TRANSIT RIDERS' PERCEPTION OF WAITING TIME AND STOPS' SURROUNDING ENVIRONMENTS

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ABSTRACT
Reducing the burden of waiting in transit travel is critical to increase the attractiveness of public transportation and encourage people's shift from automobile mode. Research shows that wait time perception is highly subjective and varies according to various factors such as mode, availability of schedule information or stops amenities. In addition, high-quality environments are known to reduce stress and to encourage walking and biking. Nevertheless, little research exists on the influence of the stops and stations surrounding environment on transit users' wait time perception. This study aims to respond to this knowledge gap in order to optimize stop localization and micro urban design around stops. The study compares transit users' actual and estimated wait time at 36 stops and stations offering a mix of environmental situations in the Twin Cities region. A regression analysis is used to explain the variation in riders' waiting time estimates as a function of their objectively observed waiting times, as well as stop and station surrounding environment characteristics. The results show that, for waits longer than five minutes, the more the environment is polluted and exposed to traffic, the more transit users tend to overestimate their wait time and that, on the contrary, the more mature trees are present the shorter the wait time is perceived. The combination of the three variables indicates that after 5 minutes wait, the presence of trees achieves to compensate the effects of both air pollution and traffic awareness. Policy implications and further research needs are discussed.

Keywords: Public transportation, transit, rail, bus, stop, station, waiting time, time perception, environment, air pollution, traffic, tree, planning, urban design.

INTRODUCTION

Improving the attractiveness of public transportation is imperative for sustainable development, given the benefits from environmental, economic, and social points of view. High-quality, attractive transit reduces air pollution, carbon emissions, congestion, oil dependency, and travel expenses due to personal vehicles.

Research on travel mode choice shows that time and service quality are key factors, before the monetary cost *(1)*. Reducing the burden of waiting appears to be critical: transit users perceive waiting time as significantly "longer" either than an equal amount of in-vehicle time, as well as significantly longer than it actually is. Long-seeming wait times may negatively affect users' satisfaction. Improving wait times perceptions is an important issue with potentially lower costs than actions focusing on reducing actual wait times *(2)*.

Previous research shows that time perception is largely subjective *(3)* and can be distorted by the context. In transportation, wait time perception varies according to several factors such as the trip length, the journey purpose, the availability of information *(4, 5, 6),* the activity while waiting *(7),* the stop amenities *(6),* or the aesthetic of the station *(8).*

Stop and station design, as well as the perceived security of surroundings have been shown to profoundly affect waiting time perceptions *(6)*. Little, however, is known regarding the impacts of the surrounding environment more generally on users' wait time perceptions. The hypothesis of this research is that the more pleasant the environment of the stops and stations, the shorter the wait time is perceived. The importance of the quality of urban public space has mostly been investigated from pedestrians' and cyclists' perspectives; little research exists on the role of the surrounding environment for transit riders' time perception. This study responds to this knowledge gap to provide policy recommendations to optimize stop locations and urban design around stops with the aim of reducing riders' perceptions of waiting time.

RELATED STUDIES

Despite the lack of specific research on transit stop environments, research in psychology and marketing generally consider how environment influences perception of time. In psychology, Droit-Volet and Gil *(3)* explain how the emotional state and the surrounding rhythm influences time perception. Marketing research also establishes the influence of the service environment on customer waiting time perception, through affect, as well as the negative relationship between waiting time and service satisfaction *(9, 10).* Hornik *(11)* shows that positive mood tends to underestimate the durations of activities while negative or neutral mood tends to overestimated them. Baker and Cameron *(12)* review the different environmental factors affecting customers' time perception such as lighting, temperature, music, color, furnishing, organization of the service, distractions available while waiting, and social interactions. Pruyn and Smidts *(13)* confirm that the waiting environment influences customers' wait perception and suggest that attractive waiting environment induce a positive mood which improves slightly the wait perception and strongly the service evaluation. Nie *(14)* approaches waiting from customers' stress management perspective and shows that uncertainty and ambiguity tend to overestimations of wait durations.

Much research exists on transit users' valuation of time, due to strong implications for mode choice. Waiting and transferring are perceived more burdensome than travelling. Indeed, out-of-vehicle times (OVT) appear longer than In-Vehicle Time (IVT). Fan, Guthrie and Levinson *(6)* summarize the research findings regarding the factors affecting waiting time perception, including the existing ratios of OVT/IVT. According to Wardman's *(2),* planners should consider an average ratio of 2.5, meaning that waiting time worth 2.5 IVT. Although, a study in the Twin cities *(15)* finds that riders perceived the waiting time 4.4 longer than the IVT.

Iseki & Taylor *(16)* propose a classification of factors affecting the perception and valuation of waiting and walking for transit: "operational factors" (frequency, reliability, and availability of information), "physical environmental factors" (safety, security, comfort and convenience), and "passenger factors" (such as activity while waiting, physical condition, familiarity with the transit system, destination).

