Transitory Optimism

Changes in Passenger Perception Following Bus Service Improvement over Time

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Passengers' perception and satisfaction have long been seen and used as important measures of transit service quality and attractiveness. This research tried to understand better transit passengers' perception of the implementation of various improvement strategies in bus service over time. The study analyzed three surveys of bus user perceptions conducted over a period of 3 years. The study also used stop-level data collected from the Société de Transport de Montréal's automated vehicle location and automatic passenger count systems and bus schedules in Montreal, Canada, to measure the actual changes in service. Descriptive statistics and regression models were used for a better understanding of the differences between perceptions and reality. The implementation of various strategies had a limited impact on the short-term overestimation by users of their waiting time benefits, whereas the implementation had a long-term impact on their travel time overestimation. This study can be of interest to marketing and planning departments at transit agencies, because it provides them with new insights into passengers' perception and satisfaction.

Passengers' perception and satisfaction have been long seen and used as important measures of transit service attractiveness. They are generally a reflection of service quality from the passengers' point of view. Further, these measures have been linked to sustaining high levels of ridership. Along one of the busiest bus corridors in Montreal, Canada, the Saint-Michel corridor, various measures have been implemented over a period of 3 years to improve the service. This corridor, with an average total daily ridership of 43,000 passengers, has received special attention from the Société de Transport de Montréal (STM), the transit provider on the island of Montreal. STM started with the implementation of smart card fare collection in April 2009, replacing the traditional flash passes to provide passengers with a more convenient transport experience and payment option (*1*). The main goal of this action was to increase passenger satisfaction and to clamp down on ticket fraud (*2*). In addition, in March 2009, STM operated a new limited-stop service, Route 467. The express route (Route 467) is overlaid on the local route (Route 67), sharing only 40% of the regular route stops. The introduction of Route 467 led to a decline in Route 67 service frequency (6.1 min to 8.2 min headway). Since the new service replaced a few trips along the local Route 67, additional trips were still made by the new service (Route 467), leading to an overall increase in combined frequency at stops served by both routes. Routes 67 and 467 are known as part of the 10-min maximum network in STM, the brand for frequent service on the island of Montreal. Then STM introduced reserved lanes during the peak hours in August of the same year, improving the service efficiency along the corridor. Next, in February 2010, STM introduced articulated buses along Route 467, increasing the level of comfort to existing users by providing more space and seating capacity on buses. Finally, in September of the same year, STM equipped several articulated buses along Route 467 with a transit signal priority (TSP) system, giving these buses priority over other road vehicles at the corridor's signalized intersections. Figure 1 presents a time line of the strategies implemented by STM along the studied routes between January 2007 and June 2013.

The goal of this paper is to better understand the change in users' perception over time in regard to their wait and travel times following the implementation of the measures as described. Previous research by the authors revealed that passengers did overestimate their travel time saving in the short term after 1 year of the implementation of the previous set of measures, even though there was a minor actual saving in their travel time (*3*). However, this information presented only one important part of the truth, since transit agencies are interested not only in making users satisfied at one point of their travel time, but also in keeping users pleased over time with the kind of service being provided. Furthermore, since each strategy implemented along the corridor began at a different point in time, this temporal difference offers a unique opportunity to understand the impact of various strategies on riders' perception.

This study employs three short passenger surveys conducted along the bus corridor to understand the short-, medium-, and long-term changes in passengers' perception and satisfaction. These surveys are used in comparison with the actual operational data collected from STM's automated vehicle location (AVL) and automatic passenger count (APC) systems for Routes 67 and 467 to understand the actual changes in service. "Short term" is defined as 1 year after STM's measures, while the medium and long term are defined as after 2 and 3 years, respectively. During the survey collections, in September 2011, STM introduced incrementally articulated buses along Route 67, offering more space and seating capacity on buses.

The paper begins with a literature review on passenger waiting and travel times perception, followed by an explanation of the surveys and the methodology used to prepare and analyze the data. Finally, the results of the statistical analysis are discussed. The paper wraps up with some main conclusions and their policy implications for transit planners and operators.

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Transportation Research Record: Journal of the Transportation Research Board, No. 2415, Transportation Research Board of the National Academies, Washington, D.C., 2014, pp. 97–106.
DOI: 10.3141/2415-11

