STATISTICAL METHODS IN RESEARCH

# Analysis of How Stress Patterns Define Human Experience and Performance in Dexterous Tasks

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Suchismitha Vedala
Lavanya Rao
Yashwanth Reddy Venati

# Contents

# INTRODUCTION

The Microsurgery performance data represents the performance of 22 medical students in microsurgery activities. The 22 medical students or subjects in our analysis, participated in a longitudinal study regarding the relationship of sympathetic arousal and skill in learning micro-surgical tasks. The subjects had to pay five visits which we regard as sessions, lasting one hour each, in order to practice micro-surgical cutting and suturing in an inanimate simulator.A pre and post study questionnaire was also given to be completed by the subjects to know a little about their biography and anxiety.

During the main part of each session, the subjects underwent the following treatments:
1.Baseline: The subjects were relaxing for 5 min, listening to spa music. They were facially recorded by a thermal and visual camera.
2.Cutting: The subjects had to precision cutting in the inanimate simulator. They were facially recorded by a thermal and visual camera.
3.Suturing: The subjects had to perform suturing in the inanimate simulator. They were facially recorded by a thermal and visual camera.

Explicit accuracy scores per task is provided in the data. Hence, the cutting task has its own accuracy scores and so is the case with the suturing task. The perspiration values are recorded in all time frames for all subjects and sessions. The subjects were asked to fill out a NASA-TLX questionnaire after each task. he NASA-TLX instrument features five subscales measuring different aspects of the subjects' perceptions regarding task difficulty.We perform an analysis with this given data.

# Initial Analysis

## Biographic Data

We draw a bar plot to see how gender defines data and histogram to see whether age has any effect on the data.

