Final Project

PSTAT122: Design and Analysis of Experiments

Fall 2025

STUDENT NAME

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Due Date

Due Date: Monday, December 8, 2025, 11:59 PM

1 Introduction

Texting has become an essential part of everyday communication, yet many people continue to use whichever typing method feels familiar, rather than the one that may allow them to type most efficiently. This project investigates how different typing methods influence texting speed. Our objective is to determine which method leads to the fastest way to text.

2 Experimental Design

This experiment evaluated one primary factor, Texting Condition, with four treatment levels representing different combinations of number of thumbs and phone orientation:

1. One thumb with vertical keyboard
2. One thumb with horizontal keyboard
3. Two thumbs with vertical keyboard
4. Two thumbs with horizontal keyboard

   The response variable was defined as the time required to correctly type a predetermined sentence, measured in seconds. The Texting Condition was considered a fixed factor, while Participant acted as a fixed blocking factor, since individual differences in typing skill were expected to contribute to variability.

   A Randomized Complete Block Design (RCBD) was used. Four participants each formed a block, and within every block all four treatments were applied exactly once. This structure ensured that each participant experienced every texting condition, allowing comparisons to be made within individuals rather than across them.

   Randomization was implemented by independently randomizing the order of the four treatments for each block. Each participant therefore completed the treatments in a unique randomized sequence.

   Replication occurred naturally from the RCBD layout, with each treatment replicated once per block, resulting in four total replicates per treatment. The sample size consisted of 4 blocks (participants), 4 treatments, 4 observations per treatment for a total of 16 observations.

This design enabled the study to control for between-participant variability while isolating the effects of the texting conditions on typing speed.

3 Data Collection

- **Procedure**: The experiment was conducted on December 3, 2025, in the campus library to reduce noise and other distractions. All participants used the same device (an iPhone 15 Pro Max running the Notes app) to ensure consistency across every trial and prevent differences in device size, keyboard sensitivity, or interface from influencing the results. Each participant typed the standardized pangram: "the quick brown fox jumps over the lazy dog". Each participant's random order using the sample() function in R(set.seed(100)) is shown below (see Appendix A).
  - Enye: One-Thumb Horizontal, Two-Thumb Vertical, Two-Thumb Horizontal, One-Thumb Vertical
  - Ryan: Two-Thumb Vertical, One-Thumb Vertical, One-Thumb Horizontal, Two-Thumb Horizontal
  - Amelia: Two-Thumb Horizontal, Two-Thumb Vertical, One-Thumb Horizontal, One-Thumb Vertical
  - Junyi: One-Thumb Horizontal, Two-Thumb Vertical, Two-Thumb Horizontal, One-Thumb Vertical

    Before each trial began, a designated timekeeper counted down "3–2–1, go," and the participant started typing on "go." Timing was recorded in seconds using the same stopwatch app for all trials. The timekeeper stopped the timer once the participant had correctly typed the full sentence, and the recorded time was logged for that specific condition. This process was repeated until each participant had completed all four conditions in their assigned sequence.
- **Challenges/Adjustments**: Although the experiment was progressing smoothly, we still encountered a few minor problems during the data collection process:
  - Even if the participants completed all conditions in a random order, we found that learning effects still inevitably occurred. To reduce the impact of these learning effects, we first ensured the randomization sequence and provided sufficient practice before each trial, until the participants were familiar with the sentences before starting the experiment.
  - At first, we planned to have someone near the participants do the timing. However, to avoid differences in the timer's reaction times, we finally decided that the same person would be responsible for all the timing tasks and use the stopwatch function on the phone to minimize timing errors.
    * **Data Presentation**:

      The collected raw data (typing time in seconds) is shown in the following table:

Participant(Block)	One Thumb-Horizontal	Two Thumbs-Horizontal	One Thumb-Vertical	Two Thumbs-Vertical
1 (Enye)	27.52	15.13	12.6	7.11
2 (Ryan)	16.02	14.38	18.2	9.88
3 (Amelia)	15.81	15.1	13.43	16.45
4 (Junyi)	17	11.18	12.8	10.18

4 Analysis (see Appendix B)

Hypothesis

$$H_0 : \tau_1 = \tau_2 = \tau_3 = \tau_4 = 0$$

No difference between mean typing speed between four typing conditions.

$$H_1 : \text{At least one } \tau_i \neq 0$$

At least one typing has a significantly different speed than the rest.

