The future of indoor air: cognitive function, intentional manipulation, and privacy

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Life Expectancy of Average Canadian (years)

81/72/54/27/4

Time spent indoors

Time spent in home

Time spent sleeping

Time spent in a vehicle

Adapted from Rich Corsi Indoor Air 2014 Closing Plenary
It is not just time spent indoors

• Many indoor sources
• Buildings = accumulators, reactors, petri dishes
• In much of the world outdoor air quality is improving, indoor air quality is getting worse
USEPA Risk Rankings (circa 1992)

1. (tie) Worker exposure to chemicals
1. (tie) Indoor radon
3. Pesticide residue on foods
4. (tie) Indoor air pollutants (non-radon)
4. (tie) Consumer exposure to chemicals
   (includes cleaning fluids, particleboard, asbestos products)
6. Hazardous/toxic air pollutants
7. Depletion of stratospheric ozone
8. Hazardous waste sites (inactive)
9. Drinking water (radon and THMs)
10. Application of pesticides
16 others .. (including groundwater contamination at 21, criteria air pollutants at 22, etc.)
Conventional Model of Indoor Air Quality

1. Source control
2. Ventilation
3. Air cleaning

“If there is a pile of manure in a space, do not try to remove the odor by ventilation. Remove the pile of manure.”

~ Max von Pettenkofer, 1858
Distance to Major Roadway

2M Canadians: 50 m
4M Canadians: 100 m
10M Canadians: 250 m
Air cleaning should be an obvious target for investment
Why Not?

• The health benefits are real and large, but
  • Very hard to motivate people about chronic health endpoints that occur decades in the future
  • Very hard to monetize health impacts when people inhabit different buildings
  • Industry (and individuals) pay the cost but don’t necessarily accrue the benefits

We need an alternative model
Figure 2. Impact of CO$_2$ on human decision-making performance. Error bars indicate 1 SD.

Satish et al. (2012) *Environ Health Persp*
Does $\text{CO}_2$ impact cognitive performance?

- Maybe, but these results are pointing to something else more important
- Variations in environmental variables, including exposures, impact cognitive function
- This is an enormous potential opportunity for IAQ community
  - It is an acute impact
  - It is easily monetizable in some environments
Invest in indoor air to improve cognitive function. Use benefits to pay for investment. Chronic health outcome improvement are a “side” benefit.
Model Evaluation

• Need to understand fundamentals of neural and cognitive processes
## Preliminary Experiment

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<th>No essential oil diffuser</th>
<th>Essential oil diffuser</th>
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Preliminary Results

- Subjects exposed to essential oil diffuser emissions made more impulsive decisions

**Abstract Matching**
- **Executive functioning**
  - Accuracy
  - Response Time
  - EOs resulted in faster responses, but had no effect on accuracy

**Stop Signal Reaction Time**
- **Response inhibition**
  - Probability of responding at different stop signal delays
  - Response Time
  - Probability of responding at different mask onsets
  - EOs result in a worse ability to inhibit responses at intermediate delays

*Courtesy of M. Tandoc*
Other Aspects of this Model

• Indoor air science has focused on reducing exposures.
• We may want to increase exposures if they improve cognitive function.
• How do we balance chronic health outcomes with acute benefits?
• Will require continuous monitoring
One Final Point

• Low-cost IAQ monitoring is becoming ubiquitous (connected monitors, air cleaners, smart thermostats, smoke alarms)

• Access to that data is very valuable and tells a lot about your activities in your home

Quantifying fine particle emission events from time-resolved measurements: Method description and application to 18 California low-income apartments

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\textit{Indoor Air} (2017)
Summary

• Indoor air is important and neglected
• Health benefits, although large, may not provide adequate motivation for investment
• We need to develop alternative models to motivate improvements in the indoor environment
• Low-cost sensors are an important piece of this
ASHRAE believes that indoor air quality and will remain the single most important health issue...

Unacceptable indoor air quality can impair our health, affect our sense of well-being and affect our productivity...

Today, we might not always want to bring in unfiltered, uncontrolled outside air...

The way we live today, spending more than 90% of our time indoors, creates the need for a better knowledge of what contaminants are present in the indoor environment and their effect on people. The issue of indoor air quality is a sleeping giant whose time has come...
Outline

• Why care about indoor air quality?
• The past of indoor air quality
• The present of indoor air quality
• The future of indoor air quality

Acknowledgments

• Current and former graduate students, colleagues, and community

• Funding