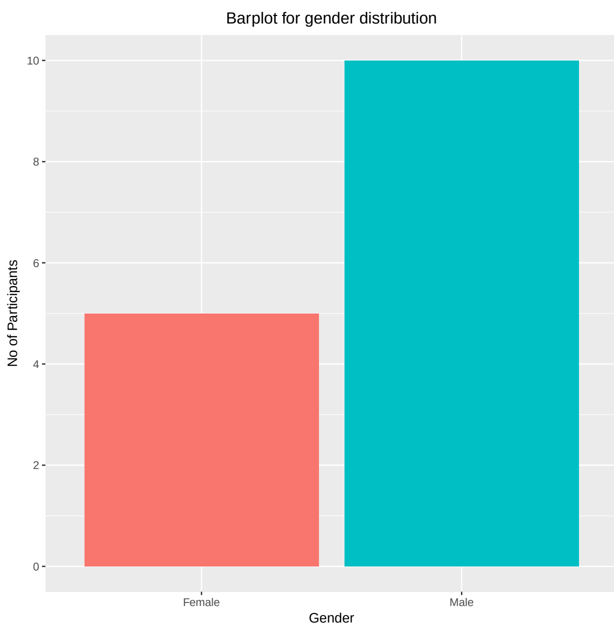


**Figure 1:** Barplot of Gender Distribution

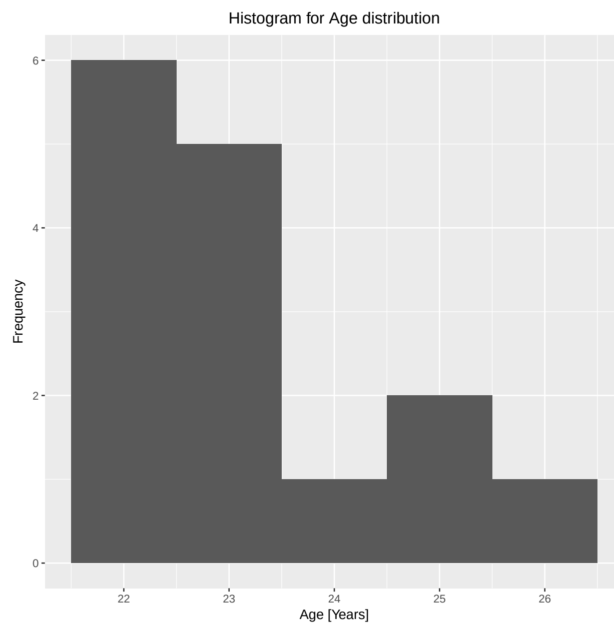


**Figure 2:** Histogram of age distribution

## Trait Psychometric Data

We draw the histogram for Trait Anxiety Inventory(TAI) scores

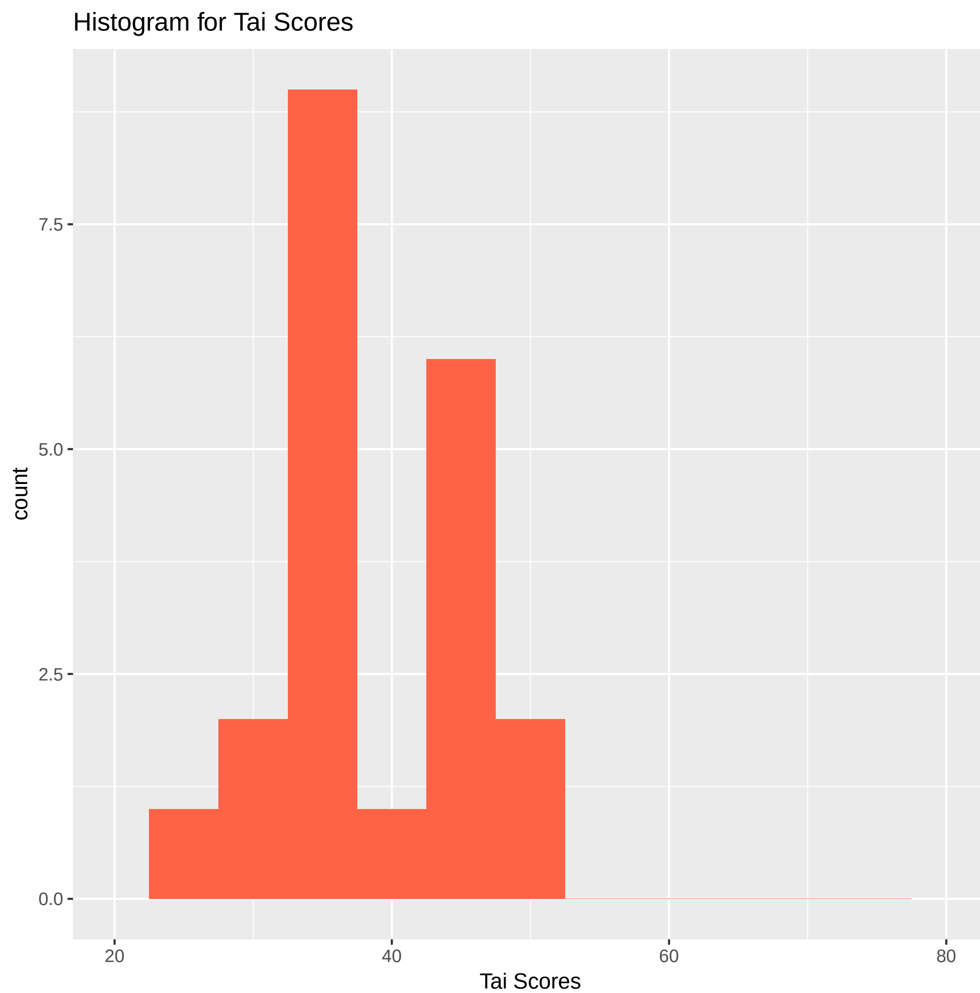


**Figure 3:** Histogram of Tai Scores

## State Psychometric Data

For each subject draw the bar plots for all the NASA-TLX subscales per task. This will give two figures per subject per subscale, one for suturing and one for cutting, where the evolution of the scores from the initial to the final session will be evident.

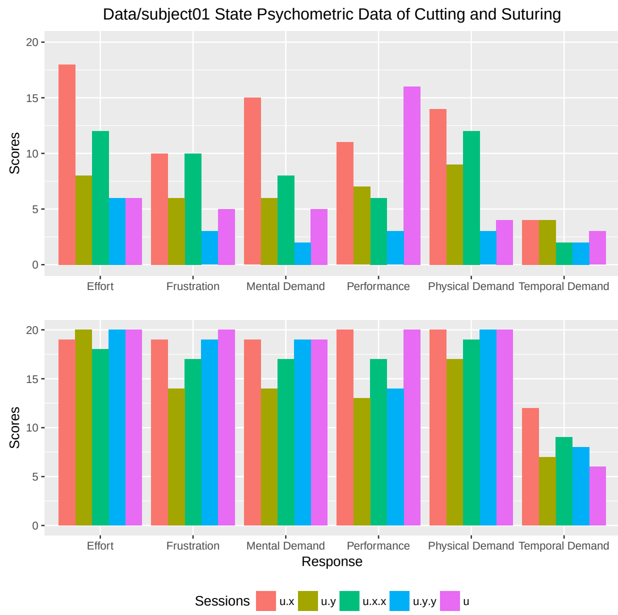


**Figure 4:** Subject 1

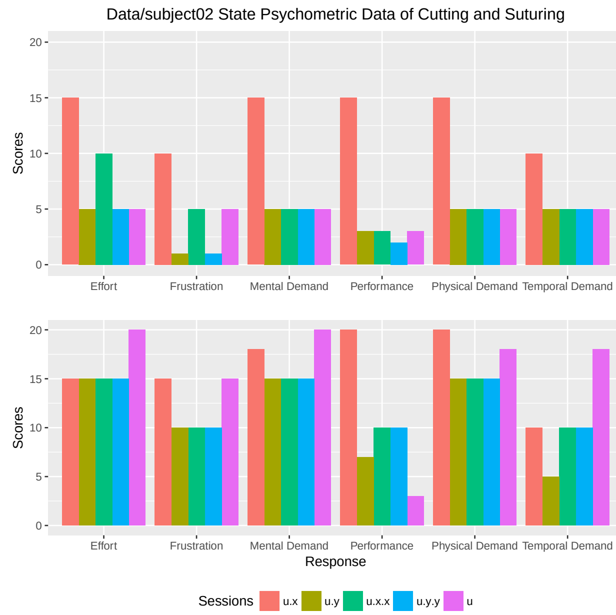


**Figure 5:** Subject 2

## Perinasal Perspiration (Stress) Signal Data

For each session of each subject we draw the perspiration values using black for baseline, green for cutting, and red for suturing.

