Lecture 12 Evaluation - 2

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Previous Lecture

Qualitative vs. Quantitative Evaluation

Heuristic Evaluation

Developed by Jakob Nielsen (1994)

Can be performed on working UI or sketches

Small set (3-5) of evaluators (experts) examine UI

- Check compliance with usability heuristics
- Different evaluators will find different problems
- Evaluators only communicate afterwards to aggregate findings
- Use violations to redesign/fix problems

Heuristics

H2-1: Visibility of system status

H2-2: Match system and real world

H2-3: User control and freedom

H2-4: Consistency and standards

H2-5: Error prevention

H2-6: Recognition rather than recall

H2-7: Flexibility and efficiency of use

H2-8: Aesthetic and minimalist design

H2-9: Help users recognize, diagnose and recover from errors

H2-10: Help and documentation

Agenda

- Controlled Experiment
  Independent vs. Dependent Variables
  Within Subject vs. Between Subject Design
  Descriptive vs. Inferential Statistics

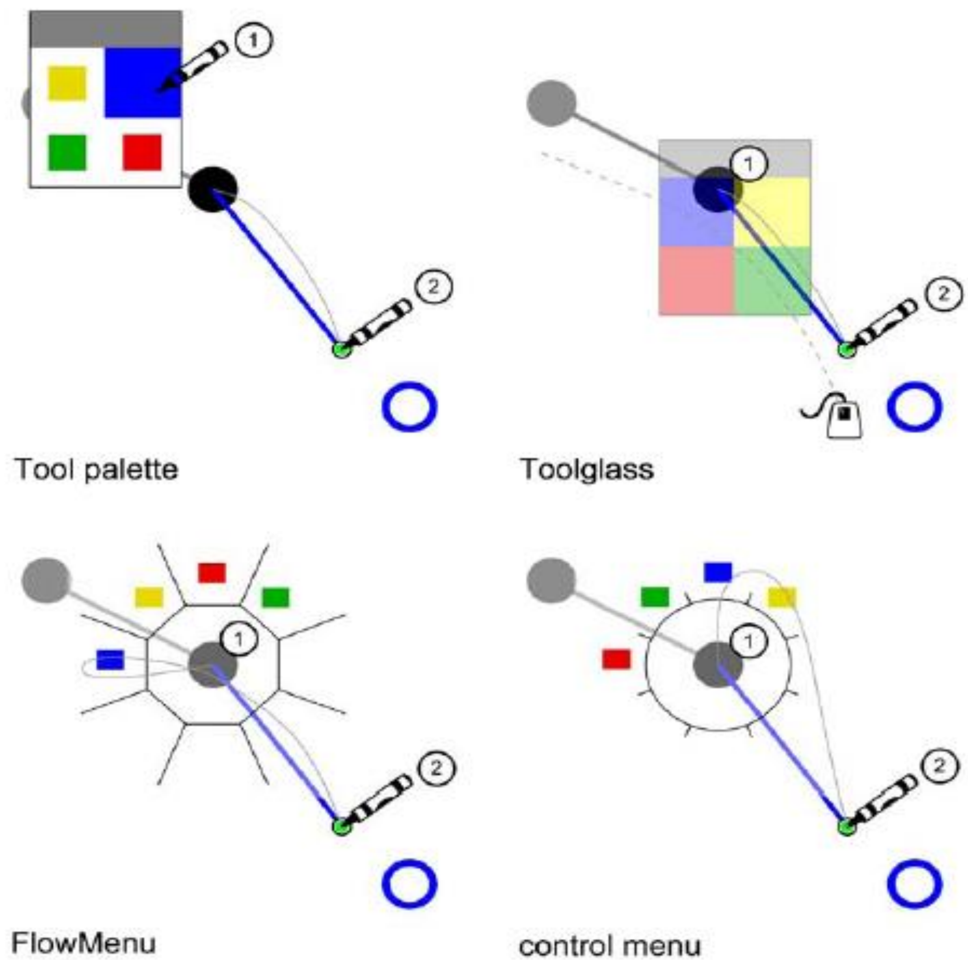
- Interaction Effects

Procedures of Running a Controlled Experiment

Steps in Designing an Experiment

1. State a lucid, testable hypothesis
2. Identify variables (independent, dependent)
3. Design the experimental protocol
4. Run pilot studies
5. Run the experiment
6. Perform statistical analysis
7. Draw conclusions

Example: Menu Selection



François Guimbretière, Andrew Martin, and Terry Winograd, Benefits of Merging Command Selection and Direct Manipulation. Transactions on Human-Computer Interaction, 12(3), pp 460 – 476, 2005

