Study Report: Impact of Hand Dominance on Pointing Performance in WebFit
CS545-A HCI Assignment 1 Group Team 9

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Introduction

The primary objective of this study was to examine the effects of hand dominance on pointing performance within the WebFit platform. Hand dominance, the preference for using one hand over the other, is known to affect fine motor skills. To investigate this phenomenon, we adopted a within-subjects design and randomly selected four participants. This approach eliminates potential participant bias and enhances the study's objectivity.

Participants

Sample Size and Selection
The study involved five participants, all randomly selected to ensure impartiality and minimize potential participant bias. This approach aimed to enhance the study's objectivity and reduce the impact of any pre-existing hand dominance preferences.

Randomized Ages
To maintain the randomness of participant selection, the study included participants with diverse ages, selected randomly. The age range of the participants is as follows:

Participant 0: 27 years old
Participant 1: 29 years old
Participant 2: 35 years old
Participant 3: 27 years old
Participant 4: 38 years old

Monitoring and Support
Throughout the study, participants were closely monitored and provided with support over the Discord platform. This approach was implemented to ensure that participants fully understood the tasks and what was expected of them. By offering guidance and clarifications, the monitoring process aimed to reduce potential sources of error and enhance the reliability of the collected data.

STUDY DESIGN

Tasks:
Participants were presented with a series of pointing tasks on the WebFit platform. These tasks were designed to evaluate their pointing performance with both their dominant and non-dominant hands.
Each participant completed a set of tasks with their dominant hand and then with their non-dominant hand. The tasks included selecting targets of varying sizes and distances on the WebFit interface.

Study Setting:
The study was conducted in a controlled environment to minimize external factors that could affect performance. All participants used modern web browsers (e.g., Chrome, Safari, Opera) on their respective Mac, Windows, or Linux computers to access the WebFit platform.

Data Collection:
Upon completing each session (one with the dominant hand and one with the non-dominant hand), the WebFit platform automatically initiated the download of a zip file containing log files for that session. The log files were in CSV (comma-separated values) format, allowing for easy analysis using spreadsheet programs and python.

Study Duration:
On average, it took each participant approximately 10 minutes to complete all the tasks with both their dominant and non-dominant hands.

STUDY RESULTS

Descriptive Statistics:
Average completion time and error rates for each participant were calculated for both dominant and non-dominant hand conditions.
Graphs were created to visualize these results, showing how performance metrics varied across different blocks and conditions.
Analysis revealed trends, differences, or patterns in completion time and error rates between the dominant and non-dominant hands.

1. T-Tests
Completion Time (ms)
A t-test was conducted to compare the "Completion Time (ms)" between conditions C1 and C2.
The t-test result for "Completion Time (ms)" is statistically significant (p-value = 1.9929947472919306e-28).
This suggests a significant difference in "Completion Time (ms)" between C1 and C2.

Error Rate

Another t-test was performed to compare the "Error Rate" between conditions C1 and C2. The t-test result for "Error Rate" is not statistically significant (p-value = 0.21627172303773398).
There is no significant difference in "Error Rate" between C1 and C2.

2. One-Way ANOVA

A one-way ANOVA was used to examine the "Completion Time (ms)" across multiple conditions.
The ANOVA result is statistically significant (p-value < 0.05).
This indicates a significant difference between at least two conditions within the study.

3. Two-Way ANOVA

A two-way ANOVA was performed to investigate the interaction between "Hand" and "Session" in relation to "Completion Time (ms)."
The ANOVA table shows that the "Hand" factor has a highly significant effect on "Completion Time."
However, the interaction between "Hand" and "Session" does not significantly impact "Completion Time."