Regarding the operational factors, Horowitz *(17)* and Wardman, *(2)* explain that mode length trip and trip purpose affect wait time values. Wait time value increases slightly with journey duration for transit walk and wait and appears higher for car and train users than for transit riders *(2)*. Parsons Brinckerhoff *(18)* shows that complete and clear information reduces the actual and perceived waiting time. Frequency appears to significantly improve the perception of waiting time *(19)* but the lack of reliability of service with unpredictable delays tends to increase the perception of waiting time *(20).*

Regarding the passengers' factors, Dziekan *(21)* finds that regular riders have relatively lower burdens for waiting than occasional transit users. Passengers' negative emotions such as anxiety, boredom or stress tend to increase time perception of time while distractions appear to reduce their wait time estimates. Millonig's and Sleszynski's *(7)* study on the effects of entertainment activities at different kinds of public transport stations show that playing while waiting can either have the effect to shorten or make longer time perception according to users' or stations characteristics. Among other activities, talking with others appears to reduce the perception of waiting time. Fan, Guthrie and Levinson *(6)* find women perceive longer waiting time at stops or stations located in an unsafe environment: at a simple curbside bus stop, a 10 minute wait seems to take nearly half an hour.

Regarding the influence of stops and stations characteristics on wait time perception, few studies are available. Research suggests that real-time information diminishes the perceived waiting time of customers by reducing their stress due to the uncertainty of bus time arrival *(3, 4, 22).* Tang (23) finds a modest increase in ridership associated with the implementation of the Chicago Transit Authority's real-time bus tracker system between 2002 and 2010. Fan & Guthrie study *(5)* suggests that shelters and posted schedules on lower frequency bus routes reduce perceived waiting time. Cascetta and Carteni *(7)* observe that the architectural design of railways terminals has a significant impact on users' behavior: Commuters are willing to wait longer in high aesthetic stations and are willing to spend more time to go to these stations, extending significantly their catchment area. It introduces the concept of "hedonic value" of stations and shows that high quality environment can reduce the cost of waiting and even procure rewarding effects such as pleasure. This study also underlines that female travelers are significantly more sensitive to high quality stations.

Few academic studies are available specifically regarding the role of stops' and stations' surrounding environments on riders' perceptions. Those that are mainly deal with safety and security issues. Loukaitou-Sideris *(24)* identifies that environmental characteristics surrounding bus stops has a significant influence on perception of safety. She indicates that the ten high crime bus stops in Los Angeles are situated at the intersections of multilane streets and have a combination of features among the following: lack of amenities in crowding areas, lack of visibility from surrounding shops, proximity to liquor stores or bars, situation in desolated places without adequate lighting, surrounded by surfaces parking lot or vacant buildings, and suffering from neglect and incivilities. In these places, grassy areas and bushes can have negative effects

providing setting for drinking or hiding attacks. She suggests that relocating the stops or improving the design of the sidewalk and shelter can increase riders' security. Iseki and Taylor *(25)* also observe that a safe environment and frequent and reliable service matter most to riders than attractive or elaborated stops.
Even though the literature does not address the specific issue of environmental impact on transit riders' time perception, it underlines the effects of the environment on people's mood and level of stress, which influence wait time perception. Noise, traffic and pollution appear factor of important stress *(26)* whereas neighborhood vegetation is found to have direct stress mitigation effects *(27)*. Research addresses the cost effectiveness of planting trees in urban settings *(28, 29)*. The cost benefit analysis of planting one million trees canopy cover in Los Angeles shows that the average annual benefits for the 35-year period were $38 and $56 per tree planted, according to the mortality scenario. 81% of total benefits were related to aesthetic, including property values and well-being, 8%were storm water runoff reduction, 6% air-conditioning savings, 4% air quality improvement, and less than 1% atmospheric carbon reduction (29).

An extensive literature is also dedicated to the influence of urban environment on travel behaviour, and especially on walking and biking *(30)*. This research does not directly address travel behavior, but proceeds from the hypothesis that shorter perceived waiting times indicate a more pleasant user experience. As more pleasant user experiences are likely to relate to higher transit use, travel behavior offers clues to conditions that may lead to shorter perceived waits.. Estupiñàn and Rodriguez *(31)* find a relation between the surrounding environment of the stops and BRT boarding in Bogota. Environmental supports for walking and barriers to cars were related to higher boardings. Cervero and Kockelman *(32)* find that pedestrian oriented urban design, such as the presence of street trees, exert a modest effects on walking non-work trips. Cervero and Duncan *(33)* also observe only a moderate influence of land-use design on walking and a far stronger effect on bicycling. Cao, Mokhtarian, and Handy *(34)* note a relationship between the built environment and changes in travel behavior. His findings suggest that the presence of bike routes, sidewalks, parks and the overall attractiveness of the neighborhood (appearance, level of upkeep, variety in housing styles, and big street trees) increase walking.

