# Lecture #7

Factorial designs continued

# Midterm

- Instructions will be posted on Blackboard
- 2 hours to complete
- 1 attempt
- Monday October 30th

# 1. Context and memory

*Br. J. Psychol.* (1975), **66**, 3, *pp.* 325–331
*Printed in Great Britain*



## CONTEXT-DEPENDENT MEMORY IN TWO NATURAL ENVIRONMENTS: ON LAND AND UNDERWATER

BY D. R. GODDEN AND A. D. BADDELEY
*Department of Psychology, University of Stirling*

In a free recall experiment, divers learnt lists of words in two natural environments: on dry land and underwater, and recalled the words in either the environment of original learning, or in the alternative environment. Lists learnt underwater were best recalled underwater, and vice versa. A subsequent experiment shows that the disruption of moving from one environment to the other was unlikely to be responsible for context-dependent memory.

# Roadmap

- Background on context-dependent memory
- The experiment
- The results
- Discussion

# Background on context-dependent memory

- Everyday experiences suggest that environmental context plays an important role in memory retrieval
- You may have had the experience of walking from the kitchen into the living room to find your keys, but having walked into the living room, forgotten what you were doing there. Only by going back into the kitchen do you remember that you were originally looking for your keys

# Background on context-dependent memory

- The living room example suggests that the environmental context (e.g., the living room, or the kitchen) can influence memory retrieval
- However, numerous attempts to produce this kind of effect in the laboratory have failed, and when they have succeeded, the environmental contexts have been highly artificial

# Purpose

- The purpose of the experiment was to provide a clear demonstration that memory performance can depend on environmental context

# Design

- 18 subjects, all expert divers
- 5 lists of 36 unrelated words were recorded on tape
- 2x2 between subjects design
  - Listened to word lists on Land or Underwater
  - Recall memory test on Land or Underwater

# Hypothesis

- Memory performance will depend on environmental context
- Better memory when test environment matches learning environment
- Worse memory when test environment does not match learning environment

# Results

Table 1. *Mean number of words recalled in Expt. I as a function of learning and recall environment*

| Learning environment | Recall environment: Dry — Mean recall score | Dry — S.D. | Recall environment: Wet — Mean recall score | Wet — S.D. | Total |
|---|---|---|---|---|---|
| Dry | 13·5 | 5·8 | 8·6 | (3·0) | 22·1 |
| Wet | 8·4 | 3·3 | 11·4 | (5·0) | 19·8 |
| Total | 21·9 | — | 20·0 | — | — |

# Results

- The results demonstrate clear evidence for context-dependent memory retrieval
- Words studied on land were remembered better on land than underwater, and words studied underwater were remembered better underwater than on land

# Simulating the data

- If you fully understand the logic of factorial designs, you should be able to:
- Create simulated data that reflect predictions for the experiment
- Compute the main effects and interactions in excel
- Analyze the data using an appropriate ANOVA in SPSS

# Creating fake data for 2x2 designs

- Follow general linear model logic
- Each data point is a linear combination of influences

DV = Population mean + IV(s) + Interaction(s) + Noise

# 2x2 design

| Encoding | Land | | Water | |
|---|---|---|---|---|
| Recall | Land | Water | Land | Water |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |

DV = Population mean + IV(s) + Interaction(s) + Noise

| Encoding | Land | | Water | |
|---|---|---|---|---|
| Recall | Land | Water | Land | Water |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |
| | ? | ? | ? | ? |

# Predictions

- Main effect of Encoding environment:
    - Land > Water
- Main effect of Recall environment
    - Land > Water
- Encoding x Recall interaction
    - Matching Environments > Mismatching Environments

DV = Population mean + IV(s) + Interaction(s) + Noise

↓

DV = Population mean + Encoding + Recall + Encoding*Recall + Noise

**What is the population mean?**

The average expected value from the population at large, in this example it is number of words recalled

Let's say 10

All data points take this starting value

DV = Population mean + IV(s) + Interaction(s) + Noise

↓

DV = Population mean + Encoding + Recall +
Encoding*Recall + Noise

**What is the Encoding influence?**

Influence of Land vs. Water Encoding environment
on # of words recalled

Land Encoding = +2
Water Encoding = -2

DV = Population mean + IV(s) + Interaction(s) + Noise

↓

DV = Population mean + Encoding + Recall +
Encoding*Recall + Noise

**What is the Recall Environment influence?**

Influence of Land vs. Water Recall environment on
# of words recalled

Land Encoding = +2
Water Encoding = -2

DV = Population mean + IV(s) + Interaction(s) + Noise

↓

DV = Population mean + Encoding + Recall + Encoding*Recall + Noise

**What is the Encoding*Recall influence?**

Additional influence on # of words recalled having to do with match between conditions

Land/Land & Water/Water = +2

Land/Water & Water/Land = -2

DV = Population mean + IV(s) + Interaction(s) + Noise

↓

DV = Population mean + Encoding + Recall +
Encoding*Recall + Noise

**What is the NOISE?**

Random number that influences # of words recalled

Otherwise known as measurement error or
unexplained variation

Noise= Pick a random number
(say between -3 & +3)

DV = Population mean + IV(s) + Interaction(s) + Noise

| Encoding | Land | | Water | |
|---|---|---|---|---|
| Recall | Land | Water | Land | Water |
| | 15 | ? | ? | ? |
| | ? | ? | ? | ? |
| ... | ? | ? | ? | ? |

= Population mean + Encoding + Recall + Encoding*Recall + NOISE

= 10 + (+2) + (+2) + (+2) + (-1)= 15

DV = Population mean + IV(s) + Interaction(s) + Noise

| Encoding | Land | | Water | |
|---|---|---|---|---|
| Recall | Land | Water | Land | Water |
| | 15 | 9 | ? | ? |
| | ? | ? | ? | ? |
| ... | ? | ? | ? | ? |

= Population mean + Encoding + Recall + Encoding*Recall + NOISE

= 10 + (+2) + (-2) + (-2) + (+1)= 9

# Full example using Excel

# Main effects & Interactions

- In a simple 2x2, there are 8 possibilities
  - main effect for factor 1 only
  - main effect for factor 2 only
  - main effects for both factors, No interaction
  - main effect for factor 1, and an interaction
  - main effect for factor 2, and an interaction
  - main effects for both factors, and an interaction
  - Only an interaction, no main effects
  - No main effects, and No interaction

What do main effects look like?

What do interactions look like?

# Main effects & Interactions

- In a simple 2x2, there are 8 possibilities
  - main effect for factor 1 only
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  - main effects for both factors, No interaction
  - main effect for factor 1, and an interaction
  - main effect for factor 2, and an interaction
  - main effects for both factors, and an interaction
  - Only an interaction, no main effects
  - No main effects, and No interaction

# Main effects?
# Interaction?

| | | Congruency | | |
|---|---|---|---|---|
| | | Congruent | Incongruent | |
| Task | Word | 350 | 350 | 350 |
| | Color | 350 | 350 | 350 |
| | | 350 | 350 | |

# Main effects? no

# Interaction? no

| | | Congruency | | |
|---|---|---|---|---|
| | | Congruent | Incongruent | |
| Task | Word | 350 | 350 | 350 |
| | Color | 350 | 350 | 350 |
| | | 350 | 350 | |

# Main effects?
# Interaction?

| | | Congruency | | |
|---|---|---|---|---|
| | | Congruent | Incongruent | |
| Task | Word | 350 | 380 | 365 |
| | Color | 350 | 380 | 365 |
| | | 350 | 380 | |

# Main effects? one

# Interaction? no

| | | Congruency | | |
|---|---|---|---|---|
| | | Congruent | Incongruent | |
| Task | Word | 350 | 380 | 365 |
| | Color | 350 | 380 | 365 |
| | | 350 | 380 | |

# Main effects?
# Interaction?

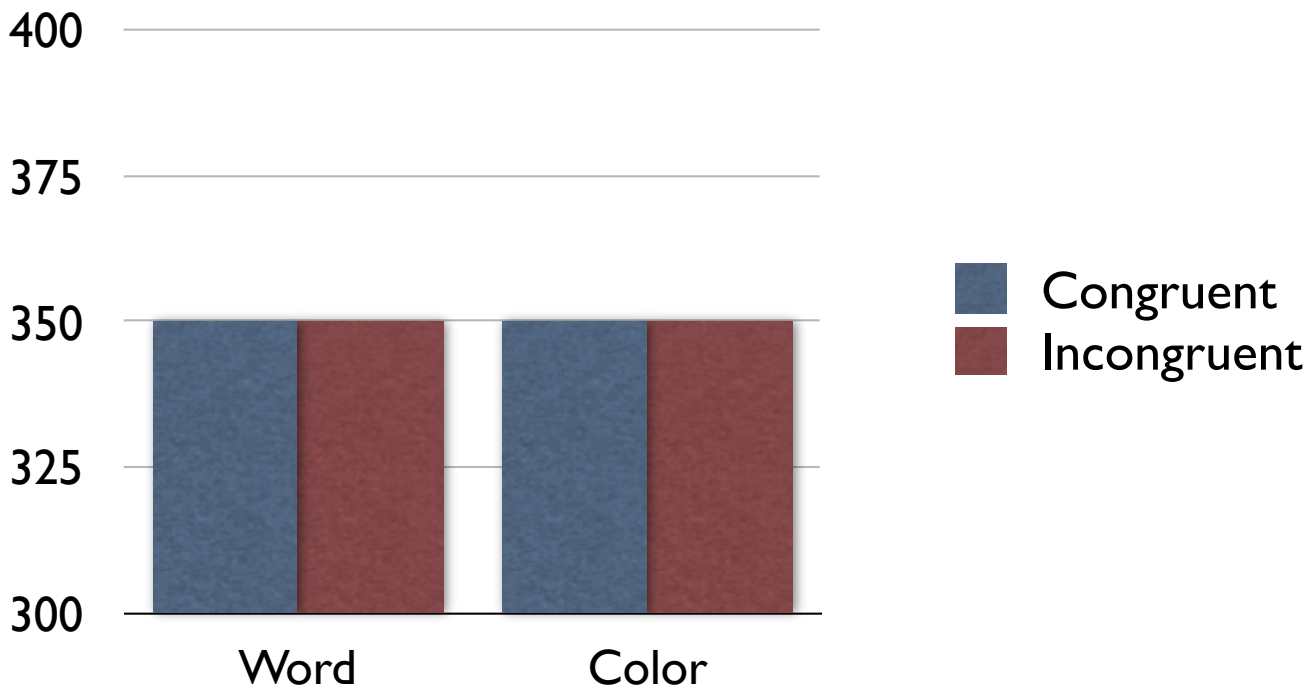
| | | Congruency | | |
|---|---|---|---|---|
| | | Congruent | Incongruent | |
| Task | Word | 350 | 370 | 360 |
| | Color | 360 | 380 | 370 |
| | | 355 | 375 | |

# Main effects? 2

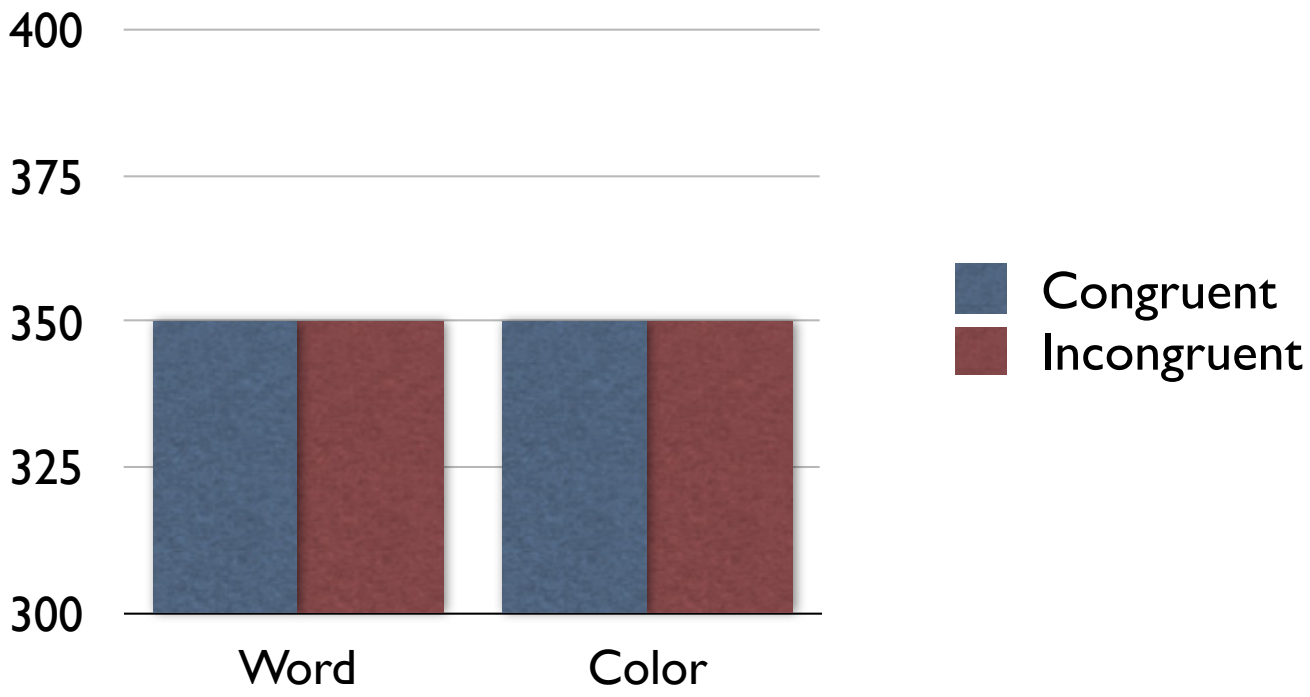
# Interaction? no

| | | Congruency | | |
|---|---|---|---|---|
| | | Congruent | Incongruent | |
| Task | Word | 350 | 370 | 360 |
| | Color | 360 | 380 | 370 |
| | | 355 | 375 | |