Steps in Designing an Experiment

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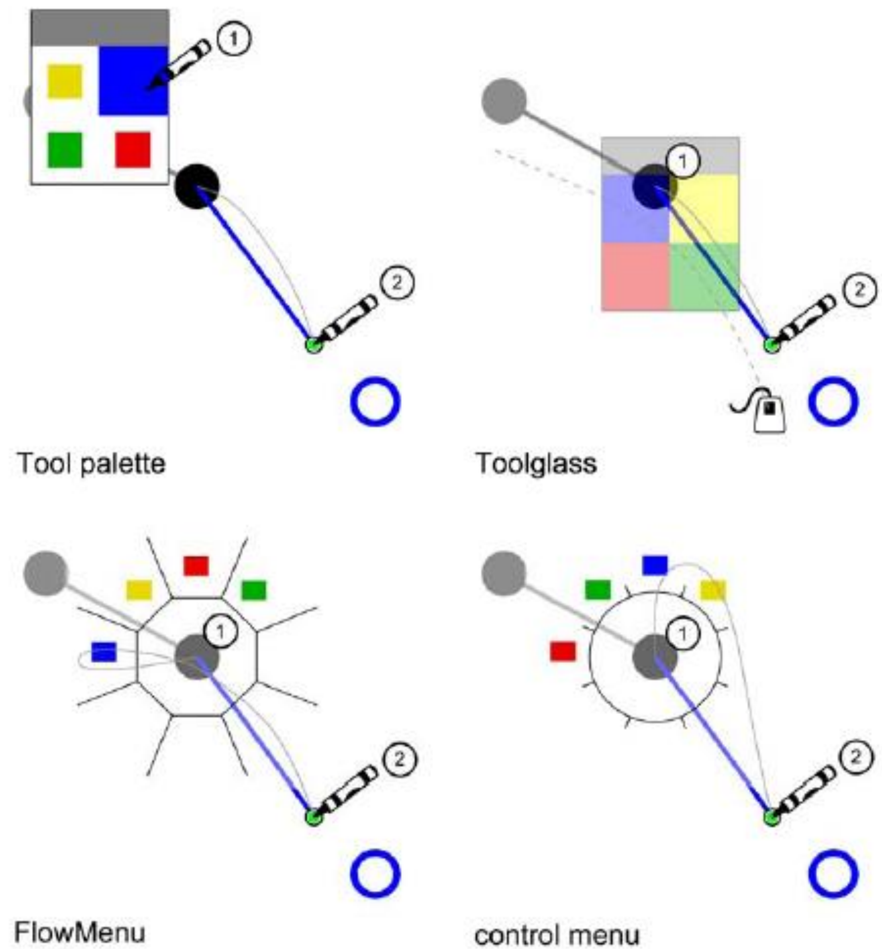
Lucid, Testable Hypothesis

Because users must reach for it, tool palette will be slower

Other hypotheses?



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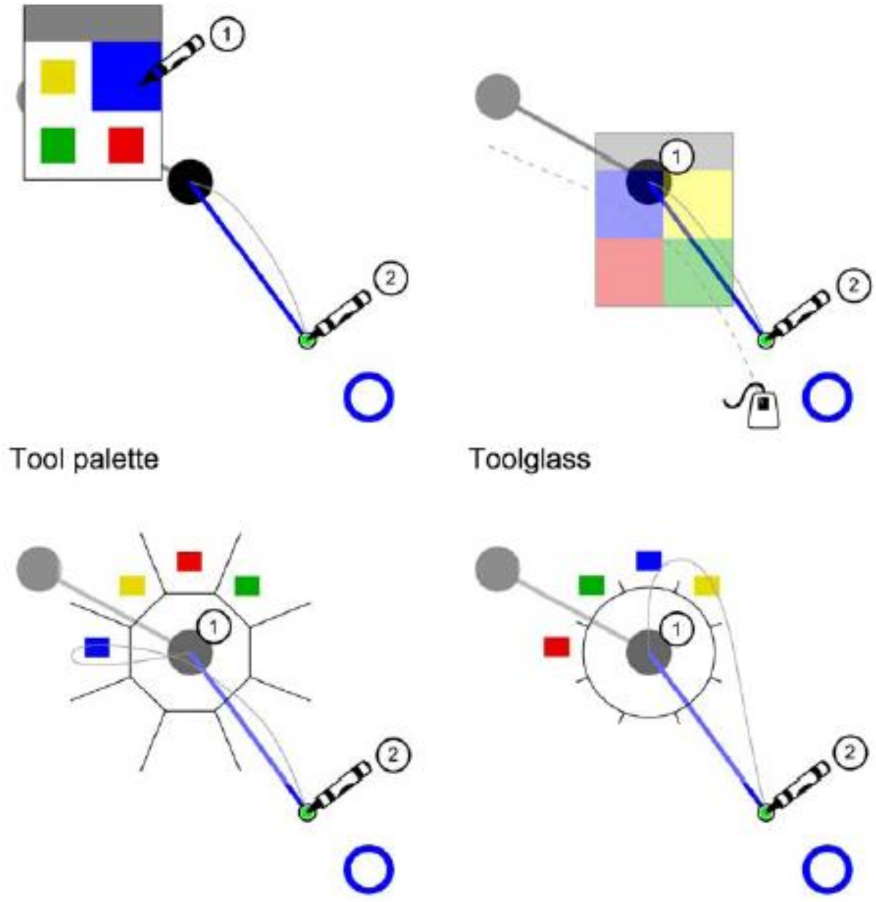
Variables

Independent variables (IV)

Dependent variables (DV)