The existing literature supports the research hypothesis that the surrounding environment of transit stops may affect riders' wait time perception but little research exists on this topic. This study has the objective to address this knowledge gap in order to understand how to optimize location and stops environment.

METHODOLOGY

The researchers Y. Fan, A. Guthrie and D. Levinson designed the methodology and collected the data. Additional details on the methodology and data collection are available (5).
The research is based on a comparison between transit riders' actual and self-reported waiting times at 36 transit stations and stops in the Twin Cities region. Regression analysis is used to explain the variation in riders' waiting time estimates as a function of their objectively observed waiting times, as well as station surrounding environment, while controlling for variables known to influences wait time perception.

Data Collection Sites

The 36 stops and stations were selected among 12,382 bus stops, 19 light rail stations, 7 commuter rail stations and 5 Bus Rapid Transit (BRT) stations in the Twin Cities region to offer a full range of station and stop types, as well as a mix of neighborhood types, urban and suburban locations and attractive and unattractive surrounding environments.

Station/Stop Type: the 36 sites include light rail, commuter rail and bus rapid transit stations, bus transit centers and curbside bus stops. Each site was recorded as a transitway station (including LRT, commuter rail and online BRT stations), a transit center (with multiple bus routes), an unimproved curbside stop ("pole-in-the-ground" stop) or an improved curbside stop (a bus stop with at least some amenity). The presence of park-and-ride facilities was also identified.

Neighborhood type: The researchers selected stops to obtain of a mix of residential and commercial surrounding areas, so as to account for any differences in perceptions based on neighborhood activity character or level. This step involved aggregating the specific residential, commercial and industrial land use categories in the Metropolitan Council's current land use shapefile into overall "Residential" and "Commercial" categories, then producing a 100m buffer around each stop and station (chosen as a rough measure of immediate surroundings within sight), and calculating the largest land use within each buffer.

Urban vs. suburban: All sites were also classified as either urban or suburban based on the bus stops/transitway stations layer and the municipality they are located in. Urban stops are located in Minneapolis or Saint Paul. Suburban stops are located in any other municipality in the 7 county metro area.

Pleasantness: a pleasantness score based on the general character of the neighborhood or suburb was assigned to each stop: "Low", "Medium" or "High". This is a rough, at-a-glance assessment to speed the selection process. Factors including sidewalk presence/width, amount and location of off-street parking, tree cover, enclosure of street scenes, architectural variety and ground floor windows were considered generally, and in more detail in cases of difficult decisions. To obtain the maximum pleasantness variation possible, we excluded neighborhoods and suburbs with a medium pleasantness score and focused on those with either high or low pleasantness.

All sites were then organized into a single spreadsheet, with one worksheet for each stop type/neighborhood type combination. Each sheet was sorted first by boardings, then by pleasantness, producing three pleasantness categories, each in order of ridership. TABLE 1 shows the final classification of sites; FIGURE 1 shows the distribution of study sites across the region.

TABLE 1: Site selection matrix

Surrounding Land Use	Pleasant-ness		Station/Stop Types - Sub-categories roughly based on degree of integration with/insulation from surrounding street scene.					
			Transitway Station		**Bus transit center**		**Curbside Stop**	
			Walk-up	Park-and-ride	Walk-up	Park-and-ride	Unimproved	Improved
Downtown	**High**	*Urban*	**Nicollet Mall LRT**	**n/a**	**Union Depot**	**n/a**	**7th St & Nicollet (NB, Mpls)**	**8th St S & Lasalle St/Nicollet Mall (EB, Mpls)**
	Mid	*Urban*	**Target Field**	**n/a**	**Minnesota & 6th St (StP)**	**n/a**	**Smith Ave & Ramp Exit/ Kellog (WB, StP)**	**LaFayette Rd & University Ave (SB, StP)**
	Low	*Urban*	**Downtown East-Metrodome LRT**	**n/a**	**n/a**	**n/a**	**10th St N & Twins Way (Mpls)**	**4th St S & Chicago Ave/ Kirby Puckett Dr (EB, Mpls)**
Residential Neighborhood	**High**	*Urban*	**50th St LRT (NB)**	**n/a**	**n/a**	**n/a**	**Como Ave SE & 22nd Ave SE (WB, Mpls)**	**University Ave SE & 25th/26th Ave (WB, Mpls)**
		Suburban	**n/a**	**n/a**	**n/a**	**117th Ave P & R (Champlin)**	**Harding St & 39th Ave N (SB, St Anthony)**	**n/a**
	Mid	*Urban*	**n/a**	**n/a**	**n/a**	**n/a**	**7th St N & Girard Ave (SB, Mpls)**	**7th St W & W Maynard Dr (NB, StP)**
		Suburban	**140th St BRT**	**Cedar Grove BRT**	**n/a**	**n/a**	**n/a**	**Minnetonka Bvd & Louisiana Ave (EB, St Louis Pk)**
	Low	*Urban*	**46th St & 35W BRT**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**
		Suburban	**n/a**	**Coon Rapids CR (SB)**	**n/a**	**n/a**	**Oakdale Ave & Wentworth Ave (NB, W StP)**	**University Ave & Mississippi St (SB, Fridley)**
Commercial/ Industrial	**High**	*Urban*	**46th St LRT**	**Lake St LRT**	**Uptown TC (NB, Mpls)**	**n/a**	**Franklin Ave E & Chicago Ave (WB, Mpls)**	**University Ave & Snelling Ave (EB, StP)**
		Suburban	**n/a**	**28th Ave LRT**	**n/a**	**n/a**	**n/a**	**n/a**
	Mid	*Urban*	**Cedar-Riverside LRT**	**n/a**	**n/a**	**South Bloomington TC (Bloomington)**	**Lyndale Ave N & W Broadway (NB, Mpls)**	**Emerson Ave N & W Broadway (NB, Mpls)**
		Suburban	**Bloomington Central LRT**	**AVTS BRT (NB)**	**Robbinsdale TC (190)**	**n/a**	**n/a**	**Nicollet Ave S & 66th St (NB, Richfield)**
		Urban	**Franklin Ave LRT**	**n/a**	**Sunray TC (StP)**	**n/a**	**Olson Mem Hwy & 7th St N (WB, Mpls)**	**1st Ave S & Lake St (NB, Mpls)**

