		
0 transfers	NA				
1 transfer	0.23**	NA			
2 or more transfers	0.7***	0.24**	NA		
Trips with zero transfers	Train	Bus	Subway		
Train	NA				
Bus	0.21*	NA			
Subway	0.08	0.29*	NA		
Mode-specific transfers	Bus–bus	Subway–subway	Bus–subway	Bus–train	Train–subway
Bus–bus	NA				
Subway–subway	0.40***	NA			
Bus–subway	0.25**	0.15	NA		
Bus–train	0.12	0.28	0.13	NA	
Train–subway	0.21	0.19	0.04*	0.09	NA

Note: NA = not available. In the case of a statistically significant difference, the level of significance is represented as follows: ***Significant at 99% **Significant at 95% *Significant at 90%.

routes. Trips that involved a transfer between a bus and a subway were more satisfied (3.73) than trips involving a transfer between a train and a subway (3.69), although this difference is at the 90% level. No significant differences in mean satisfaction were observed between the remaining mode-specific transfers.

Regression Analysis

The first regression model presented in Table 4 concentrates on the direct impacts of the number of transfers on satisfaction levels among public transport users while controlling for other personal and trip characteristics. Trips involving one transfer compared with zero transfers have the same odds of being satisfied, while keeping all other variables constant at their mean. The odds of being satisfied drops by 32% when two transfers or more are required in a trip compared with zero transfers. In this sample only 3% of respondents transferred either three or four times, and because of the rarity of these trips they were combined with two transfers to avoid bias in the estimations.

With respect to other trip characteristics, travel time decreased the odds of satisfaction by 5% for every additional 15 min minute spent traveling. However, the square term of travel time is positive and therefore

Table 4. Satisfaction with Last Trip Model

Variable	Odds ratio	Sig.	95% Conf. interval	
Personal characteristics				
Car ownership	1.25		0.92	1.71
Household size	0.97		0.86	1.09
Child at home	1.08		0.76	1.55
Female	0.72	**	0.54	0.95
Other (ref = male)	1.42		0.24	8.38
Age	1.01	*	1.00	1.03
High income	1.55		0.89	2.69
Medium income (ref = low income)	1.48	*	0.99	2.21
Trip characteristics				
Fall trip	1.43	**	1.10	1.85
Downtown campus	2.53	*	0.83	7.66
Travel during peak hour	0.97		0.72	1.31
Travel time (minutes)	0.95	***	0.93	0.97
Travel time squared	1.01	***	1.00	1.01
Number of transfers (ref = 0 transfers)				
One transfer	1.02		0.75	1.39
Two or more transfers	0.68	**	0.49	0.96
Constant	3.77	*	0.95	14.98
AIC	1445.329			
BIC	1528.56			
Log likelihood	–706.66			
Observations	1,342			

Note: ***Significant at 99%; **Significant at 95%; *Significant at 90%; blank cell indicates no statistical significance.

indicates that there are diminishing effects of travel time on overall trip satisfaction. This is mostly related to commuter train users, as they are generally more satisfied and have the longest commute time. A modest decrease in satisfaction is seen for those who traveled during peak hours compared with non-peak hours, although this variable was not statistically significant. Although travel at peak hours can be frustrating for riders because of crowding, higher frequency service during peak-hour travel, including shorter waiting times for transfers, may for some passengers be more important in their overall perception of service quality and is therefore a more satisfying time to travel. Individuals who spend the majority of their time at McGill's downtown campus are far more likely to be satisfied with their trip compared with those who work on McGill's Macdonald Campus or another location affiliated with McGill, although this variable was not statistically significant. This is mostly related to the level of service and the way the Montreal public transport system is designed as a direct-system to downtown. Furthermore, McGill University offers a shuttle service between the two campuses, which likely explains why only 1% of the study sample reported commuting by public transport to the suburban campus.

In relation to differences in satisfaction levels across seasons, commuters in the fall were 1.43 times more likely to be satisfied with their last trip compared with winter commuters. In the 2017/2018 academic year, weather conditions differed substantially between the two seasons in which the survey was active. Mean temperatures varied from 10 degrees Celsius in fall to −7 degrees Celsius in winter. Snow on the ground also changed by season, with an average of less than 1 cm in fall, to an average of 67 cm in winter.