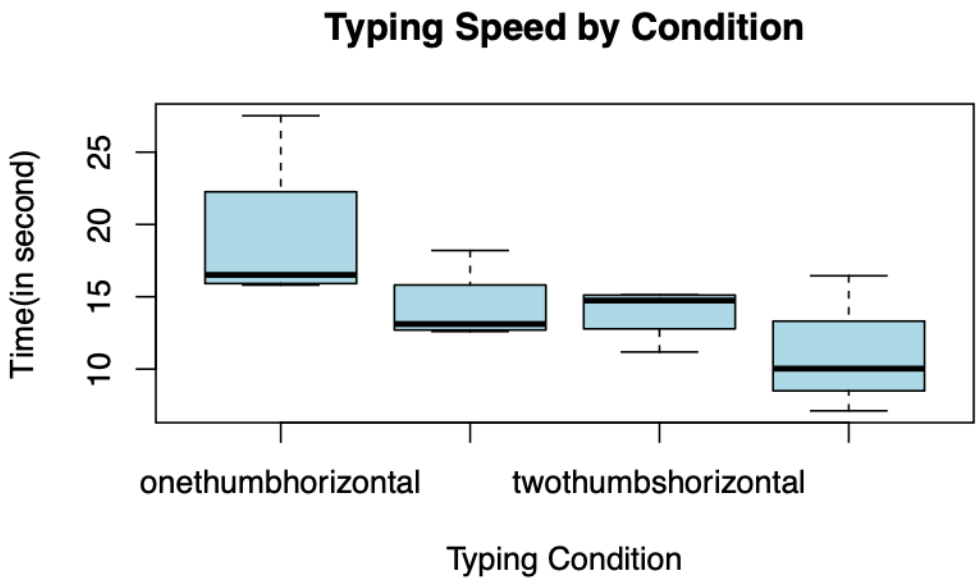
```r
summary_table <- typing.data %>%
  group_by(condition) %>%
  summarise(
    N = n(),
    Mean = mean(time),
    SD = sd(time)
  )
kable(summary_table,
      caption = "Summary Statistics",
      col.names = c("Typing Condition", "Sample Size", "Mean (sec)", "Std Dev"))
```

Table 2: Summary Statistics

Typing Condition	Sample Size	Mean (sec)	Std Dev
onethumbhorizontal	4	19.0875	5.645537
onethumbvertical	4	14.2575	2.652023
twothumbshorizontal	4	13.9475	1.877292
twothumbsvertical	4	10.9050	3.946530

Boxplot

```r
boxplot(time ~ condition,
        data = typing.data,
        main = "Typing Speed by Condition",
        xlab = "Typing Condition",
        ylab = "Time(in second)",
        col = "lightblue")
```