# Main effects?
# Interaction?

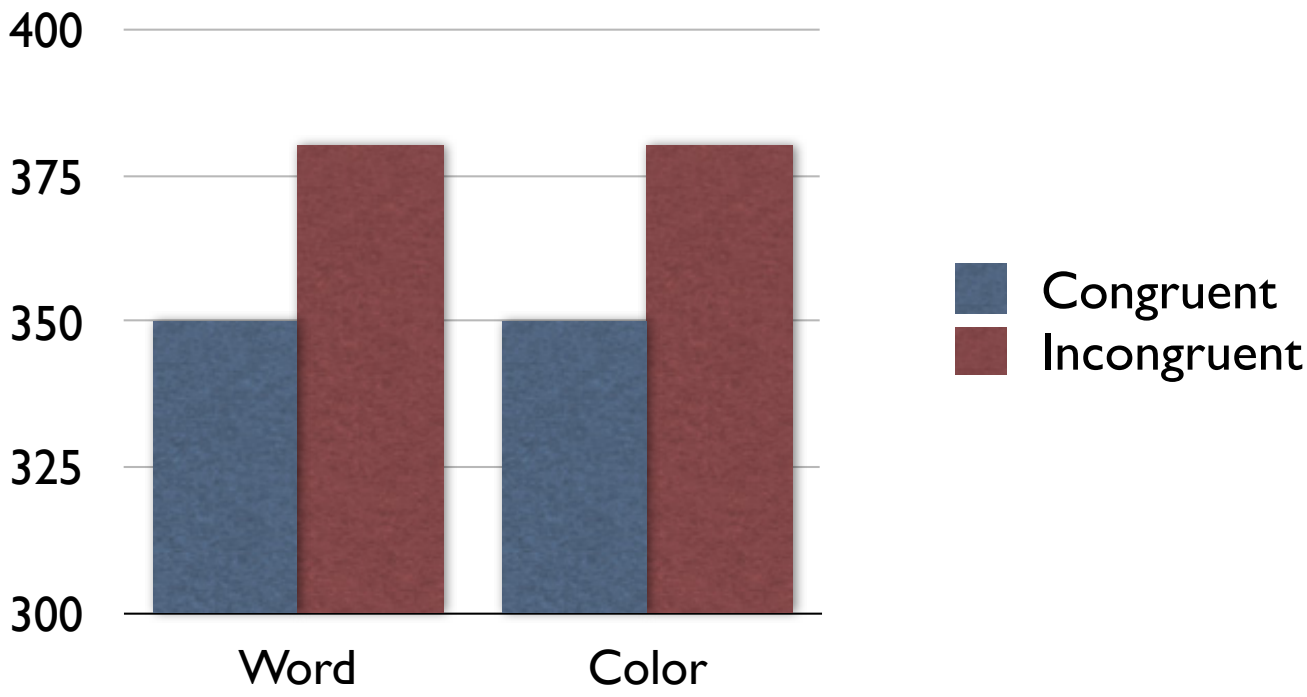


# Main effects?
# Interaction?

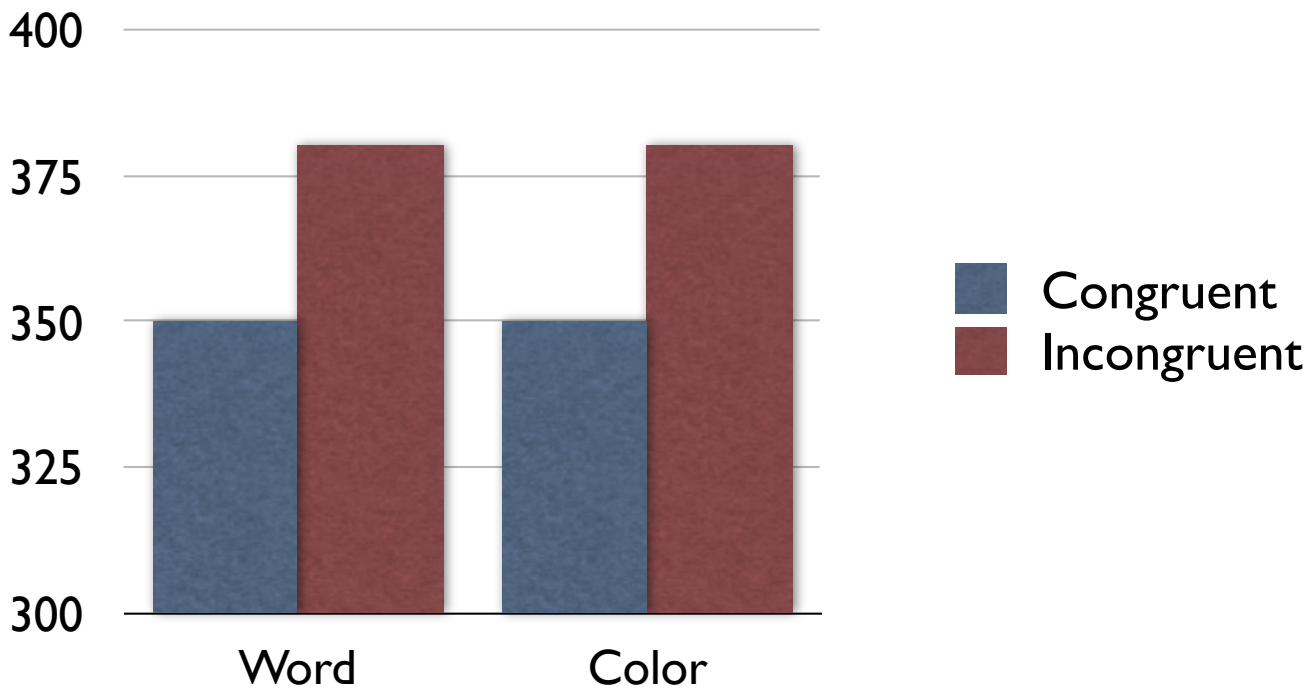



no main effects, no interaction

# Main effects?
# Interaction?

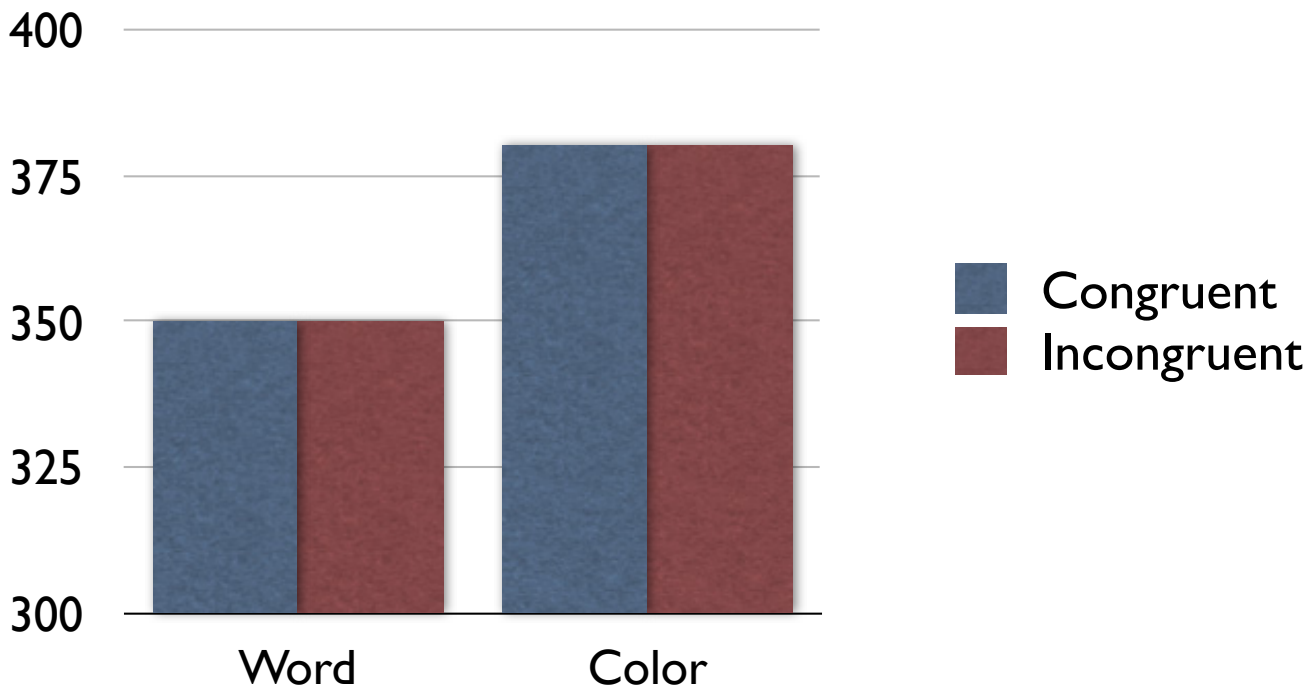


# Main effects?
# Interaction?

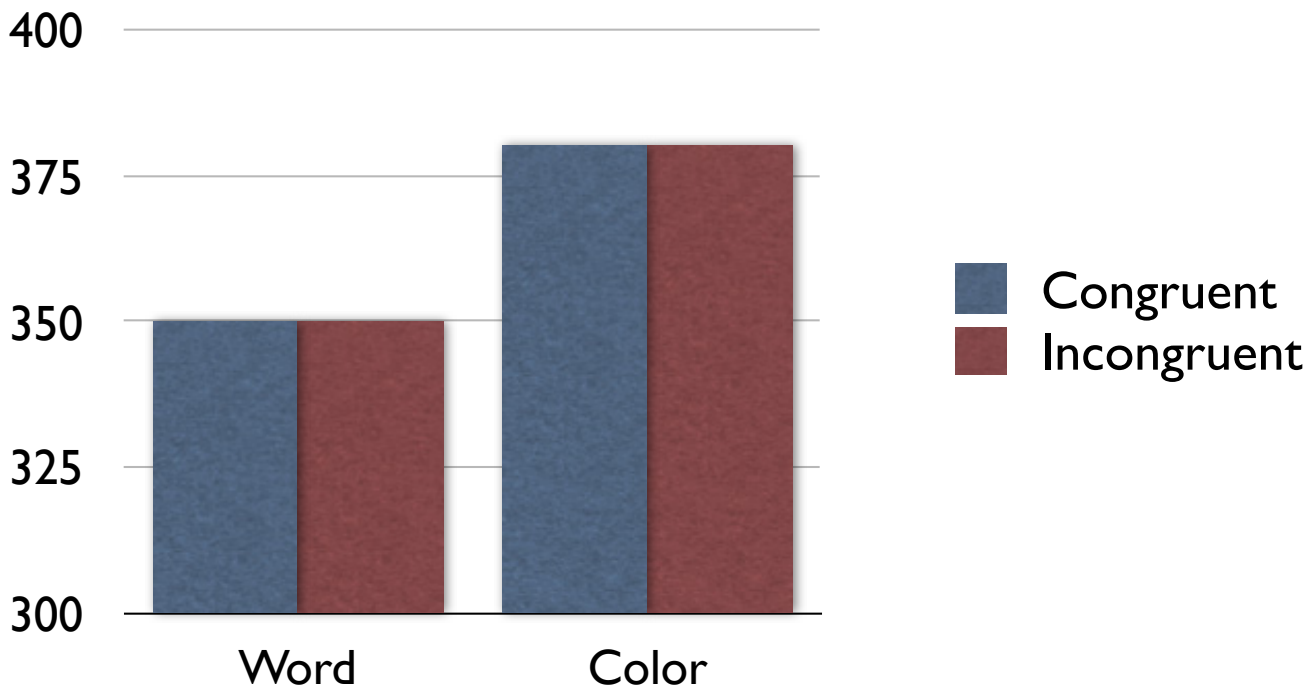



one main effect, no interaction

# Main effects?
# Interaction?

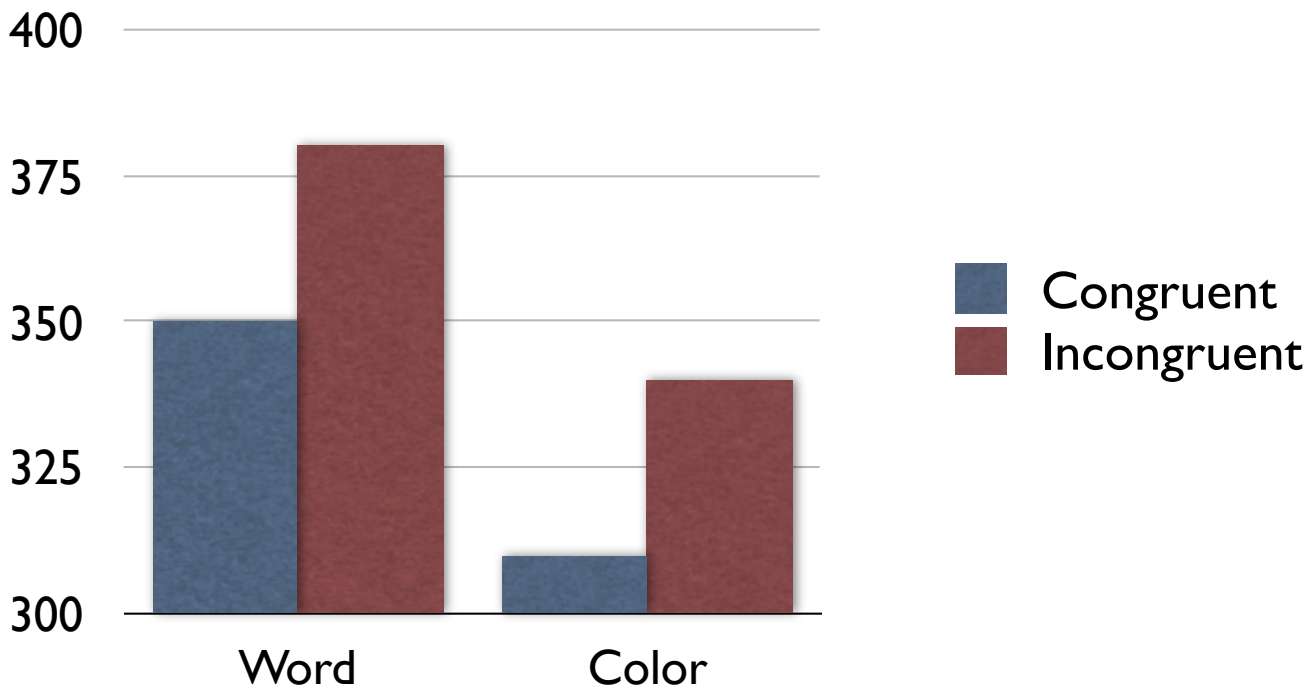


