

# PSYCH 363 - Stroop Effect: Congruency and Response Time

Keagan McMahon, Brigitta Munds,  
Benjamin Brown, & Christina Rachmadita

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## Contents

<b>1</b>	<b>Introduction</b>	<b>1</b>
<b>2</b>	<b>Methods</b>	<b>1</b>
<b>3</b>	<b>Results</b>	<b>3</b>
<b>4</b>	<b>Discussion</b>	<b>5</b>
<b>5</b>	<b>References</b>	<b>6</b>
<b>6</b>	<b>Testing Plots here.....</b>	<b>6</b>
6.1	All Of the available plots below... . . . . .	6

## 1 Introduction

Previous studies in the Stroop literature have demonstrated that participants might respond differently based on if Stroop items are congruent with their displayed state and some have found evidence of congruency effects [2]. For example, words that are presented in the same colour that the word is describing (i.e. the word "Red" presented in the colour red) would be known as a congruent trial, whereas words presented in a different colour (i.e. "Red, but presented in the colour blue) would be an incongruent trial.

Rey-Mermet discusses the idea of attentional-control processes, namely, our ability to “activate goal-relevant information and to inhibit irrelevant information” [1]. Our study approaches this idea and seeks to understand if reaction time differences arise when comparing congruent to incongruent trials. A participants goal is to correctly report words that are congruent, while inhibiting the irrelevant information presented during incongruent trials and we hypothesize that ones reaction time should differ as a function of the extended cognitive process one must engage in to correctly make this rejection.

## 2 Methods

**Participants.** We utilized our 4 group members, and each completed 20 trials 5 times yielding 100 total trials per person. This gave us enough data to be confident in our results, although with such a small sample size of participants it is clear that these results will struggle to generalize to the broader population more broadly.

**Materials.** A program was developed for use in our experiment to randomly choose different colour words (i.e. red, blue, green, etc) and an associated colour that the words were written in. The words are presented on a plain solid grey background and participants were instructed to either press "z" or "/" on a keyboard to indicate whether the word and its associated colour were congruent (i.e. the written word

matched the colour of the word) or incongruent (i.e. the written word did not match the colour of the word). After each user response a new word would be randomly generated for them to respond to and once the participant completes 20 trials, the program closes itself, the data is exported and procedure ends. Importantly, the colour and word displayed were all randomly selected, and each value available within the program have an equal probability of being selected. We chose not to present the participant with a specific number of congruent/incongruent trials to ensure that they could not try to predict/learn what to expect next and maintain complete randomness.

Please see below for a copy of the Python code used in designing the program:

```
from psychopy import visual,core,clock,event
import random as r
import csv
from datetime import datetime

now=datetime.now()
date_time=now.strftime("%Y-%m-%d_%H:%M:%S")
filename="stroop"+date_time+".csv"

keyAssign=["q","z","slash"]
colourOptions=["yellow","red","blue","green"]

probCongruent=0.25

numberTrials=20
RTclock=core.Clock()

win=visual.Window(size=(600,600))

instructionText="Press 'z' for congruent words & colours and '/' when incongruent. Press any key to start"

showInstruction=visual.TextStim(win,instructionText,color="black",height=0.1)
showInstruction.draw()
win.flip()
event.waitKeys()

for i in range(numberTrials):

    r.shuffle(colourOptions)

    if r.random()<probCongruent:
        writtenColour=colourOptions[0]
        displayColour=colourOptions[0]
        congruent=1
    else:
        writtenColour=colourOptions[0]
        displayColour=colourOptions[1]
        congruent=0

    displayText = visual.TextStim(win,writtenColour,color=displayColour,height=0.2)

    displayText.draw()
    win.flip()
    RTclock.reset()
```

```

key=event.waitKeys(keyList=keyAssign)
rt=RTclock.getTime()
if (key[0]==keyAssign[0]):
core.quit()

with open(filename,'a',newline='') as csvfile:
posnerwrite=csv.writer(csvfile,delimiter=' ')
posnerwrite.writerow([writtenColour] + [displayColour] + [congruent] + [key[0]] + [rt])

core.wait(1)
core.quit()

```

### 3 Results

Data structure:

```

dt <- read.csv("363Stroop_Data_Dec_4.csv")

## An example of how our data is structured
head(dt, 10)