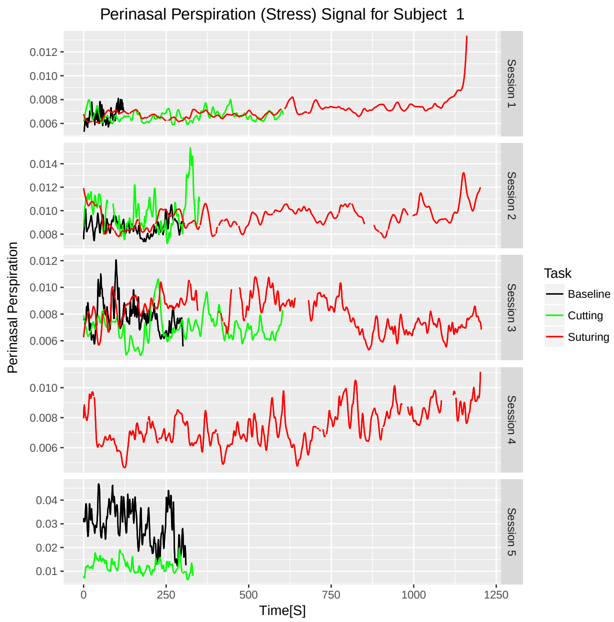


**Figure 6:** Subject 1

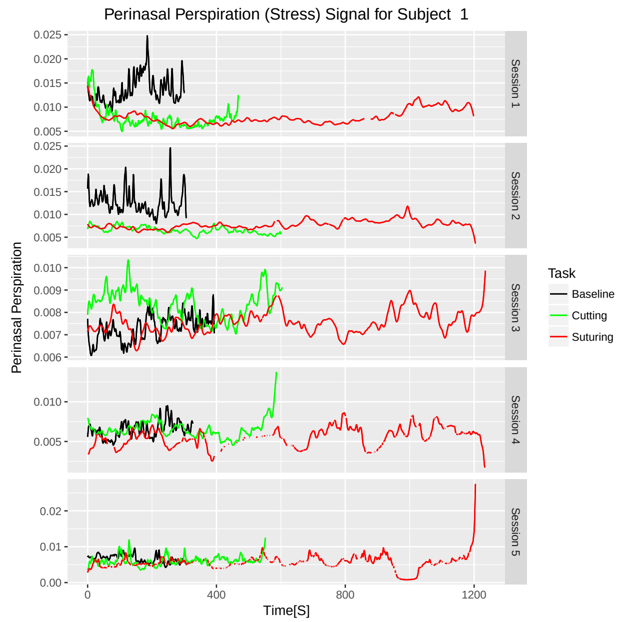


**Figure 7:** Subject 2

## Performance Data

We draw the accuracy and time bar plots of each subject for each session and each task.