# Main effects?
# Interaction?

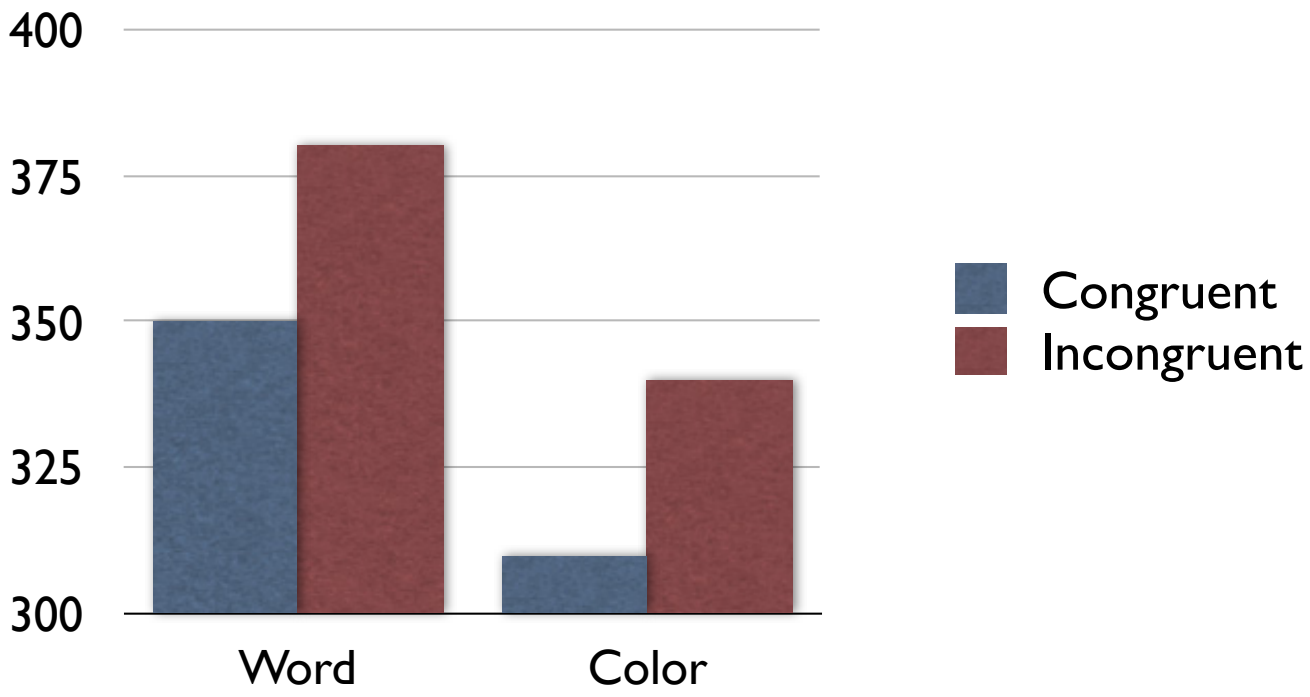



one main effect, no interaction

# Main effects?
# Interaction?



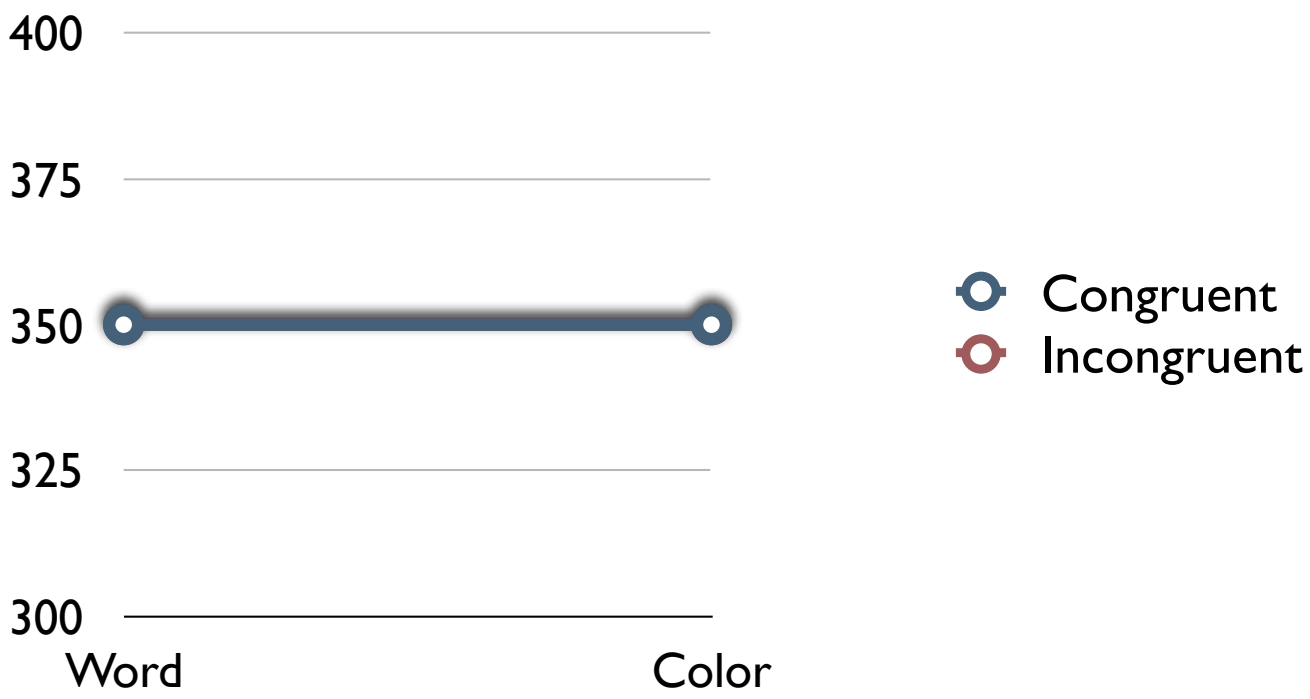
# Main effects?
# Interaction?




2 main effects, no interaction

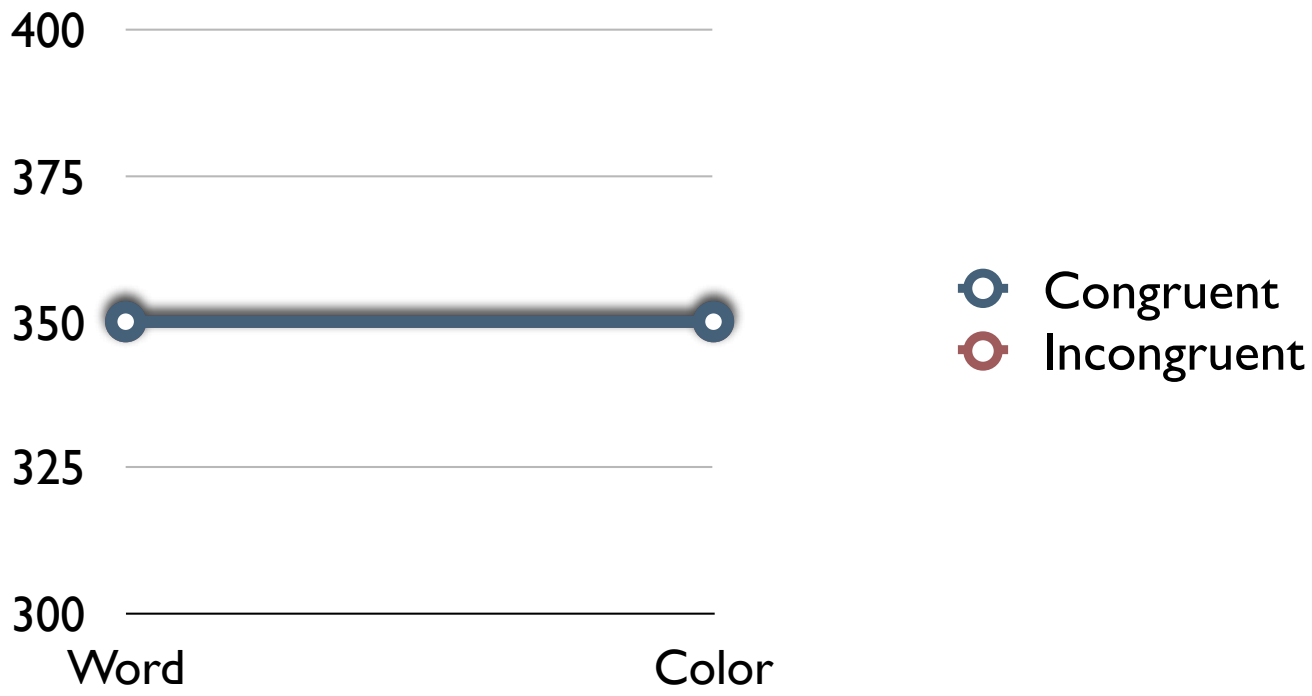
# Main effects?
# Interaction?

Note: blue and red lines are overlapping



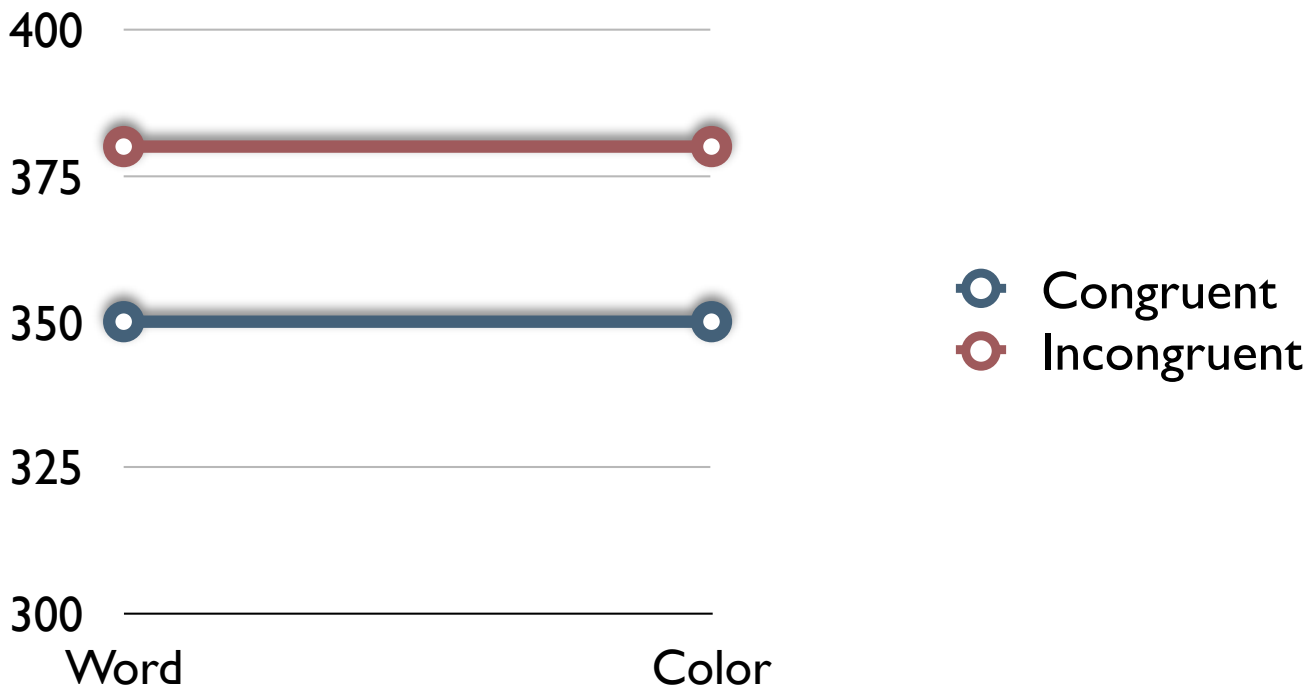
# Main effects?
# Interaction?