Tool palette

Toolglass

FlowMenu

control menu

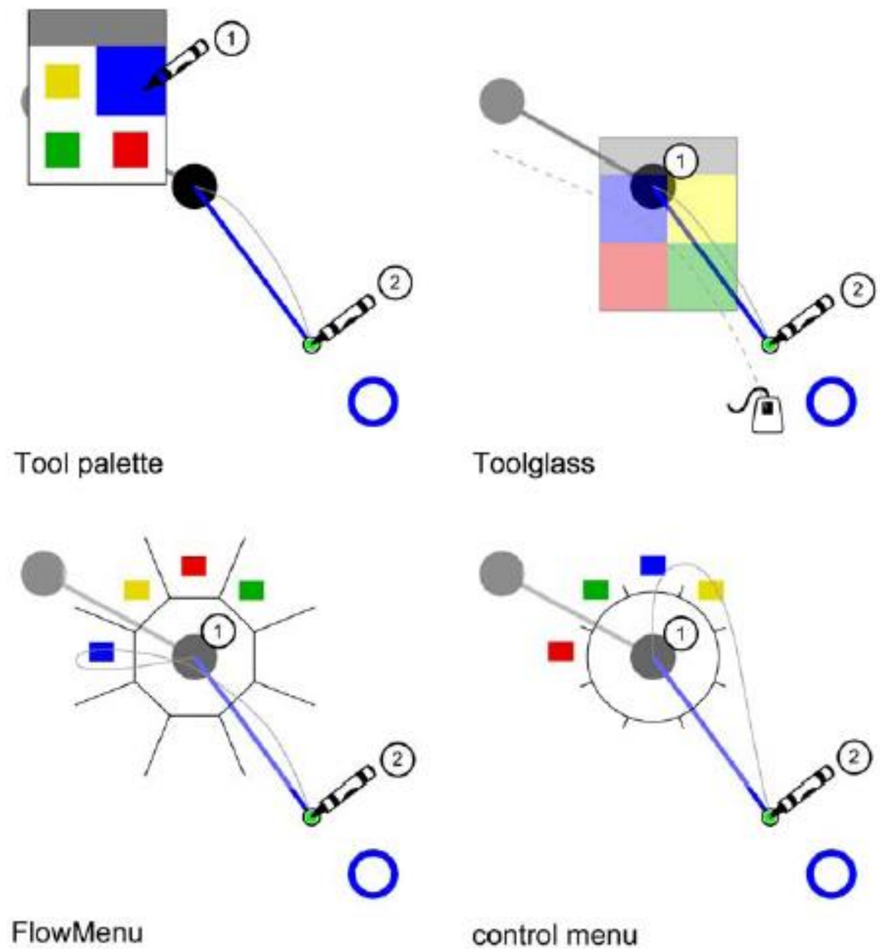
Variables

Independent variables (IV)

- Menu type (4 choices)

Dependent variables (DV)

- Time
- Error rate
- User satisfaction



Internal and External Validities

Internal validity

- Manipulation of IV is cause of change in DV
  - Requires eliminating confounding variables (turn them into IVs or RVs)
  - Requires that experiment is replicable

External validity

- Results are generalizable to other experimental settings
- *Ecological validity* – results generalizable to real-world settings

Steps in Designing an Experiment

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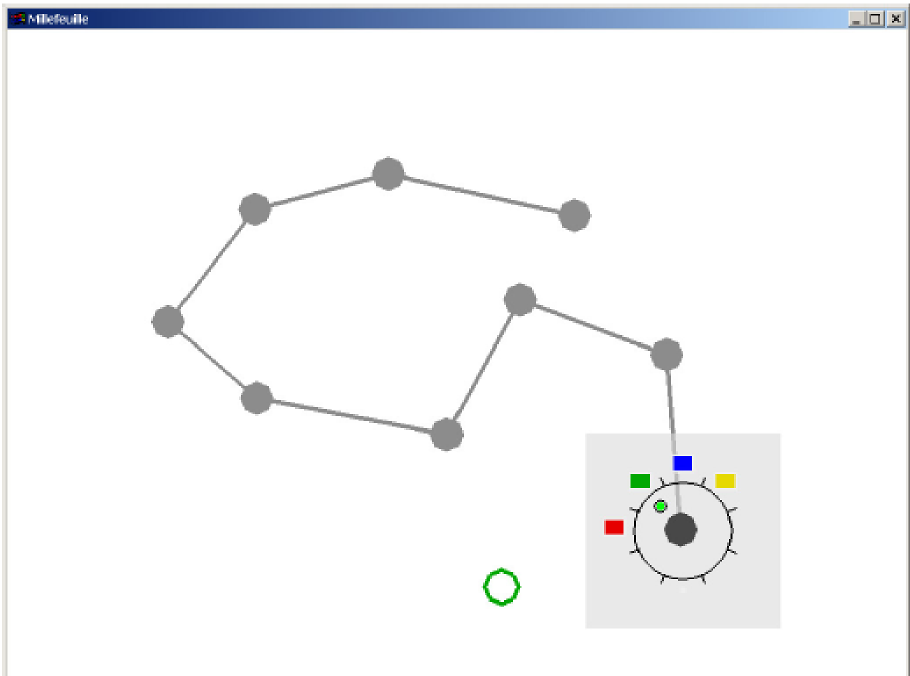
Experimental Protocol

- What is the task?
- What are all the combinations of conditions?
- How often to repeat each combination of conditions?
- Between subjects or within subjects
- Avoid bias (instructions, ordering, …)

Task: Must Reflect Hypothesis



- Connect the dots choosing the given color for each one.
- Connected dots filled in gray. Next dot is open in green.

