PSY 501: Classic Experimental Designs

Week 9

Outline

One Factor Designs

Factorial Experiments

Between subject & Within subject Designs

Outline

One Factor Designs

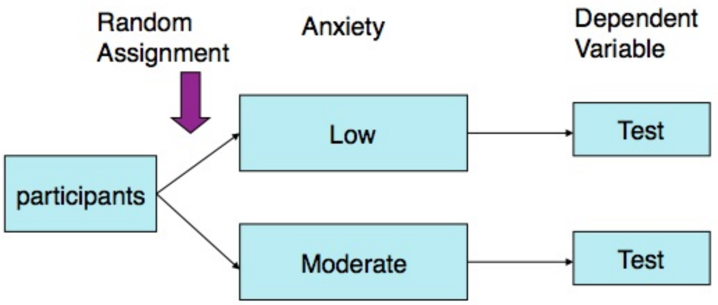
Factorial Experiments

Between subject & Within subject Designs

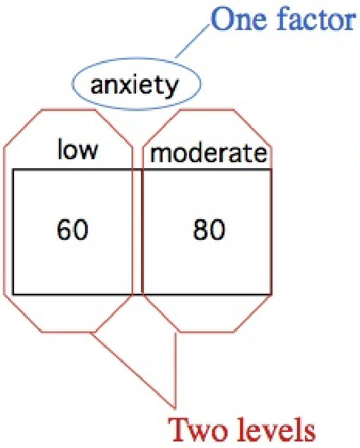
Single variable – One Factor

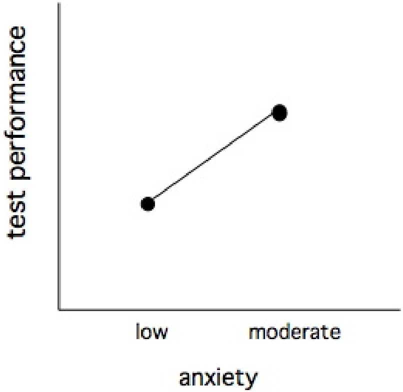
Ex: How does anxiety level affect test performance?

- Two groups take the same test
  - Group 1 (moderate anxiety group): 5 minute lecture on the importance of good grades for success
  - Group 2 (low anxiety group): 5 minute lecture on how good grades don't matter, just trying is good enough



Single variable – One Factor





Single variable – One Factor

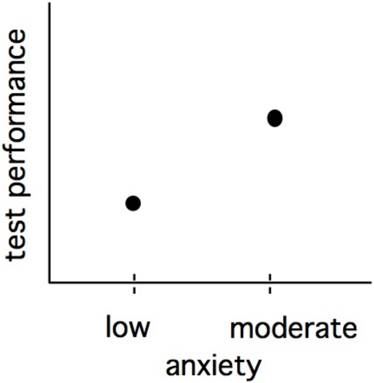
Advantages:

- Simple statistics – only need a t-test
- Simple way to pilot the effect of an independent variable
  - If no effect in this case, then usually don't bother with a more complex design
- Sometimes two levels is all you need
  - One theory predicts one pattern, another predicts a different pattern – see which one happens

Single variable – One Factor

Disadvantages:

- True shape of function is hard to see
  - Interpolation: what happens within the ranges you test?



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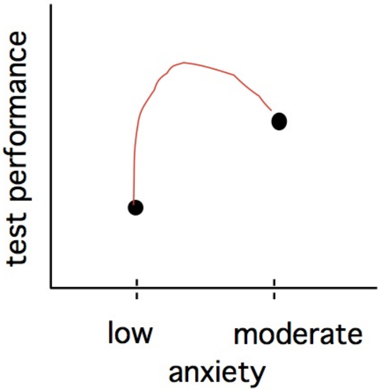

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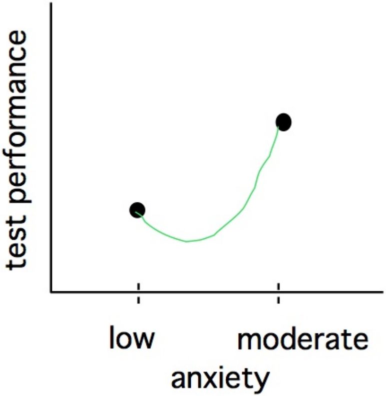

