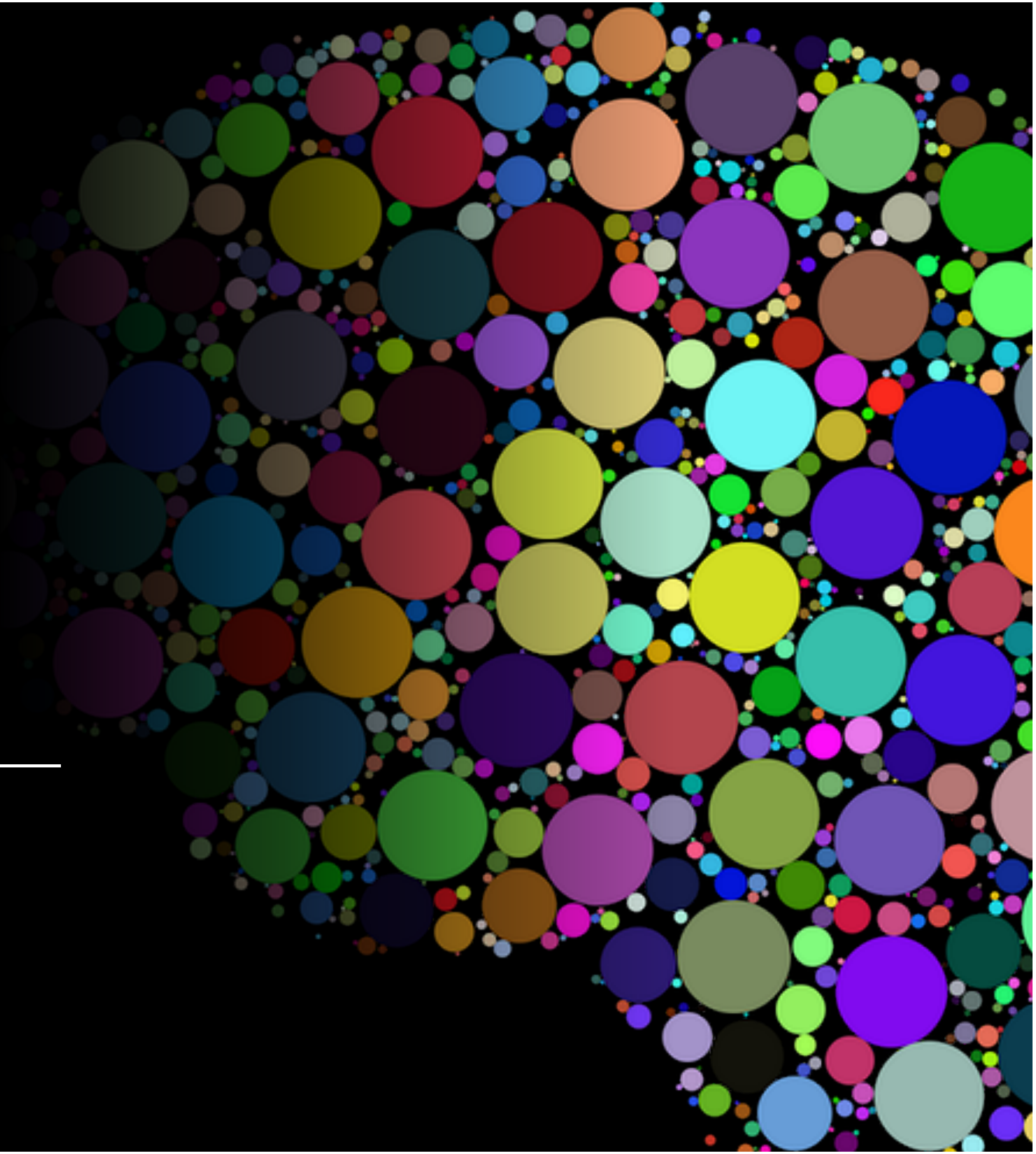
The Paired-Samples *t* Test

Chapter 10



Research Design Issues

> So far, everything we've worked with has been *one* sample
  - One person = Z score
  - One sample with population standard deviation = Z test
  - One sample no population standard deviation = single t-test

Research Design Issues

> So what if we want to study either *two* groups or the same group *twice*

- Between subjects = when people are only in one group or another (can't be both)
- Repeated measures = when people take all the parts of the study

Research Design Issues

- Between subjects design = independent t test (chapter 11)
- Repeated measures design = dependent t test (chapter 10)

Research Design Issues

- So what do you do when people take things multiple times?
  - Order effects = the order of the levels changes the dependent scores
    - Weight estimation study
    - Often also called fatigue effects
  - What to do?!

