Test a Perceptual Phenomenon

Student Notes   Project Review   + Create Audit

Does Not Meet Specifications

Question 1: Identify variables in the experiment

SPECIFICATION
Question response correctly identifies the independent and dependent variables in the experiment.

MEETS SPECIFICATION

Reviewer Comments
You have correctly identified the Independent and Dependent Variables. Well done!

Question 2: Establish a hypothesis and statistical test

SPECIFICATION
An appropriate hypothesis test has been stated along with an appropriate statistical test to apply to collected data, with appropriate justification.

DOES NOT MEET SPECIFICATION

Reviewer Comments
❌ **Null and Alternative Hypotheses stated without ambiguity to the variables they represent**

- It is important that students be able to articulate the hypotheses statements accurately. In the scope of this class, they always involve comparing means not the "timings". Are we talking about the population means or the sample means? Please be specific.
- The idea of hypothesis testing is that we have limited data, **samples**, and from that limited data, we are trying to test our **hypotheses about the population**. Please take a look at the following material to help create a complete answer.
  Types of Hypotheses, and what they are hypothesizing about

Every hypothesis test requires the analyst to state a null hypothesis and an alternative hypothesis. The hypotheses are stated in such a ne is true, the other must be false; and vice versa.

The table below shows three sets of null and alternative hypotheses. Each makes a statement about the difference *d* between the mean of one population μ_1 and the mean of another population μ_2. (In the table, the symbol ≠ means " not equal to ".)

Set	Null hypothesis	Alternative hypothesis	Number of tails
1	$\mu_1 - \mu_2 = d$	$\mu_1 - \mu_2 \neq d$	2
2	$\mu_1 - \mu_2 \geq d$	$\mu_1 - \mu_2 < d$	1
3	$\mu_1 - \mu_2 \leq d$	$\mu_1 - \mu_2 > d$	1

The first set of hypotheses (Set 1) is an example of a two-tailed test, since an extreme value on either side of the sampling distribution would cause a researcher to reject the null hypothesis. The other two sets of hypotheses (Sets 2 and 3) are one-tailed tests, since an extreme value on only one side of the sampling distribution would cause a researcher to reject the null hypothesis.

When the null hypothesis states that there is no difference between the two population means (i.e., d = 0), the null and alternative hypothesis are often stated in the following form.

$$H_0: \mu_1 = \mu_2$$

$$H_a: \mu_1 \neq \mu_2$$

Examples of explicitly Stated Hypotheses

TABLE 16.2 Examples of Null and Alternative Hypotheses in Inferential Statistics

Research Question	Verbal Null (H_0) Hypothesis	Symbolic H_0 Hypothesis	Verbal Alternative (H_1) Hypothesis	Symbolic H_1 Hypothesis
Do teachers score higher on the GRE verbal than the national average?	The teacher population GRE verbal mean is equal to the national average of 476.	$H_0: \mu_{\text{GRE V}} = 476$	The teacher population GRE verbal mean is different from the national average of 476.	$H_1: \mu_{\text{GRE V}} \neq 476$
Do males or females tend to score better on the GRE verbal?	The male and female population means are not different.	$H_0: \mu_M = \mu_F$	The male and female population means are different.	$H_1: \mu_M \neq \mu_F$
Do education, arts and sciences, and business students have different starting incomes?	The education, arts and sciences, and business student populations have the same mean starting incomes.	$H_0: \mu_E = \mu_{A\&S} = \mu_B$	At least two of the three population means are different.	H_1: Not all equal
Is there a correlation between GPA (X), and starting salary (Y)?	The population correlation between GPA and starting salary is equal to zero.	$H_0: \rho_{XY} = 0$	The population correlation between GPA and starting salary is not equal to zero.	$H_1: \rho_{XY} \neq 0$
Is there a relationship between GRE verbal (X_1), and starting salary (Y), controlling for GPA (X_2)?	The population regression coefficient is equal to zero.	$H_0: \beta_{YX_1 \cdot X_2} = 0$	The population regression coefficient is not equal to zero.	$H_1: \beta_{YX_1 \cdot X_2} \neq 0$

✔ **Statistical Test is Correct**
✔ **Justification has been provided for the Statistical Test**

Question 3: Report descriptive statistics

SPECIFICATION
Descriptive statistics, including at least one measure of centrality and one measure of variability, have been computed for the dataset’s groups.