Note: blue and red lines are overlapping

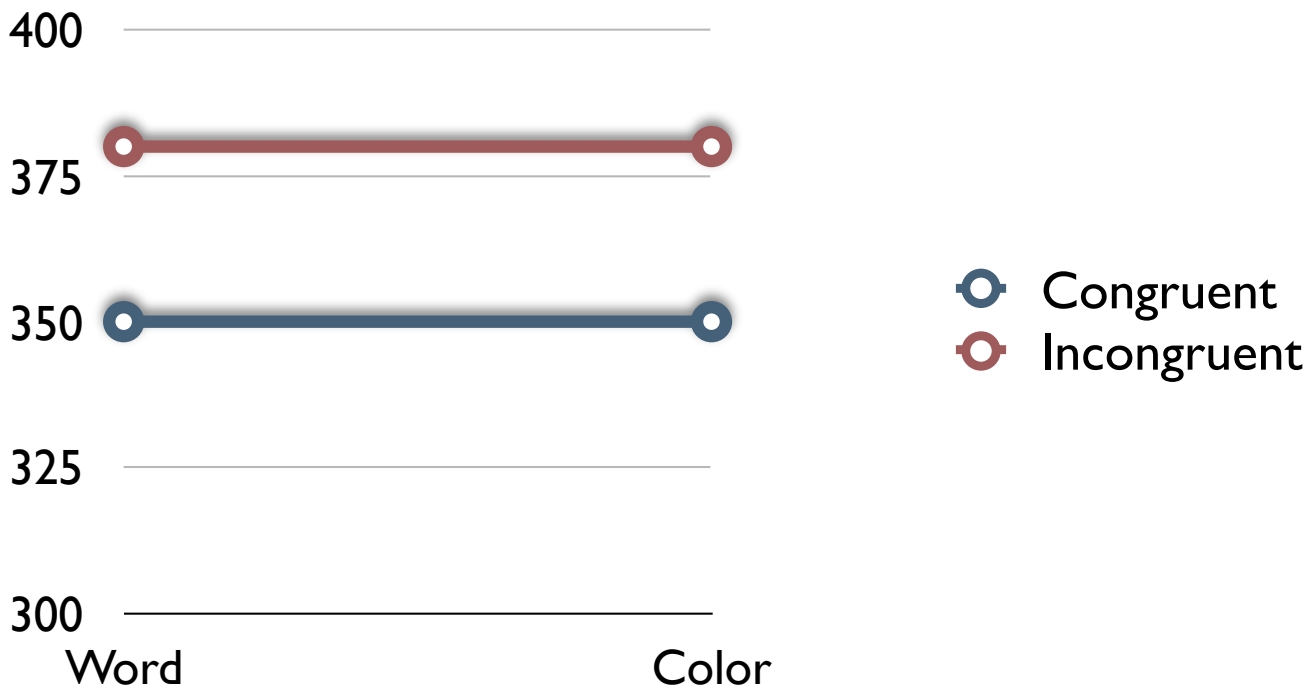



no main effects, no interaction

# Main effects?
# Interaction?



# Main effects?
# Interaction?

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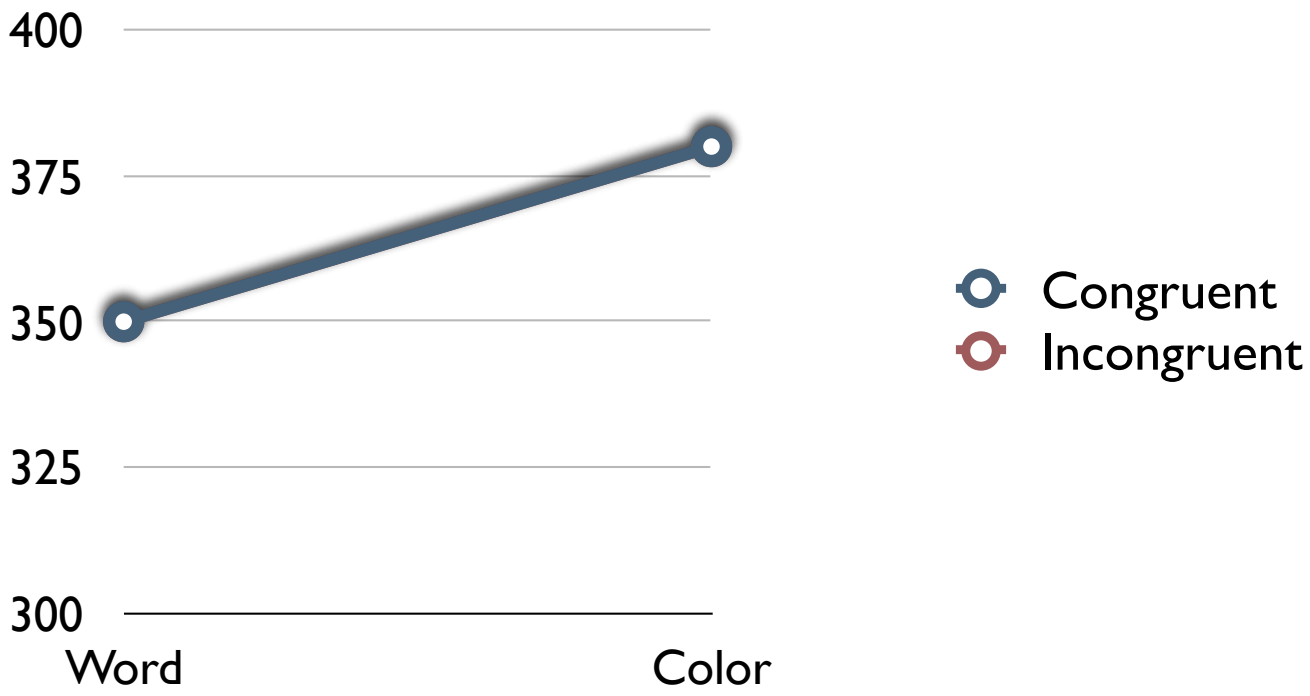
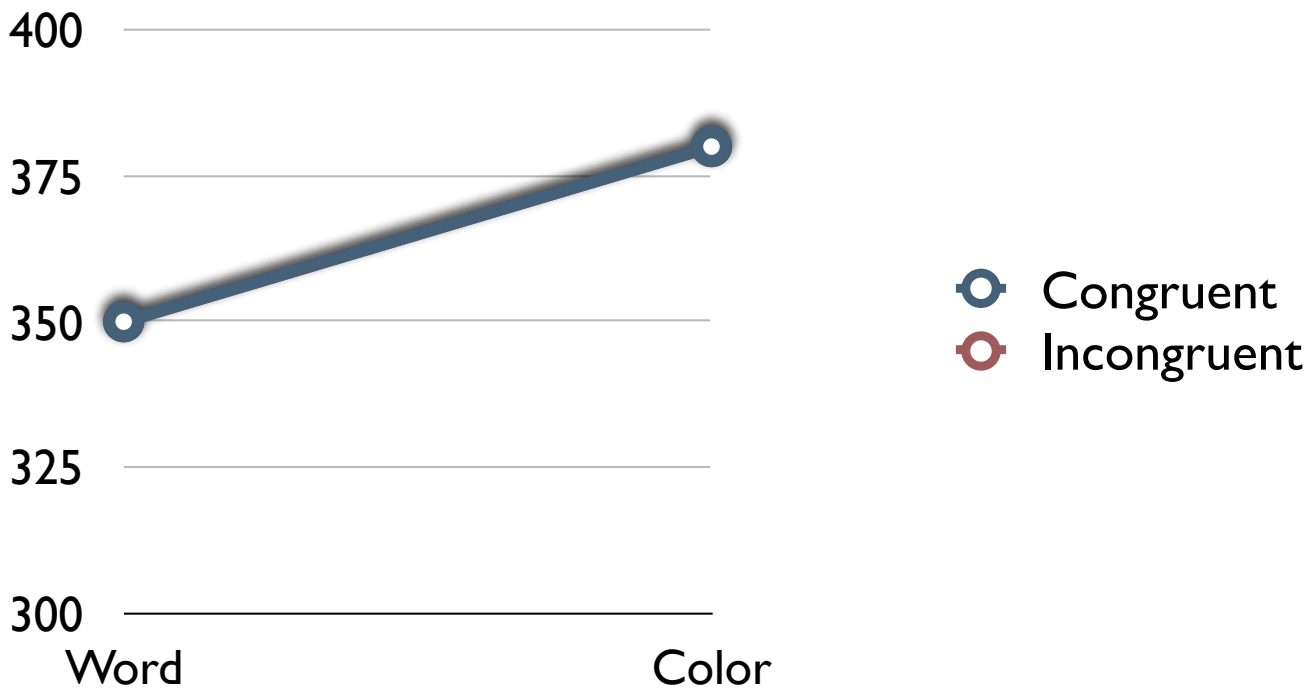


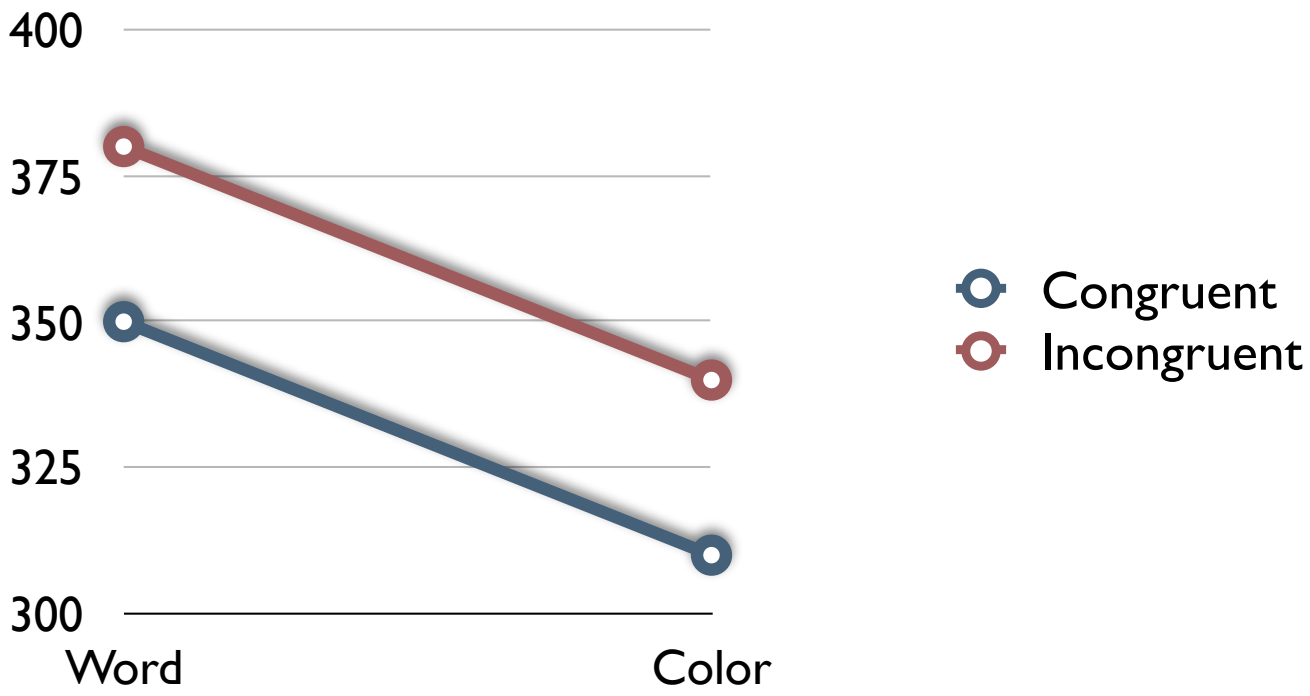
# Main effects?
# Interaction?