```

	Trial	Congruent	Colour	Response	Time
1	1	1	blue	z	1.0113984
2	1	0	blue	slash	0.9906640
3	1	0	red	slash	0.7729855
4	1	0	green	slash	0.7496739
5	1	0	green	slash	0.6566195
6	1	1	yellow	z	0.5783305
7	1	0	green	slash	1.0228071
8	1	0	green	slash	1.3865062
9	1	0	yellow	slash	0.7888217
10	1	0	blue	slash	0.9663929

Statistical summary of the data:

```
summary(dt)
```

	Trial		Congruent		Colour		Response		Time
Min.	: 1.00	Min.	:0.0000	blue	:110	slash:	312	Min.	:0.2039
1st Qu.:	5.75	1st Qu.:	0.0000	green	: 82	z	: 88	1st Qu.:	0.6608
Median	:10.50	Median	:0.0000	red	:102			Median	:0.7536
Mean	:10.50	Mean	:0.2175	yellow:	106			Mean	:0.8997
3rd Qu.:	15.25	3rd Qu.:	0.0000					3rd Qu.:	0.9482
Max.	:20.00	Max.	:1.0000					Max.	:4.5227

Number of rows:

```
nrow(dt)
```

```
[1] 400
```

Linear regression model:

```
lmresults <- lm( Time ~ Congruent, data = dt)
summary(lmresults)
```

Call:

```
lm(formula = Time ~ Congruent, data = dt)
```

Residuals:

Min	1Q	Median	3Q	Max
-0.7115	-0.2423	-0.1421	0.0377	3.6073

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	0.91539	0.02736	33.456	<2e-16 ***
Congruent	-0.07234	0.05867	-1.233	0.218

---

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4841 on 398 degrees of freedom

Multiple R-squared: 0.003806, Adjusted R-squared: 0.001303

F-statistic: 1.52 on 1 and 398 DF, p-value: 0.2183

Specialised T-test:

```
t.test(Time ~ Congruent, mu=0, alt="two.sided", conf=0.95, var.eq=F, paired=F, data = dt)
```

Welch Two Sample t-test

data: Time by Congruent

t = 1.6466, df = 241.61, p-value = 0.1009

alternative hypothesis: true difference in means is not equal to 0

95 percent confidence interval:

-0.01420303 0.15888674

sample estimates:

mean in group 0 mean in group 1

0.9153860 0.8430441

One way ANOVA:

```
anova(lmresults)
```

Analysis of Variance Table

Response: Time

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Congruent	1	0.356	0.35627	1.5205	0.2183
Residuals	398	93.258	0.23432		

More linear regression:

```
lmresults2 <- lm( Time ~ Congruent + Trial + Colour + Response, data = dt)
```

```
summary(lmresults2)
```

Call:

```
lm(formula = Time ~ Congruent + Trial + Colour + Response, data = dt)
```

Residuals:

	Min	1Q	Median	3Q	Max
	-0.5683	-0.2452	-0.1264	0.0476	3.5778

Coefficients:

	Estimate	Std. Error	t value	Pr(> t )
(Intercept)	0.985707	0.067434	14.617	<2e-16 ***
Congruent	0.727180	0.488648	1.488	0.138
Trial	-0.006801	0.004213	-1.614	0.107
Colourgreen	0.065221	0.070966	0.919	0.359
Colourred	-0.045419	0.066993	-0.678	0.498
Colouryellow	0.004813	0.065793	0.073	0.942
Responsez	-0.799422	0.486281	-1.644	0.101

---

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.4829 on 393 degrees of freedom

Multiple R-squared: 0.02085, Adjusted R-squared: 0.005901

F-statistic: 1.395 on 6 and 393 DF, p-value: 0.2154

One way ANOVA:

```
anova(lmresults2)
```

Analysis of Variance Table

Response: Time

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Congruent	1	0.356	0.35627	1.5275	0.2172
Trial	1	0.505	0.50535	2.1667	0.1418
Colour	3	0.460	0.15330	0.6573	0.5788
Response	1	0.630	0.63034	2.7026	0.1010
Residuals	393	91.662	0.23324		

## 4 Discussion

test discussion text stuff

## 5 References

### References

- [1] Alodie Rey-Mermet. Finding an interaction between stroop congruency and flanker congruency requires a large congruency effect: A within-trial combination of conflict tasks. *Attention, perception psychophysics*, 82(5):2271–2301, 2020.
- [2] Giacomo Spinelli, Kesheni Krishna, Jason R Perry, and Stephen J Lupker. Working memory load dissociates contingency learning and item-specific proportion-congruent effects. *Journal of experimental psychology. Learning, memory, and cognition*, 46(11):2007–2033, 2020.