4. Post-Hoc Testing and Shapiros Wilk Testing for Normality

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2-way ANOVA for completion time within hand and sessions:
                                 sum_sq    df             F       PR(>F)
Hand_Dominance                2.275703e+06   1.0   107.394809   7.776698e-14
Session_Code                  7.273357e+04   5.0     0.686488   6.359744e-01
Hand_Dominance:Session_Code   5.246979e+04   5.0     0.495230   7.782046e-01
Residual                      1.017123e+06  48.0          NaN          NaN
Tukey's HSD post-hoc test:
     Multiple Comparison of Means - Tukey HSD, FWER=0.05
==========================================================
 group1     group2    meandiff p-adj  lower    upper    reject
----------------------------------------------------------------
Dominant Non-Dominant 420.7317   0.0 342.7683 498.6951    True
----------------------------------------------------------------
Shapiro-Wilk Test for normality:
(1.6138910543269205, 0.00033842520061808286)
2-way ANOVA for log-transformed completion time within hand and sessions:
                                 sum_sq   df          F       PR(>F)
Hand_Dominance                2.471246   1.0  62.975018   2.754708e-10
Session_Code                  0.118471   5.0   0.603801   6.972384e-01
Hand_Dominance:Session_Code   0.074009   5.0   0.377196   8.618830e-01
Residual                      1.883601  48.0        NaN          NaN
```

