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*Institute for
Research in
Construction*

The effect of personal lighting controls on energy use and occupant well-being in offices

**Jennifer A. Veitch, Guy R. Newsham,
Sandra Mancini, Chantal Arsenault**



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Proceedings of the 13th International Conference for Enhanced Building Operations, Montreal, Quebec, October 8-11, 2018

Canada

Building the Evidence

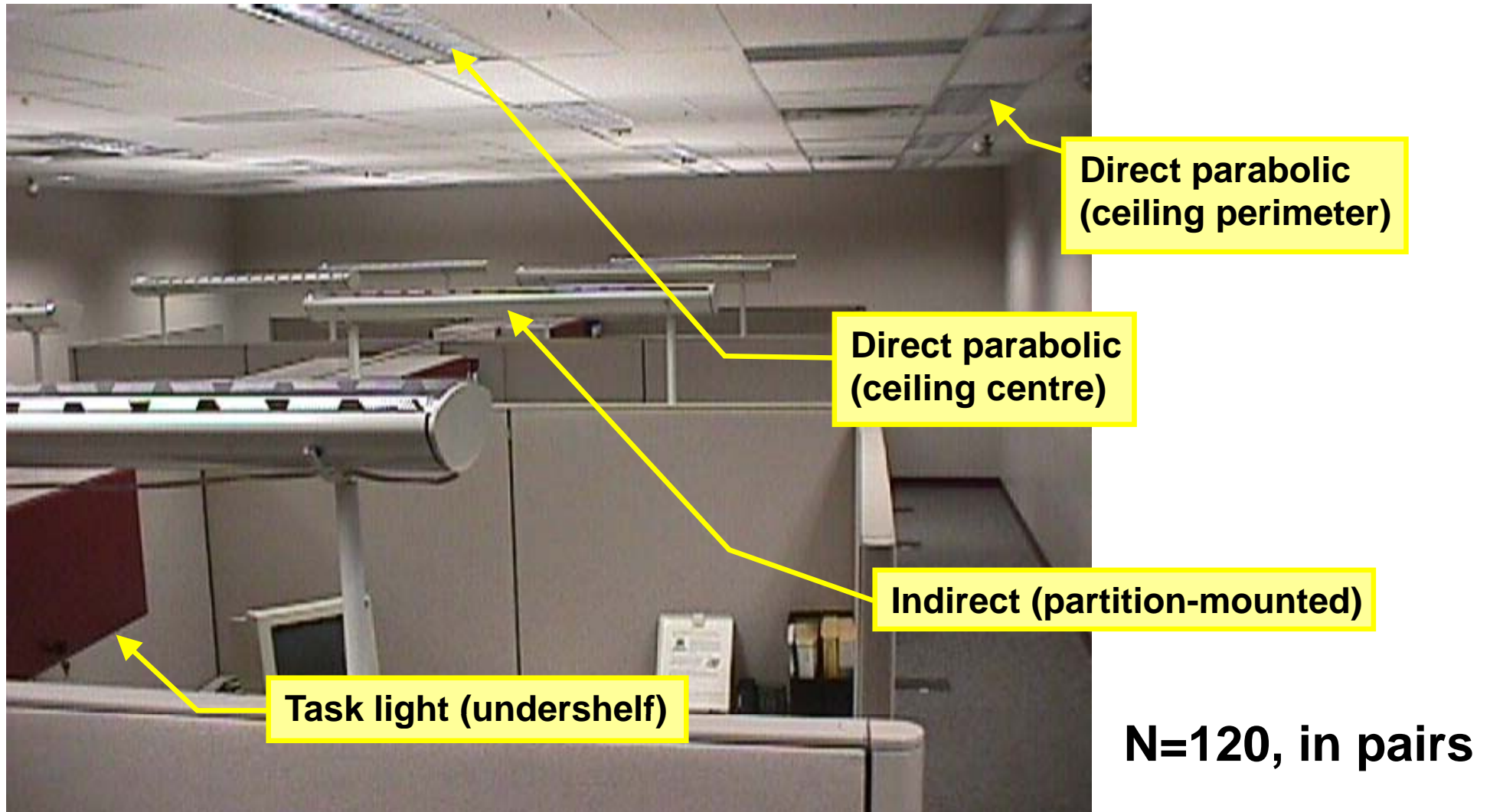
- Highly-controlled laboratory studies
- Quasi-realistic laboratory study
- Field study