MEETS SPECIFICATION

Reviewer Comments

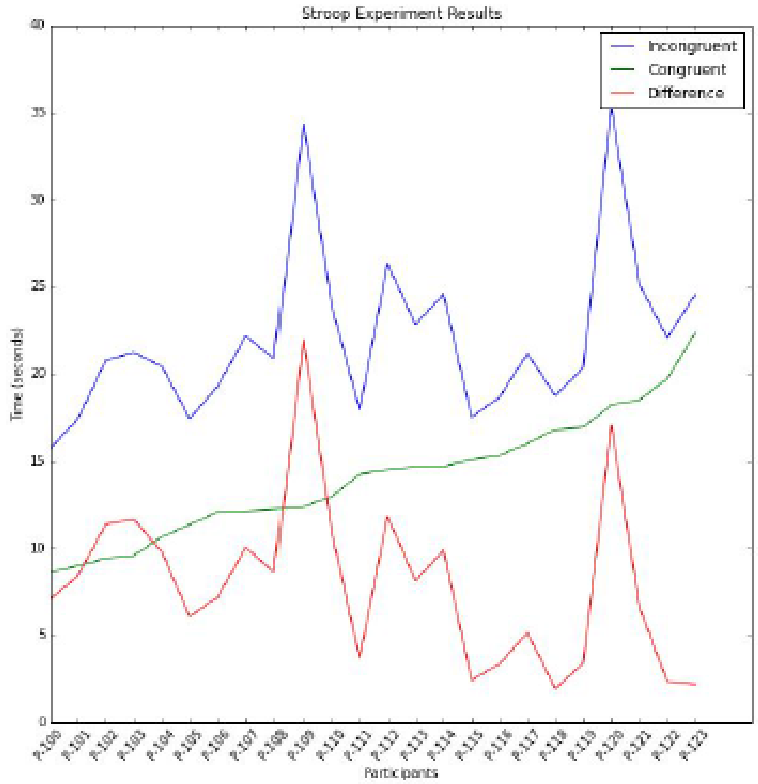
✔ Measurements of centrality are correct
✔ Measurements of Variability are correct
You have correctly reported measurements of centrality and variability. Great work!

Question 4: Plot the data

SPECIFICATION
One or two visualizations have been created that show off the data, including comments on what can be observed in the plot or plots.