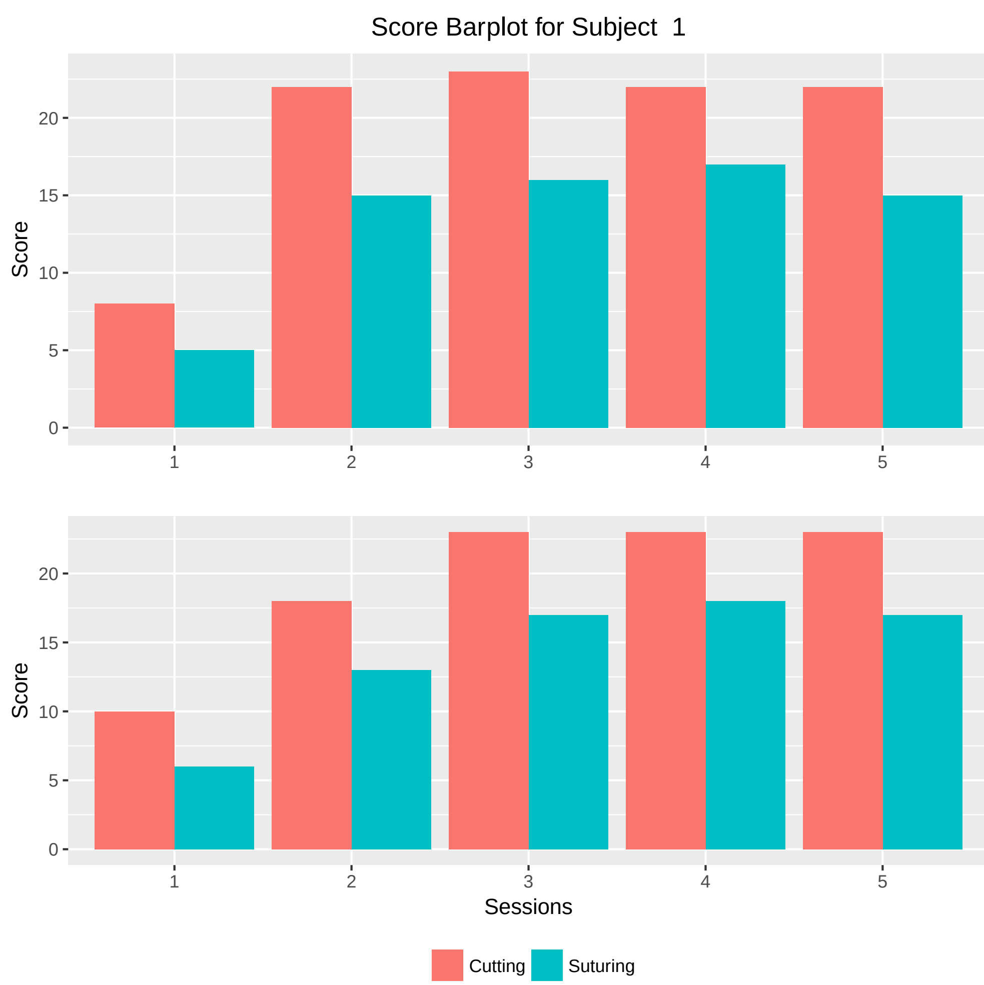


**Figure 8:** Subject 1 Score Barplot

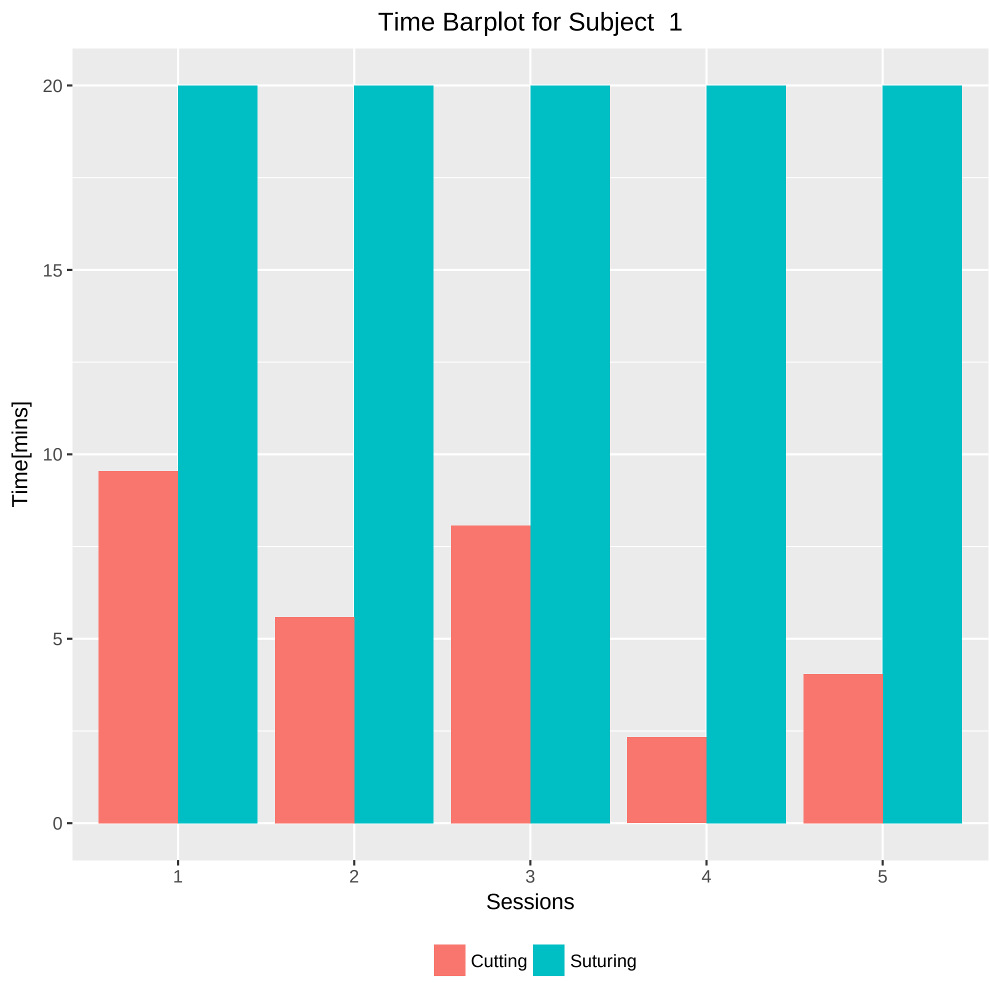


**Figure 9:** Subject 1 Time Barplot

# HYPOTHESIS TESTING

We normalize the perspiration values and perform the log of the values for our analysis.

## 1. Analysis of effect of each attribute on Score

**Hypothesis**:
$Null Hypothesis : H_0$ = The score obtained does not depend on the demographics of the subject , session , age , year , sex and perspiration.
$Alternate Hypothesis : H_1$ = The score obtained depends on the demographics of the subject , session , age , year , sex and perspiration.

**Approach:Linear Modelling**:
Linear modeling gives the relationship between the dependent and independent variables. In our data set we are finding the hypothesis between each attribute such as Age, sex, year and mean perspiration with the scores of scorer.

**Inference**:
The above equation informs us that scores will increase by -34.67 for every one percent increase in mean Perspiration value , and score is directly proportional to age which states that the if older age people are hired the score would have increased

```
Call:
lm(formula = Scores ~ log(Normalised_PP) + Age + Sex + Task +
    Scorer + Session, data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-9.0904 -2.0812  0.1778  2.4703  8.4800

Coefficients:
                   Estimate Std. Error t value             Pr(>|t|)
(Intercept)         0.43830    5.71336   0.077              0.93891
log(Normalised_PP) -1.13961    0.74582  -1.528              0.12772
Age                 0.49486    0.17195   2.878              0.00433 **
SexMale            -2.17630    0.47007  -4.630        0.00000576827 ***
TaskSuturing       -0.97517    0.42795  -2.279              0.02349 *
ScorerScorer2       0.02941    0.42648   0.069              0.94507
SessionSession2     4.26300    0.69164   6.164        0.00000000267 ***
SessionSession3     6.38075    0.69130   9.230 < 0.0000000000000002 ***
SessionSession4     7.68358    0.70093  10.962 < 0.0000000000000002 ***
SessionSession5     8.17553    0.71138  11.492 < 0.0000000000000002 ***

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
---
Residual standard error: 3.517 on 262 degrees of freedom
  (28 observations deleted due to missingness)
Multiple R-squared:  0.4606,    Adjusted R-squared:  0.442
F-statistic: 24.86 on 9 and 262 DF,  p-value: < 0.00000000000000022
```

