NRC·CNRC

Institute for Research in Construction

Links Between Office Lighting Appraisal and Organizational Outcomes

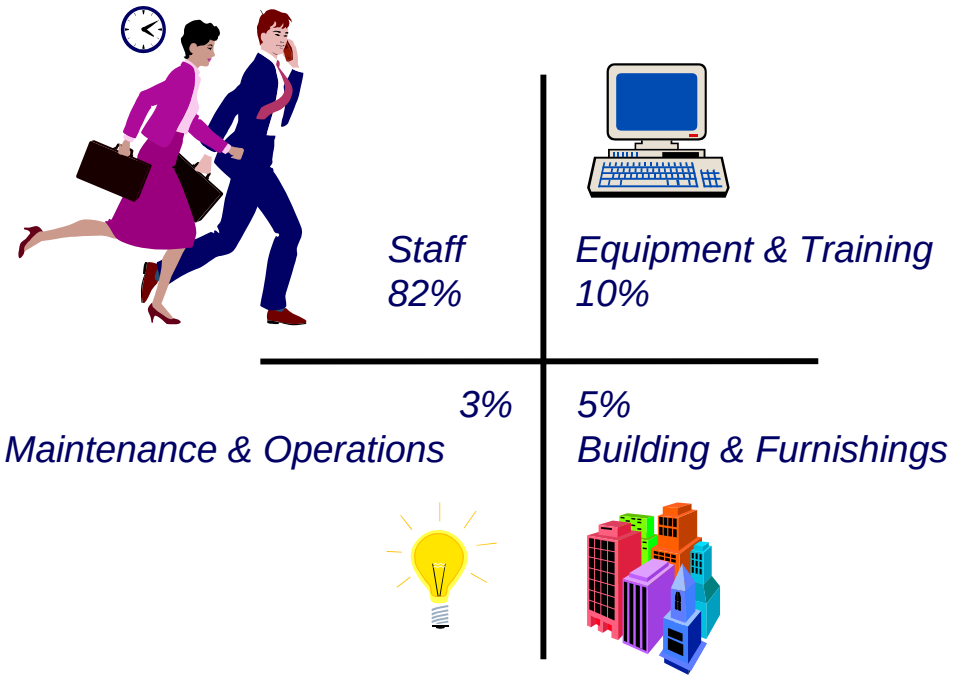
Jennifer A. Veitch, Ph.D., FIESNA

National Research Council Canada
Conseil national de recherches Canada
Canada

NRC·CNRC
Institute for Research in Construction

The Cost of Work

- People cost more than buildings by all estimates



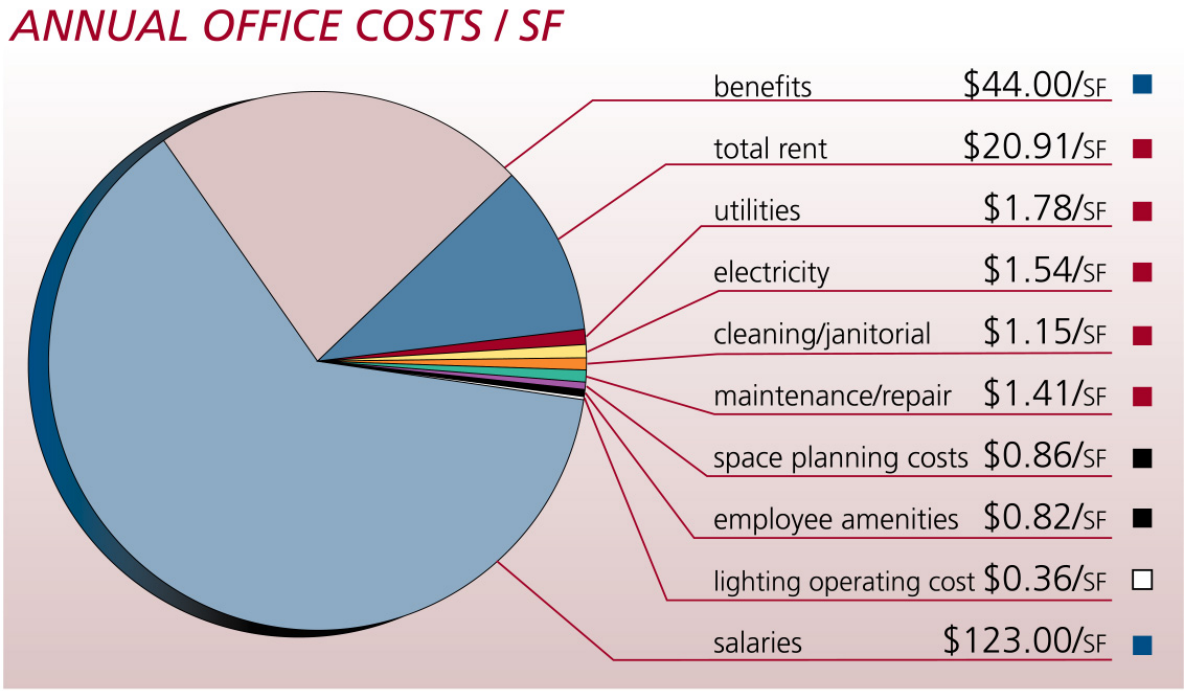
Source: Brill, M., Weidemann, S., & BOSTI Associates. (2001). *Disproving myths about workplace design*. Jasper, IN: Kimball International.

