

Design a stroop effect test

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Background Information

In a Stroop task, participants are presented with a list of words, with each word displayed in a color of ink. The participant's task is to say out loud the color of the ink in which the word is printed. The task has two conditions: a congruent words condition, and an incongruent words condition.

- In the congruent words condition, the words being displayed are color words whose names match the colors in which they are printed: for example RED, BLUE.
- In the incongruent words condition, the words displayed are color words whose names do not match the colors in which they are printed: for example PURPLE, ORANGE.

In each case, we measure the time it takes to name the ink colors in equally-sized lists. Each participant will go through and record a time from each condition.

1. What is our independent variable? What is our dependent variable?

Answer:

The independent variable is the congruency condition and incongruency condition - whether the name of the color matches with the ink color or not. The dependent variable is the time it takes to name the ink colors in equally-sized lists.

2. What is an appropriate set of hypotheses for this task? What kind of statistical test do you expect to perform? Justify your choices.

Answer:

The hypothesis test that can use is: the difference between the time used to identify the colors under congruent words condition and incongruent words condition, namely, the Stroop Effect is in existence.

To be more specifically, here I will refer to the population means of congruence words group and incongruence words group - average times for the respective groups to recognize the colors. By comparing the mean time of two groups, we can find that there the difference exists between the two groups' recognition color time. But the fact is we are not able to collect all the data about time reaction of stroop effect, or do the experiment with all potential subjects in the world. Base on this condition, we need to work with the sample we have to make inferential statistic about the population means, for example, to use the observation means, standard deviation and other statistics to infer about the population means. In this case, the observation is the difference between the two groups' reaction times. With this observation, we can construct new statistics such as means and standard errors.

To achieve this, We will use T-test to verify. T-test assesses whether the means of two groups are statistically different from each other. First of all, we need to address the uncertainty in sample standard error resulted from the unknown population standard deviation; two, we are comparing the means of two groups that are dependent; three, the same subject is involved under both conditions.

Below is the hypothesis to test:

H0: $\mu_{diff} = 0$ (The real difference between group population means is zero)

HA: $\mu_{diff} \neq 0$ (The real difference between group population means is not zero)

3. Report some descriptive statistics regarding this dataset. Include at least one measure of central tendency and at least one measure of variability.

```

# Read in the data
library(readr)
dat <- read_csv("stroopdata.csv")
# Tidy up the data for later analysis
library(tidyr); suppressMessages(library(dplyr))
# Add a column identifying subjects
dat.subject <- mutate(dat, subject = 1:nrow(dat))
# Tidy up data by keeping one variable in one column
tidy.dat <- gather(dat.subject, congruency, time, -subject)
# Calculate the average time for both groups
tidy.dat %>%
  group_by(congruency) %>%
  summarise(round(mean(time), 2), round(median(time), 2), round(sd(time), 2), round(var(time), 2))

