

Research Methods

Week 3: Experimental Designs (Continued)
Within subjects

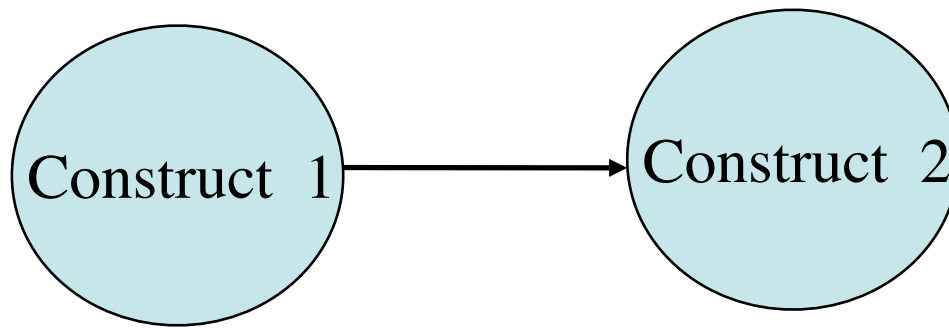
Arousal and Working Memory I

- An investigator was interested in the effect of arousal on short term memory. The hypothesis being tested was that caffeine induced arousal helps short term memory. Subjects were given a list of 20 words to study for 2 minutes, and were then asked to count backwards by 3s from 91. They were then asked to recall as many of the words as possible. The average number of words recalled was 10 (sd=3)
- After the recall was completed, subjects were given 200 mg of caffeine and allowed to read for 30 minutes while the caffeine took effect. They were then given the same list to study for 2 minutes, followed by counting backwards again from 91. They were then asked to recall as many words as possible from the list. The average this time was now 12 (sd=3). There were 20 subjects in this within subject experiment and the t-test of the correlated differences was 3.6 (d.f. =19, $p < .01$).
- From these results, the investigator concluded that the hypothesis that caffeine induced arousal helps working memory was supported.
- Do these results follow?
- Can you think of an alternative explanation for the results?

Questions for evaluating research

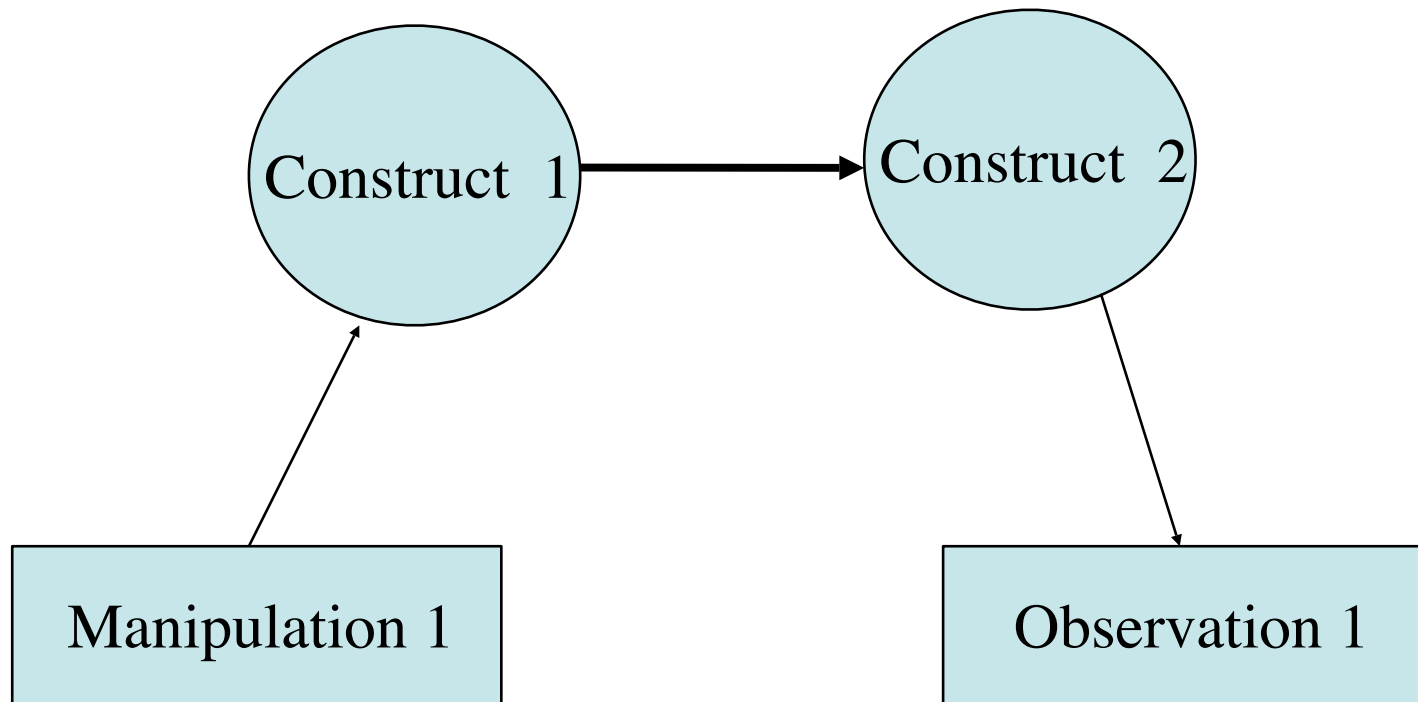
- What are the basic constructs being studied?
- What are the particular operationalizations (observations) associated with the constructs?
- How much of the variability in a construct is due to the (experimental manipulation) independent variable?
- What are possible alternative sources of variation?

Theory and Theory Testing I: Theory



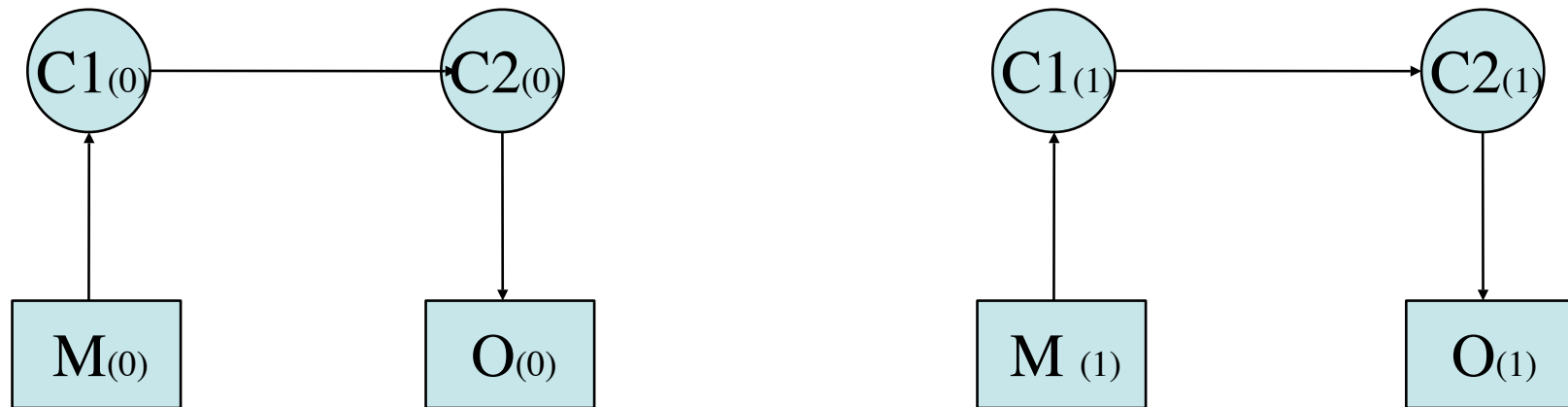
What are the constructs of interest?

