Transferring matters: An analysis of the influence of transfers on trip satisfaction

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ABSTRACT

Public transport rider's satisfaction level is determined from their experience with the system. Conventional wisdom in public transport planning suggests that transfers should be minimized due to negative perceptions associated to them. However, little is known about how transferring impacts 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 to 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 differential impacts on overall satisfaction levels? Using data from a 2017/18 commuting survey of students, faculty and staff at McGill University, Montreal, Canada, we try to answer the above questions through two statistical models, general and mode-specific. The general model showed that compared to trips involving zero transfers, no statistical difference in trip satisfaction was observed for one-transfer trips, whilst 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 impact trip satisfaction. However, transferring between subway lines did not show an impact in our models. These results show that transferring between high frequency routes does not impact 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.

Keywords: Customer satisfaction, public transport, transfers, intermodal travel

INTRODUCTION

As cities have grown more dispersed and auto-oriented, the demand for travel has become increasing 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 due to 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 to other modes (*6*). Difficulty in wayfinding can invoke anxious feelings in passengers (*7*), and these impressions of unfamiliar travel can influence overall attitudes towards 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 due to negative perceptions associated with them (*9*). Despite the seeming consensus in the literature regarding public transport users' aversion of 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 to 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 differential 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 rider's 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 (for example (*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 labour (*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 (*11)* 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. Interestingly, the authors observed different transfer penalties depending on the transfer station and time of day, and also found that the pedestrian environment impacts how far people are willing to walk to avoid transferring, thus impacting 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. In theory, to maximize the appeal of transfer-based networks agencies need to minimize the circuity of routes, operate high frequency service across the network, and ensure that the network is easy to understand. Badia, Argote-Cabanero and Daganzo (*9)* presented a case study of a reshaped bus network in Barcelona, which transitioned from a direct-service network to a transfer-based network, which increased demand for service. This experiment suggests that bus users are less averse to transfers than previous literature found due to 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 (*16)* 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. Similarly, Susilo and Cats (*17)* found that the ease of transferring impacts overall satisfaction. de Abreu e Silva and Bazrafshan (*18)* evaluated passengers' satisfaction of intermodal transfer facilities, to understand which characteristics of these infrastructures have the greatest influence on passenger satisfaction. The authors concluded that investments in station maintenance, signage and security are important for increasing satisfaction levels. Similarly, Hernandez, Monzon and de Oña (*19)* 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 due to their low performance ratings yet high importance. Lastly, Guo and Wilson (*11)* showed that presence of escalators increase the willingness of passengers to transfer, and 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.

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 (*20)* found that the influence of the physical characteristics of the facility were minor compared to factors related the frequency and reliability of service and personal safety. In a study specifically focusing on the experience of bus transfers, Stradling, Anable and Carreno (*21)* similarly found that the previously mentioned service characteristics were most important to passengers, with the addition of protection against the weather. While the customer satisfaction literature discussed above focused closely on satisfaction with transferring and/or transferring facilities, surprising little is known about how transferring impacts overall satisfaction levels.

DATA

The data used in this study was obtained from the 2017/18 McGill University Travel Survey. The majority of McGill 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 in their daily commute, however McGill does have a second 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. Montreal's public transport network is comprised of buses, subways and commuter train lines, however the subway and bus network are operated by the Société de transport de Montreal (STM), while 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 compared to when 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. Figure 1 shows the location of downtown campus and Macdonald campus in relation to the public transport network. With regards 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 next arrival 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.