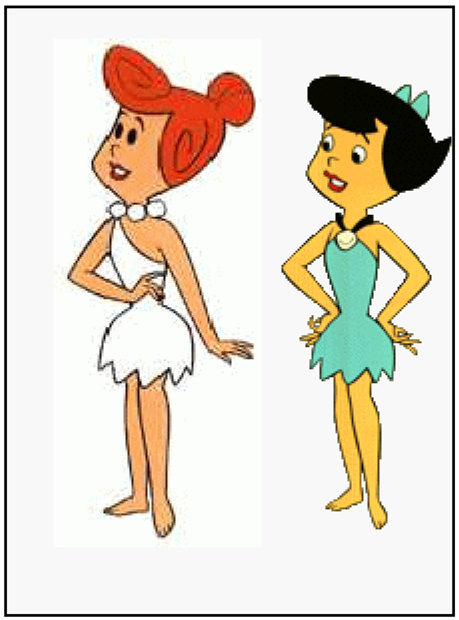
Number of Conditions

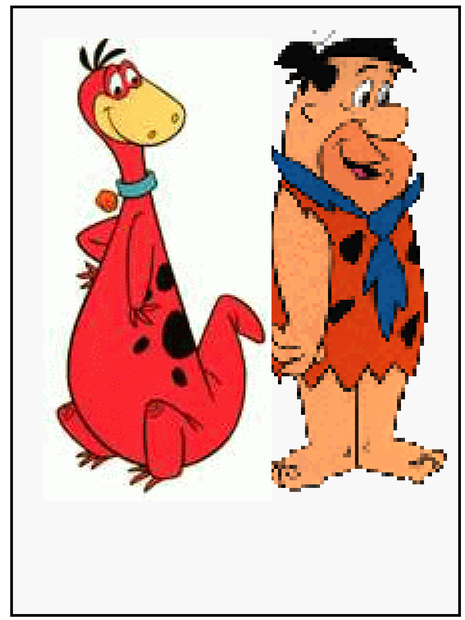
- Tool Palette
- Tool Glass
- Flow Menu
- Control Menu

