Contents

1. Eye Tracking Analysis

This analysis was conducted on three experiments to check effect of lexical-retrieval by a speaker in a statement to anticipated referent object by listeners. In the experiments data was collected on both fluent and dis-fluent conditions and also from low frequency to high frequency conditions.

2. Experiment 1

Experiment 1 data had a total of 47865 observations. There were 50 participants however; data from 2 participants was removed as the participants were observed to have a low frequency. The hypothesis for testing was incase native English listeners will more likely expect LF referents when they encounter a dis-fluency in native English speech. So, listeners' looks at the LF object will increase in the dis-fluent condition.

2.1. Exploratory data analysis

2.1.1. Number of trials

Out of the 48 participants the experiment was repeated several times with interchange of points and recording of the eye tracks depending on zone looked to. The mean of the trials was 15.47 with a standard deviation of 8.82. The maximum number of trials was 30 with the lowest as 1. Below is visualization on the time number of trials

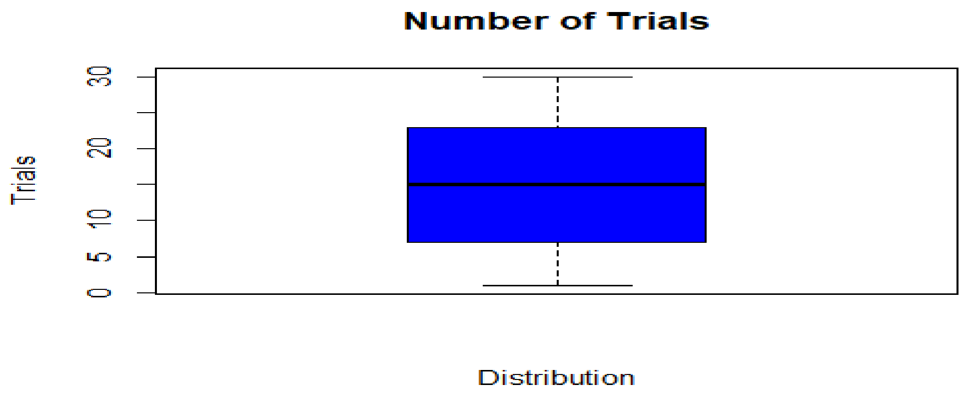


Figure 1 Exp 1 no of trials

2.1.2. Fluency conditions

There were two fluency conditions that are fluent and dis-fluent. 58.7% that is (28,102) were on dis-fluent while 41.3% were on fluent condition.

