

Overcooling of Offices Reveals Gender Inequity in Thermal Comfort

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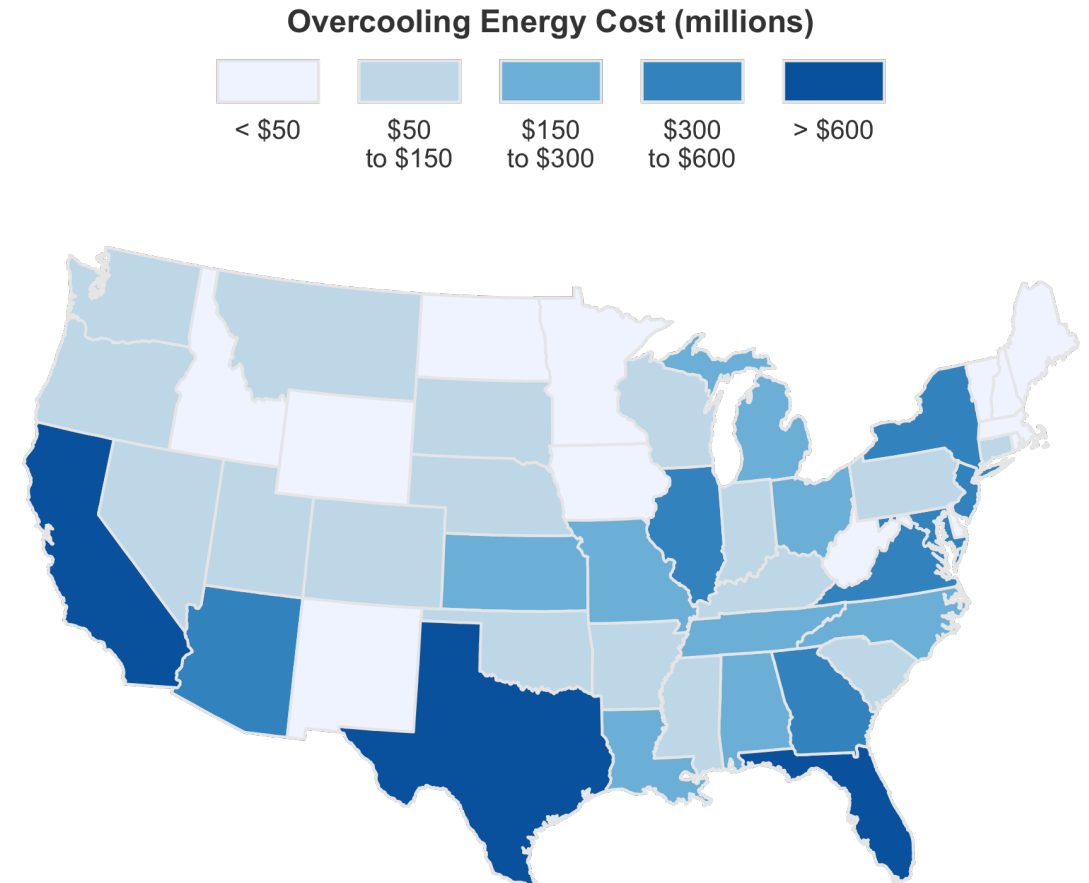
Cooling requirements in the US

Cooling is increasing

- Accounted for 23% of increased electricity demand from 1990-2016
- 84% increase by 2050 due to climate change

Overcooling of offices

- Offices can be cooler in summer than winter
- Evidence that it is a global problem
- Annual costs:
 - USD 10 billion
 - 8% of total building electricity use
 - 57,000 kt of CO₂e
 - decreased occupant satisfaction



Source: Derrible and Reeder (2015)

THE
NEW YORKER

AND TECH The Warning Light on Richard Branson's Space Flight A Life-Saving Checklist Why Walking H

ANNALS OF TECHNOLOGY

IS YOUR THERMOSTAT SEXIST?

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Women, There's A Reason Why You're
Shivering In The Office

The New York Times

Can an Office Temperature Be 'Sexist'? Women, and Science, Say So

NEW YORK POST



LIVING

**Cold office temperatures are hurting
women's productivity, study says**

Project overview

Objective

- Explore gender inequity in office overcooling

Approach

- Analyze CBE Occupant Survey responses about office temperatures
- Collect Tweets about cold offices



Source: Shutterstock

Thermal comfort questions in the CBE Occupant Survey

Thermal comfort is a common issue

- 38% of respondents are dissatisfied with the thermal environment
- Second most common issue behind acoustics

Branching questions on temperature

- Dissatisfied respondents evaluate the temperature in summer and winter
- Analyzed over 38,000 responses from 435 offices

CBE Occupant Survey Example Thermal Comfort Question

How satisfied are you with the temperature of your workspace?

Very dissatisfied	Dissatisfied	Somewhat dissatisfied	Neither	Somewhat satisfied	Satisfied	Very Satisfied
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



In warm/hot weather, the temperature in my workspace is:

<input type="radio"/> Often too hot	<input type="radio"/> Often too cold
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In cool/cold weather, the temperature in my workspace is:

<input type="radio"/> Often too hot	<input type="radio"/> Often too cold
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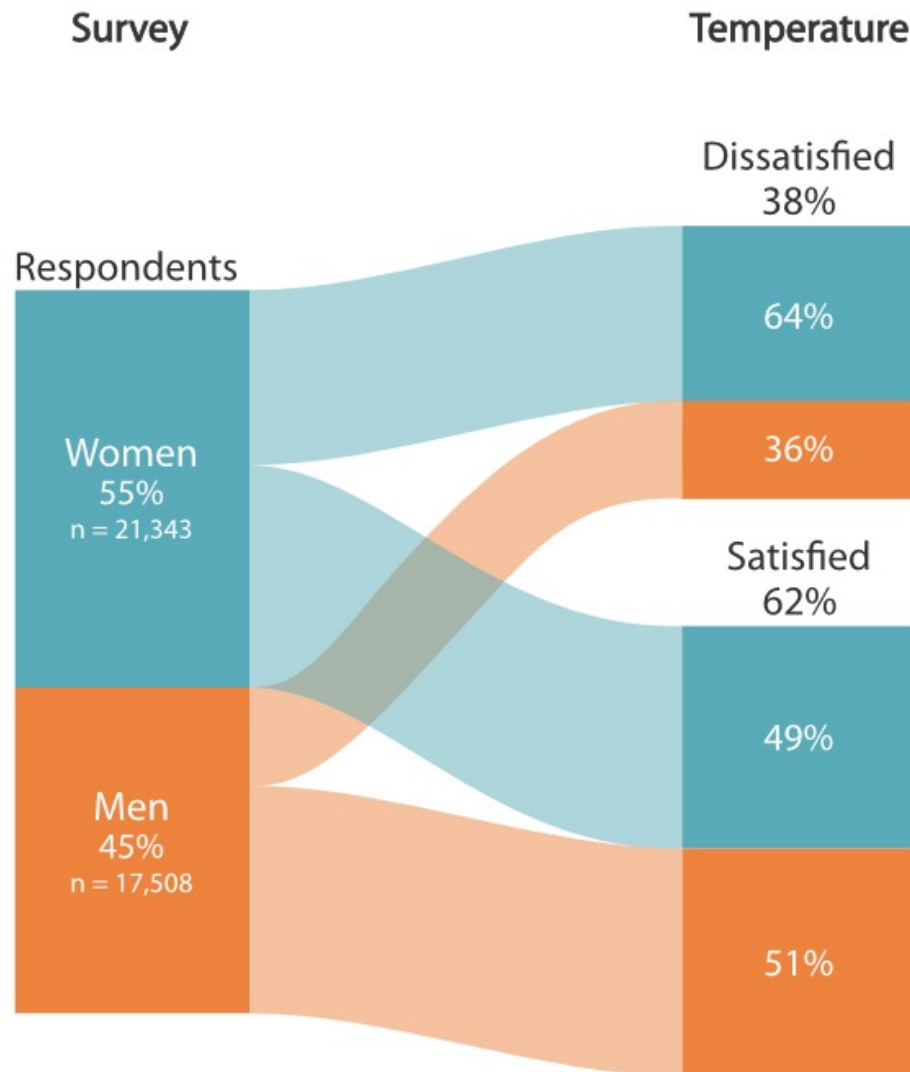
Overcooling and gender in the CBE Occupant Survey

