Likert Scale Analysis

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Likert Scales

In the realm of UI/UX research, Likert scales play a pivotal role in quantitatively capturing opinions, attitudes, and responses to various questions. These scales, typically ranging from "strongly disagree" to "strongly agree," offer a simple yet powerful way for respondents to express their level of agreement with a given statement. The versatility of Likert scales makes them a staple in HCI.

For a list of Likert scale examples, see here.

> **BEFORE YOU BEGIN**
> This guide uses R to read the data from an Excel file, generate plots, summary statistics, and conduct the analysis. Please install an IDE that supports R programming, such as RStudio or PyCharm with the R plugin.

Step 1: Preparing Data

At this point, you should have a set of survey responses to one or more Likert scale questions.

The responses should be stored in an Excel file, with each row representing a respondent. Each question gets its own column, though how the design prototype is incorporated is dependent on whether you ran a between or within-subjects design experiment.

> **Experimental Design**
> * If you ran a **between-subjects** design, you only need a column for the prototype version.
> * If you ran a **within-subjects** design, you should have one column for the prototype version and another column for a user's identifier (e.g., participant ID).
>
> In either case, the remainder of your columns should correspond to each Likert scale question.

This is an example of what your Excel file should look like for a **between-subjects** design:

	A	B	C	D	E	F	G	H
1	Version	Question_1	Question_2	Question_3	Question_4	Question_5	Question_6	Question_7
2	A	5	4	2	5	4	4	5
3	A	3	4	1	4	5	3	2
4	A	4	3	3	3	4	2	3
5	A	5	3	2	3	4	3	3
6	A	5	3	3	2	2	2	5
7	A	2	3	2	3	4	4	3
8	A	4	4	2	3	3	5	2
9	A	3	1	3	3	4	4	2
10	A	3	3	4	2	4	3	3
11	A	3	3	4	4	1	3	5
12	A	3	2	4	3	3	4	3
13	A	5	5	2	3	3	3	4
14	A	4	3	4	3	3	3	3
15	A	3	5	4	2	1	1	3
16	A	3	2	3	2	2	2	5

And for a **within-subjects** design:

	A	B	C	D	E	F	G	H	I
1	Participant_ID	Version	Question_1	Question_2	Question_3	Question_4	Question_5	Question_6	Question_7
2	1	A	5	4	2	5	4	4	5
3	1	B	3	3	1	3	4	2	3
4	2	A	3	4	1	4	5	3	2
5	2	B	3	3	3	4	3	3	2
6	3	A	4	3	3	3	4	2	3
7	3	B	4	3	5	3	3	2	4
8	4	A	5	3	2	3	4	3	3
9	4	B	3	2	2	4	3	3	3
10	5	A	5	3	3	2	2	2	5
11	5	B	3	2	3	2	3	3	4
12	6	A	2	3	2	3	4	4	3
13	6	B	2	3	2	3	4	2	2
14	7	A	4	4	2	3	3	5	2
15	7	B	1	3	4	5	2	3	2
16	8	A	3	1	3	3	4	4	2
17	8	B	1	3	1	2	1	1	2

Step 2: Loading Data into R

Now that you have your data in an Excel file, you can load it into R. The easiest way to do this is to use the `read_excel()` function from the `readxl` package.

If you haven't installed the package yet, be sure to uncomment the `install.packages()` line in the code chunk below.

```r
# install.packages("readxl")
library(readxl)

likert_data_multiple_ws <- read_excel("usability_study_likert_within_subjects_data.xlsx")
```

Step 3: Creating Plots

It may be useful to create some bar graphs to show the distribution of Likert scores by version and by question.

