

# Grouping in Experiments

# EXPERIMENTS

```
graph LR; A[EXPERIMENTS] --- B[Completely Randomized Design]; A --- C[Randomized Block Design]; A --- D[Matched Pairs Design];
```

Completely Randomized Design

Randomized Block Design

Matched Pairs Design

# Topics

1. Blocking
2. Matched pairs design
3. Blinding and placebo
4. Generalizing study results

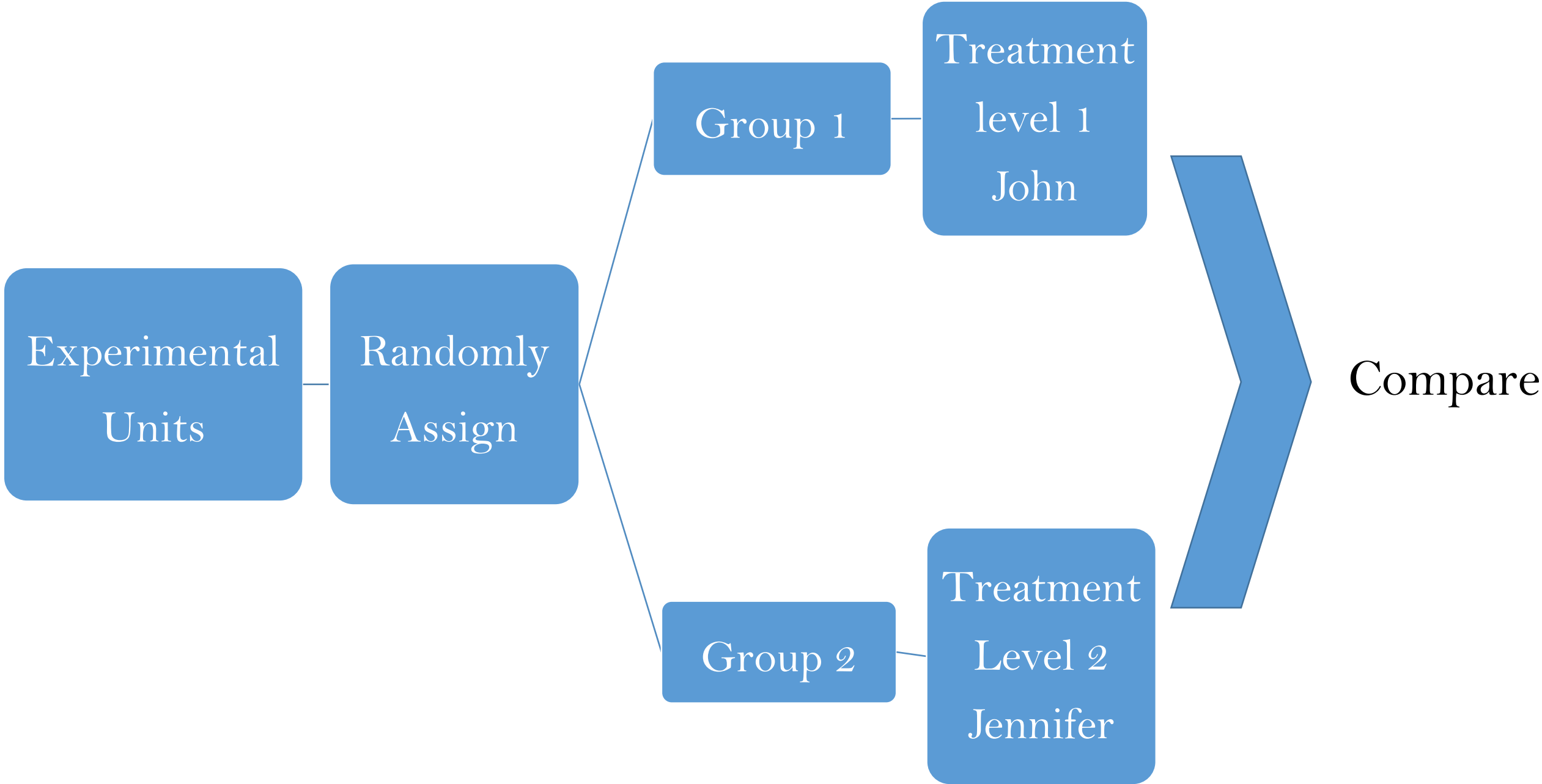
# Topics

1. **Blocking**
2. Matched pairs design
3. Blinding and placebo
4. Generalizing study results

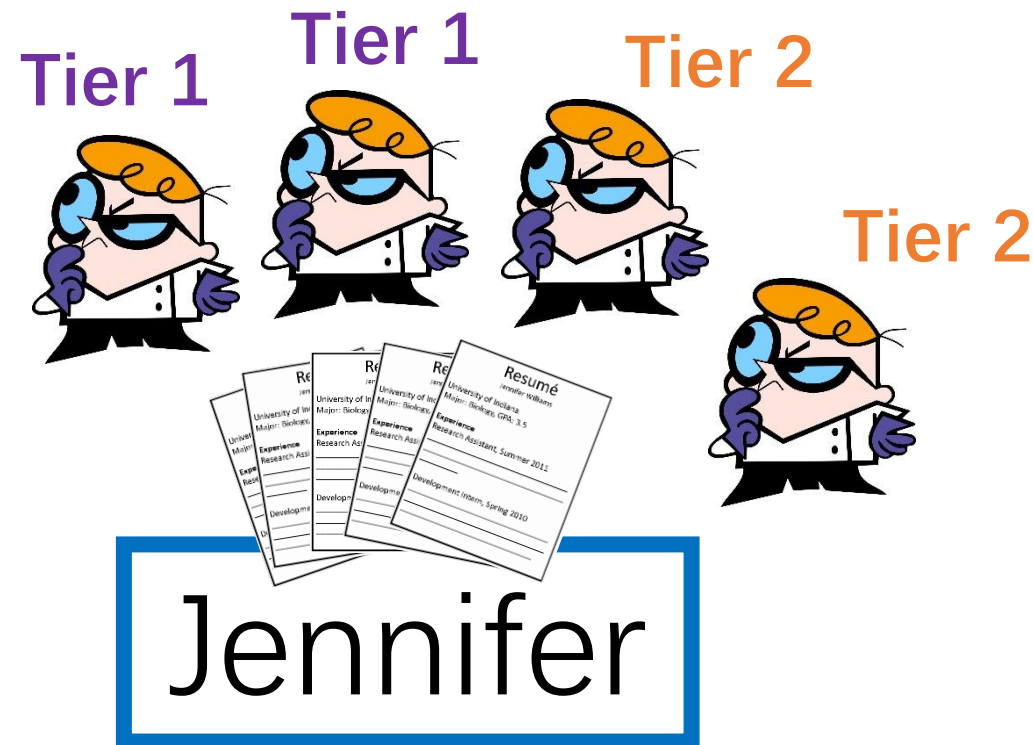
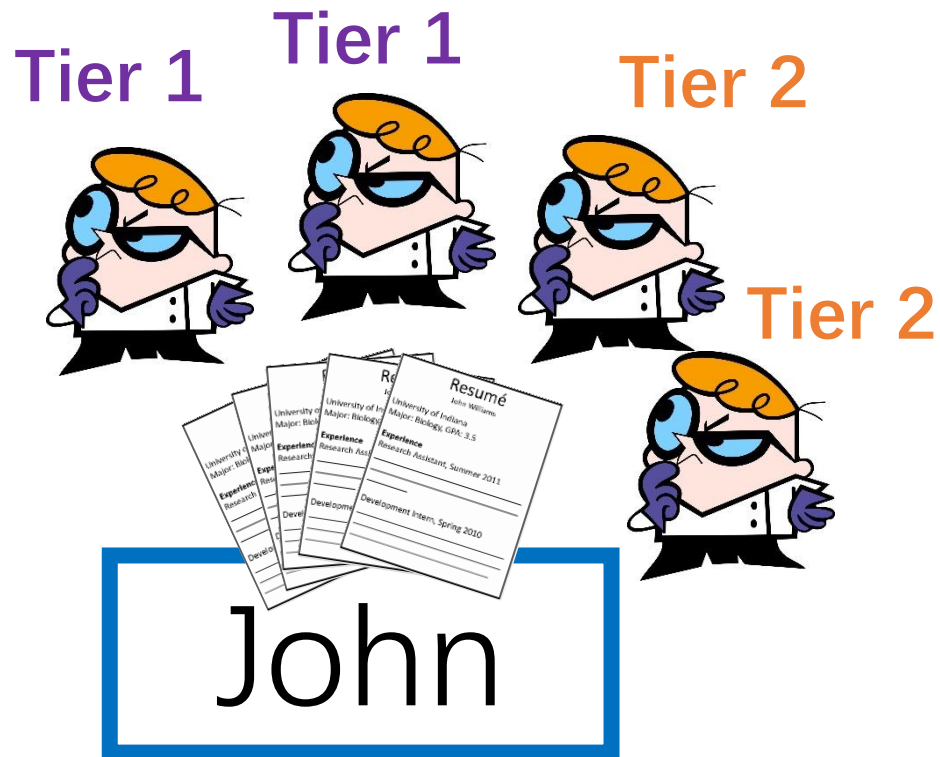
# Completely Randomized Design