Survey

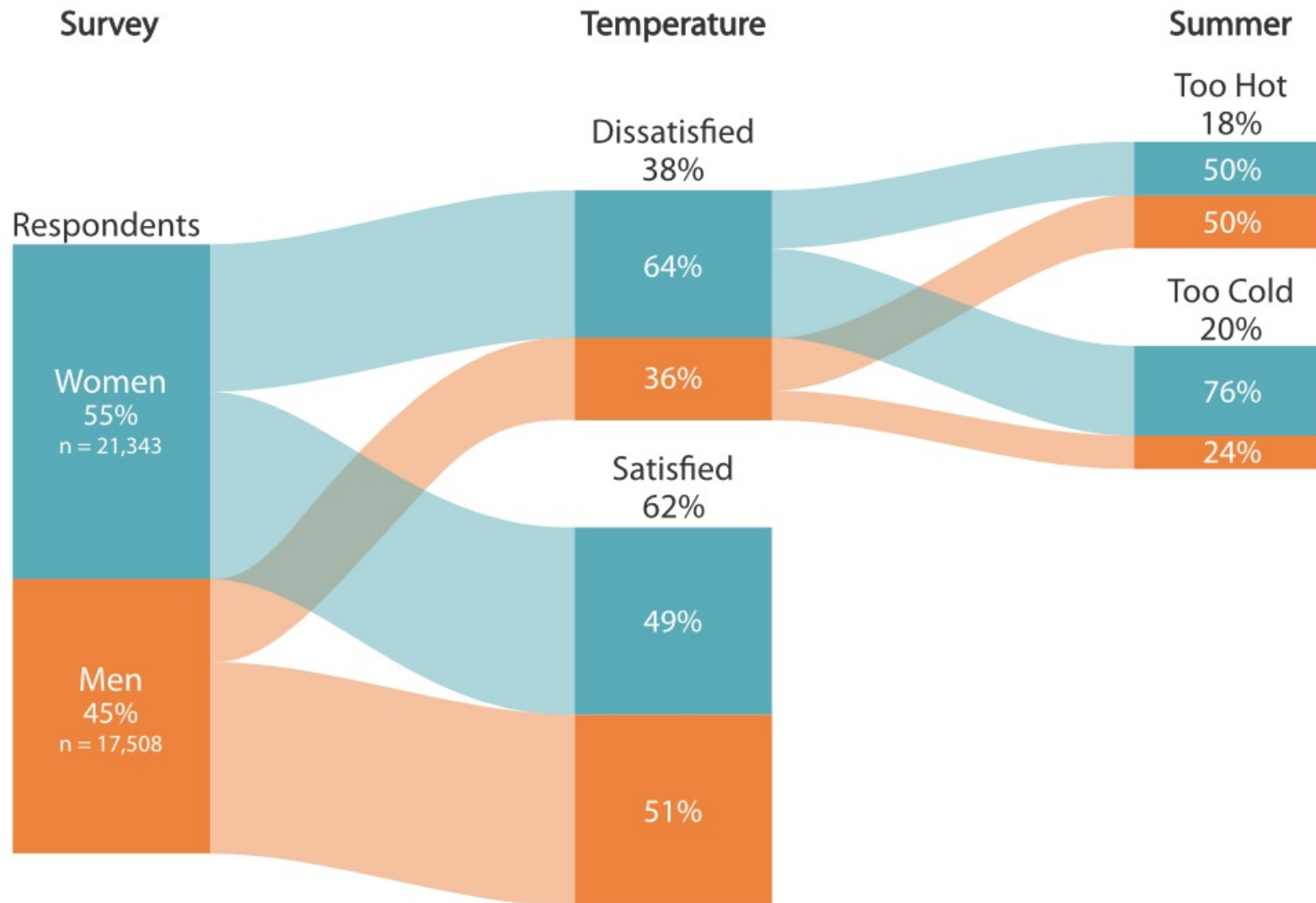
Respondents



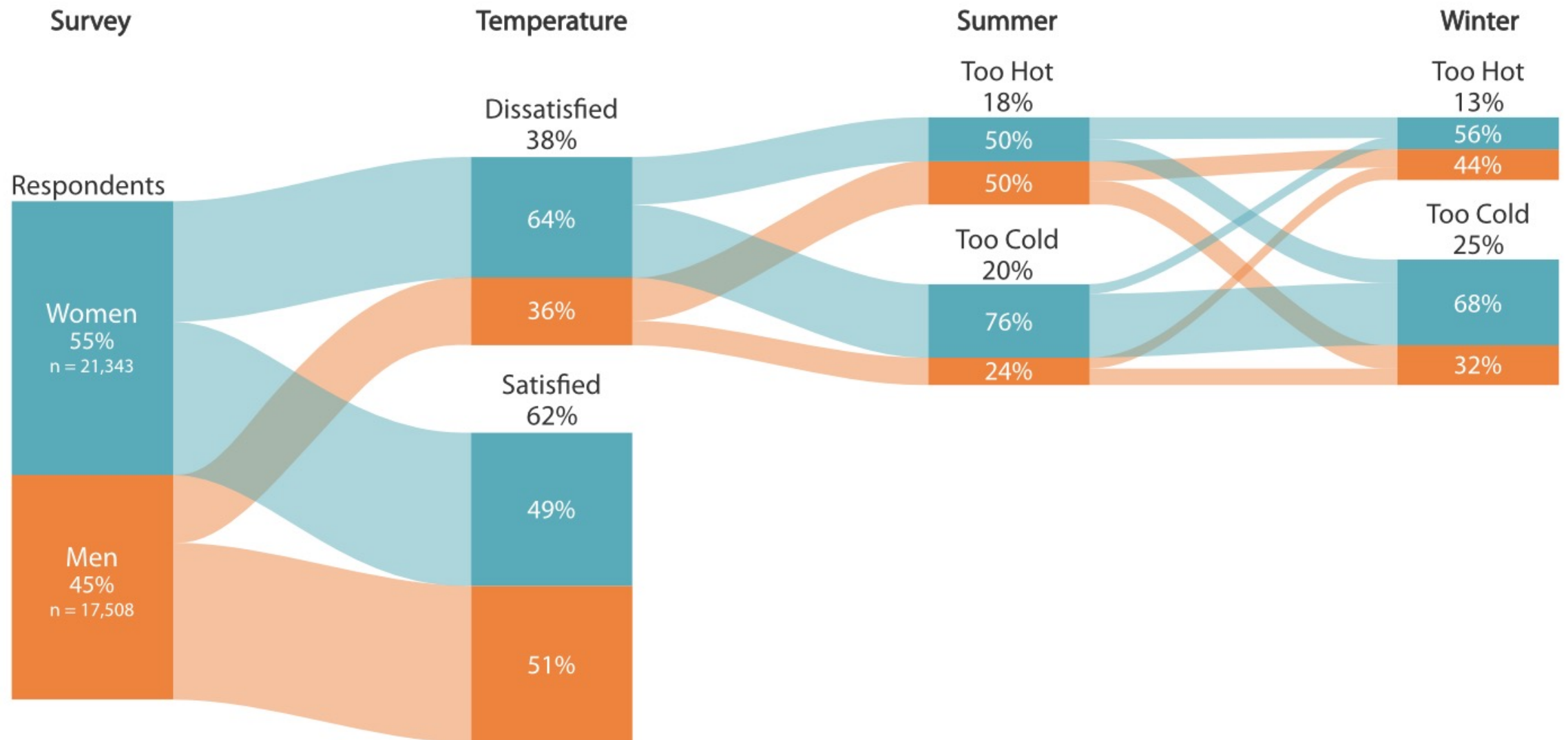
Overcooling and gender in the CBE Occupant Survey