NRC·CNRC
Institute for Research in Construction

Value of the Investment

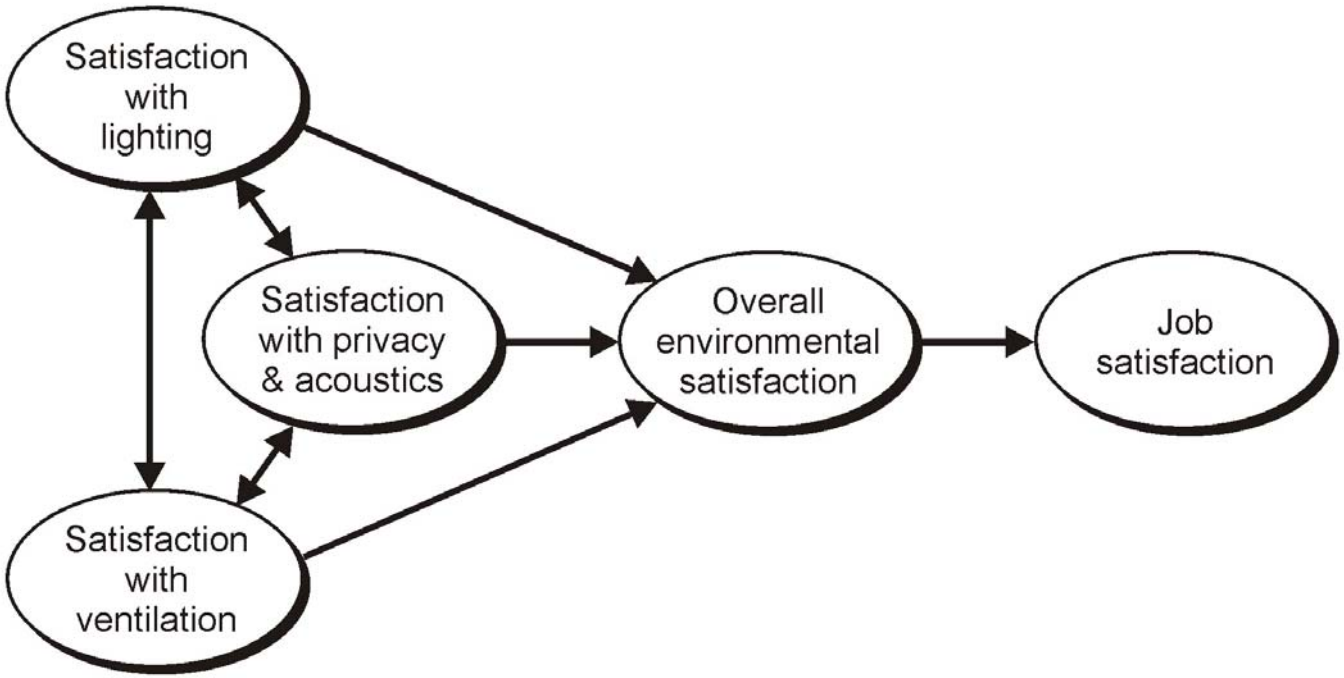
- In the USA, the cost of salaries and benefits taken together is $167/sf as compared to $0.36/sf for the lighting operating cost.

Source: www.lightright.org



NRC·CNRC
Institute for Research in Construction

NRC-IRC's COPE Field Study



Veitch, J. A., Charles, K. E., Farley, K. M. J., & Newsham, G. R. (2007). A model of satisfaction with open-plan office conditions COPE field findings. *Journal of Environmental Psychology*, *27*(3), 177-189.

NRC·CNRC
Institute for Research in Construction

Employee Attitudes

Carlopio, J. R. (1996). Construct validity of a physical work environment satisfaction questionnaire. *Journal of Occupational Health Psychology*, *1*(3), 330-344.

NRC·CNRC
Institute for Research in Construction

Organizational Outcomes

Harter, J. K., Schmidt, F. L., & Hayes, T. L. (2002). Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: A meta-analysis. *Journal of Applied Psychology, 87*(2), 268-279.

NRC·CNRC
Institute for Research in Construction

Research Questions

- Lighting practice is effective at eliminating visibility problems
  …but less effective at creating visually interesting or satisfying spaces
- Does "better lighting" beneficially affect the performance or well-being of office workers?
- Do these effects have any bearing on organizational productivity?

- Two studies: one lab, one field

NRC·CNRC
Institute for Research in Construction

Lab Study - Light Right Albany Expts

Light Right
CONSORTIUM

- Project sponsored by the Light Right Consortium
  - Alliance to Save Energy, IESNA, IALD, IFMA, Johnson Controls, NEMA, NYSERDA, Steelcase, US DoE, US EPA
  - Managed by Pacific Northwest National Laboratory, operated by Battelle for the US Department of Energy.
- "Albany Experiments" were a collaboration between Peter Boyce at the LRC and Jennifer Veitch and Guy Newsham at NRC-IRC, with Carol Jones and Judi Heerwagen at PNNL

NRC·CNRC
Institute for Research in Construction

LR Phase One: Market Research

- When asked to consider whether the following prompted factors were considered when making decisions about the built environment, respondents answered as follows, with corresponding importance ratings:

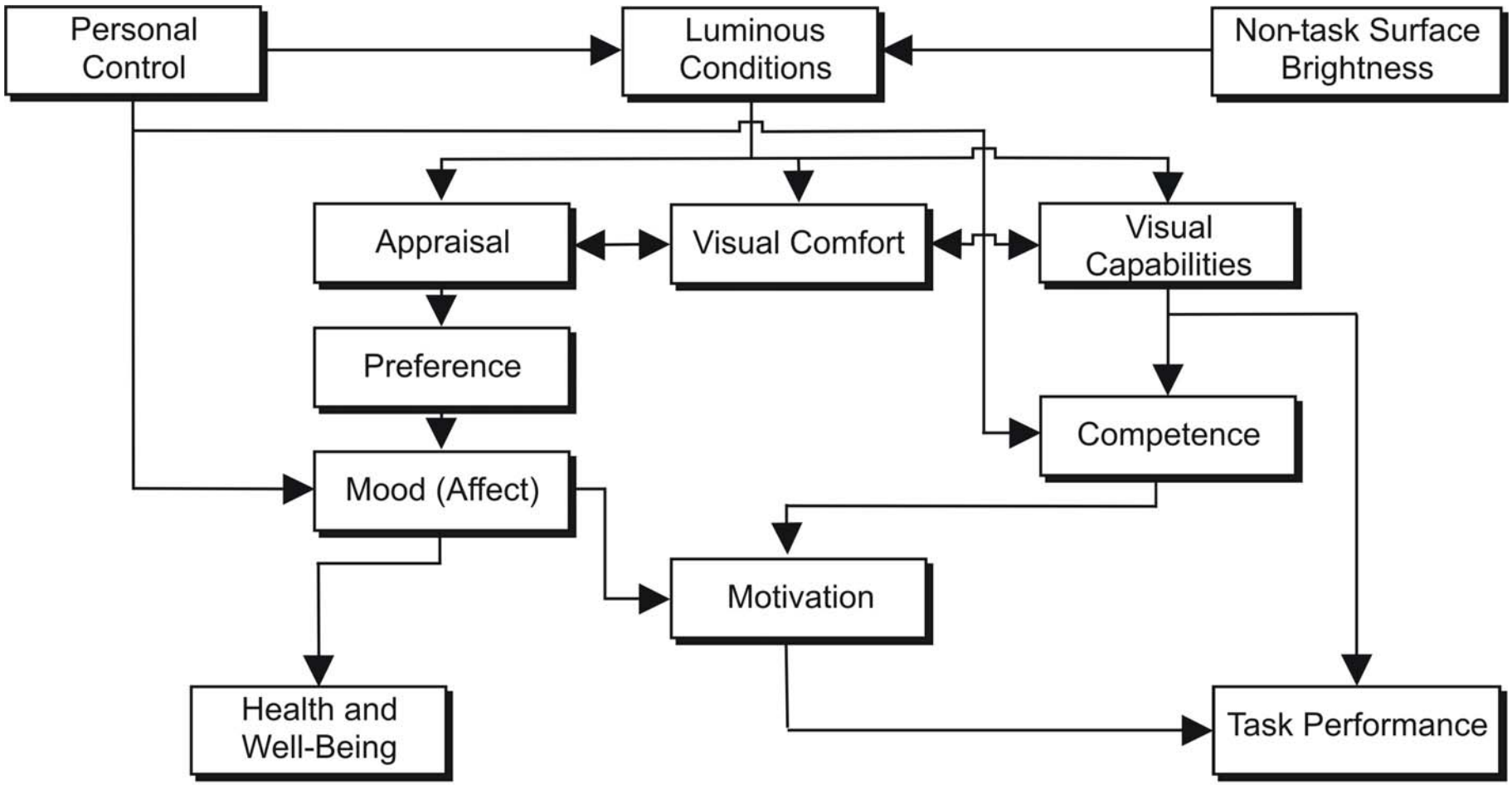
PROMPTED FACTORS	OVERALL	
	FREQUENCY	MEAN
Employee/Occupant Satisfaction	99%	4.28
Worker Output	74%	4.08
Employee Retention and/or Recruitment	70%	3.86
Churn Rate	70%	3.63
Creativity	68%	3.56
Absenteeism	24%	2.80

KEY: Frequency of mention.
Mean importance rating; with 5 being the most important and 1 being least important

FIG.1

NRC·CNRC
Institute for Research in Construction

Linked Mechanisms Map - Proposed



NRC·CNRC
Institute for Research in Construction

Light Right - Study Method

- Field simulation study: a commercial office space outfitted for research purposes
- Temporary office workers participated
- Worked for a complete day on set tasks to simulate elements of office work, and on questionnaires relating to concepts in the linked mechanisms map
- Experiment 1:
  - 4 lighting conditions (between-groups) [N=181]
  - subset of people also came a 2nd time (repeated-measures)
- Experiment 2:
  - 2 lighting conditions (between-groups) [N=107]