**Figure 10:** Linear model of score vs all other attributes

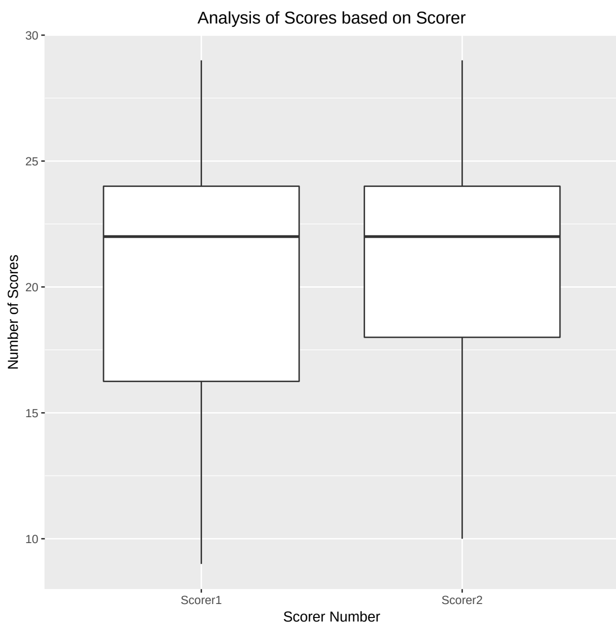


**Figure 11:** Analysis of Scores based on Score

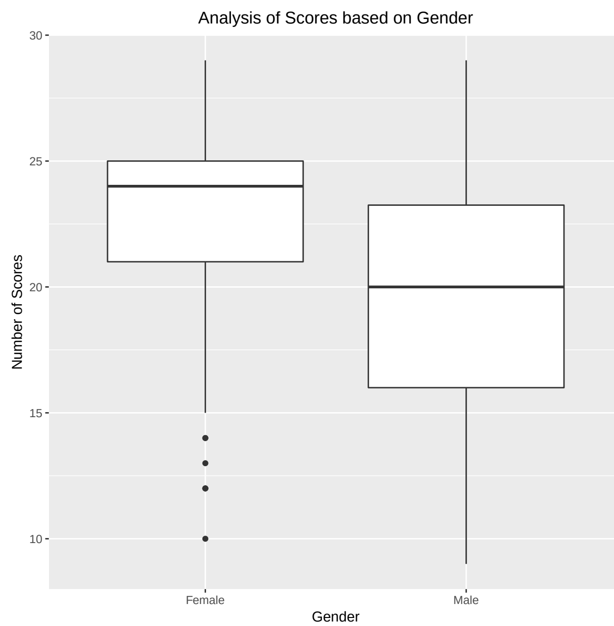


**Figure 12:** Analysis of Scores based on Gender

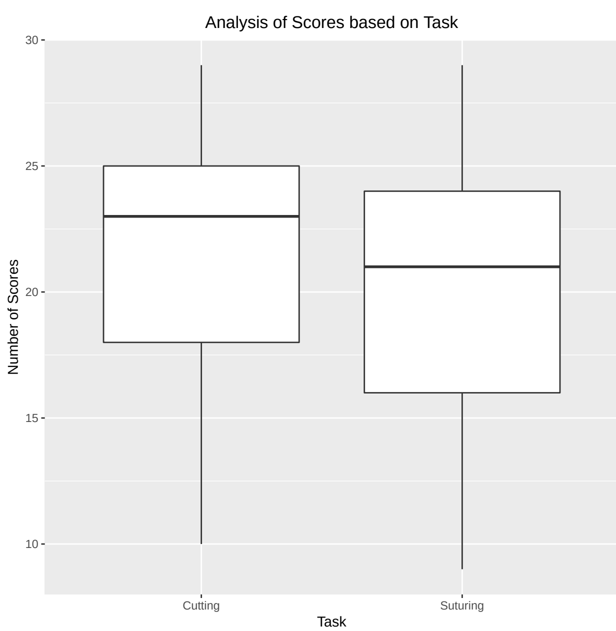


**Figure 13:** Analysis of Scores based on Task

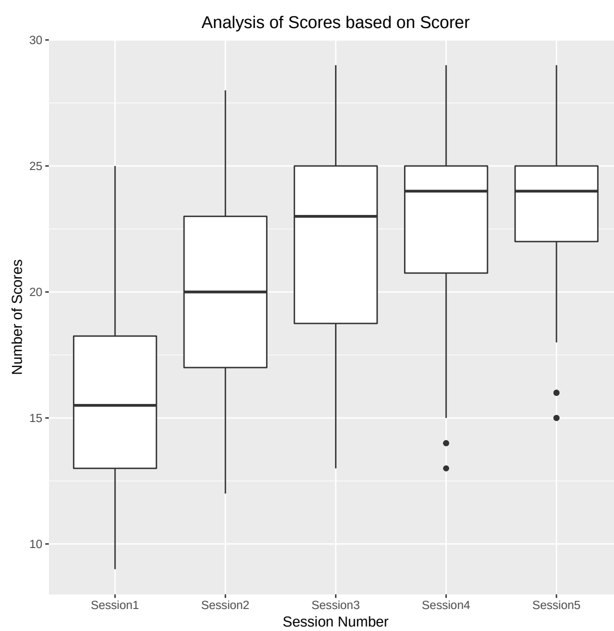


**Figure 14:** Analysis of Scores based on Session

## 2. Analysis of effect of each attribute on Time

**Hypothesis**:

$NullHypothesis : H_0$ = The time taken to do a task is not dependednt of age, session, sex, Perspiration.

$AlternateHypothesis : H_1$ = he time taken to do a task depends on age, session, sex, Perspiration.

**Approach:Linear Modelling**:

Linear modeling gives the relationship between the dependent and independent variables. In our data set we are finding the hypothesis between each attribute such as Age, sex, year and mean perspiration with the time taken to do the task.

```
Call:
lm(formula = Time ~ log(Normalised_PP) + Age + Sex + Task + Session,
    data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-340.68  -66.10    4.40   78.19  302.39

Coefficients:
                   Estimate Std. Error t value             Pr(>|t|)
(Intercept)          90.273    189.620   0.476                0.634
log(Normalised_PP)  -15.595     24.770  -0.630                0.530
Age                   7.915      5.711   1.386                0.167
SexMale              18.922     15.612   1.212                0.227
TaskSuturing        872.331     14.213  61.375 < 0.0000000000000002 ***
SessionSession2    -105.645     22.971  -4.599   0.0000065992793776 ***
SessionSession3    -113.626     22.959  -4.949   0.0000013335710345 ***
SessionSession4    -185.969     23.279  -7.989   0.0000000000000429 ***
SessionSession5    -170.059     23.626  -7.198   0.0000000000064042 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 116.8 on 263 degrees of freedom
  (28 observations deleted due to missingness)
Multiple R-squared:  0.9365,    Adjusted R-squared:  0.9345
F-statistic: 484.7 on 8 and 263 DF,  p-value: < 0.00000000000000022
```