ANOVA

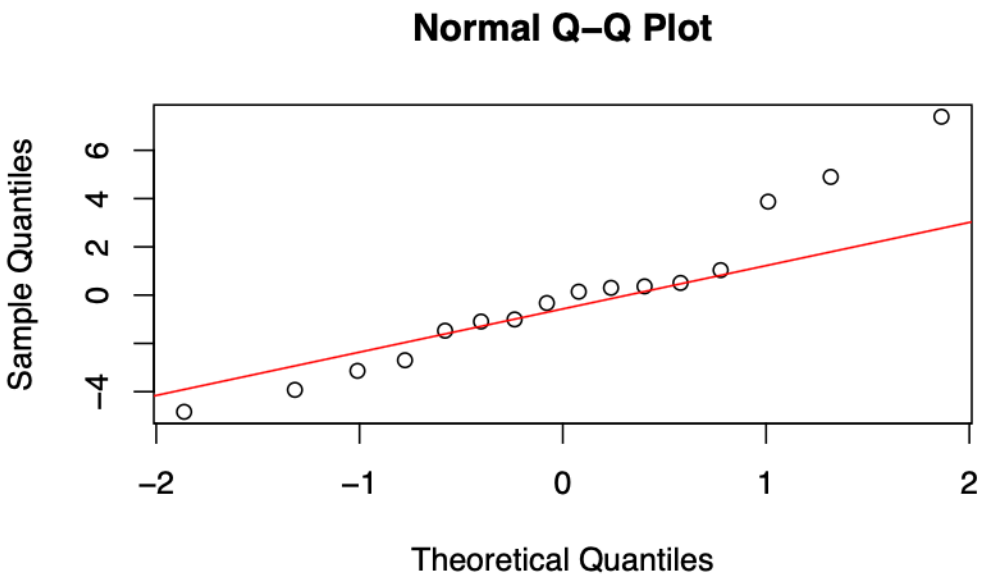
```r
model.rcbd <- aov(time ~ condition + typist, data = typing.data)

summary(model.rcbd)
```

```
            Df Sum Sq Mean Sq F value Pr(>F)
condition    3 137.29   45.76   2.647  0.113
typist       3  18.41    6.14   0.355  0.787
Residuals    9 155.60   17.29
```

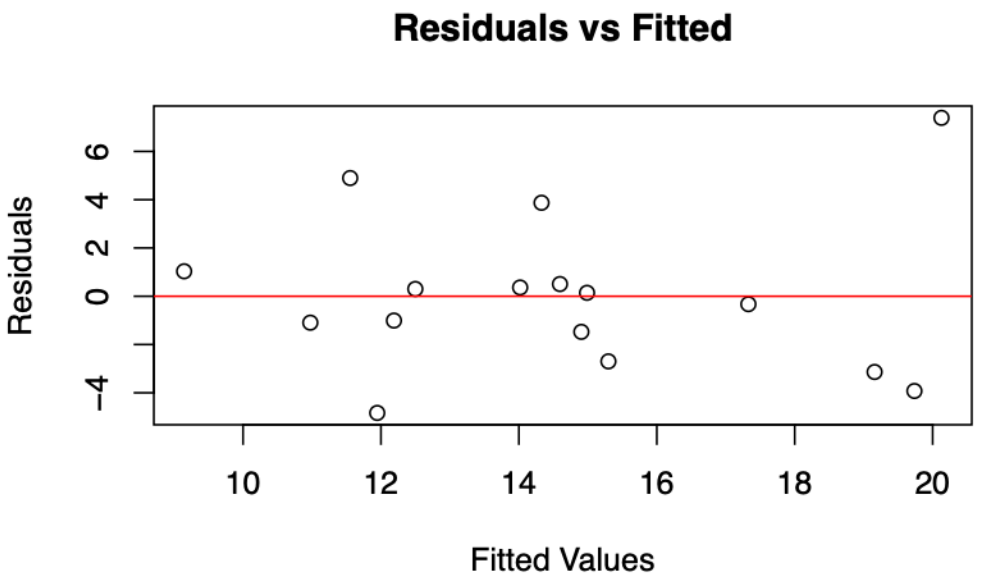
Q-Q

```r
res <- residuals(model.rcbd)
qqnorm(res, main = "Normal Q-Q Plot")
qqline(res, col = "red")
```



Residuals vs Fitted for Equal Variance

```r
plot(fitted(model.rcbd), res,
     main = "Residuals vs Fitted",
     xlab = "Fitted Values",
     ylab = "Residuals")
abline(h = 0, col = "red")
```



Shapiro-Wilk Test

```
shapiro.test(res)
```

```
    Shapiro-Wilk normality test

data:  res
W = 0.94024, p-value = 0.352
```

Bartlett Test

```
bartlett.test(time ~ condition, data = typing.data)
```

```
    Bartlett test of homogeneity of variances

data:  time by condition
Bartlett's K-squared = 3.3696, df = 3, p-value = 0.3381
```

5 Conclusions

Across all four texting conditions, the observed typing times showed noticeable differences in speed, with the two-thumb methods generally outperforming the one-thumb methods. The boxplot indicates that the two-thumb horizontal condition resulted in the fastest overall typing speeds, while the one-thumb horizontal condition produced the slowest and most variable times. Both vertical conditions fell between these, but two-thumb vertical remained faster on average than one-thumb vertical.