15 yrs

Realism

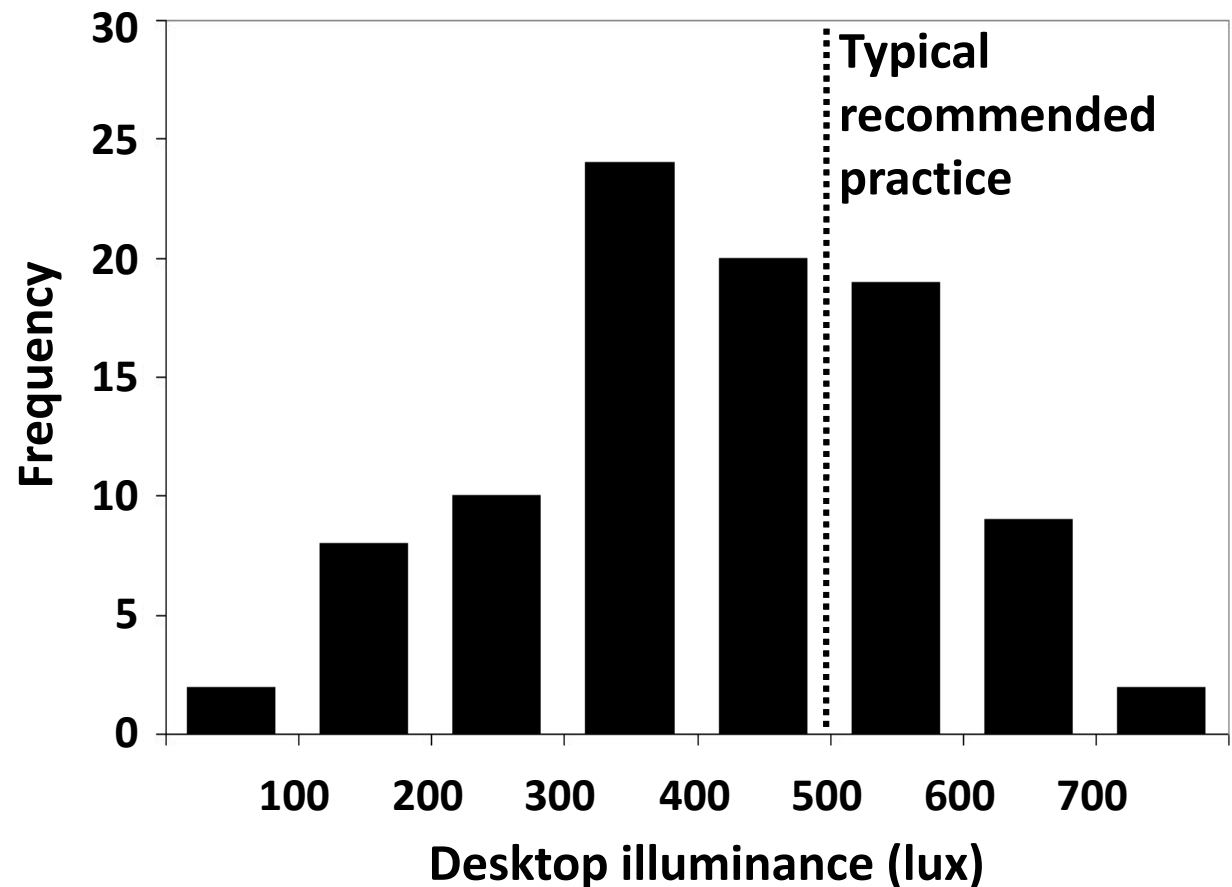
Prior NRC Research

- First laboratory experiment



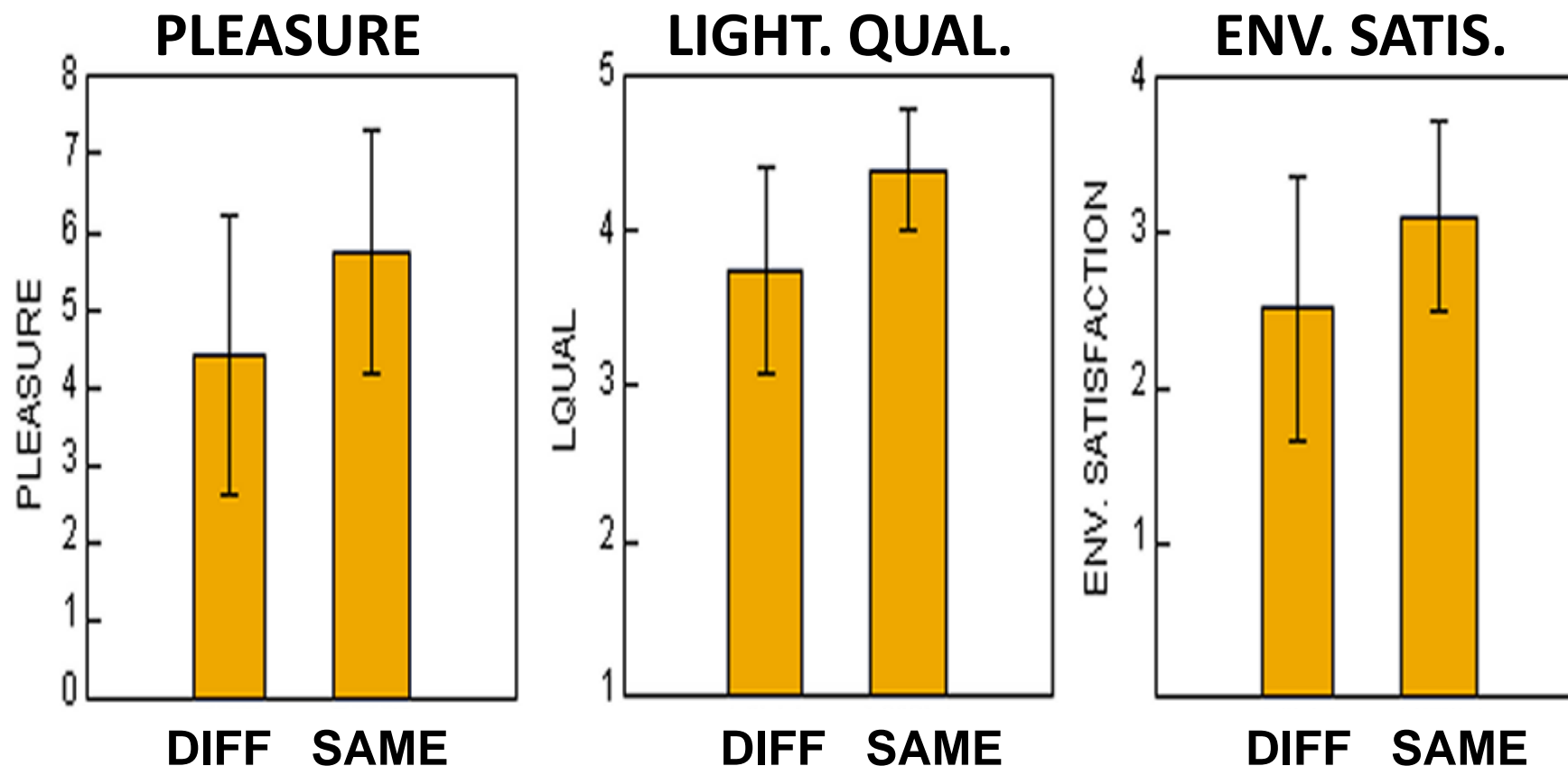
Prior NRC Research (cont'd)

- Chosen illuminance
 - Individual preferences vary
 - Mean ~425 lx ...
 - ... therefore, energy saving 15%



Prior NRC Research (cont'd)

- Satisfaction benefits
 - Within 100 lx of your own preference
 - Further study showed benefits for physical comfort



Prior NRC Research (*cont'd*)

- Preference for a balanced combination of direct and indirect light
 - Desktop illuminance (on average):
60% from direct sources, 40% from indirect
- Supported by more recent studies