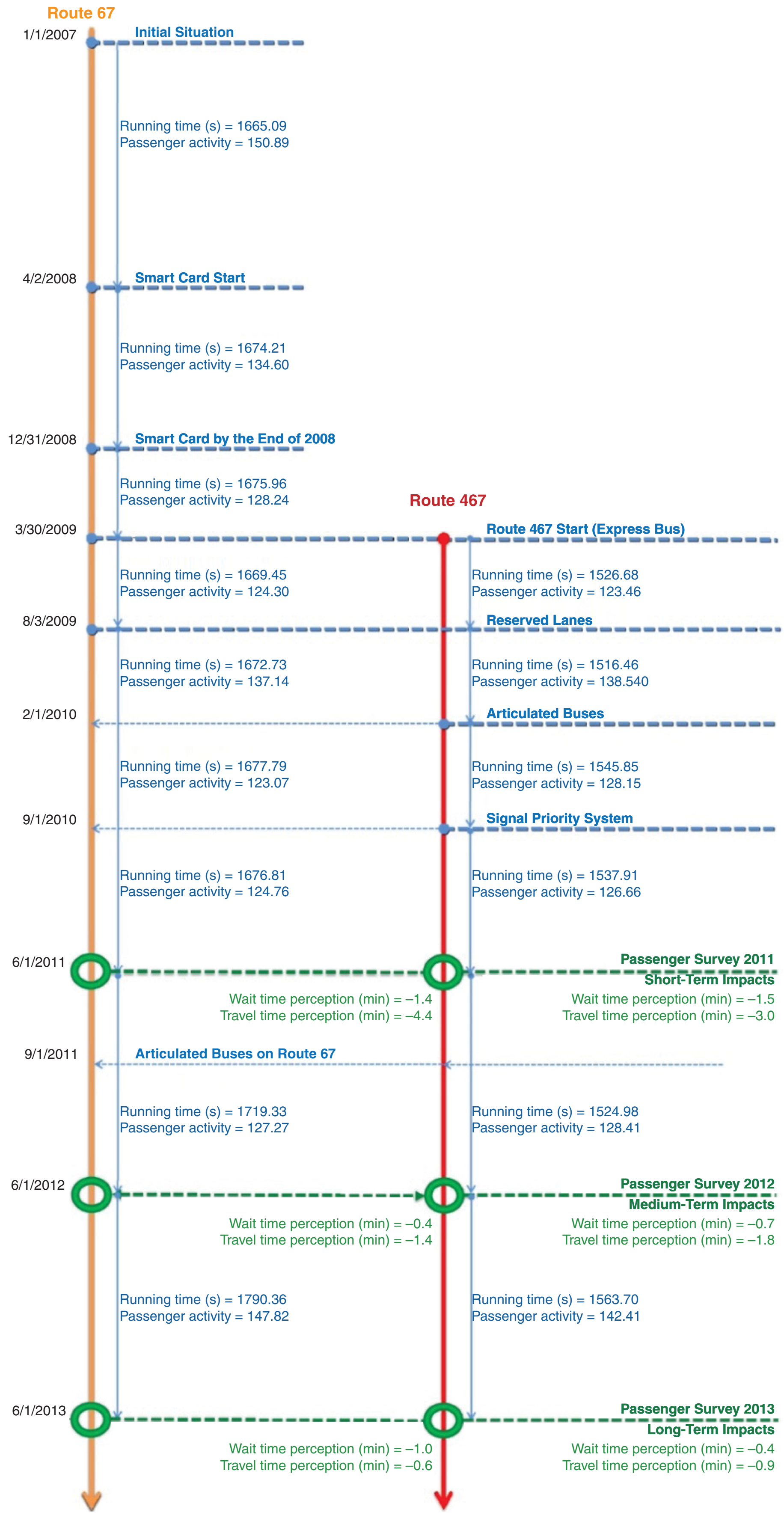

FIGURE 1 Time line of surveys and changes made to bus service.

LITERATURE REVIEW

Reducing car use and increasing that of public transit is a big challenge. Therefore, increasing investment in various service improvement strategies is becoming more popular in bus public transit, to provide passengers with an attractive service. Thus, it is essential to understand passengers' perception after experiencing these improvements. Researchers indicate that users' perceived service quality is positively related to satisfaction (*4–7*), considered the main driver of consumer loyalty and behavior (*8*). Therefore, researchers have linked good perceived transit quality to continued use of a service (*9*). In addition, while transit agencies focus on measuring overall satisfaction, researchers indicate that agencies should use customer satisfaction in conjunction with perceived values to better understand users' intentions and loyalty (*10*). Other researchers found that time costs present an important predictor of behavior changes (*5, 11*).

Much literature has developed around how users perceive time during a transit trip (*12–16*). Time perception, an important aspect of human experience, has deep roots in psychological research (*17*). Researchers recognize that passengers have a biased perception of actual physical time (*17–19*). For example, researchers agree on the fact that passengers perceive waiting time differently from the actual time (*12*). Mishalani et al. used linear regression to investigate the relationship between passengers' perceived and actual waiting times, and they found that passengers overestimated their waiting time by 0.84 min (*15*). Psarros et al. revealed that for all trip purposes, there appears to be a strong overestimation of waiting time (*14*). Other researchers indicate that waiting time perceptions change depending on whether passengers make a conscious decision to wait or whether the wait is imposed on them (*13, 20*). For example, researchers report that passengers overestimate their waiting time by a factor of two compared with the actual waiting time when it is imposed by the transit system (*13*).

In regard to travel time perception, researchers indicate that travel time perception influences individuals' route choice (*21*) and mode choice (*18*). In addition, researchers have highlighted the appropriateness of using perceived values compared to observed attribute values in utility calculations in mode choice models (*22*). The *Transit Capacity and Quality of Service Manual* indicates that perceived travel time equals actual travel time (*23*). In addition, researchers reveal a nonlinear relationship for values that individuals put for travel time when there is a travel time variation (*24*). This situation indicates that the cost of travel time variation may be greater than the cost of regular travel time (*25, 26*). Further suggested is that travel time variation greatly affects decision making and daily time planning processes (*27–29*). However, none of the aforementioned studies have focused on understanding the impacts of implementation of various transit improvement strategies on travelers' perception.

Other research focused on measuring users' perception and satisfaction immediately or at one time point after implementation of a new measure or route (*30*). For instance, in a before-and-after survey in Chicago after implementation of a limited stop service running parallel to a bus route, users indicated a high satisfaction level in many areas, including overall satisfaction, running time, and waiting time, at both the regular and the limited stop service routes (*31*). A survey in Vancouver, after implementation of new bus rapid transit, indicated a strong satisfaction by passengers with the service (*30*). Similar findings were found after a bus rapid transit service implementation in Honolulu (*32*). Another study focused on users' travel time perception, indicating that users overestimate their perceived benefits after implementation of new a limited stop service (*33*). However, to the authors' knowledge, none of these studies have understood how these estimated perceptions can change over time. Only one recent study has investigated the effects of the introduction of real-time information on people's waiting time perception changes over time, using surveys 1 month before and 3 months and 16 months after the system implementation. The study revealed that passengers' waiting time perception decreased after the implementation by 1.30 min without their reporting any actual improvement in service, with no significant change in perception in the long term (*16*).