Research Design Issues

> Counterbalancing

- Randomly assigning the order of the levels, so that some people get part 1 first, and some people get part 2 first
- Ensures that the order effects cancel each other out
- So, now we might meet step 2!

Assumptions

Assumption	Solution
Normal distribution	N >=30
DV is scale	Nothing – do nonparametrics
Random selection (sampling)	Random assignment (to which counterbalance order! We can do this now!)

Paired-Samples *t* Test

> Two sample means and a within-groups design

> We have two scores for each person … how can we test that?

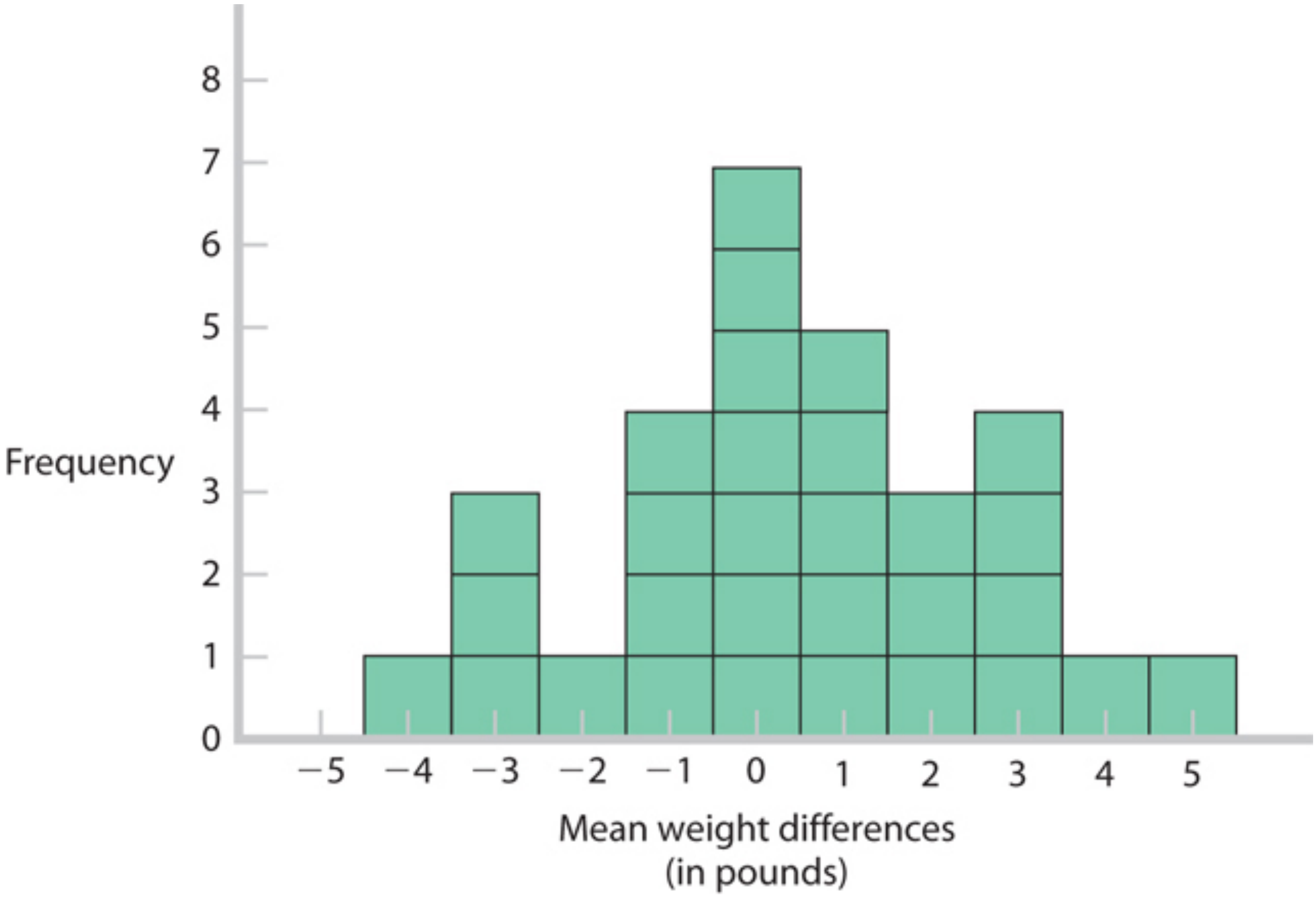
- The major difference in the paired-samples *t* test is that we must create difference scores for every participant

Paired-Samples *t* Test

> Distributions

- Z = Distribution of scores
- Z = distribution of means (for samples)
- t = distribution of means (for samples with estimated standard deviation)
- t = distribution of differences between means (for paired samples with estimated standard deviation)

Distribution of Differences Between Means



Distribution of Differences Between Means

> So what does that do for us?