Light Right Albany Experiments

Experiment #1



Experiment #2



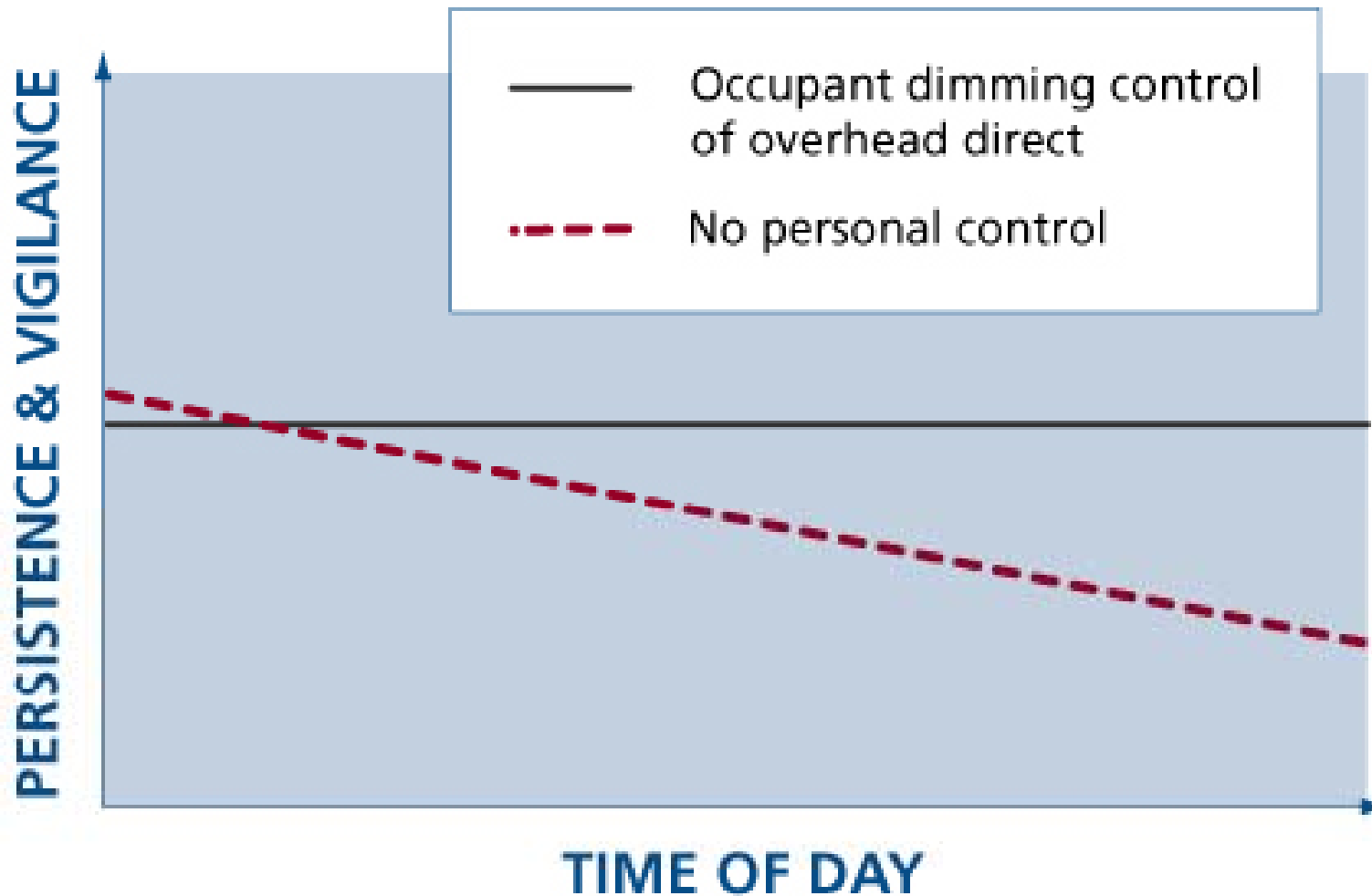
- Temps, 1-day exposure
- Tasks & questionnaires

Light Right Albany Lighting Appraisals

<i>Selected Office Lighting Survey results</i> (* X^2 test shows $p < .05$)	Norm (%)	BG - Afternoon	Repeaters - PM
Overall, the lighting is comfortable	69	% Agree	% Agree
Base Case		71	80
Best Practice		85*	
Switching Control		81	
Dimming Control		91*	98*
How does the lighting compare to similar workplaces in other buildings?	19 60 22	Worse - Same - Better	Worse - Same - Better
Base Case		8 69 24	9 60 30
Best Practice		3 45 53*	
Switching Control		9 52 39*	
Dimming Control		7 43 50*	0 50 50*

Boyce, P. R., Veitch, J. A., Newsham, G. R., Jones, C. C., Heerwagen, J., Myer, M., et al. (2006). Lighting quality and office work Two field simulation experiments. *Lighting Research and Technology*, 38(3), 191-223.

Light Right Albany Control & Persistence



Light Right Field Study

- What about a real workplace?

Method

- Host organization renovation
 - Old lighting: parabolic-louvered luminaires
 - New lighting: workstation-specific direct-indirect with individual control
 - + occupancy sensors and daylight-harvesting
 - Furniture change
- 3 measurement waves (May-June 2008, June 2009, Sept. 2009)
 - Online questionnaire: N=1750 (many > once)
28%-37% response rates
 - Site visit: photometry, acoustics, temperature

Method

Lighting and furnishings combinations in the three buildings, **with valid sample sizes (N) for T₀, T₁, T₂ shown beneath.**

	PARAB	WSDI	WSD
Old panels – teal	Bldg 1, 2 474, 451, 373		
Old panels – grey	Bldg 3 4, 10, 12		Bldg 3 69, 80, 62
New panels	Bldg 1 20, 12, 8	Bldg 1, 2 61, 56/21*, 43	Bldg 3 35*, 50, 45

* Individual control withheld from this group at this time only

Luminous Conditions Nighttime

- HDR photography



Old (Teal) - PARAB



New - WSDI

Luminous Conditions

Nighttime HDR measurements

Furniture	Lighting	N	Picture Ave I	Field of View Ave I	FOV Log(Max:Min)	Ceiling Ave I
Old Teal	PARAB	120	27	19	1.38	62
Old Grey	WSD	30	50	19	1.12	149
New	WSD	29	80	37	1.25	164
New	WSDI	53	103	43	1.18	226