```

```

## # A tibble: 2 x 5
##   congruency `round(mean(time), 2)` `round(median(time), 2)`
##   <chr>          <dbl>          <dbl>
## 1 Congruent      14.05          14.36
## 2 Incongruent    22.02          21.02
## # ... with 2 more variables: `round(sd(time), 2)` <dbl>, `round(var(time),`
## #   2)` <dbl>

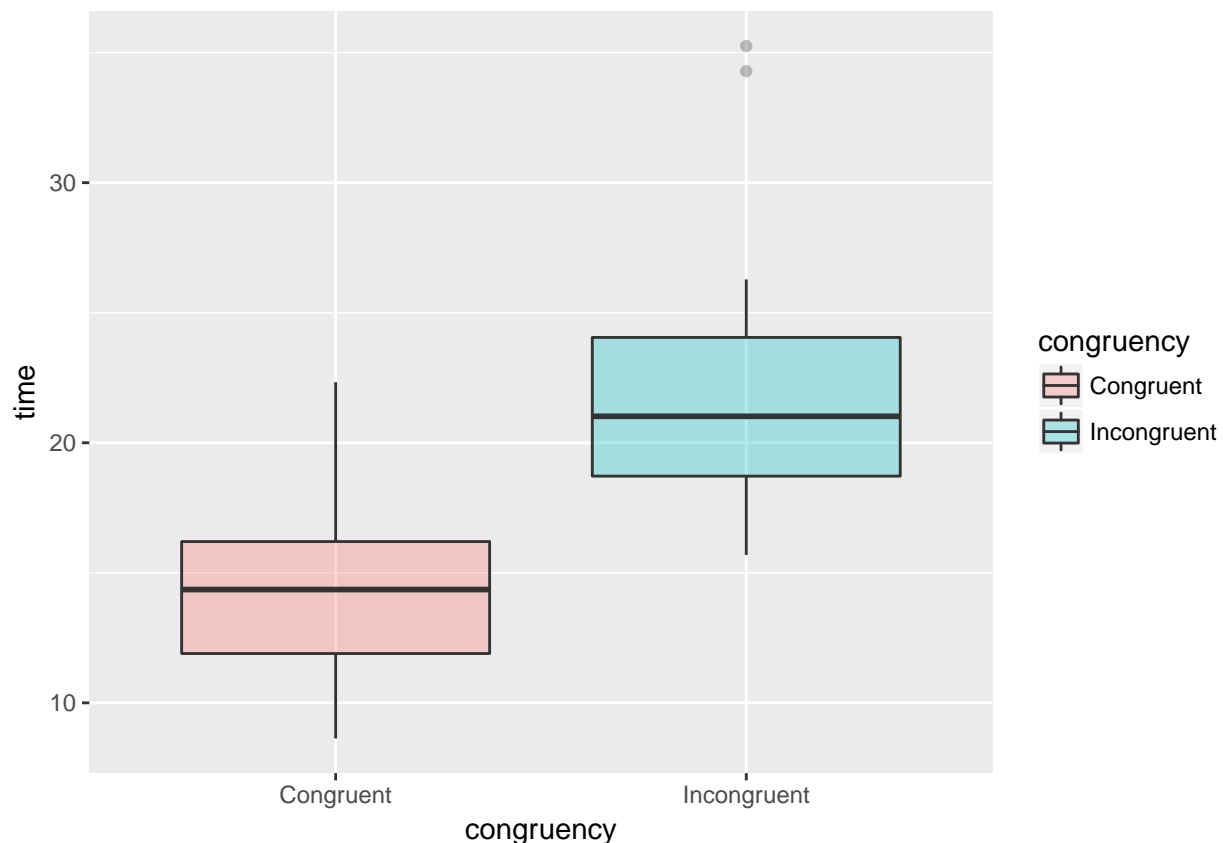
```

4. Provide one or two visualizations that show the distribution of the sample data. Write one or two sentences noting what you observe about the plot or plots.

```

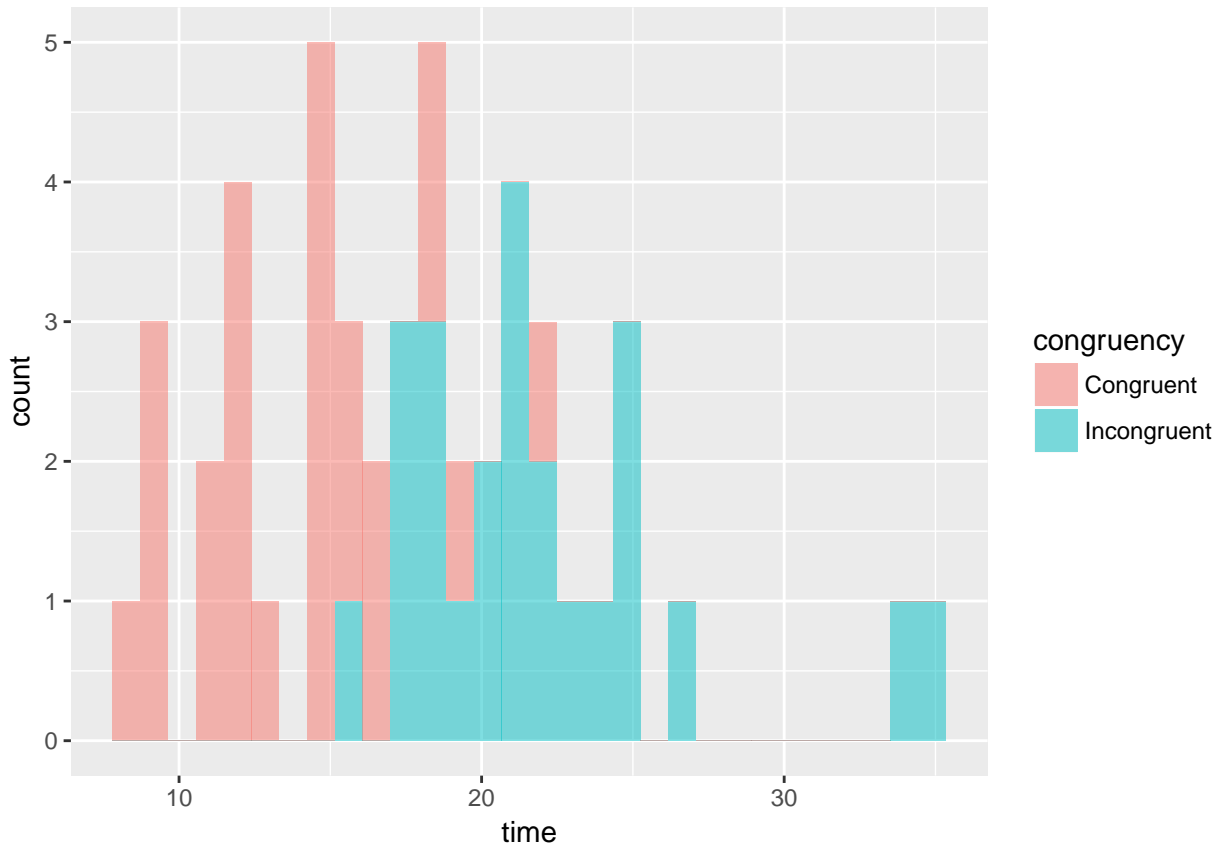
library(ggplot2)
b <- ggplot(tidy.dat, aes(y = time, x = congruency, fill = congruency))
b + geom_boxplot(alpha=0.3)