## 6 Testing Plots here. ....

### 6.1 All Of the available plots below...

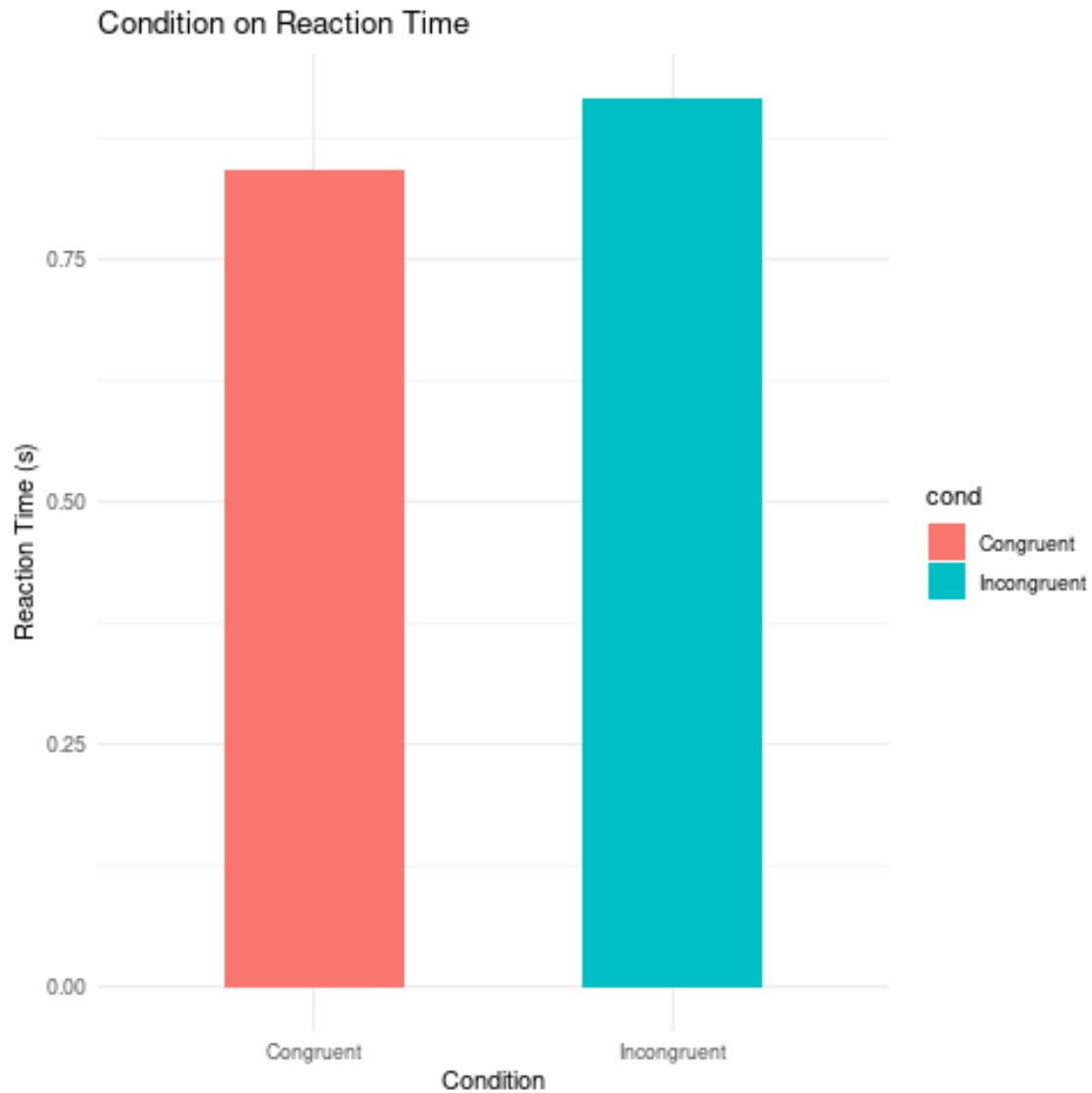
```
library(ggplot2)

data <- read.csv("363Stroop_Data_Dec_4.csv")

incongruent <- data[which(data$Congruent == 0),]$Time
congruent <- data[which(data$Congruent == 1),]$Time
df <- data.frame(cond = c("Incongruent", "Congruent"),
rt = c(mean(incongruent), mean(congruent)))

p <- ggplot(df, aes(x = cond, y = rt, fill = cond)) + geom_bar(stat = "identity",
width = 0.5) + labs(title = "Condition on Reaction Time", x = "Condition",
y = "Reaction Time (s)") + theme(legend.position = "right") + theme_minimal()