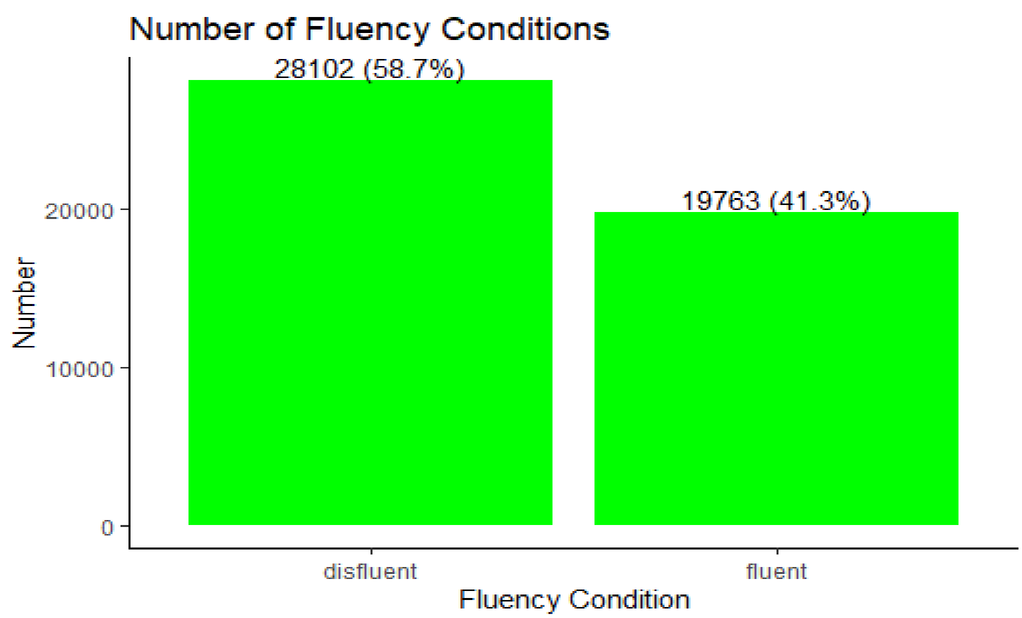


Figure 2 Exp 1 fluency condition

2.1.3. Looks to low frequency object

There were 13153 (27.5%) looks to the low frequency object out of the 47865 total observations.

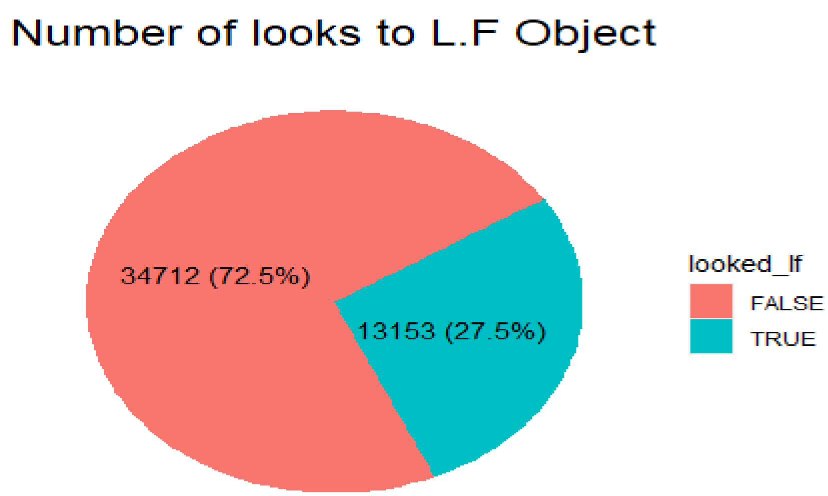


Figure 3 Exp 1 looks to low frequency object

Among the 13,153 looks, 8143 looks were under dis-fluent condition. This therefore implied that under fluent condition there were 5010 looks to low frequency object.

