

The Street Tree Effect and Driver Safety

**THIS PILOT PRESENTS
EMPIRICAL FINDINGS
ON STREET TREES AND
THEIR EFFECT ON DRIVING
BEHAVIOR, SAFETY
PERCEPTION AND SPEED. THE
EXPERIMENT INVESTIGATED
THE EFFECT OF TREES ON
PERCEPTION OF SAFETY AND
DRIVING SPEEDS IN URBAN
OR SUBURBAN SETTINGS.
TREE-LINED STREETS WERE
PERCEIVED TO BE SAFER
IN BOTH URBAN AND
SUBURBAN CONDITIONS.
INDIVIDUAL DRIVING SPEEDS
WERE SIGNIFICANTLY
REDUCED IN THE SUBURBAN
SETTINGS WITH TREES.**

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INTRODUCTION

Street trees are dangerous, difficult to install and expensive to maintain, but there is not a transportation engineer who has not had to negotiate tree planting or tree preservation to reach project completion. Engineering design and transportation planning guidelines consider street trees obstacles in the roadside environment. Transportation research related to street trees in the United States focuses on fatal off-road crashes. Although much of this research is highway focused, it impacts the roadside environment of arterials and collectors as well.

Although there is an historical aversion to invest in the installation and maintenance of street trees from an operational perspective, the multimodal traveling public loves them. U.S. National Cooperative Highway Research Program Project 17-18(3) summarizes the street tree issue facing transportation engineers: "A complicating factor in addressing fatal tree crashes is the widespread interest and indeed promotion of tree-planting and preservation associated with highways."¹ This is even more true with the local network.

In the United States, the "no trees" guidelines are housed primarily with the American Association of State Highway and Transportation Officials and reiterated in municipal manuals and standards.² The objective is to improve road safety by prohibiting obstacles that drivers running off the road might encounter during a crash event, reducing the severity of the event. The only roadside features permitted in

the clear zone are ones that contribute positively to the safe performance of drivers and/or road operations. Recent research into the effect of street trees calls for re-examining these standards as they pertain to streetscape, suggesting that the aesthetic effect may provide safety benefits to road operation, safety and pedestrian use.^{3,4}

Links between pedestrian modalities and physical activity underscore the importance of roadside environment to public health.⁵ The public participation and project review process in North America has evolved recently to produce the Institute of Transportation Engineers' (ITE) *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: An ITE Recommended Practice* and the Federal Highway Administration's *Flexibility in Highway Design*.^{6,7} In Europe, transportation psychologists are challenging the premise suggesting safer behavior is generated by altering the landscape to include streetscape treatments.

Researchers Dumbaugh, Topp, Rosenblatt and Bronfman-Bahar and Mok revealed that streetscape had a positive effect on reducing the frequency and severity of crashes.⁸⁻¹¹ These streetscape improvements, which included street trees, were installed in response to environmental mitigation or economic development pressure. The safety effect measured in these studies was incidental or coincidental and not an original intention.

Design standards that incorporate the safety benefit of street trees on drivers and other users of the roadway must be performance-based and tested. This pilot study sought a proof of concept that there is a positive street tree effect on safer driver behavior.

THEORETICAL FRAMEWORK

The fields of experimental psychology and urban design suggested a respected paradigm to explore the effect of roadside landscape on behavior. The measure developed for use in simulation was derived from Berlyne's theory of visual complexity in the field of environmental psychology and Lynch's work in the aesthetic dimensions of city legibility. Findings from these seminal authors were used to develop a framework for the inquiry.

Street trees can be visually understood by



Figure 1. The center pane of the simulation pairs used for the drive-through shows the difference with and without curbside street trees.

measuring their color, texture, line and form throughout the seasons. Driver perception is manipulated by the edge of the visual environment affecting the scale, proportion and rhythm of the driving experience. Berlyne observed how different levels of visual complexity affect attention and alertness.¹²

When “on alert,” movements through space tend to be more careful. The street tree may be defining the edge of space by providing a diverse visual edge that also is repetitively simple in color, texture and form. According to Berlyne, optimum levels of complexity that maximize attentiveness fall within this mean: a visual landscape that is diverse but not overwhelmingly so; simple but not to the point of boring.

According to Lynch, spatial edge acts as a structural reference allowing people to find their way and feel “at home.”¹³ The tree-lined street may present an edge to the driver between the travel way and the contextual environment. Lynch theorizes that “edge” contributes to the legibility of the city, engendering a feeling of familiarity and comfort. The resultant comfort and reduction in stress could have a positive effect on drivers. Lower stress is known to have a positive effect on human performance.

Based on these theories, a starting point in the inquiry was to measure attributes of the street tree effect on perception of safety and edge related to driver performance. To isolate the street tree effect, both self-reported and kinesthetic behavior were measured and analyzed in driving environments simulated both with and without curbside trees.

RESEARCH METHOD

Simulated Landscape Tool

To control for the multiple variables that affect driver perception in the roadway and, thereby, accurately test the isolated effect of curbside street trees on driver performance, a simulation environment was employed. This study utilized a real-time, three-dimensional simulation in an interactive driving simulator known as Drive Safety (DS), which uses “tiles” of standard transportation corridor configurations that are combined into “smart” virtual landscapes.