This output represents the results of a 2-way ANOVA (Analysis of Variance) for completion time, analyzing the impact of two categorical factors: "Hand Dominance" and "Session Code." The purpose of this analysis is to determine whether these two factors, and their interaction, have a significant effect on the mean completion time.

1. **Hand Dominance Factor (Main Effect)**:
   - The sum of squares (sum_sq) associated with the "Hand Dominance" factor is 2.275703e+06.
   - The degrees of freedom (df) for this factor are 1.
   - The F-statistic (F) is 107.394809.
   - The p-value (PR(>F)) is very small (7.776698e-14), which is less than the significance level (typically 0.05). Therefore, there is a significant main effect of "Hand Dominance" on completion time**. This indicates that the hand dominance (dominant or non-dominant) significantly affects the mean completion time.**

2. **Session Code Factor (Main Effect)**:
   - The sum of squares (sum_sq) associated with the "Session Code" factor is 7.273357e+04.
   - The degrees of freedom (df) for this factor are 5.
   - The F-statistic (F) is 0.686488.
   - The p-value (PR(>F)) is relatively large (0.6359744), which is greater than the typical significance level of 0.05. Therefore, there is no significant main effect of "Session Code" on completion time. **This suggests that session codes do not significantly affect the mean completion time.**

3. **Interaction Effect Between Hand Dominance and Session Code (Interaction Term)**:
   - The sum of squares (sum_sq) associated with the interaction term between "Hand Dominance" and "Session Code" is 5.246979e+04.
   - The degrees of freedom (df) for this interaction term are 5.