Further investigation is required to understand transit passengers' changes in waiting and travel time perception of bus service over time following the implementation of improvement strategies. This is a policy-relevant issue, since agencies should not only understand the quantitative effects of their policy and implemented strategies on their performance, but also on passenger perception. The impacts of STM-implemented strategies on bus running time and its variation are well documented in the literature (*3, 34*). The availability and the accuracy of AVL-APC data offer a good opportunity to study changes in passenger perceptions while controlling for the actual changes in service. The use of archived AVL-APC data is common in the transit literature to understand the changes in bus running time and its variation, dwell time, and on-time performance (*34–36*).

METHODOLOGY

The objective of this analysis is to understand the temporal changes in passengers' perception pertaining to their waiting and travel times following the implementation of improvement measures. Data used in the analysis come from three short field surveys. These surveys are meant to capture the short-, medium-, and long-term changes in passengers' perception. Routes 67 and 467 run for approximately 9.4 km (5.8 mi) along the eastern side of Montreal's central business district area and connect two metro stations. The routes share Boulevard Saint-Michel, which has three traffic lanes in each direction. There have been no significant changes in the built environment of the corridor during the past 7 years.

The surveys were carried out from May to June of 2011, 2012, and 2013 on regular weekdays between 7:00 a.m. and 10:30 a.m., and between 2:00 p.m. and 6:30 p.m., to cover both morning and afternoon commuting periods, while isolating the seasonal impact of weather on users' perception. The surveys were done at the southern direction stops during the morning peak to capture the opinion of travelers heading toward the Montreal downtown area, and at the northern direction stops during the afternoon peak to capture travelers returning home. During the surveys, weather conditions were normal, with no major events affecting the typical delivered bus and metro service.

The surveys were self-administered, and each survey team consisted of at least two surveyors at each stop. They handed out surveys and answered any questions that passengers might have had. Surveyed passengers were chosen randomly from the bus waiting lines, or based on who arrived first at stops. Over 90% of the distributed surveys were filled by the passengers along the three waves of surveys. The surveyed bus stops were selected mainly according to the highest number of boarding passengers for both routes covering the main streams of passengers' flow. A total of five northbound stops and six southbound stops on average were used during the surveys, and most of the stops are served by both routes.

The survey was one page long, and it included French and English versions. Passengers were asked to indicate which bus route (67 or 467) they use most often, and to report when they started using this route. They were also asked to report how often they use this route, by selecting one of three options: 1 day a week or less, 2 to 4 days a week, or 5 days a week or more. Then respondents were asked if they changed their usual stop to another stop, to use the Route 467 express service, selecting one of three options: no, yes, and I am new user of the 467 service. Next, riders were required to report if they see a difference in their waiting time now compared with when they started using this route. Three options (or checkboxes) were given: (*a*) yes, longer by . . . minute(s); (*b*) no change; and (*c*) yes, shorter by . . . minute(s). A similar question was asked for travel time. The surveys also requested that riders identify their alighting stop along the route and report their age and gender. In the medium- and long-term surveys, another question was added to understand riders' level of satisfaction with their overall trip, waiting and travel times using rating systems (1 being unsatisfied to 5 being satisfied). In total, about 1,040 survey responses were collected during the three surveys.

More than 4 million individual stop observations were collected from STM's AVL-APC archival data between January 1, 2007, and May 1, 2013, for both routes. The AVL-APC stop level observations include bus arrival, departure, and schedule times, and information about passenger activity and load, and bus type. Because the purpose of this paper is to understand the change of passengers' waiting and travel time perception over time, stop-by-stop travel time, bus load at stops, and delay at each stop were calculated. Delay was calculated as bus departure time minus scheduled time. Then, this data set was aggregated according to the implemented strategy time or the year of survey period, route number, and direction. The following survey year periods were calculated: Year 2011 survey period from after TSP implementation to June 2011; Year 2012 survey from July 2011 to June 2012; and finally Year 2013 survey from July 2012 to the end of the study time line.

For each surveyed passenger, the actual change in waiting time and travel time was matched to this data set. For each user, the actual travel time change was considered as the difference between the average travel time and its standard deviation during the survey time compared with when the user started using the service. Similarly, the actual waiting time change was calculated as the difference between half of the scheduled headway and average delay at each user's boarding stop. While Route 67 average headway increased after introduction of Route 467, some of the Route 67 passengers have experienced improvements in headways compared with when they started using the service after implementation of Route 467 along the corridor.

This research uses descriptive statistics and two statistical models based on the survey data to capture and isolate the change in passengers' perception over time. Several *t*-tests are employed to understand the changes in passengers' estimated perceptions and to compare estimated perceptions with actual waiting and travel time changes. Then, two statistical models are generated to understand overestimation of passengers' waiting and travel times. Table 1 includes a detailed description of the variables incorporated in the statistical analysis. Other variables were tested but were eliminated from the study because of their nonsignificance, such as age, gender, change in seating capacity (%), and time of the day.