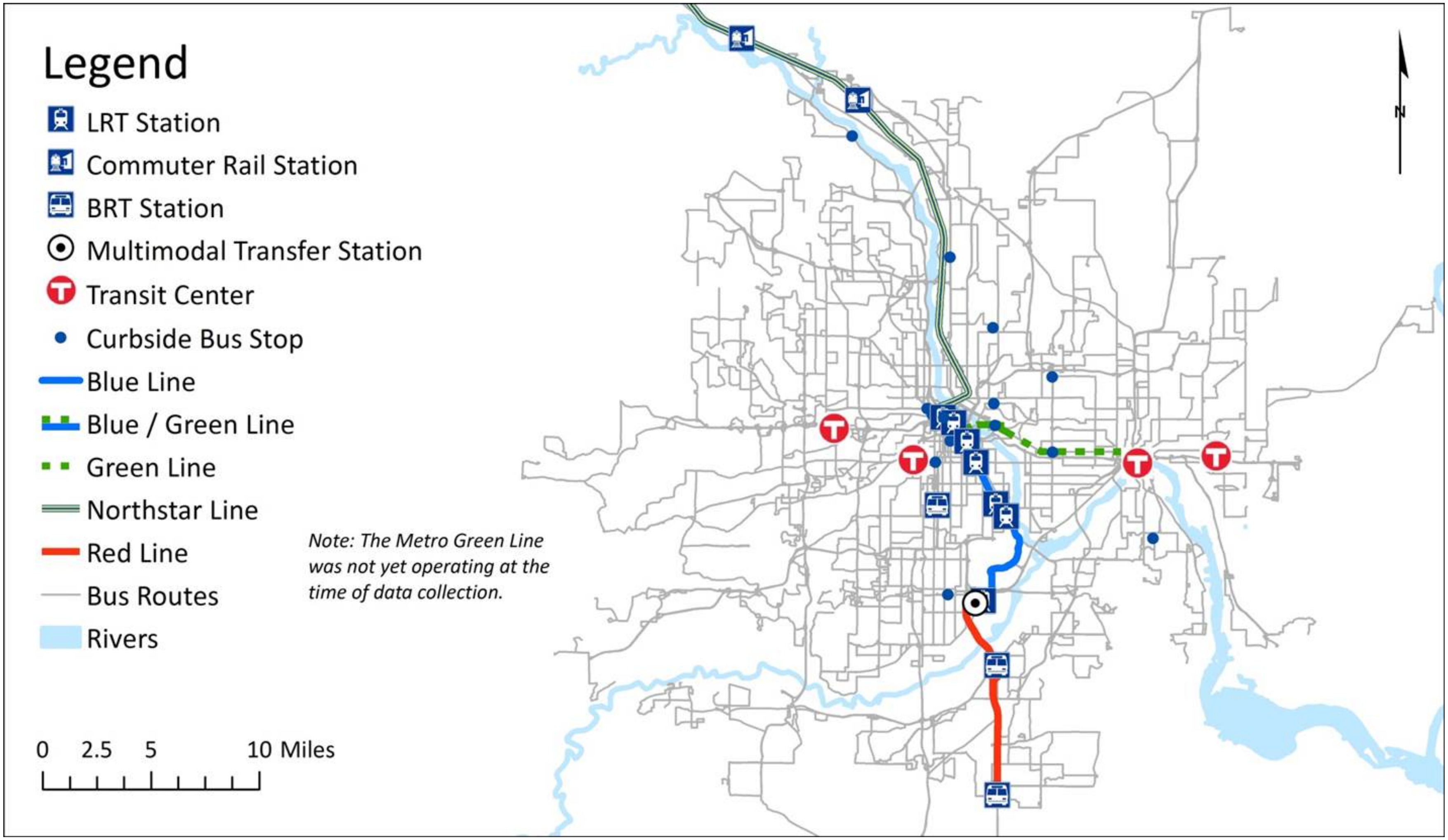

FIGURE 1: Data collection sites

Data Collection Method

Data were collected with three different instruments and the three resulting datasets were then connected together: an audit of the 36 selected stations and stops, a video footage of riders' while waiting, and an onboard survey of riders. In order to take into account the weather, the data collection took place in summer (July and August, 2013) and also in winter and early spring (February, March and April, 2014).