Theory and Theory Testing II: Experimental manipulation



How are the constructs measured/manipulated?

Theory and Theory Testing II: Experimental manipulation



Independent
Variable

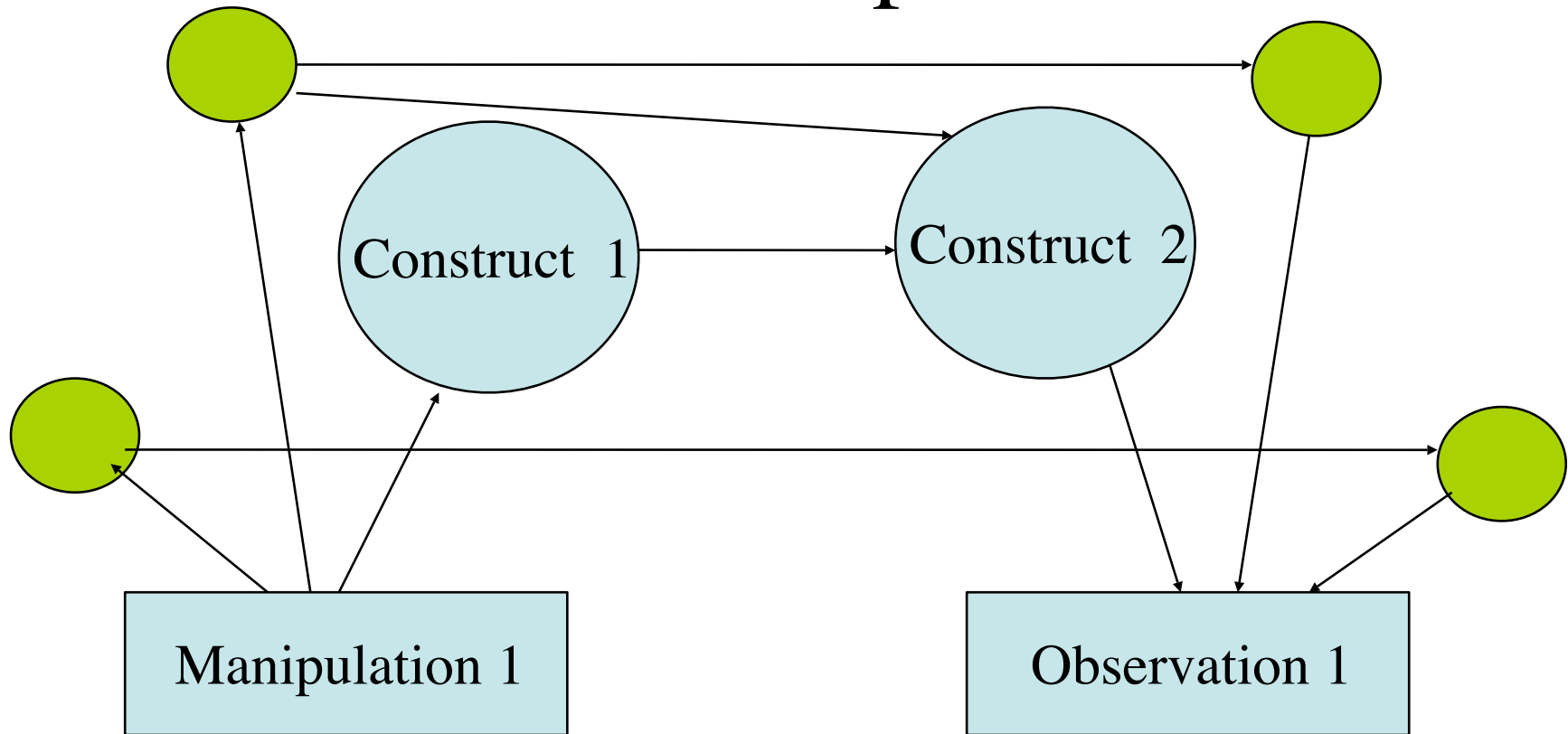
Dependent
Variable

Independent
Variable

Dependent
Variable

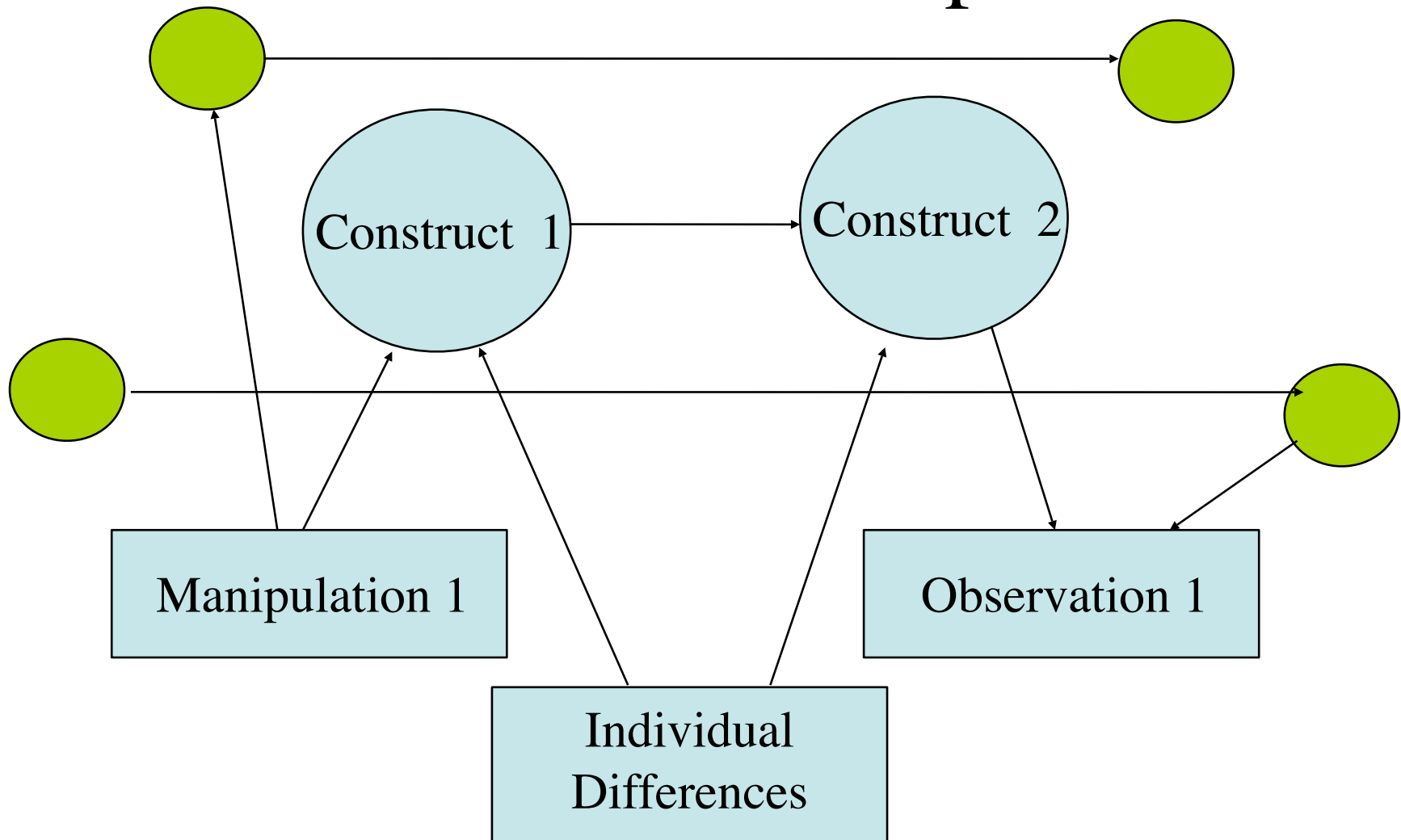
How are the constructs measured/manipulated?