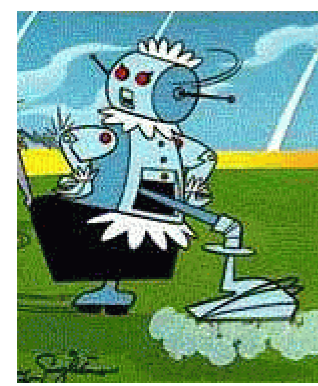
Between Subjects Design

Wilma and Betty use one interface

Dino and Fred use the other

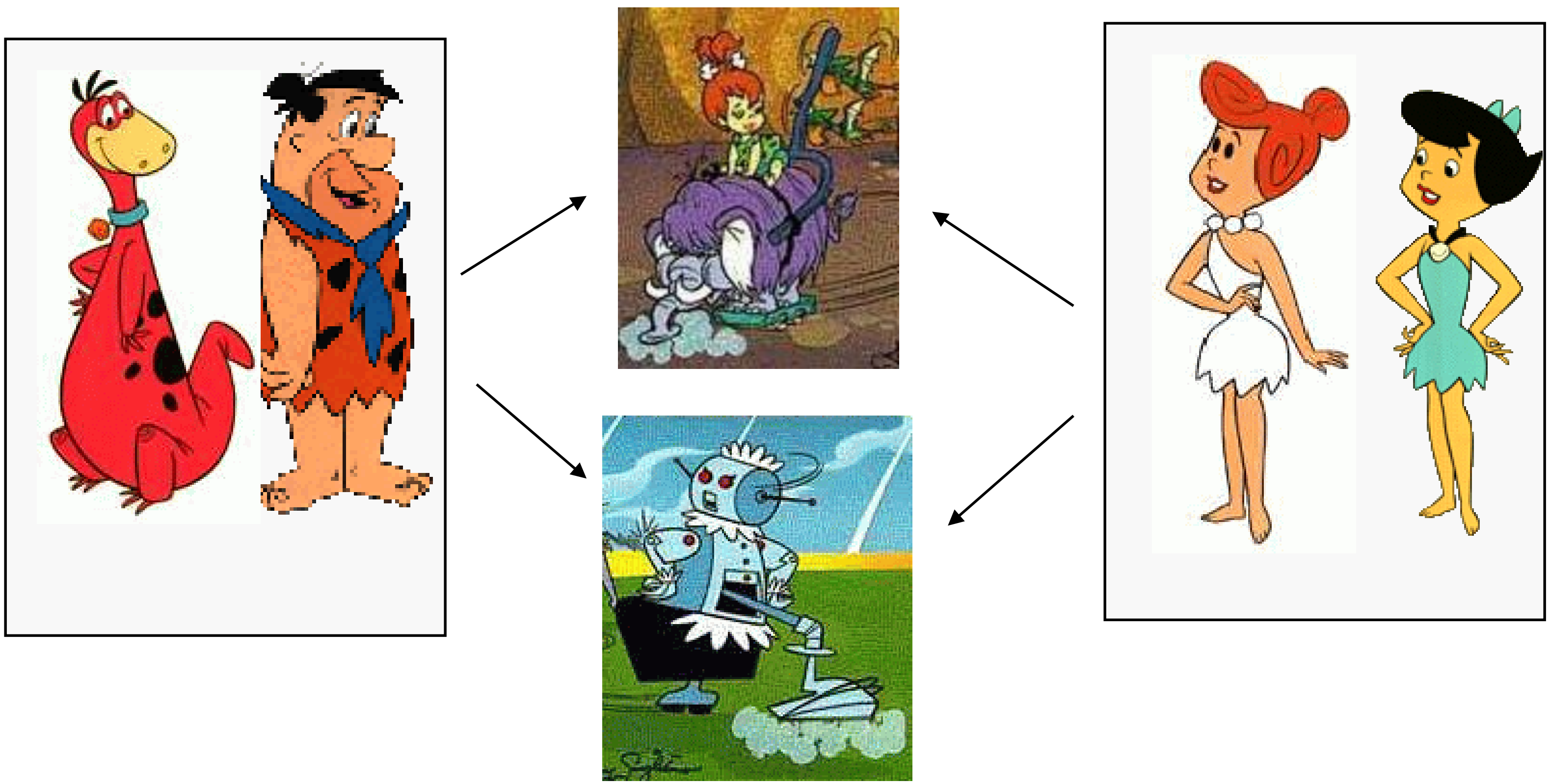






Within Subjects Design

Everyone uses both interfaces



Between vs. Within Subjects

Between subjects

- Each participant uses one condition
  - + Can collect more data for a given condition
  - + Avoid carry-over learning effects
  - - Participants cannot compare conditions
  - - Need more participants

Within subjects

- All participants try all conditions
  - + Compare one person across conditions to isolate effects of individual diffs
  - + Requires fewer participants
  - - Fatigue effects
  - - Bias due to ordering/learning effects

Menu selection example: Within-subjects, each subject tries each condition multiple times, ordering counterbalanced

Steps in Designing an Experiment

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Run the Experiment

Always pilot it first!

- Reveals unexpected problems
- Can’t change experiment design after starting it

Always follow same steps – use a checklist

Get consent from subjects

Debrief subjects afterwards

Steps in Designing an Experiment

1. State a lucid, testable hypothesis
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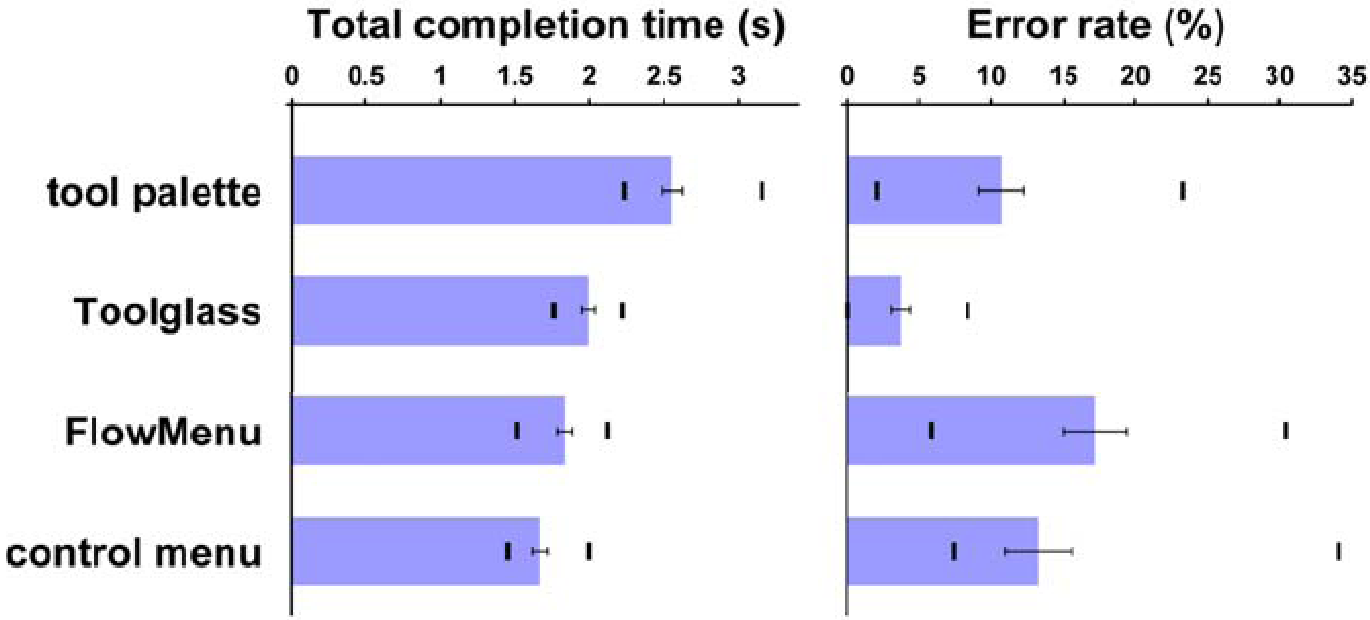
Descriptive Statistics

Results: Statistical Analysis

Compute central tendencies (descriptive summary statistics) for each independent variable

- Mean
- Standard deviation



Inferential Statistics

Are the Results Meaningful?