Demographic characteristics were also important predictors of trip satisfaction. The findings indicate that females are 28% less likely to be satisfied when compared with males and individuals who stated their gender as other. This finding echoes Handy and Thigpen (*24*), who observed that on average women were less satisfied with their commutes, reported higher levels of stress, higher sense that their time while traveling is wasted, and a stronger dislike for their selected transport mode compared with men. A positive relationship between age and satisfaction was also seen. A 1-year increase in age is associated with 1% higher odds of satisfaction. With respect to income level, it was observed that medium-income individuals are 1.48 times more likely to be satisfied compared with low-income individuals. Age and income were highly correlated with position at the university (student, faculty, or staff), and previous studies of commuting to universities have observed a significant effect of role at the university. Handy and Thigpen observed that faculty are highly satisfied with their

Table 5. Satisfaction with Last Trip with Mode-Specific Controls

Variable	Odds ratio	Sig.	95% Conf. interval	
Personal characteristics				
Car ownership	1.21		0.89	1.66
Household size	0.97		0.86	1.09
Child at home	1.09		0.76	1.57
Female	0.73	**	0.55	0.96
Other (ref = male)	1.30		0.23	7.47
Age	1.01	*	1.00	1.03
High income	1.53		0.88	2.67
Medium income (ref = low income)	1.48	*	0.99	2.21
Trip characteristics				
Fall trip	1.38	**	1.06	1.79
Downtown campus	2.44		0.79	7.55
Travel during peak hour	0.94		0.70	1.28
Travel time (min)	0.95	***	0.93	0.97
Travel time squared	1.01	**	1.00	1.01
Type of transfer				
Bus–bus transfer	0.63	**	0.43	0.92
Subway–subway transfer	1.03		0.76	1.40
Bus–subway transfer	0.73	**	0.54	0.97
Bus–train transfer	1.12		0.52	2.44
Train–subway transfer	0.63		0.31	1.26
Constant	3.94	**	0.98	15.81
AIC	1445.84			
BIC	1544.68			
Log likelihood	–703.92			
Observations	1,342			

Note: Sig = significance; Conf = confidence interval.
***Significant at 99%; **Significant at 95%; *Significant at 90%; blank cell indicates no statistical significance.

commute, which they hypothesize is a result of higher satisfaction in other domains such as income, job security, and intellectual fulfillment (*24*). Similarly, Sprumont et al. observed satisfaction levels of PhD students, professors, and staff, and found that PhD students were the least satisfied with their commuting trip (*25*).

The second regression model (Table 5) is similar to the first model, but it distinguishes between different types of transfers. Demographic and trip characteristics in Model 2 all had the same direction, statistical significance, and similar odds ratios as in Model 1. Focusing first on transfers between a single public transport mode, a transfer between two bus routes decreases the odds of satisfaction by 37%, compared with a non-transferring trip, all else equal. In contrast, a transfer between subway lines does not negatively impact satisfaction; rather, this type of transfer has no statistically significant impact on trip satisfaction. Looking at transfers between different public transport modes, it can be seen that commuters who transferred from a subway to a bus or vice versa have 27% lower odds of satisfaction compared with their non-transferring counterparts. The remaining transfers were not statistically significant in the model; however, they will be discussed below. Trips involving a transfer from a train to a subway, or in the reverse order, although not statistically significant, have 37% lower odds of satisfaction when compared with a trip that does not involve a transfer, while holding all other variables at their mean. Commuter trains in Montreal run at a low frequency and mostly during the peaks, whereas the subway system is more frequent. A small delay in the subway system, which frequently happens in Montreal, can lead to a missed transfer, because the train and subway network are not synchronized for transfers. Lastly, transferring between a bus and a train was not found to have a statistically significant impact on the odds of satisfaction when compared with a non-transferring trip. However, only 3% of the sample transferred from a bus to a train, or vice versa.