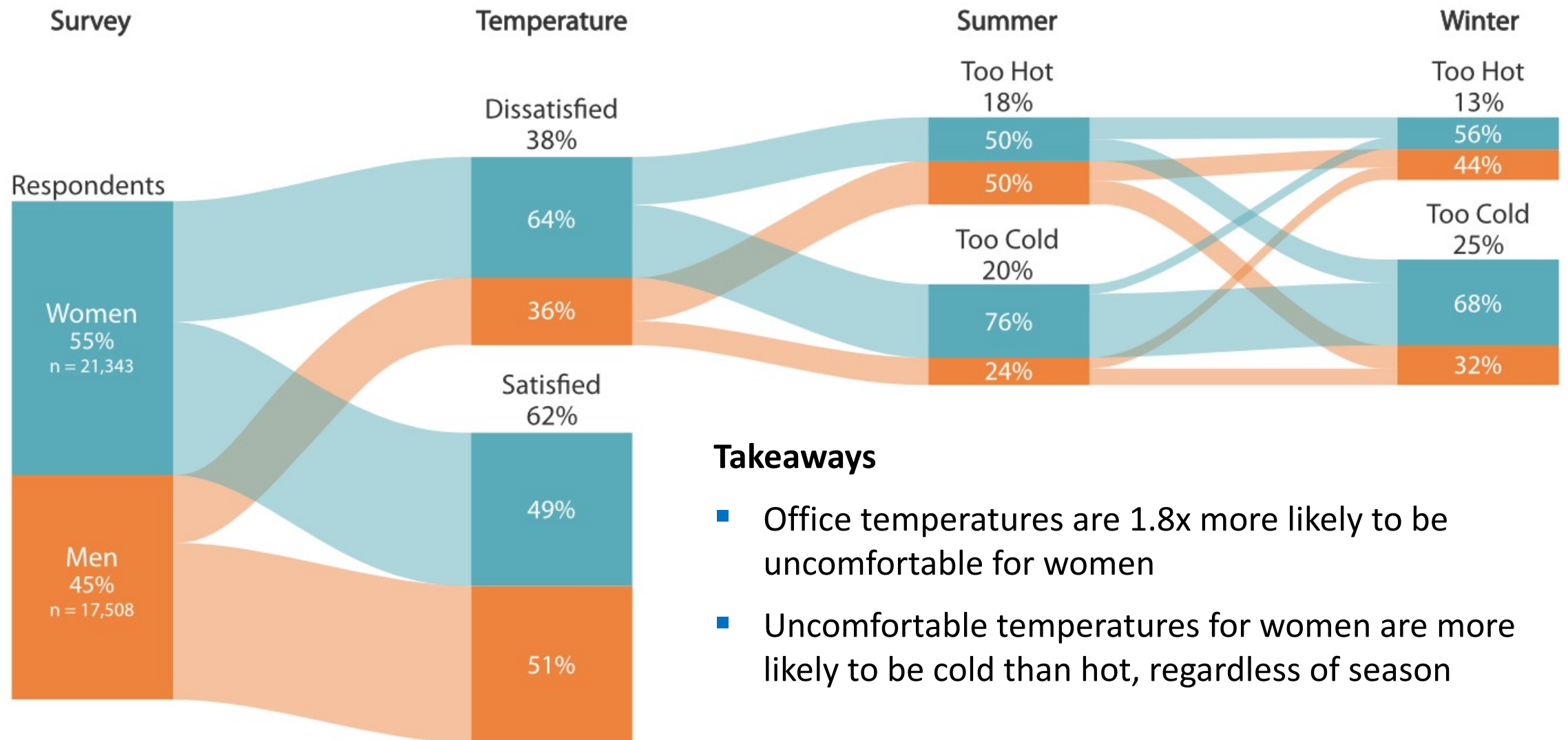
Overcooling and gender in the CBE Occupant Survey



Overcooling and gender in the CBE Occupant Survey



Overcooling and gender in the CBE Occupant Survey



Takeaways

- Office temperatures are 1.8x more likely to be uncomfortable for women
- Uncomfortable temperatures for women are more likely to be cold than hot, regardless of season

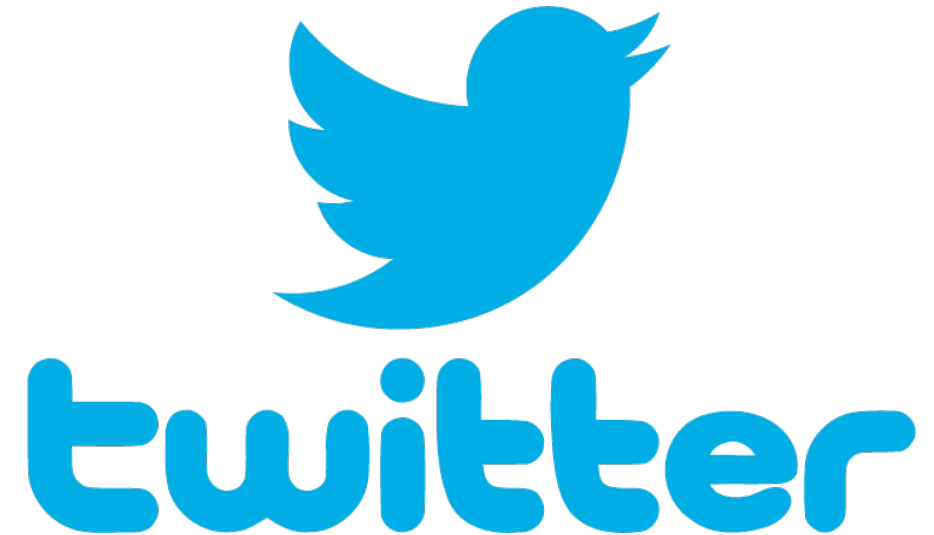
Mining Twitter for cold office complaints

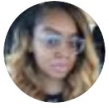
Novel crowdsourcing method

- Tweets about cold offices
- Complements the CBE Occupant Survey

Tweets about cold offices

- Keyword search for "cold", "office", "freezing", "desk", "🥶" etc.
- Must include geotag and in the US
- Found 16,791 tweets:
 - 14,771 users
 - 3,761 cities





How is a million?
@LancasterPA



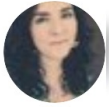
It doesn't need to be this cold in the office 😞

3:22 PM · Jul 30, 2019 from Lancaster, PA



Copy link to Tweet

[Tweet your reply](#)



How much money?
@LancasterPA



Apparently it was over 100 today but i had no idea because I was in my office, freezing and warming myself with my space heater because this building is forever cold.