Hypothesis testing

- **Hypothesis:** Manipulation of IV effects DV in some way
- **Null hypothesis:** Manipulation of IV has no effect on DV
- Null hypothesis assumed true unless statistics allow us to reject it

Statistical significance (p value)

- Likelihood that results are due to chance variation
- $p < 0.05$ usually considered significant (Sometimes $p < 0.01$)
  - Means that < 5% chance that null hypothesis is true

Statistical tests

- T-test (1 factor, 2 levels)
- ANOVA (1 factor, > 2 levels, multiple factors)

Explaining Psychological Statistics
Barry H. Cohen

ANOVA

Single factor analysis of variance (ANOVA)

- Compare manes for 3 or more levels of a single independent variable

Multi-Way Analysis of variance (n-Way ANOVA)

- Compare more than one independent variable
- Can find interactions between independent variables

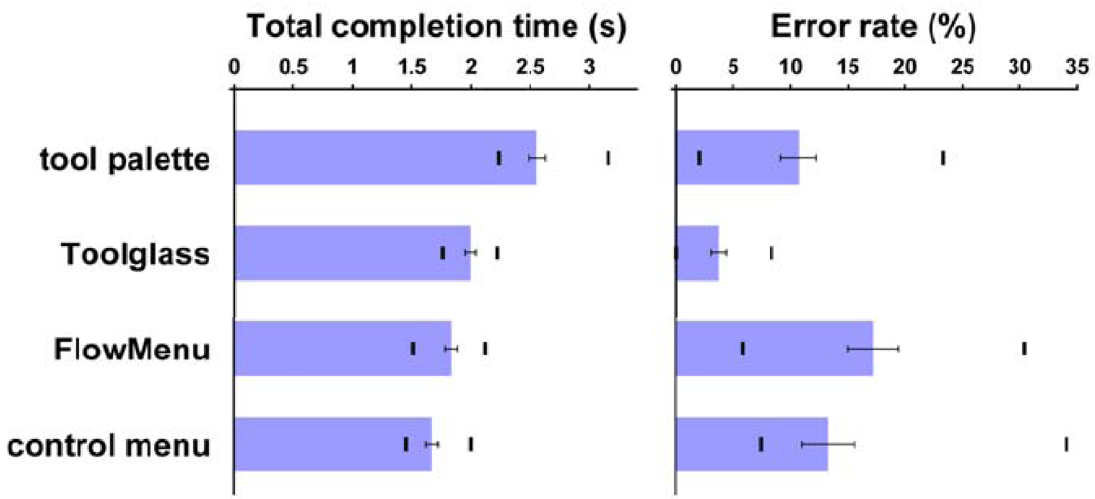
Multi-variate analysis of variance (MANOVA)

- Compare between more than one dependent var.

ANOVA tests whether means differ, but does not tell us which means differ – for this we must perform pairwise t-tests

Which should we use for the menu selection example?

Menu Selection Example



ANOVA → means for completion times were significantly different (F(3,33) = 73.4, p < .0005)

- Tool palette significantly slower than others (p < .0001 in all cases)
- Control menu faster than FlowMenu but not sig (p = .2)
- FlowMenu faster than Toolglass (p < .01)
- Control menu faster than Toolglass (p < .0005)