Theory and Theory Testing III: Alternative Explanations

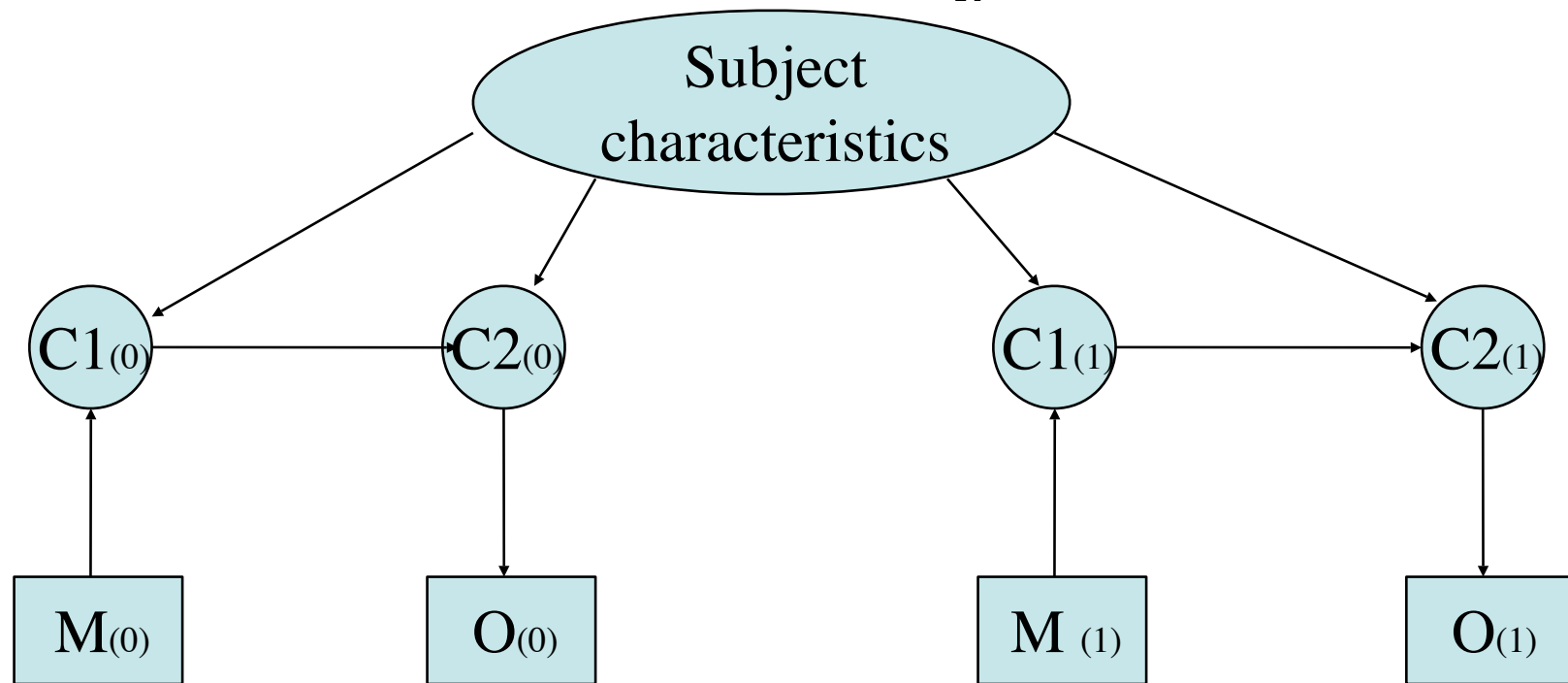


- What are possible alternative sources of variation?

Theory and Theory Testing IV: Eliminate Alternative Explanations



Theory and Theory Testing II: Experimental manipulation- Within Subjects



Experimental Designs

- Within Subjects
 - Controls for subject variability
 - Sensitive to within subject changes such as fatigue, learning, differential transfer
- Between subjects
 - Controls for within subject changes
 - Sensitive to between subject variability
 - Effects due to subject selection, attrition, randomization
- Mixed designs

Analysis of any study

- What are the constructs of interest?
- How are they measured/manipulated?
- What are possible alternative sources of variation?
 - Within subjects threats
 - Between subject threats
- How strong is the relationship between the manipulation/observation of the IV and the measurement of the DV?

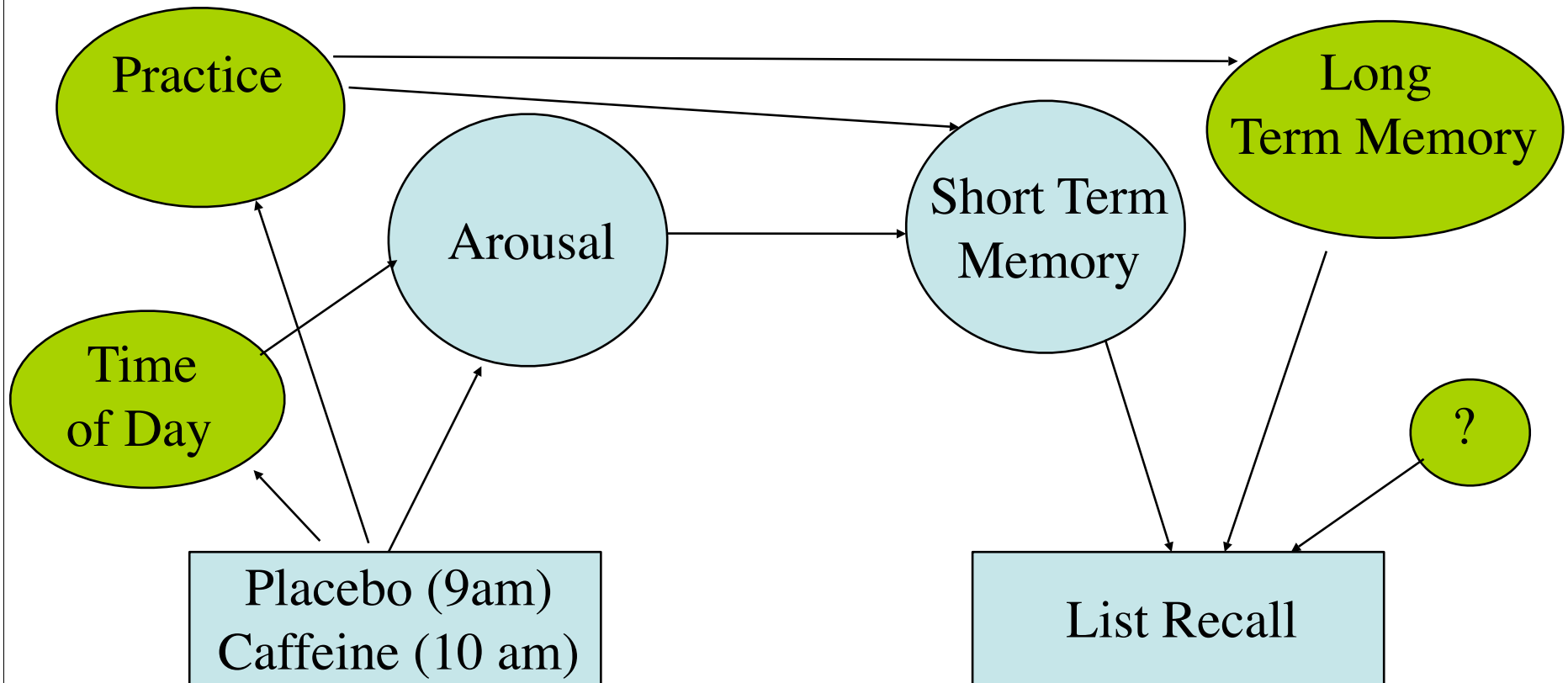
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Arousal and Working Memory