Completely randomized design: An experimental design in which experimental units are assigned to treatments completely at random.

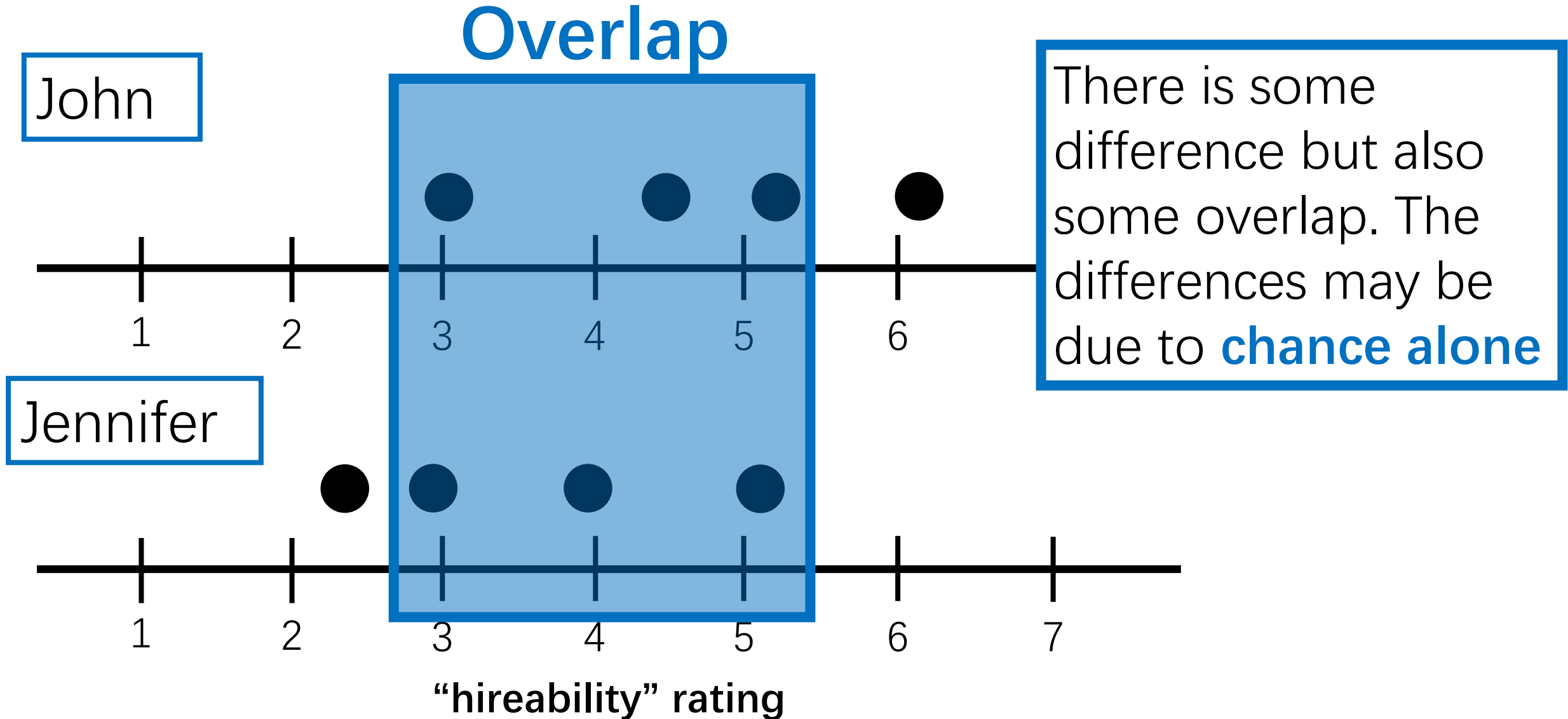
- This is the “**SRS**” of experiments – the simplest (but still effective) randomized experiment.



What if the faculty members were from both **Tier 1** and **Tier 2** Universities?