The key variables in these models are Year 2011 survey and Year 2012 survey, dummy variables that will distinguish the short- and medium-term impacts of STM's implemented strategies on respon-

TABLE 1 Description of Variables Used in Regression Models

Variable Name	Description
Difference in estimated waiting time (s)	Passenger's estimated waiting time saving in seconds minus the actual time change.
Difference in estimated travel time (s)	Passenger's estimated travel time saving in seconds minus the actual time change.
Yes, change my stops to use R467	Dummy variable that is equal 1 if the rider indicated that she or he changed her or his usual stop to use R467.
Year 2011 survey	Dummy variable that equals 1 if the survey was conducted between May to June 2011 and zero otherwise. When it is equal to 1, the variable captures the short-term impacts of STM's strategies on perception.
Year 2012 survey	Dummy variable that equals 1 if the survey was conducted between May to June 2012 and zero otherwise. When it is equal to 1, the variable captures the medium-term impacts of STM's strategies on perception.
After articulated buses	Dummy variable that equals 1 if the surveyed passenger has started using the service after the introduction of articulated buses on boulevard Saint-Michel on February 1, 2010. When it is equal to 1, the variable means that the passenger has only witnessed the implementation of the TSP system.
After reserved lane	Dummy variable that equals 1 if the surveyed passenger has started using the service after the operation of the reserved bus lanes along the corridor on August 3, 2009. When it is equal to 1, the variable means that the passenger has witnessed the implementation of the articulated buses and the TSP system along the corridor.
After Route 467	Dummy variable that equals 1 if the surveyed passenger has started using the service after the implementation of the express service (Route 467) on March 30, 2009. When it is equal to 1, the variable means that the passenger has witnessed the implementation of the reserved lanes, articulated buses, and the TSP system along the corridor.
After smart cards	Dummy variable that equals 1 if the surveyed passenger has started using the service after the introduction of a smart card payment system (named OPUS) on April 1, 2008. When it is equal to 1, the variable means that the passenger has witnessed the implementation of the Route 467, reserved lanes, articulated buses, and the TSP system along the corridor.
Initial situation	Dummy variable that equals 1 if the surveyed passenger has started using the service before any of the strategies implementation. When it is equal to 1, the variable means that the passenger has witnessed the implementation of all measures.
Waiting time change (s)	Actual difference in passenger waiting time in seconds between when the survey was collected period and when she or he started using the service.
Travel time change (s)	Actual difference in passenger travel time in seconds between when the survey was collected period and when she or he started using the service.
Bus load change (%)	Difference in the occupied bus load percentages between the period when the survey was collected and when the passenger started using the service, at her or his boarding stop.
Distance (km) * load change (%)	Interaction variable between passengers' traveled distance in kilometers and the change in bus load percentage.

dents' perception compared with the long-term impact survey (conducted in the 2013 year period), respectively. These variables will capture the change in passengers' perception over time. A positive value indicates an increase in the overall perceived waiting and travel time saving compared with that of the long-term survey, while a negative value indicates a decline in perceived time saving.

In addition, various dummy variables were included to control the impact of different improvement strategies. A dummy, after articulated buses, distinguishes the users who started using the service after articulated buses were implemented and before the TSP. In other words, it distinguishes travelers who witnessed only the TSP implementation. A second dummy variable, after reserved lanes, distinguishes the passengers who started using the service after implementation of the reserved lane and witnessed the introduction of articulated buses and the TSP system. A third dummy variable, After Route 467, characterizes travelers who started using the service after implementation of the express service and saw the use of reserved lanes, articulated buses, and TSP. Finally, the fourth variable, after smart cards, differentiates passengers who started using the service after the introduction of smart cards, while the fifth variable, initial situation, distinguishes passengers who started using the service before any STM measures.

The dependent variable in the first model is the difference in estimated waiting time saving. It is meant to capture the overall impact of STM's strategies on users' estimated travel time saving changes over time. The model contains the variable of waiting time change to control the actual changes in passengers' waiting time service. The dependent variable in the second model is the difference in estimated travel time saving. It is meant to capture the overall impact of STM's strategies on users' estimated travel time saving changes over time. The model includes three variables to control for the actual changes in service: travel time change; bus load change (%); and distance (km) * bus load (%), an interaction between the change in used bus load and distance in kilometers. Bus load change was calculated at each passenger boarding stop, and it is used to control the impacts of increasing the total available capacity of buses along the route, as STM increased the number of articulated buses.

GENERAL DESCRIPTION OF SURVEY ANSWERS

Table 2 presents a general summary of the surveys' respondents. There were 354, 373, and 310 surveys collected in 2011, 2012, and 2013, respectively. Furthermore, the table shows the percentage of

TABLE 2 General Characteristics of Survey Respondents

	Year 2011 Survey		Year 2012 Survey		Year 2013 Survey		Total	
Characteristic	*N*	Percentage	*N*	Percentage	*N*	Percentage	*N*	Percentage
Route								
467	183	52	159	43	138	45	480	46
67	104	29	144	39	123	40	371	36
67 and 467	67	19	68	18	49	16	184	18
Frequency of use								
5 days a week or more	224	63	251	67	216	70	691	67
2 to 4 days a week	91	26	89	24	72	23	252	24
1 day a week or less	39	11	33	9	21	7	93	9
Change your stop to use 467 service								
No	223	63	222	60	215	69	660	64
Yes	103	29	101	27	87	28	291	28
I am a new user of the 467 service	10	3	26	7	8	3	44	4
Period when started using the service								
Initial situation	99	28	119	32	89	29	307	30
After smart cards	33	9	15	4	17	5	65	6
After Route 467	88	25	45	12	38	12	171	16
After reserved lanes	17	5	44	12	32	10	93	9
After articulated buses	57	16	39	10	14	5	110	11
During the survey collections	60	17	111	30	120	39	291	28
Waiting time perception								
Decrease in time	133	38	122	33	70	23	325	31
Increase in time	38	11	55	15	77	25	170	16
No change	179	51	189	51	163	53	531	51
Travel time perception								
Decrease in time	184	52	123	33	91	29	398	38
Increase in time	24	7	27	7	31	10	82	8
No change	142	40	218	58	188	61	548	53
Gender								
Female	204	58	221	59	186	60	611	59
Male	150	42	145	39	124	40	419	40
Age (years)								
18–30	109	31	116	31	95	31	320	31
31–45	78	22	95	25	100	32	273	26
46–65	71	20	69	18	80	26	220	21
>65	15	4	19	5	18	6	52	5
Count of cases	354	5.2[a]	373	5.1[a]	310	5.5[a]	1,037	100

[a]The confidence interval (also called margin of error) at the 95% confidence level.

passengers according to when they started to use the service and which route they used most often, and the percentage of passengers according to their waiting and travel times perception. In addition, the table shows the respondents' gender and average age.

