Perception of Waiting Time at Signalized Intersections

Introduction
Perceived waiting time (PWT) at signalized intersections differs from the real value of waiting time (WT), and varies with signal design. The onerousness of delay depends on the conditions under which it is experienced. Using weighted travel time may contribute to optimal signal control if its use can improve upon assuming that all time is weighted equally by users. This research explores the perception of waiting time at signalized intersections based on the results of an online survey, which directly collected the perceived waiting time and the user ratings of the signal designs of each intersection on an arterial including 3 intersections. Statistically analyzing the survey data suggests the perception of waiting time is a function of the real time; and a quadratic model better can describes relationship. The survey also indicates that there exists a tradeoff between the total waiting time and the individual waiting time of each intersection. It turns out that drivers prefer to split the total waiting time at different intersections at the price of a longer total wait if the difference of the total waiting time of two signal designs is within 30 seconds. The survey data shows that the perceived waiting time, instead of the real waiting time, better explains how users will rate the individual signal designs for both intersections and arterials including multiple intersections.

Online Survey
To obtain information about perceived waiting time, surveys are required, as this cannot be directly measured. A virtual experience stated preference, putting drivers in the driver seat of a virtual car, has advantages in this regard, as the situation can be highly controlled. In this survey four scenarios are designed (Table1). The travel situations are vividly presented by several 3D traffic simulation videos which are generated by AIMSUN, a commercial traffic micro-simulator (Figure 1 & 2). The four scenarios are specifically designed to explore the tradeoff between different signal settings. As indicated in Table 1, Scenario 1 has the shortest total waiting time but requires drivers to stop as long as 120 seconds at the first intersection. The other scenarios have longer total waiting times but relatively shorter waiting time at each intersection. The tradeoff is made for users to either wait a two minutes at one intersection to reduce total time by 10 or 20 seconds; or sacrifice about 20 seconds to get relative shorter waiting time at subsequent intersections. About 76 undergraduate students were invited to do the survey; and 65 students participated in this survey.

The modeling summary and ANOVA are presented in the left figure. Although two models are significant at 95% confidence interval, Model 2 has a slightly better fit than Model 1 as seen by comparing adjusted R2 values.

Table 1: Scenarios and Statistical Results of Rating for 4 Scenarios

<table>
<thead>
<tr>
<th>Model</th>
<th>Rating PWT</th>
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<tbody>
<tr>
<td>Model 1: PWT = β0 + β1WT</td>
<td>Model 2 : PWT = β0 + β1WT + β2WT2</td>
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Data Analysis and Hypotheses Testing

Perceived Waiting Time: The survey directly provides the perceived waiting time and real waiting time. The comparison is presented in following left figure. As indicated in the figure, the perceived waiting time varies widely around the real waiting time. The average perceived waiting time is lower than the true value, but the variance is increasing with the true value of waiting time (Figure 4). The common argument about perceived travel time is that the perceived value is a nonlinear function of real travel. Two simple models are proposed to test this.

A Model of Rating: Perceived waiting time, instead of real waiting time, would more accurately reflect user satisfaction for a single design. User ratings for the arterial and for each intersection are used here to fit Ordinary Least Squares regression models to compare.

Individual Intersection Level: Two Ordinary Least Squares regression models, one is based on the real waiting time and the other is based on the perceived waiting time, are fit here to verify which one is best. The results show that model 4 fits better, indicating perceived time affects user quality ratings more than the actual time.

Arterial Level: The participants are also required to rate the whole arterial design. Two nonlinear regression models are proposed here to verify whether real waiting time or perceived waiting better estimate arterial rating. The result indicates that Model 5 is not significant and the R2 is quite small. Model 6, using perceived waiting time, is more significant.

Conclusions
This research aims to answer some related questions about perceived waiting time based on the preliminary results of Virtual Experience Stated Preference. Statistically analyzing the survey data implies that:

1. The perception of waiting time is a function of the real time; and a quadratic model better describes this relationship.
2. This survey also indicates that there exists a tradeoff between the total waiting time and the individual waiting time before each intersection. It turns out that drivers prefer not to spend all of their time at one intersection.
3. Moreover, the survey data shows that the perceived waiting time, instead of the real waiting time, better explains user rankings.