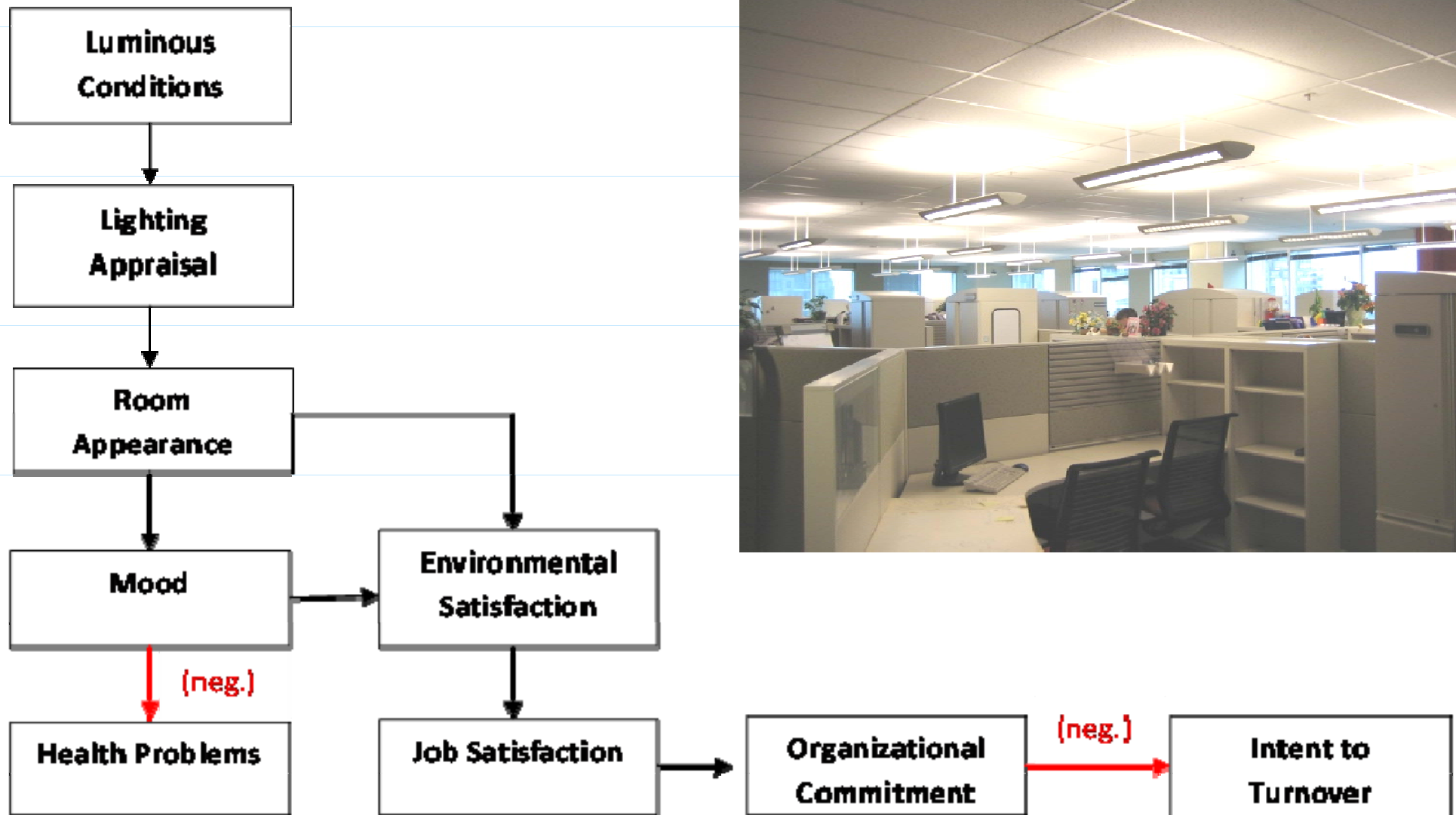
		N	SCALAR_E	V_S_RATIO	E_EYE	E_DESK	TOP:SIDE
Old teal	PARAB	124	259	2.20	168	486	3.66
Old grey	WSD	30	242	2.34	130	367	4.10
New	WSD	28	340	1.96	245	488	3.12
New	WSDI	53	395	2.04	281	557	3.03

Lighting Appraisal

Old Furn Group	N	Comfortable %	N	Worse %	Same %	Better %
<i>Norm</i>		69%		19	60	22
T ₀ Parab	435	83	428	13	74	14