Waiting Environment Audit

The researchers (5) conducted a Waiting Environment Audit for each selected stop and station in order to collect data on their amenities and their surrounding environment.

Regarding the stops /stations characteristics, the audit covered the following topics: physical layout of the waiting area, presence of shelter, seating, or other amenities such as water fountains or restrooms, overall physical comfort, presence of route and schedule information, station/ stop security, maintenance, and cleanliness.

Regarding stops and stations surrounding environment, the audit recorded the following elements:

- Safety and traffic level: number of lanes of the street, speed limits, street design features, sidewalk characteristics, traffic volume and traffic awareness.
- Neighborhood security: vacant lot or abandoned buildings, graffiti visible, litter or trash visible, streetlights, buildings with street level windows.
- Noise and air quality: level of noise and air pollution in term of smell and in terms of look.
- Appeal: presence of landmarks, identifiers for building use, mature trees, ground covered by vegetation, and overall appeal.
- Overall perception of pleasantness.

Two members of the research team, one male and one female, conducted the audit in order to minimize personal bias and the average of both auditors' responses was taken into account. Environmental variables were mainly assessed using a Likert scale with a score ranging from 1 to 4 ("Not at all", "Somewhat", "Mostly", "Very"). The audit was repeated during the winter when the users' survey took place with snow on the ground.

Video Observations

A video of transit users at the stops allowed to record the counter times at which they arrived at the station or stop and at which they boarded the train or bus. The difference between boarding time and the arrival time provided the observed waiting time used for the analysis.

The video served also to make a series of observations about the respondent, including demographics, mobility devices, activities while waiting, and travelling companions, if any.

Onboard Survey

A brief survey of transit riders who boarded trains or buses at study sites allowed to obtain the respondent's reported waiting time. The survey also gathered information on:

- Perceptions of the "pleasantness" of the station/stop,
- Forms of schedule information used (pocket schedules, realtime information app, etc.),
- Approximate trip origin and destination,
- Primary activities at origin and destination,

- Access and planned egress modes,
- General travel behavior, and
- Basic demographic information.

A photograph of each respondent holding up their questionnaire enabled the visual identification of respondents and the connection with the dataset from the video observation.

RESULTS

Observed Wait Time and Reported Wait Time

A total of 822 responses were considered valid connecting the datasets from the video and the survey. The sample represents a population who use more likely transit, including more low income people (38% under $25,000 per year), people belonging to minorities (41%), and people without cars (59%).

Approximately half of respondents actually waited less than 5 minutes, a third waited between 5 and 10 minutes, and 8% waited between 10 and 15 minutes. Longer waits are much less common. The FIGURE 2 shows the distribution of wait times and the FIGURE 3 shows a significant correlation between reported and observed waiting times with an average overestimation of waiting time of 19%.

