Learning Objectives

- **Review** *hypotheses* and *hypothesis testing*

- **Practice** creating valid sets of hypothesis

- **Describe** *statistical significance* (what it is, and what it is not)

- **Perform** a *sign test* to assess the likelihood of data from a repeated-measures study

Hypothesis Testing

- A ***hypothesis*** is a proposed explanation for an observation or phenomenon
  - "Patients are less fearful of phobic stimuli after attending therapy sessions"

- *Hypothesis testing* involves constructing two hypotheses
  - H_1: "Patients are less fearful of phobic stimuli after attending therapy sessions"
  - H_0: "Patients are not less fearful after therapy"

Null Hypothesis, H_0

- H_0 says any observed change is due to chance, or unexplained factors
  - *Anything* other than the IV

- Null hypothesis is the **boring** hypothesis
  - IV does not effect DV
  - There is no relationship between the variables
  - The groups did not differ from each other

Alternative Hypothesis, H_1

- H_1 says that any observed change is <u>not</u> due to chance, or unexplained factors
  - *This is the **exciting** possibility!*
  - IV has an effect on DV
  - There is a relationship between the variables
  - The groups differ from each other

Hypothesis Testing

- Hypotheses must be mutually exclusive, and exhaustive
  - H_1: "Patients are less fearful of phobic stimuli after attending therapy sessions"
  - H_0: "Patients are equally fearful after therapy"

Revised:

- H_0: "Patients are equally fearful, **or even more fearful** after therapy"

Two Types of Hypothesis Sets

<u>Directional</u> hypotheses:

- H_1: "My therapy will reduce fear levels"
  - Also called a <u>one-tailed</u> hypothesis

<u>Non-directional</u> hypothesis:

- H_1: "My therapy will change fear levels"
  - Also called a <u>two-tailed</u> hypothesis

Recommendation: First construct H_1, then fill in remaining space with exhaustive & exclusive H_0

Try it!

- Generate a valid set of research hypotheses about the relationship between two variables
  - Example: "I think exercising in the evening improves sleep quality"

- What is your H_1?
- What is your H_0?

- Flip it; make it directional/non-directional!

Hypothesis **Testing**

- When we test our hypotheses, we begin by ***assuming*** that H_0 is correct ☹
  - "My therapy has no effect on fearfulness…"

- Collect patient data: How fearful were they after therapy?
  - If about the same level, or inconsistently less, fearfulness…could very well be due to chance.
  - If consistently lower fearfulness…***probably*** not due to chance.

Retain H_0
or, fail to reject H_0

Reject H_0,
or, accept H_1**

Statistical Significance

- We claim ***statistical significance*** when we reject H_0 as an explanation for our observations

- "My therapy produced a *statistically significant* reduction in fearfulness"
  - This <u>does not</u> mean the therapy is meaningful
  - A statistically significant reduction could be very small

- "Aspirin has a *statistically significant* effect in preventing heart attack"
  - Reduction is equivalent to $r = -.03$
  - With aspirin: 427 out of 1000
  - Without: 431 out of 1000

Statistical Significance

- *Reliable* is a better term!

- Aspirin has a reliable effect…
  - How big is the effect?
  - Is the cost worth it?
  - Are there side effects?

Sign Test

- ***Sign Test*** can be our first use of hypothesis testing!
  - Uses *binomial distribution*, which we already know

- Requires <u>repeated-measures</u> (or within-subjects) research design
  - Usually a **pre-post design**

- **IV:** Therapy for phobia
- **DV:** "How fearful are you?"
  - **Pre:** Start of therapy
  - **Post:** End of therapy

Patient	Fear rating: Pre	Fear rating: Post	Difference Score	Sign
1	9	6	-3	--
2	9	6	-3	--
3	8	7	-1	--
4	7	2	-5	--
5	9	7	-2	--
6	8	3	-5	--
7	6	7	+1	+
8	7	4	-3	--
9	9	3	-6	--
10	8	2	-6	--