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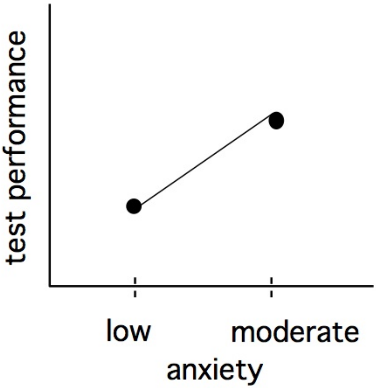

Single variable – One Factor

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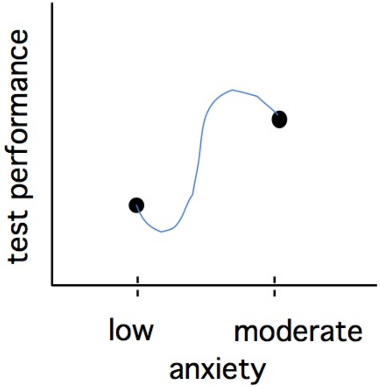
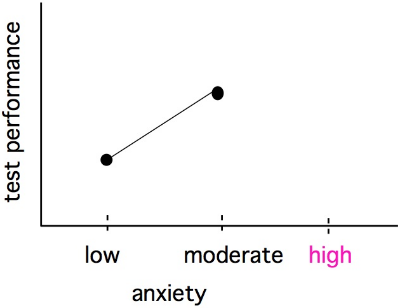


Single variable – One Factor

Disadvantages:

- True shape of function is hard to see
  - Extrapolation: what happens outside the ranges that you test?



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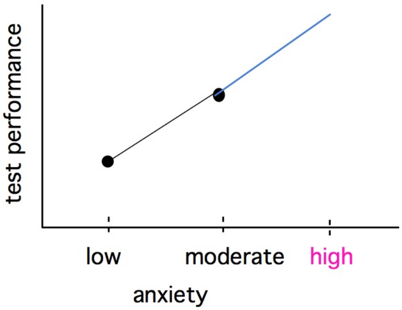

Single variable – One Factor

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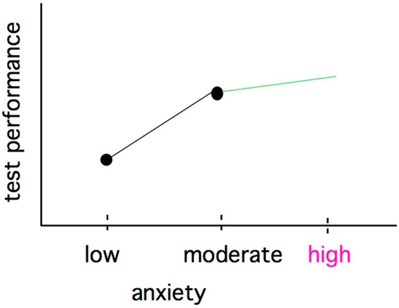

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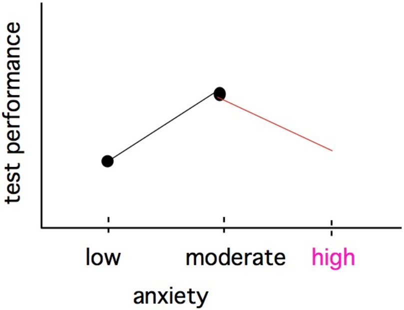


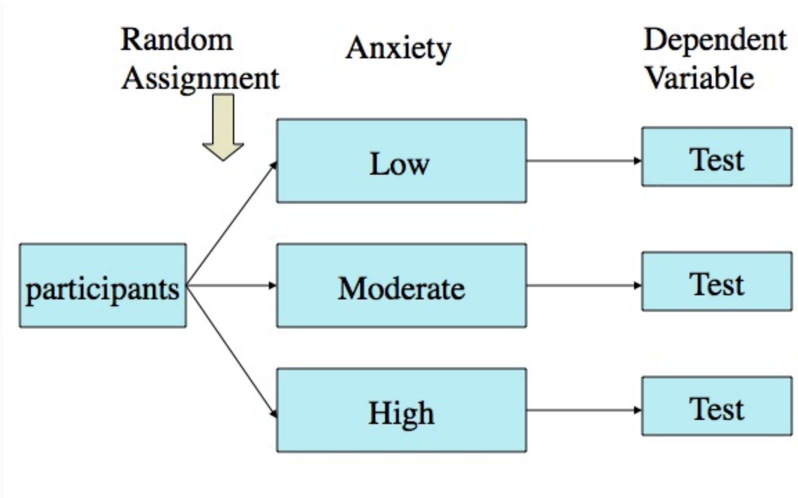
One Factor – multilevel experiments

Ex: How does anxiety level affect test performance?