MEETS SPECIFICATION

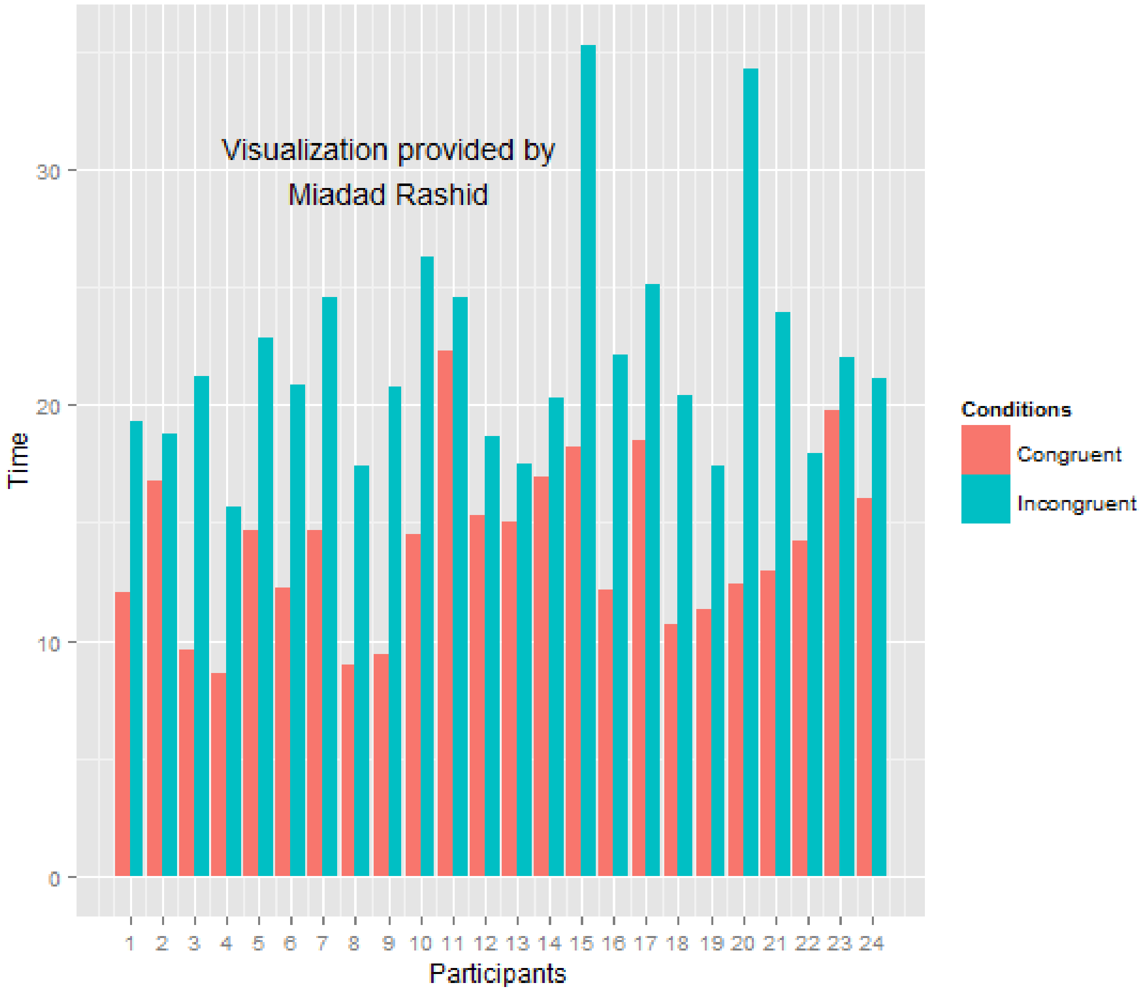
Reviewer Comments



Line Graph (OPTIONAL)

Please note that line graphs are used when the values on the x-axis are continuously related instead of being discrete. For example, when the x-axis is used to represent **Participants**, the values of the x-axis are **discrete**, meaning 4 represents the 4th **Discrete Participant** not a number on a continuous line (i.e. number that is 1 greater than 3). Using a line graph misrepresents the values to seem continuous when in fact they is no continuity between the values. Please remember this for future plots. What could be used instead is the bar plot below.