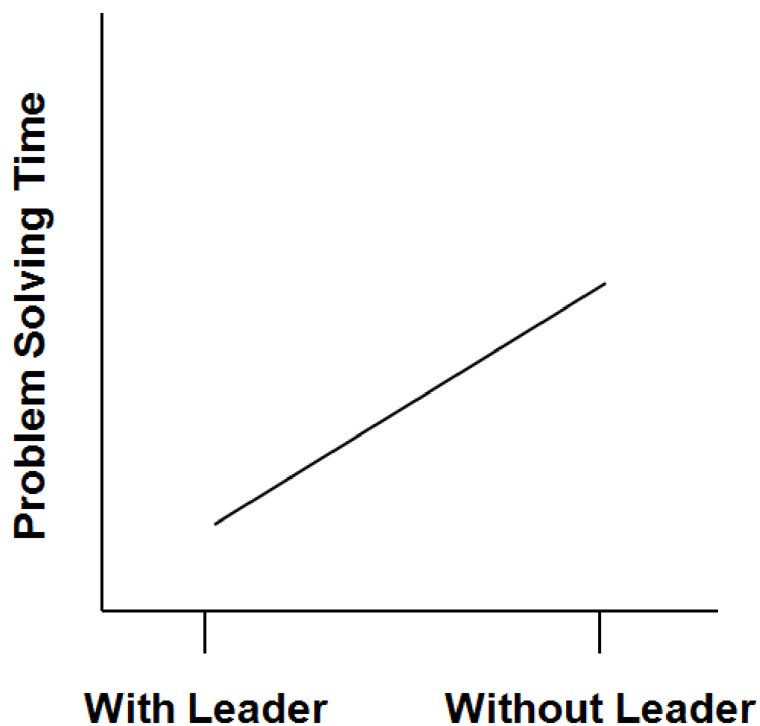
Separate analysis for error rates

Interaction Effects

Example of Interactions

Group problem solving

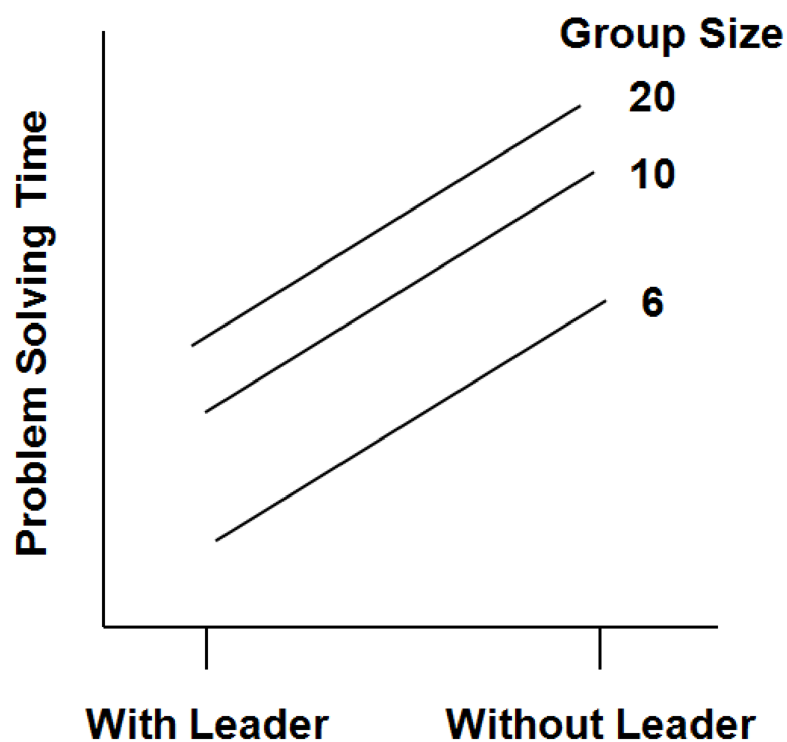
- Independent variable: Leadership



[from Martin 04]

Example of Interactions

Group problem solving
- Independent variable: Leadership
- Independent variable: Group size



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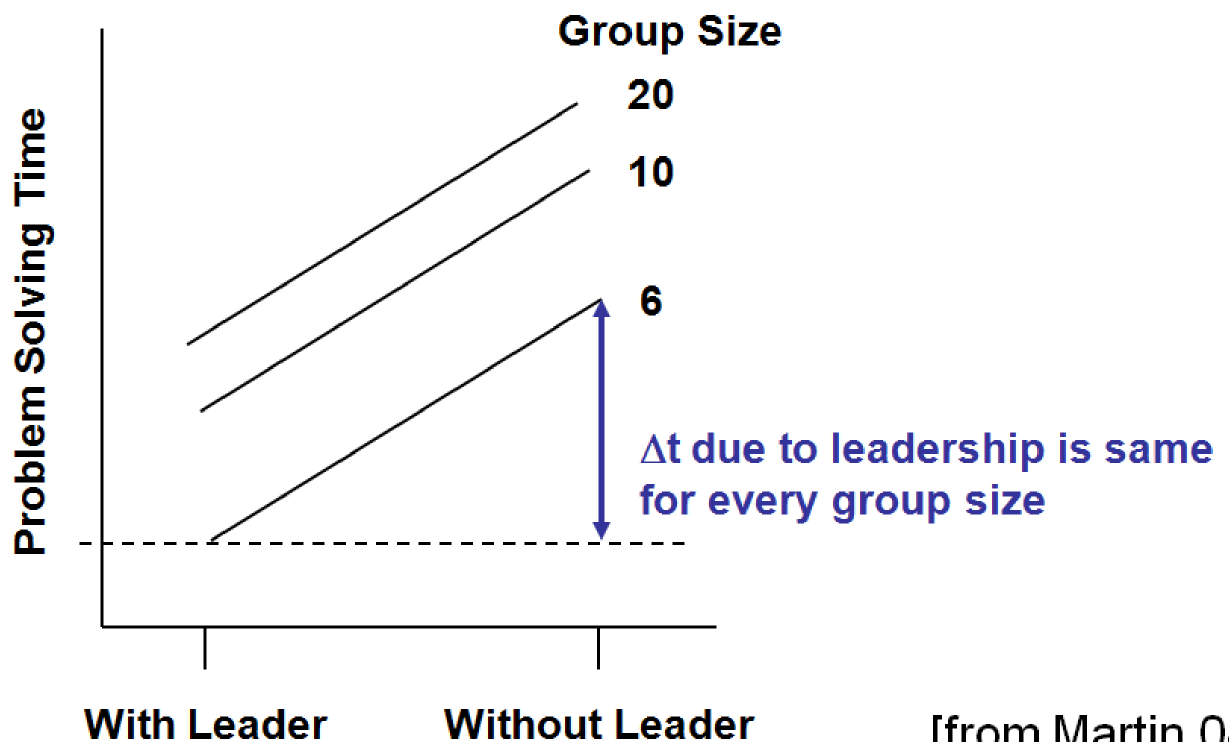
Example of Interactions