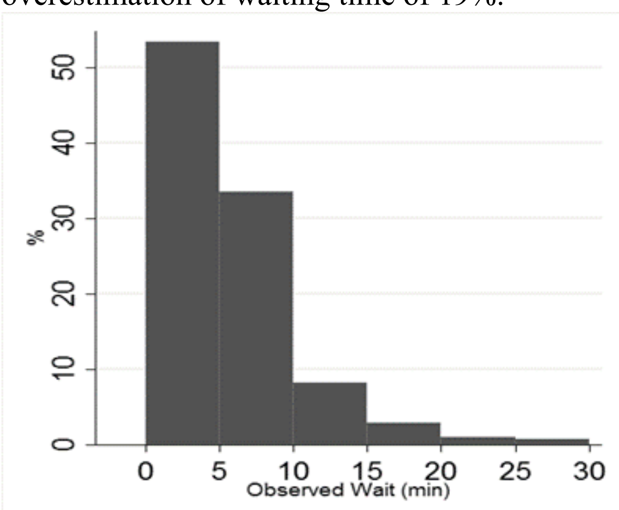

FIGURE 2: Distribution of observed wait times

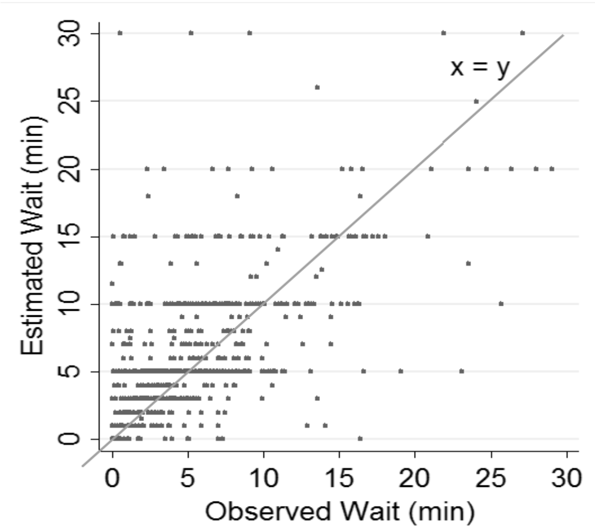

FIGURE 3: Reported waits versus observed waits

The Reported Wait variable has a mean of 6.78 minutes and a median of 5 minutes; whereas the Observed Wait variable has lower values with a mean of 5.57 and a median of 4.6 minutes.

The analysis shows that, for shorter Observed wait, riders tend to overestimate their Reported Wait, with a median ratio of Reported/Observed Wait Times of 1.52 for 0 to 5 minutes. This ratio approaches 1 for longer observed waits (more than 5 minutes) implying more accurate estimates of longer wait times.

Regression Model

To assess the relationship between estimation of wait time and stops environment variables for our sample of riders, we use the following equation:

$Y=c+\beta_1 x_1+\beta_2 x_2+\beta_1 x_1 \beta_2 x_2+...+\beta_i x_i+\beta_{1i}(x_1 * x_i),+e$,

where Y is the natural logarithm of Reported Wait Time (with 0.01 added to the raw variable to avoid losing 0 values), x_1 is the natural logarithm of Observed Wait Time (also with 0.01 added), and x_2 through x_i represent the binary explanatory variables. These explanatory variables include variables related to the stops and stations surrounding environment and additional variables related to the station type and to the respondents' characteristics.

The explanatory variables are defined as following:

- Polluted Air: The surrounding environment of the stop is "mostly" or "very polluted" in terms of either smell (vehicles emissions, industrial activity or other sources) or appearance (diesel exhaust soot or construction dust) according to the Waiting Environment Audit. The audit itself produced two pollution variables, Smell Pollution and Look Pollution. These two variables were combined into a single one for this model due to collinearity.
- Aware of traffic: The situation of the stop leads the transit user to be "mostly" or "very aware of traffic" in the nearest street, according to the Waiting Environment Audit.
- Lot of Trees: "A lot" of mature trees are visible from the waiting area according to the Waiting Environment Audit.
- Shelter: Presence of some form of shelter at the stop according to the Waiting Environment Audit. Included as control variable because research shows that it is a strong predictor of wait time perception.

- Rail Station: Light rail or commuter rail station. Included as a control variable due to potential effect of mode on wait time perception.
- High Frequency Bus Stop: A response collected on a route in Metro Transit's Hi-Frequency network of arterial routes with all-day guaranteed short headways. Included as a control variable.
- Knew Schedule: Respondent who reported having known the schedule before arriving at the stop. Included as control variable because research shows that the impacts of known length of wait on time perceptions.
- Traveled Alone: Respondent who traveled alone according to observations made from video footage. Included as control variable.
- Snow Fall : A response was collected on a day during which snow fell. Included as control variable to capture the impact the weather conditions.
- Female: Female respondent. Included to control for gender differences.
- Female and Not/Somewhat Safe: Included as control variable because previous research shows it significantly influences wait time perception.

Stop Environment variables were interacted with ln(Observed Wait) in order to account for potential differences in environmental factors' impacts over time. The initial model included a larger set of stop environment variables such as "Traffic Volume", "Vacant lot or abandoned buildings", "Graffiti visible", "Litter or Trash visible", "Buildings with Street level Windows", "Ground covered by Vegetation", and "Overall Appeal" and "Overall Pleasantness". Inclusion of a large number of environmental explanatory variables is complicated by natural correlations between various aspects of stop environments. For example the "Noise" and "Appeal" variables are also related to Traffic and Pollution variables. In addition, "Trafic Aware" and "Traffic Volume" variables are distinct but strongly related (r=0.52). Due to such considerations, the model focuses on a limited number of explanatory variables which reveal clearer significant correlations with stop environment variables.

Regression Results

The model takes into account 712 observations and the adjusted R^2 equals 0.265. It means that 26.5% of the variation is explained by the model, which is acceptable for a model based on people's perceptions.

The TABLE 2 presents the regression results. Ln(Observed Wait) is significant with a positive coefficient indicating that a longer observed wait time is still correlated with longer reported waiting times.

Among the "stop surrounding environment" variables, Polluted Air and Aware of Traffic are significant along with their interaction terms. Both have a negative base coefficient and a positive interaction coefficient. Lot of Trees variable is also relatively significant ($P < 0.1$) with a negative coefficient but its interaction is not significant. It means that Lot of Trees has more initial effects on shortening wait time and less effects on longer waits.