WSD-C	64	95	65	5	26	69
T ₁ Parab	415	84	407	18	68	14
WSD-C	76	95	76	8	42	50
T ₂ Parab	344	81	340	17	69	14
WSD-C	59	95	59	8	46	46

- Effects statistically significant

Linked Mechanisms Map Test



Prior Energy Study Building 3

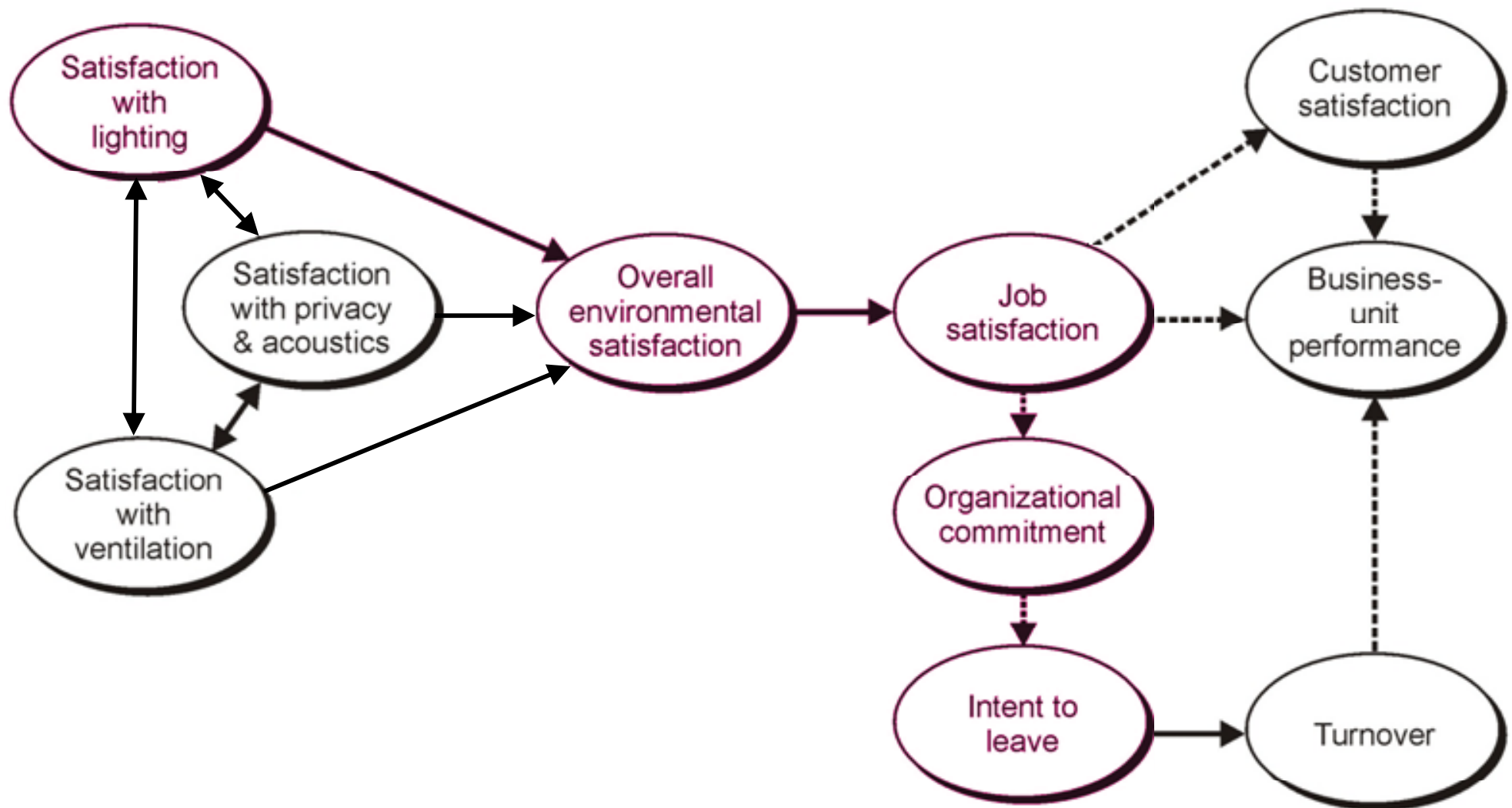
	LPD W/m²	Energy Savings %	Peak Load (W/workstation)
PARAB	10		174
WSDI, 100%	5.6	43	97
WSDI-C actual	3	69	53

