On the study of cooling effect of shade and different paving materials in a park

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Introduction

Introduction

- The cooling effect **beyond boundaries of parks** is influenced by:

Physical setting of parks

- Park area
- Park geometry
- Type of plant cover
- Type of land cover
- Proportion of vegetated versus paved surfaces within a park

Nature of area around parks

- Surrounding streets and buildings

Introduction

- Urban greening can also provide cooling effect **inside parks**
- The cooling ability is influenced by:
  - **Park geometry**
  - **Tree characteristics**
    - Leaf Area Density
    - A tree with a wide canopy could even lower the surrounding air temperature up to 3.5°C during daytime
  - **Area of shade**
    - Shade can lower surrounding air temperature by 3°C and surface temperature by 8°C
  - **Types of paving materials**

Motivations

- To study the cooling ability of different types of paving materials under shaded and unshaded condition
- To study the cooling effect provided by trees in an urban park
- To study the effect of perception of trees and shade on thermal comfort

Methodology/Site characteristics

- A urban park in Tsim Sha Tsui in Hong Kong (Kowloon Park)

	Kowloon Park
Area	317m x 417m
Tree coverage inside park	90%
With water features in parks	Yes
Height of Surrounding buildings	100-120m
Distance between the parks and building	30m

Field measurement campaigns

- Two mobile microclimatic stations had been assembled for recording the microclimatic conditions under shaded and unshaded areas of the center of the park
- Measurements were carried out from 12:00 to 23:00 for about ten days from October to November 2015

Factors	Instrument used
Air temperature and humidity	HOBO U23 Prov2 Temperature/Relative Humidity Data Logger with weatherproof temperature and relative humidity sensors
Globe temperature	Globe thermometer consists of a 40mm grey table tennis ball and temperature sensor
Long-wave radiation	Pyranometer
Wind speed	Dantec low velocity flow analyzer with Robust temperature-compensated velocity probe (54T35)

Spatial thermal environment Info

Thermal camera (Testo 875-1i)

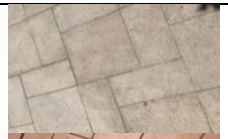
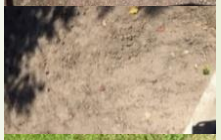
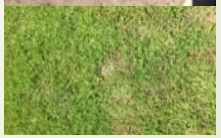
- with a resolution of 320*240 pixels
- used to measure the surface temperatures
- by taking remote sensing images

GIS-System (Holux M-241)

- Used to determine the geographic information of the park such as the total park area and the proportion of greenery areas

Measurement locations and materials

- Both natural and synthetic paving materials (e.g. sand and grass, clay, concrete, brick, rubber) were used in different functional areas of a park

	Type of Material	Emissivity Value	Photos of the materials		Type of Material	Emissivity Value	Photos of the materials
A	Clay	0.91		F	Concrete	0.91	
B	Clay	0.91		G	Concrete	0.91	
C	Brick	0.90		H	Sand	0.75	
D	Clay	0.91		I	Grass	0.92	
E	Rubber	0.89					