**Figure 15:** Linear model of Time vs all other attributes

**Inference**:

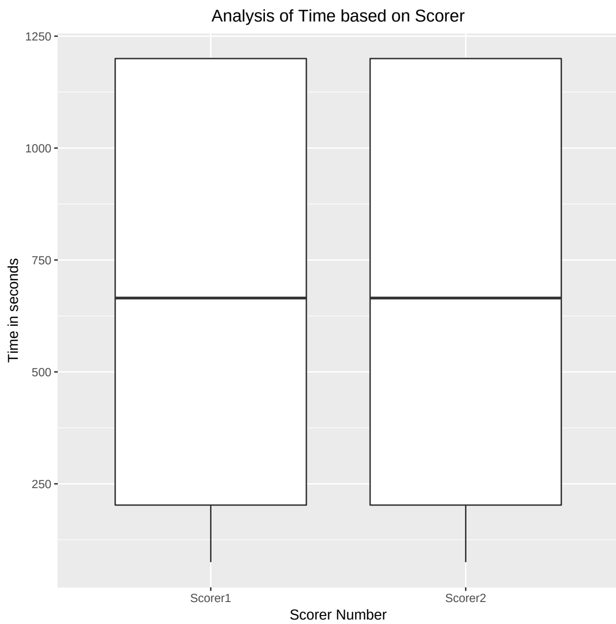


**Figure 16:** Analysis of Time based on Score

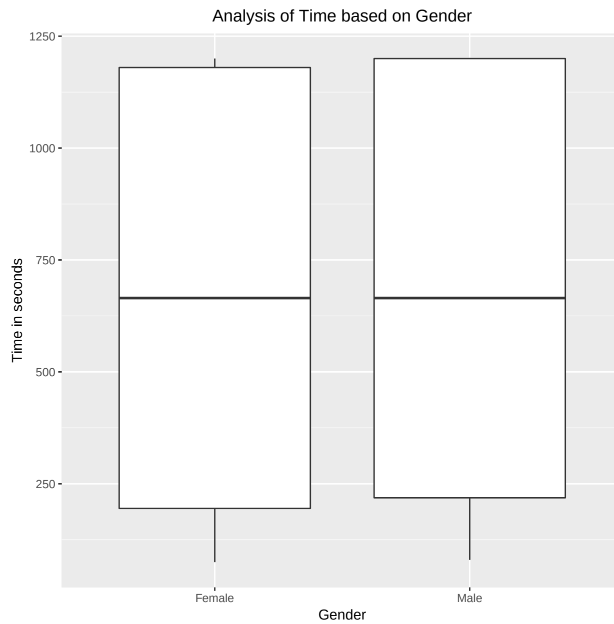


**Figure 17:** Analysis of Time based on Gender

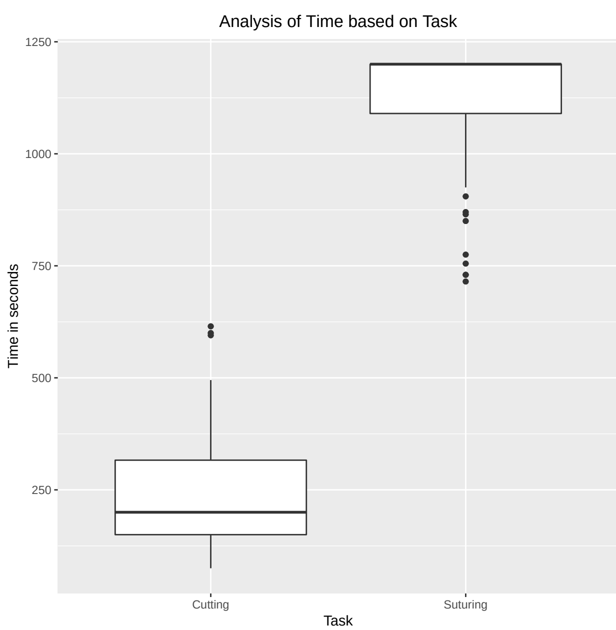


**Figure 18:** Analysis of Time based on Task

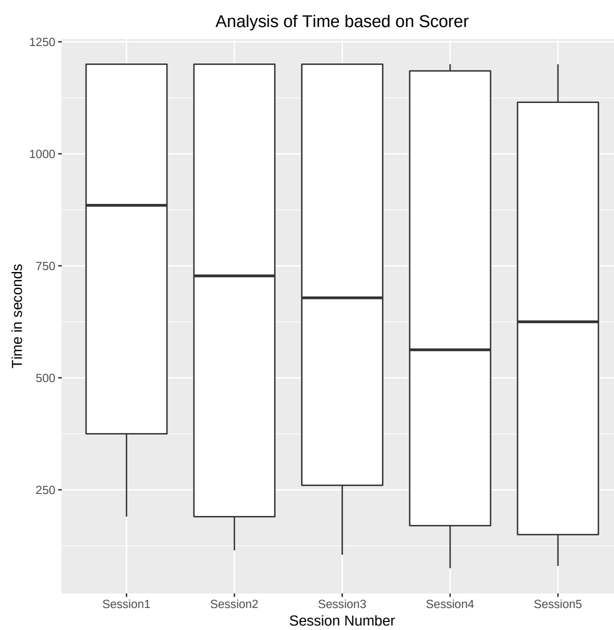


**Figure 19:** Analysis of Time based on Session

We observe that the means of Time vs Scorer or Gender do not have highly significant difference. Although, Task does have significant difference, we do not take it as a notifiable inference, because the time limits are different for each tasks, with time to complete suturing task being. 20 minutes. Hence, From the summary and the plots we infer that the time taken highly depends on the sessions.