Galasiu, A. D., Newsham, G. R., Suvagau, C., & Sander, D. M. (2007). Energy saving lighting control systems for open-plan offices a field study . *Leukos*, 4(1), 7-29.

Conclusions

- Lighting is more than visibility!
- Energy-efficiency can deliver good lighting quality that benefits occupants and organizations, when it is delivered along with:
 - Light distribution that lights all the room surfaces
 - Room surfaces that contribute to the light distribution
 - Individual control to accommodate different needs and desires

Why it Matters



Veitch, J.A., Charles, K.E., & Newsham, G.R. (2004). *Workstation design for the open-plan office* (Construction Technology Update No. 61). Ottawa, ON: National Research Council Canada, Institute for Research in Construction.

Acknowledgements

- NRCan, PERD, CEA
- Light Right Consortium:
 - US Department of Energy, National Electrical Manufacturers Association, New York State Energy Research and Development Authority, BC Hydro, Illuminating Engineering Society of North America, International Association of Lighting Designers, International Facility Management Association, National Research Council of Canada.

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Thank You

Questions?



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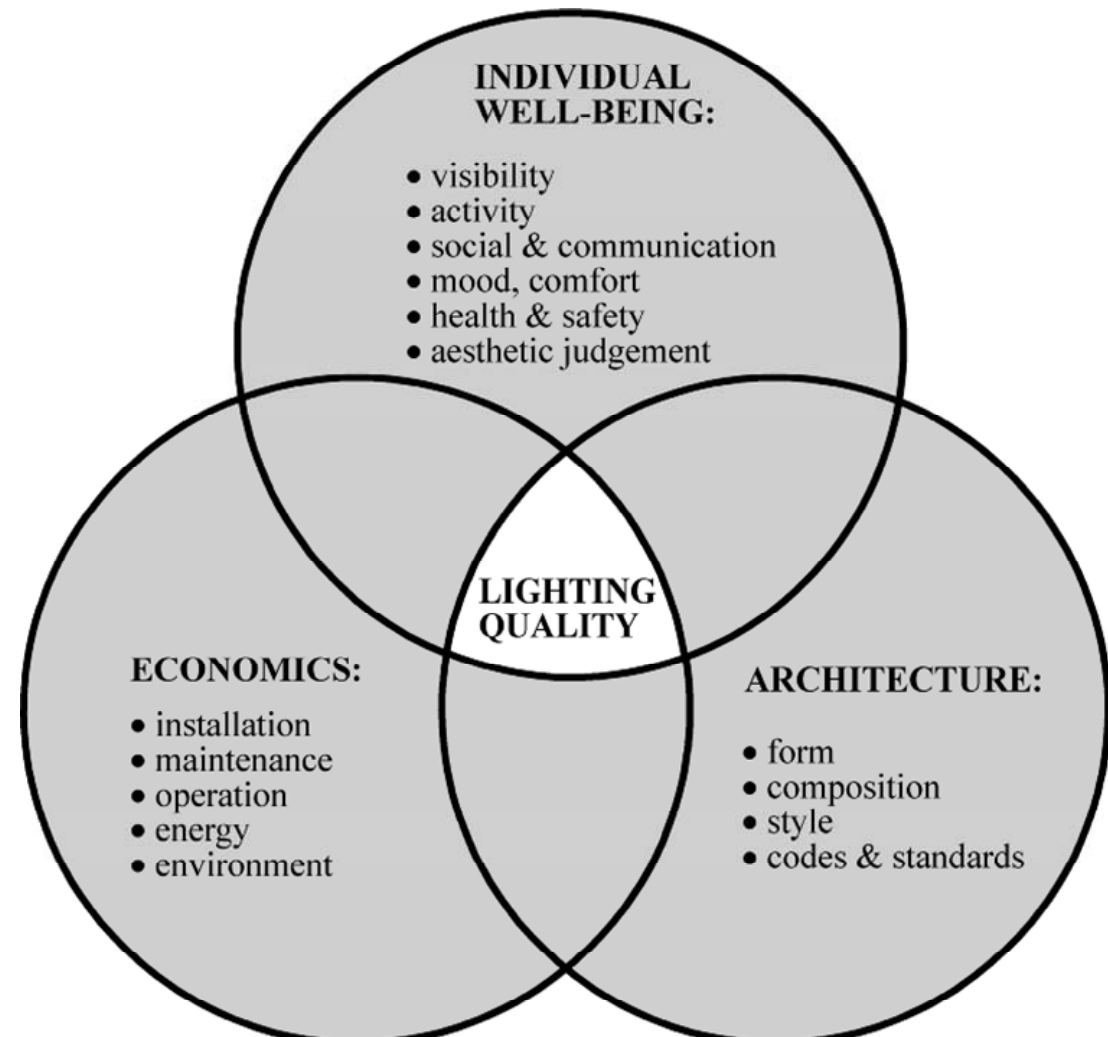
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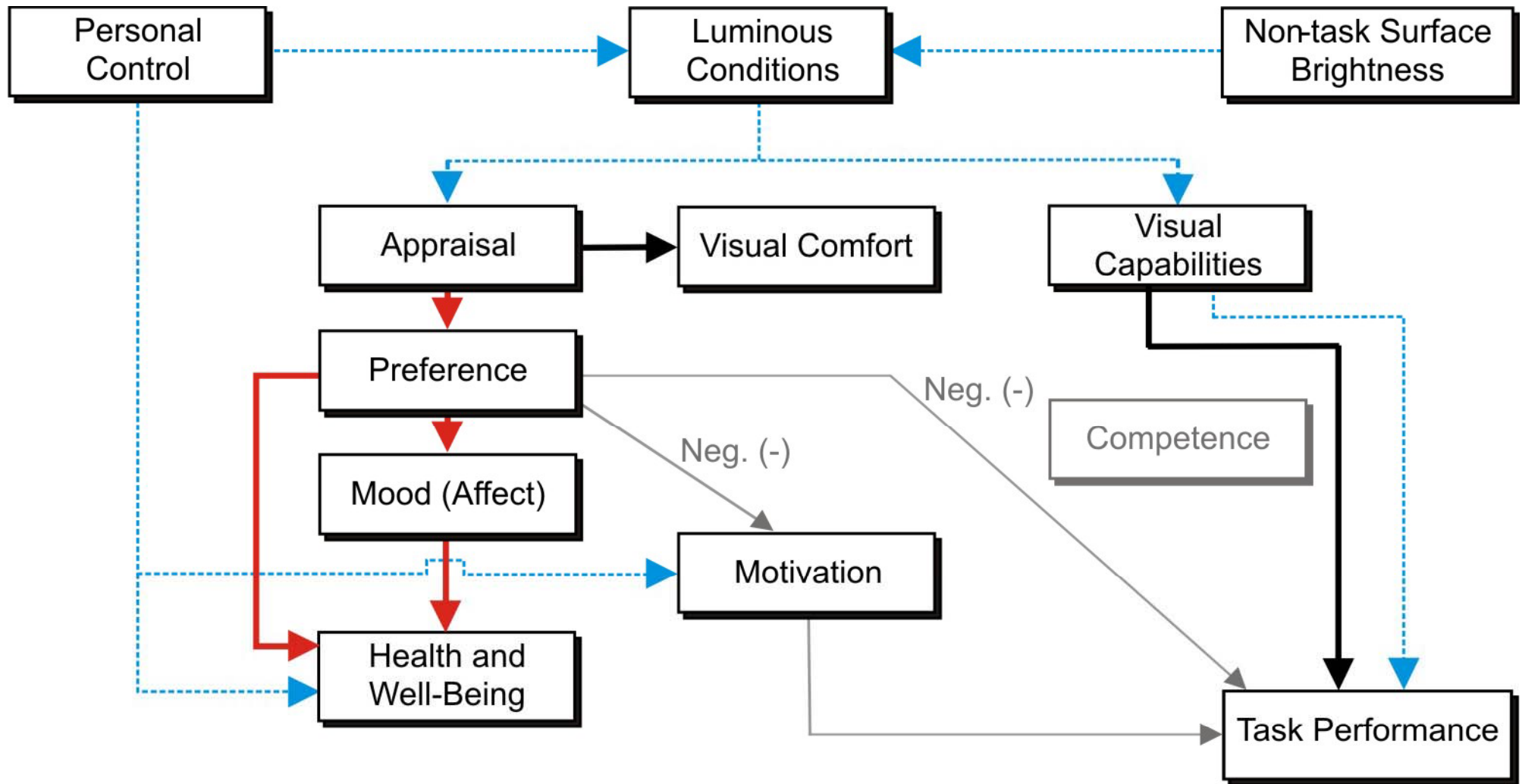
Research Question

- Can office lighting go beyond providing adequate conditions for seeing?
- Can it affect organizational productivity?