12:20 AM · Sep 11, 2018 from Santa Rosa, CA



3



Copy link to Tweet

[Tweet your reply](#)



How much money?
@LancasterPA



My office is so cold that walking outside in 93 degree heat feels like heaven on my 15 minute break

8:37 PM · Aug 8, 2018 from Florida, USA

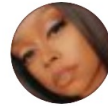


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Copy link to Tweet

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How much money?
@LancasterPA



I hate being in a freezing cold building. Like why is that a norm?

9:47 PM · Sep 9, 2019 from Austin, TX



Copy link to Tweet

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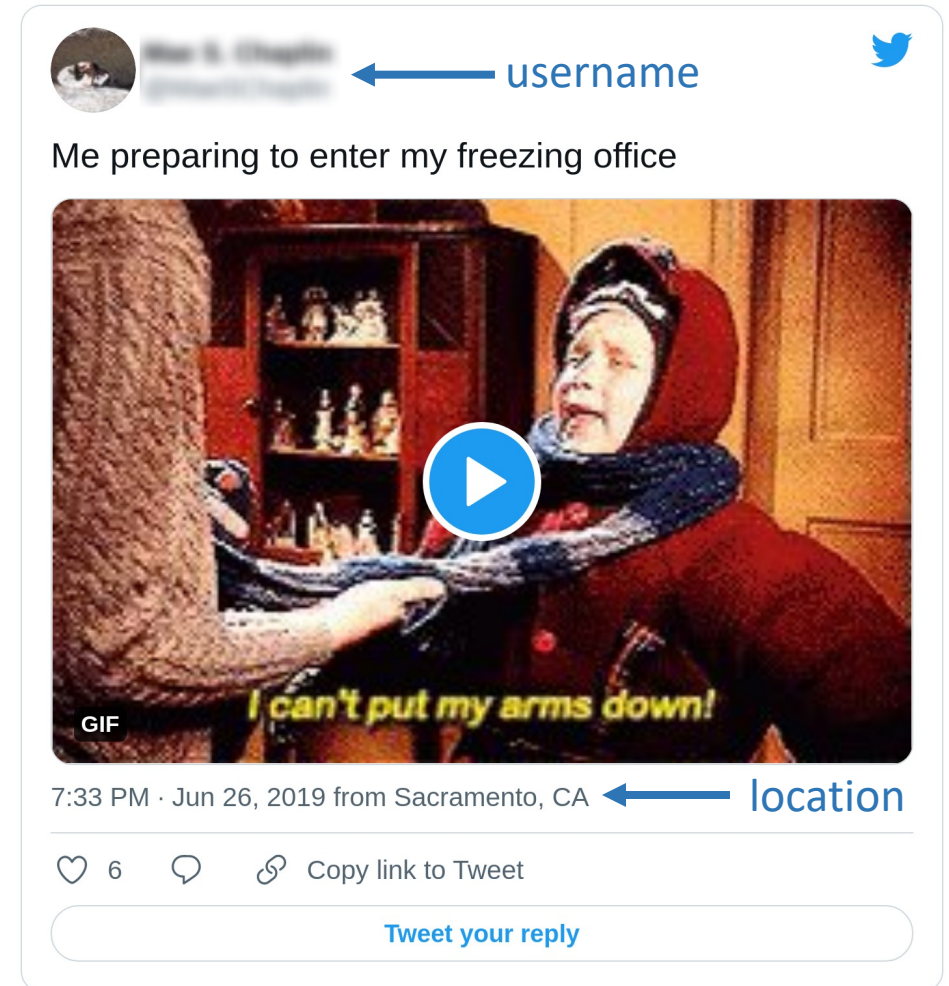
Adding context to cold office tweets

Gender

- Based on Twitter username
- Guess gender using algorithm on list of names from Social Security Administration
- Manual verification found 93% accuracy

Weather

- Based on tweet time and location
- Retrieve daily temperature from nearest weather station on the day of the tweet
- 75% of stations <10 km (6 mi) from user



Gender and cold office tweets

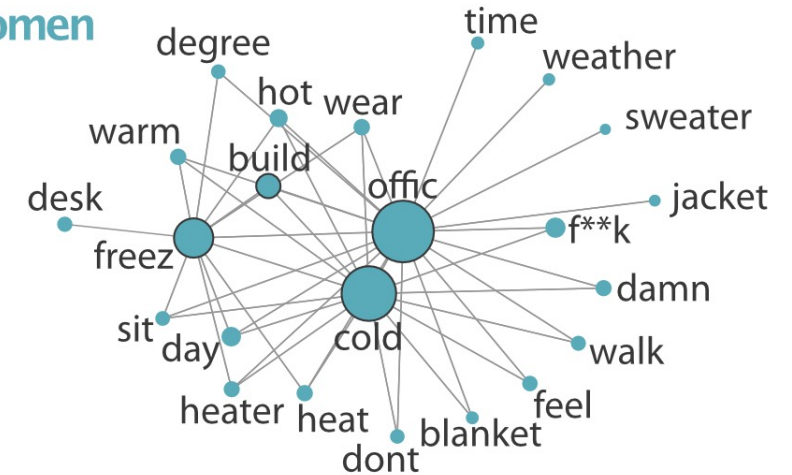
Guessing gender

- 66% of the matched usernames were women
- Higher than the estimated 55% of Twitter users who are woman

