Analyzing transit-based heat exposure and behaviors to enhance urban climate adaptation and mitigation strategies in the southwest USA

Dzyuban, Y. [1]*, Hondula, D. [2], Redman, C. [1], Middel, A. [3]

[1] School of Sustainability/ Arizona State University, Wrigley Hall, 800 Cady Mall, Tempe, AZ 85281; [2] School of Geographical Sciences and Urban Planning / Arizona State University, 975 S Myrtle Ave, Tempe, AZ 85281; [3] School of Arts Media and Engineering / Arizona State University, 950 S Forest Mall, Tempe, AZ 85281

Introduction

Public transportation systems represent an intersecting point between urban climate change adaptation and mitigation strategies. Increasing the use of public transit systems can help cities meet a wide range of sustainability and health goals including reductions in greenhouse gas emissions. Simultaneously, public transit use typically necessitates exposure to outdoor weather. In extreme climates, uncomfortable or dangerous weather conditions may suppress public transportation system without sufficient infrastructure to moderate exposure. We will present results from an ongoing research project in the hot desert city of Phoenix, Arizona, that aims to understand and improve public transit riders' experiences and resilience to heat. Researchers used environmental measurements and surveys to assess environments, conditions, and the behaviors and perceptions of public transit riders. Survey data revealed key behaviors and perceptions that should influence transit stop design strategies: stops that are perceived more beautiful and pleasant are also rated as more thermally comfortable; riders identified infrastructure elements and coping behaviors that make them feel cooler. Findings also showed that current infrastructure standards and material choices for bus stops are not ideal for providing thermal comfort and can contribute to hotter microclimates. As cities in warming climates shift toward increasing the use of public transit, continued attention to the experiences and preferences of transit riders—especially during the summer months—will improve the likelihood that they can meet or exceed public transportation and sustainability goals.

Background

Currently, low-income and marginalized communities use public transit and engage in non-motorized transit activities more often than other users (Karner et al., 2015). For instance, in South Mountain Village, more than half of residents do not own a car and use public transit as their primary transit mode. Such neighborhoods are also the most vulnerable to heat related morbidity and mortality (Karner et al., 2015). For vulnerable populations that do not have access to AC, exposure to heat due to transit related activities can be a critical component that adds to total exposure (Karner et al., 2015).

Riders' heat exposure is characterized by two factors: a walk time to the stop and the wait time at the stop. Estimated walking time in the area serviced by the Regional Public Transportation Authority ranges from 1.9 to 9.9 minutes and increases with lower density. The waiting time at the neighborhood stops averages 9.0–14.1min in the Valley Metro service area. The highest frequency routes are connecting major activity centers and longest waiting times are along non-arterial roads and at the fringe developments (Fraser & Chester, 2016).

Average public transit rider exposure in Phoenix Metro Area

Empirical evidence suggests that adaptation plays a significant role in how comfortable people feel outdoors. That is why scientists have developed adaptive model of thermal comfort that is based on the assumption that people adapt to the environment to minimize discomfort, it includes three aspects: physiological (body acclimatization to the climate), psychological (expectations in relation to particular environment and thermal history) and behavioral/physical (adjusting clothing, changing posture, using umbrella etc.) (Nikolopoulou & Steemers, 2003; Rupp, Vásquez, & Lamberts, 2015).

Nikolopoulou & Steemers found that microclimate properties of the environment accounted for 50% of the variation, authors attribute the rest to the psychological factors discussed above (Nikolopoulou & Steemers, 2003).

In this study we examine both environmental variables that affect physiological thermal comfort and psychological perceptions of heat.

Research Questions

- ***Is bus stop infrastructure effective in influencing environmental variables that affect thermal comfort?***
- ***How is thermal sensation vote influenced by the perception of stop aesthetics?***
- ***What infrastructure and natural elements are perceived to have cooling benefits?***

Methods

Measurements

- Air T
- Globe T
- Surface T
- Humidity
- Wind

Surveys

- Access and wait time
- Coping strategies
- Stop perception
- Thermal sensation
- Demographic

Study sites

6 bus stops were selected based on the infrastructure characteristic and daily ridership. Standard and Advertising bus stop types are prevalent in Phoenix. Several stops were upgraded and include art features, vegetated awnings and trees. All stops in this study are located along the Baseline Rd. and face north.