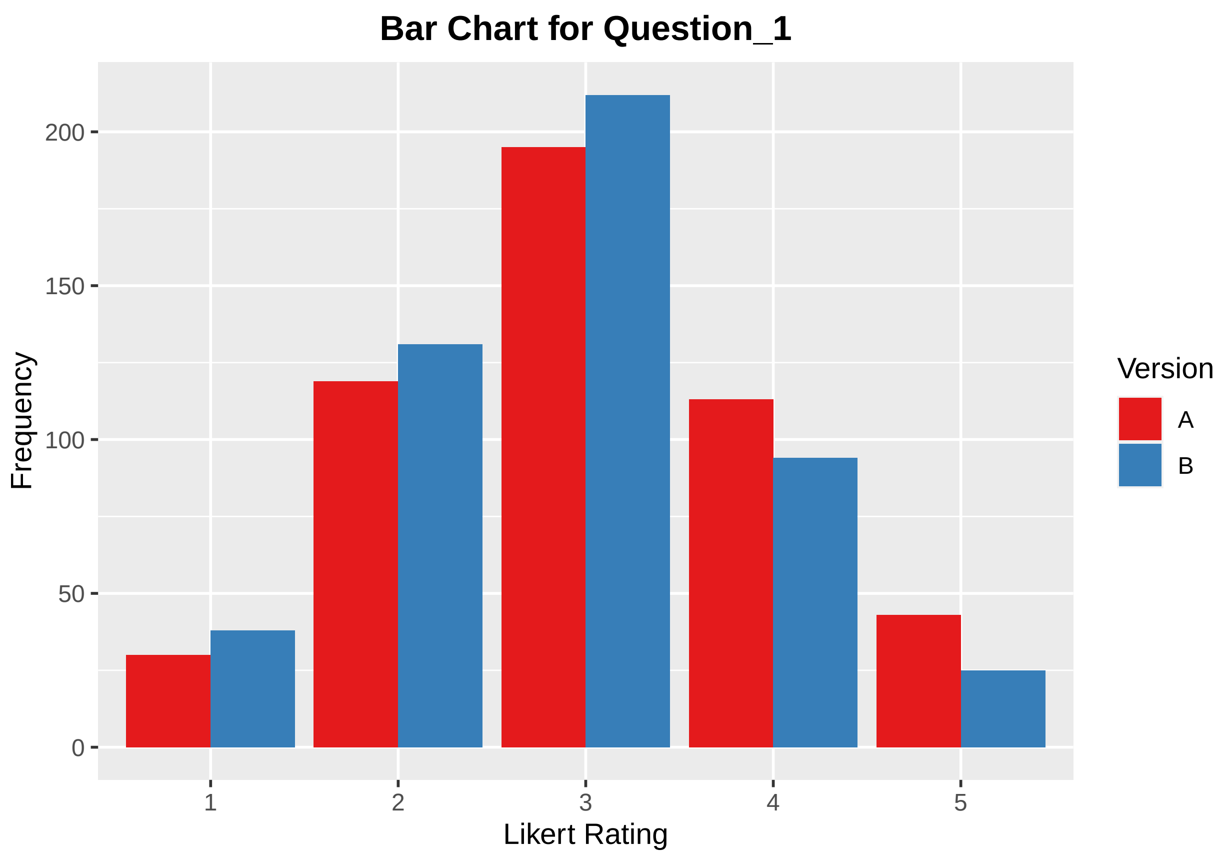
```
# install.packages("ggplot2")
# install.packages("dplyr")
library(ggplot2)
library(tidyr)

# Reshape the data to long format
data_long <- pivot_longer(likert_data_multiple_ws,
                          cols = starts_with("Question"),
                          names_to = "Question",
                          values_to = "Likert_Rating")

# Function to create a bar chart for a given question
plot_question_versions <- function(question) {
  filtered_data <- filter(data_long, Question == question)

  ggplot(filtered_data, aes(x = as.factor(Likert_Rating), fill = Version)) +
    geom_bar(position = position_dodge()) +
    scale_fill_brewer(palette = "Set1", name = "Version") +
    labs(title = paste("Bar Chart for", question),
         x = "Likert Rating",
         y = "Frequency") +
    theme(plot.title = element_text(hjust = 0.5, face = "bold"))
}

# Get unique questions
unique_questions <- unique(data_long$Question)
print(plot_question_versions(unique_questions[1]))
```



If you want to get an individual plot for each question, you can use a for loop to iterate through each question and call the `plot_question_versions()` function.

```
# Loop through each question and plot
for (question in unique_questions) {
  print(plot_question_versions(question))
}
```