- Hypothesis
 - Alertness (arousal) facilitates short term memory
- Constructs
 - Arousal
 - Short Term Memory (memory for very recent events)
- Manipulations/Observables
 - Caffeine increases arousal
 - Study list - Filled Delay interval (why)
 - Immediate List recall
- Alternative Explanations

Confounded Within Subject design



- What are possible alternative sources of variation?

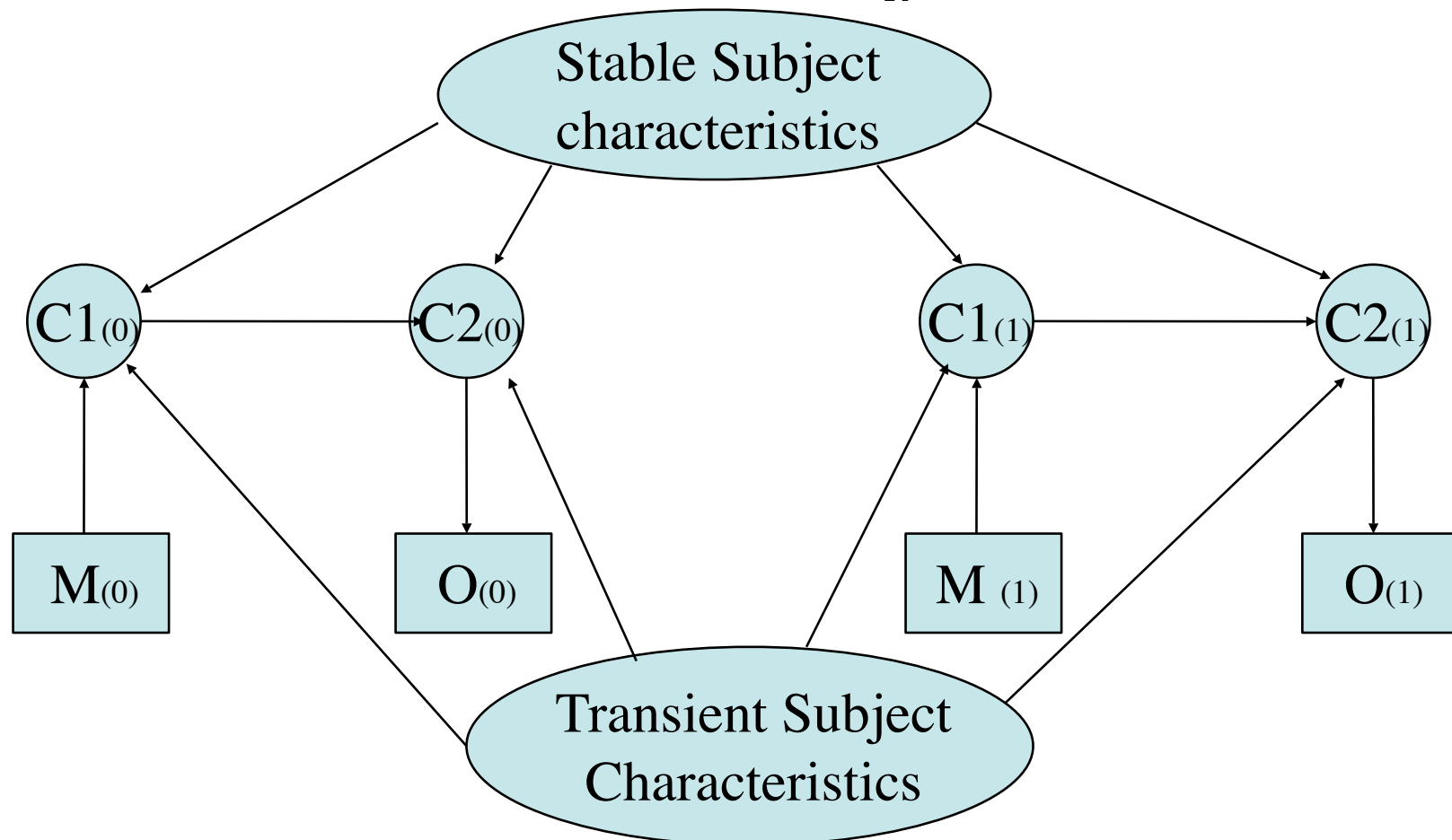
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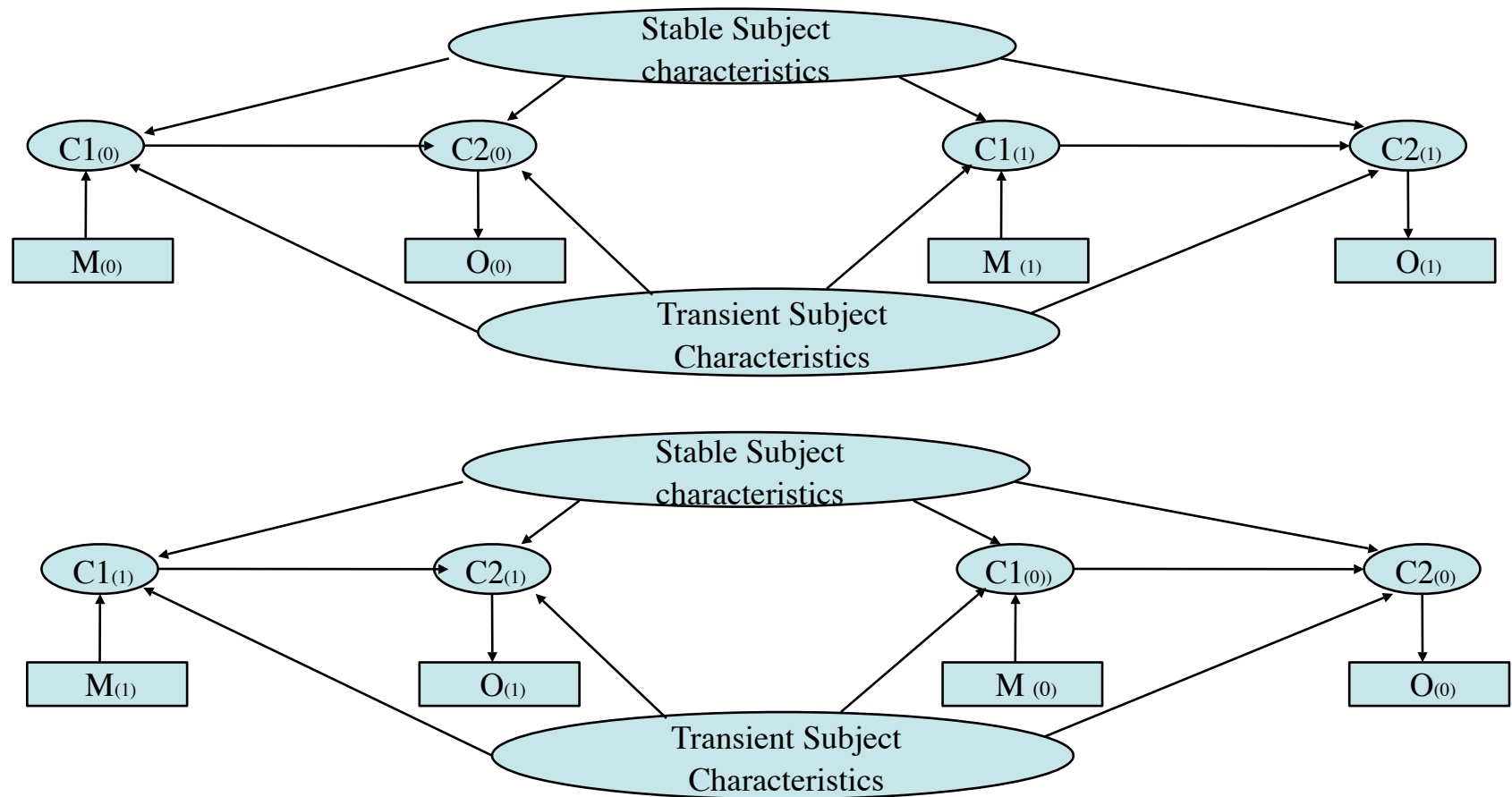
Arousal and Working Memory II