ANALYSIS OF RESPONDENTS' PERCEIVED TIME CHANGES AND SATISFACTION

Several *t*-tests were conducted to test the impacts of the different measures on estimated waiting and travel time changes. Table 3 shows the statistical results for the perceived changes: means, standard deviations, and significance levels. In this analysis, included were only passengers using Route 67 or Route 467 who provided a time value or who indicated that there was no change in their waiting and travel times. This analysis helps in understanding the change in the mean value of perceived benefits along the studied bus routes.

As seen in Table 3, for Route 67, the average estimated waiting time saving in the short-term survey (2011) was 1.4 min. This average decreased to 0.4 min in the medium-term survey (2012). In the long-term survey (2013), passengers, on average, perceived an increase in their waiting time by 1.1 min. There was no significant difference in means between the short- and medium-term surveys, but there was a significant difference between the medium- and long-term surveys, indicating that long-term perception was much lower than for the previous years. A similar trend is noticeable for Route 467: the average perceived waiting time saving on the short-term survey was 1.6 min, decreasing to 0.7 and –0.4 min in the medium- and long-term surveys, respectively.

In regard to travel time perception for Route 67, the average perceived travel time saving in the short-term survey was 4.4 min, decreasing to 1.1 and 0.6 min in the medium- and long-term surveys, respectively. There was a significant difference in means between the short- and medium-term surveys, while no significant difference was found between the medium- and long-term surveys, indicating that short-term perception is different from that of other years. For Route 467, similar changes in the significance and values of passengers' perceived travel time throughout the surveys can be noticed. The average perceived travel time saving in the short-term survey was 3.0 min, decreasing to 1.8 and 0.9 min on the medium- and long-term surveys, respectively. To better understand the previous findings, the next section compares perceptions with actual changes by using *t*-tests.

For benchmarking purposes, overall satisfaction of passengers and passengers' satisfaction with travel and waiting times were collected. Overall satisfaction pertains to a holistic evaluation after a service delivery experience (*6, 9*). Both routes' percentages of overall trip satisfaction are comparable with STM's general reported overall trip satisfaction with bus service in 2012, about 82% (*37*).

PERCEPTION CHANGE IN RELATION TO ACTUAL CHANGE IN SERVICE

For a better understanding of how passengers overestimated their waiting and travel time saving, and how this overestimation changed over time, a paired difference in means *t*-test was used to compare perceptions with the actual waiting and travel time changes for passengers. The analysis in this and the following section was completed for riders who reported their alighting stops and who indicated the right starting period while the service is operated (particularly for Route 467 users). Figure 2*a* shows the waiting time paired differences, and Figure 2*b* shows the travel time paired differences.

TABLE 3 Perception of and Satisfaction with (*t*-Test) Waiting and Travel Times

	Route 67, by Survey Year			Route 467, by Survey Year		
Statistic	2011	2012	2013	2011	2012	2013
Waiting Time Perception (min)						
N	97	126	114	167	137	121
Mean (SD)	1.4 (4.9)	0.4 (5.8)	−1.1 (5.8)	1.6 (3.9)	0.7 (4.3)	–0.4 (4.0)
Significant level (α)[a]	0.15	**0.00**		0.08	**0.00**	
Travel Time Perception (min)						
N	92	127	112	162	132	126
Mean (SD)	4.4 (5.9)	1.1 (4.6)	0.6 (3.5)	3.0 (4.3)	1.8 (5.0)	0.9 (5.3)
Significant level (*R*[a], α)	**0.00**	0.38		**0.03**	0.17	
Satisfaction (out of 5)						
Overall trip satisfaction						
N	NA	136	116	NA	154	130
Mean (SD)	NA	3.9 (0.9)	4.0 (0.9)	NA	4.2 (0.7)	3.9 (0.8)
Significant level (*R*[a], α)	NA	0.24		NA	**0.00**	
Waiting time satisfaction						
N	NA	136	116	NA	155	130
Mean (SD)	NA	3.7 (0.9)	3.7 (1.0)	NA	3.9 (1.0)	3.6 (1.0)
Significant level (*R*[a], α)	NA	0.94		NA	**0.00**	
Travel time satisfaction						
N	NA	136	116	NA	153	130
Mean (SD)	NA	3.9 (0.9)	4.1 (0.9)	NA	4.2 (0.8)	4.0 (0.8)
Significant level (*R*[a], α)	NA	0.33		NA	**0.03**	

NOTE: Boldface indicates statistical significance. SD = standard deviation; NA = not available; blank cells = no 2014 data for comparison.
[a]Significant level of difference in means *t*-test between consecutive years (e.g., Route 67 2011 and 2012 records).