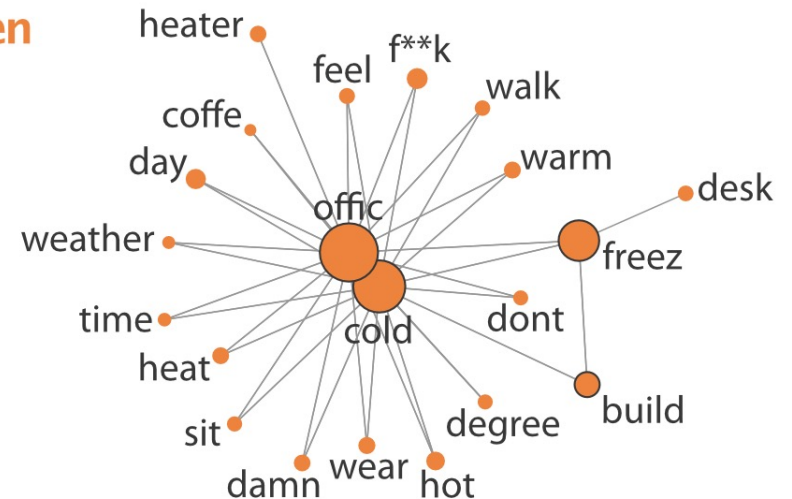
Text mining of tweets

- Cooccurrences of frequent words in tweets
- Search keywords (cold, office, freezing) shown in the center
- Women discussed responses to overcooling e.g., clothing, blanket, heater etc.

Women



Men



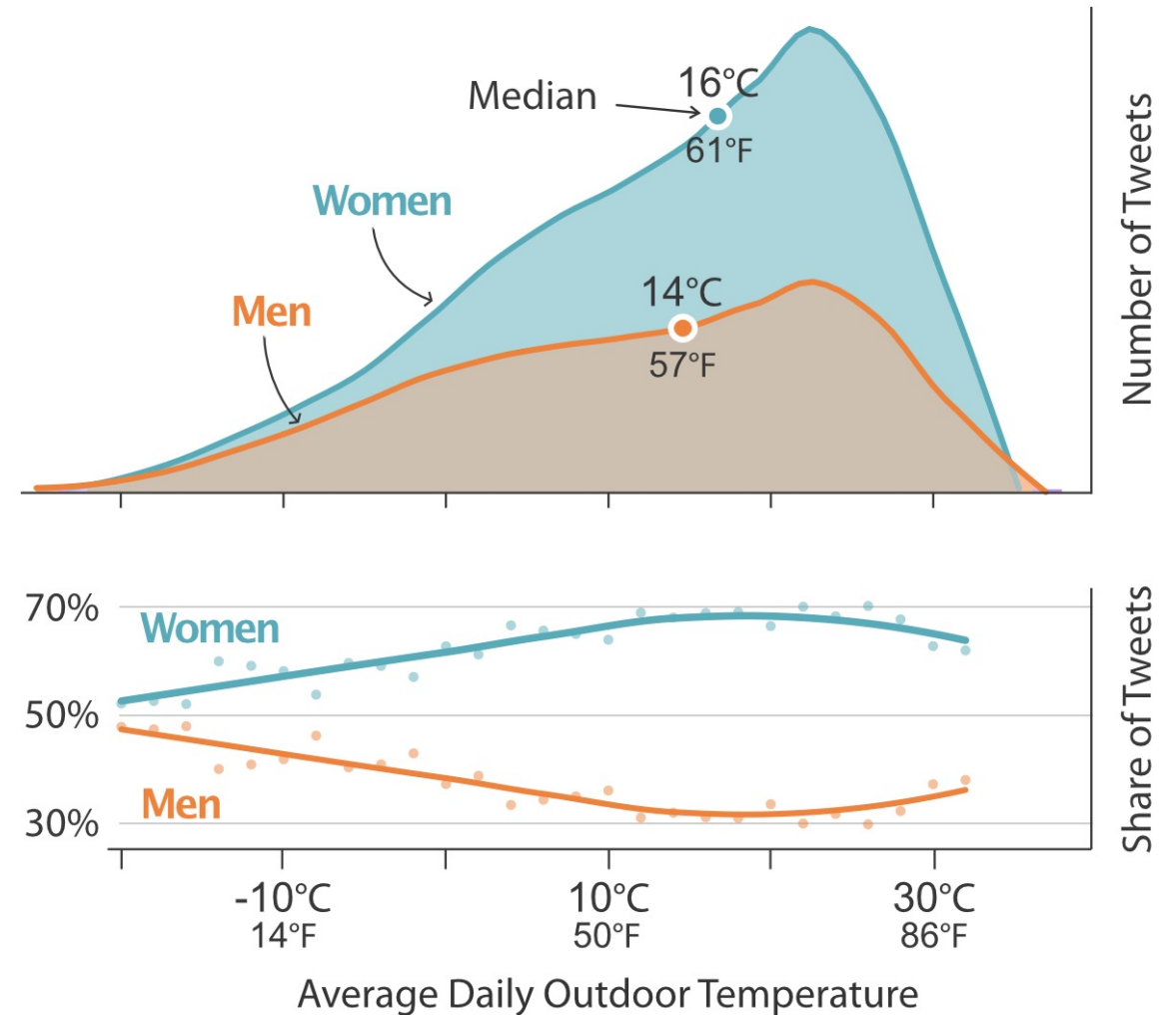
Weather and cold office tweets

Outdoor temperature

- Tweets were common when daily temperature was above 20°C (68°F)
- Share of tweets from women increased with outdoor temperature

Regional differences

- 40% of cold office tweets were from Southern states
- Median temperature was higher for women in all regions
- Similar share by gender in all regions