- Another investigator was interested in the effect of caffeine induced arousal on short term memory. The hypothesis being tested was that caffeine induced arousal helps short term memory. To control for time of day effects, all subjects were run at 8 am. Subjects were given a list of 20 words to study for 2 minutes and were then asked to count backwards from 91 by 3s. They were then asked to recall as many of the word as possible. The average number of words recalled was 11 (sd=3.)
- After the recall was completed, subjects were allowed to read quietly for an hour in order to minimize any possible carry over from the previous trial. Then the participants were given 200 mg. of caffeine and then allowed to read for 30 minutes while the caffeine took effect. They were then given a new list of words to study for 2 minutes, followed by counting forwards by 7s from 17. they were then asked to recall as many words as possible from the list. The average this time was now 12 (sd=2.5). With 30 subjects, this difference had a t-test of correlated differences of 2.8, df=29, $p < .01$.
- From the results of this within subject study, the investigator concluded that the hypothesis that caffeine induced arousal helps working memory as supported.
- Do these results follow?
- Can you think of an alternative explanation for the effects?
- How would design a study to control for this alternative explanation?

Theory and Theory Testing II: Experimental manipulation- Within Subjects



Theory and Theory Testing II: Experimental manipulation- Within Subjects-Counter balancing



Arousal and Working Memory III

- Yet another investigator was interested in the effect of caffeine induced arousal on short term memory. The hypothesis being tested was that caffeine induced arousal helps short term memory. To control for time of day effects, all subjects were run at 8 am.
- However, to control for possible order effects, 1/2 of the participants were run in one within subject condition, the other half in the other condition.
- That is, half were given a list of 20 words to study for 2 minutes and were then asked to count backwards from 91 by 3s. They were then asked to recall as many of the word as possible. The average number of words recalled for this group was 11 (sd=3.) Then the participants were given 200 mg. of caffeine and then allowed to read for 30 minutes while the caffeine took effect. They were then given a new list of words to study for 2 minutes, followed by counting forwards by 7s from 17. they were then asked to recall as many words as possible from the list. The average this time was now 14 (sd=2.5). With 30 subjects, this difference had a t-test of correlated differences of 2.8, df=29, $p < .01$.
- The other half of the participants were given the caffeine on trial one and not given anything on trial 2. Their performance on trial 1 was 13 (sd=2) and on trial 2 was 12.8 (sd=2). This difference was not reliably different from a chance difference ($t = .4$ ns.)
- Although the one order showed the effect and the other did not, the investigator then pooled the data from the two orders and found that the caffeine condition in general led to better performance. (mean caffeine = 13, mean control = 11.9). From these results the investigator concluded that the hypothesis that caffeine induced arousal helps working memory as supported.
- Do these results follow?
- Can you think of an alternative explanation for the effects?
- Can you think of an explanation for the difference between the two orders?

Experimental Designs

- Within Subjects -- Every subject is own control
 - Every subject is a complete experiment
 - Controls for subject variability
 - Ability
 - Motivation
 - Sensitive to within subject changes
 - Fatigue
 - Learning
 - Counterbalancing controls for some transient effects but is open to threats of
 - Differential transfer

Varieties of Counterbalancing

- Within subject counterbalancing
 - ABBA and BAAB controls for linear order effects but not transfer
 - Within subject randomization if many trials
 - possible to do block randomization
- Complete counterbalancing across subjects
 - One order for each subject, all orders appear
 - Two conditions: two Orders AB BA
 - Three conditions: six orders
 - ABC, ACB, BAC, BCA, CAB, CBA
 - Four conditions, 24 orders! N of orders = $C!$

Example of within subject counterbalancing

- Class replication of Roediger and McDermott
- How to examine study time, recall interval, and recall vs. math within subjects
- Why not do between subjects?
 - consider subject “cost”
 - also consider sources of between subject error
- how to study several variables at a time within subjects
 - need to manipulate IV_1 and IV_2 independently

How to study several within subject variables at the same time

- Counterbalancing to avoid confounding
 - IV_1 and IV_2 are experimentally independent
- Conditions crossed with conditions
 - All conditions for IV_1 occur with all conditions of IV_2
 - no systematic relationship between IV_1 and IV_2
- Conditions balanced across orders of presentation