Shelter, Knew Schedules and Female Not/Somewhat Safe are not significant indicating that these variables do not affect the effect of stop environment variables in the model. It is notable because previous research (5) shows that these variables have a strong impact on wait time perception. It demonstrates that, as intended, the model explains variations in estimated wait time as a function of environmental characteristics of stops.

Rail Station and High Frequency Bus Stop are significant, both with a positive coefficient, indicating that these kinds of stations, and especially the High frequency Bus Stops, is related to an increase of the wait time perception. Traveled Alone is also significant but with a positive coefficient. Unexpectedly, Snow Fall is also significant but with a negative coefficient reducing the wait time perceived.

TABLE 2: Regression Model Results

	Observations	N=	712
		R^2	
		Adj R^2	0.265
	Response Variable: ln(Estimated Wait)		β
	ln(Observed Wait)		0.3730***
Stops and Stations Surrounding Environment	Mostly/ Very Polluted Air	-	0.3858**
	Mostly/ Very Polluted Air *ln(Observed Wait)		0.2207**
	Mostly/ Very aware of Traffic	-	0.3882**
	Mostly/ Very aware of Traffic*ln(Observed Wait)		0.2278***
	Lot of mature Trees	-	0.28611*
	Lot of mature Trees*ln(Observed Wait)		0.1477
	Snow Fall	-	0.3871***
Stops Type	Light rail station		0.02459**
	High Frequency Bus Stop		0.1715***
	Shelter	-	0.391
Respondent Characteristics	Female & Not/Somewhat Safe	-	0.2345
	Traveled alone		0.2430
	Knew schedules		0.2794
	Constant		1.13511***

Legend: * p<.1; ** p<.05; ***p<.01

Model Predictions

The results are more easily understandable and interpretable with the support of model predictions graphics. The FIGURE 3 predictions of Reported Wait Times under environment variables over values of observed Wait time from zero to fifteen minutes. 95% of participating responses have an Observed Wait Time of 15 minutes or less. In each case, the named dummy variable is set equal to one, and ln(Observed Wait Time) and the dummy variable's interaction term are set equal to the natural logarithm of each x-axis value shown on the graph. Unless stated otherwise, all other dummy variables are held at their modal values.

This FIGURE 3 shows the impact on Reported Wait Time of Air Polluted, Traffic Aware and, Lot of Trees variables, the combination of the two first variables, the combination of the three variables and a baseline scenario.

The baseline scenario is based on median values of explanatory variables. The baseline line indicates an overestimate of waiting time for shorter waits and more accurate estimations for longer waits. For example, a 2.5 minutes wait is perceived 5.58 minutes whereas a 10 minutes wait is perceived as 9.3 minutes.

Polluted Air and Traffic Awareness lead to moderate overestimation for wait time shorter than 5 minutes and to larger overestimations for wait longer than 5 minutes. For example a 2.5 minutes wait is perceived as 3.88 minutes and 10 minutes wait is perceived as 12.13 minutes.

Lot of Tree significantly decreases the overestimation of waiting time for short wait and lead to significantly underestimate longer wait: a 2.5 minutes wait is perceived as 4.19 minutes and a 10 minutes wait as 7 minutes.

The combination of all three factors shows that Lot of Trees compensate the negative effects of Polluted Air and Traffic Aware on Waiting Time perception especially for wait longer than 5 minutes and conduct to almost accurate estimations of time. The High Frequency Bus stops increase the wait time perception.