NRC·CNRC
Institute for Research in Construction

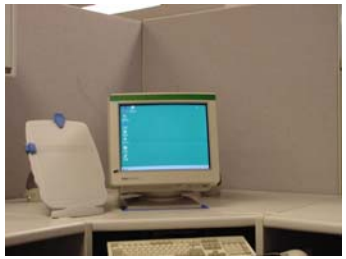
Open-Plan Views - Experiment 1

NRC·CNRC
Institute for Research in Construction

Workstation Views - Experiment 1

NRC·CNRC
Institute for Research in Construction

Views - Experiment 2



NRC·CNRC
Institute for Research in Construction

Experimental Designs

Experiment #1

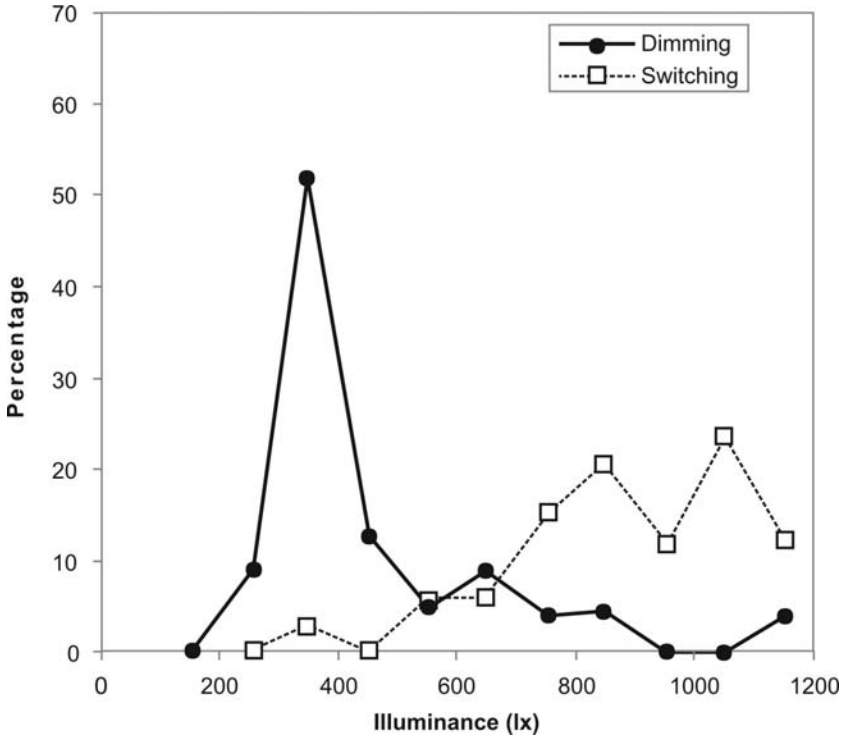
Experiment #2

- 2 data analysis strategies
  - Lighting conditions
    (see *LRT 38*(3), 191-223)
  - Linked mechanisms
    (in press)
- Separate analysis for controls use

  (see *LRT 38*(4), 358-378)

Expt 1 – Controls Use

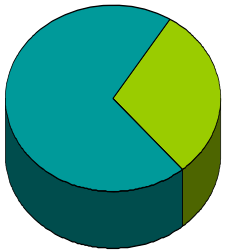
- Control used sparingly, but effectively.
  - When they had control, most people used it once, near the start of the day, to choose a preferred condition.



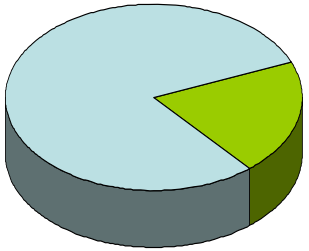
Percentage of participants choosing a mean desktop illuminance in 100 lx bins for the Switching Control and the Dimming Control conditions. For the Switching Control condition N = 33. For the Dimming Control condition, N = 56.

NRC·CNRC
Institute for Research in Construction

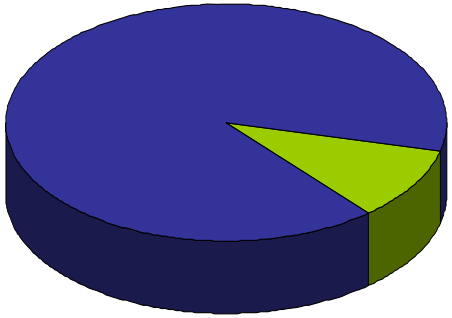
Lighting Condition Effects



PERCENTAGE COMFORTABLE
- Base Case - 70%
- Still uncomfortable- 30%



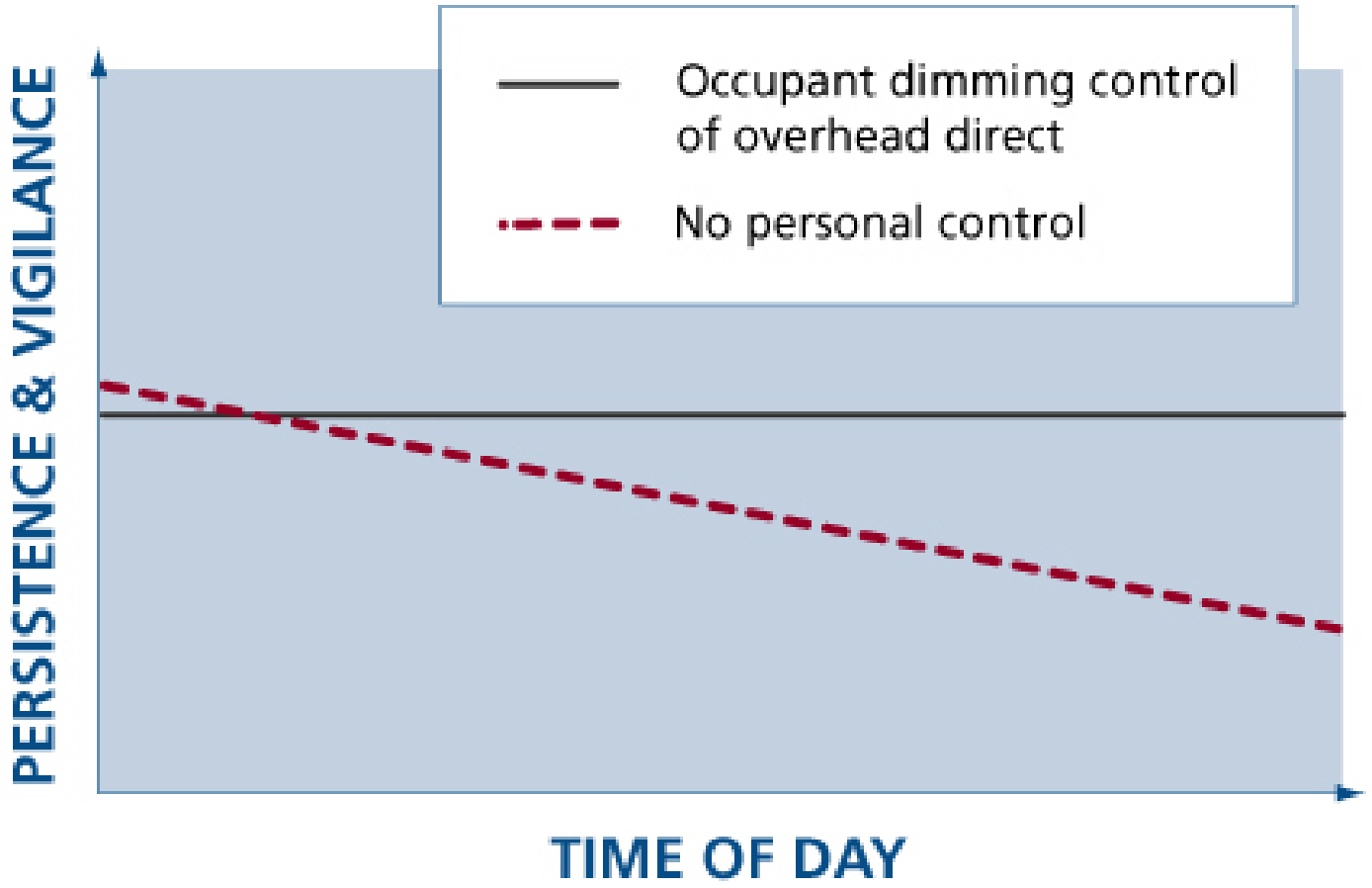
PERCENTAGE COMFORTABLE
- Best Practice - 80%
- Still uncomfortable- 20%



