International Commission on Illumination
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Drawing Causal Inferences in Applied Lighting Research: Threats to Validity

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NRC·CNRC

CIE Expert Tutorial & Workshop on Research Methods for Human Factors in Lighting
Copenhagen, Denmark
August 2018

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Definitions

- *Scientific research* is a systematic, controlled, empirical, and critical investigation of hypothetical propositions about the presumed relations among natural phenomena.
  What happens to Y when X changes?
- *Hypothesis:* a tentative proposition about the relation between two or more phenomena or variables.
  X causes Y.

(Above credit to F. N. Kerlinger)

- Inductive inference:
  - Causes covary with effects
  - Causes precede effects
  - Spurious causes can be eliminated

More Definitions

- *Construct*: a concept which is invented or adopted for a special scientific purpose, e.g., “brightness."
- *Operational definition*: assigns meaning to a construct or a variable by specifying the operations necessary to measure it.

(Above credit to F. N. Kerlinger)

- ***Examples?***

Research Designs

- True experiments
  - Laboratory experiments
    - Maximal experimenter control over:
      - manipulated independent variables
      - elimination of unwanted variability
      - participant characteristics
    - Limited contextual richness
  - Field experiments
- Correlational investigations:
  - Observations
  - Surveys

Laboratory Experiments

- Two common research designs
  - Within-subjects - everyone experiences all experimental conditions
  - Between- subjects - participants randomly assigned to one experimental condition

Demonstration: The Law of Large Numbers

Research Design Decisions

- How will my investigation eliminate alternative explanations?
  - internal validity [Fotios too]
  - construct validity [Fotios too]
  - statistical conclusion validity [Uttley]
- To what people, settings, or times do I want to apply the results, and how far may I take this?
  - external validity

Internal Validity

- Test falsifiable hypotheses
  - Comparison group!
- Eliminate alternative hypotheses
- Eliminate sources of bias, including...
  - Participant expectations
  - Experimenter expectations
  - Participant selection (non-random group assignment)
  - Differential attrition
  - Testing (learning, fatigue, familiarity...)

Experiment #1

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

Construct Validity of Causes

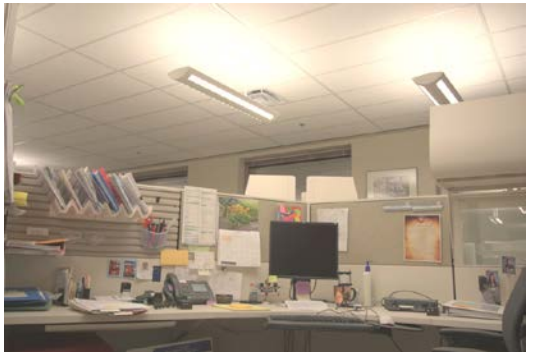
- Confounding
  - When more than one variable changes at a time
- Inadequate specification of conditions
  - See Day 1 presentations!
- Arbitrary choice of conditions
  - Refer back to the theory you want to test
  - Include levels that provide a meaningful comparison
  - Consider including extremes for which you have knowledge

Construct Validity of Outcomes

- Specify measurement operations
  - If a validated measurement of Y exists, use it!
- Multiple measures – avoid mono-method bias
- Assess validity & reliability of measurement tools

External Validity

- Generalizability
- Random selection from population
- Sample representativeness, preferably not just :
  - WEIRD: White, Educated, Industrialized, Rich, and Democratic. 99% of all published studies rely on participants recruited from populations that fit those criteria.
- Setting representativeness



Conclusions and Discussion

- Research design is a creative – and balancing – act
- There are few right and wrong answers – mostly trade-offs

- ***Discussion and thoughts...***

Classic Resources

- Cook, T. D., & Campbell, D. T. (Eds.). (1979). *Quasi-experimentation: Design and analysis for field settings*. Boston, MA: Houghton Mifflin.
- Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Boston, MA: Houghton Mifflin.
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- Ghiselli, E. E., Campbell, J. P., & Zedeck, S. (1981). *Measurement theory for the behavioral sciences*. San Francisco, CA: W. H. Freeman.

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