- **Three** groups take the same test
  - Group 1 (moderate anxiety group): 5 minute lecture on the importance of good grades for success
  - Group 2 (low anxiety group): 5 minute lecture on how good grades don't matter, just trying is good enough
  - Group 3 (high anxiety group): 5 minute lecture on how the students must pass this test to pass the course

One Factor – multilevel experiments

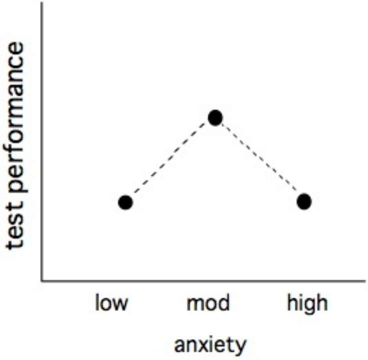
Ex: How does anxiety level affect test performance?



One Factor – multilevel experiments

Ex: How does anxiety level affect test performance?

	anxiety	
low	mod	high
60	80	60



One Factor – multilevel experiments

Advantages:

- Gives a better picture of the functional relationship
- More levels = less worry about the range of IV

Disadvantages:

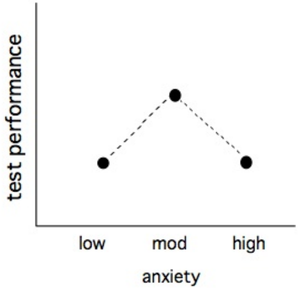
- Need more resources (participants and/or stimuli)
- Need more complex statistics (at least ANOVA with **pairwise comparisons**)

Pairwise Comparisons

- The ANOVA just tells you that not all the groups are equal
- If this is your conclusion (you run an ANOVA with $p < 0.05$), then you should do further tests to see where the differences are:
  - High vs. Low ($\times$)
  - High vs. Moderate ($\checkmark$)
  - Low vs. Moderate ($\checkmark$)

anxiety

low	mod	high
60	80	60



Outline

Factorial Experiments

Two or more factors

- Factors – independent variables
- Levels – the levels of your independent variables
  - 2×4 design means two IVs, one with 2 levels, and one with 4 levels
  - Number of conditions is calculated by multiplying the levels, so a 2×4 design has 8 conditions

	B1	B2	B3	B4
A1				
A2				

Factorial Experiments

Two or more factors (cont'd)

- Main effects – the effects of your independent variables, ignoring the other independent variables
  - This is called *collapsing* data
- Interaction effects – how your independent variables affect each other
  - Typically this is where the interesting stuff is!

Why are factorial experiments interesting?

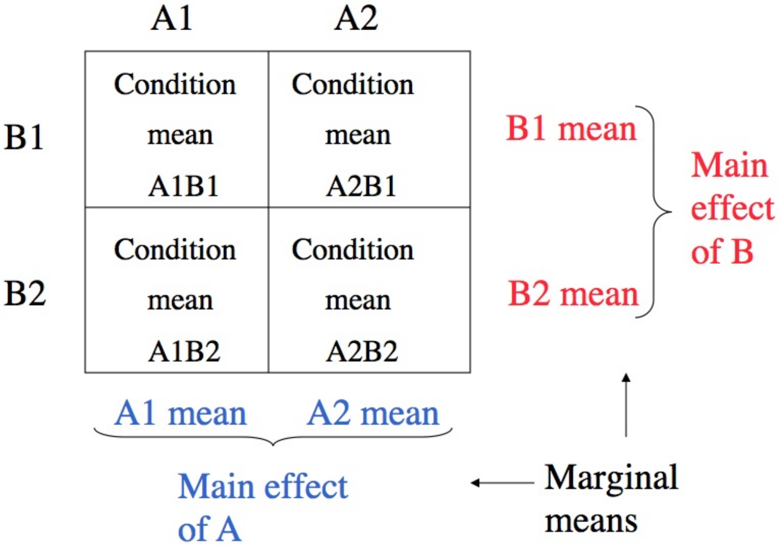
There are a lot of possible outcomes of a factorial experiment:
Consider:

- A = main effect of factor A
- B = main effect of factor B
- AB = interaction of A and B

So, with two factors (A and B), there are 8 possible outcomes:

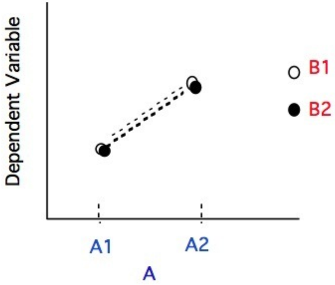
1. No effects at all
2. A only
3. B only
4. AB only
5. A and B, but not AB
6. A and AB, but not B
7. B and AB, but not A
8. A, B, and AB

Anatomy of a 2×2 design



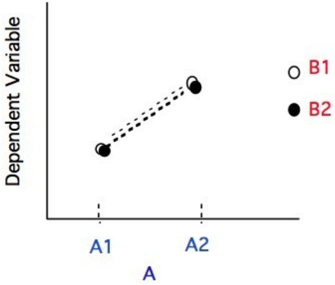
Example: 2×2 design

B \ A	A1	A2	Main Effect of B
B1	30	60	45
B2	30	60	45
Main Effect of A	30	60	



Example: 2×2 design

		A: A1	A: A2	Main Effect of B
B	B1	30	60	45
B	B2	30	60	45
	Main Effect of A	30	60	

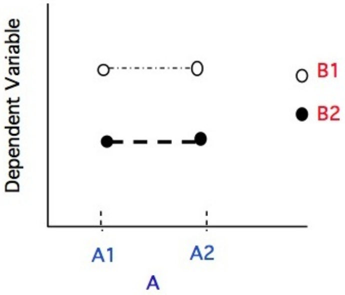


Effects:

- A (✓)
- B (×)
- A × B (×)

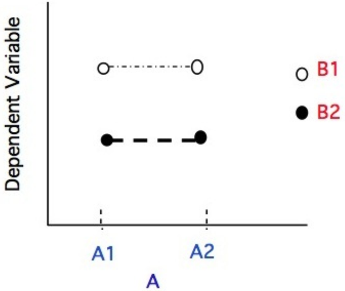
Example: 2×2 design

		A: A1	A: A2	Main Effect of B
B	B1	60	60	60
	B2	30	30	30
	Main Effect of A	45	45	



Example: 2×2 design

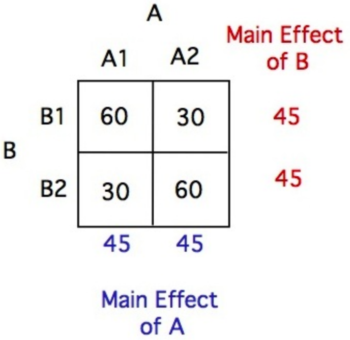
		A: A1	A: A2	Main Effect of B
B	B1	60	60	60
B	B2	30	30	30
	Main Effect of A	45	45	

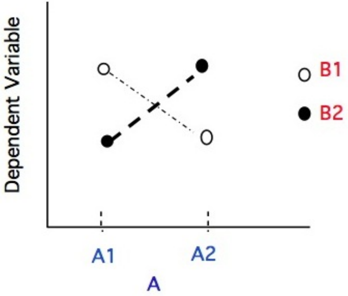


Effects:

- A (×)
- B (✓)
- A × B (×)

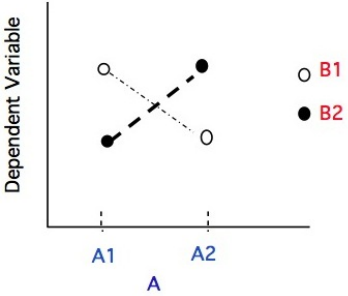
Example: 2×2 design





Example: 2×2 design

		A1	A2	Main Effect of B
B	B1	60	30	45
	B2	30	60	45
	Main Effect of A	45	45	



Effects:

- A (×)
- B (×)
- A × B (✓)

Example: 2×2 design

		A		
		A1	A2	Main Effect of B
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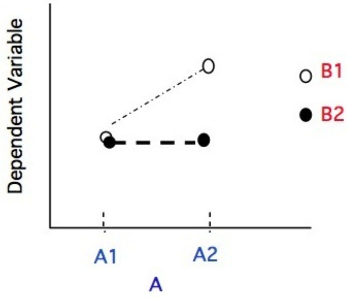
	B2	30	30	30
	Main Effect of A	30	45	



Example: 2×2 design

		A		
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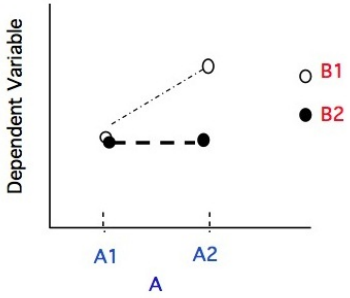


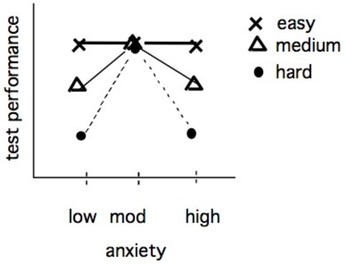
Effects:

- A (✓)
- B (✓)
- A × B (✓)

Example: Anxiety and Test Peformance (again)

Recall our example from earlier.

Let's add another variable: test difficulty

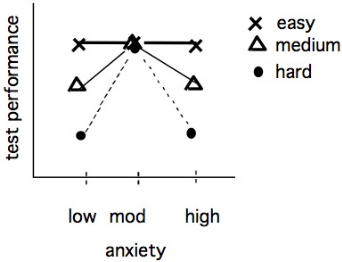


Test difficulty / anxiety	low	mod	high	main effect of difficulty
hard	35	80	35	50
medium	65	80	65	70
easy	80	80	80	80
main effect of anxiety	60	80	60	

Example: Anxiety and Test Peformance (again)

Recall our example from earlier.

Let's add another variable: test difficulty



Test difficulty	anxiety: low	anxiety: mod	anxiety: high	main effect of difficulty
hard	35	80	35	50
medium	65	80	65	70
easy	80	80	80	80
main effect of anxiety	60	80	60	

Effects:

- Anxiety ✓
- Difficulty ✓
- Anxiety × Difficulty ✓

Factorial Designs

Advantages:

- Interaction effects
  - One should always consider the interaction effects before trying to interpret the main effects
- Adding factors decreases variability
  - This is because you're controlling more of the variables that influence the dependent variable (turning NR_{other} into NR_{exp})
  - Increases statistical power of your design!
- Increases generalizability

Factorial Designs

Disadvantages:

- Experiments become very large and unwieldy
- Statistical analyses become much more complex
  - Need software packages that are either expensive (SAS, SPSS) or difficult to learn (R)
- Interpretation of results can be hard
  - This is particularly true for 3-way or 4-way interactions

Describing your design

When you begin your "Results" section, you need to describe

- How many factors
- How many levels of each factor
- Whether the factors are within or between groups (more on this next time)

Example 1 (from Beilock, Rydell, & McConneyll, JEPG 2007)

> Accuracy and corresponding RTs for MA problems to which responses were correct were compared in a 2 (group: control, ST) × 2 (block: baseline, posttest) × 2 (problem working memory demand: low demand, high demand) design, with group as a between-subjects variable.