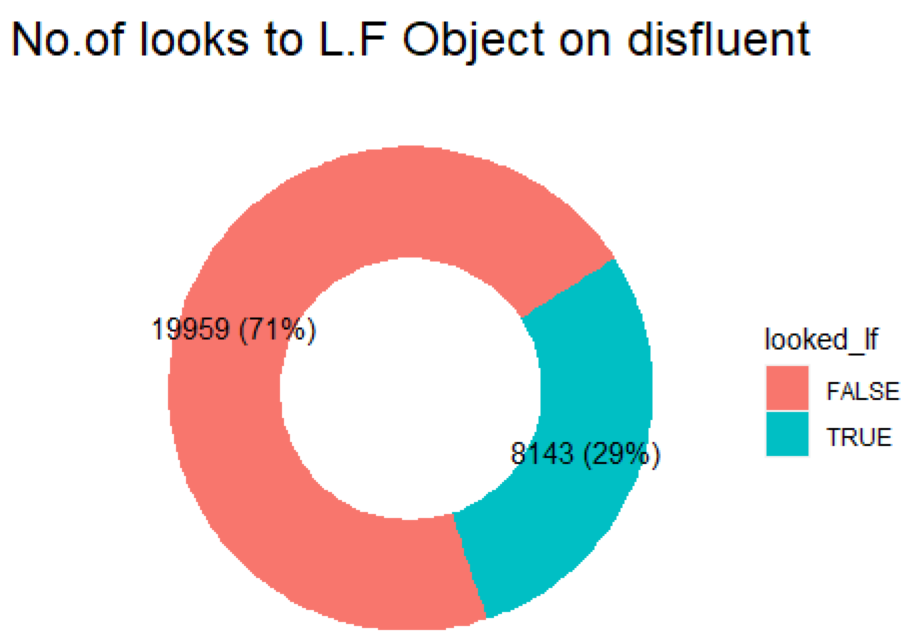


Figure 4 Exp 1 looks to l.f under dis-fluency

2.1.4. **Looks to high frequency object**

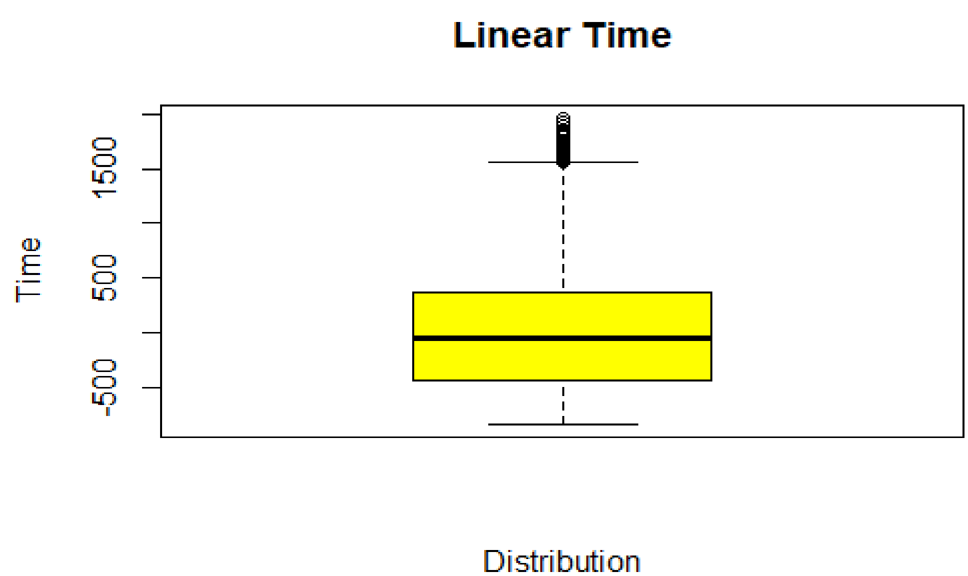
There were 11,641 looks to high frequency object.

Looks to HF	Number	Percentage
TRUE	11641	75.68%
FALSE	36224	24.32%

Among the 11,641 looks to high frequency object 6419 were under dis-fluent condition while 5222 were under fluent condition.

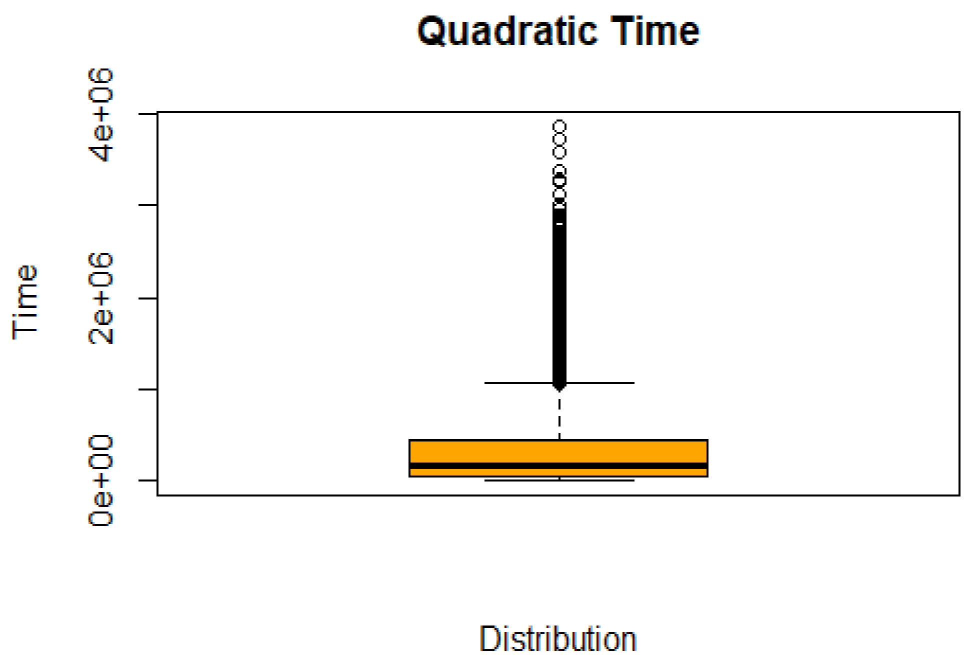
2.1.5.Linear Time

The linear had a standard deviation of 534.1687, mean of 0, a minimum value of -843 and a maximum value of 1967.5. Linear time which was the centered duration between the onsets of the trial to time of dis-fluency was highly affected by outliers hence not normally distributed.