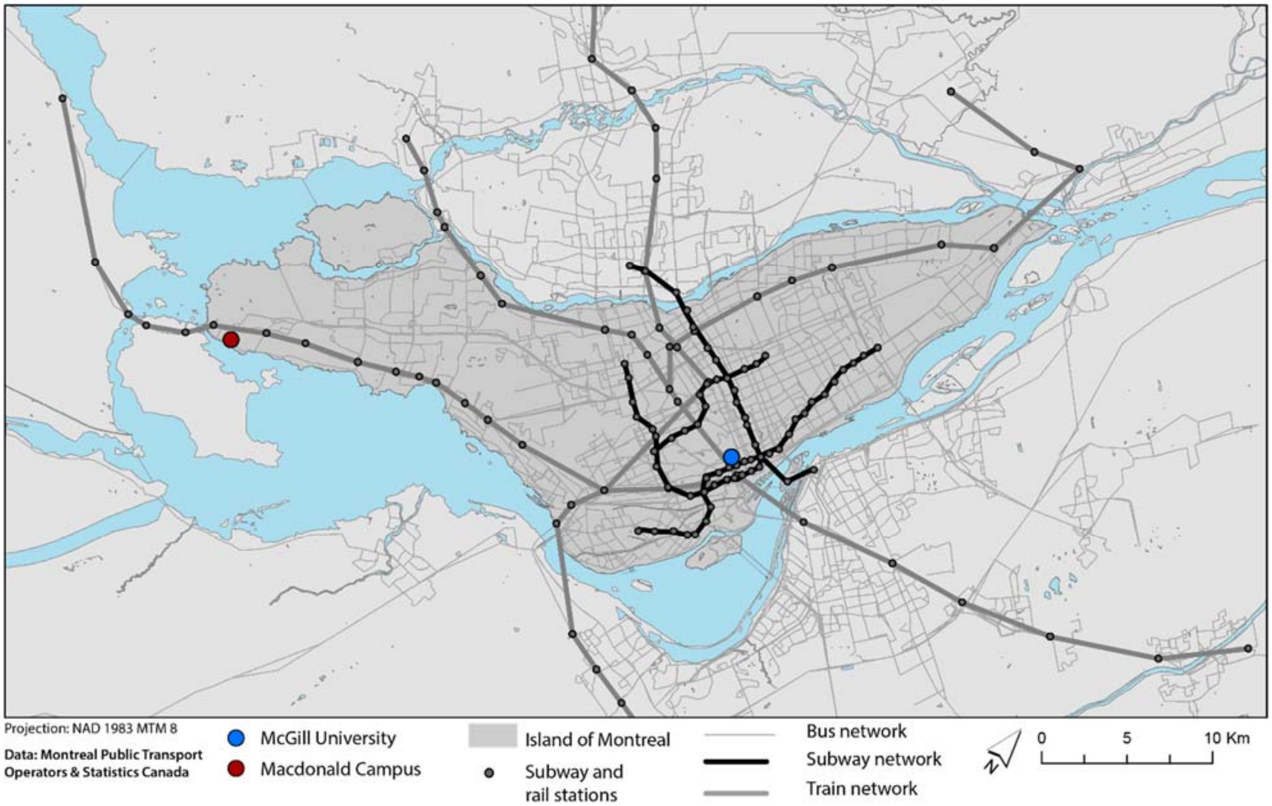

Figure 1 Context map of the location of McGill University relative to the Montreal public transport network.

The survey was distributed to all McGill staff and faculty, while a random sample of one third of the student population were selected to complete the survey. All selected participants received an invitation via email to complete the survey online, and various prizes were offered to entice participants to complete the survey. One reminder email was sent to each participant who had not completed the survey within two weeks of receiving the initial invitation. Half of the selected participants were invited to participate in the survey in fall 2017, while the other half were invited to complete the survey in winter 2018. A total of 16,930 invitations were sent in the two seasons. This allowed us to obtain a representative sample of commutes under different weather trends. A total of 4,859 completed responses were obtained, representing a 33.4% response rate. Our final sample consisted of 1,342 responses who commuted to either of McGill's campuses by public transport and answered questions related to their home address or postal code, satisfaction with commute, travel time, and 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 hours, 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, we did not remove respondents who drove or bicycled to a public transport station from our sample.

METHODOLOGY

Statistical analysis

Our analysis begins by presenting descriptive statistics of the relationship between satisfaction levels of each respondents 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 required two subway lines would be a two-transfer trip. We then disaggregate the relationship between transferring and satisfaction further by segmenting our 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, we conducted two binary logistic models 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. Due to the failure of the parallel assumption test and for the ease of communicating our model findings, we recoded this satisfaction variable 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 respondents’ trip. While Model 2 controls for the mode-specific transfers that were observed, which includes: 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 due to multicollinearity. For intermodal transfers, we do not know the order in which the transfer occurred. Also, we were unable to study satisfaction when transferring between train lines as no responses in our study sample reported using more than one train line. It is a rare occasion in the Montreal train system to transfer between train lines due to 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 respondents’ reported arrival and departure time of their morning commute to McGill. Our 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 our model allows us to isolate the relationship between transferring and satisfaction, to determine how significantly other factors associated with transferring impact overall trip satisfaction. Lastly, to capture non-linear effects of travel time, we included the square of travel time in the model.

Additional trip characteristics were included in our 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 to 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, we tested whether individuals’ responses were spatially nested in their neighborhoods, requiring a multilevel modeling approach to reduce potential spatial estimation bias. However, the test indicated that a multilevel model was not needed for our data.