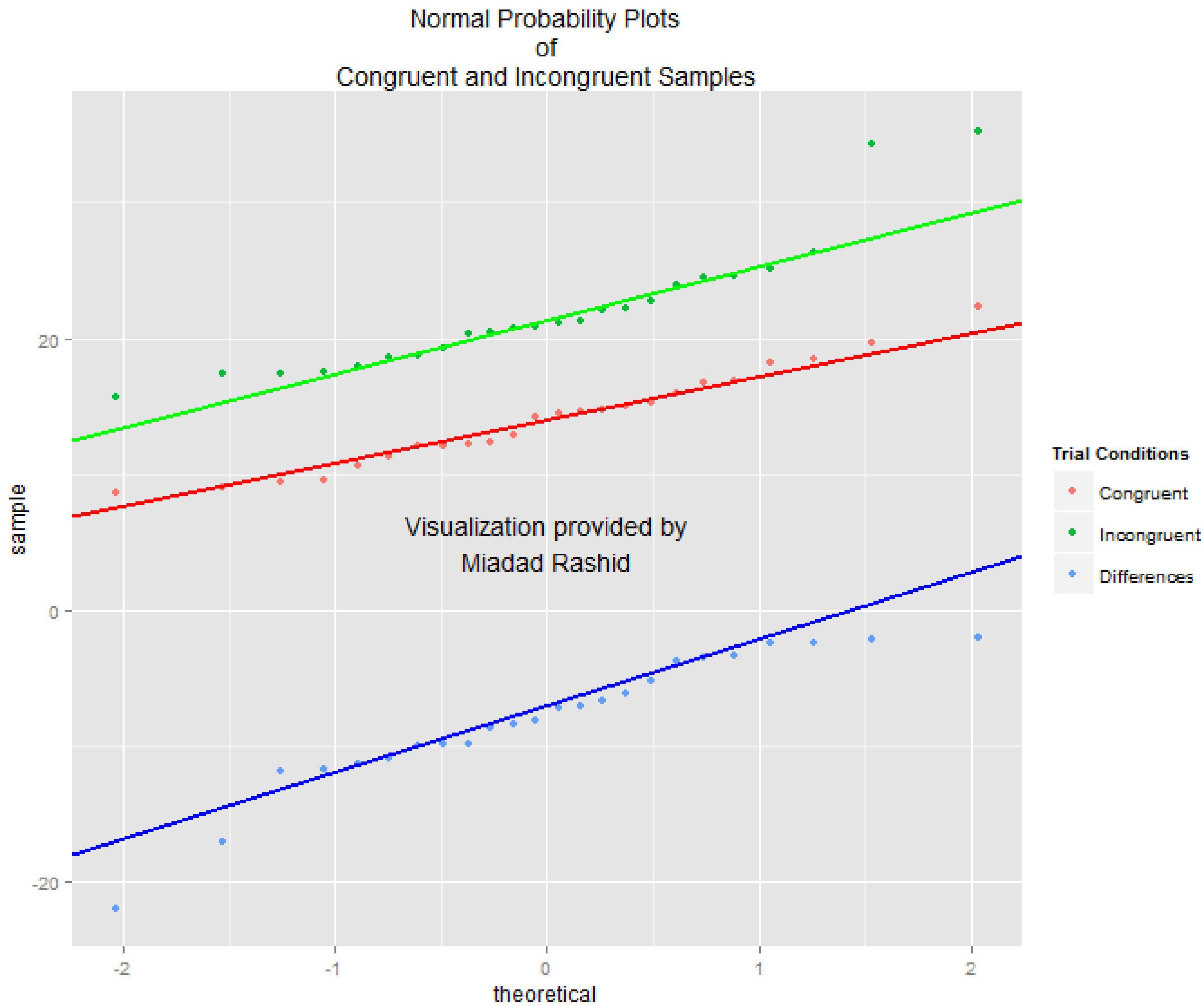
Bar-plot of both Trials Another great tool is a barplot of the 2 conditions side by side. If a bar plot of Congruent and Incongruent samples were overlaid with a bin size = 1 and each bar next to each corresponding bin, it would represent each individual's response time differences. This can offer great insight simultaneously showing times of each individual, and their delays. Here is an example.



Normality (OPTIONAL)

I have noticed your reference to normality in the project. There are a couple of ways to test normality of sample distributions besides looking at the histograms. I wanted to talk about some of them as they are a more accurate way to judge the normality of distributions and will be a valuable tool later on in your career. For the level of this class, we let students assume the distributions are normal and therefore can use a T-test which assumes normality. Upon further investigation, we find this is not quite true.

Normal Probability Plot



- The line you see for each conditions represents the line they would follow if they were normally distributed.
- As you can see, the Congruent samples seem to be barely on the line and the Incongruent Samples have some definite divergence from the line. As for the differences between the two, the assessment of normality seems inconclusive, but I would suspect that it is not..

We must be sure so we apply a quantifiable test to determine normality.

