

Experimental Control
How to avoid threats to validity

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Experimental Control

- I. Introduction: Goals
- II. Types of Experimental Control
- III. Means of Achieving Control
- IV. Summary

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I. Introduction: Goals

- A. Infer true causal relations
 - 1. Rule out alternative explanations (threats to validity)
 - 2. Hold “all other things equal” constant influence of extraneous factors

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I. Introduction: Goals

B. Determine true functional relations

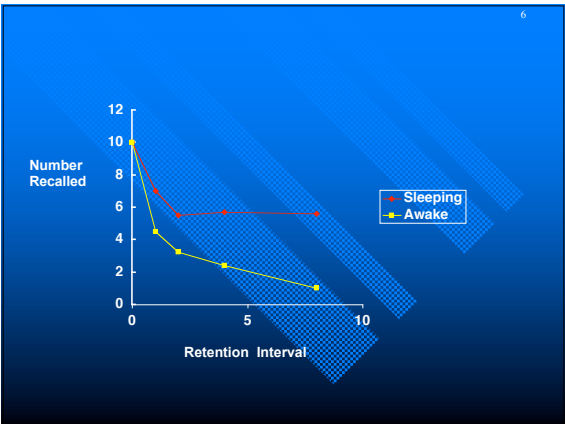
1. control over the levels of a variable
2. Hold all else constant

Example: Jenkins & Dallenback (1924)
Memory as a function of retention interval

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Jenkins & Dallenback (1924)

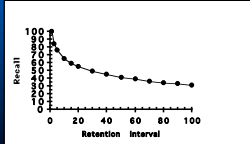
Two subjects studied non-sense syllables
They were tested either immediately, 1, 2, 4 or 8 hours later
During the retention interval they either were **awake** doing daily activities, or they **slept**.



The retention Curve

If memory is the result of two (or more) processes (STS and LTS), it should show up in the shape of a curve plotting retention as a function of time.

Classic Shape of the curve: (Woodworth, 1938)



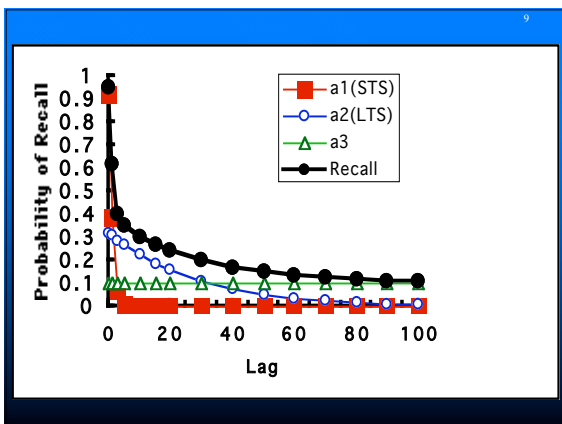
$$y = b - m \cdot \ln(t)$$

B. Rubin, Hinton, & Wenzel (1999)

Used a continuous recall task to get a lot of data to precisely model the time course of retention.

The best fitting curve was the sum of three different log functions.

$$recall = a_1 e^{-t/1.15} + a_2 e^{-t/27.55} + a_3$$



II. Types of Experimental Control ¹⁰

A. Experimental versus Control groups

Experimental group: treatment

Control group: no treatment

Control group is necessary for a comparison

Example: use of a computer to aid instruction

II. Types of Experimental Control ¹¹

B. Control over the levels or values of the independent variable

Example: the effects of cigarette smoking on the number of colds a person gets in a year
- must control cigarette smoking.

II. Types of Experimental Control ¹²

C. Control over the experimental setting - preventing extraneous variables

Example: controlling the noise in an auditory perception experiment

II. Types of Experimental Control

D. Control Variable: a potential independent variable that is held constant across conditions in an experiment.

Example: survey of attitudes toward sexual harassment in the workplace

Control: gender, age, race, etc.

III. Means of Achieving Control

A. Randomization

1. Random selection

each person in a population has an equal opportunity to participate in the research.

- issue external validity of the results
- not really possible

A. Randomization (cont)

2. Random Assignment:

each participant or item has an equal opportunity to be in each treatment condition.

- easy to accomplish
- necessary to protect internal validity

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A. Randomization (cont)

3. What randomization accomplishes

- a) avoids systematic differences

- b) controls both known and unknown variables.