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%	--
Household size	Number of people residing in the respondents' 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%	--
Male	Dummy variable equal to 1 if respondent is a male	37%	--
Other	Dummy variable equal to 1 if respondent identified as other	1%	--
Age	Age of the respondent	36.43	13.51
High income	Yearly personal income above $80,000	16%	--
Medium income	Yearly personal income between $40,000 and $79,999	37%	--
Trip characteristics			
Fall trip	Dummy variable equal to 1 if the surveyed trip in question occurred in the fall semester (September - December 2017)	48%	--
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 (7AM and 9AM)	65%	--
Downtown campus	Dummy variable equal to 1 if the individual reported spending the majority of time at McGill's downtown campus	99%	--
Model 1 *Number of transfers*			
One transfer	Dummy variable equal to 1 if 1 transfer was needed to complete the respondents' last trip	32%	--
Two transfers	Dummy variable equal to 1 if 2 or more transfers were needed to complete the respondents' last trip	23%	--
Model 2 *Mode-specific types of transfers*			
Bus-bus transfer	Dummy variable equal to 1 if a respondent transferred bus routes	11%	--
Subway-subway transfer	Dummy variable equal to 1 if a respondent transferred subway lines	32%	--
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*	31%	--
Bus-train transfer	Dummy variable equal to 1 if a respondent transferred from a bus route to a commuter train*	3%	--

Train-subway transfer	Dummy variable equal to 1 if a respondent transferred from a commuter train route to a subway line*	4%	--

* For cross-model transfers, order of transfer between modes is unknown

RESULTS

Descriptive statistics

Table 2 presents summary statistics of our study sample, average trip satisfaction, travel time, and trip distance, according to the number and type of transfers taken on each respondents' 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 we observe 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.

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

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

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

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%

Regression analysis

The first regression model presented in Table 4 concentrates on the direct impacts of the number of transfers on satisfaction with last trip among public transport users while controlling for other personal and trip characteristics excluding the type of transfer. Trips involving one transfer compared to 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 to zero transfers. In our sample only 3% of respondents transferred either three or four times, and due to the rarity of these trips we combined them with two transfers to avoid bias in our estimations.

With respect to other trip characteristics, travel time decreased the odds of satisfaction by 5% for every additional minute spent travelling. However, the square term of travel time is positive and therefore 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. We see a modest decrease in satisfaction for those who travelled during peak hours compared to non-peak hours, although this variable was not statistically significant. While travel at peak hours can be frustrating for riders due to 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 to those who work on McGill's Macdonald

Campus, 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 design as a direct-system to downtown. Furthermore, McGill University offers a shuttle service between the two campuses, which likely explains why only 1% of our study sample reported commuting by public transport to the suburban campus.

In terms of differences in satisfaction levels across seasons, we see that commuters in the fall were 1.43 times more likely to be satisfied with their last trip compared to 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 one centimeter in fall, to an average of 67 centimeters in winter.

Demographic characteristics were also important predictors of trip satisfaction. Our findings indicate that females are 28% less likely to be satisfied when compared to 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 to men. We also see a positive relationship between age and satisfaction. A one-year increase in age is associated with 1% higher odds of satisfaction. With respect to income level, we observe that medium income individuals are 1.48 times more likely to be satisfied compared to 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 (*24)* observed that faculty are highly satisfied with their commute, which they hypothesize is a result of higher satisfaction in other domains such as income, job security and intellectual fulfillment. Similarly, Sprumont, Astegiano and Viti (*25)* observed satisfaction levels of PhD students, professors and staff and found that PhD students were the least satisfied with their commuting trip.

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			

†*** Significant at 99% ** Significant at 95% * Significant at 90%, blank cell indicates no statistical significance

The second regression model (Table 5), is similar to the first model yet 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 one public transport mode, we see that a transfer between two bus routes decreases the odds of satisfaction by 37%, compared to 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, we see that commuters who transferred from a subway to a bus or vice versa have 27% lower odds of satisfaction compared to their non-transferring counterparts. The remaining transfers were not statistically significant in our model, however will be discussed below. A trip involving a transfer from a train to a subway, or in the reverse order, although not statistically significant, has 37% lower odds of satisfaction when compared to 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, whilst the subway system is more frequent. A small delay in the subway system, which frequently happens in Montreal, can lead to a missed transfer since 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 to a non-transferring trip. However, only 3% of our sample transferred from a bus to a train, or vice versa.