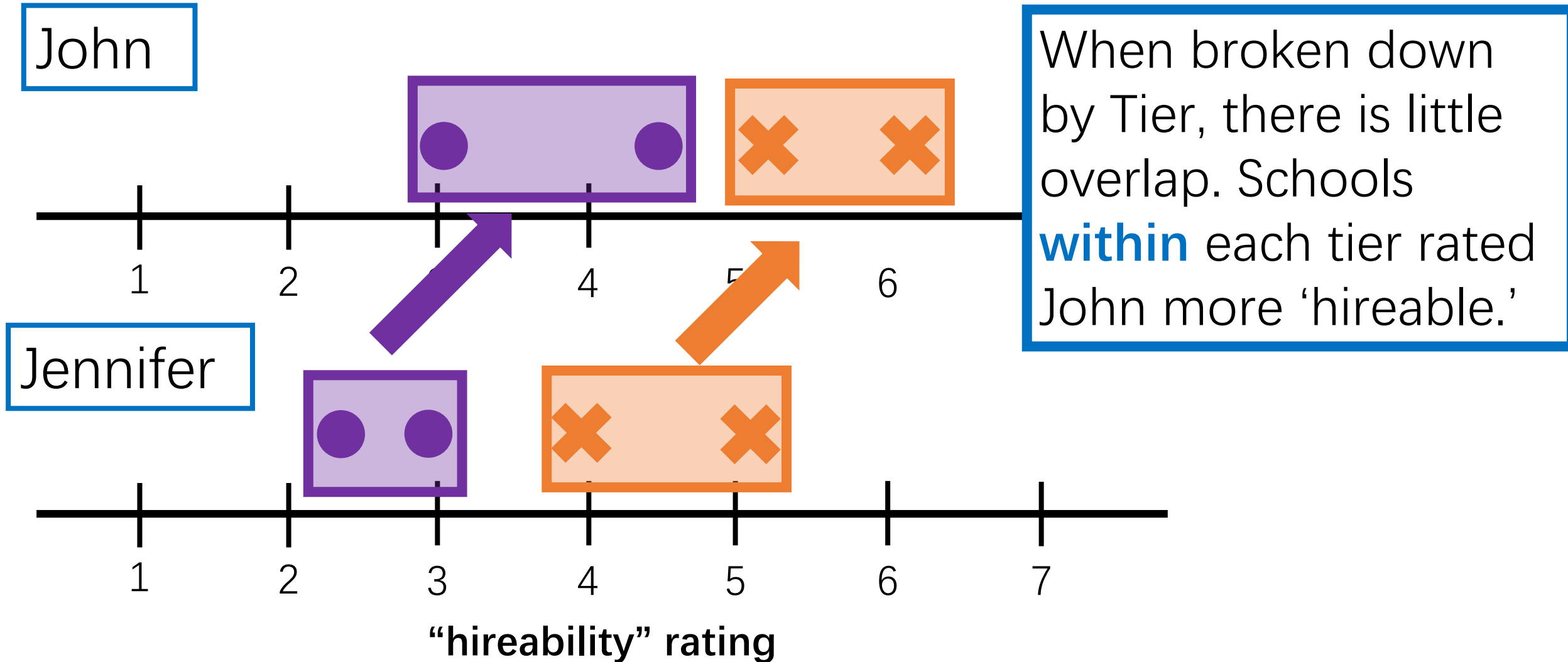


# Variation in Random Assignment





# Variation in Random Assignment



How do we reduce the  
**variability** due to school  
tier?

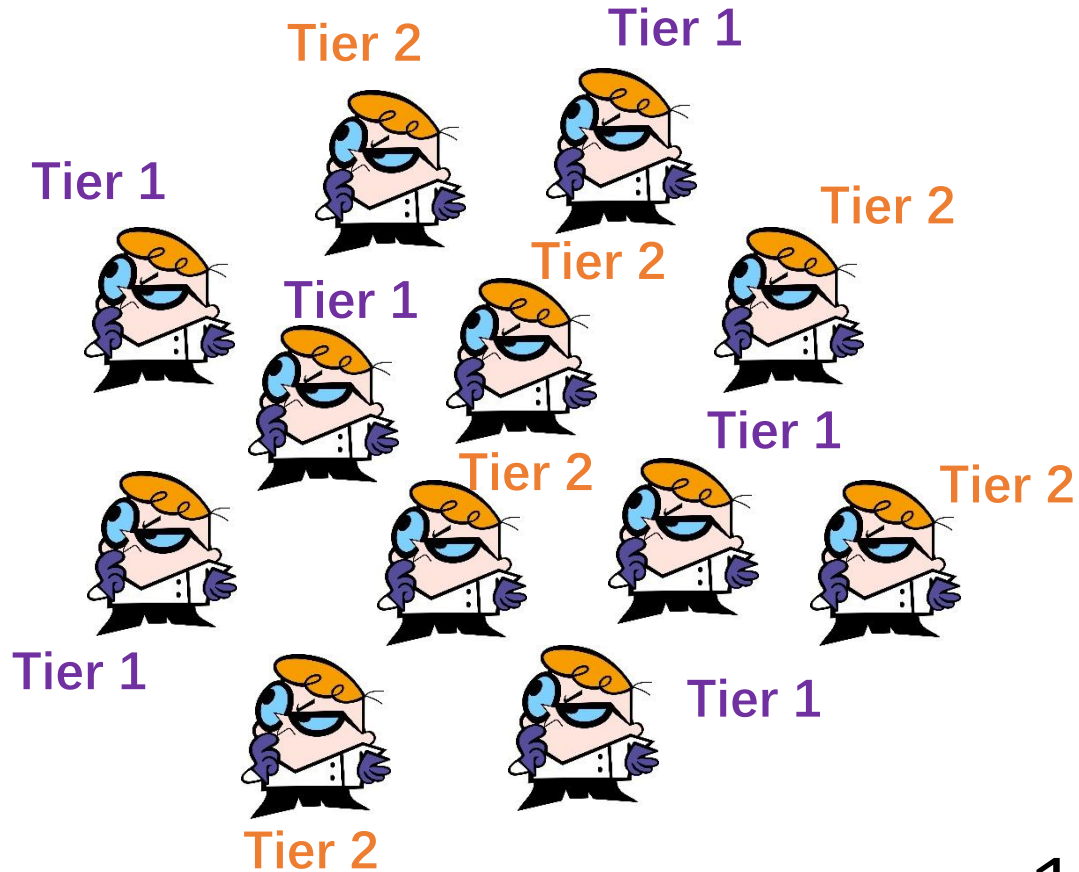
# Randomized Complete Block Design

## Randomized Complete Block Design:

experimental units are first blocked (**grouped**) by a similar trait that may affect response. Then, units from each block are randomly assigned to treatment.

- This is the “**stratified sample**” of experiments
- It reduces variation between treatment groups at the start of the experiment. This makes it easier to show that differences in response are really **due to treatment**, rather than chance variation in the random assignment.

“Describe a randomized block...”

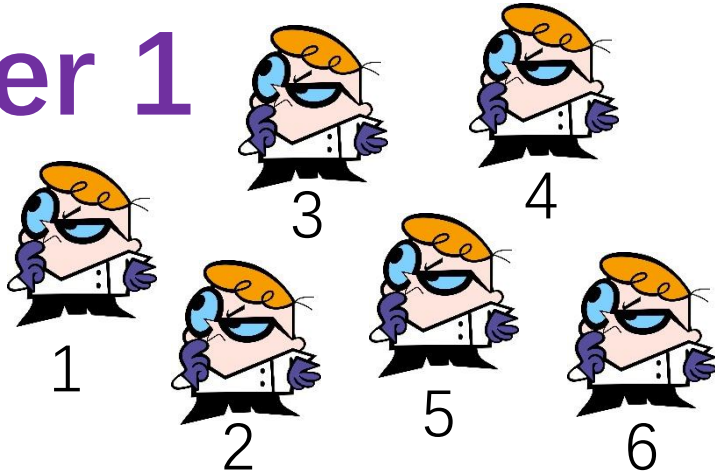


$n = 12$

Block the science lab faculty members by University tier. In each block, assign each faculty member **a number 1 – 6**.