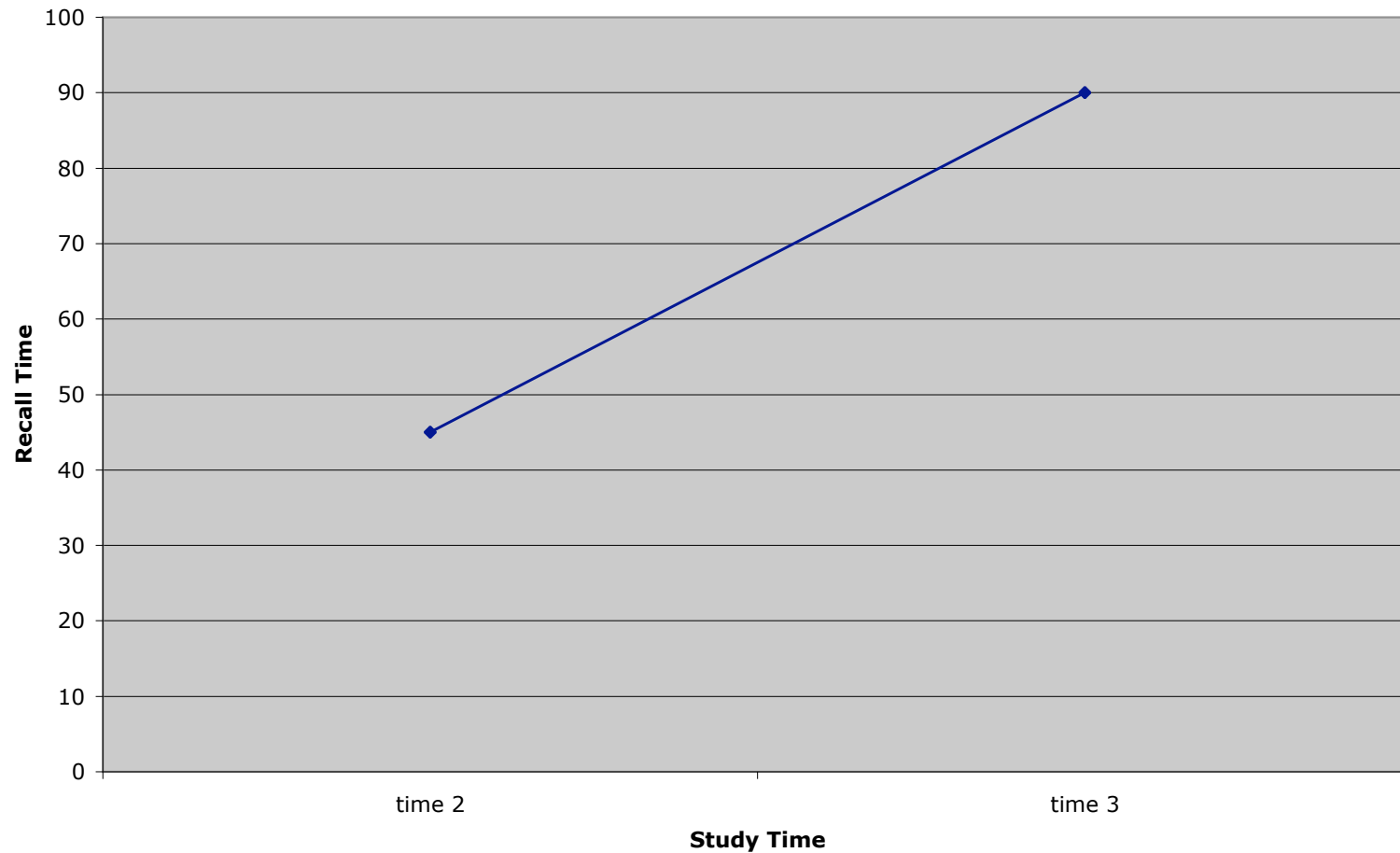
Complete Confounding!

Math and study and recall time

1	2	45	Math
2	2	45	Math
3	2	45	Math
4	2	45	Math
5	2	45	Math
6	2	45	Math
7	2	45	Math
8	2	45	Math
9	3	90	Recall
10	3	90	Recall
11	3	90	Recall
12	3	90	Recall
13	3	90	Recall
14	3	90	Recall
15	3	90	Recall
16	3	90	Recall

Complete confounding of Study time with recall time

Confounding Study and Recall

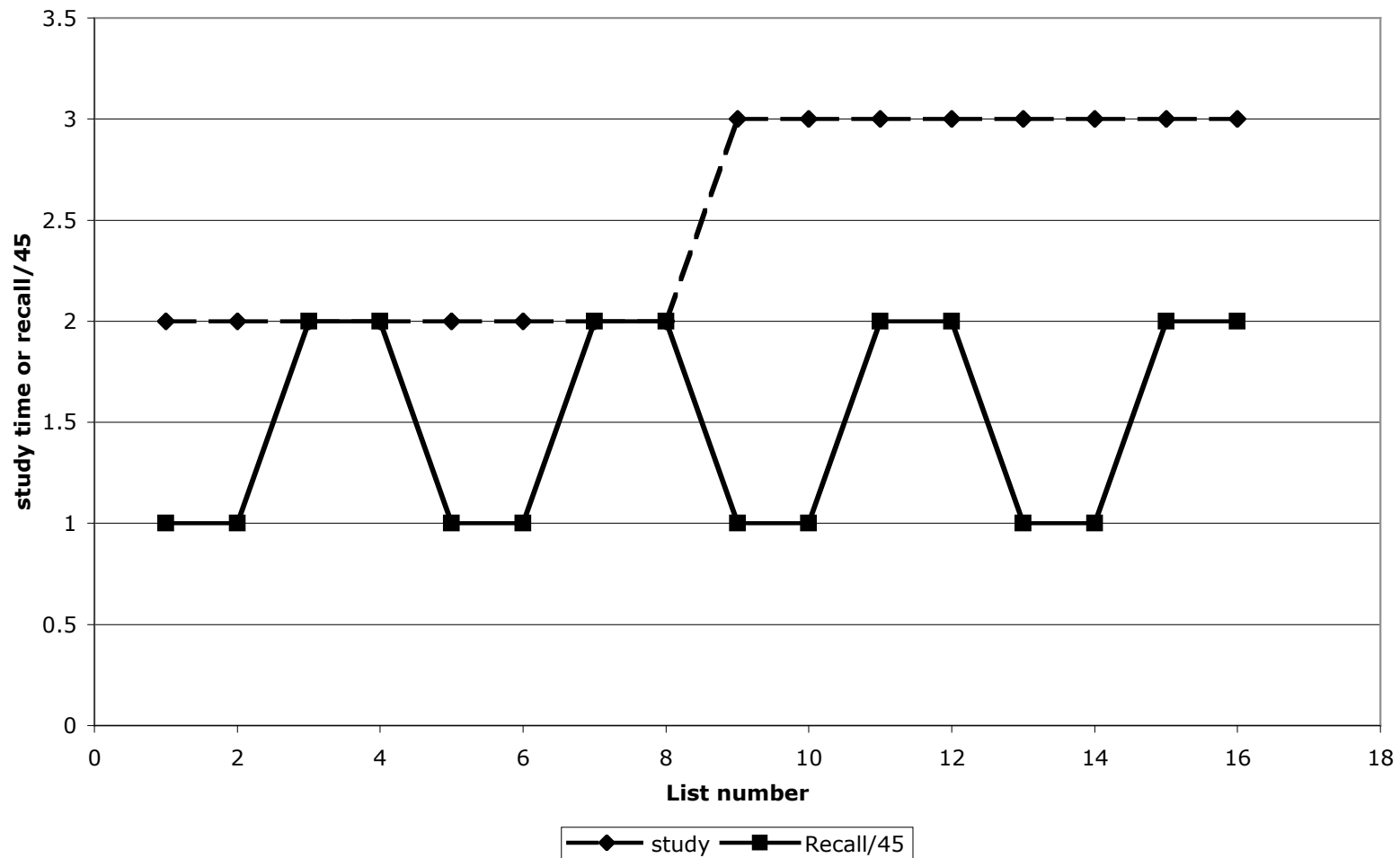


Partial Confounding

1	2	45	Math
2	2	45	Recall
3	2	90	Math
4	2	90	Recall
5	2	45	Math
6	2	45	Recall
7	2	90	Math
8	2	90	Recall
9	3	45	Math
10	3	45	Recall
11	3	90	Math
12	3	90	Recall
13	3	45	Math
14	3	45	Recall
15	3	90	Math
16	3	90	Recall