## 3. Performance Analysis With Respect to Number of Sutures Made

**Approach:Linear Model**:

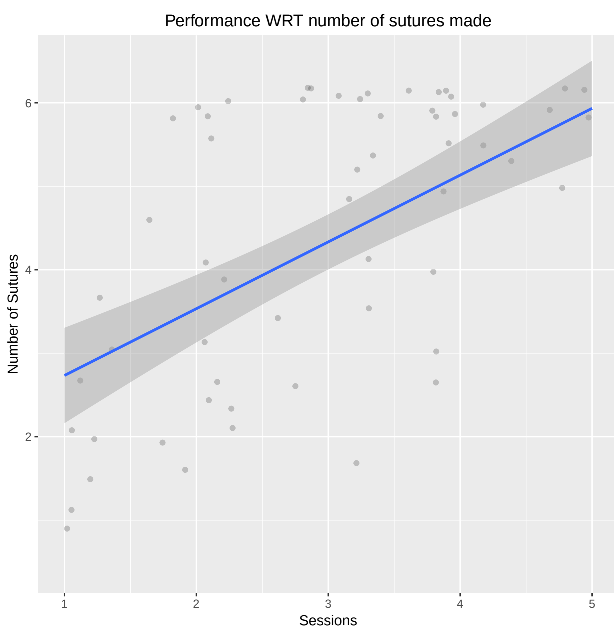


**Figure 20:** Performance WRT number of sutures made

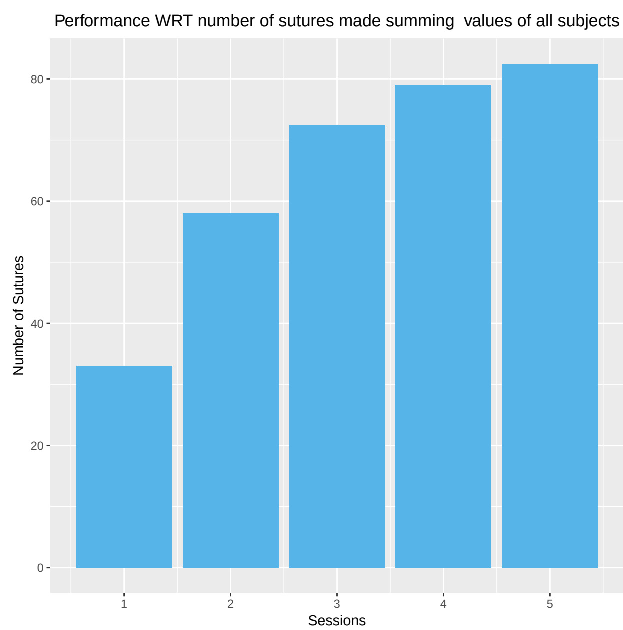


**Figure 21:** Performance WRT number of sutures summed across all subjects

From the figures, we understand that the number of sutures increases with each session.
To summarize it over all the subjects, we draw the bar plot with values of all subjects summed under each session , which gives us an understanding that with each session, the performance increases across all subjects.

When creating the linear model, and performing the analysis, we observe that the number of sutures is highly dependent on sessions . **Inference**:

```
Call:
lm(formula = Sutures ~ Sex * session)

Residuals:
   Min     1Q Median     3Q    Max 
 -2.95  -0.70   0.30   0.75   2.80 

Coefficients:
                         Estimate Std. Error t value    Pr(>|t|)    
(Intercept)                3.2000     0.5732   5.582 0.000000499 ***
SexMale                   -1.5000     0.7021  -2.136    0.036409 *  
sessionSession2            2.1000     0.8107   2.590    0.011823 *  
sessionSession3            2.4000     0.8107   2.960    0.004284 ** 
sessionSession4            2.5000     0.8107   3.084    0.002999 ** 
sessionSession5            2.8000     0.8107   3.454    0.000978 ***
SexMale:sessionSession2   -0.6500     0.9929  -0.655    0.515003    
SexMale:sessionSession3    0.3500     0.9929   0.353    0.725601    
SexMale:sessionSession4    0.8500     0.9929   0.856    0.395098    
SexMale:sessionSession5    0.7500     0.9929   0.755    0.452759    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.282 on 65 degrees of freedom
Multiple R-squared:  0.5661,	Adjusted R-squared:  0.5061 
F-statistic: 9.425 on 9 and 65 DF,  p-value: 0.000000005144
```

**Figure 22:** Analysis of Linear Model

The number of sutures made increases with each session, i.e the subjects are performing well.

## 4. Analysis of Scorers on Task:

**Hypothesis**:

$NullHypothesis: H_0$ = The mean of scores is same for both the Scorers

$AlternateHypothesis: H_1$ = The mean of scores is different for both the Scorers