Standard

Advertising

Art

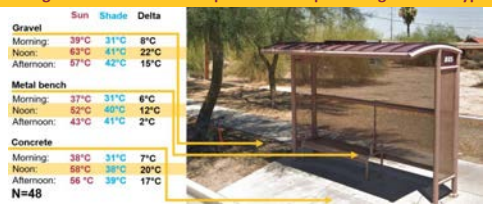
Results

Reductions in the shade vs sun (combined averages for June and July 2018)

	Standard	Advertising	Art
T Air	No effect	-0.9°C in T air	-1.6°C in T air
T Globe	- 9.3°C in T globe	-8.2°C in T globe	-9.8°C in T globe

N=210

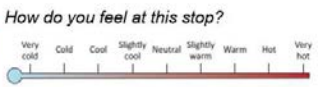
Average summer surface temperatures for prevailing material types



Grey and green infrastructure elements are perceived as beneficial for cooling

Thermal sensation votes

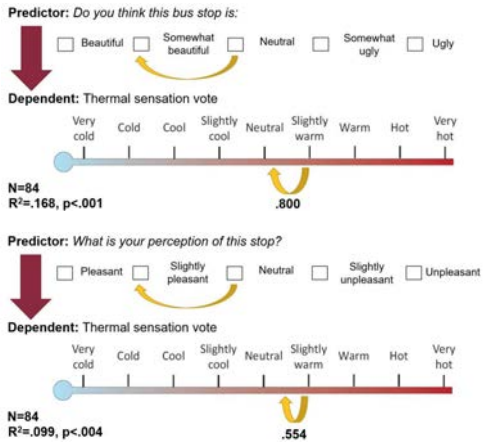
	n	%
Very cold	1	1.2%
Cool	4	4.9%
Slightly cool	8	9.9%
Neutral	17	21.0%
Slightly warm	9	11.1%
Warm	4	4.9%
Hot	20	24.7%
Very hot	18	22.2%



46.9%

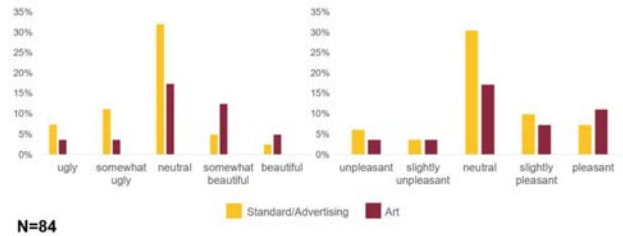
N=84

Relationship between aesthetic preferences and stop perception



Results show that aesthetic perception of the stop affects perception of thermal comfort. The more beautiful/pleasant the stop is, the cooler one feels.

Standard vs Art stop perception



N=84

Conclusions and Discussion

In conclusion, current bus stop infrastructure in Phoenix does not provide thermally comfortable conditions for bus riders. Majority feels hot. However, design matters for reducing actual temperatures and influencing psychological thermal comfort. Stops with artistic features provided higher temperature range and were more effective for cooling. Moreover, people who felt that stop is beautiful or pleasant felt more thermally comfortable. Investing in improving psychological thermal comfort can be a cost effective strategy to make people feel more comfortable.

Climate change models suggest that more cities will face climate challenges similar to Phoenix. Thus, we need to rethink how to integrate cooling functions into infrastructure systems in addition to their primary purpose.

References

Fraser, A. M., & Chester, M. V. (2016). Transit system design and vulnerability of riders to heat. *Journal of Transport & Health*. https://doi.org/10.1016/j.jth.2016.07.005

Karner, A., Hondula, D. M., & Vanos, J. K. (2015). Heat exposure during non-motorized travel: Implications for transportation policy under climate change. *Journal of Transport and Health*, *2*(4), 451–459. https://doi.org/10.1016/j.jth.2015.10.001

Nikolopoulou, M., & Steemers, K. (2003). Thermal comfort and psychological adaptation as a guide for designing urban spaces. *Energy and Buildings*, *35*(1), 95–101. https://doi.org/Pii S0378-7788(02)00084-1\nDoi 10.1016/S0378-7788(02)00084-1

Rupp, R. F., Vásquez, N. G., & Lamberts, R. (2015). A review of human thermal comfort in the built environment. *Energy and Buildings*, *105*, 178–205. https://doi.org/10.1016/j.enbuild.2015.07.047