Solutions to overcooling

Adjust thermostats

- Seasonal changes to thermostats

Modify HVAC configuration

- Reduce VAV minimum air flow setpoints

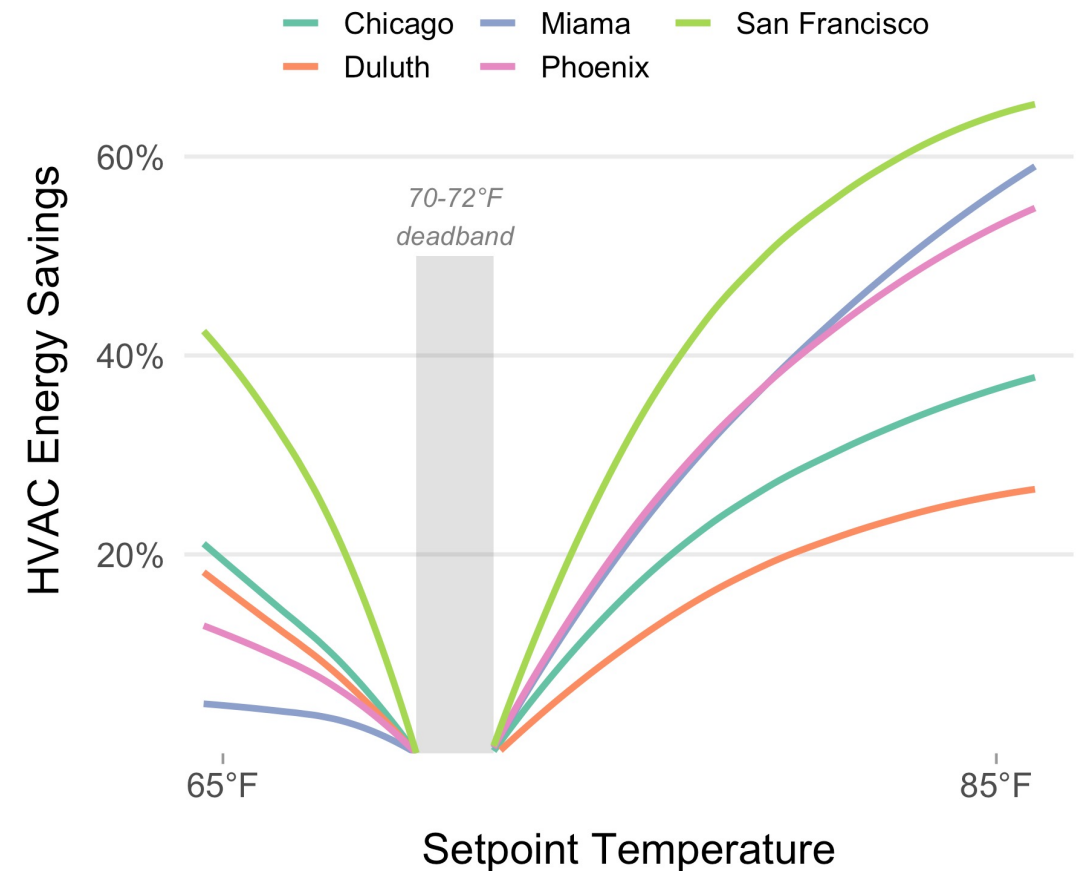
Use personal comfort systems

- Meet individual thermal preferences without making office uncomfortable for others



Adjust office thermostats

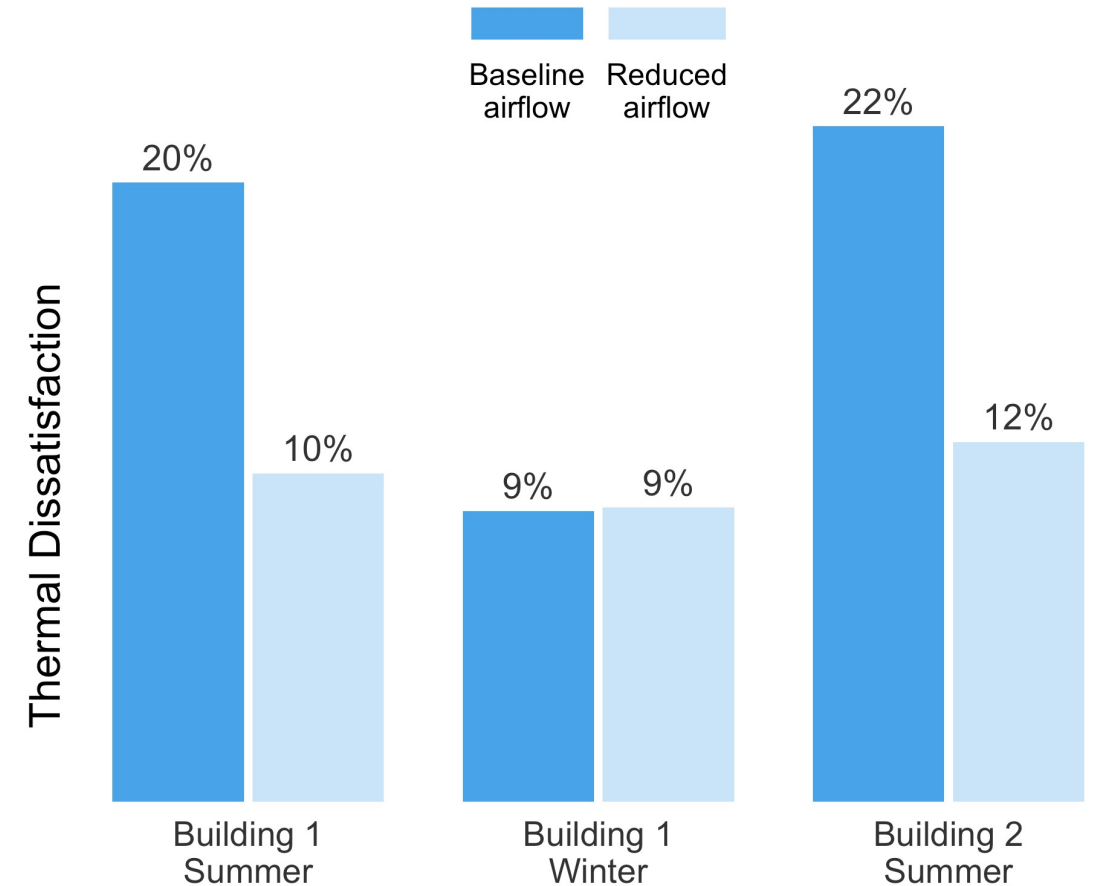
- Thermal preference shifts warmer in summer and cooler in winter
- Office setpoints:
 - rarely change
 - often at the cool end of the comfort range
- Seasonal setpoint adjustments improve thermal comfort
- Co-benefit of reducing HVAC costs by bring indoor and outdoor temperatures closer