Partial Confounding

Partial confounding



Class Design- counterbalancing

List	Time	Recall	A/B
1	2	45	Recall
2	3	90	Math
3	3	45	Math
4	2	90	Recall
5	3	90	Recall
6	2	45	Math
7	2	90	Math
8	3	45	Recall
9	3	90	Math
10	2	45	Recall
11	2	90	Recall
12	3	45	Math
13	2	45	Math
14	3	90	Recall
15	3	45	Recall
16	2	90	Math

Results - Descriptive

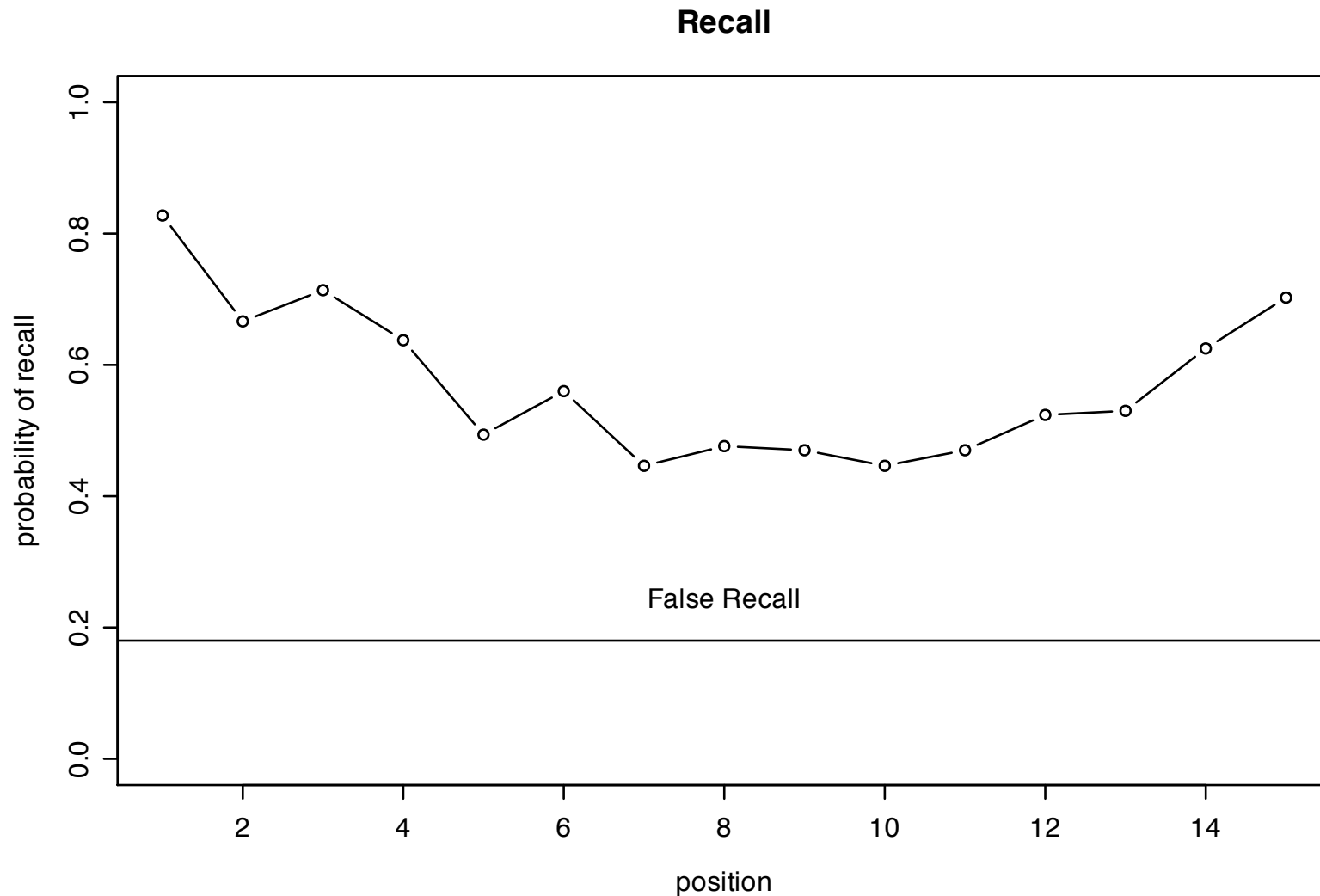
- Descriptive statistics vs. Inferential stats
- Describe the results --
 - Say it in words
 - Say it in pictures (figures)
 - Say it in numbers
- Inferential: What is the likelihood that the results could happen by chance?
 - Estimate a parameter and give confidence intervals for that parameter

Results

- Recall (manipulation check)
 - Is there a serial position effect?
 - Primacy
 - Recency (particularly given the instructions)
 - Did people just recall on recall tasks?
 - Do the lists differ in recall ease?
- Recognition
 - Is there a false memory effect?
 - What manipulations affect it?