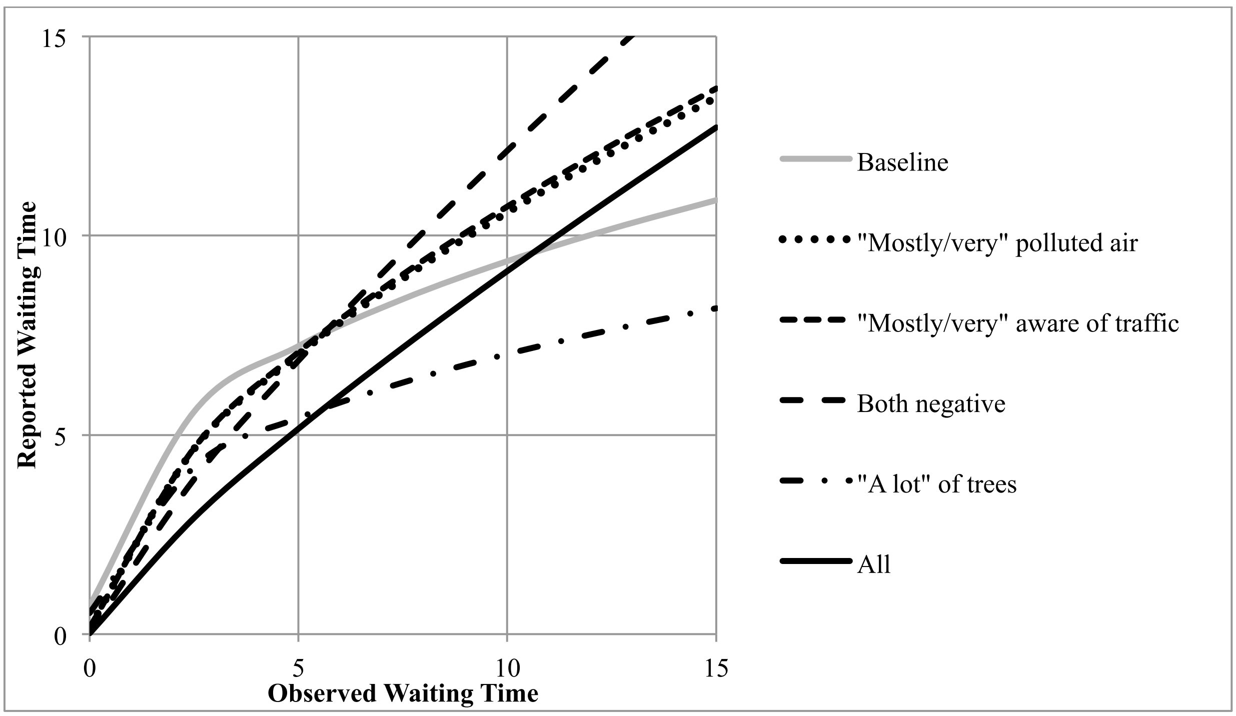

FIGURE 4: Prediction of observed waiting times

CONCLUSION

The results strongly support the research hypothesis that the surrounding environment of transit stops and stations affects transit user's wait time perception. They show in particular that air pollution, traffic awareness, and presence of mature trees are significantly correlated with wait time perception. The model predicts significant overestimates of the relatively short waits most riders who participated experienced. For waits longer than 5 minutes, both air pollution and traffic awareness increase the overestimation of wait time. The presence of a lot of mature trees, however, reduces the wait time perception and even leads transit users to underestimate the wait times for waits longer than 5 minutes. The combination of the three variables indicates that after 5 minutes wait, the presence of trees achieves to compensate the effects of both air pollution and traffic awareness. During the first 5 minutes the quality of the environment appears to have less impact on the respondent perception and its impact becomes progressively more important as the wait time increases. The results also show that, at the high frequency bus stops, the wait time appears more likely overestimated than at other kinds of stops but with shorter wait in absolute terms. This appears coherent with the results above because high frequency bus stops are mostly located on streets with high levels of pollution and exposure to traffic. The effect of the snow cover is unexpectedly positive and shows that the weather does not affect negatively transit users' time perception. Transit users may be happy about the fact they aren't driving, and alternatively, transit users on such days may have a high tolerance for cold weather, due to self-selection.

Generally, the results suggest that the more trees are present, the shorter the wait time is perceived by riders while the more polluted and exposed to the traffic the more transit users tend to overestimate wait time. These findings advocate for high quality urban environment surrounding stops and stations.

The findings regarding traffic awareness and air pollution lead to the conclusion that transit users will perceive shorter waits at stops located on quiet streets. In practice, of course, transit routes need to be located on streets with high travel demand, which often equates to high traffic volumes. This contradictory situation suggests two practical interventions to reduce waiting time perceptions: first, the implementation of traffic calming measures along primary transit routes, particularly at stops. Creating exclusive transit lanes or streets reserved for transit, bicycles and pedestrians (where feasible) are likely to reduce waiting time perceptions the most, due to low traffic volumes in terms of vehicle frequency compared with automotive traffic. Second, the alignment of transit routes and the location of stops avoiding highly polluted areas where possible without affecting travel demand can also contribute to shorter wait time especially when headways are greater than five minutes.

The findings also point to the importance of cooperation between transit providers and local governments to improve the transit user experience through urban greening. Planting trees around stops offers local authorities an opportunity to significantly improve users' wait time perception, but falls outside the purview of transit providers themselves. The ability of the presence of trees to compensate for the negative effects of pollution and traffic suggests that planting trees or moving a problematic stop to take advantage of existing tree cover can significantly improve the user experience at reasonable costs. These costs should be compared to other costs of measures able to enhance customer satisfaction such as higher frequency, transit information and stops amenities. In addition, studies on the cost effectiveness of planting trees should take into account their effect on travel behavior.

The findings call for further research to refine understanding of issues such as the specific roles of traffic volumes, streetscapes and stop locations in shaping transit users' perception of traffic and air pollution. In addition research on the minimum numbers and sizes of trees needed to reduce perceived waiting times would also be useful. Even so, these findings suggests that avoiding spots with traffic and pollution and developing stops and stations surrounded with trees can significantly contribute to enhance riders' waiting experience and attractiveness of transit.

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