p
```



```
library(ggplot2)

data <- read.csv("363Stroop_Data_Dec_4.csv")

Lincongruent <- c()
counter = 1
while(counter <= 20) {
  T = data[which(data$Trial == counter & data$Congruent == 0),]
  mean_RT = mean(T$Time)
  Lincongruent = append(Lincongruent, mean_RT)
  counter = counter + 1
}

Lcongruent <- c()
counter = 1
while(counter <= 20) {
  T = data[which(data$Trial == counter & data$Congruent == 1),]
  mean_RT = mean(T$Time)
```

```

  Lcongruent = append(Lcongruent, mean_RT)
  counter = counter + 1
}

cond_rt_df <- data.frame(Condition = rep(c("Congruent", "Incongruent"), each = 20), RT = c(Lcongruent, Lincongruent))
df <- data.frame(Congruent = Lcongruent, Incongruent = Lincongruent)
df$Interference <- df$Incongruent - df$Congruent

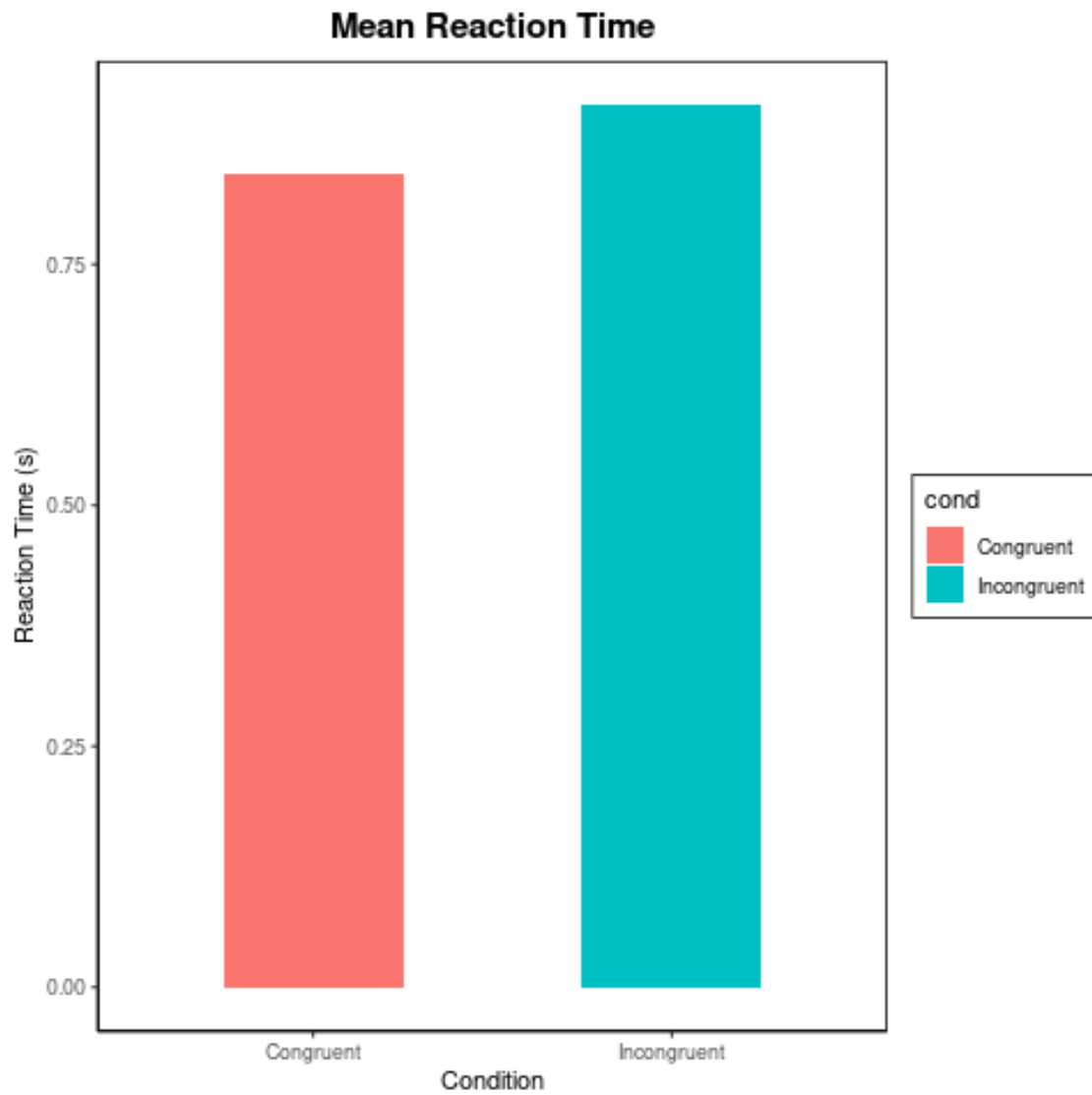
incongruent_mean <- mean(data[which(data$Congruent == 0),]$Time)
congruent_mean <- mean(data[which(data$Congruent == 1),]$Time)
overall <- data.frame(cond = c("Incongruent", "Congruent"), rt = c(incongruent_mean, congruent_mean))

      Incongruent 0.915385980111821
      Congruent  0.843044126528736

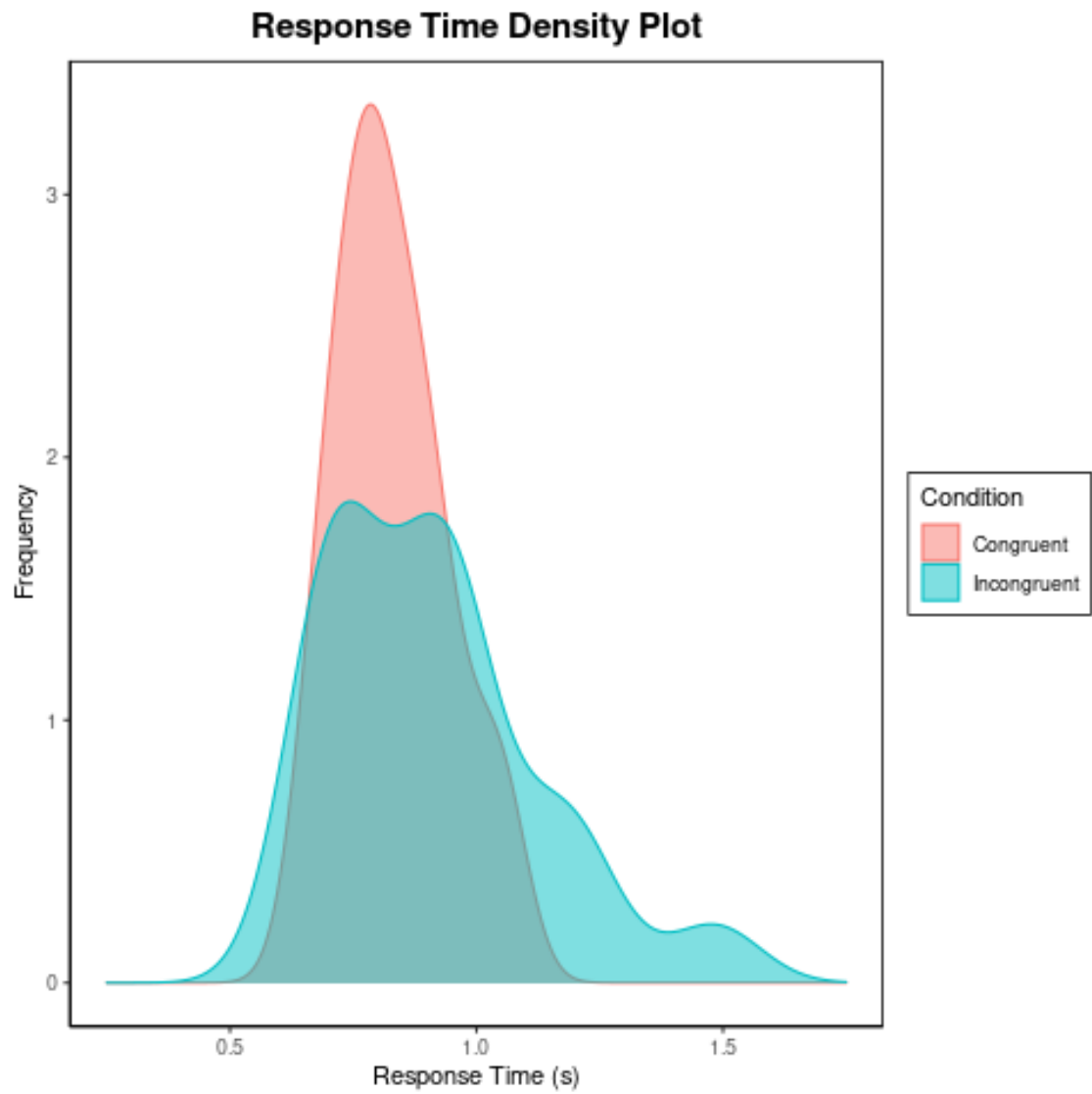
p <- ggplot(overall, aes(x = cond, y = rt, fill = cond)) + geom_bar(stat = "identity", width = 0.5) + labs(
  p