Note: blue and red lines are overlapping

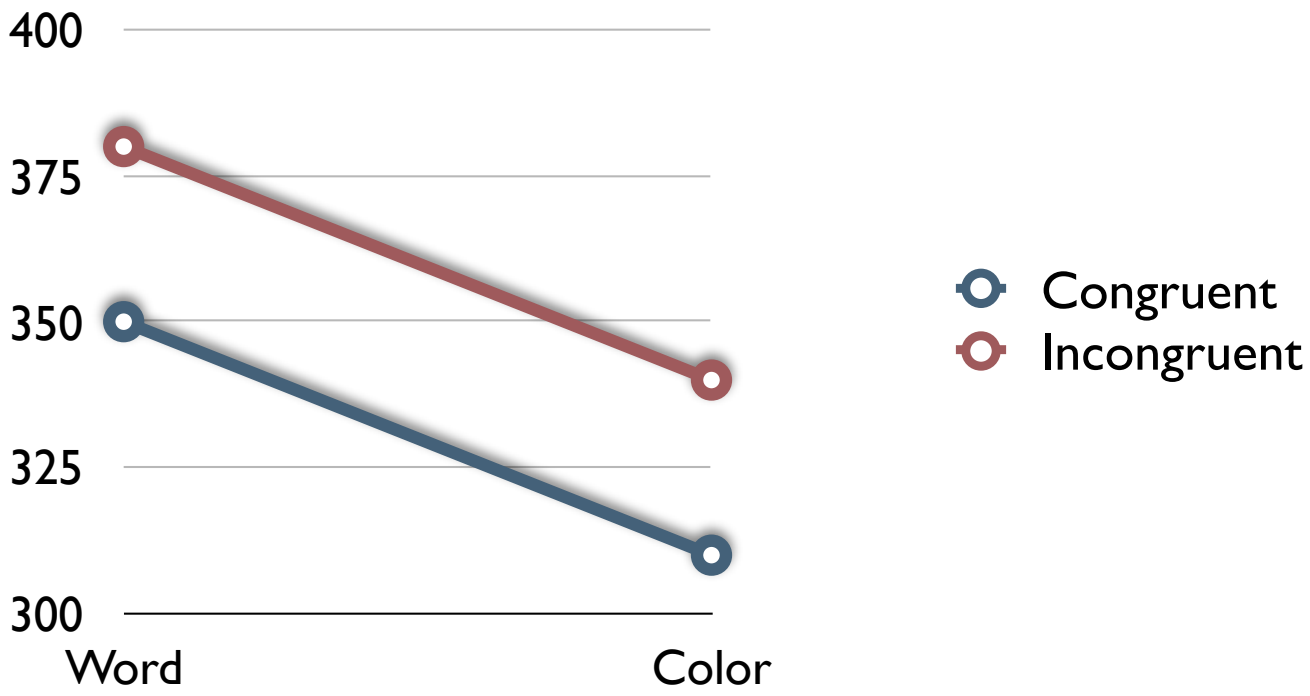



one main effect, no interaction

# Main effects?
# Interaction?

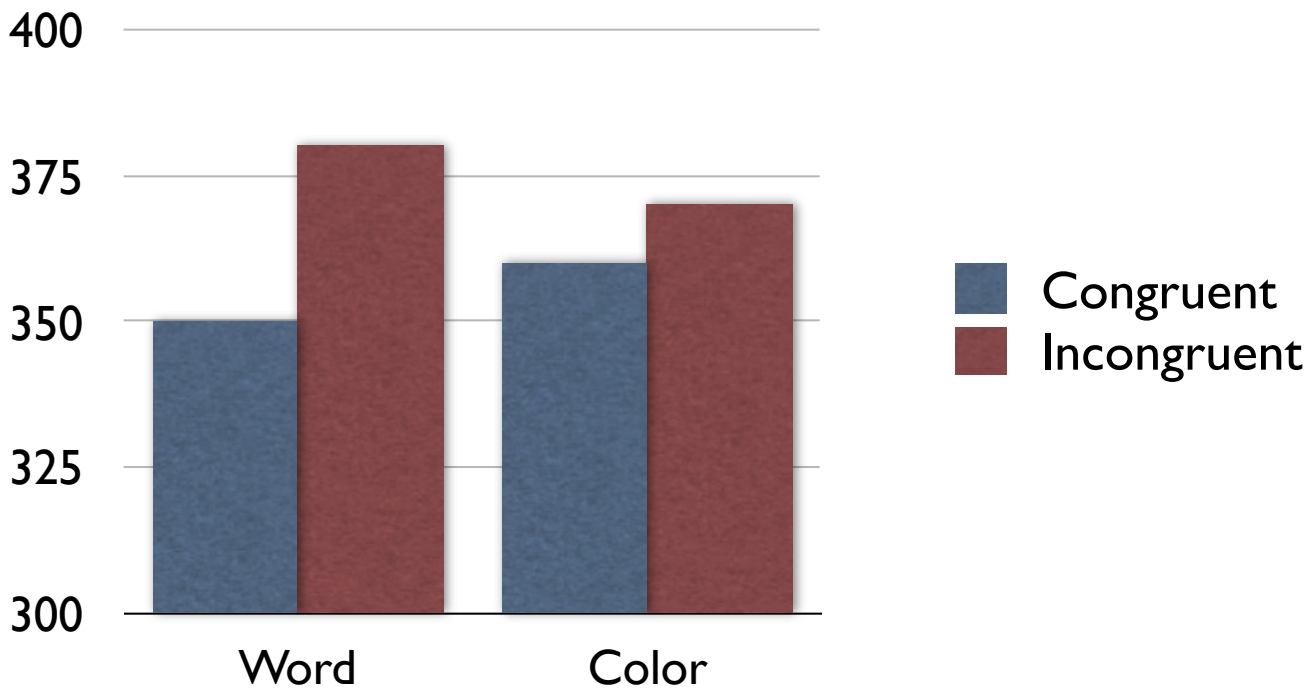


# Main effects?
# Interaction?

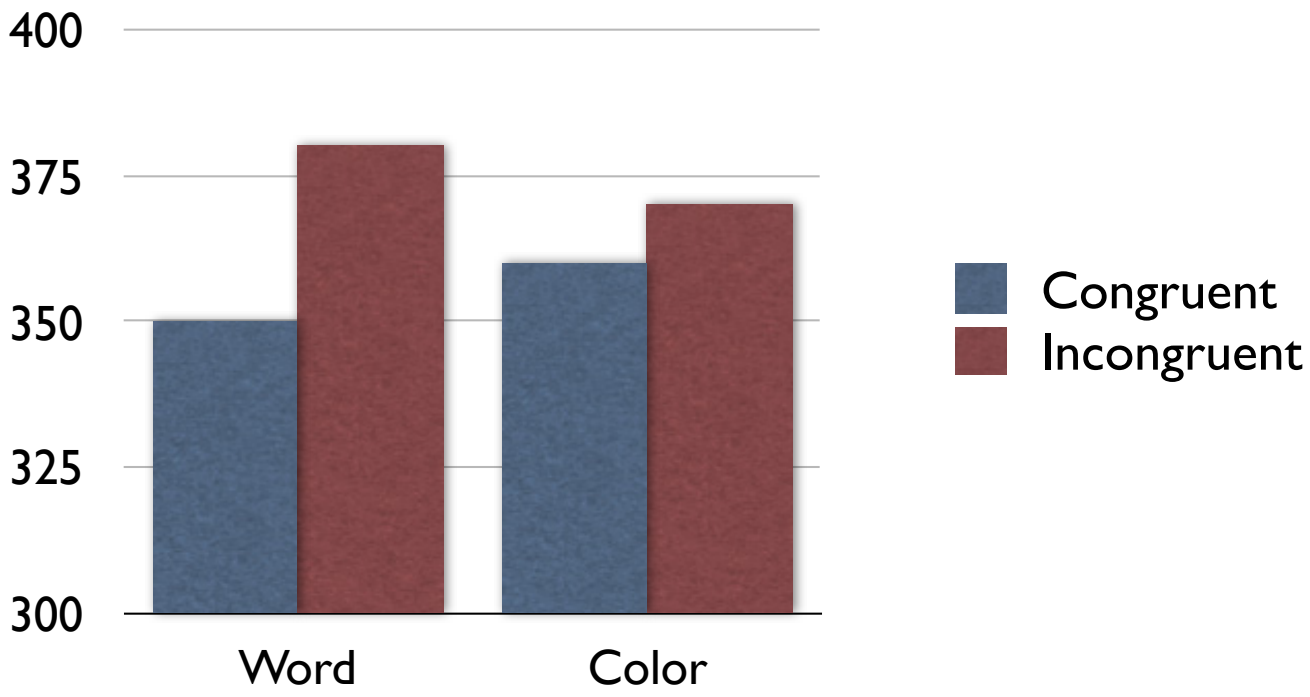



2 main effects, no interaction

# Main effects?
# Interaction?

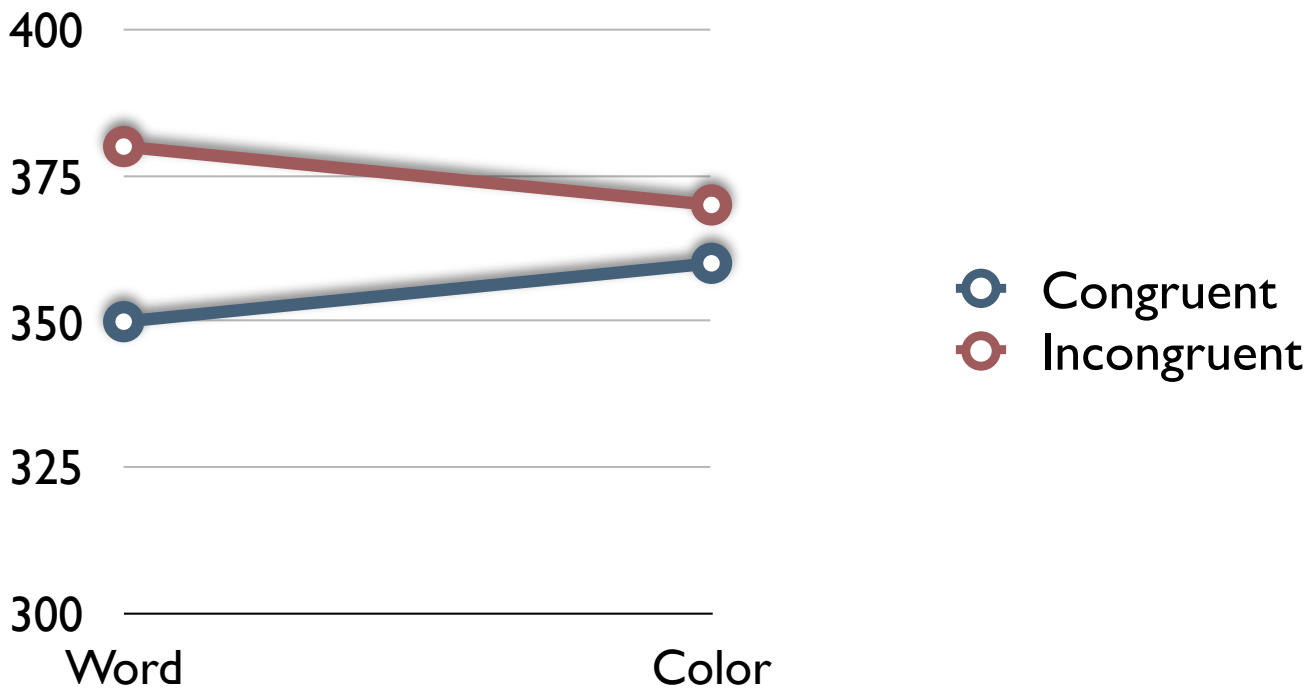


# Main effects?
# Interaction?

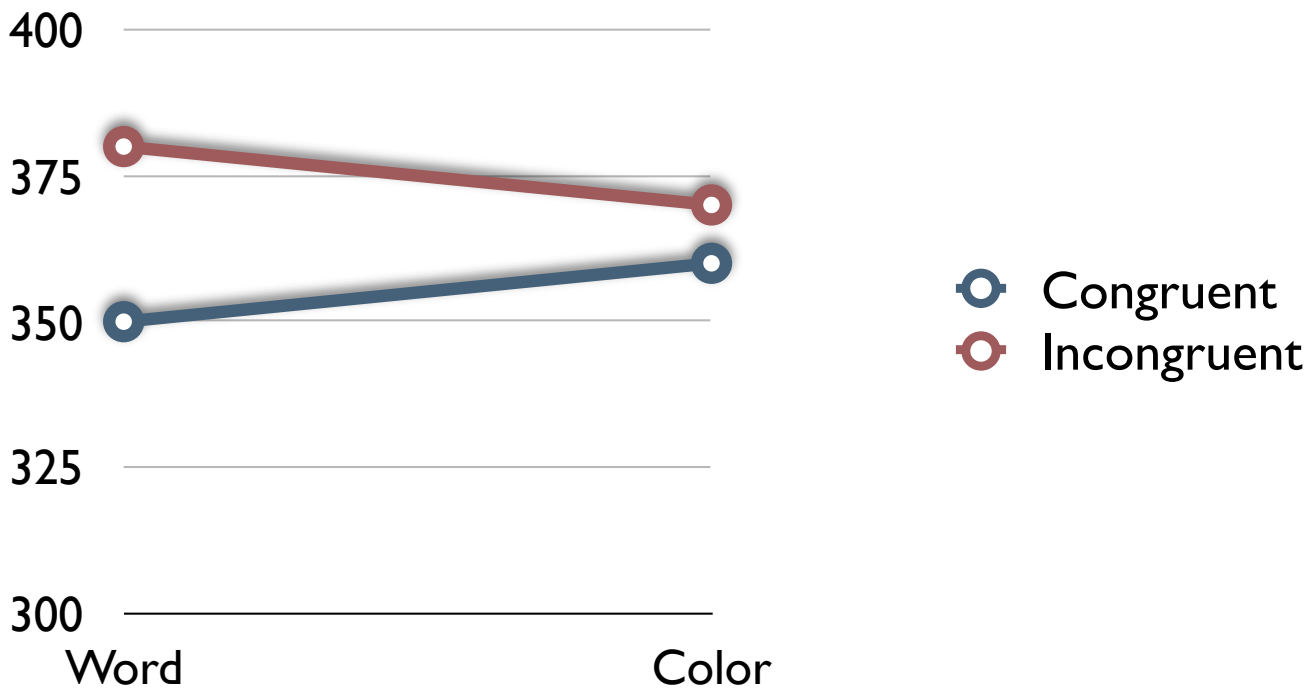



1 main effect, and an interaction

# Main effects?
# Interaction?

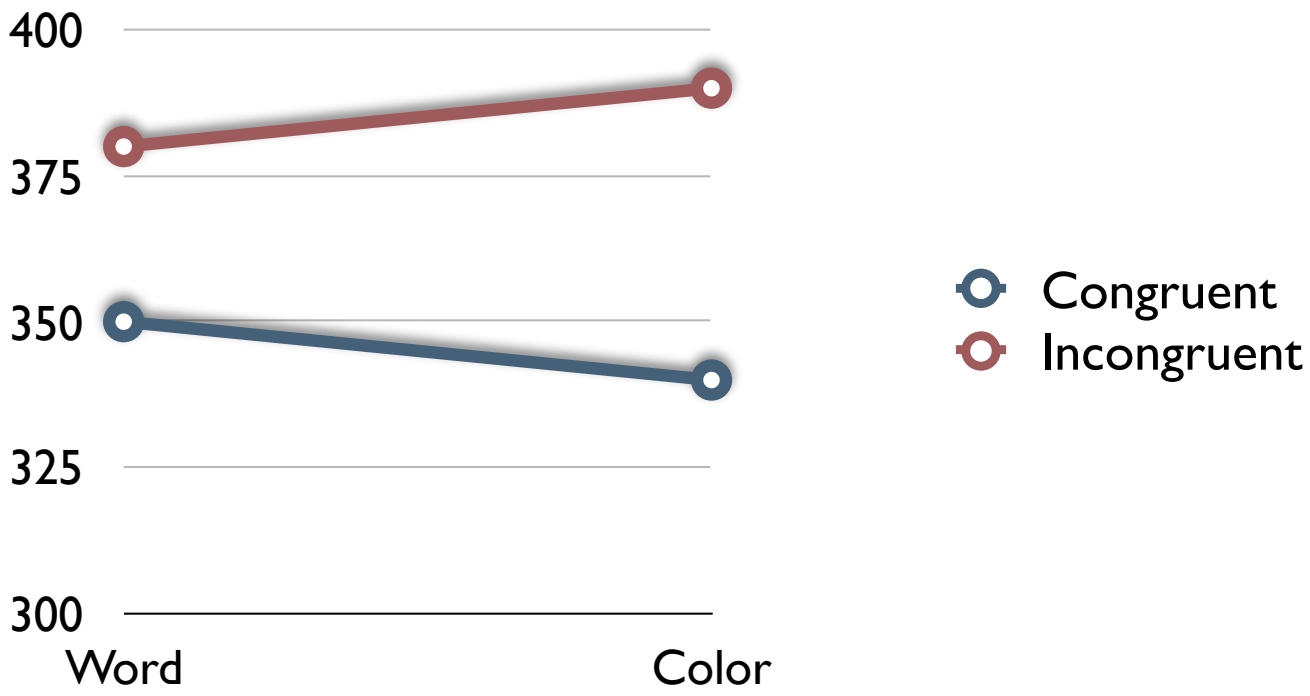


# Main effects?
# Interaction?

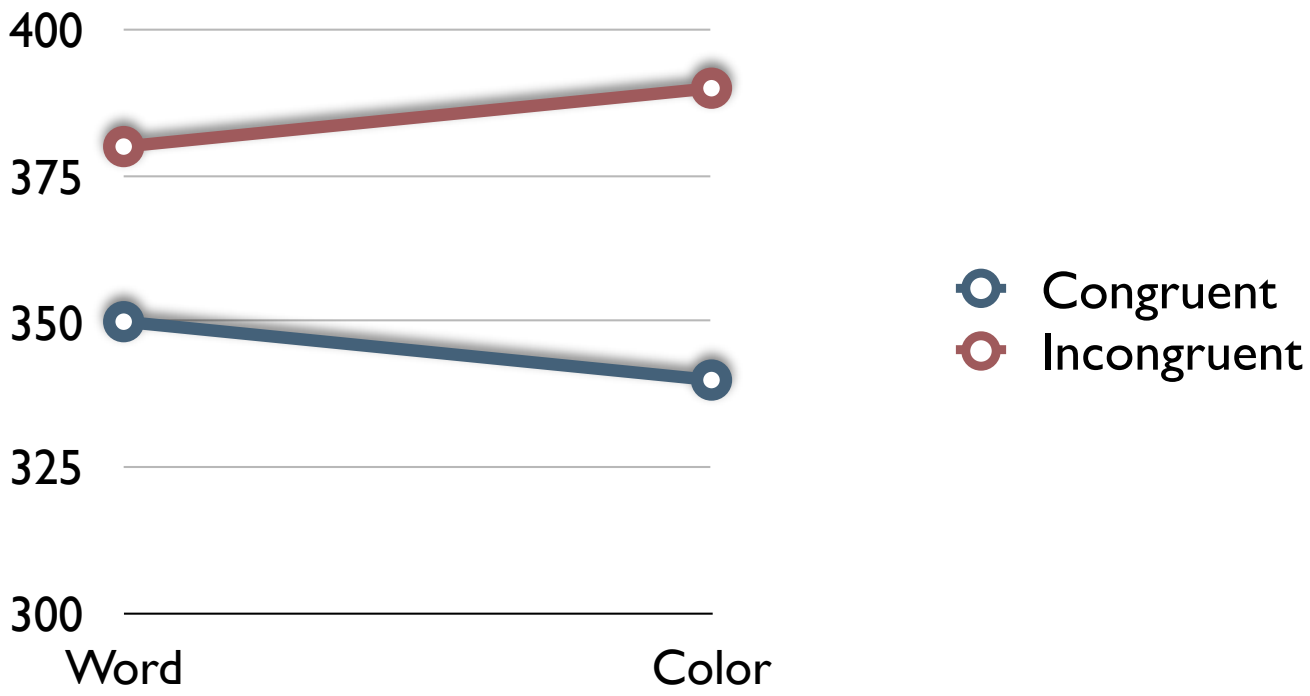



1 main effect, and an interaction

# Main effects?
# Interaction?

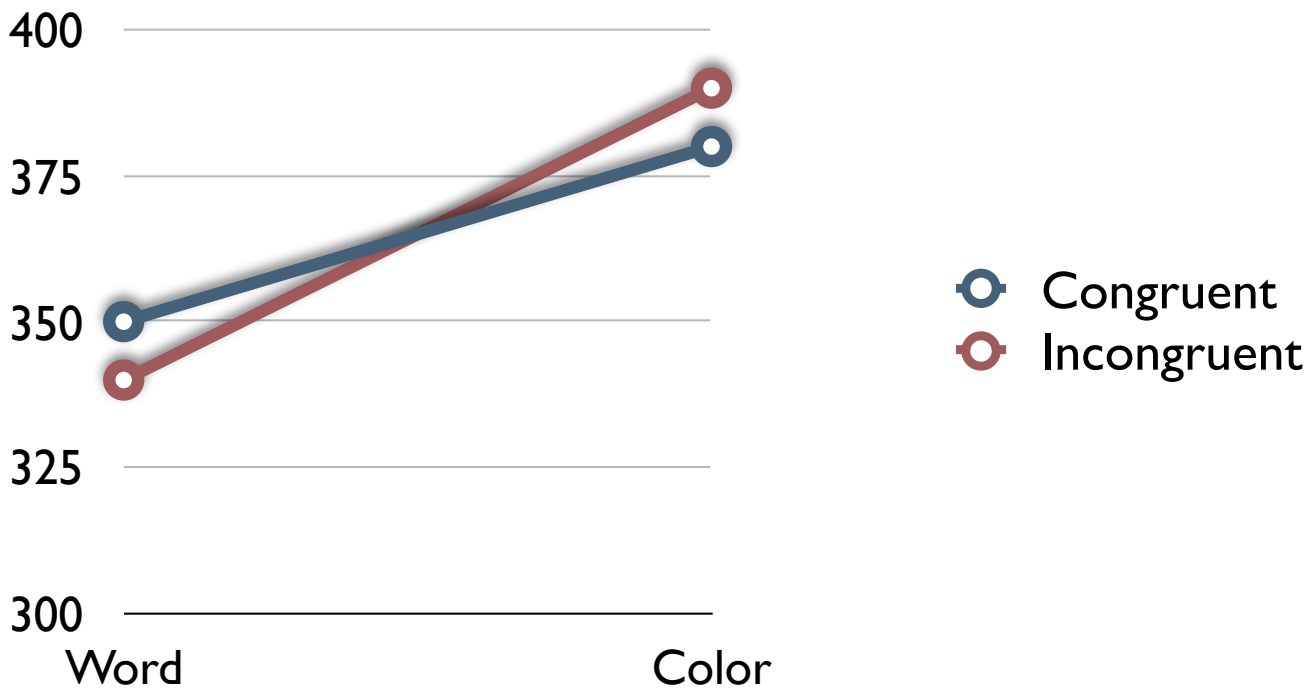


# Main effects?
# Interaction?

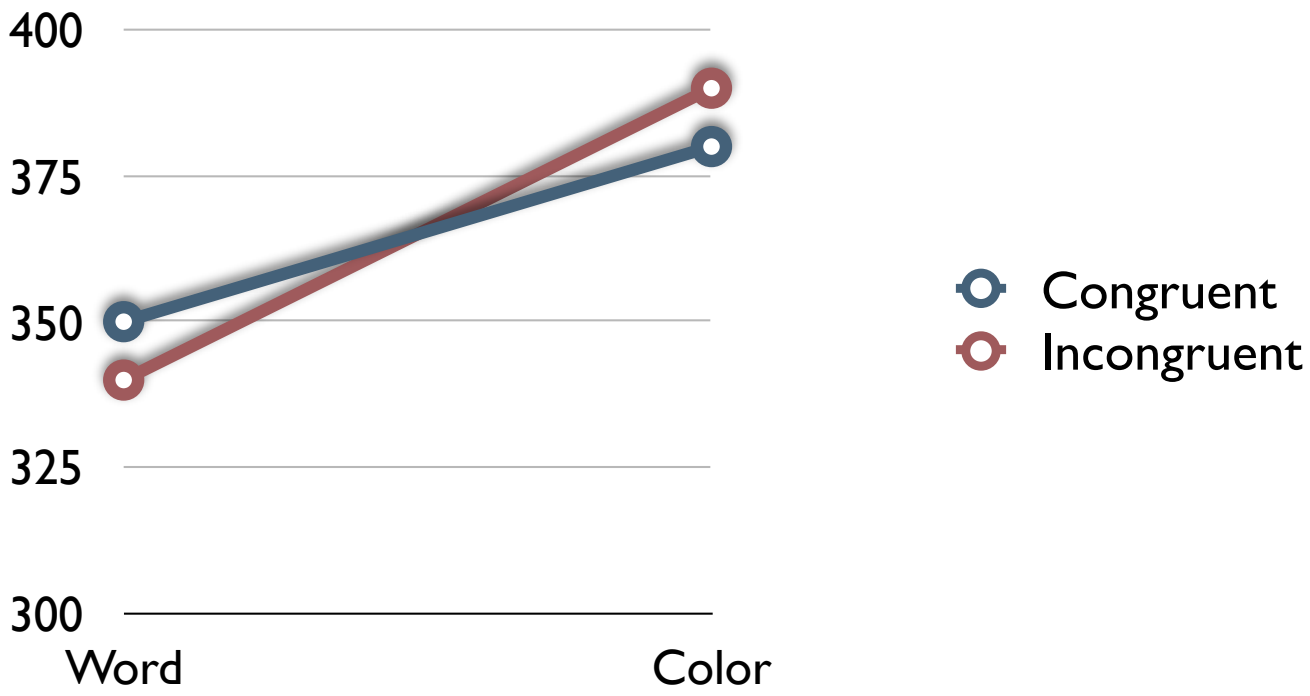



1 main effect, and an interaction

# Main effects?
# Interaction?

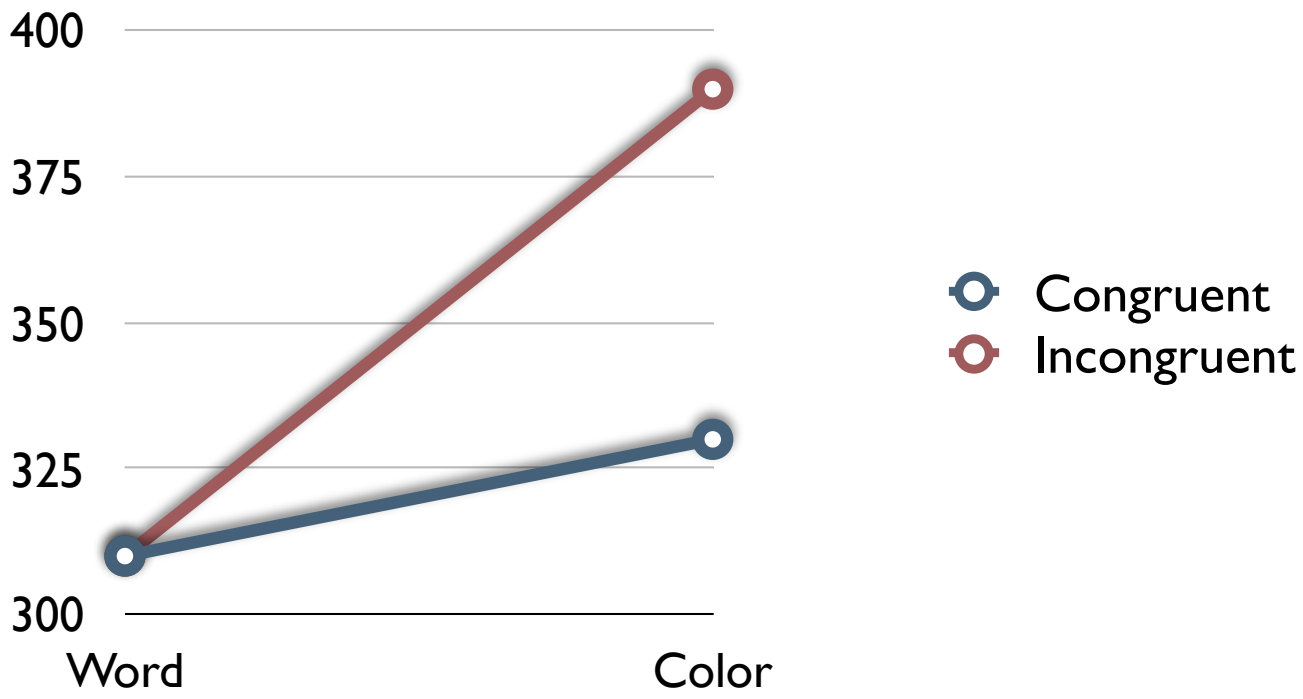


# Main effects?
# Interaction?

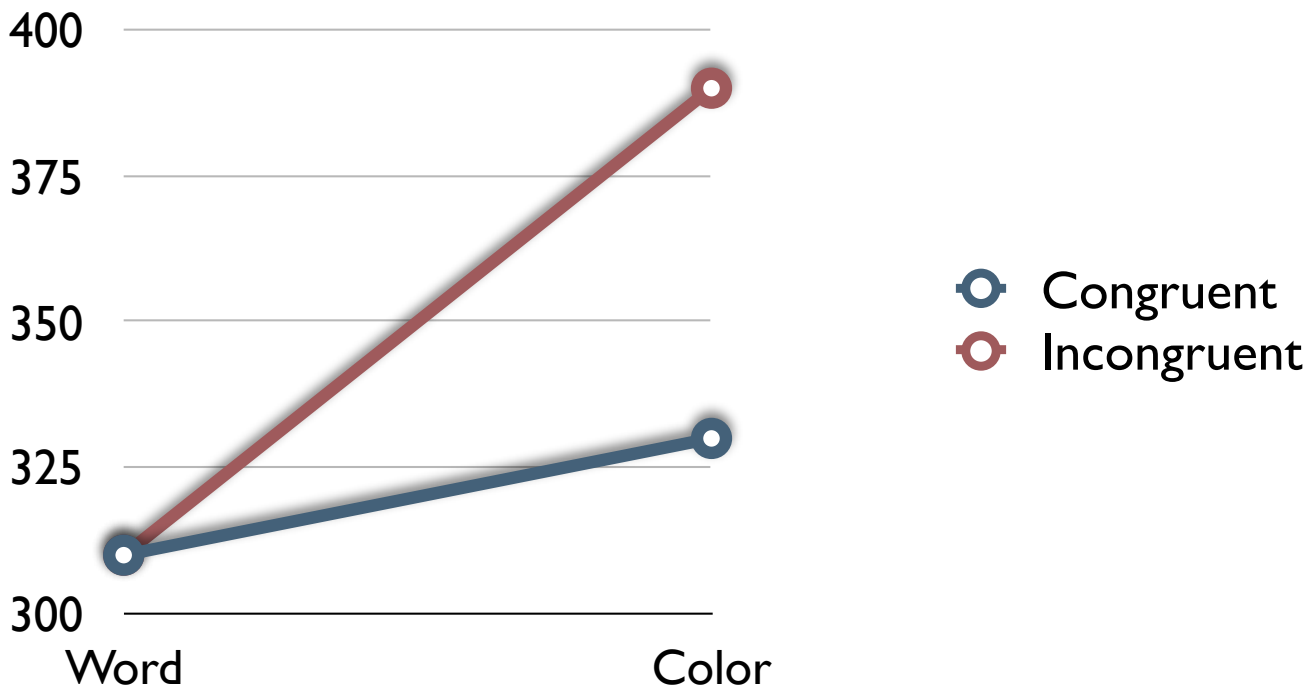



1 main effect, and an interaction