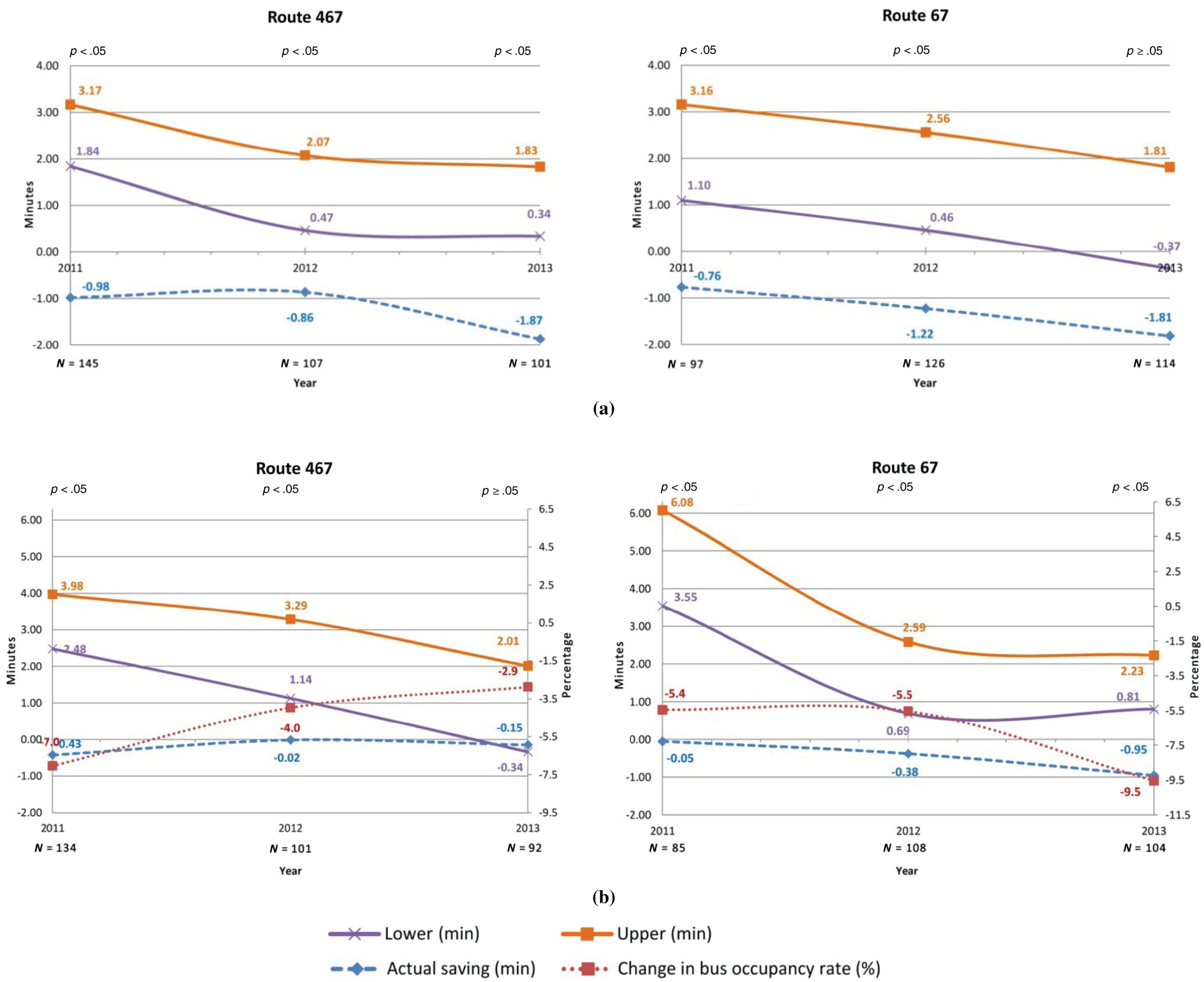

FIGURE 2 Paired differences: (*a*) passengers' waiting time and (*b*) passengers' travel time.

On Route 467, passengers overestimated their waiting time savings by 1.8 to 3.2 min in the short term. This range of estimated time saving dropped in the medium term to be within 0.5 to 2.1 min of saving, while there was an improvement in their actual waiting time saving. This demonstrates a negative bias in their answers since there was a slight improvement in the service. The improvement in service may result from increases in the operational quality of TSP system. In the long term, travelers' overestimated waiting time saving dropped to be within the range of 0.3 to 1.8 min. These decreases in perception were positively correlated with decreases in the actual waiting time ($p < .05$), implying a strong relationship between the actual and estimated waiting times.

For Route 67 passengers, there was a trend of decline in perceived waiting time throughout the three periods. Passengers overestimated significantly their waiting time saving within a range of 1.1 to 3.2 min, and 0.5 to 2.6 min in the short and medium terms, respectively, while the difference between their estimated waiting time saving and the actual changes was not significant in the long term. This result indicates a diminishing trend of waiting time overestimation in the long term. That is understandable, since passengers are more sensitive to their waiting time changes compared with other components of the trip.

In regard to passengers' travel time along Route 467, as seen in Figure 2*b,* there is a consistent decrease in their overestimated travel time saving over time. In the short term, they overestimated their travel time savings within a range of 2.5 to 4.0 min. In the medium term, the range of overestimated time saving dropped to a range of 1.1 to 3.3 min saving, although there was a slight positive enhancement in the actual running time. This decline in users' estimated time benefits corresponds to the increase in the bus occupancy rate, indicating that buses are more crowded in the medium and long terms compared with the short term. In the long term, the difference between passenger travel time perception and actual changes was not significant. This insignificance may result from the high level of fluctuations in passengers' travel time overestimation along the route.

For Route 67, passengers overestimated their travel time saving by 3.6 to 6.1 min in the short term. This range dropped sharply to the range of 0.7 to 2.6 min in the medium term, although there was a minor decline in the actual service travel time. In the long term, travelers overestimated their travel time saving by 0.8 to 2.2 min.