Measurement locations

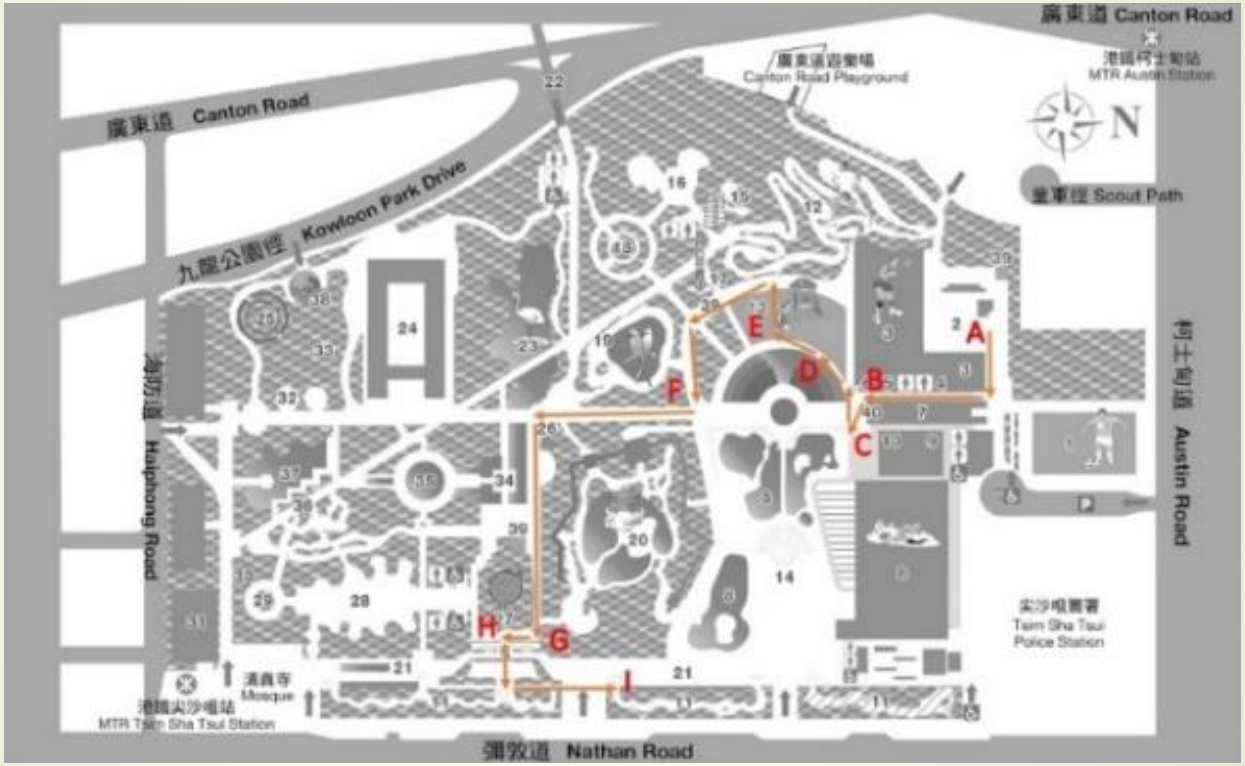


Figure 4 Measurement route

Measurement locations and materials

- One of the selected survey spots contained a banyan tree located in the Banyan Court for investigating the cooling ability of a tree
- Ground temperatures at 2m, 4m, 6m and 8m away from the center of Banyan tree were measured at different orientations (South, West and North)
- Questionnaire surveys were carried out with 1000 park visitors to elicit their thermal comfort responses as a result of perceiving trees and shade

Figure 5 Location of the surveyed tree

Figure 6 Photo of the surveyed tree location

The cooling ability of different types of paving materials under shaded and unshaded condition

Types of materials	Location	Maximum surface temperature in the afternoon
Rubber	Children Playground	66°C (Highest)
Sand and Grass	Natural environment	Ard 35°C (Lowest)
Clay and Concrete	Paving materials	40-45°C
Brick	Paving materials	50°C