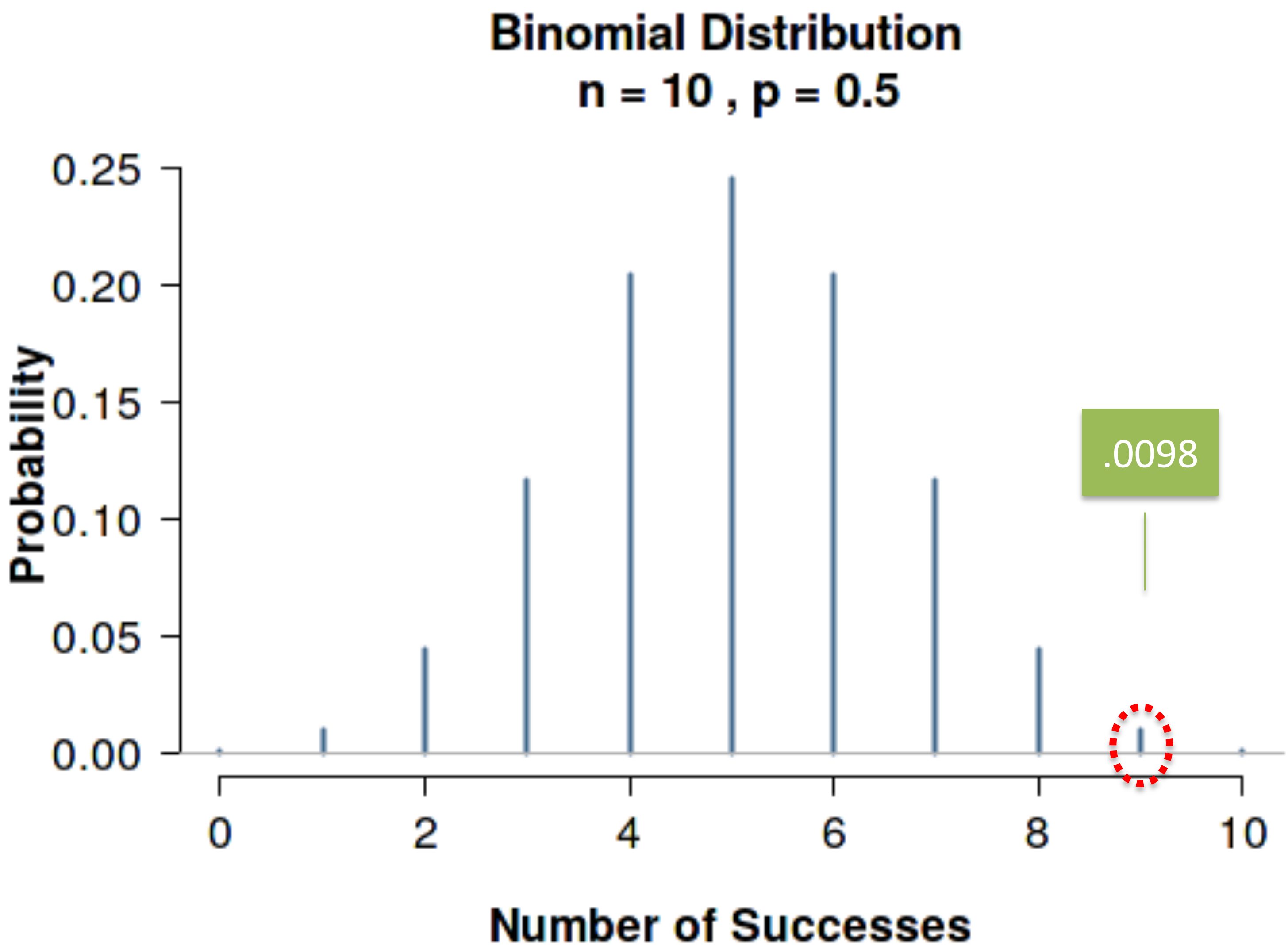
- H_0: Chance accounts for all change
  - ***a priori*** probability: $P(-) = ?$
  - ***a posteriori*** probability: $P(-) = ?$