Step 4: Creating Summary Statistics

You can also create summary statistics for each question and each version, such as the mean, median, standard deviation, minimum, and maximum.

```
# Compute summary statistics for each version and question
summary_stats_likert_multiple <- data_long %>%
  group_by(Question, Version) %>%
  summarize(
    Count = n(),
    Mean = mean(Likert_Rating),
    Median = median(Likert_Rating),
    Standard_Deviation = sd(Likert_Rating),
    Min = min(Likert_Rating),
    Max = max(Likert_Rating)
  )
```

```
## `summarise()` has grouped output by 'Question'. You can override using the
```

```
## `.groups` argument.
```

```r
# Print the summary statistics
options(dplyr.print_max = Inf)
print(summary_stats_likert_multiple)
```

```
## # A tibble: 40 x 8
## # Groups:   Question [20]
##    Question    Version Count  Mean Median Standard_Deviation   Min   Max
##    <chr>       <chr>   <int> <dbl>  <dbl>              <dbl> <dbl> <dbl>
##  1 Question_1  A         500  3.04      3              1.02      1     5
##  2 Question_1  B         500  2.87      3              0.970     1     5
##  3 Question_10 A         500  3.40      3              0.991     1     5
##  4 Question_10 B         500  2.54      3              1.00      1     5
##  5 Question_11 A         500  3.56      4              0.967     1     5
##  6 Question_11 B         500  2.54      2              1.03      1     5
##  7 Question_12 A         500  3.49      4              0.980     1     5
##  8 Question_12 B         500  2.43      2              1.00      1     5
##  9 Question_13 A         500  3.51      3              0.984     1     5
## 10 Question_13 B         500  2.39      2              0.967     1     5
## 11 Question_14 A         500  3.66      4              0.935     1     5
## 12 Question_14 B         500  2.38      2              0.952     1     5
## 13 Question_15 A         500  3.76      4              0.898     1     5
## 14 Question_15 B         500  2.30      2              0.926     1     5
## 15 Question_16 A         500  3.73      4              0.978     1     5
## 16 Question_16 B         500  2.28      2              0.931     1     5
## 17 Question_17 A         500  3.94      4              0.901     1     5
## 18 Question_17 B         500  2.23      2              0.954     1     5
## 19 Question_18 A         500  3.75      4              0.971     1     5
## 20 Question_18 B         500  2.19      2              0.943     1     5
## 21 Question_19 A         500  3.89      4              0.903     1     5
## 22 Question_19 B         500  2.08      2              0.898     1     5
## 23 Question_2  A         500  3.15      3              0.978     1     5
## 24 Question_2  B         500  2.89      3              1.00      1     5
## 25 Question_20 A         500  3.99      4              0.878     1     5
## 26 Question_20 B         500  2.1       2              0.919     1     5
## 27 Question_3  A         500  3.14      3              1.01      1     5
## 28 Question_3  B         500  2.8       3              0.966     1     5
## 29 Question_4  A         500  3.12      3              1.00      1     5
## 30 Question_4  B         500  2.78      3              1.03      1     5
## 31 Question_5  A         500  3.22      3              1.02      1     5
## 32 Question_5  B         500  2.8       3              1.00      1     5
## 33 Question_6  A         500  3.26      3              0.990     1     5
## 34 Question_6  B         500  2.70      3              0.960     1     5
## 35 Question_7  A         500  3.31      3              1.04      1     5
## 36 Question_7  B         500  2.70      3              0.970     1     5
## 37 Question_8  A         500  3.33      3              0.967     1     5
## 38 Question_8  B         500  2.57      3              0.994     1     5
## 39 Question_9  A         500  3.39      3              0.975     1     5
## 40 Question_9  B         500  2.57      3              0.977     1     5
```

Step 5: Running Statistical Tests

The statistical test you run depends on the experimental design you used. For within-subjects design, you should use the Wilcoxon signed rank test. For between-subjects design, you should use the Wilcoxon rank sum test.

The Wilcoxon signed ranked test is a non-parametric test that compares two related samples. The Wilcoxon rank sum test (a.k.a. the Mean-Whitney U test) is a non-parametric test that compares two independent samples. These tests are non-parametric tests–used when the data is not normally distributed or when the sample size is small. Such is the case with Likert scale data.

Within-subjects:

```
# Initializing a dataframe to store the results
test_results <- data.frame(Question = character(),
                           Wilcoxon_Statistic = numeric(),
                           P_Value = numeric(),
                           stringsAsFactors = FALSE)

data_wide <- data_long %>%
  pivot_wider(names_from = Version, values_from = Likert_Rating)

# Looping through each question to perform the test
for (q in unique(data_long$Question)) {
  # Extracting the paired responses for each version
  responses <- filter(data_wide, Question == q)

  # Performing the Wilcoxon signed-rank test
  test <- wilcox.test(responses$`A`, responses$`B`, paired = TRUE)

  # Storing the results
  test_results <- rbind(test_results,
                        data.frame(Question = q,
                                   Wilcoxon_Statistic = test$statistic,
                                   P_Value = test$p.value))
}

# Displaying the test results
print(test_results)
```

```
##         Question Wilcoxon_Statistic      P_Value
## V     Question_1            35867.0 1.757328e-02
## V1    Question_2            39954.5 1.007498e-04
## V2    Question_3            45495.0 7.592614e-08
## V3    Question_4            44448.0 7.418933e-07
## V4    Question_5            41782.0 8.047282e-11
## V5    Question_6            50335.0 1.671821e-16
## V6    Question_7            50244.5 2.395226e-20
## V7    Question_8            58378.0 5.517323e-27
## V8    Question_9            56533.0 1.509075e-30
## V9   Question_10            66626.0 5.275079e-31
## V10  Question_11            69713.5 8.375511e-39
## V11  Question_12            67279.5 2.602166e-41
## V12  Question_13            73528.5 9.147343e-43
## V13  Question_14            76277.5 6.002662e-53
```

```
## V14 Question_15            81107.0 8.814582e-60
## V15 Question_16            84973.0 8.156181e-58
## V16 Question_17            92695.0 3.100225e-68
## V17 Question_18            92430.5 2.289302e-62
## V18 Question_19            94250.5 2.055136e-69
## V19 Question_20            98981.0 4.808506e-72
```

For a **between-subjects** design, you can use the Wilcoxon rank sum test. See the GitHub page for more information.