PERCENTAGE COMFORTABLE
- Dimming Control - 90%
- Still uncomfortable- 10%

NRC·CNRC
Institute for Research in Construction

Lighting Condition Effects



NRC·CNRC
Institute for Research in Construction

Linked Mechanisms Approach

- Links expressed as successive sets of regressions
- Example

  Lighting Appraisal → Preference → Mood

  1. Lighting appraisal → Mood
  2. Lighting appraisal → Preference
  3. Lighting appraisal + Preference → Mood

- 3 independent data sets
  - Ex 1 Between-groups
  - Ex 1 Repeated measures (2nd visit)
  - Ex 2

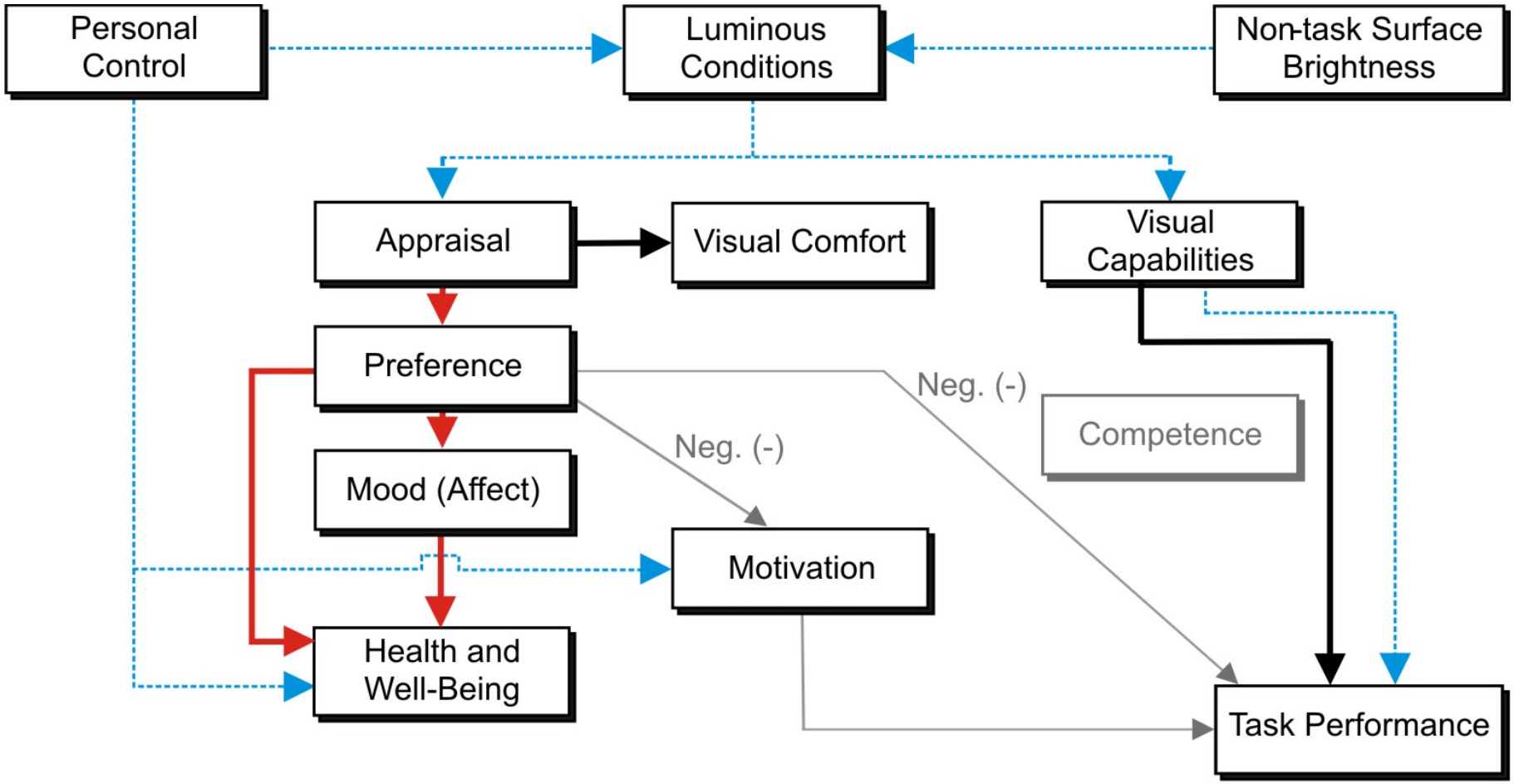
NRC·CNRC
Institute for Research in Construction