Assess $P(\text{Data}|H_0)$

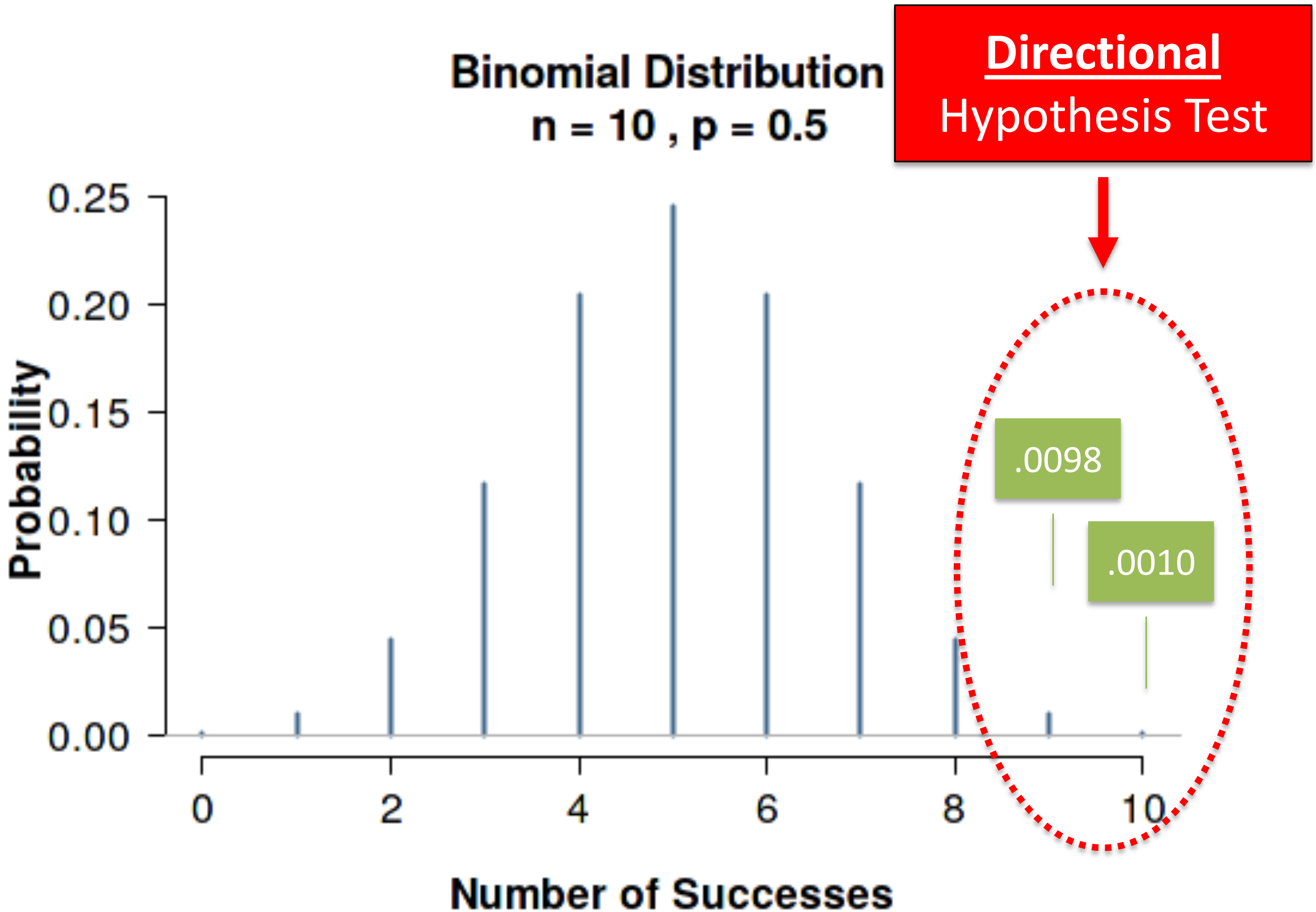
- H_0*:* Chance accounts for all change
  - ***a priori***: $P(-) = 0.5$
  - ***a posteriori***: $P(-) = 0.9$

- What is probability of observing 0.9 if we assume H_0?
  - Use binomial distribution (pp. 596), where:
    - $N = 10$
    - $P = 0.5$
    - # P events = 9