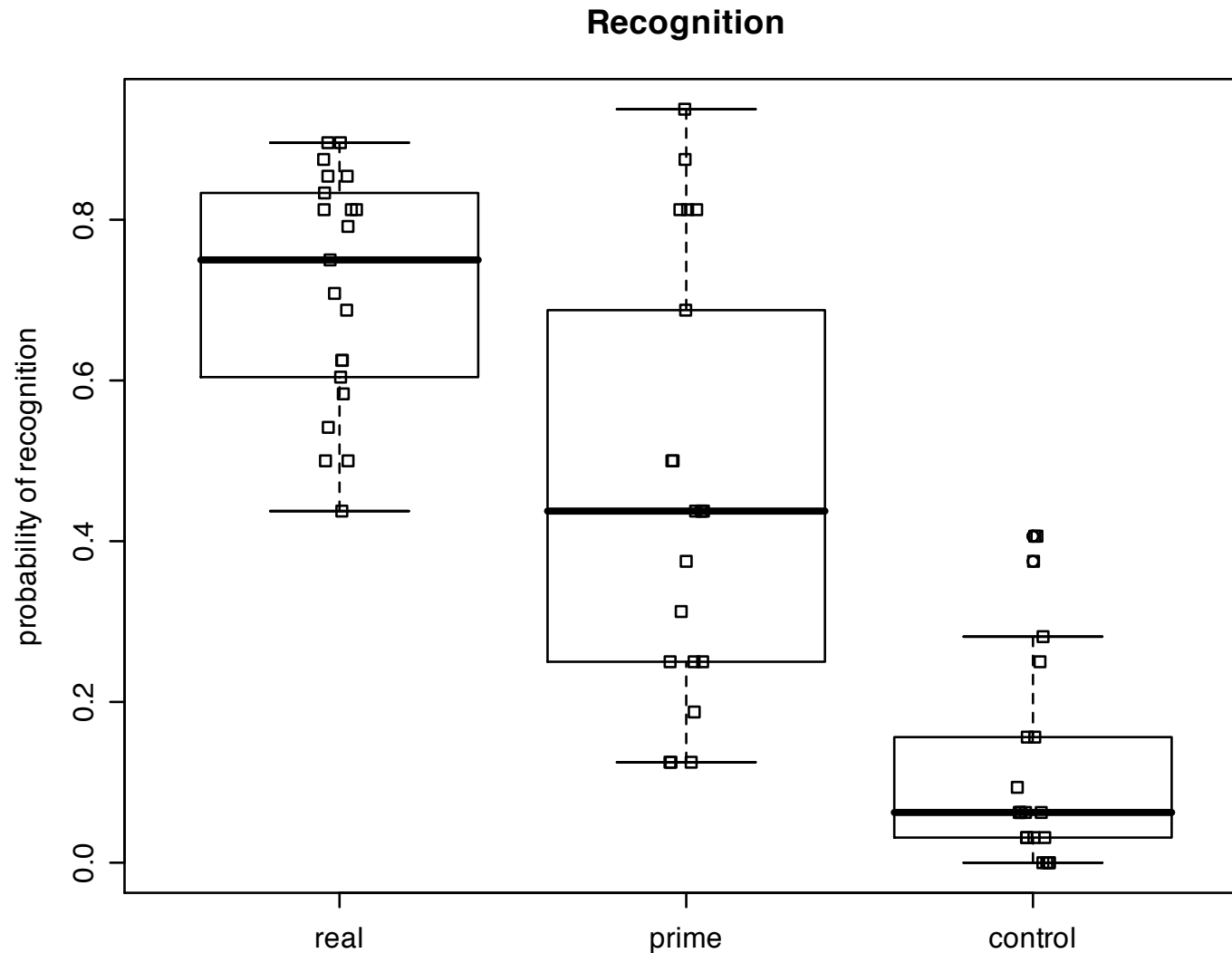
Recall by serial position

```
recall.stats <- describe(position)
plot(recall.stats$mean/8,ylim=c(0,1),type="b",ylab="probability of recall", xlab="position", main="Recall")
abline(h=.18)
text(8,.25,"False Recall")
```



Recognition by word type

```
boxplot(recognition,ylab="probability of recognition",main="Recognition")  
stripchart(recognition,method="jitter",jitter=.05,vertical=T,add=T)
```



Analysis of results

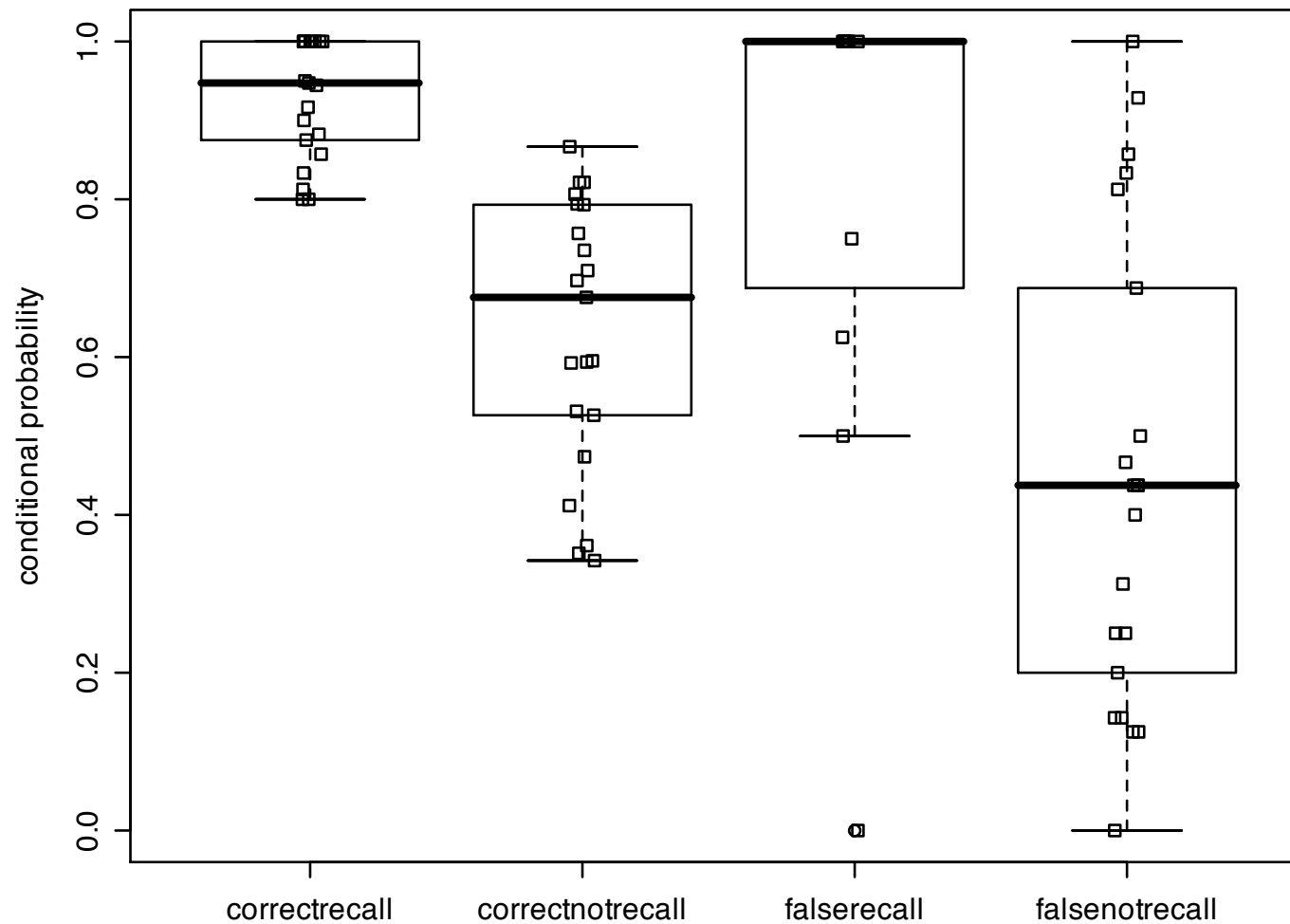
- Descriptive statistics of effects
 - what are the means by conditions
 - mean recognition for words on recall trials
 - recall and later recognition as a function of study interval
 - recall and later recognition as a function of recall interval
 - does recalling a word facilitate later recognition

Calculate Conditional Probabilities

```
attach(memory)
probcrecall <- prr/(prr+prnr)
probcnrecall <- pnrr/(pnrr+pnrnr)
probfrecall <- crr/(crr+crnr)
probfncrecall <- cnrr/(cnrr+cnrnr)
conditional <- data.frame(correctrecall =probcrecall,
correctnotrecall = probcnrecall, falserecall = probfrecall,
falsenotrecall = probfnrecall)
boxplot(conditional,ylab="conditional probability",main="Probability
of Recognition depends upon prior recall" )
stripchart(conditional,method="jitter",jitter=.05,vertical=T,add=T)
```

Preliminary results

Probability of Recognition depends upon prior recall



Descriptive and Inferential Statistics

- Describe the data
 - Central Tendencies and Dispersion
 - Means, standard deviations
- Inferential -- the Null Hypothesis model
- How likely are the data given a model of no difference
 - consider the t-test