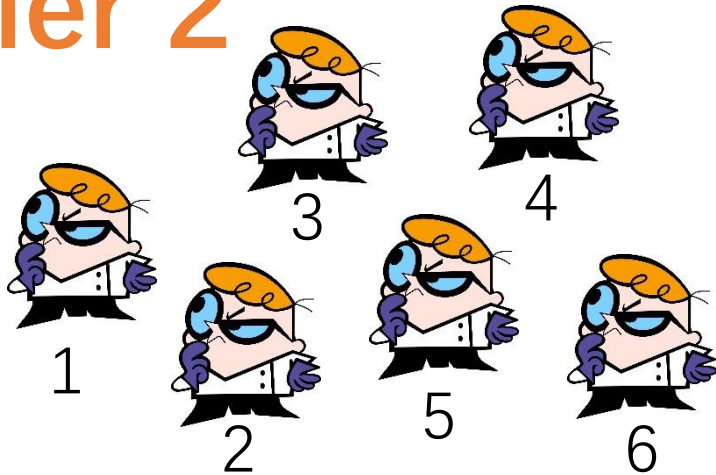
# “Describe a randomized block…”

## Tier 1



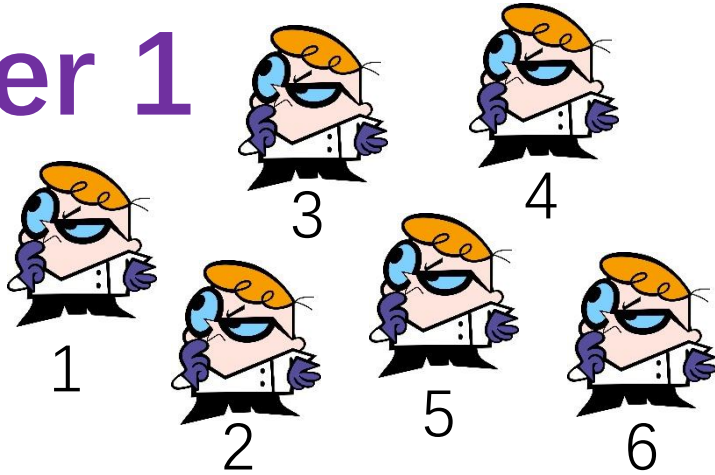
Block the science lab faculty members by University tier. In each block, assign each faculty member **a number 1 – 6**.

## Tier 2



# “Describe a randomized block…”

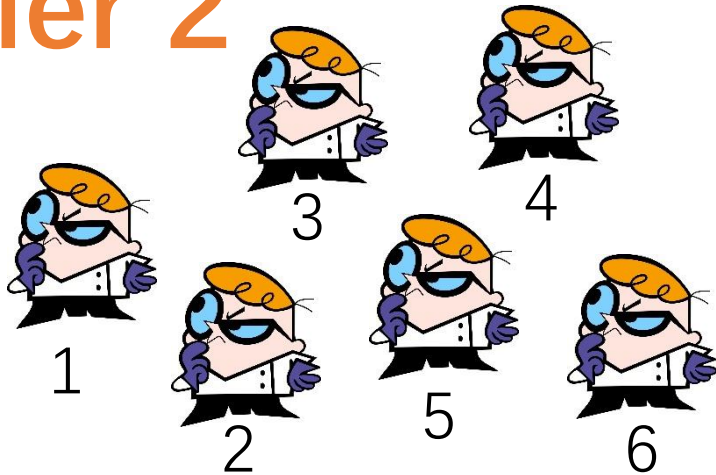
## Tier 1



For the Tier 1 block, write all the numbers on identical slips of paper, put into a hat, and mix well.

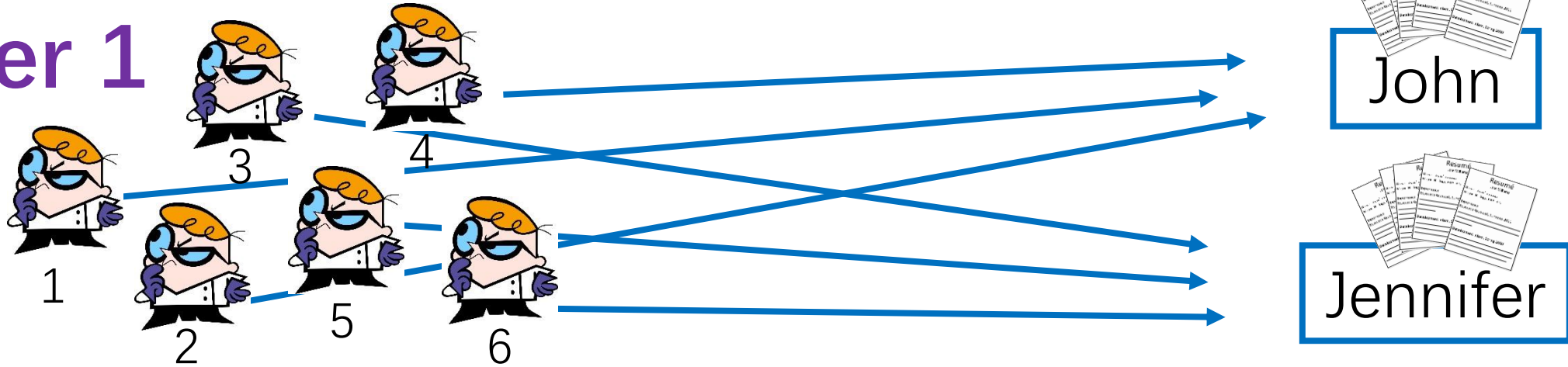
Draw out 3 slips of paper, **without replacement**. The corresponding faculty are assigned ‘Jennifer’ application materials. The remaining are assigned ‘John’ materials.