**Approach:Wilcox Test**:

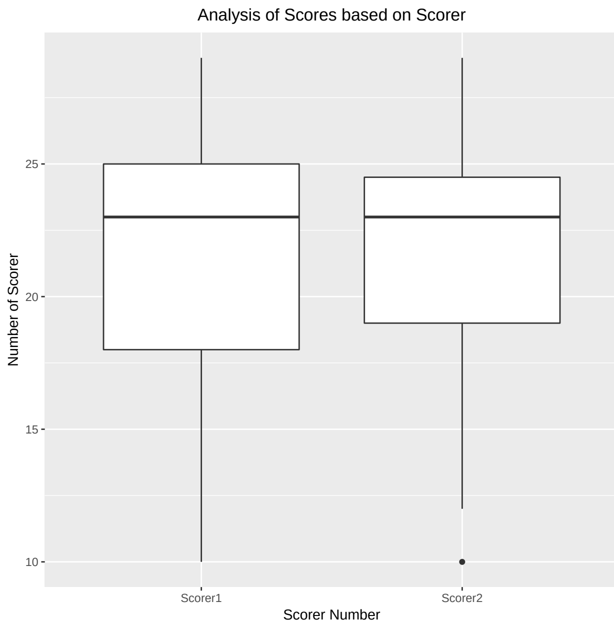


**Figure 23:** Cutting Scores

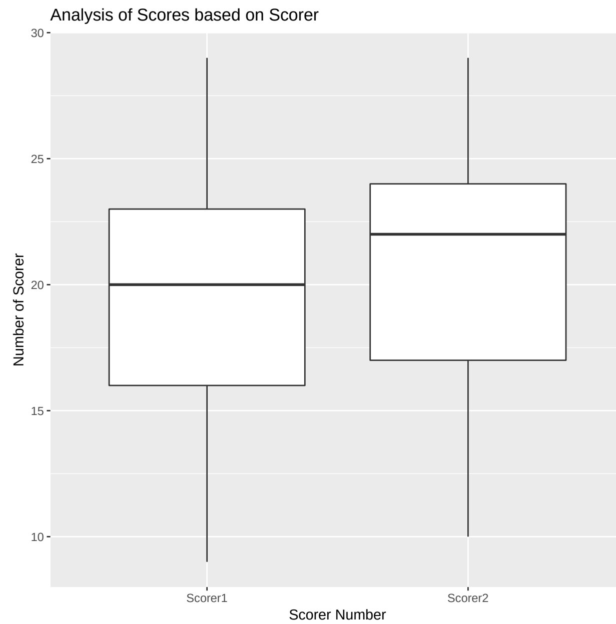


**Figure 24:** Suturing Scores

Cutting : When performed Wilcox test, p-value is greater than 0.05, which applies the means have not changed
Suturing: When performed Wilcox test, p-value is less than 0.05, which states that the means of the scorers is different.

**Inference**:
Scorer has an effect for Suturing and Cutting

## 5. Analysis of Number of Sutures made with respect to sex and sessions:

**Hypothesis**:
$NullHypothesis: H_0$ = The number of sutures made is not significant on sex of the subject

$AlternateHypothesis: H_1$ = The number of sutures made is significant on sex of the subject

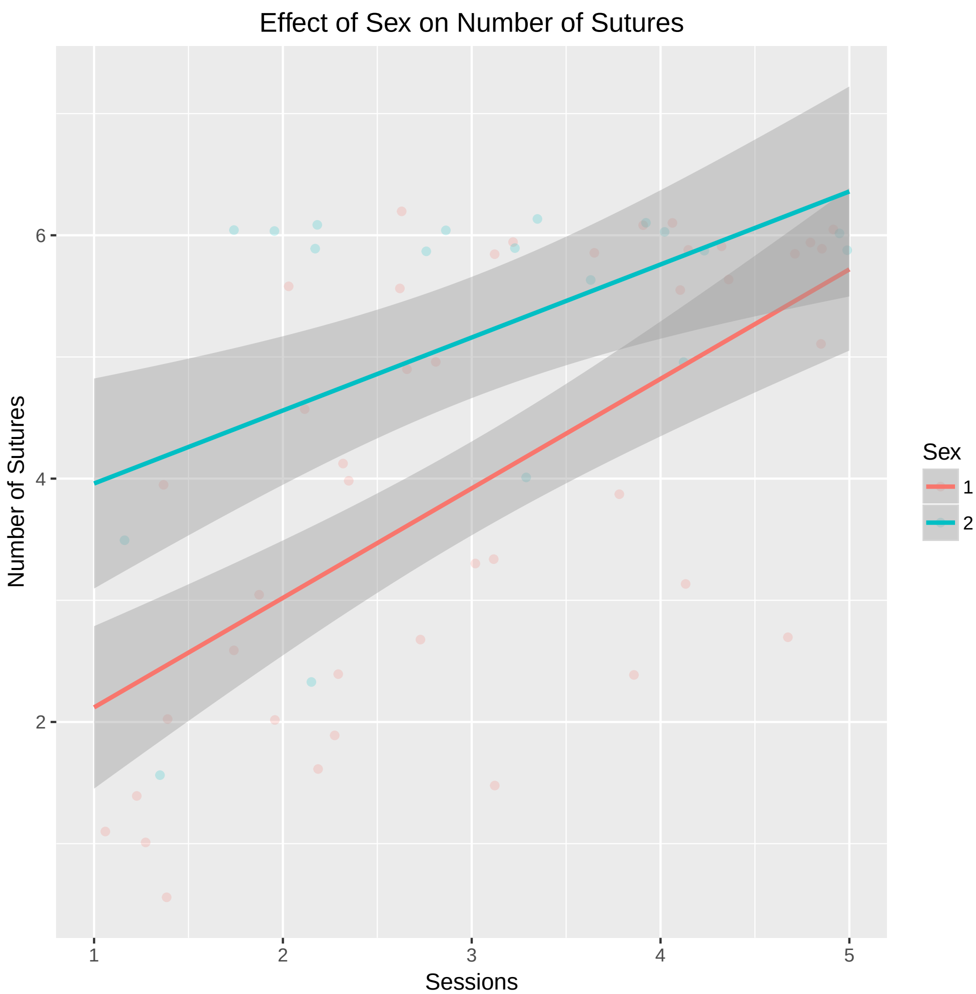


**Figure 25:** Interaction plot of Number of Sutures made wrt to Sex and Session

When performing the analysis for effect of Sutures on interaction of Sex and Sessions, we observe that, the p-value is 6.44e-11 which is way less than 0.05.
Also, from the interaction plot, we understand that the number of sutures made increases with the number of sessions and females make more number of sutures than males in average.

**Inference**:

Sex has an effect on Number of Sutures made and females made more number of Sutures in 20 minutes and the number os sutures increases with each session, i.e subject's performance gets better with each session.

# CONCLUSION

# Appendix

## List of Figures

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# REFERENCES