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			

†*** Significant at 99% ** Significant at 95% * Significant at 90%, blank cell indicates no statistical significance

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) being used in a trip. Our results indicated that there was no statistically significant difference between those who transferred once compared to those who did not transfer, all else equal. However, we see that the odds of satisfaction decline by 32% for those who require two or more transfers. Imaz et al. (*26)* similarly found that trips involving 2 or more transfers negatively impact customer loyalty. Public transport agencies should try to either minimize the number of trips involving two or more transfers, or place efforts towards minimizing waiting times for these trips through strategies such as increasing service frequency or a transfer synchronization approach.

Our results suggest that different types of transfers impact trip satisfaction differently. Transferring between bus routes was the most dissatisfying transfer observed in our study. Currie (*27)* summarized transfer penalties observed from a range of studies and found far higher valuations of transfer penalties compared to rail-based modes, due to the average time spent transferring buses. Therefore, we would expect satisfaction to be impacted among those who transfer bus routes since waiting time is negatively associated with trip satisfaction (*28*). This should be explored further with detailed data related to the time associated with transferring, including walking time between stops, and time waiting for the next vehicle. Furthermore, as we observed trips that occurred in the fall had higher odds of satisfaction compared to trips in the winter, we would hypothesize that respondents transferring buses would be most affected by time associated with transferring in the winter. Future research on the design of bus stops, including how features such as heated shelters impact customer satisfaction levels in other cold cities would provide agencies with insight into the importance of investing in these features at bus stops.

We hypothesize, that variance in satisfaction with transferring buses would be observed according to service frequency. For example, if transferring to a high frequency bus route, that individual may not be worried about timing their connection, as they know the bus runs very frequently. Furthermore, bus travel in general has been associated with higher stress levels despite their shorter travel time relative to other public transport modes (*24*), which can be explained by crowding and lack of control of the situation (*28*). The degree to which stress is associated with transferring was overlooked in the previous research and evidence presented in this study highlights the negative impact of transferring between bus routes.

Finally, we 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. For those transferring from the subway to a bus, missing a bus due to slower than usual service can impact satisfaction. While knowledge of the order of a bus-subway transfer would have been valuable for this analysis, we would expect that most of these transfers occurred from the bus to subway, since McGill University is located in close proximity to two subway station.

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 the peak and at a low frequency, while the subway and bus network are operated by the Société de transport de Montreal (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 the train commuters to miss his/her connection.

A limitation of this data is that we cannot analyze satisfaction of non-public transport riders. In a global review of the crucial strategic and tactical steps for designing and scheduling a public transport network, and in regards to transferring the authors wrote, “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 our study sample reported transferring three times, the authors assertion that public transport users are unwilling to complete three transfers appears to hold true in our study context. A stronger understanding of overall willingness to transfer can be attained through mode choice analysis, for example (*14*). A mode choice analysis similar to the aforementioned study can shed light on the role that transferring plays on travel behaviour, or the choice to take public transport compared to 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, etc. Lastly, as the survey data used in this study was collected in the fall and winter, collection of data in the summer would provide a complete picture of how under different weather conditions users are satisfied with their trip, as well as how transferring impacts 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 our conceptualization of transferring should be extended to include a ‘transfer’ from the first leg of our 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 users’ 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 to those who missed their connection.

CONCLUSIONS

Findings of this study indicate that overall satisfaction declines when riders must transfer at least two times. However, the evidence presented in this paper reveals that not all transfers have an equal impact on satisfaction. Transfers between a train and subway were found to have the largest negative impact on overall satisfaction, although was not statistically significant mostly due to sample size. One means of addressing this dissatisfying transfer is by providing a seamless fare integration between modes and coordinate schedules and delays. As expected, transferring between bus routes and transferring between a subway and a bus both negatively impacted 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, since 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 metro holdings for substantial amounts of time till a bus or a metro 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 impact satisfaction. Moreover, this result shows that transferring between high frequency routes does not impact total trip satisfaction levels in the same way as transfers involving low frequency services, namely bus service. This corroborates findings from Badia, Argote-Cabanero and Daganzo (*9)* where they noticed an increase in demand in a Spanish network after it moved to high frequency transfer-based bus network. 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.

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*). In light 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 we saw in this study and help in retaining existing riders and attract new ones. A limitation in our study is 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 our analysis and enabled comparisons to online trip planner suggestions. In this study we used binary logistic regressions to model satisfaction for the ease of communicating our results, future research can explore other modeling techniques such as ordered or generalized ordered logits.

AUTHOR CONTRIBUTIONS

The authors confirm contribution to the paper as follows: study conception and design: Grisé & El-Geneidy; data collection: Grisé & El-Geneidy; analysis and interpretation of results: Grisé & El-Geneidy; draft manuscript preparation: Grisé & El-Geneidy. All authors reviewed the results and approved the final version of the manuscript.

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