Shapiro-Wilk Normality Test

1. A Shapiro-Wilk Test is a statistical test that returns a Wilk Score and p-value. The Null is that the Distribution is Normal. So let's set up an α = 0.05.
    - **Congruent Samples**

      ```
              Shapiro-Wilk normality test

      data:  df$Congruent
      W = 0.97092, p-value = 0.6898
      ```
    - Fails to reject the Null - it is normally distributed. What do you think the Incongruent Samples will do?
    - **Incongruent Samples**

```
        Shapiro-Wilk normality test

data:  df$Incongruent
W = 0.85395, p-value = 0.00259
```

- It **Rejects the Null** - the samples are not normally distributed, as we suspected from the Probability Plots.
- **Differences**

```
        Shapiro-Wilk normality test

data:  diff
W = 0.91042, p-value = 0.03602
```

- It **Rejects the Null** - the samples are not normally distributed.

Although it is out of the scope of the class, we have grounds here to not use a T-test since a T-test assumes normality of the samples in question. We would require a Statistical test that is more robust and resistant to the outliers we are seeing in the plot. This would be a non-parametric test. We will go into this much deeper in the next class so I do not want to ruin it. If you would like to get a head start, start researching non-parametric tests. Which would you use for this dataset? *HINT* remember the samples are paired.

Question 5: Perform the statistical test and interpret your results

SPECIFICATION

A statistical test has been correctly performed and reported, including test statistic, p-value, and test result. The test results are interpreted in terms of the experimental task performed.