Source: Hoyt, Arens and Zhang (2015)

Improve HVAC configuration

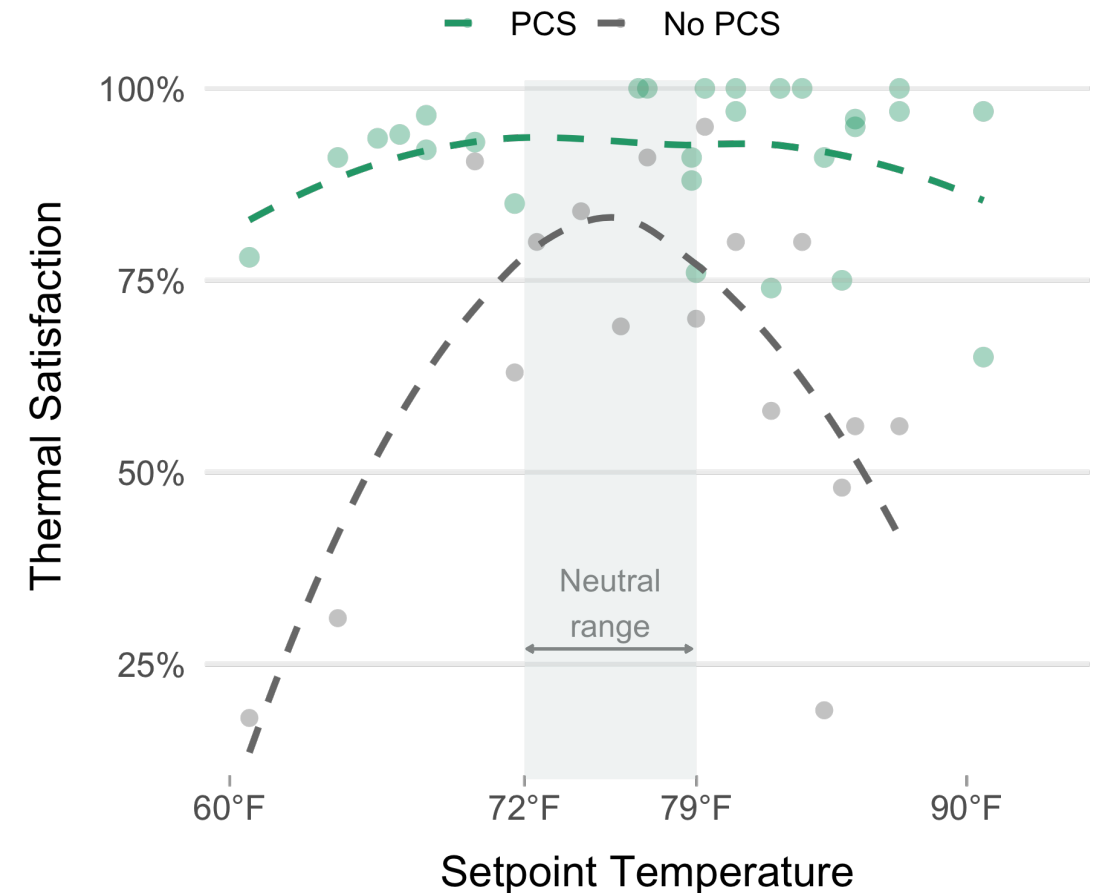
- Variable air volume (VAV) systems are common in US office buildings
- Engineering assumptions about low VAV airflow setpoints:
 - Dump cool air on occupants
 - Poorly-mixed ventilation air
 - Unstable airflow control
- CBE study of reduced VAV airflow setpoints found all assumptions are unwarranted:
 - Increased thermal comfort
 - Improved perceived air quality
 - Reduced HVAC energy by 10-30%



Source: Paliaga et al. (2019)

Personal comfort systems (PCS)

- There is no universal comfort temperature
- Preferences vary between people, through time, and across spaces
- Lab studies of PCS found they maintained satisfaction across a range of temperatures
- CBE field study found 96% thermal satisfaction when using PCS system
- HVAC setpoint temperatures can be relaxed to save energy



Source: Zhang, Arens and Zhai (2015)

Summary

- Cool office temperatures in summer cause occupant dissatisfaction
- Overcooling disproportionately effects women
- Gender inequity confirmed by two independent datasets
- Existing solutions would improve thermal comfort for all occupants and save energy



Thank you

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