   - The F-statistic (F) is 0.495230.
   - The p-value (PR(>F)) is relatively large (0.7782046), which is greater than the typical significance level of 0.05. Therefore, there is no significant interaction effect between "Hand Dominance" and "Session Code" on completion time. **This indicates that the combined effect of hand dominance and session code does not significantly affect the mean completion time.**

4. **Residual (Error)**:
   - The sum of squares (sum_sq) for the residuals, representing unexplained variability, is 1.017123e+06.
   - The degrees of freedom (df) for the residuals are 48.

The "Tukey's HSD post-hoc test" is used to compare group means, in this case, "Dominant" and "Non-Dominant." It shows that there is a statistically significant difference between the mean completion times of these two groups because the "reject" column is marked as "True."

The "Shapiro-Wilk Test for normality" is used to check the normality of the residuals. It returns a test statistic (1.613891) and a p-value (0.0003384). A low p-value (typically less than 0.05) suggests that the residuals are not normally distributed.

Finally, the analysis is repeated with log-transformed completion times. The results show that log-transformed data provides similar conclusions, with a significant main effect of "Hand Dominance" and no significant effect of "Session Code" or their interaction on the completion time.

In summary, this ANOVA analysis indicates that "Hand Dominance" significantly affects completion time, but "Session Code" and the interaction between these two factors do not.