2.1.6.Quadratic time

The standard deviation of the quadratic time was 327513.7 and a mean of 285330. The quadratic time which is the square of linear time was too affected by outliers hence not normally distributed. The minimum and maximum of the quadratic time was o and 3871066 respectively.



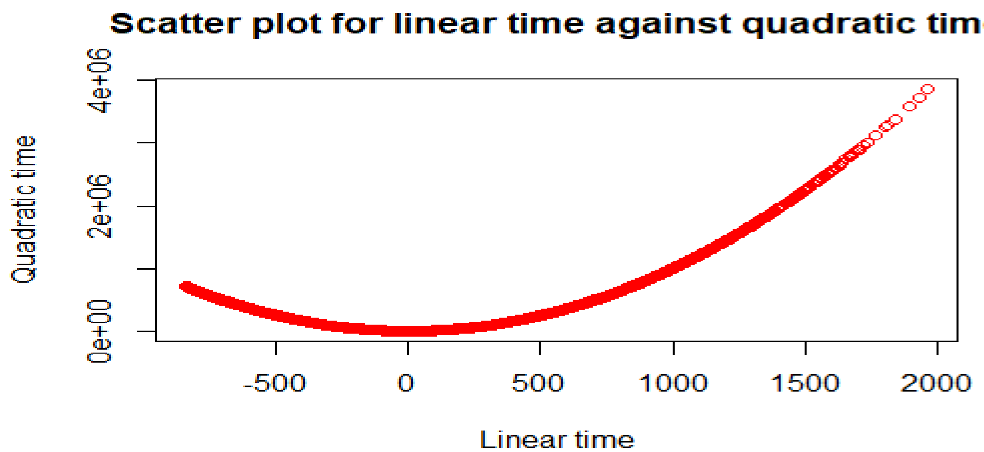
2.2. Determining whether fluency condition is significant predictor to looking at low frequency object.

To determine significant predictors for fluency conditions I chose to use the logistic regression because my outcome variable was a categorical variable of two levels. There assumptions for logistic regression that should be met;

- No outliers should exist between continuous variables
- No multicollinearity between continuous variable
- The outcome variable should be categorical of two levels

Since the linear and quadratic time variables were highly affected by outliers I used square root and logarithmic functions to eliminate the outliers.

I also tested for multicollinearity effect between linear and quadratic time and obtained a correlation of 0.38 which indicated that there was a weak linear relationship between the two variables.