Discussion of Results

Transferring is strongly associated with trip satisfaction; however, the results of both models indicate that the relationship varies according to the number of transfers and the mode(s) comprising a trip. The results indicate that there are no statistically significant differences between those who transferred once compared with those who did not transfer, all else equal. However, the odds of satisfaction decline by 32% for those who require two or more transfers. Imaz et al. similarly found that trips involving two or more transfers negatively affect customer loyalty (*26*). Public transport agencies should try to either minimize the number of trips involving two or more transfers, or place efforts toward minimizing waiting times for these trips through strategies such as increasing service frequency or a transfer synchronization approach.

The results suggest that different types of transfers affect trip satisfaction differently. Transferring between bus routes was the most dissatisfying transfer observed in this study. Currie summarized transfer penalties observed from a range of studies and found far higher valuations of transfer penalties for bus trips compared with rail-based modes, as a result of the time delays caused by transferring routes (*27*). The observed declines in overall satisfaction levels among riders who transfer bus routes can largely be attributed to waiting time, which is negatively associated with trip satisfaction (*28*). Vuchic classifies transfers not according to mode but according to short and long headways, as he explains that transferring to a route with a short headway (high service frequency) is convenient because of the short time delay imposed by this transfer (*15*). This would explain why little impact was seen on overall satisfaction for passengers who transfer subway lines, as headways are short (around 3–4 min during peak service) and therefore waiting time is minimal. With detailed data on the bus routes taken by each passenger and their associated headways, future research should control for the headway of bus routes and explore whether the observed differences in satisfaction levels still stand when analyzing mode-specific transfers. For example, transferring bus routes in the winter may still negatively affect overall trip satisfaction for bus users of a frequent service as a result of waiting times outdoors in cold temperatures, whereas subway riders transfer within heated stations.

Finally, it was observed that a transfer between a bus and a subway decreases the odds of satisfaction by 27%, all else equal. When transferring from a bus to a subway, this decline in odds is potentially attributed to walking between the bus stop and subway platform, which can be stressful if unfamiliar with the station layout. Improved wayfinding has been shown to positively influence trip satisfaction, particularly among those who are unfamiliar with a station. Also, when crowded it can be unpleasant walking through a station, and during rush hour subway cars can be overcrowded, requiring that people wait for the next subway. Alternatively, for those transferring from the subway to a bus, missing a bus as a result of slower than usual service can affect satisfaction. Although knowledge of the order of a bus–subway transfer would have been valuable for this analysis, the authors expect that most of these transfers occurred from the bus to subway, as McGill University is located in close proximity to two subway stations.

Lastly, it is interesting to note that switching from a train to a subway (or a subway to a train) shows a negative impact on trip satisfaction, although not statistically significant. In Montreal, the commuter train network is operated by Exo mostly during peak hours and at a low frequency, whereas the subway and bus network are operated by STM at a much higher frequency, with little coordination in schedules between the two agencies. Transferring between these two modes requires walking up and down many stairs, and can be particularly crowded and uncomfortable in rush hour. Also, a slight delay in a bus or a subway ride can lead train commuters to miss their connection. It is also important to note that the subway and bus network require an additional fare for train riders, which potentially contributes to dissatisfaction among these users. Providing seamless fare integration for these riders will potentially improve their satisfaction levels as well as encourage more riders to use these services.

A limitation of these data is that the satisfaction of non-public transport riders cannot be analyzed. In a global review of the crucial strategic and tactical steps for designing and scheduling a public transport network, Guihaire and Hao write: “In a general manner, if a trip requires more than two transfers, it is assumed that the user will switch to another means of transportation” (*29*). Given that only 3% of the study sample reported transferring three times, Guihaire and Hao’s assertion that public transport users are unwilling to complete three transfers appears to hold true in this study context. A stronger understanding of overall willingness to transfer can be attained through mode choice analysis, for example Eluru et al. (*14*). A mode choice analysis similar to the aforementioned study can shed light on the role that transferring plays on travel behavior, or the choice to take public transport compared with other modes of travel. Furthermore, as this study only modeled the relationship between transferring and satisfaction of trips that were taken for work and study purposes, future research should explore the impact of transferring on trip satisfaction for other trip purposes such as leisure, utilitarian, and so forth. Lastly, as the survey data used in this study were collected in the fall and winter, collection of data in the summer would provide a complete picture of how users are satisfied with their trip under different weather conditions, as well as how transferring affects satisfaction across all seasons.