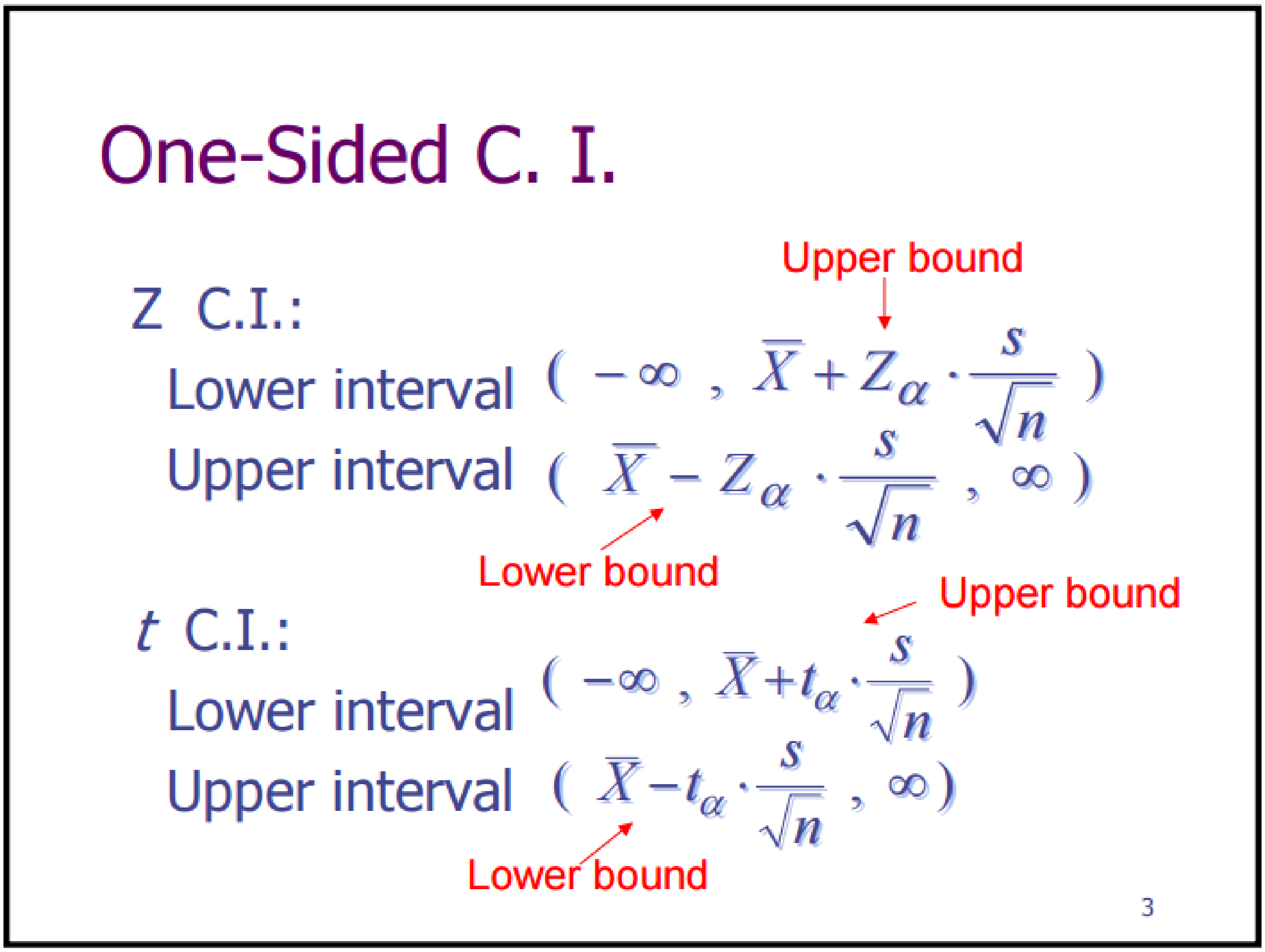
DOES NOT MEET SPECIFICATION

Reviewer Comments

Now. perform the statistical test and report your results
Figure 6 shows the t critical region for $\alpha = 0.05$, $df = 23$. This illustrates that the t -statistic of 8.02 is well beyond the t-critical point on the plot. The effect size measures of Cohen's d = 1.64 and r^2 = .74 further demonstrate the significance of the results.
t(23) = 8.02 p-value = 4.10e-08, right-tailed **Incorrect**
Confidence interval on the mean difference; 99.9%, CI = (6.262741 to 9.666843)
Cohen's d = 1.64
r^2 = .74

Your t-statistic (8.02) is correct. Well done. You hypotheses statements and reference of a right-tail indicates you need to produce a one-tail results. The p-value, however, is for a two-tailed test, not a one-tailed. Also, the outer limits of a one-tail confidence interval is +/- ∞. If you have a two-tailed p-value, what would one of those tails equal?

One-sided Confidence Interval



Question 6: Digging deeper and extending the investigation

SPECIFICATION
Hypotheses regarding the reasons for the effect observed are presented. An extension or related experiment to the performed Stroop task is provided, that may produce similar effects.

MEETS SPECIFICATION

Reviewer Comments
Thank you for extending and thinking deeper with the investigation. Do you think that the effects of incongruency can be observed in other senses like hearing and touch?

Chemosensory Experiment

http://chemse.oxfordjournals.org/content/32/4/337.full

Additional Reviewer Comments

Student Notes

> 1) I added observations on the study. Was this appropriate to add in this report?

All your observations were appreciated. I have commented on all that was out of the ordinary.

> 2) I verified the calculations using excel. Is this typical in reports? Should I have highlighted it more?

The scope of this class allows for whatever tools you are comfortable with. Typically, Google is used, although, I use R and Python.

> 3) Should I have included the appendix items on the study protocol or is that extraneous?

It is goo practice to include the items that you have included. Keep it up. Although, we do not require it in this project, in later project we will.

> Analysis questions
> 1) An alternative hypothesis that I thought of was whether the percent difference was greater than some value. Would this have been a valid investigation or is it enough that the times are different.

Before I answer your question, it is important to discuss what a hypothesis test is testing. In a hypothesis test, we are technically only testing for the Null hypotheses - whether we reject it or fail to reject it. If the test results are within the boundaries to reject the Null, typically we accept the Alternative, however, it does not mean the Alternative is true or the Null is false. What this test merely does is allows to a confidence level to reject the Null. Take the p-value - this is the probability of observing the mean difference **if** one were to assume the Null is true. An extremely low p-value means that the difference we are witnessing is extremely unlikely to occur if the Null were true so we have good reason to assume the Null *isn't* true.

The point in the previous section I was trying to make is that the testing revolves around the null. So any specific value in which you want to test against has to be stated in the Null. Then the alternative is the opposite of that. Usually, the null is that there is no difference, or that that the difference is zero. If you want to test against a different number, say 7, then you can make your null that the mean difference is greater than 7 and the alternate is that they aren't.

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Best practices for your project resubmission

Ben shares 5 helpful tips to get you through revising and resubmitting your project.

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