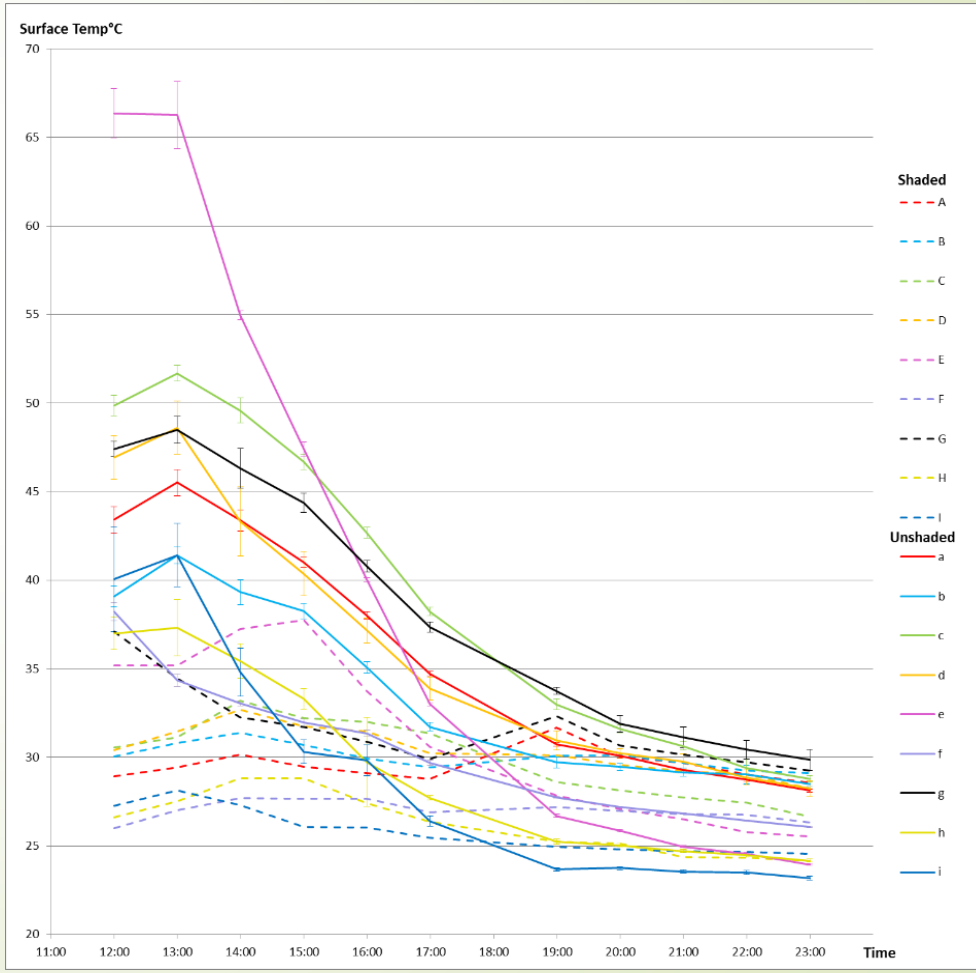


Figure 7 **Surface temperatures for nine different types of paving materials located in shaded areas and unshaded areas**

The cooling ability of different types of paving materials under shaded and unshaded condition

- Significant differences in surface temperatures between shaded and unshaded condition during daytime, but no sig diff after sunset
- Shading could lower the surface temperatures substantially during the afternoon periods
- The decreasing trends of surface temperature for all different types of paving materials slowed down and became stabilized at night time
- Ambient air temperature measured at the clay surface was linearly correlated with surface temperatures for both shaded (*r=0.716*) and unshaded areas (*r=0.653*)