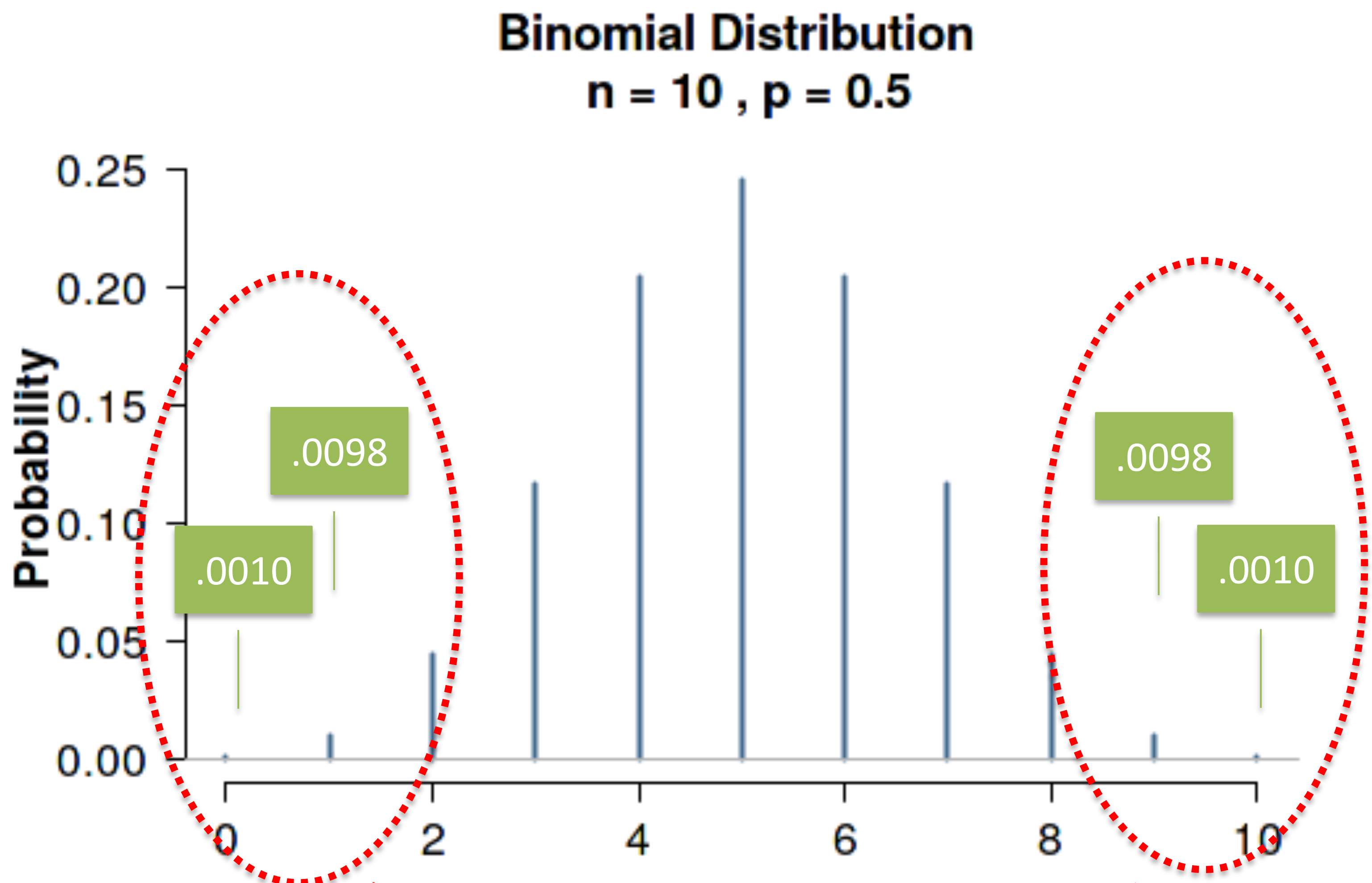
How rare are ***exactly*** 9 out of 10 reductions?



How rare are ***at least*** 9 out of 10 reductions?



How rare are ***at least*** 9 out of 10 reductions ***or increases***?



<u>Non-Directional</u>
Hypothesis Test

$P(\text{data} | H_0)$

- $P(\text{data} | H_0)$ depends on H_0/H_1
  - ***Exactly*** 9 out of 10 reductions occur at .0098
    - We would <u>rarely</u> (if ever) report this probability
  - ***At least*** 9 out of 10 reductions occur at .0108
    - This probability evaluates <u>one-tail</u> of the distribution
  - ***At least*** 9 out of 10 ***reductions or increases*** occur at .0216
    - This probability evaluates <u>two-tails</u> of the distribution

p-value

- Our *p*-value for a two-tailed (or non-directional) hypothesis test is $p = .0216$

- Do we reject H_0? Or fail to reject H_0?

- It depends…

    on how often we are willing to be wrong when rejecting H_0

p-value Traditions

- Almost always use a *non-directional hypothesis*
- Accept being wrong 5% when rejecting H_0
  - Set $\alpha = .05$
    - Observed $p_{\text{2-tail}} = .0216$, when $\alpha = .05$
    - Observed p is less than α, thus we ***reject*** H_0
      - "At post-test, patients were significantly less likely to report being fearful compared to pre-test, $p = .0216$."