Participants in the experiments “drove” a four-door sedan while viewing the passing landscape projected onto three surround screens that encompassed 160 degrees of their horizontal field of view. This simulator tool is commonly used in transportation research for design of safety features and evaluation of driver behavior. Eye movement; facial expression; use of brake and accelerator; and position in the driving lane were recorded digitally during the experience.

Research Design and Participants

This was a four-cell within-group design testing driver perception. Speed of travel also was evaluated. In the four-cell within-group design, two factors were evaluated: city form and landscape type. The four worlds built for this experiment utilized existing landscape tiles from within the DS library of corridor standards.

Two landscapes were developed: suburban and urban. The suburban and urban landscapes were duplicated and

street trees were added to the second version (see Figure 1). The duplicate landscapes were designed with a typical single row of 20-year-old curbside deciduous street trees. The blocks in the urban environment were shorter than in the suburban environment.

Two important concepts measured were sense of safety and sense of edge as perceived by the participants. Sense of safety was measured on a five-point scale where 1 = very poor and 5 = very good; sense of edge was a four-point scale where 1 = very ill defined and 4 = very well defined. Based on the environment, participants were asked to evaluate their safety and the edge as they perceived them.

Thirty-one participants ranged from 19 to 51 years old with a mean age of 29.6. There were 21 males and 10 females. The volunteers responded to a call for participants sent out by e-mail and word of mouth through the transportation research institute.

Procedure

Preliminary questions were presented to identify participants’ predisposition to the positive or negative effect of certain roadside features on perceptions of safety, particularly street trees. Initial questions were designed to identify any biases toward safety and roadside facilities. The participants’ answers to these questions revealed their overall sense of the safety of the roads they drive; the characteristics of environment that decrease their sense of safety; and the features they would recommend increasing or decreasing to improve their sense of safety.

Each participant then drove through the four landscapes in random order (Russian square to remove order effect). The entire driving time in the simulator did not exceed 15 minutes. They filled out responses to the same set of questions at the end of each of the four driving sequences. Participants were asked about the overall safety of the road they just drove, perception of edge conditions and perception of safety. Parallel speed data were collected from the sedan along the entire length of the driving experiences. Each participant was debriefed.

Table 1. Mean and standard deviation scores for safety and edge.

	Suburban		Urban	
	Tree mean (SD)	No tree mean (SD)	Tree mean (SD)	No tree mean (SD)
Safety	4.55 (.63)	4.10 (.98)	4.14 (.74)	3.38 (.90)
Edge	3.45 (.63)	3.10 (.79)	3.24 (.69)	2.79 (.77)

RESULTS

Each section of the written surveys and digital speed data collected generated a unique set of results. Each of these results is presented sequentially in three parts: predisposition, survey questions and speed data.

Results of Predisposition Toward Existing Sense of Safety

From the pre-trial questions, the participants generally ranked the overall safety of the roads they drove in the study area with a mean of 2.33 on a scale where 1 = excellent and 6 = very poor. This rating is consistent with the safety rating of the Texas roadway system: less than national average.

Results of Survey Questions

The following inferential analyses examined three questions used in the measure:

1. Do landscape types (trees or no trees) and/or different city forms (suburban or urban) influence people's perception of safety?
2. Do different city form and landscape types influence people's perception of edge?
3. How are perception of safety and edge related to each other?

Means indicated that people perceived suburban streets with trees ($M = 4.45$) as the most safe streets and urban streets without trees ($M = 3.38$) as the least safe streets (see Table 1). In terms of edge definition, suburban streets with trees were perceived as the streets with the most defined edges ($M = 3.45$); urban streets with no trees ($M = 2.79$) were perceived as the streets with the least defined edges.

Perception of spatial edge had a stronger correlation with perception of safety in the city form without trees compared to the one with trees (see Table 2). This may be due to the consistently low rating of both safety and edge on urban and suburban landscapes without trees.

The first set of inferential analyses tested whether different city forms (suburban or urban) and landscape types (trees or no trees) influenced people's perception of safety. In an analysis of variance for within subjects, both city forms ($F(1, 28) = 14.39, p = .0007$) and landscape types ($F(1, 28) = 19.77, p = .0001$) influenced the participants' perception of safety (see Table 3). However, there is no significant interaction between the two variables.

Regarding a sense of spatial edge, the presence or absence of street trees ($F(1, 28) = 14.56, p = .001$) had a stronger effect on perception of safety than the surrounding land use (see Table 4).

Table 2. Inter-correlation between safety and edge for different city forms and landscape types.

	Suburban	Urban
Tree	.52 (.003)	.35 (.06)
No tree	.89 (<.0001)	.68 (<.0001)

Note: Values enclosed in parentheses represent p-values.