The above plot shows a scatter plot which appears to be curved upwards hence validating the correlation of 0.38. Having met the assumptions I carried the logistic regressions for both fluent and dis-fluent cases.

```
Coefficients: (1 not defined because of singularities)
                            Estimate Std. Error z value Pr(>|z|)    
(Intercept)               -3.484e+02  4.797e+01  -7.264 3.77e-13 ***
fluency_combineddisfluent  1.218e-01  8.133e-02   1.497    0.134    
sqrt(linear_time)          4.317e-03  4.765e-03   0.906    0.365    
log(quadratic_time)       -2.192e-02  1.721e-02  -1.274    0.203    
participant_id             3.286e-05  4.535e-06   7.245 4.33e-13 ***
`sentence template`D2      3.124e-02  4.501e-02   0.694    0.488    
`sentence template`D3      2.296e-02  4.258e-02   0.539    0.590    
`sentence template`F1     -6.932e-02  8.815e-02  -0.786    0.432    
`sentence template`F2     -1.352e-01  8.359e-02  -1.617    0.106    
`sentence template`F3             NA         NA      NA       NA    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 25927  on 22188  degrees of freedom
Residual deviance: 25828  on 22180  degrees of freedom
  (25676 observations deleted due to missingness)
AIC: 25846

Number of Fisher Scoring iterations: 4
```

```
Coefficients: (1 not defined because of singularities)
                          Estimate Std. Error z value Pr(>|z|)    
(Intercept)              -3.483e+02  4.797e+01  -7.261 3.84e-13 ***
`fluency condition`fluent -1.218e-01  8.133e-02  -1.497    0.134    
sqrt(linear_time)         4.317e-03  4.765e-03   0.906    0.365    
log(quadratic_time)      -2.192e-02  1.721e-02  -1.274    0.203    
participant_id            3.286e-05  4.535e-06   7.245 4.33e-13 ***
`sentence template`D2     3.124e-02  4.501e-02   0.694    0.488    
`sentence template`D3     2.296e-02  4.258e-02   0.539    0.590    
`sentence template`F1    -6.932e-02  8.815e-02  -0.786    0.432    
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AIC: 25846

Number of Fisher Scoring iterations: 4
```

From the above results fluency condition in either fluent or dis-fluent conditions is a significant predictor of looks on low frequency objects. Participant id is also a significant predictor however, linear time, quadratic time and sentence templates are not significant predictors.

2.3. Comparing the looks to both high and low frequency conditions under fluent and dis-fluent conditions and proving our hypothesis

Since we have determined that fluency condition is significant predictor to anticipated reference object, we would like to check whether it is true that incase a native speaker experiences dis-fluency then native speakers will reference to a low frequency object.

We will achieve our comparison by checking whether, under dis-fluency condition the numbers of looks were different between low frequency objects to high frequency objects and if they are different and looks to low frequency object are more the we shall accept our hypothesis that; Native English listeners will more likely expect LF referents when they encounter a dis-fluency in native English speech. So, listeners’ looks at the LF object will increase in the dis-fluent condition.

Since the two variables under consideration that is fluency condition and looks to frequency object are categorical variables I employed Chi-square to check the comparison

Chi-square

			fluency condition		
Variable	**N**	**Overall**, N = 47,865[1]	**disfluent**, N = 28,102[1]	**fluent**, N = 19,763[1]	**p-value**[2]
looked_lf	47,865	13,153 (27%)	8,143 (29%)	5,010 (25%)	<0.001
looked_hf	47,865	11,641 (24%)	6,419 (23%)	5,222 (26%)	<0.001

[1] Median (IQR) or Frequency (%)

[2] Pearson's Chi-squared test

From the chi-square results under dis-fluent condition low frequency had 8,143 looks against 6,149 looks to high frequency object. The p-value was less than 0.001 hence signifying looks to low frequency object were significantly different to looks to high frequency object. Since under dis-fluency condition low frequency object has the most looks then we accept our hypothesis that native English listeners will more likely expect LF referents when they encounter a dis-fluency in native English speech. So, listeners' looks at the LF object will increase in the dis-fluent condition.

3. Experiment 2

Experiment 2 data had a total of 58372 observations. There were 50 participants however; data from 3 participants was removed as the participants were observed to have a low frequency hence omitted. The hypothesis for testing was native English listeners will not expect LF referents when they encounter a dis-fluency in non-native English speech. So, listeners' looks at the LF object will not increase in the dis-fluent condition.

3.1. Exploratory data analysis

3.1.1. Number of trials

Out of the 47 participants the experiment was repeated several times with interchange of points and recording of the eye tracks depending on zone looked to. The mean of the trials was 16.05 with a standard deviation of 8.72. The maximum number of trials was 30 with the lowest as 1. Below is visualization on the time number of trials