5. Visualizations

Several visualizations were created to explore and present the study findings.
These include line plots comparing "Average Completion Time" and "Error Rate" for each session and participant, as well as box plots to compare variances in "Completion Time." These results provide valuable insights into the study, indicating differences in "Completion Time" between conditions and the impact of different factors on this metric. Additionally, the visualizations offer a clear representation of the data, making it easier to interpret and communicate the study outcomes.

C1 = Dominant hand was used for the test
C2 = Non-Dominant Hand was used for the test

Average Completion Time by Condition Code (Hand Dominance)
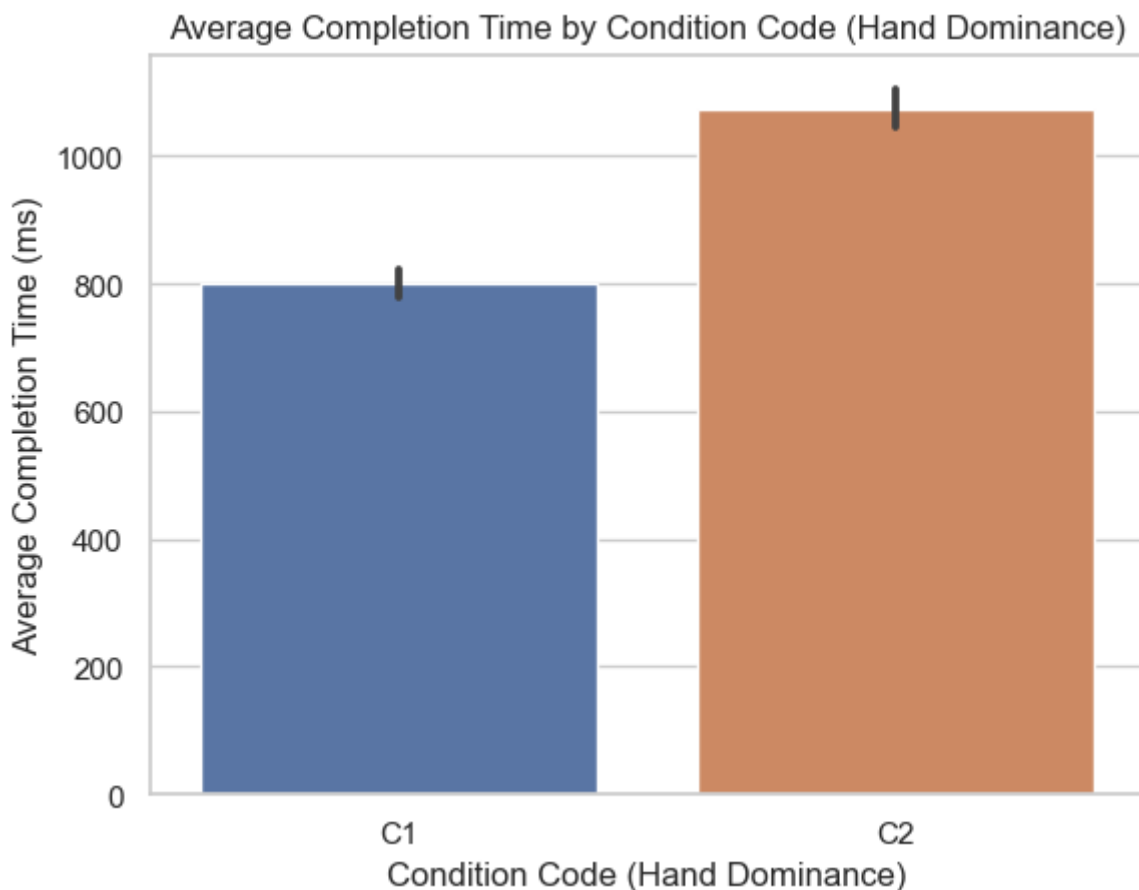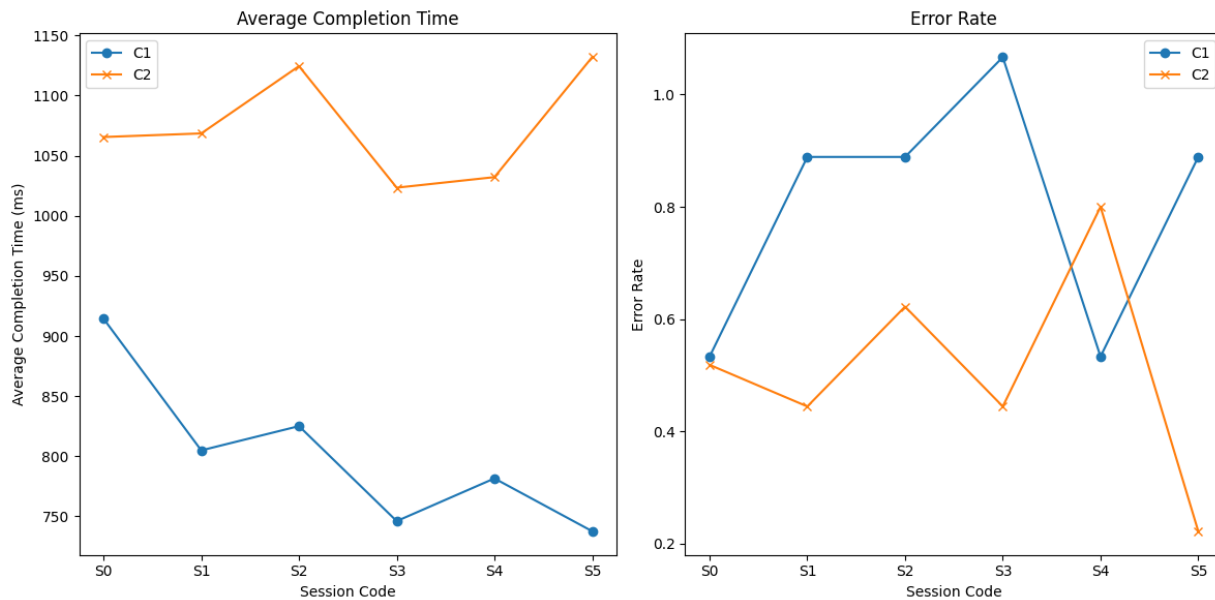
The Average Completion time for all the 4 participants was plotted for both conditions c1 and c2 for each attempt and It was seen generally the participants did better with their dominant hand.
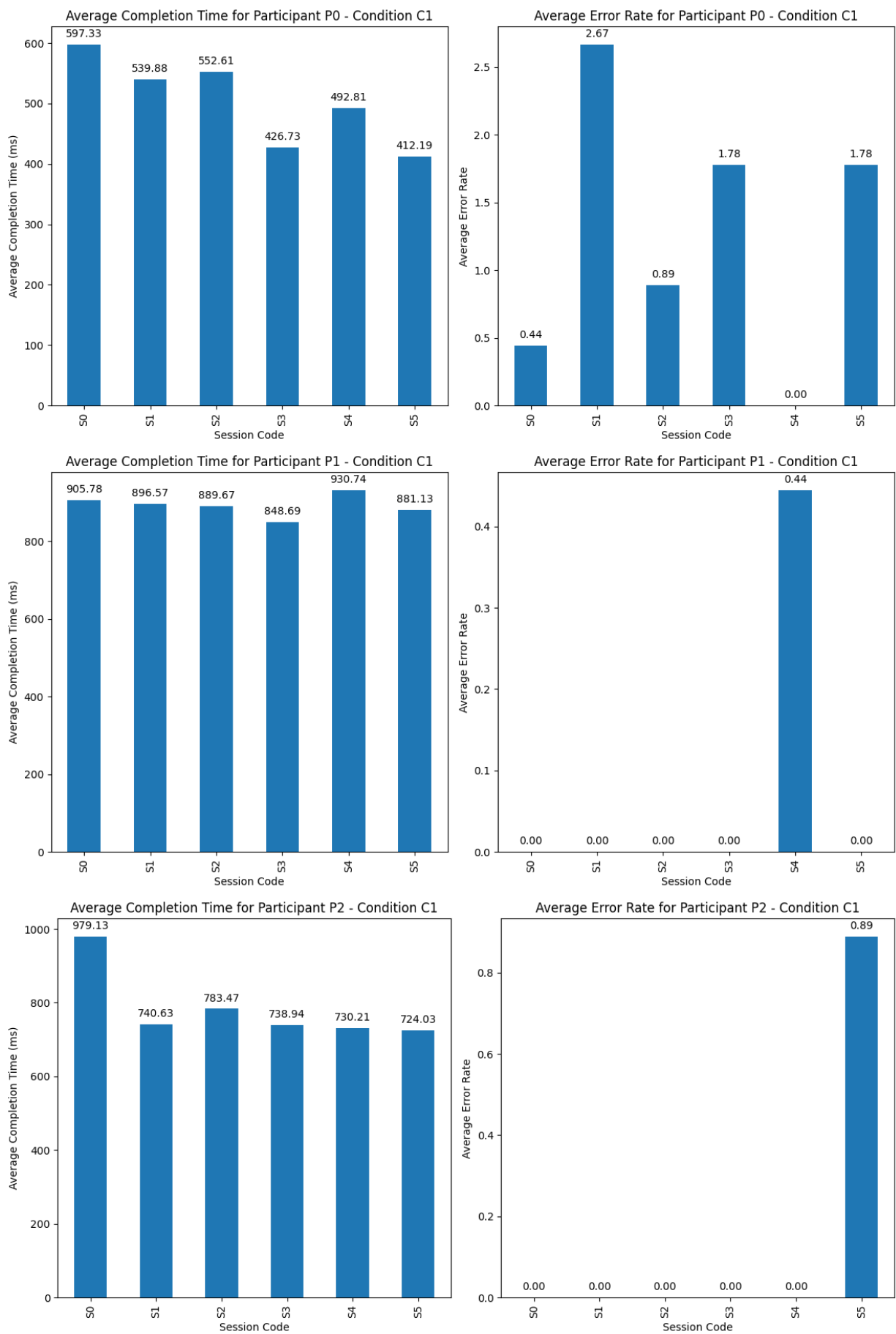

Here we See in the swarm plot of completion time by condition which is color coded for each participant that mostly all participants with their dominant hand had a completion time close to the median or average completion time whereas with their non dominant hand generally all participants were taking significantly more time to complete the task.

Variance of Completion Time by Participant for Each Condition
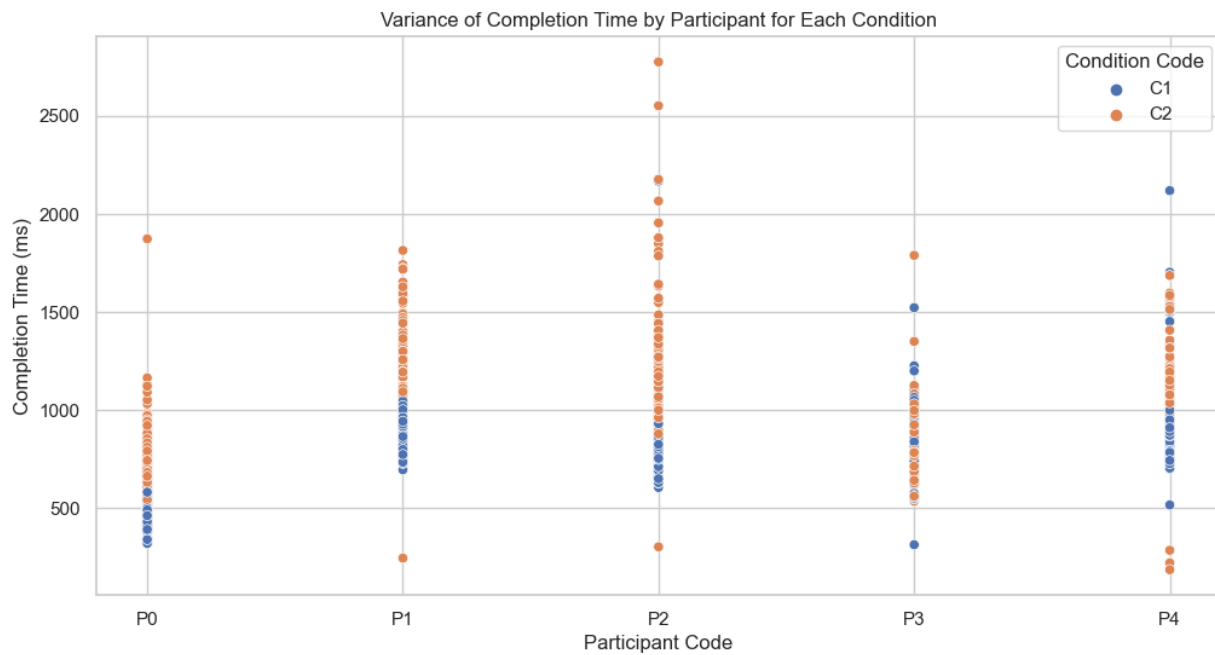