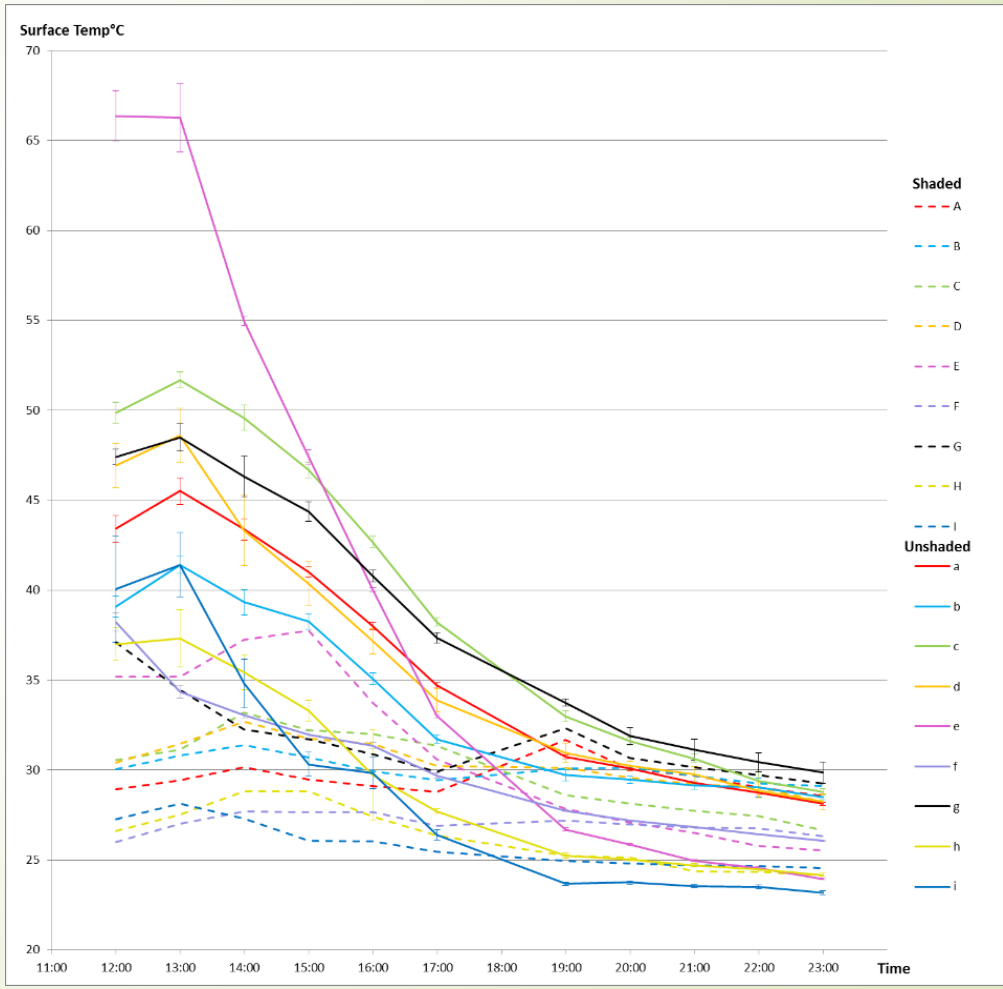


Figure 7 **Surface temperatures for nine different types of paving materials located in shaded areas and unshaded areas**

The cooling effect provided by Trees in the urban park

Locations 1 and 2 (2m and 4m away from the center of the tree respectively) were mostly shaded by the tree
Locations 3 and 4 (6m and 8m away from the center of the tree respectively) were not shaded