Linked Mechanisms Approach

- Clear support for an appraisal path, from lighting appraisal → preference → mood → health and well-being
  - mediation supported in all 3 data sets
  - large effect sizes
- Effects less clear for a vision path from visual capabilities → task performance
  - conditions were all relatively easy to see
  - other analyses (e.g., print size effects) showed expected results

NRC·CNRC
Institute for Research in Construction

Linked Mechanisms Map - Final



NRC·CNRC
Institute for Research in Construction

Light Right — Conclusions

- Lighting conditions — and their appraisal — influence feelings of health and well-being
- First step towards demonstration that better-quality lighting supports organizational productivity
- Lighting conditions that support employees should achieve…
  - high task visibility
    AND
  - favourable appraisals of lighting quality

NRC·CNRC
Institute for Research in Construction

Light Right — Limitations

- People in organizations might have a different response than temps
- Short-term versus long-term exposures
- Lab setting doesn't permit measurement of organizational outcomes

So…

- Next, study real people in a real organization over the long term

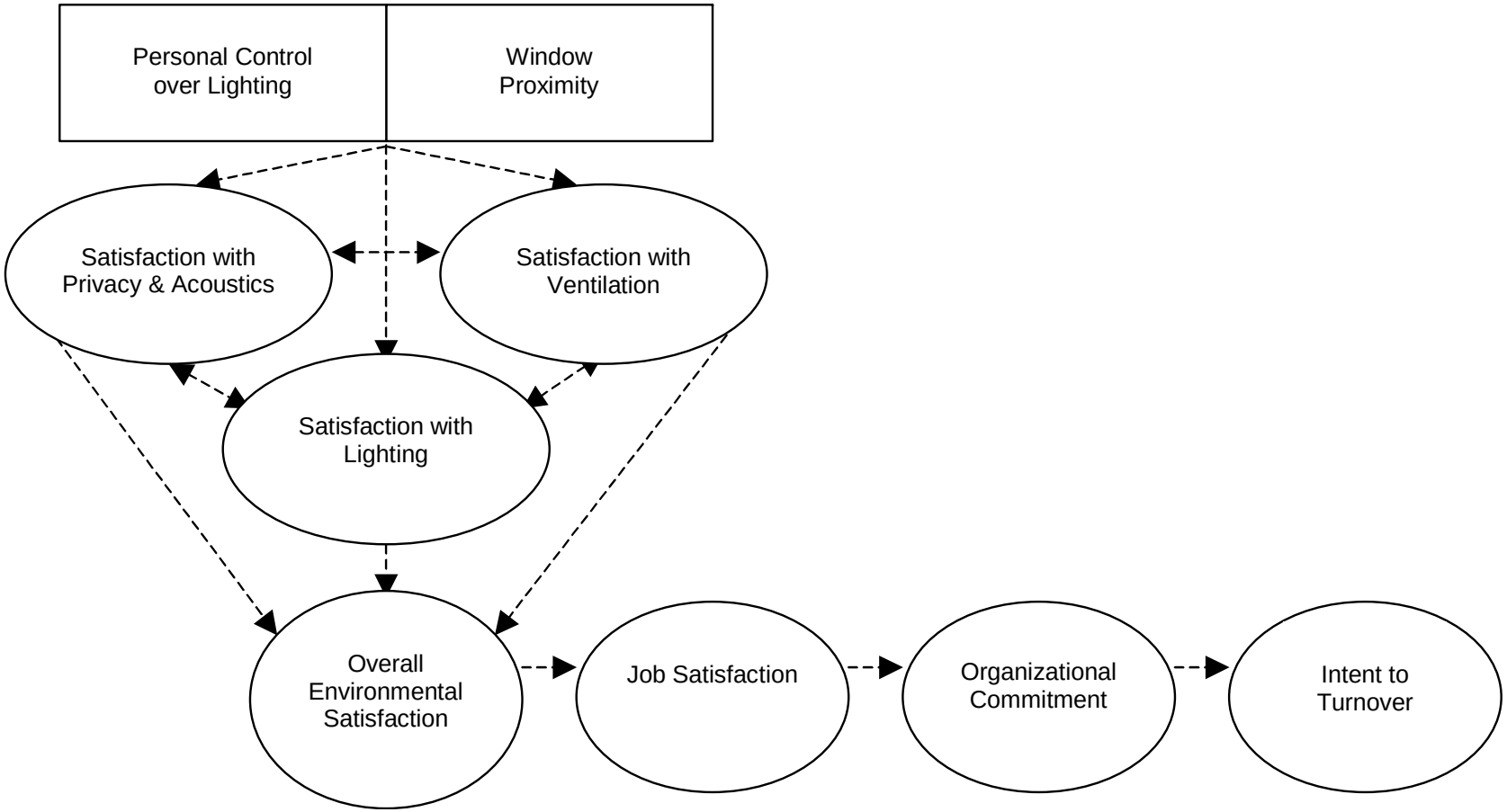
NRC·CNRC
Institute for Research in Construction

Field Study — BC Hydro PowerSmart

- Do people with WS-specific D/I have greater satisfaction with their lighting than those with parabolic louvered luminaires?
- What's the consequence for organizational effectiveness?
  - job satisfaction, organizational commitment, intent to turnover
- Did the intervention (reminders) change opinions?
- Are people with windows more satisfied than those without?