Group problem solving

- Change in time due to leadership is same regardless of group size



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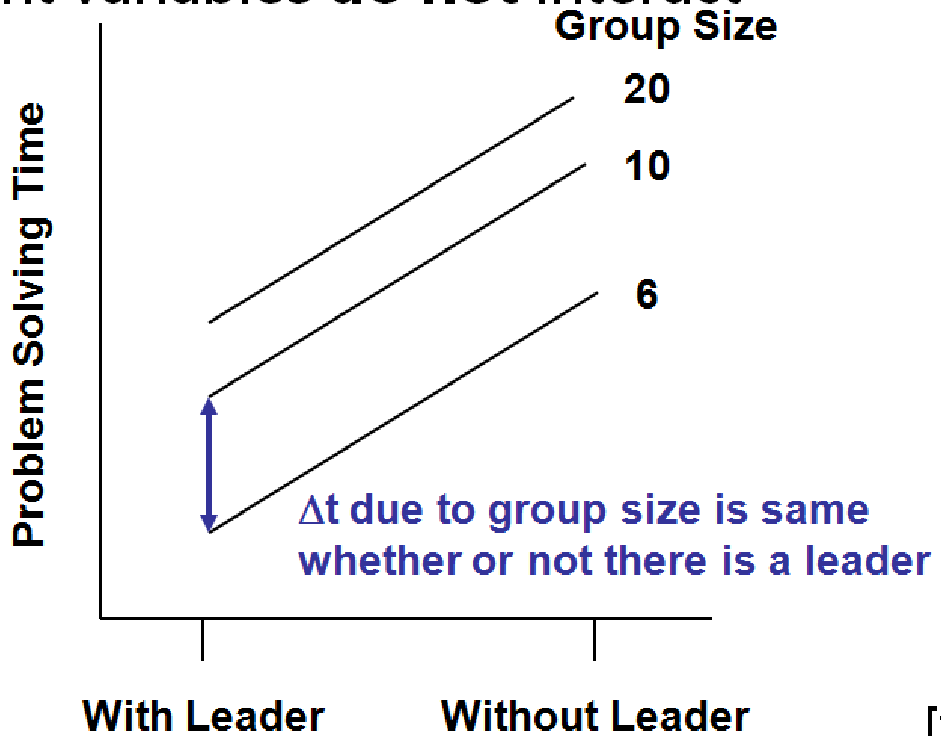
Example of Interactions

Group problem solving

- Change in time due to leadership is same regardless of group size
- Change in time due to group size is same regardless of leadership
- Independent variables **do not** interact

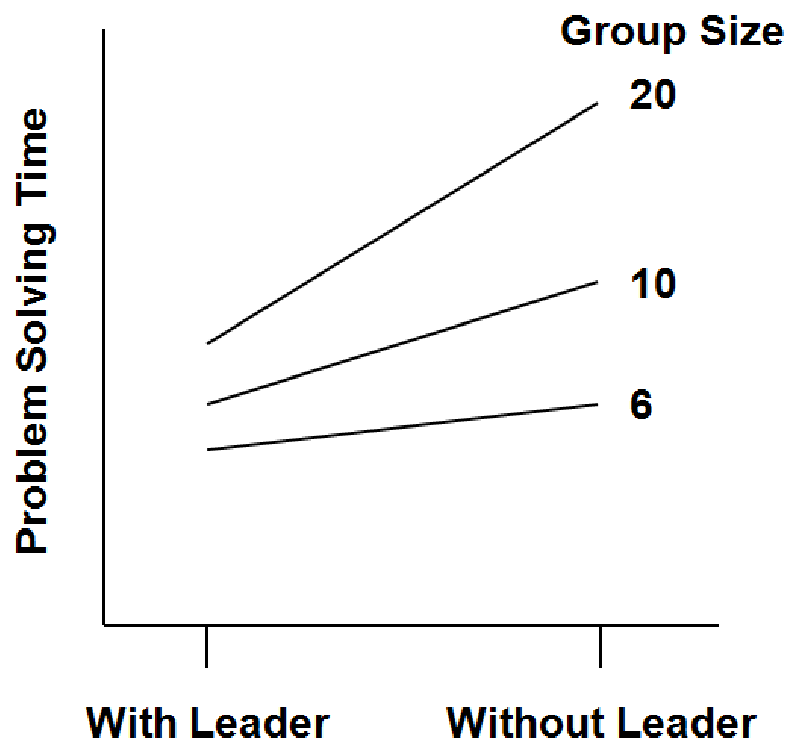


[from Martin 04]

Example of Interactions

Multiple IVs effect DV non-additively

- Change in time due to leadership differs with changes in group size
- Independent variables **do** interact



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Summary

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  Independent vs. Dependent Variables

  Within Subject vs. Between Subject Design

  Descriptive vs. Inferential Statistics

- Interaction Effects