- Creates a comparison distribution (still talking about *t* here … remember the comparison distribution is the “population where the null is true”)

Where the difference is centered around zero, therefore um = 0.

Distribution of Differences Between Means

> When you have one set of scores by creating a difference score …

- You basically are doing a single sample t where um = 0.
- Whew! Same steps.

Steps for Calculating Paired Sample *t* Tests

- > Step 1: Identify the populations (levels), distribution, and assumptions.
- > Step 2: State the null and research hypotheses.
- > Step 3: Determine the characteristics of the comparison distribution.
- > Step 4: Determine critical values, or cutoffs.
- > Step 5: Calculate the test statistic.
- > Step 6: Make a decision.

Step 1

- Let’s work some examples: chapter 10 docx on blackboard.
- List out the assumptions:
  - DV is scale?
  - Random selection or assignment?
  - Normal?

Step 2

> List the sample, population, and hypotheses

- Sample: difference scores for the two measurements
- Population: those difference scores will be zero (um = 0)

Step 3

> List the descriptive statistics

> M difference:

> SD difference:

> SE difference:

> N:

> um = 0

Calculating in *R*

> You will have two sets of scores to deal with.

- We can use these scores in wide format, so let's enter them that way.
- Excel file is online.

Filter

	old	new
1	2	4
2	1	2
3	5	5
4	3	5
5	3	4
6	2	3
7	5	4

Calculating in *R*

- We want to get a mean difference score first.
  - Important! Think about the hypothesis. If you pick a one-tailed test, the order of subtraction is important!

Calculating in *R*

> Create a difference score to calculate the numbers you need:
  - difference = *data$column – data$column*

Calculating in *R*

> Get the mean, sd, and se in the same way we did in the last chapter:
  - summary(difference)
  - sd(difference)
  - sd(difference) / sqrt(length(difference))

Step 4

- > Figure out the cut off score, $t_{critical}$
- > Less test:
  - qt(.05, df, lower.tail = T)
- > Greater test:
  - qt(.05, df, lower.tail = F)
- > Difference test:
  - qt(.05/2, df, lower.tail = T)

May also be .01 – remember to read the problem.

Step 5

> Find t_{actual}

t.test(*data*$*column*,

data$column,

paired = T,

alternative = “less” OR “greater” OR “two.sided”,

conf.level = .95 OR .99)

Step 5

> Stop! Make sure your mean difference score, df, and hypothesis all match.

```
	Paired t-test

data:  chapter10.data$new and chapter10.data$old
t = 2.1213, df = 6, p-value = 0.03907
alternative hypothesis: true difference in means is greater than 0
95 percent confidence interval:
 0.07197946        Inf
sample estimates:
mean of the differences
              0.8571429
```

Step 6

- Compare step 4 and 5 – is your score more extreme?
  - Reject the null
- Compare step 4 and 5 – is your score closer to the middle?
  - Fail to reject the null

Confidence Interval

> Lower = $M_{difference} - t_{critical}*SE$

> Upper = $M_{difference} + t_{critical}*SE$

> A quicker way!

- Use t.test() with a TWO tailed test to get the two tailed confidence interval.
- Or use the effect size coding R script!

Effect Size

> Cohen's d:

- Note this S = s of the difference scores not s of either level.
- Remember, SD = s.

$$d = \frac{(M - \mu)}{s}$$

Effect Size

- Run all the effsize.R to get the right functions.
- d.deptdiff(mdiff = .857, sddiff = 1.07, n = 7, a = .05, k = 2)

M = 0.86, SD = 1.07, SE = 0.40, 95%CI[-0.13 - 1.85]
t(6) = 2.12, p = 0.08, d = 0.80, 95%CI[-0.09 - 1.64]

- Remember that t values here are always two-tailed, t will match but not necessarily p.