The results of the RCBD ANOVA, however, showed that these differences were not statistically significant at the 0.05 level. The factor Texting Condition had a p-value of 0.113, thus we fail to reject the null hypothesis that texting methods have at least one different mean texting speed. The blocking factor Typist had a p-value of 0.787, indicating that differences among participants did not significantly contribute to variation in typing time.

Model diagnostics support the validity of the ANOV A assumptions. The Normal Q-Q plot showed only a slight S-shape deviation from the reference line, and the Shapiro–Wilk test produced a p-value of 0.352, indicating no strong evidence against normality. The residuals vs. fitted plot showed a reasonably random scatter, consistent with constant variance. The Bartlett test for homogeneity of variances had a p-value of 0.3381, suggesting that the treatment groups did not differ significantly in variance. These results indicate that the model assumptions were adequately met, and the ANOV A results are reliable for this data set.

In summary, while the numerical trends suggest that two-thumb horizontal typing is the fastest condition and one-thumb horizontal is the slowest, the sample size was not large enough to confirm these differences statistically.

This study had several limitations that should be considered when interpreting the results. The small sample size of four participants made it difficult to detect significant differences among the texting conditions even when visual trends suggested meaningful patterns. Although randomization and brief practice helped reduce learning effects, repeated typing of the same sentence may still have improved performance over time. Timing was conducted manually with a stopwatch, which introduces reaction-time variability; using automated timing tools would increase accuracy in future studies. Additionally, the experiment relied on a single device and keyboard layout, meaning the results may not generalize to other phones or typing interfaces.

6 References

(If needed.)

7 Appendices

Appendix A:

```r
set.seed(100)
conditions <- c("onethumbvertical", "onethumbhorizontal", "twothumbsvertical", "twothumbshorizontal")
enye_order <- sample(conditions)
#"onethumbhorizontal"  "twothumbsvertical"   "twothumbshorizontal" "onethumbvertical"
ryan_order <- sample(conditions)
#"twothumbsvertical"   "onethumbvertical"    "onethumbhorizontal"  "twothumbshorizontal"
amelia_order <- sample(conditions)
#"twothumbshorizontal" "twothumbsvertical"   "onethumbhorizontal"  "onethumbvertical"
junyi_order <- sample(conditions)
#"onethumbhorizontal"  "twothumbsvertical"   "twothumbshorizontal" "onethumbvertical"
```

Appendix B:

```r
time <- c(
  # enye's order 1th, 2tv, 2th, 1tv
  27.52, 7.11, 15.13, 12.6,

  # ryan's order 2tv,1tv, 1th,2th
  9.88, 18.2, 16.02, 14.38,

  # amelia's order 2th, 2tv, 1th, 1tv
  15.1, 16.45, 15.81, 13.43,

  # junyi's order 1th, 2tv, 2th, 1tv
  17, 10.18, 11.18, 12.8
)

condition <- c(
  # Enye
  "onethumbhorizontal", "twothumbsvertical", "twothumbshorizontal", "onethumbvertical",
  # Ryan
  "twothumbsvertical", "onethumbvertical", "onethumbhorizontal", "twothumbshorizontal",
  # Amelia
  "twothumbshorizontal", "twothumbsvertical", "onethumbhorizontal", "onethumbvertical",
  # Junyi
  "onethumbhorizontal", "twothumbsvertical", "twothumbshorizontal", "onethumbvertical"
)

typist <- c(
  rep("Enye", 4),
  rep("Ryan", 4),
  rep("Amelia", 4),
  rep("Junyi", 4)
)

typing.data <- data.frame(time, condition, typist)
typing.data$condition <- as.factor(typing.data$condition)
typing.data$typist <- as.factor(typing.data$typist)
```