# Main effects?
# Interaction?

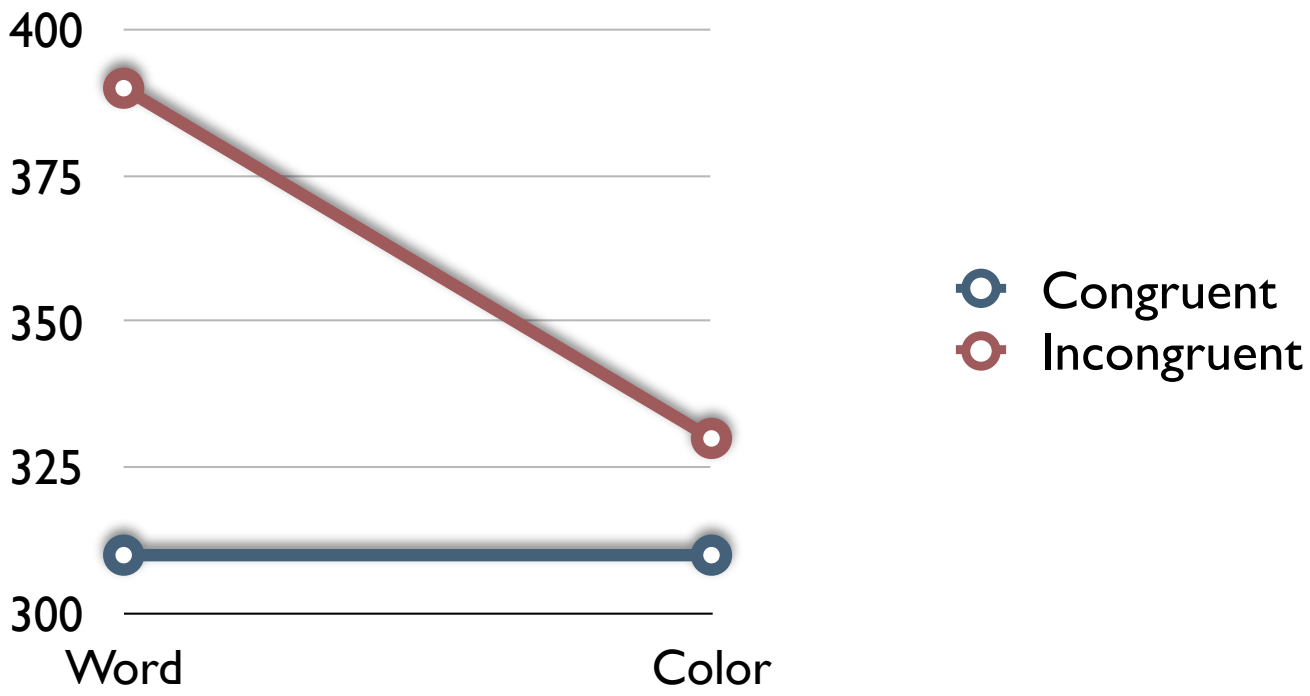


# Main effects?
# Interaction?

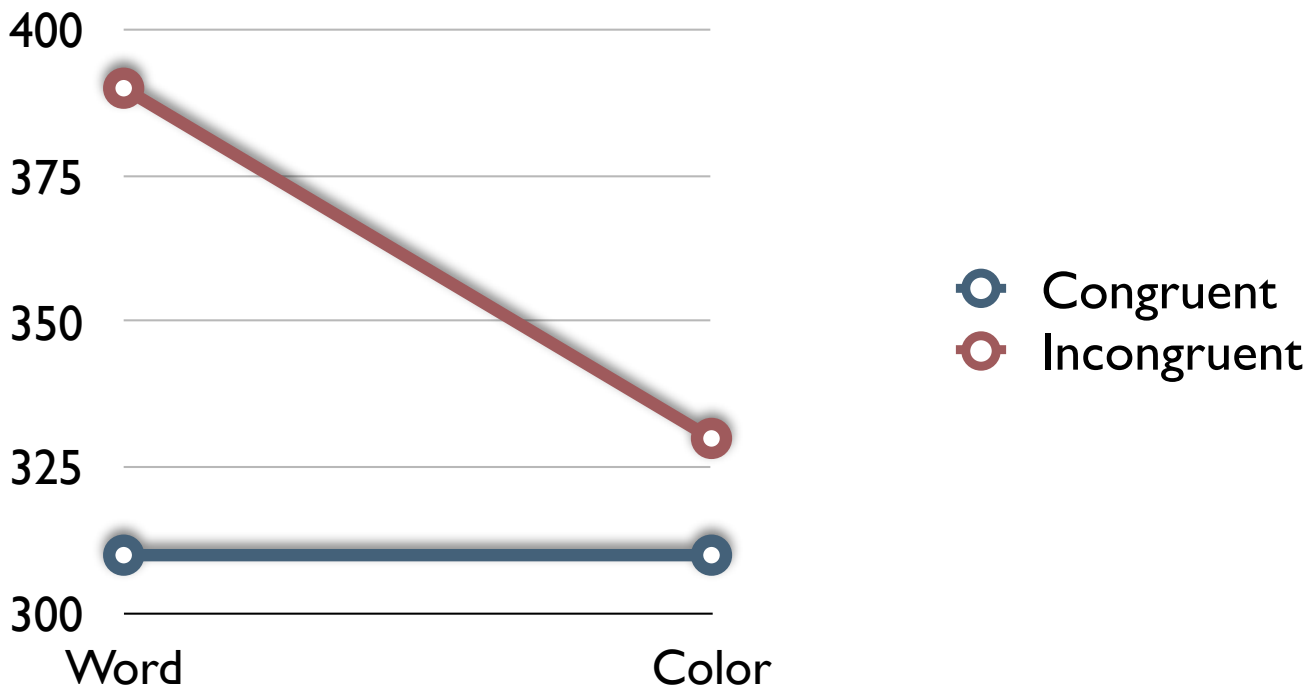



2 main effects, and an interaction

# Main effects?
# Interaction?

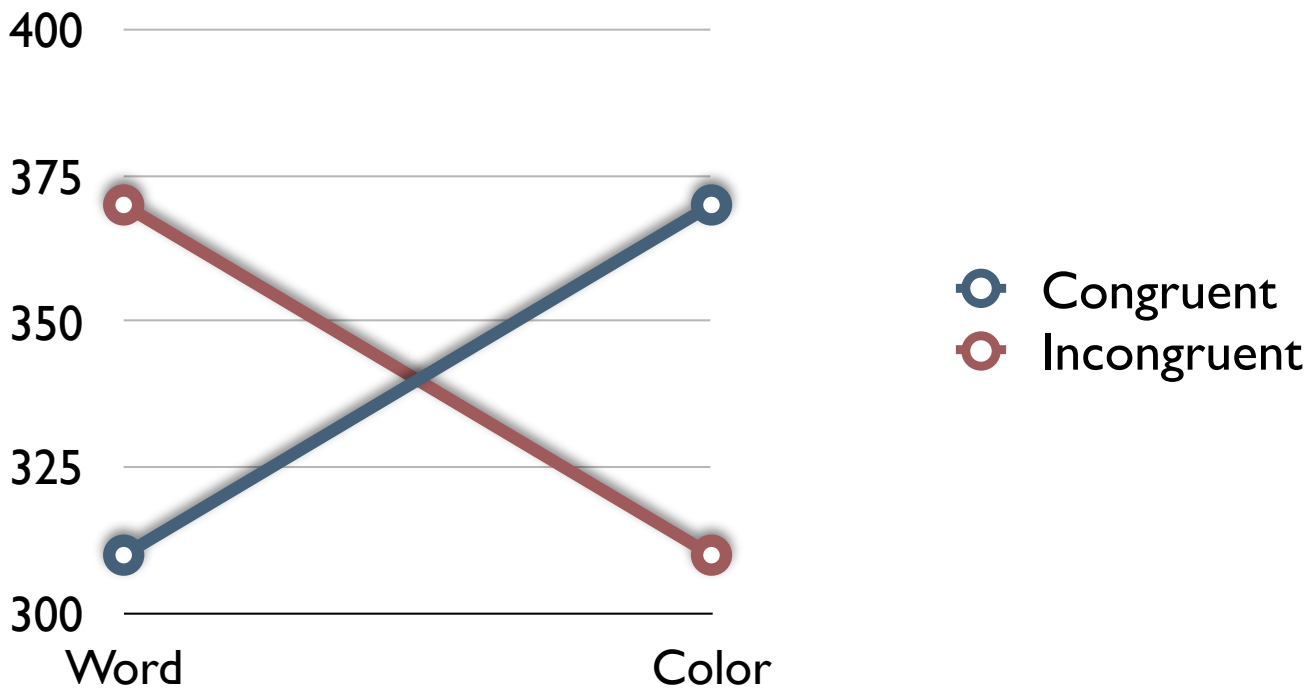


# Main effects?
# Interaction?

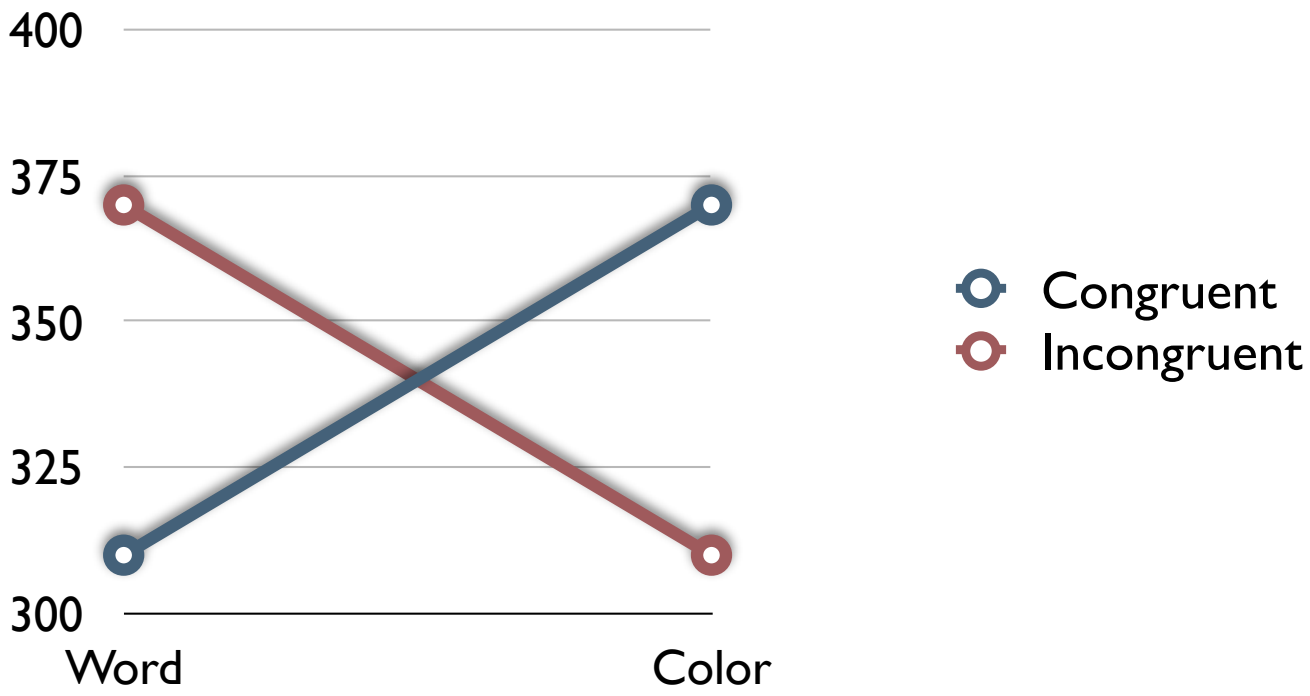



2 main effects, and an interaction

# Main effects?
# Interaction?

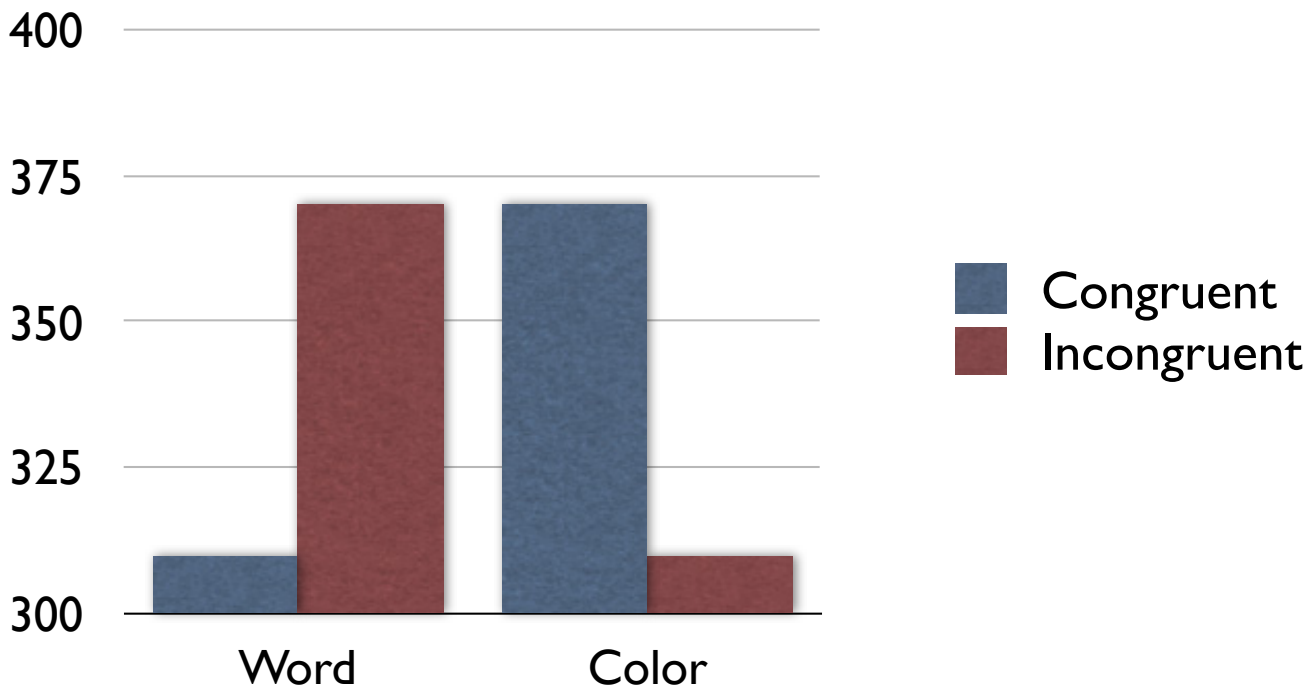


# Main effects?
# Interaction?

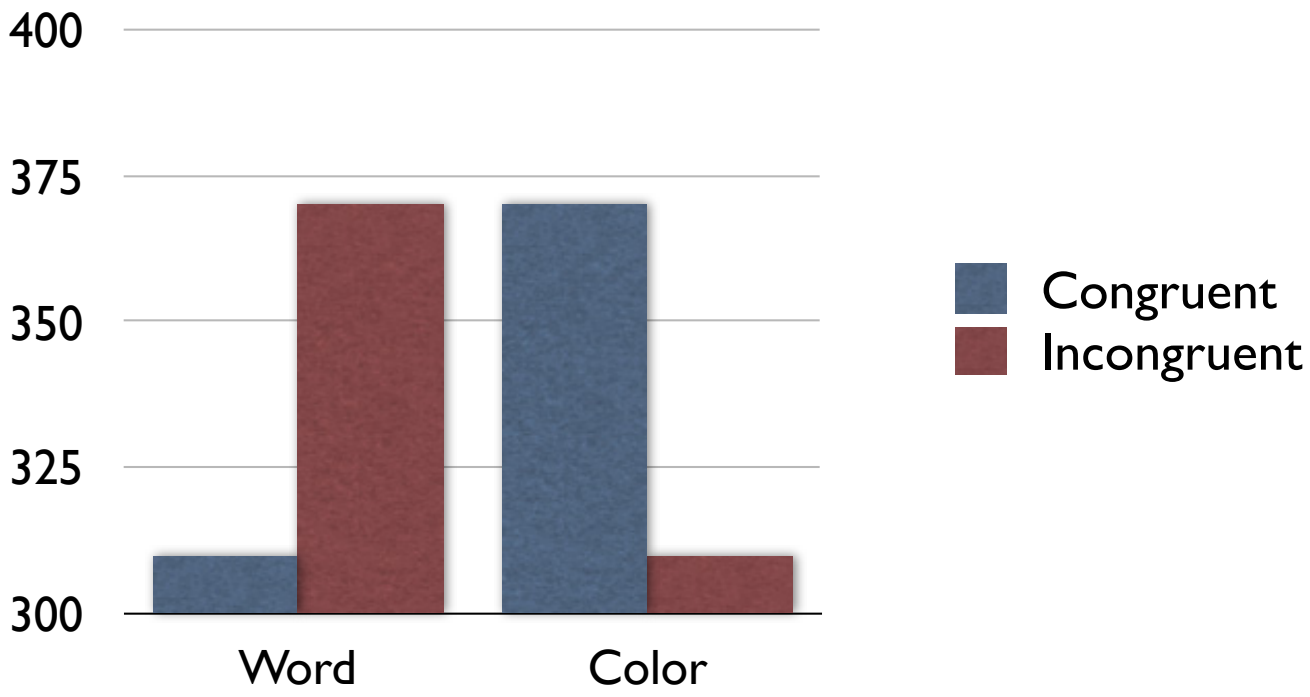



0 main effects, and an interaction

# Main effects?
# Interaction?



# Main effects?
# Interaction?

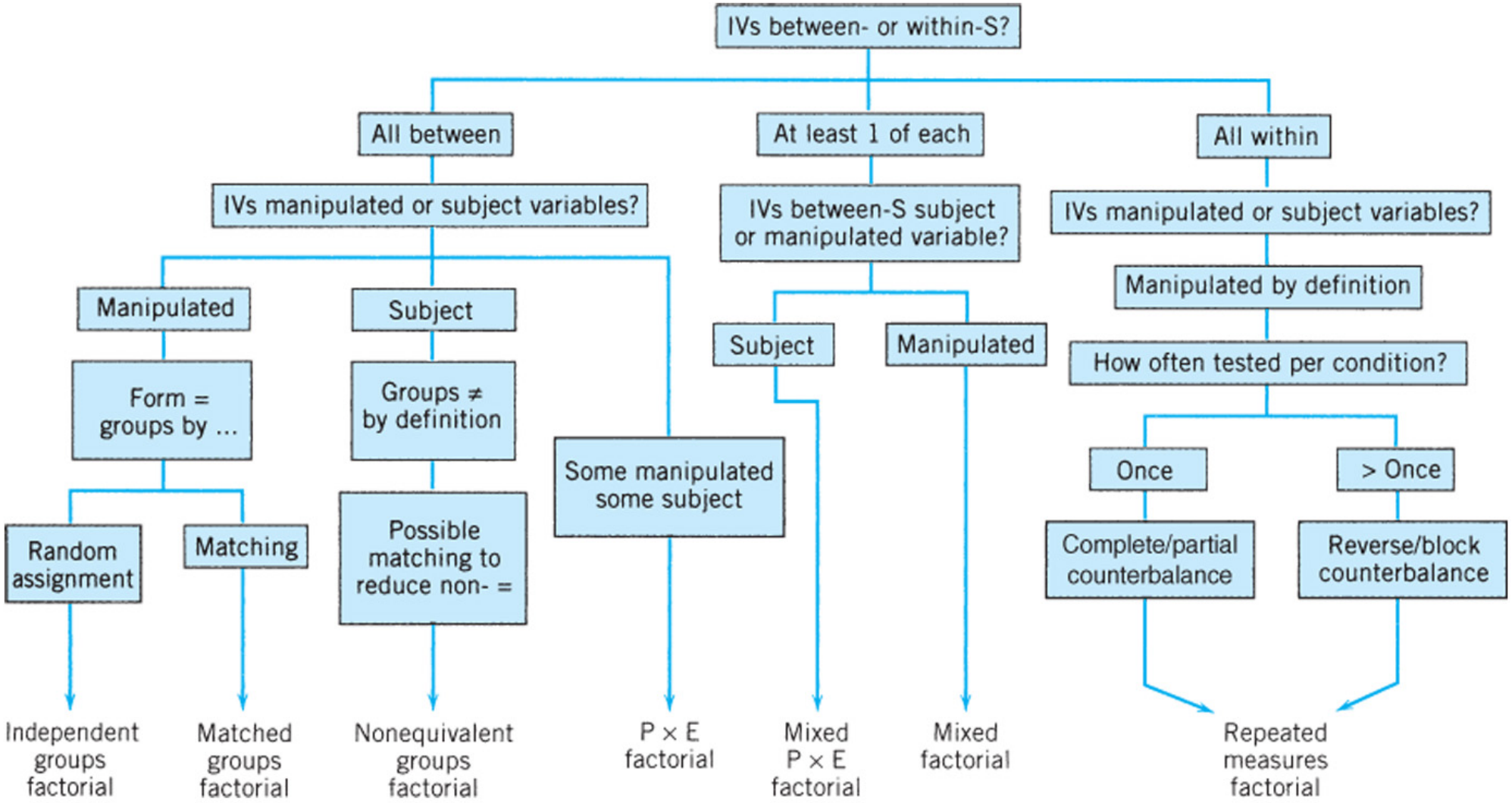



0 main effects, and an interaction

# Main effects & Interactions

- In a simple 2x2, there are 8 possibilities
  - main effect for factor 1 only
  - main effect for factor 2 only
  - main effects for both factors, No interaction
  - main effect for factor 1, and an interaction
  - main effect for factor 2, and an interaction
  - main effects for both factors, and an interaction