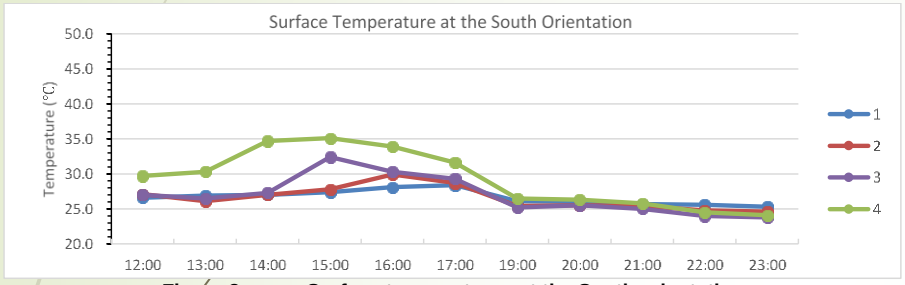


Figure 8 **Surface temperatures at the South orientation**

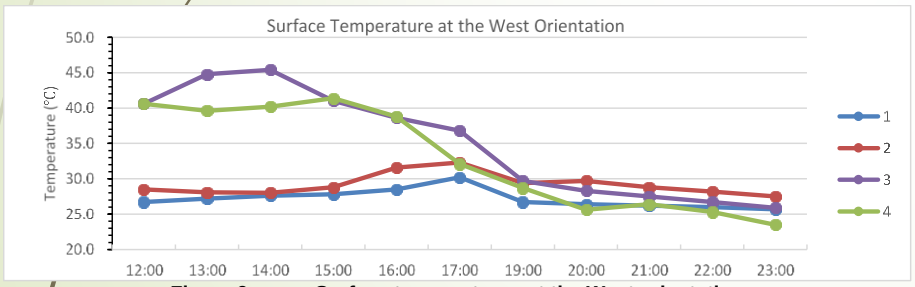


Figure 9 **Surface temperatures at the West orientation**

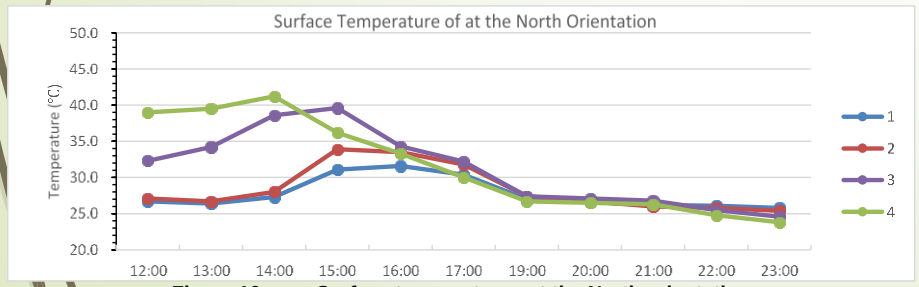


Figure 10 **Surface temperatures at the North orientation**

- The temperatures at tree shaded locations (1 and 2) were generally lower than those at the corresponding unshaded counterparts (Locations 3 and 4)
- The cooling ability of tree varied with orientation
  - At the West orientation, the surface temperatures remained around 40°C till 4pm
  - Surface temperatures at South and North orientation lowered with time after 2pm

The cooling effect provided by Trees in the urban park

- Shade provided by trees could lower the surface temperatures by at least 15°C during afternoon periods
- the presence of tree would not alter the cooling effect at the nighttime