In the scatted plot above for each participant we clearly see using their dominant hand was the generally the most quicker and better option amongst the participants.

Only for P3 we notice a huge overlap which indicated the sample size chosen for the research needs more people to notice the trend or pattern possibly for ambidextrous users who are equally good with both hands for a given task.
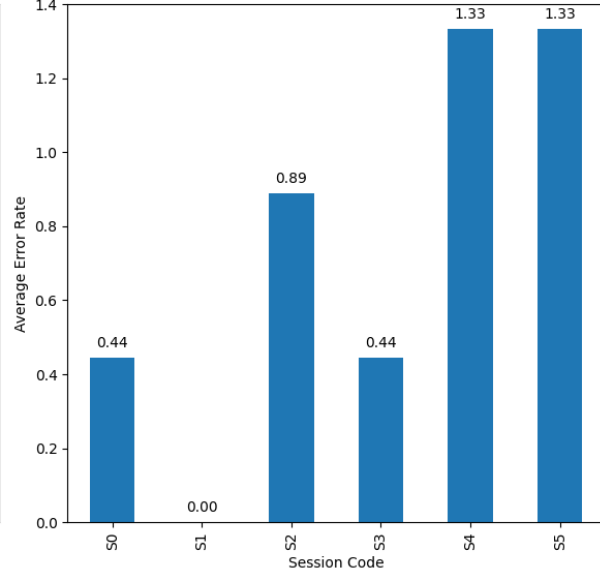
The Average Completion time in ms for each Participant with his dominant hand along with error rates of each session
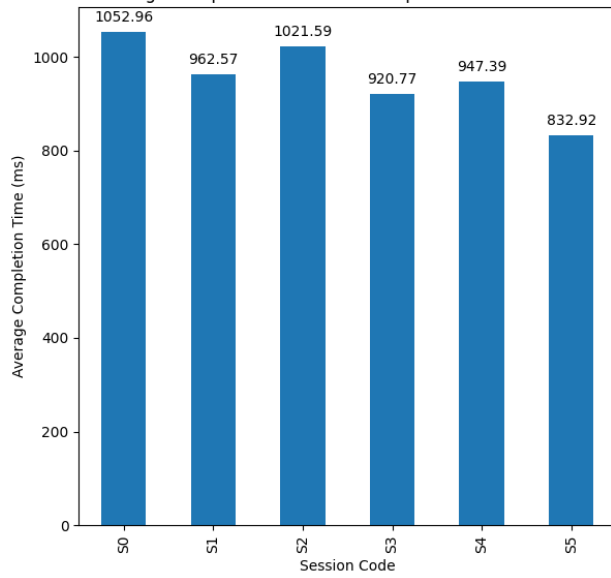

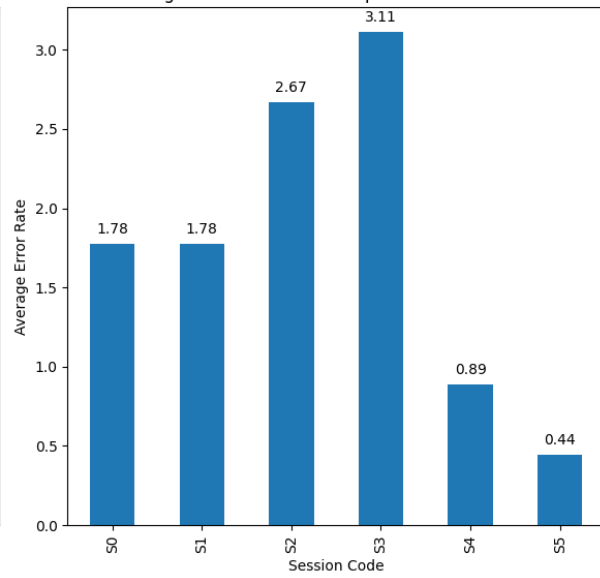Average Completion Time for Participant P0 - Condition C1

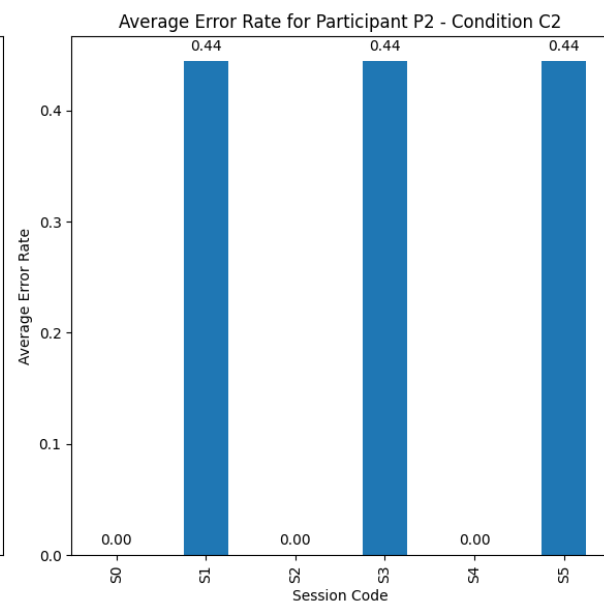Average Error Rate for Participant P0 - Condition C1

Average Completion Time for Participant P1 - Condition C1

Average Error Rate for Participant P1 - Condition C1

Average Completion Time for Participant P2 - Condition C1
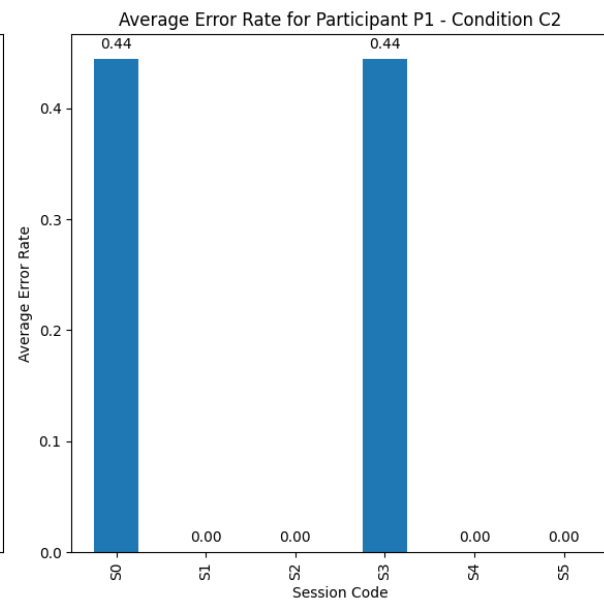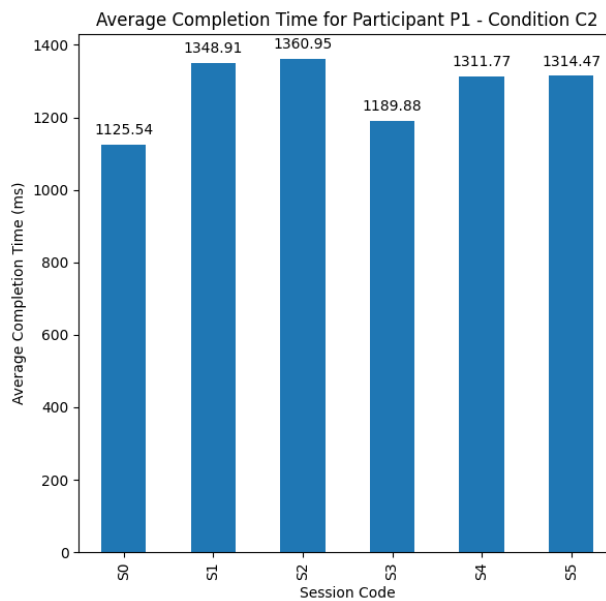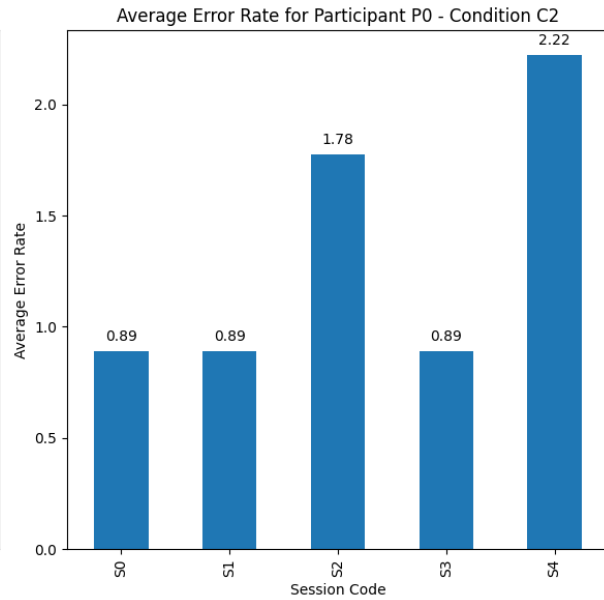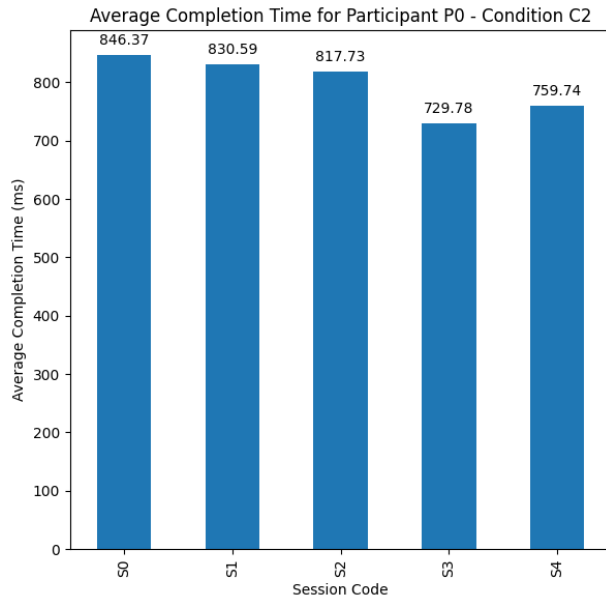
Average Error Rate for Participant P2 - Condition C1

Average Completion Time for Participant P3 - Condition C1

Session Code	Average Completion Time (ms)
S0	1036.91
S1	884.77
S2	877.99
S3	795.21
S4	806.67
S5	838.01

Average Error Rate for Participant P3 - Condition C1

Session Code	Average Error Rate
S0	0.44
S1	0.00
S2	0.89
S3	0.44
S4	1.33
S5	1.33

Average Completion Time for Participant P4 - Condition C1

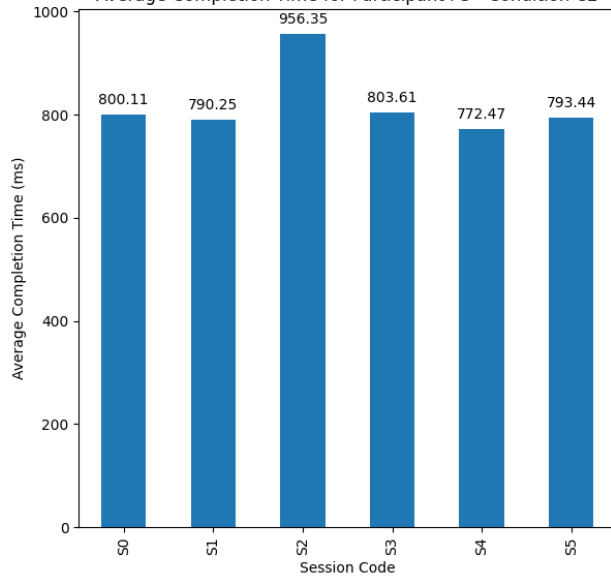| Session Code	Average Completion Time (ms)
S0	1052.96
S1	962.57