This result indicates a stabilization in passengers' overestimated saving, while there was a decline in the actual service from 0.4 to 1.0 min. This result may stem from the increasing bus capacity along the route, and that increased the level of comfort and perception. For an understanding of the change in passengers' perception of their waiting and travel times, two statistical models are generated and reported in the next section.

MODELS ON OVERESTIMATED BENEFITS AND PERCEPTIONS

Two linear regression models are developed using the difference in passengers' overestimated perceived waiting and travel time compared with actual change in waiting and travel times as the dependent variable. In these models, included were only passengers who indicated a positive estimation of their waiting and travel times or who saw no change in the service. This was done to understand the difference between users' overestimations over time and to understand the estimated coefficients sign direction. Table 4 presents the regression results. The first model, the difference in estimated waiting time savings model, contains 565 records and explains 27% of the variation in the overestimated waiting time. The second model, the difference in estimated travel time savings model, contains 558 records and explains 20% of the variation in the difference between estimated and actual travel time. This proportion of explained variance in both models is comparable with previous models in the literature (*38*).

As seen in Table 4 for the waiting time model, the key policy variable Year 2012 survey, accounting for medium-term perception, has a positive coefficient but is not significant compared with long-term impacts of STM's strategies on users' perception. This result indicates no significant difference in passengers' perception between the 2 years. In contrast, the variable Year 2011 survey has a positive significant coefficient. This coefficient suggests that passengers in the short term after STM's implemented strategies overestimated their time saving by 58 s compared with in the long term. The result suggests that implementation of the improvement strategies has a positive impact on estimation of saving in the short term, but the impact diminishes in the medium and long terms—while controlling for the type of strategy that users witnessed and the actual changes in service.

In regard to the control variables, users who indicated that they changed their usual stop to another stop to use the express 467 service perceived a 28-s saving in their waiting time compared with passengers who indicated they did not change their usual stop and with new passengers. This finding suggests that while the users do walk more to use the faster service, they perceive the service more positively. In regard to when the passengers started using the service, those who used the service after the presence of articulated buses and who saw only the introduction of the TSP system did not feel a significant difference in their waiting time compared with passengers who used the service during the survey collection periods (2011, 2012, and 2013). In contrast, passengers who started using the service after the implementation of reserved lanes and who witnessed the implementation of articulated buses perceived 65 s more of time saving than the previous group did. One explanation may be that articulated buses offer more bus capacity, thus decreasing the importance of waiting in line. In addition, passengers are less likely to have to wait for a following bus, as happened in some cases when the regular bus was full as a result of the increase in bus load. Thus, this increase in capacity may lead to decreases in passengers' waiting anxiety, which is linked to their overestimation of their actual waiting time (*39*). Passengers who started using the service after the introduction of the express service and after the use of smart cards did not perceive a significant saving compared with the previous cohort. Passengers who started using the service before the implementation of any strategy indicate perceived waiting time saving of 102 s compared with the previous cohorts.

Finally, a 1-s increase in actual waiting time is expected to increase the difference in passengers' overestimated time saving

TABLE 4 Perception Models of Waiting and Travel Times

	Difference in Estimated Waiting Time Savings[a] (s)			Difference in Estimated Travel Time Savings[b] (s)		
Variable	Mean	Coefficient	*t*-Statistic	Mean	Coefficient	*t*-Statistic
(Constant)	—	7.55	0.71	—	0.24	0.01
Yes, change stops to use Route 467	0.26	**28.2***	**1.70**	0.27	**74.9*****	**3.29**
After articulated buses	0.64	4.59	0.17	0.65	–3.48	–0.11
After reserved lanes	0.50	**65.8****	**2.02**	0.51	**94.8****	**1.95**
After Route 467	0.42	1.82	0.06	0.43	**93.2****	**2.03**
After smart cards	0.23	–42.5	–0.81	0.25	**112.2***	**1.70**
Initial situation	0.21	**102.4****	**2.07**	0.22	–101.2	–1.60
Year 2012 survey	0.34	28.8	1.44	0.32	**48.6***	**1.85**
Year 2011 survey	0.37	**58.2*****	**2.52**	0.37	**112.5*****	**4.21**
Route 467	0.53	17.6	0.91	0.51	29.2	1.13
Actual change in wait time (s)	69.8	**0.97*****	**6.00**			
Actual change in travel time (s)				22.7	**0.93*****	**3.82**
Bus load change (%)				–5.60	**9.23*****	**2.80**
Distance (km) * load change (%)				–14.9	**–1.91*****	**–2.73**

NOTE: Boldface indicates statistical significance. — = not calculable; blank cells = variable was not included in model.
[a]$N = 565$; $R^2 = .27$; F-statistic [degrees of freedom (df)] = 22.65 (9, 564); F-significance [Probability (Prob) > F] = 0.
[b]$N = 558$; $R^2 = .20$; F-statistic (df) = 11.51 (12, 545); F-significance (Prob > F) = 0.
*Significant at 90%; **significant at 95%; ***significant at 99%.

compared with the actual one by 1 s. This result may stem from the fact that passengers use homogenous time value (such as 2, 5, and 10 min) to report their time saving regardless of the actual change impact. It also suggests that overestimation is not only related to actual changes, but also to other factors associated with strategies.

In regard to the second model of estimated travel time saving, the key policy variables Year 2012 survey and Year 2011 survey had positive significant coefficients. This indicates that passengers, in the medium term and short term, overestimated their time saving by 49 s and 113 s more compared with the long term, while keeping all other variables at their mean values. This suggests that incremental implementation of improvement strategies over longer periods is more appropriate to keep a higher level of perceived trip benefits.