Describing your design

When you begin your "Results" section, you need to describe

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- How many levels of each factor
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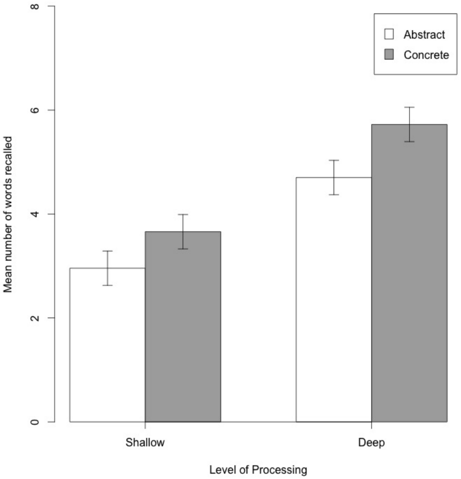
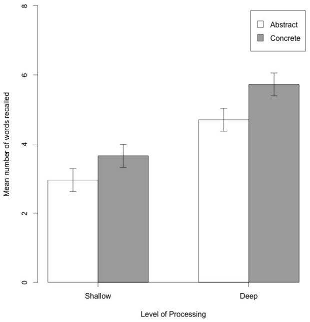
Example 2 (from Trbovich & LeFevre, M&C 2003)

2001; Seyler et al., in press). The combined error scores and the median correct latencies to arithmetic problems were analyzed in separate 2 (memory task: visual vs. phonological) × 2 (format: vertical vs. horizontal) × 2 (operand order: single digit + double digit vs. double digit + single digit) × 3 (load: control, easy, or hard) ANOVAs, with repeated measures on the last two factors. Unless otherwise indicated, the alpha level was .05.

Class Experiment: Memory



Class Experiment: Memory



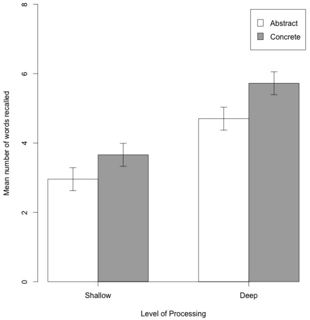
Results section:

_____ was analyzed in a _____ × _____ design with _____ as a between-subjects factor and _____ as a within-subjects factor.

Class Experiment: Memory

Results section:

Number of words recalled was analyzed in a **2 (Word Type: abstract, concrete)** $\times$ **2 (Level of processing: shallow, deep)** design with **Level of Processing** as a between-subjects factor and **Word Type** as a within-subjects factor.



Effects:

- Level of Processing ($\checkmark$)
- Word Type ($\checkmark$)
- LOP $\times$ Word Type ($\times$)

Outline

Between subject versus Within subject Designs

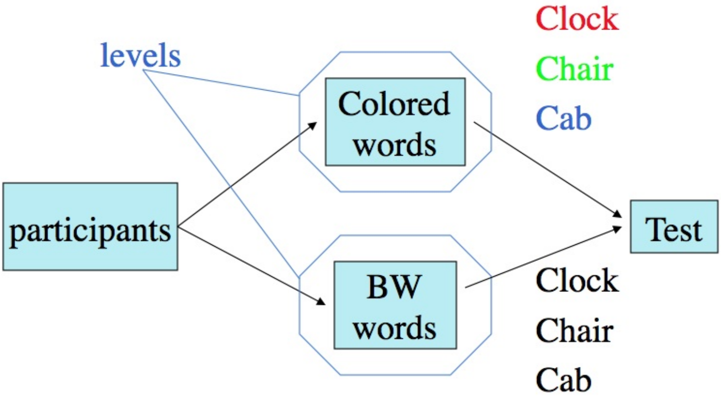
- **Between subjects designs**
  - Each participant participates in one (**and only one**) condition of the experiment
- **Within subjects designs**
  - All participants participate in all of the conditions of the experiment

Example

What is the effect of presenting words in color on memory for those words?

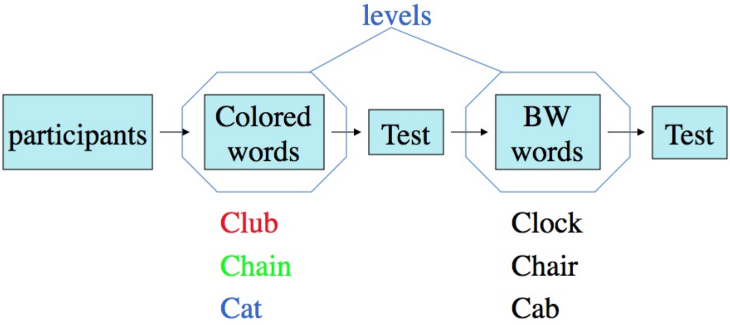
- So you present lists of words for recall either in color or in black-and-white
- Do you do this as a **within subjects design** or **between subjects design**?