## Tier 2



# “Describe a randomized block…”

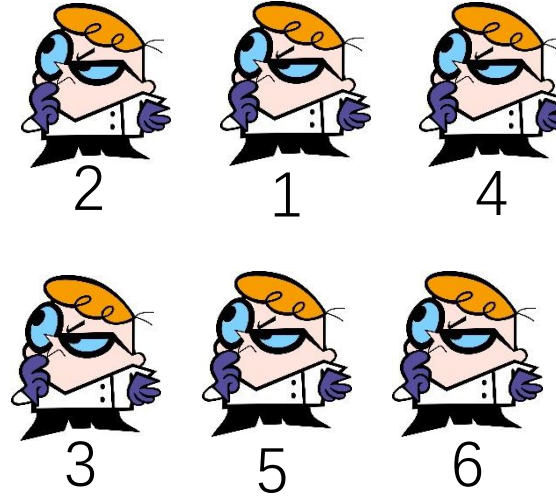
## Tier 1



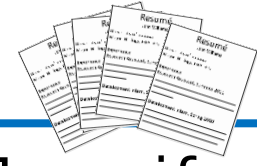
## Tier 2



# “Describe a randomized block…”



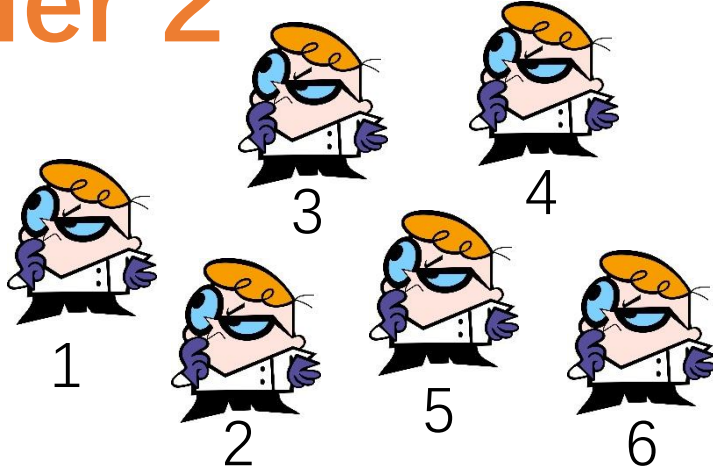
John



Jennifer

Tier 1

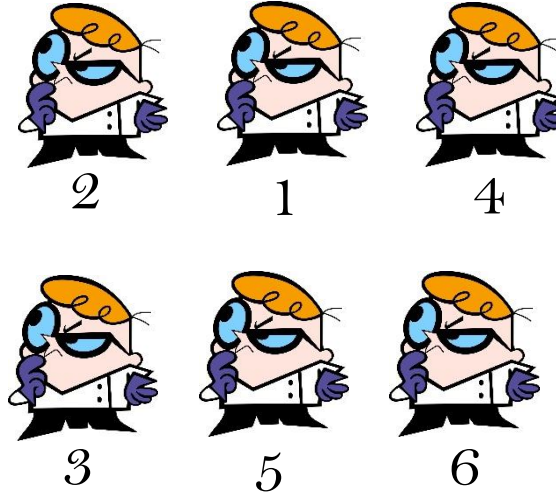
## Tier 2





# “Describe a randomized block...”

**Repeat** the same random assignment process for the Tier 2 block.

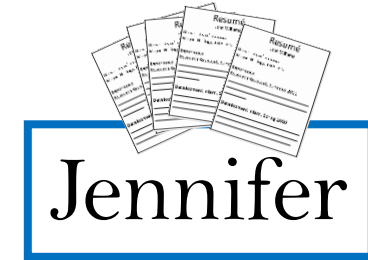
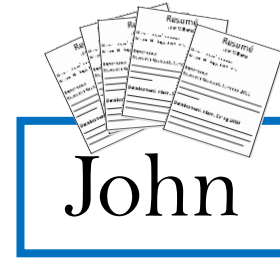


Tier 1

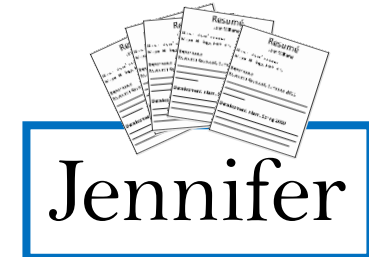
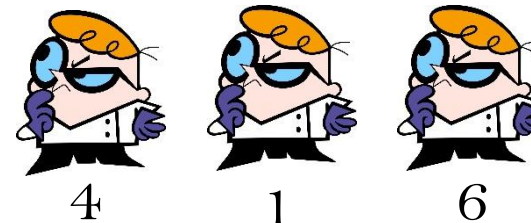
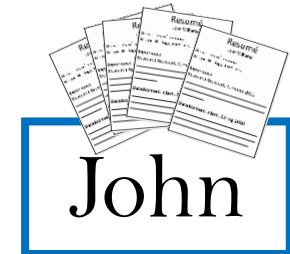
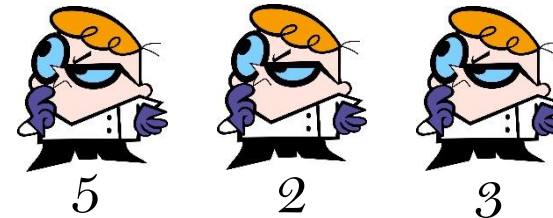
## Tier 2



# “Describe a randomized block...”



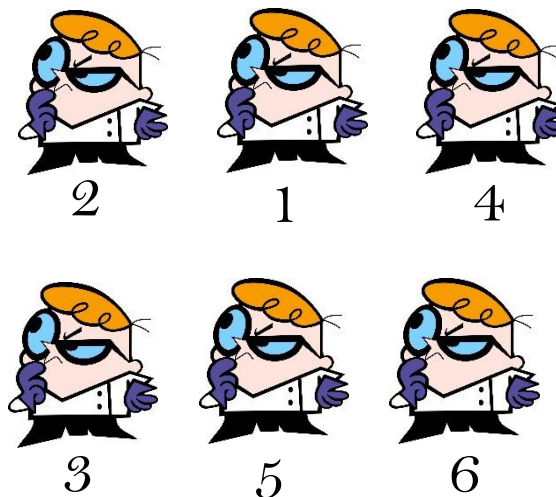
Tier 1



Tier 2

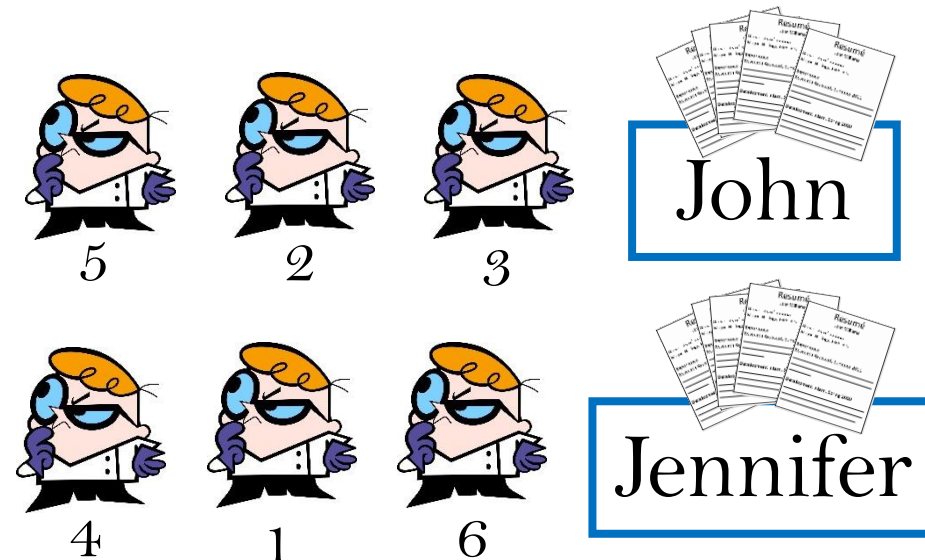
# “Describe a randomized block...”

“Compare ‘hireability’ ratings between the Jenn/John groups **within** each block.”



Tier 1

“Compare ‘hireability’ ratings between the Jenn/John groups **within** each block.”



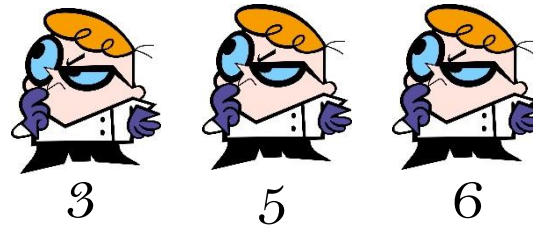
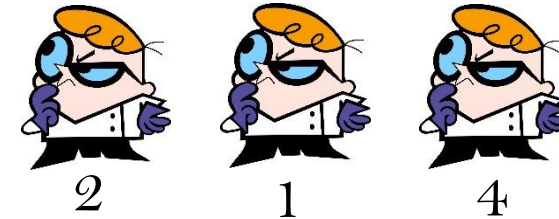
Tier 2

# “Describe a randomized block...”

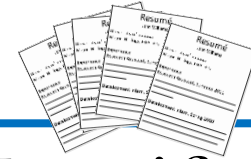
Compare ‘hireability’ ratings between the Jenn/John groups **within** each block.