S2	1021.59
S3	920.77
S4	947.39
S5	832.92

Average Error Rate for Participant P4 - Condition C1

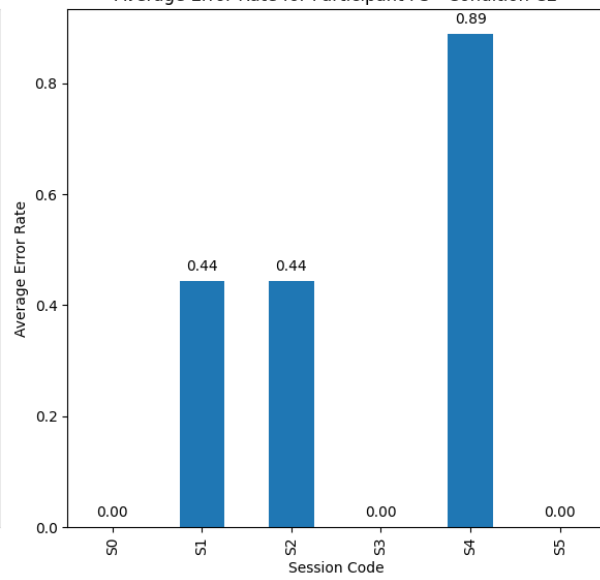| Session Code	Average Error Rate
S0	1.78
S1	1.78
S2	2.67
S3	3.11
S4	0.89
S5	0.44

Average Completion Time in ms for all Participants with non dominant hand

| Average Completion Time for Participant P0 - Condition C2	Average Error Rate for Participant P0 - Condition C2
S0: 846.37, S1: 830.59, S2: 817.73, S3: 729.78, S4: 759.74	S0: 0.89, S1: 0.89, S2: 1.78, S3: 0.89, S4: 2.22
Average Completion Time for Participant P1 - Condition C2	Average Error Rate for Participant P1 - Condition C2
S0: 1125.54, S1: 1348.91, S2: 1360.95, S3: 1189.88, S4: 1311.77, S5: 1314.47	S0: 0.44, S1: 0.00, S2: 0.00, S3: 0.44, S4: 0.00, S5: 0.00
Average Completion Time for Participant P2 - Condition C2	Average Error Rate for Participant P2 - Condition C2
S0: 1286.42, S1: 1252.09, S2: 1382.42, S3: 1237.64, S4: 1258.95, S5: 1145.07	S0: 0.00, S1: 0.44, S2: 0.00, S3: 0.44, S4: 0.00, S5: 0.44

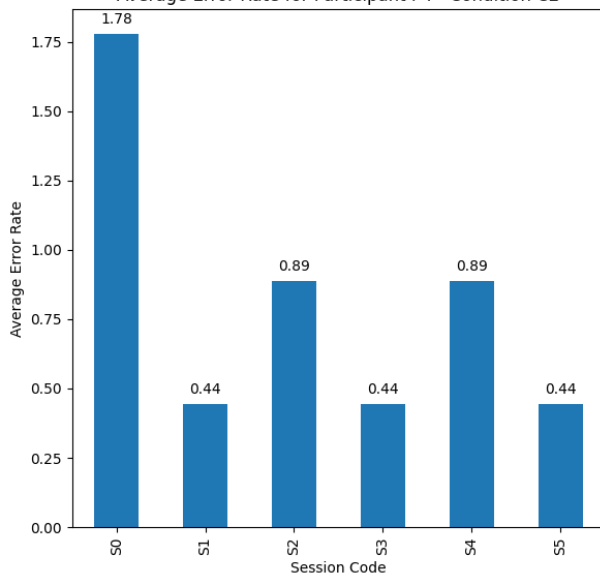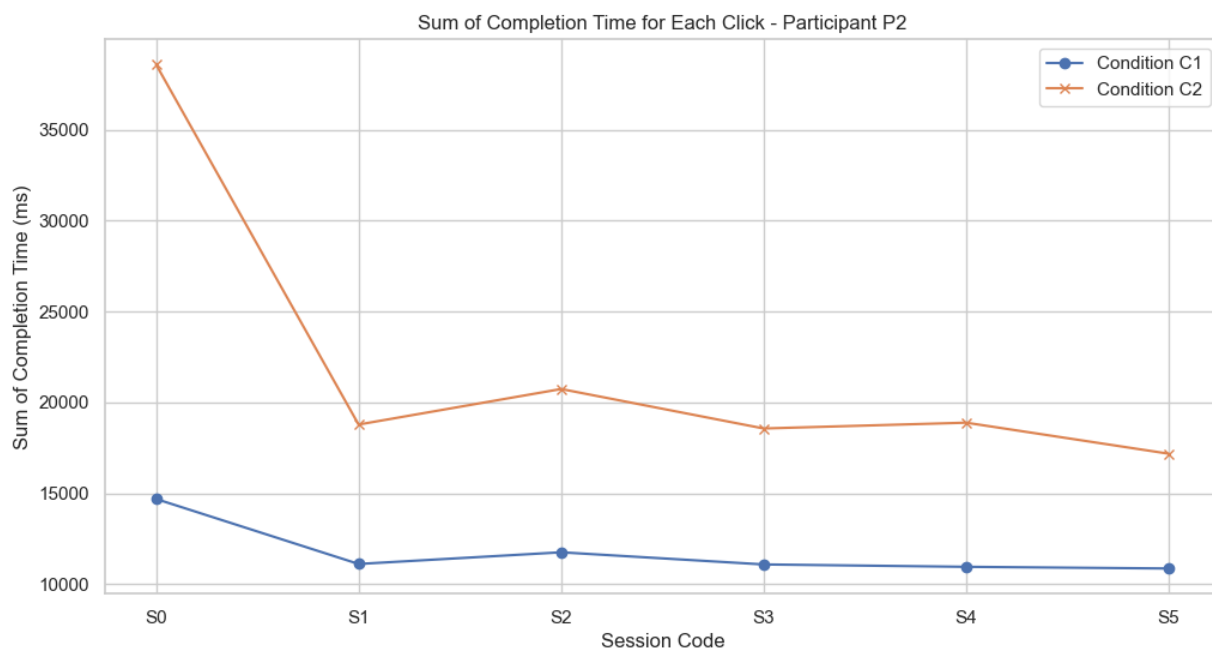Average Completion Time for Participant P3 - Condition C2 | Average Error Rate for Participant P3 - Condition C2
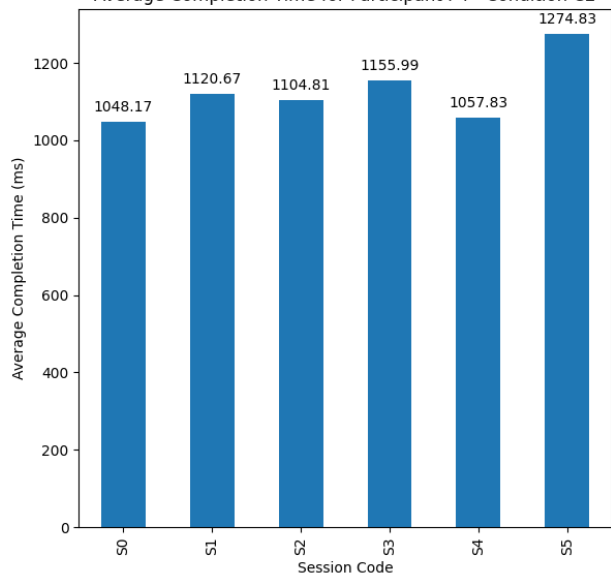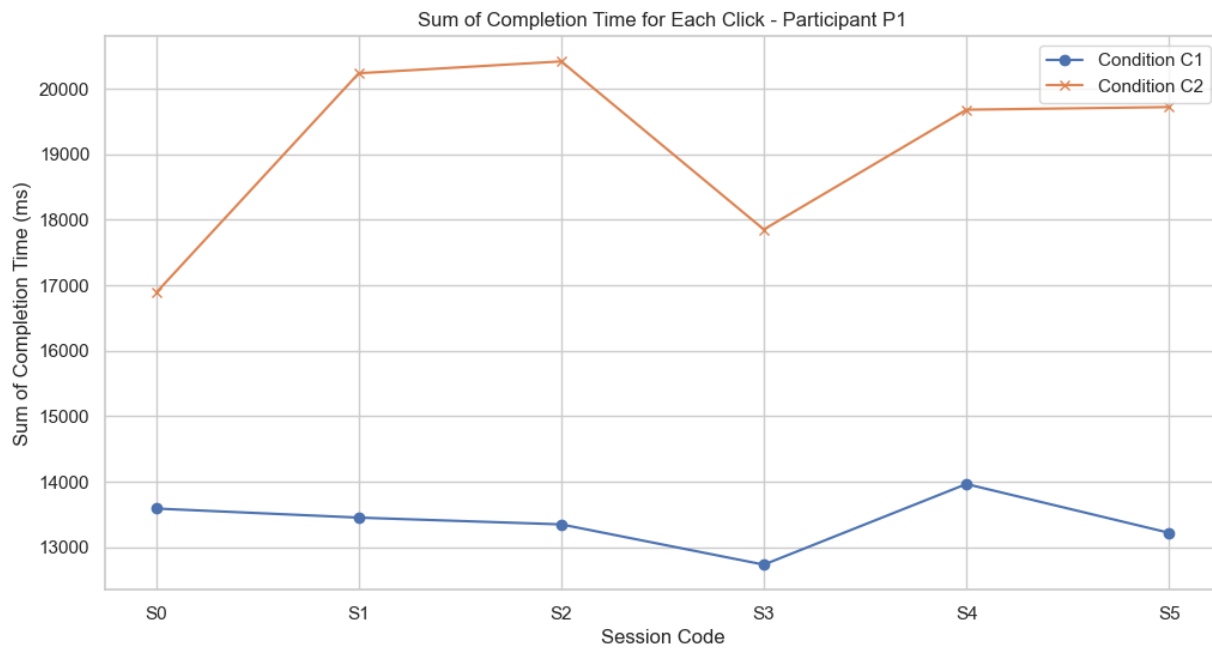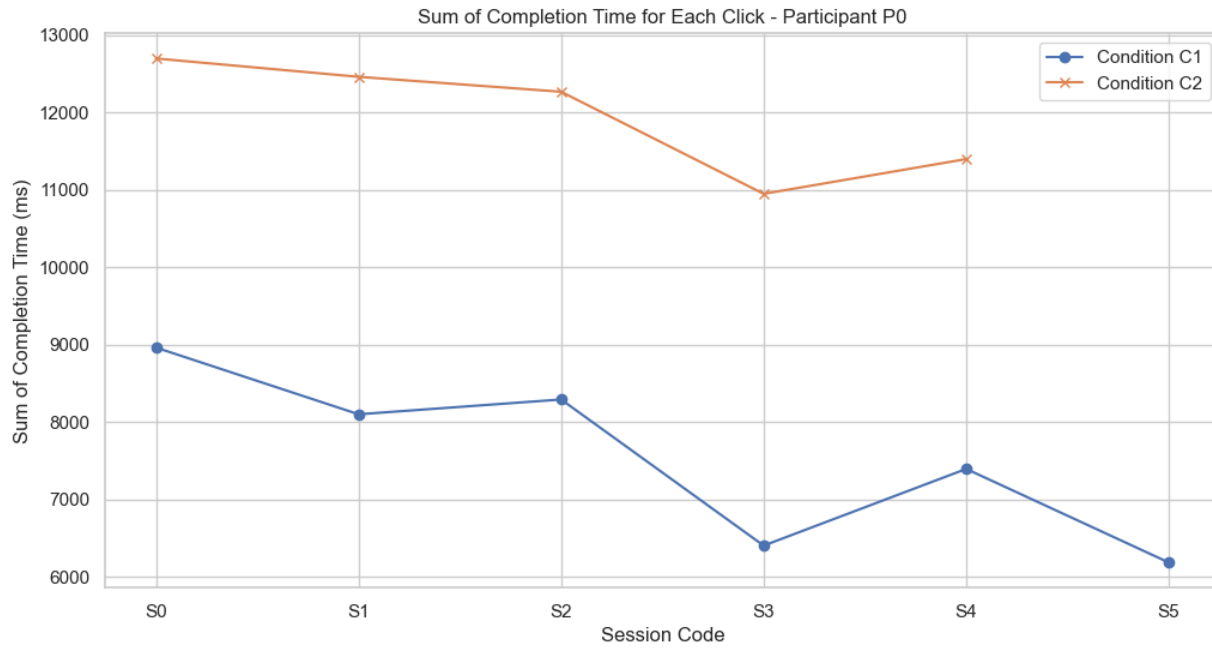
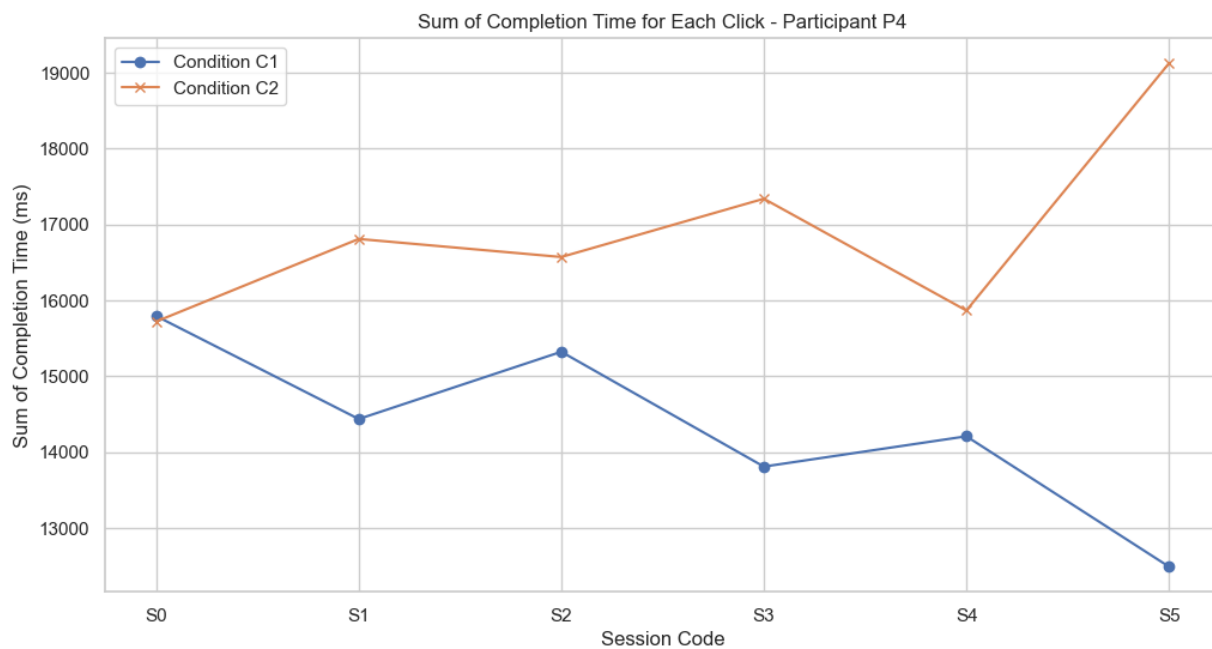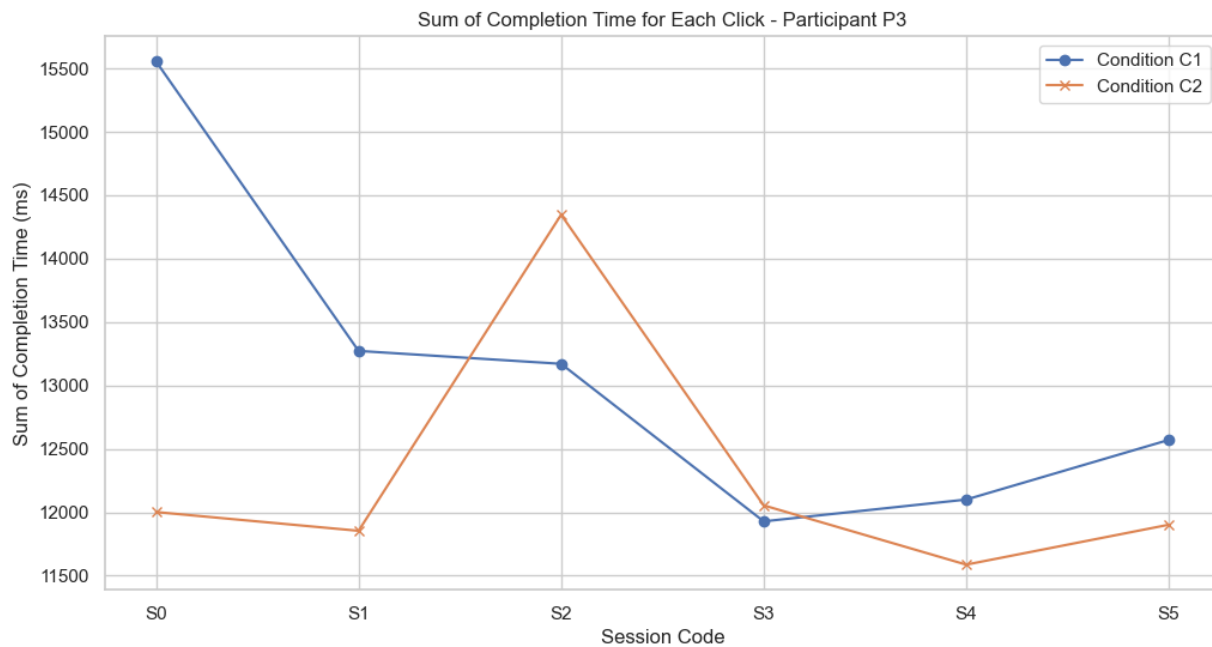Average Completion Time for Participant P4 - Condition C2 | Average Error Rate for Participant P4 - Condition C2

Total time taken by participants for each session attemp with both dominant and non dominant hand

Sum of Completion Time for Each Click - Participant P0

Sum of Completion Time for Each Click - Participant P1

Sum of Completion Time for Each Click - Participant P2

Sum of Completion Time for Each Click - Participant P3

Sum of Completion Time for Each Click - Participant P4

Across all 5 participants we notice that the overall time taken using dominant hand is generally less as compared to the overall time taken with their non dominant hand.

Only for participant P3 we noticed that their average completion time got almost equal if not better with their non dominant hand with more sessions indicating the possibility of an ambidextrous user.

REFLECTION

Conducting this study as a team of two has been an enlightening experience. We faced challenges in participant recruitment, ensuring a diverse pool of participants from different demographics. However, the study's core goal, which is to investigate the impact of hand dominance on pointing performance in the WebFit platform, remained a fascinating subject of exploration. Working in a controlled environment provided a structured approach to data collection, and using contemporary web browsers and technology streamlined the process. The diversity among our participants enriched the study's findings and clearly indicated that there is a possibility of ambidextrous users and the research requires a much larger audience to solidify the findings. In conclusion, collaborating on this research has been intellectually stimulating and rewarding, despite the inherent challenges.