  - Only an interaction, no main effects
  - No main effects, and No interaction

# Varieties of Factorial Designs



# Independent groups factorial

- 2 manipulated IVs
- Different groups of subjects for each condition

| | Congruent | Incongruent |
|---|---|---|
| Name Word | 1 2 3 4 5 | 6 7 8 9 10 |
| Name Color | 11 12 13 14 15 | 16 17 18 19 20 |

#s refer to individual subjects

# Matched groups factorial

- 2 manipulated IVs
- Different groups of subjects for each condition

| | congruent | incongruent |
|---|---|---|
| word | 1 2 3 4 5 | 6 7 8 9 10 |
| color | 11 12 13 14 15 | 16 17 18 19 20 |

#s refer to individual subjects

# Nonequivalent groups factorial

- 2 subject IVs
- Different groups of subjects for each condition, subjects are matched on some variable

| | male | female |
|---|---|---|
| old | 1 2 3 4 5 | 6 7 8 9 10 |
| young | 11 12 13 14 15 | 16 17 18 19 20 |

#s refer to individual subjects

# PxE Factorial

- 1 subject IV, 1 manipulated IV
- Different groups of subjects for each condition

| | Male | Female |
|---|---|---|
| Congruent | 1 2 3 4 5 | 6 7 8 9 10 |
| Incongruent | 11 12 13 14 15 | 16 17 18 19 20 |

#s refer to individual subjects

# Mixed PxE Factorial

- 1 subject IV, 1 manipulated IV
- One of the factors is within-subjects

| | Male | Female |
|---|---|---|
| Congruent | 1 2 3 4 5 | 6 7 8 9 10 |
| Incongruent | 1 2 3 4 5 | 6 7 8 9 10 |

#s refer to individual subjects

# Mixed Factorial

- 2 manipulated IVs
- One of the factors is within-subjects, the other is between

| | Name word First block | Name word second block |
|---|---|---|
| Congruent | 1 2 3 4 5 | 6 7 8 9 10 |
| Incongruent | 1 2 3 4 5 | 6 7 8 9 10 |

#s refer to individual subjects

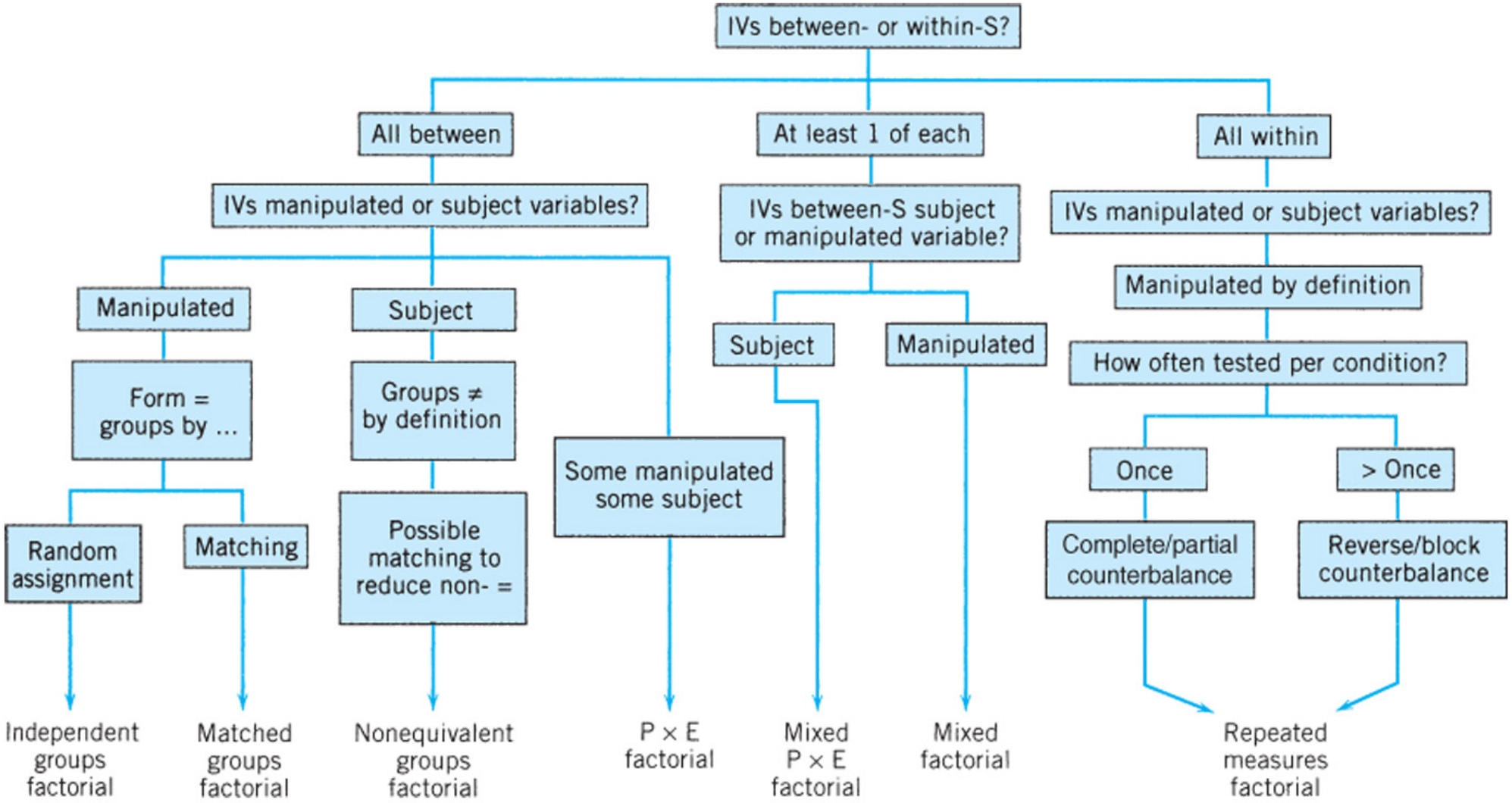
# Repeated measures Factorial

- 2 manipulated IVs
- All IVs are within

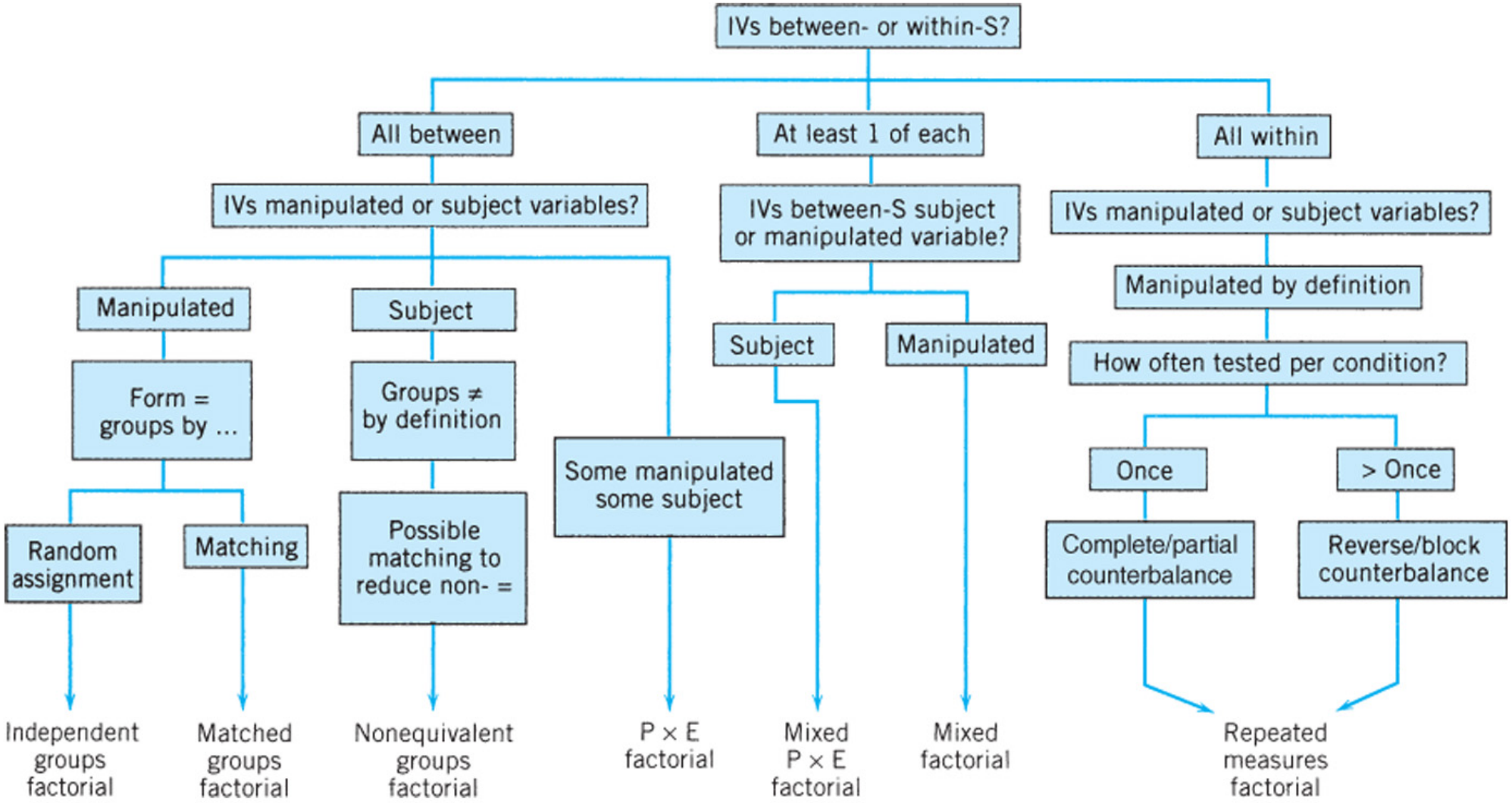
| | Name Word | Name Color |
|---|---|---|
| Congruent | 1 2 3 4 5 | 1 2 3 4 5 |
| Incongruent | 1 2 3 4 5 | 1 2 3 4 5 |

#s refer to individual subjects

# Varieties of Factorial Designs...



# Are analyzed with different ANOVAs



# Are analyzed with different ANOVAs