**Combine** the results, after accounting for the average difference in each block.

Compare ‘hireability’ ratings between the Jenn/John groups **within** each block.

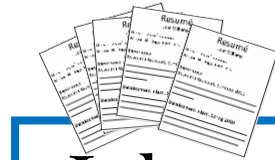
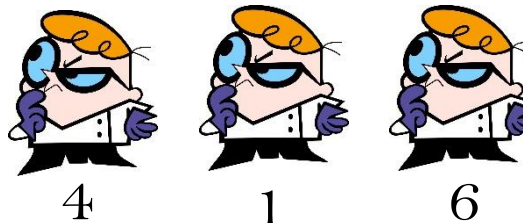
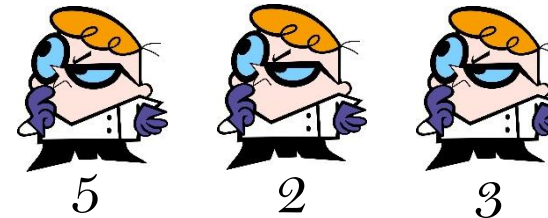


John



Jennifer

Tier 1

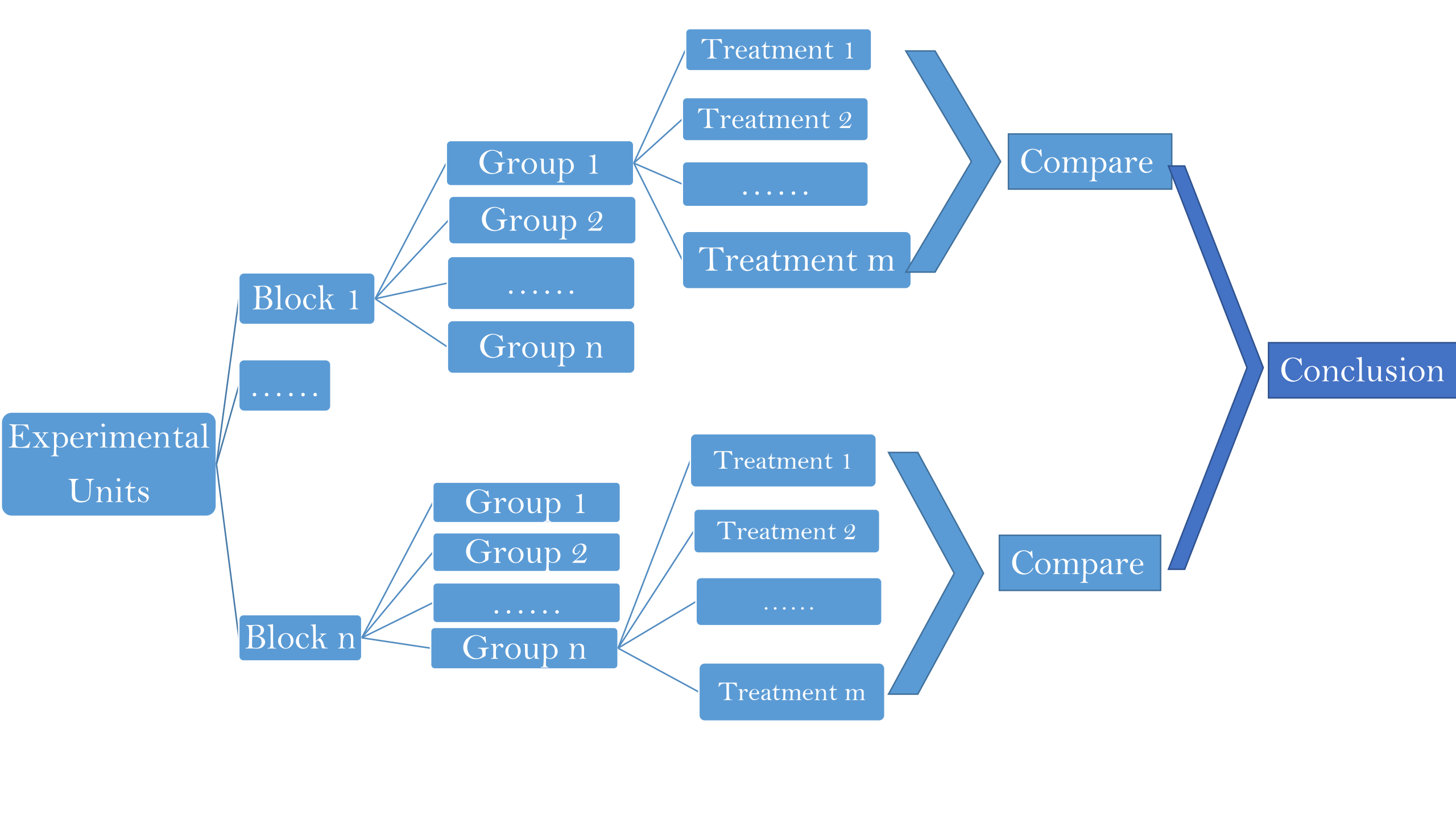


John



Jennifer

Tier 2



# Topics

1. Blocking
- 2. Matched pairs design**
3. Blinding and placebo
4. Generalizing study results

# Studying Depression

- Depression arises from a complex interaction of biological, psychological, and social factors.
- Knowing which factor is most influential could help treatment.

# Studying Depression

- Depression arises from a complex interaction of biological, psychological, and social factors.
- Knowing which factor is most influential could help treatment.