In this study, transferring was conceptualized in the traditional sense: a transfer either between a public transport mode or across different modes. Recent literature has begun to recognize the importance of conceptualizing a trip as a sequence of legs from origin to destination with one trip purpose (*30*). These different trip legs, including access and egress, can influence satisfaction with the main leg (*17*), and therefore inclusion of satisfaction with each trip leg is becoming increasingly prevalent in the literature for improved understanding of overall trip satisfaction (*31–33*). Future research should explore whether the conceptualization of transferring used here should be extended to include a "transfer" from the first leg of the trip, for example walking to a station or stop, to the first or main mode of public transport used to complete that trip. Choice of station or stop access likely has an impact on this first "transfer," particularly when taking a mode of public transport that is infrequent. For example, choosing to bicycle to a train station rather than taking the bus might positively impact that user's overall trip satisfaction, as bicycling provides a high degree of travel time reliability relative to the bus. In this example, passengers who are satisfied with this first "transfer" are potentially more likely to be satisfied with their trip overall, compared with those who missed their connection.

Conclusion

Results of this study indicate that trips involving one transfer have similar satisfaction levels to trips of a similar travel time that do not require a transfer, whereas steep declines in overall satisfaction levels were observed for trips involving two or more transfers. The evidence presented in this paper reveals that not all transfers have an equal impact on satisfaction. As expected, transferring between bus routes and transferring between a subway and a bus both negatively affected satisfaction levels. Whenever possible, agencies should plan to coordinate transfers to reduce the waiting time associated with each transfer. However, improvements to service frequency and reliability will likely have the most significant impact on improving satisfaction among these riders, as synchronizing transfers can come at a high cost for agencies and requires strict schedule adherence for this strategy to be effective. Also synchronizing transfers can lead to bus or subway holdings for substantial amounts of time until a bus or a subway arrives from another direction to enable the synchronized transfer, which can delay other commuters. In addition to increasing service frequency, improvements in station and stop design should be considered, such as seating, cleanliness, and protection from weather, to reduce the perceived waiting time of passengers.

Interestingly, no significant impact on satisfaction was observed from transferring subway lines. This is an encouraging finding for public transport agencies, as it presents evidence that not all transfers negatively affect satisfaction. Moreover, this result shows that transferring between high-frequency routes does not affect total trip satisfaction levels in the same way as transfers involving low-frequency services, namely bus service. Service frequency has been identified as a major factor influencing patronage growth (*34*), and researchers have found that operating a high-performance bus service with frequency levels and operational characteristics similar to rail service can result in similar ridership attraction as rail (*35*). This corroborates findings from Badia et al., who observed an increase in passenger demand in a Spanish network after it moved to high-frequency transfer-based bus network (*9*). A longitudinal analysis of satisfaction before and after such a network redesign would contribute to the knowledge of whether dissatisfaction with transferring is mitigated in light of high-frequency service. In view of declining public transport ridership that has recently been seen in many North American cities (*36*), results of this study suggest that increases in service frequency across the public transport network, mainly train and bus service, would strongly reduce the observed dissatisfaction of transferring seen in this study, and should help in retaining existing riders and attracting new ones.

A limitation in this study is that almost all questions were not mandatory, which led to a decline in the sample size, and therefore future research should consider making all satisfaction questions mandatory to yield a higher sample size. Also, finer detail of information related to each trip, such as route number for every mode used, would have enriched the analysis and enabled comparisons to online trip planner suggestions. This study used binary logistic regressions to model satisfaction for ease of communicating the results; future research can explore other modeling techniques such as ordered or generalized ordered logits.

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Author Contributions

The authors confirm contribution to the paper as follows: study conception and design: EG, AE-G; data collection: EG, AE-G; analysis and interpretation of results: EG, AE-G; draft manuscript preparation: EG, AE-G. Both authors reviewed the results and approved the final version of the manuscript.

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