In regard to the control variables, passengers who indicated that they changed their usual stop to use the Route 467 service felt they saved 75 s more in their waiting time compared with passengers who indicated that they did not change their usual stop and to new users. This suggests self-selection impacts on perception: although these users walk more than other passengers do to use the express service, they perceive their travel time and waiting times more positively.

Passengers who used the service after the implementation of articulated buses along the corridor and saw only the introduction of the TSP system did not feel a significant difference in their travel time compared with passengers who used the service during the survey collection periods. Passengers who started using the service after the operation of reserved lanes and witnessed the introduction of articulated buses perceived a 95-s time saving more than the previous group did. Those who started using the service after implementation of Route 467 and before the operation of reserved lanes perceived an additional 93-s time saving. Finally, passengers who started using the service before implementation of Route 467 perceived 112 s of additional time saving. Passengers who began using the service before any strategy implementation do not significantly differ, in response, from the last group's value. This result suggests that implementing strategies that have a visible, physical component that people can see—such as the articulated buses—has a positive impact on passengers' overestimation of their benefits, in comparison with strategies that do not have a clear physical component, such as the TSP system. Nevertheless, more in-depth study may be useful to identify and prioritize the different features in the studied strategies that have a positive impact on riders' perception.

Every 1-s increase in the actual travel time is expected to increase the difference between the estimated saving and the actual change by 1 s. Every additional 1% in the bus load is expected to increase the overestimated travel time saving by 9 s. However, the model includes a variable of distance (km) * load change (%), which captures the combined impacts of passenger-traveled distance and load change on passengers' perceptions. Every one-unit increase in this variable decreases the estimated travel time saving by 1.9 s. In other words, this indicates that decreasing bus load is appreciated by passengers who take the bus for longer distances. Further, this indicates a threshold of 4.9 km (by dividing the two variables' coefficients) in which passengers will report a decrease in their travel time estimation that corresponds to increases in buses used load (%), while keeping all other variables at their mean values.

Finally, using the previous two models' coefficients, it is possible to predict the changes in users' estimated waiting and travel time saving by conducting a sensitivity analysis while keeping all variables constant at their mean values. In the short term, passengers overestimated their wait time by 131 s. This value dropped by 22% in the medium term to reach 101 s with no significant difference in the long-term impacts. In regard to travel time perception, in the short term, passengers overestimated their travel time by 224 s. This value went down by 29% in the medium term to reach 160 s, and by 50% in the long term to reach 112 s.

DISCUSSION OF RESULTS AND CONCLUSIONS

This paper aims to understand the change in passengers' perception of a bus service following the implementation of a set of improvement measures by STM along Boulevard Saint-Michel, in Montreal, Canada. Comparing passengers' perceptions with the actual changes in service along the bus corridor showed that passengers overestimated their waiting and travel times saving in the short, medium, and long terms. However, there was on average no actual saving on average in bus running times compared with when they started using the service in most cases. This was kept in mind, and to understand the difference in passengers' overestimations, two statistical models have been generated, concerning passengers who felt a positive or null change in their waiting and travel times. Findings from these models suggest that in the short term, passengers feel a significant difference in their estimated waiting time saving compared with the long term, while in the medium term, there is no significant difference in perception compared with the long term. This result suggests that implementation of various strategies have only a limited impact in the short term for users' overestimation of their waiting benefits, and that their overestimation diminishes in the medium and long terms.

In regard to travel time perception, passengers felt a significant positive saving in the short and medium terms compared with the long term. This finding confirms a declining trend of perceived travel time saving over time while controlling for the period when the passenger started using the service and for actual changes in service. It suggests that if an operator wishes to upgrade the quality of its service pertaining to travel time, an incremental implementation of improvement strategies is suggested, to maintain a higher level of passenger perception for a longer period. This higher level of perceived saving would increase passenger satisfaction, and it would retain passengers and ridership despite fluctuations in the quality of the system.

For passengers' overestimation of travel time saving, it is suggested that adopting improvement strategies having a component that passengers can directly witness as having positive tangible impacts may be preferable over slightly enhancing the service quality, in regard to bus speed. In other words, the model suggests that passengers will overestimate their travel time saving more after implementation of a new type of bus than after equipping the buses with a TSP system, for example—unless, perhaps, the TSP system is well-advertised along the corridor. In addition, the model indicates that decreasing the bus load is appreciated by passengers who take the bus for longer distances. Using articulated buses is further associated with a positive impact on passengers' waiting and travel time perception. This may be linked to the presence of a third door, as well as the decrease in users' anxiety of finding a space on the bus while waiting for it. Therefore, transit agencies planning to use articulated buses in general are required to increase their operation efficiency by applying all-door boarding strategies. These strategies may increase boarding speed and also enhance passenger perception and satisfaction. Furthermore, in-depth qualitative study may be useful to identify and prioritize the different features on articulated buses that may have an impact on user's perception.

Finally, this article indicated that passengers who choose to walk more to use the faster service perceive more waiting and travel time saving. Thus, a more detailed study concerning the impacts of other strategies, such as bus stop consolidation, on perception and satisfaction changes over time is recommended, to maximize the benefits of the implementation of various improvement strategies on passengers' perception.

ACKNOWLEDGMENTS

The authors acknowledge the Société de Transport de Montréal for providing the AVL-APC data used in the project. Special thanks go to Michel Tremblay and Sébastien Gagné for their feedback and support during this project. The authors thank Evelyne St-Louis and Gabriel Damant-Sirois for their help in proofreading the manuscript. This research was funded by the Natural Sciences and Engineering Research Council of Canada collaborative research and development program.

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The Public Transportation Marketing and Fare Policy Committee peer-reviewed this paper.