NRC·CNRC
Institute for Research in Construction

PowerSmart Study - Overall Model



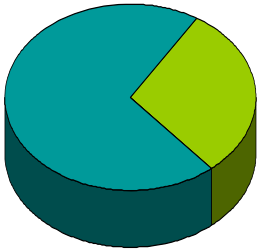
NRC·CNRC
Institute for Research in Construction

PowerSmart Survey

- 3 survey times: April, August, November 2005
- Same survey each time
- E-mail invitation to Internet survey on NRC server in Ottawa
- Voluntary participation, confidentiality assured
- Questions about lighting appraisals, environmental satisfaction, job satisfaction, organizational commitment, intent to turnover, demographics

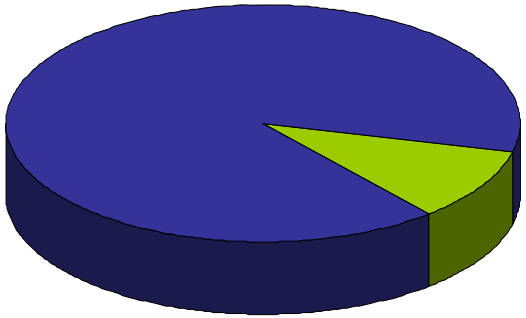
NRC·CNRC
Institute for Research in Construction

PowerSmart Results - Lighting Appraisals



PERCENTAGE COMFORTABLE

- Direct only (parabolic)- ~70%
- Still uncomfortable- 30%



PERCENTAGE COMFORTABLE

- Ergolight - ~90%
- Still uncomfortable- 10%

NRC·CNRC
Institute for Research in Construction

PowerSmart Results - Environmental Satisfaction

- People with WS-specific D/I were more satisfied with the lighting and the work environment than those with parabolic-louvered luminaires.
- No effect of the intervention campaign
- Windows generally preferred, especially in April survey

NRC·CNRC
Institute for Research in Construction

PowerSmart Results - Comments

- Comments indicated that lighting and daylighting are frequently mentioned as a plus for occupants; infrequently, a source of problems, e.g.:

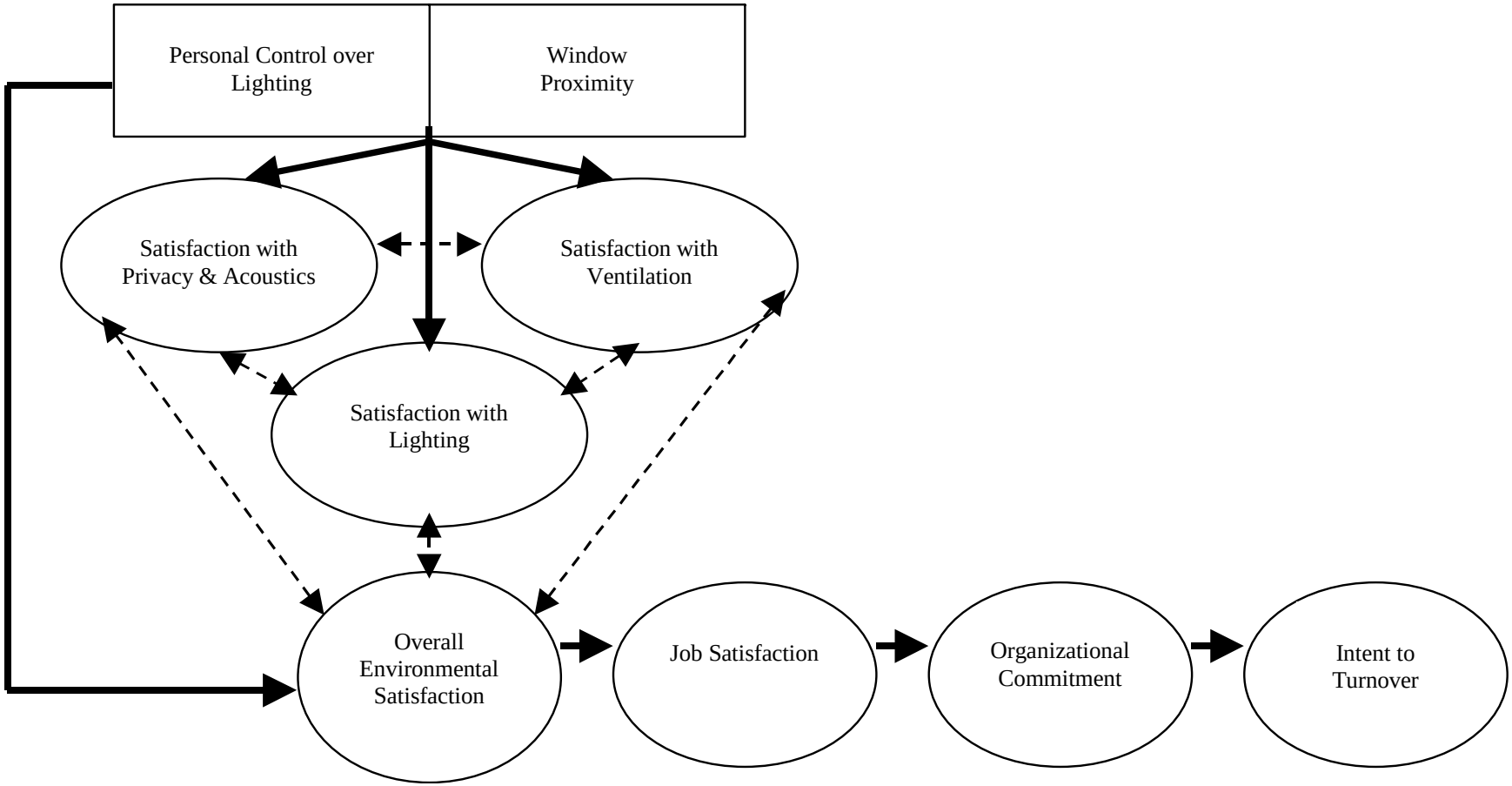
[What do you like most about your office?]