→ **Yes.**

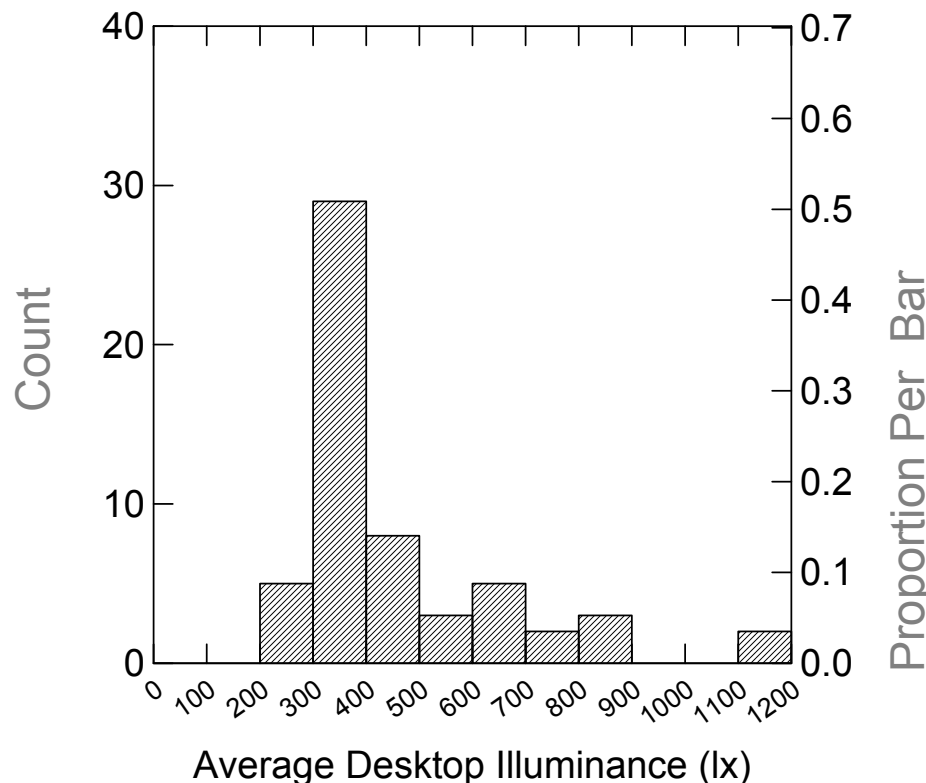


Linked Mechanisms Map - Final



Light Right Albany Preferences

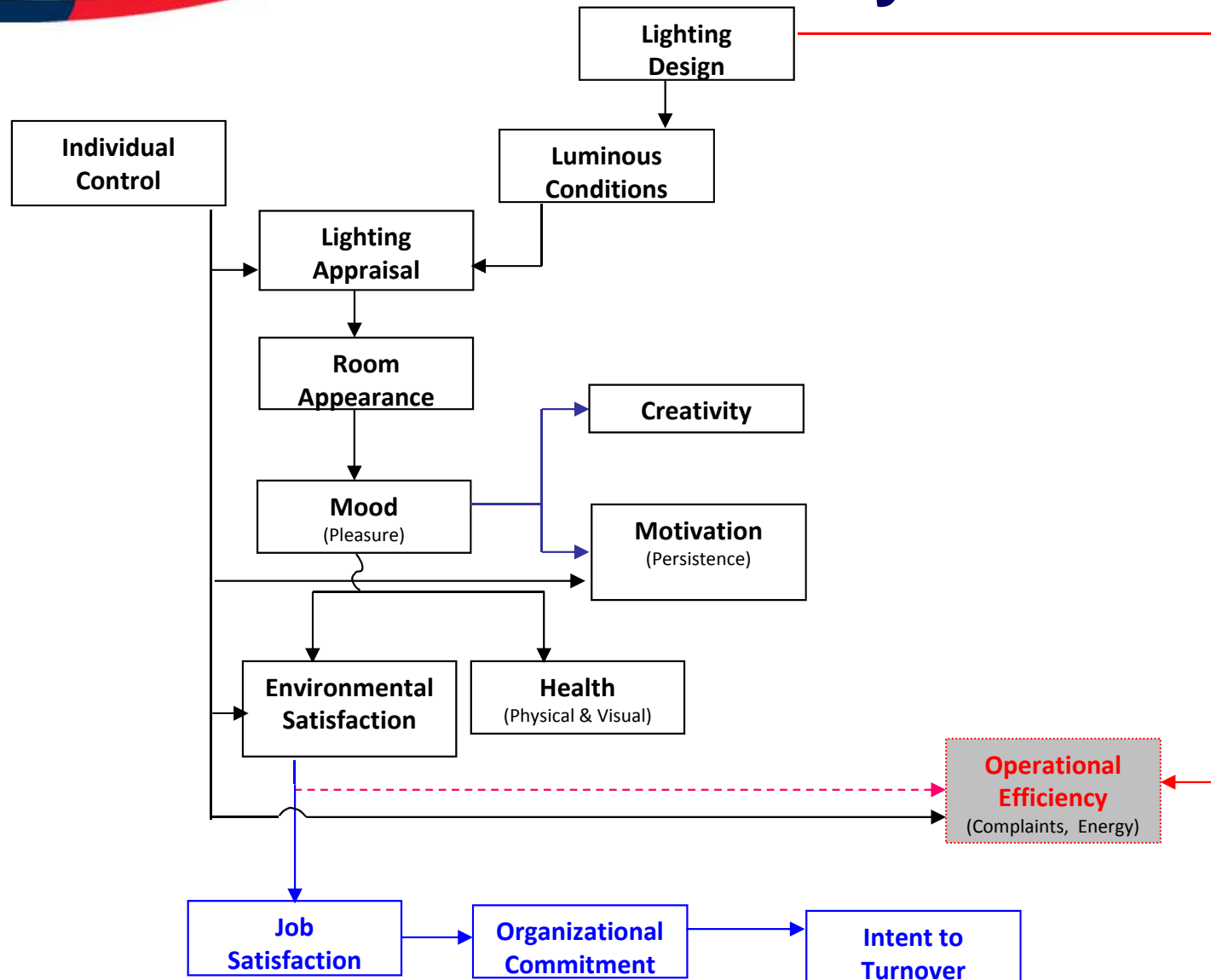
- Control used sparingly, but effectively.
 - Most people used it once, near the start of the day, to choose a preferred condition.