```

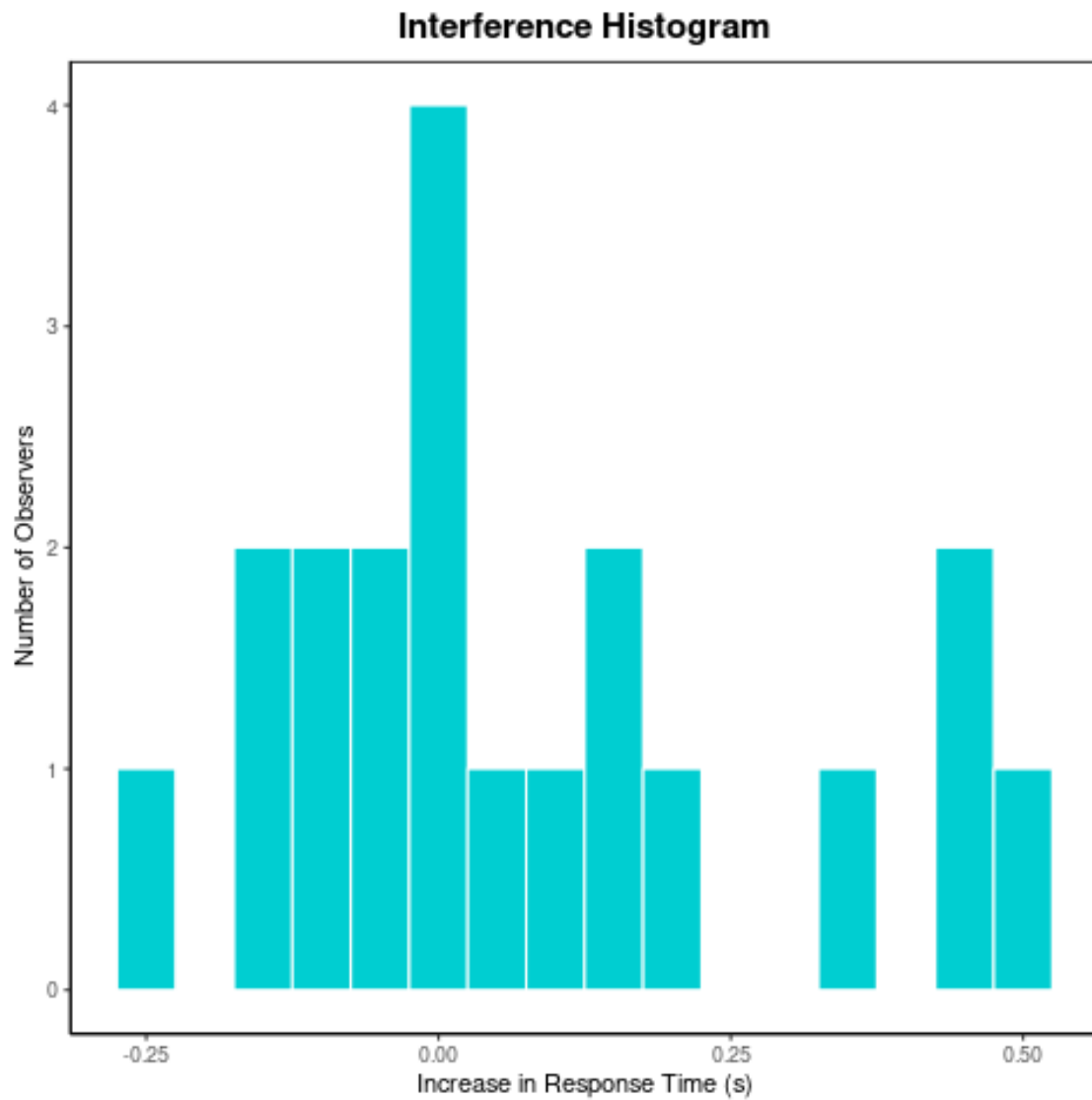




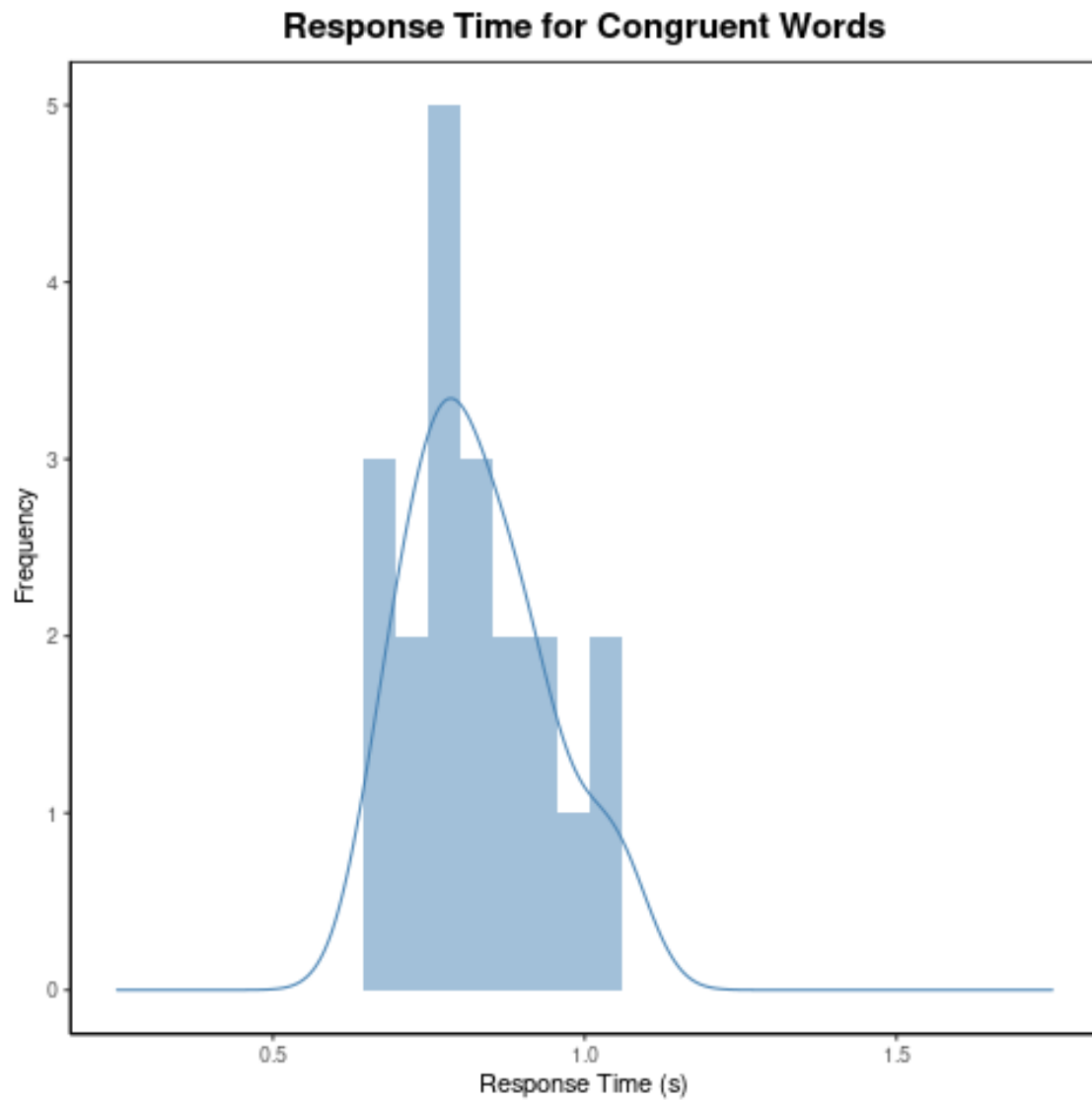
```
density_plot <- ggplot(cond_rt_df, aes(x = RT, color = Condition, fill = Condition)) + geom_density(alpha = 0.5)
density_plot
```



```
interference_hist <- ggplot(df, aes(x = Interference)) + geom_histogram(binwidth = 0.05, color = "white")
interference_hist
```