Results of Speed Data Collection

Speed data were collected in meters per second. The shorter blocks confounded data generated in the urban condition, and cruising speeds were not able to be cleanly determined. For the suburban landscape, the presence of trees significantly dropped the cruising speed of drivers by an average of 4.87 kilometers per hour (3.02 miles per hour). Faster drivers and slower drivers both drove slower with the presence of trees (see Figure 2).

Table 3. Repeated measure of analysis of variance for safety.

Source	df	F	η	Power
Between subjects				
Subject	28	(.96)		
Within subjects				
City form (CF)	1	14.39**		.97
Landscape type (LT)	1	19.77***		1.00
CF X LT	1	.89		.14
Error	28	(.62)		

Note: Value enclosed in parentheses represents a mean square error.

** $p < .001$ *** $p < .0001$

Table 4. Repeated measures of analysis of variance for the edge condition.

Source	df	F	η	Power
Between subjects				
Subject	28	(.60)		
Within subjects				
City form (CF)	1	2.23		.28
Landscape type (LT)	1	14.56**		.97
CF X LT	1	.02		.05
Error	28	(.46)		

Note: Value enclosed in parentheses represents a mean square error.

** $p < .001$

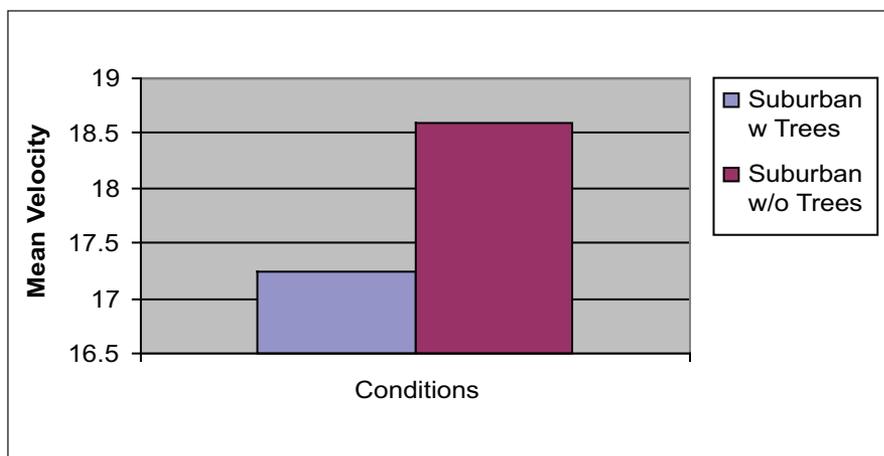


Figure 2. Comparison of mean velocity for all participants in units of meters per second.

DISCUSSION

This pilot study yielded a proof of concept for a positive street tree effect on collector roads. Increases in driver perception of safety had a significant relationship with increases in driver perception of edge. The addition of curbside trees significantly increased driver perception of spatial edge.

Rules generated from the pilot indicate that if curbside trees are present, results can include a positive effect on driver perception of safety regardless of contextual environment; a reduction in driving speed in suburban landscapes for both faster and slower drivers; and a more significant increase in driver perception of safety in urban landscapes than in suburban (urban landscape was perceived as less safe than suburban).

The sample size in the pilot was too small to make general conclusions but did identify some of the possible positive effects that street trees might have on driver behavior. Further study with a larger sample size is warranted.

The self-reports indicate that trees contribute to a sense of safety. The significant reduction in driver speeds in the suburban condition indicates that street trees may provide positive operational values. Although collisions with trees are horribly fatal, there may be fewer crashes overall. This may partially explain reductions in severity and frequency of crashes on streets that have streetscape enhancements, as noted by Dumbaugh and Rosenblatt and Bronfman-Bahar.

The pilot identified measures related to street tree performance and generated a replicable method for future study. The simulation method contributed empirical

data to the growing body of knowledge assessing streetscape and street tree design proposals on driver behavior. As a tool in the development and testing of safety standards, the driving simulator was able to be successfully used to identify street tree effect without placing individual drivers at risk.

Besides the small sample size, a limitation in the pilot was the short block and distance, leaving out the possible effect of landscape variation over a longer duration of exposure. Additionally, street tree pattern and type are regionally specific and results may vary accordingly.

CONCLUSIONS

In this pilot study, the results from the driving trials in the simulator indicated that the street tree effect may provide positive safety benefits for drivers.

Confronted with public demand for street trees, a workable set of engineer-friendly, evidence-based design guidelines that consider the positive effects of street trees on road operations is needed. Design standards regarding placement, tree species, the size and spacing of underground "soil ducts," city "floor" detailing and many others needed to protect necessary public investment should reflect a consideration of the safety effect. This requires development of regionally specific guidelines with input from the traveler, the arborist and the transportation engineer. A national process needs to be developed to facilitate this multi-disciplinary input that considers the positive effects of street trees on the transportation network.

Communities striving for healthy neighborhoods and economic vibrancy

identify numerous positive values of the street tree effect. If this constituency can be efficiently directed to address safety benefits from trees, hard data can be generated to enable improved investment and design decisions site-specifically. In this way, projects can achieve the safest possible outcome from the street tree effect.

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