- I have large windows that let in natural light. Also the view gives you a break from the day. The lighting system is great, dimming the lights when full output is not needed.

[What do you like least about your office?]

- The lighting. The floor I'm now on doesn't have the same lighting technology. I no longer have my dedicated overhead luminaire that I could control the intensity through my PC. We're stuck with general lighting. Quite a difference.

PowerSmart Results - Job Satisfaction



NRC·CNRC
Institute for Research in Construction

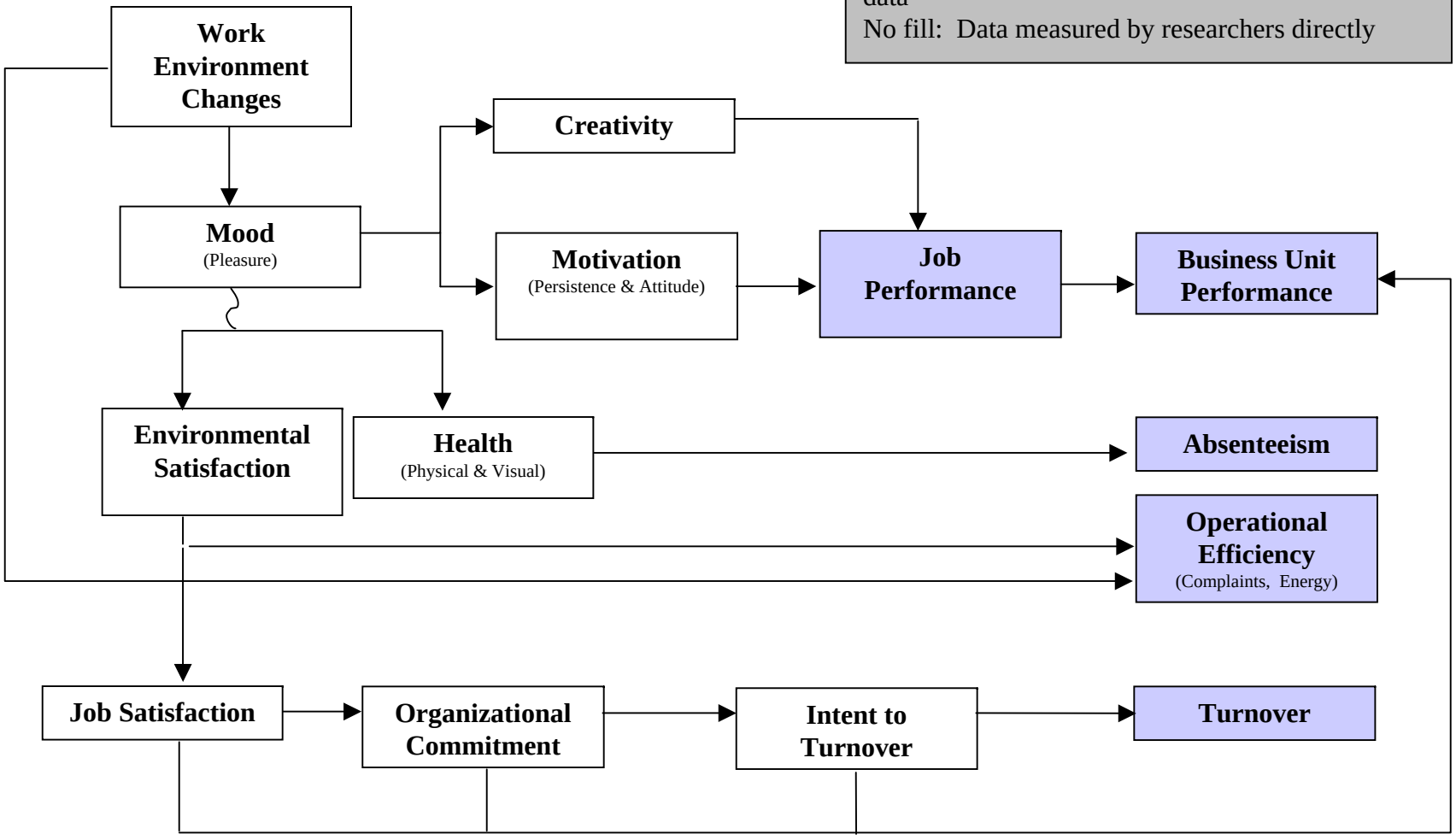
Survey Conclusions

- WS-specific D/I are preferred over the recessed parabolic-louvered luminaires - results almost identical to the Light Right experiments
- Conditions that improve job satisfaction lead to reduced intent to turnover
- Limitations:
  - small sample size (and unequal group sizes)
  - seasonal differences between survey times
  - uncontrolled variation between groups

NRC·CNRC
Institute for Research in Construction

Next Step: Light Right Field Study

Legend
Grey fill: Organizational outcomes with archival data
No fill: Data measured by researchers directly



NRC·CNRC
Institute for Research in Construction

General Conclusion

- Thoughtful lighting – designed rather than delivered as a commodity -- delivers higher satisfaction to occupants.
- Lighting that people appraise as better improves their well-being.
- Individual control over lighting contributes to organizational effectiveness through job satisfaction AND through reduced energy costs.