**Which factor is the most prominent cause of depression?**



# Studying Depression

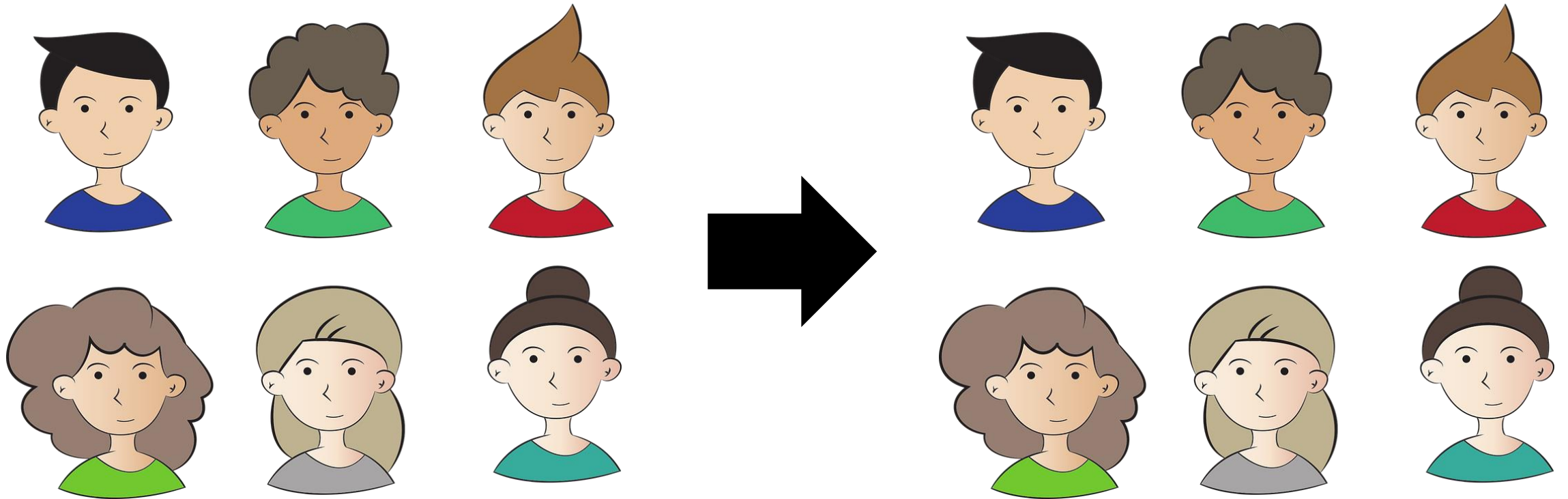
Difficult to control for variation. Individuals have different:

- Levels of depression
- Types of depressive symptoms
- Array of biochemical, psychological, and environmental conditions
- Side-effects from treatment



**Who could be  
the control  
group  
?**

# Matched pairs design



Subjects are **their own** control group!

# Matched pairs design

Matched Pairs Design: a type of randomized blocked experiment in which each block is composed of **two** similar experimental units (a “matched pair”).

- Often, the “matched pair” is simply the **same experimental unit** receiving both treatments. The **order** of the treatments is **randomized**.

# 2015 Depression Study in the Journal of the American Medical Association

Home » News & Events » NIH Research Matters

## NIH RESEARCH MATTERS

October 19, 2015

### Placebo Effect in Depression Treatment

This lesson describes a simplified version of the depression study. See full paper (below) for full study details.

**Study:** Association Between Placebo-Activated Neural Systems and Antidepressant Responses: Neurochemistry of Placebo Effects in Major Depression. Peciña M, Bohnert AS, Sikora M, Avery ET, Langenecker SA, Mickey BJ, Zubieta JK. JAMA Psychiatry. 2015 Sep 30:1-8. doi: 10.1001/jamapsychiatry.2015.1335. [Epub ahead of print]. PMID: 26421634.

# Depression: Is it all in your head?

- Researchers wanted to test if taking a “fake pill” would actually alleviate depression symptoms, even though the pill had no active ingredients.
- 35 people enrolled in study. All had major depression and none were taking any medications.

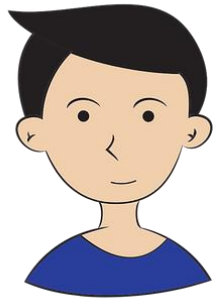
“Describe a matched pairs design...”



$n = 35$   
subjects

“Describe a matched pairs design...”

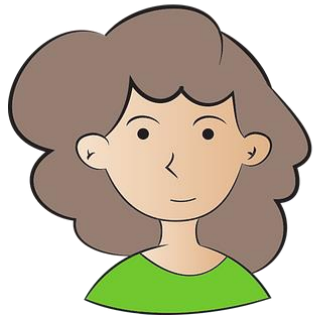
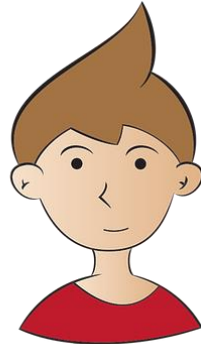
Pill 2nd



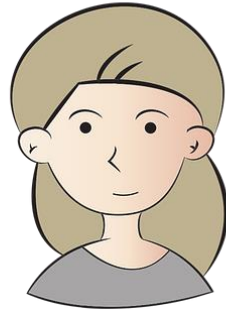
Pill 1st



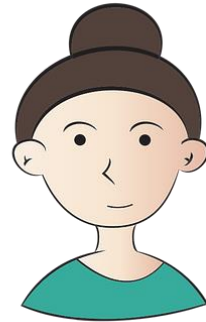
Pill 2nd



Pill 1st



Pill 1st



Pill 2nd

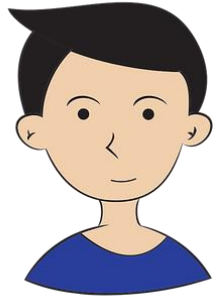
$n = 35$  subjects

For each subject, flip a coin. Heads indicates they get the fake pill for the first week, no pill for the second week. Tails indicates the **opposite treatment order**.



“Describe a matched pairs design...”

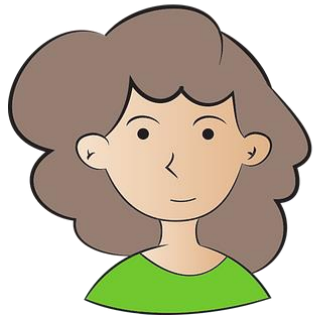
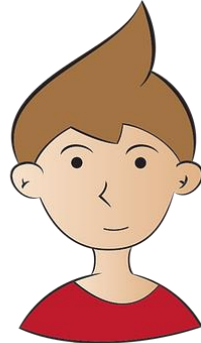
Pill 2nd



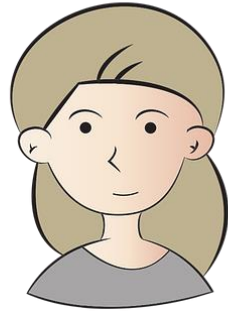
Pill 1st



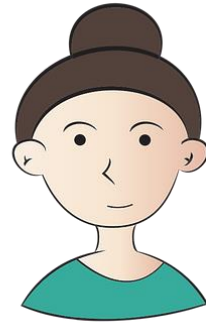
Pill 2nd



Pill 1st



Pill 1st



Pill 2nd

Have each subject fill out a depression questionnaire and undergo a PET brain scan at the end of each week.

Compare measurements **for each subject** and compile the results.

$n = 35$  subjects

# Experiment Ethics

**Note:** all subjects were given real depression treatments after this two-week phase of the study. When living subjects are involved, researchers must make their studies **ethical**.

# Depression study results

1. On average, participants reported less severe depressive symptoms after their week with the fake pill.
  - **Maybe depression *is* all in their head...**
2. On average, participants showed “increased  $\mu$ -opioid receptor brain activity in regions of the brain associated with emotion and stress regulation.”\*
  - **Belief in the pill caused a *biochemical change***

\*Study summary: <https://www.nih.gov/news-events/nih-research-matters/placebo-effect-depression-treatment#:~:text=At%20the%20end%20of%20the,they%20took%20the%20inactive%20placebo.>

“Fake pills” have also shown significant beneficial effects for...