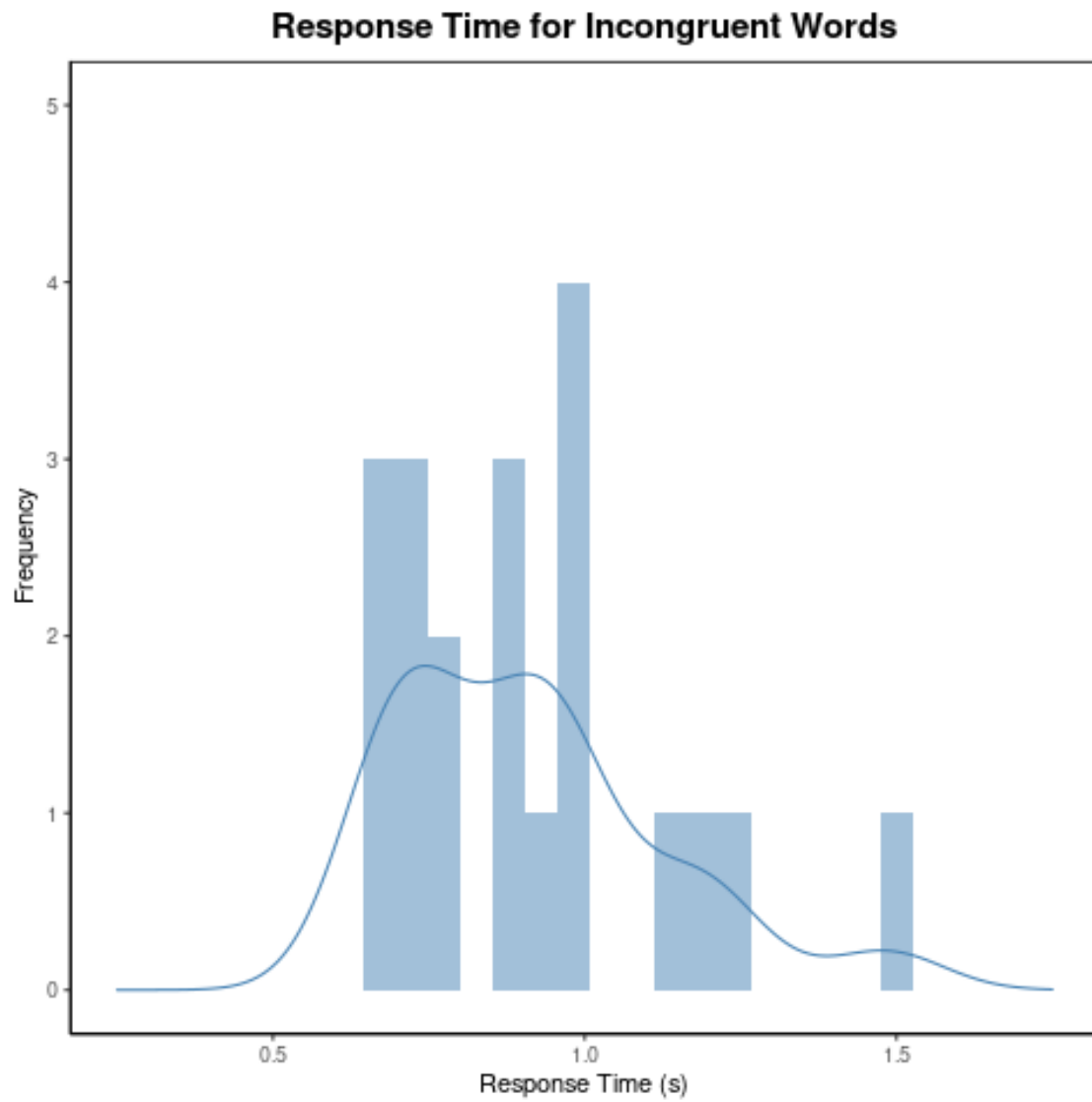


```
RT_congruent <- ggplot(df, aes(x = Congruent)) + geom_histogram(alpha = 0.5, fill = "steelblue") + geom.  
RT_congruent
```



```
RT_incongruent <- ggplot(df, aes(x = Incongruent)) + geom_histogram(alpha = 0.5, fill = "steelblue") + g
```

```
RT_incongruent
```



```
RT_cond <- ggplot(cond_rt_df, aes(x = RT, color = Condition, fill = Condition)) + geom_histogram(color = "blue", fill = "blue", bins = 30)
RT_cond
```

### Response Time for Congruent vs. Incongruent Words