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A. Randomization (cont)

4. Things to randomize:

- subject assignment to condition
- use of research materials or items
(e.g., words in a list)
- order of treatments
(e.g., drug, no drug, . . .)
- order of questions on a questionnaire

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A. Randomization (cont)

5. How to randomize

- step 1: assign values to outcomes
(e.g., heads = females)
- step 2: create a random series of outcomes
 - flip coins
 - draw cards
 - use a random numbers table

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Random numbers table (p. 446)

10480	15011	01536	02011
22368	46573	25595	85393
24130	48360	22527	97265
42167	93093	06243	616580
37570	39975	81837	16656
77921	06907	11008	42751
99562	72095	56420	69994
96301	91977	05463	07972

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III. Means of Achieving Control

B. Counterbalancing

Definition: A means to systematically vary important control variables so that their influences are equally distributed across conditions.

Insures that each condition precedes and follows each other condition an equal number of times.

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Counterbalancing (cont)

Things to counterbalance:

- order of treatments
- order of questions
- position of items
- subject variables (e.g., reading level)

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Counterbalancing (cont)

With 2 levels of an independent variable:
Intra-subject counterbalancing:
A B B A

Example: effects of caffeine on reading speed.
Without counterbalancing: Caffeine, No Caffeine
With counterbalancing:
No Caffeine, Caffeine, Caffeine, No Caffeine

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Counterbalancing (cont)

Intragroup Counterbalancing:

Group 1: A B
Group 2: B A

Example
Group 1: Caffeine, No Caffeine
Group 2: No Caffeine, Caffeine

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Counterbalancing (cont)

With four levels of an independent variable:
A= caffeine
B= cold medicine
C= alcohol
D= no medication

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Counterbalancing (cont)

<u>Latin Square</u> A B C D B C D A C D A B D A B C	<u>Balanced Latin Square:</u> A B C D B D A C C A D B D C B A
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Counterbalancing (cont)

Counter balancing a subject variable:
(e.g. reading speed)
Rank the subjects: 1, 2, 3, 4, 5, 6, . . .
Cond 1: 1, 4, 5, 8
Cond 2: 2, 3, 6, 7

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III. Means of Achieving Control

Matching
Definition: A means of controlling a variable by attempting to equate it across conditions.

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Matching (cont)

Things to match:

- subject variables: IQ, SES, Age, Gender, . . .
- stimulus variables: word frequency, word length . . .
- environmental variables: time of day, room . . .

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Matching (cont)

Matching procedures:

- 1) **Hold the variable constant**:
 - example: hold reading level constant in drug study.
 - problem: limits external validity

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Matching procedures: (cont)

2. **Matched Groups**:
 - hold the average across groups constant
 - Example: construct 2 groups that have the same mean reading level
 - Problem: may hold the mean constant, but the range and variance may be very different.

Matching procedures: (cont)

3. Incorporate the Variable as an additional independent variable.

Example:

	Caffeine	No Caffeine
Reading level 1		
Reading level 2		
Reading level 3		

Problem: may lead to very large experimental designs.

Matching procedures: (cont)

4. Yoking

Pair subjects or items on an important dimension, and then randomly assign one member of each pair to each condition.

Yoking

Brady (1958) “executive monkey”
(an example in yoking)

Monkeys trained to avoid an electric shock by pressing a lever whenever a light came on.

Each press of the lever postponed the shock for 20 sec.

Four pairs of monkeys were paired so that one monkey received the same shock as the “executive” that could avoid the shock.

Brady (1958) "executive monkey"

Results: All four executive monkeys developed ulcers, while none of the yoked monkeys did.

Conclusion: The stress of making decisions caused the ulcers.

And now for the rest of the story!

Executive Monkeys Part Deux"

How were the monkeys select for the executive positions?

Monkeys that were easy to train (high responders) were selected as executives. Weiss (1971) demonstrated that high responders were more prone to ulcers than low responders.

Executive Monkeys Part Deux"

Study repeated with the animals equated for activity level.

Animals that had control had less severe ulcers than those that do not have control (Faltz & Millett, 1964; Naletson, 1976)

IV. Summary

- A. Goal: to conduct research that is free from threats to validity.
- B. This means exercising control over the important variables
- C. Primary Means of Achieving that control:
 - randomization
 - counterbalancing
 - matching