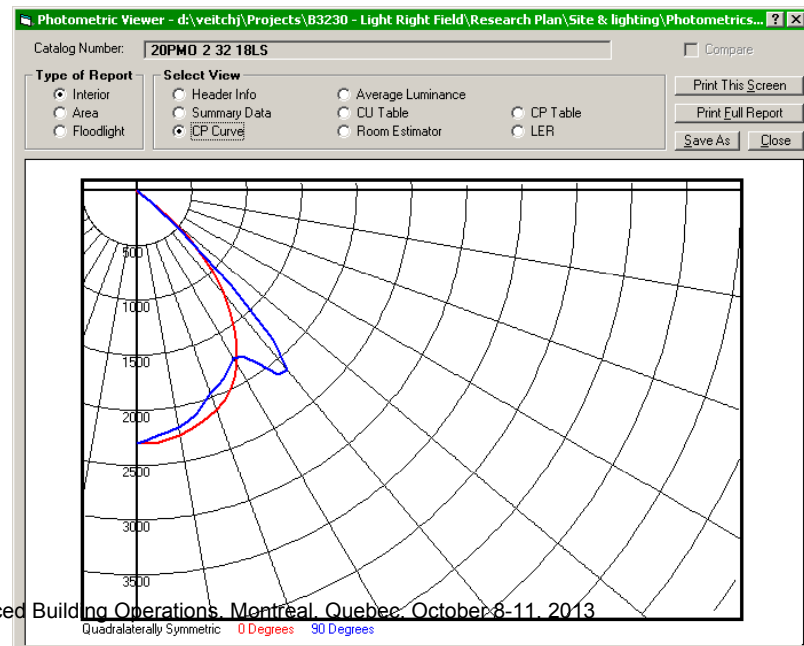
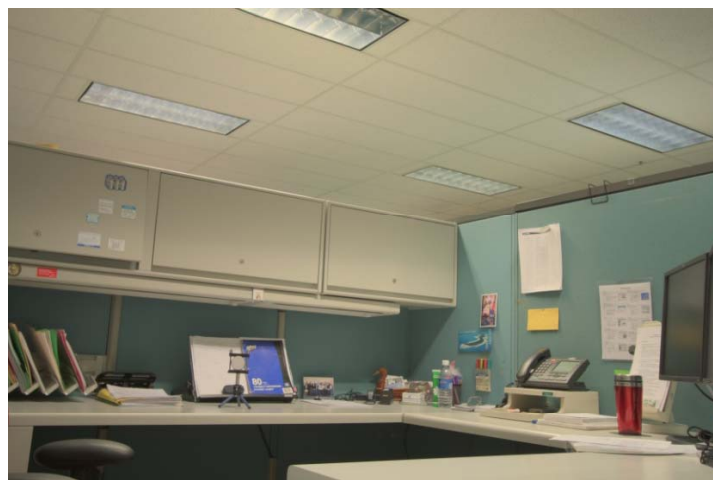
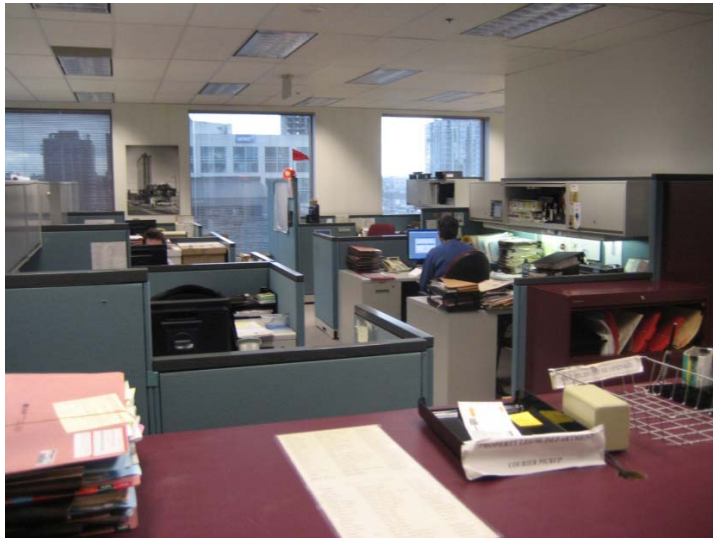
Mean desktop illuminance chosen by participants with Dimming Control.

Boyce, P. R., Veitch, J. A., Newsham, G. R., Jones, C. C., Heerwagen, J., Myer, M., et al. (2006). Occupant use of switching and dimming controls in offices. *Lighting Research and Technology*, 38(4), 358-378.

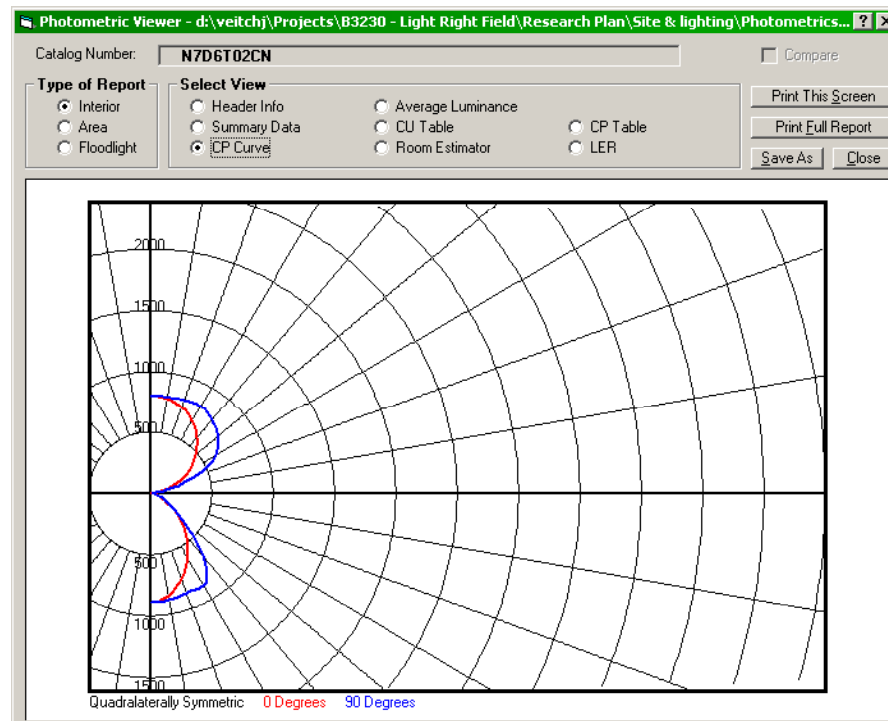
Light Right Field Study - LMM



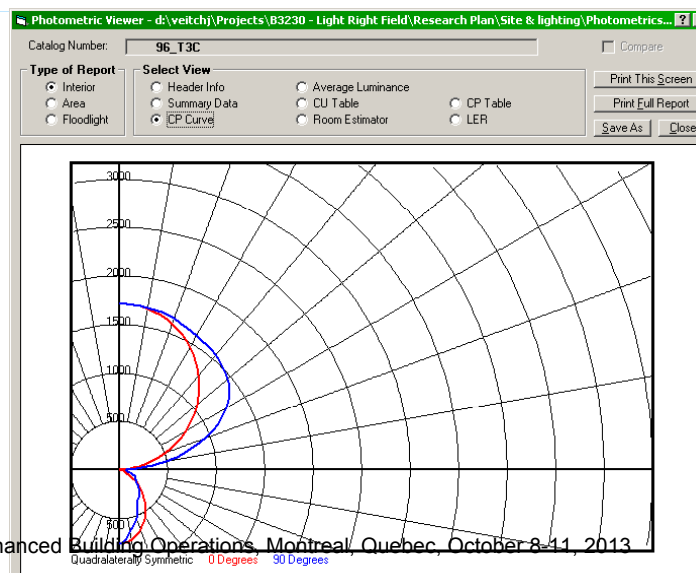
Lighting Conditions — Parab., Old Furniture



Lighting Conditions — WSD, Old Furniture



Lighting Conditions — WSDI, New Furniture



Questionnaire: Analyses

- Total participation over 3 surveys: 1750 people (many more than once) (28%-37% response rates)
- Slightly more women (49% vs 45%), slightly younger (41 vs 42.7), than organization
- Planned comparisons
- Checked for pre-existing differences between groups: age, sex, job category, education, organizational tenure, first language, job demands, communication & social support