```



```
h <- ggplot(tidy.dat, aes(x = time, fill = congruency))
h + geom_histogram(alpha=0.5)
```

```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```



Answer

The boxplot in the above plot indicates that the two groups have significant difference in median times of, and the two groups also have different x value ranges. the Incongruent words group presenting much longer times than the congruent words group.

5. Now, perform the statistical test and report your results. What is your confidence level and your critical statistic value? Do you reject the null hypothesis or fail to reject it? Come to a conclusion in terms of the experiment task. Did the results match up with your expectations?

Hypothesis: the two groups have significant difference in their mean times.

```
# H0: mu_diff = 0
# HA: mu_diff != 0

mu_diff <- 0 # the null value
dat.diff <- mutate(dat.subject, diff = Congruent - Incongruent) # add a new diff column
diff <- dat.diff$diff # grab all the diff values into a vector
sigma <- sd(diff) # sample sd
diff_bar <- mean(diff) # sample mean
n <- length(diff) # sample size
DF <- n - 1 # degree of freedom
SE <- sigma/sqrt(n) # standard error
# Calculate the T-statistic:
```

```

T <- (diff_bar- mu_diff)/SE; T

## [1] -8.020707
#find out the p-value
p_value <- pt(T, df = DF, lower.tail = TRUE) * 2; p_value

## [1] 4.103001e-08
# Build the confidence interval based on 5% confidence level
diff_bar + c(1, -1) * qt(.975, df = DF, lower.tail = FALSE) * SE

## [1] -10.019028 -5.910555
# Verify using the t.test() function
t.test(x=dat$Congruent, y=dat$Incongruent, alternative = "two.sided", mu = 0, paired = TRUE, conf.level

##
## Paired t-test
##
## data: dat$Congruent and dat$Incongruent
## t = -8.0207, df = 23, p-value = 4.103e-08
## alternative hypothesis: true difference in means is not equal to 0
## 95 percent confidence interval:
## -10.019028 -5.910555
## sample estimates:
## mean of the differences
## -7.964792

```

Since the p-value is less than 0.05, we reject the null hypothesis and conclude that the difference between congruence and incongruence group time difference is statistically significant, namely, the stroop effect is present. This is in line with my expectation.

Based on the confidence intervals, we're 95% confident that the true difference between the congruence and incongruence group average times is between -10.019028 and -5.910555.

6. What do you think is responsible for the effects observed? Can you think of an alternative or similar task that would result in a similar effect? Some research about the problem will be helpful for thinking about these two questions!

Answer:

I think this effect is caused by the distraction resulted from the occurrence of the words and particularly, the incorrectly labeled words. Because humans are so sensitive to words that there is already a "conditioned reflex" established. Therefore, whenever a word is present, eyes and brain will automatically capture and decompose them, which leads to a delay and a interference with the color recognition.

"Warped words" is a similar situation. A similar experiment involving hard to read words can be used to test the effect.