Between subjects design



So each participant is in **only one** level of IV

Within subjects design



So all of the participants are in **both** levels of the IV

Between subjects designs

Advantages:

- Independence of groups (levels of IV)
  - Harder to guess what the experiment is about when participants don't experience other levels of IV
  - No "order effects" to worry about
    - Counterbalancing not required
  - Sometimes, this design is a **must** because you can't reverse the effects of prior exposure to the other levels of IV

Between subjects designs

Disadvantages:

- Individual differences between the people in the groups
  - Non-equivalent groups
    - The groups may differ not only because of IV, but also because the groups are composed of **different** indivduals
  - Excessive variability
    - Harder to detect the effect of IV (if there is one)

Dealing with individual differences

Equivalent groups:

- Created equally – use the same process to create both groups
- Treated equally – keep the experience as similar as possible for the two groups
- Composed of equivalent individuals
  - *Random assignment to groups*
  - *Matching groups* – match each individual in one group to an individual in the other group on relevant characteristics

Within subjects designs

Advantages:

- Don't have to worry about individual differences!
  - Same people in all conditions
  - Variability between groups is smaller (statistical power is increased!)
- Fewer participants are required

Disadvantages:

- Order effects
  - Carry-over effects
  - Progressive error
  - Counterbalancing is probably necessary

Order effects

Carry-over effects

- Transfer between conditions is possible
- Effects may persist from one condition into another
  - E.g., Alcohol vs. no alcohol experiment on the effects on hand-eye coordination. Hard to know how long the effects of alcohol may persist

Progressive error

- Practice effects – improvement due to repeated practice
- Fatigue effects – performance deteriorates as participants get bored, tired, distracted

Dealing with order effects

Counterbalancing conditions

- Ideally, use every possible order
- Assumes that AB and BA have reverse effects (symmetrical transfer) and thus cancel out in a counterbalanced design

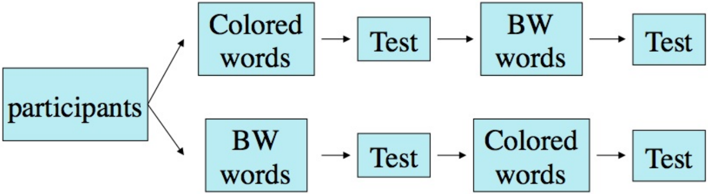
Examples:

- 2 conditions (A,B), $2 = 2!$ orders
  - AB,BA
- 3 conditions (A,B,C), $6 = 3!$ orders
  - ABC, ACB, BAC, BCA, CAB, CBA
- 4 conditions (A,B,C,D), $24 = 4!$ orders
- N conditions, $N!$ orders

Counterbalancing

Simple case:

- Two conditions (A,B)
- Two counterbalanced conditions (AB, BA)



Counterbalancing

Often, it is not practical to use every possible ordering (i.e., in 4 or greater conditions, there are 24 possible orderings!)

- Partial counterbalancing
  - **Latin square design** – a form of partial counterbalancing where each group of trials occur in each position an equal number of times
  - Example (an *unbalanced* Latin square): each condition appears in each order position

Order 1	A	B	C	D
Order 2	B	C	D	A
Order 3	C	D	A	B
Order 4	D	A	B	C

Partial counterbalancing

Example (a *balanced* Latin square): each condition appears **before and after** all others

A	B	D	C
B	C	A	D
C	D	B	A
D	A	C	B

See Appendix D in your text for an algorithm to construct balanced Latin squares

Mixed factorial designs

In factorial designs, we can treat some factors as within-subjects and others as between subjects.

- Must specify clearly (either in Methods section or at beginning of Results section)

> Accuracy and corresponding RTs for MA problems to which responses were correct were compared in a 2 (group: control, ST) × 2 (block: baseline, posttest) × 2 (problem working memory demand: low demand, high demand) design, with group as a between-subjects variable.