- Migraines
- Blood Pressure
- Asthma
- Arthritis
- Many other ‘physical’ illnesses

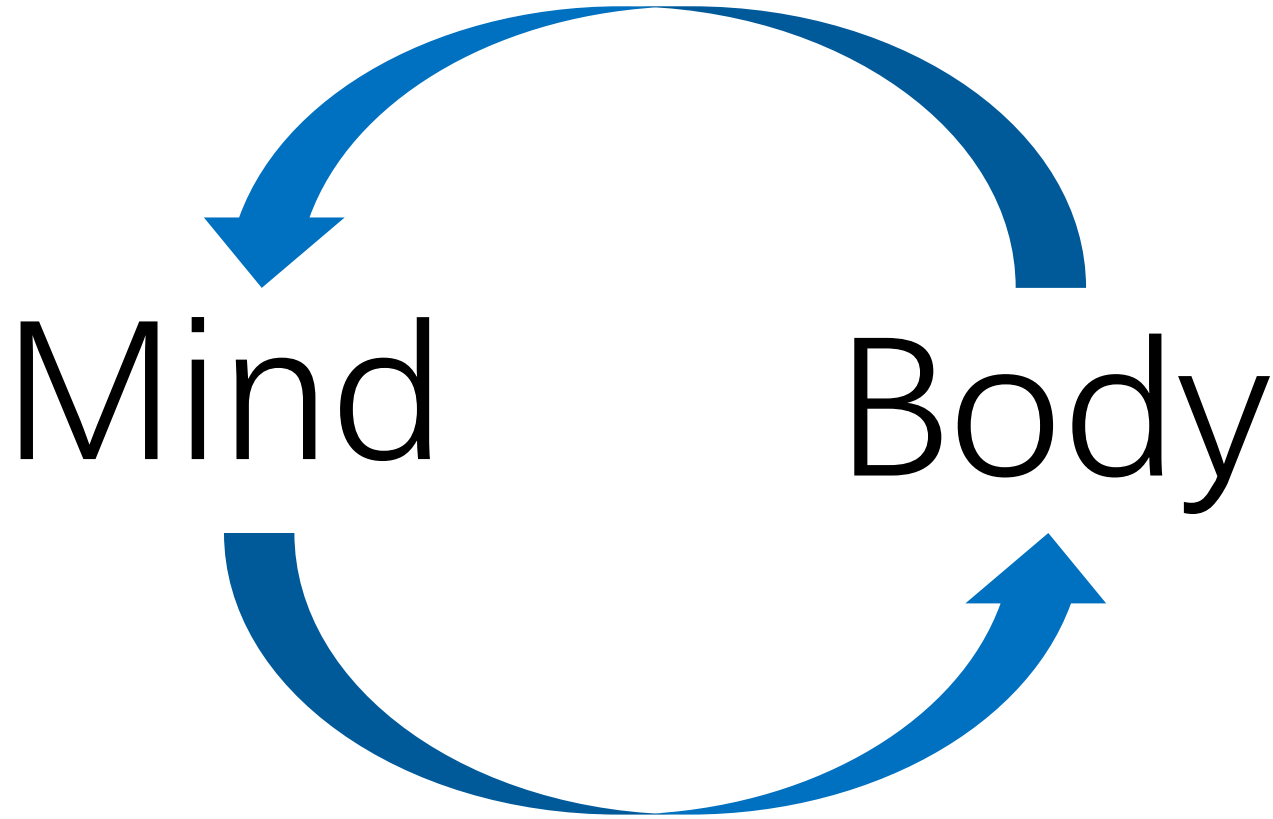
Source: <https://www.ncbi.nlm.nih.gov/books/NBK513296/>

“Fake pills” have also shown significant beneficial effects for...

- Migraines
- Blood Pressure
- Asthma
- Arthritis
- Many other ‘physical’ illnesses

Called the:  
**placebo effect**

Source: <https://www.ncbi.nlm.nih.gov/books/NBK513296/>



For both physical and mental illnesses, it's often hard to distinguish between mental and physical phenomenon.

# Topics

1. Blocking
2. Matched pairs design
- 3. Blinding and placebo**
4. Generalizing study results

# Placebo effect

Placebo: An **inactive** treatment (e.g. sugar pill or salt water IV drip)

Placebo effect: when subjects' belief of receiving an active treatment leads to a measured response, even though the treatment is **actually inactive**.



# Blinding

Single-blind study: **either** the subjects or the researchers are unaware of who receives active treatment or placebo.

Double-blind study: **both** the subjects and the researchers are **unaware** of who receives active treatment or placebo.

# Blinding

Why blind subjects? **Controls for placebo effect**

Why blind researchers? **Prevents confounding**

- Researchers trying to prove that a treatment works may favor treatment group in their measurements

# Topics

1. Blocking
2. Matched pairs design
3. Blinding and placebo
4. **Generalizing study results**

# Generalizing study results

Generalization: using study results to make inferences about a **larger population**.

# Generalizing study results

In the Jenn/John study, all faculty participants were from one of three science departments: biology, chemistry, or physics.

# Generalizing study results

In the Jenn/John study, all faculty participants were from one of three science departments: biology, chemistry, or physics.

**Discussion Question:** Can we generalize the result of gender hiring discrimination to all scientific subjects? Explain your reasoning.

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**No.** The faculty members in this study may not be **representative** of faculty from other science departments.

# Scope of inferences

Were subjects randomly assigned to treatment?

Were subjects randomly sampled?

	Subjects <b>were</b> randomly assigned to groups (experiment)	Subjects were <b>not</b> randomly assigned to groups (observational study)
Subjects <b>were</b> randomly sampled from the population	Generalize to the population: __ Determine cause and effect: __	Generalize to the population: __ Determine cause and effect: __
Subjects were <b>not</b> randomly sampled from the population	Generalize to the population: __ Determine cause and effect: __	Generalize to the population: __ Determine cause and effect: __



# Scope of inferences

Were subjects randomly sampled?

Were subjects randomly assigned to treatment?		
	Subjects <b>were</b> randomly assigned to groups (experiment)	Subjects were <b>not</b> randomly assigned to groups (observational study)
Subjects <b>were</b> randomly sampled from the population	Generalize to the population: <b>Yes</b> Determine cause and effect: <b>Yes</b>	Generalize to the population: <b>Yes</b> Determine cause and effect: <b>No</b>
Subjects were <b>not</b> randomly sampled from the population	Generalize to the population: <b>No</b> Determine cause and effect: <b>Yes</b>	Generalize to the population: <b>No</b> Determine cause and effect: <b>No</b>

**Part (a):**

Acceptable blocking schemes:

Blocks:	1 and 12	2 and 3	4 and 5
	6 and 7	8 and 9	10 and 11

Blocks:	1 and 12	2 and 5	3 and 4
	6 and 7	8 and 11	9 and 10

Blocks: 1 and 12	2, 3, 4, and 5	6 and 7	8, 9, 10, and 11
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We want to create blocks of homogeneous “units.” Exposure (side of house) would have an effect on heat gain through a window, so the best blocking scheme would take side of house into account when creating blocks.

The blocking schemes above create blocks that are similar with respect to exposure (side of house). Since there are two treatments (types of windows), the optimal blocking scheme would create blocks consisting of two window boxes each.

**Part (b):**

For each block we could select one of the window boxes and then flip a coin to determine which type of window would be installed in that window box. For example, if the coin lands face up, install type A; otherwise install type B. Continue this process until half of the windows in the block are assigned to one type, then install the remaining window type in the other boxes.