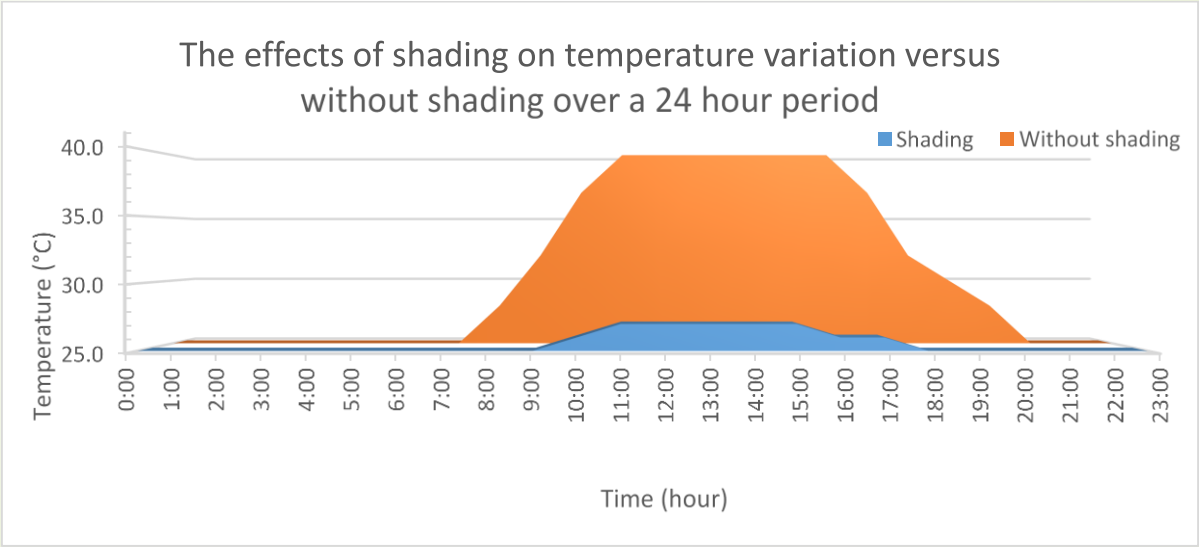
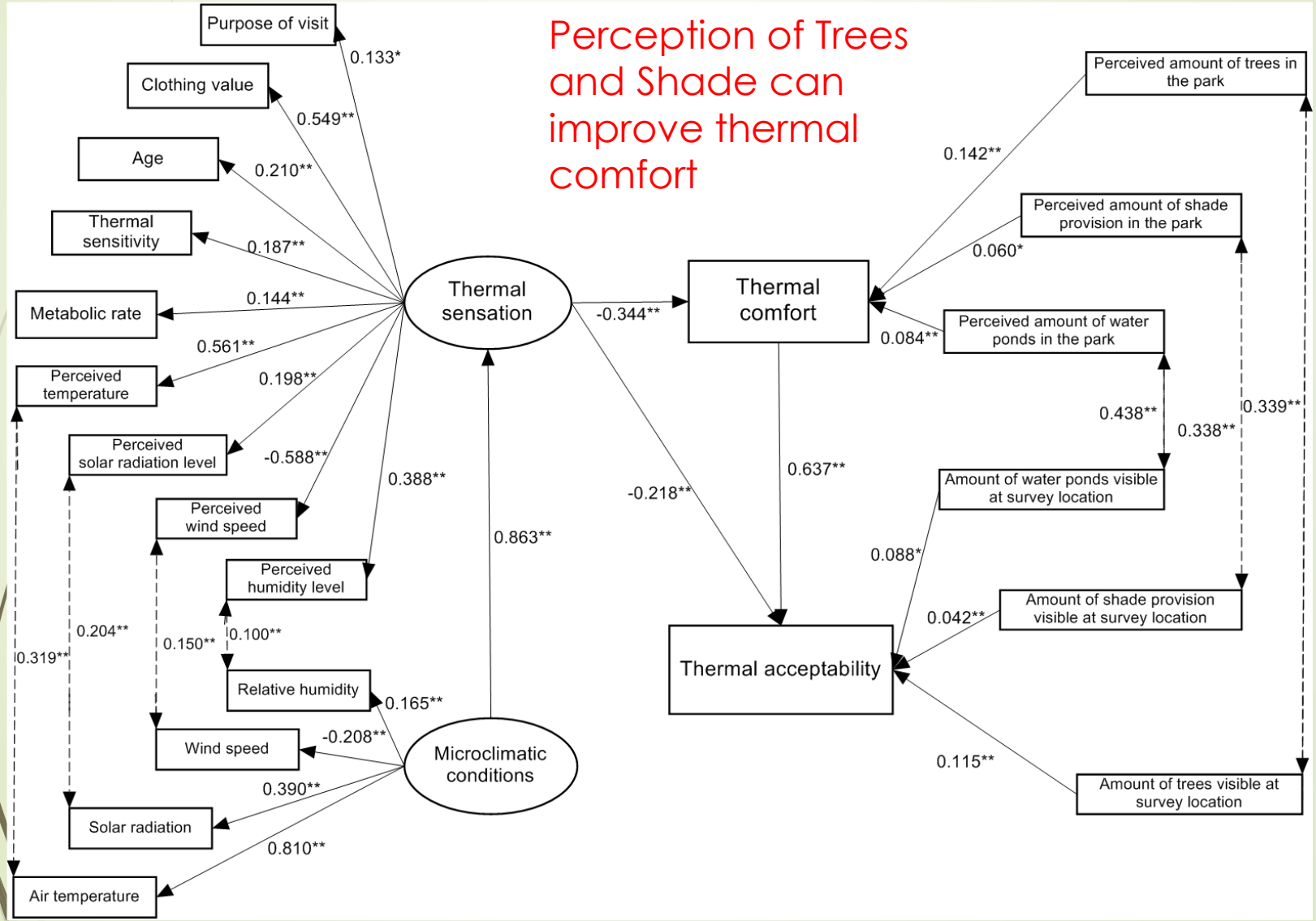


Figure 11 **The effects of shade on temperature variation over 24-hour period**

Path model formulated from questionnaire responses in summer



Conclusion

- Shade is an important means for lowering the ground surface temperature inside a park in the presence of sunlight
  - The more natural the paving material, the cooler the ground surface
- Perception of Trees and Shade can improve thermal comfort
- The surface temperatures of clay and concrete (about 40°C) were comparatively lower in the afternoon periods, with higher surface temperatures being detected for bricks (up to 50°C)
- Alarmingly higher surface temperatures were determined for the rubber paving in children playground (up to 65°C or above), which may pose serious health threats to children playing inside the playground