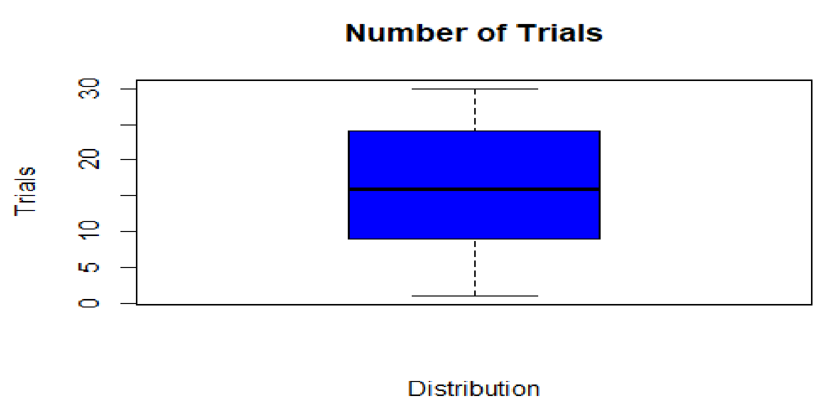


Figure 3

3.1.2. Fluency conditions

There were two fluency conditions that are fluent and dis-fluent. 70.7% that is (41,263) were on dis-fluent while 29.3% were on fluent condition.

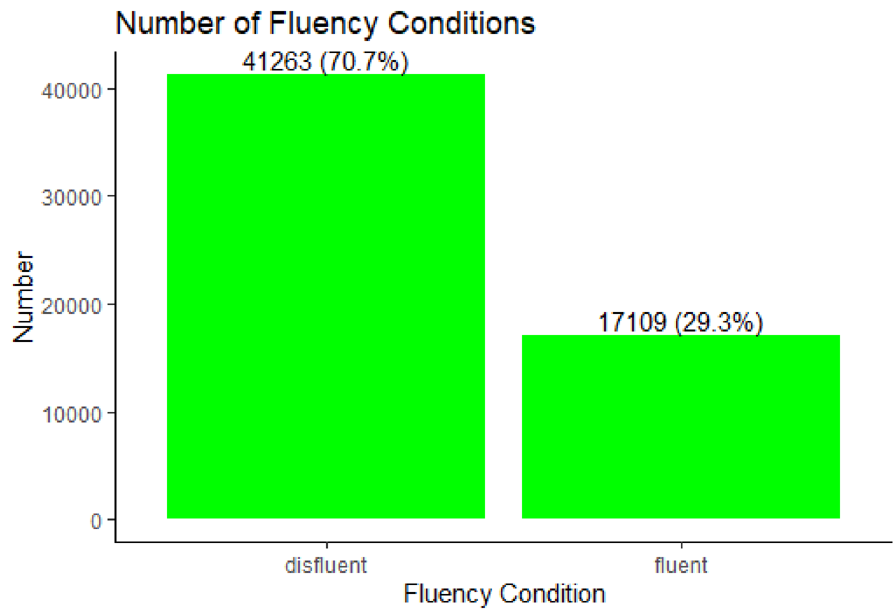


Figure 4 for fluency condition

3.1.3. Looks to low frequency object

There were 16393 (28.1%) looks to the low frequency object out of the 58372 total observations.

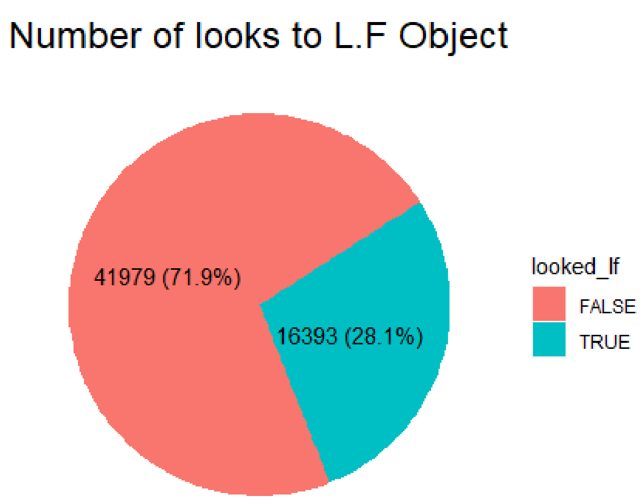


Figure 4 looks to low frequency object

Among the 16,393 looks, 11978 looks were under dis-fluent condition. This therefore implied that under fluent condition there were 4415 looks to low frequency object.

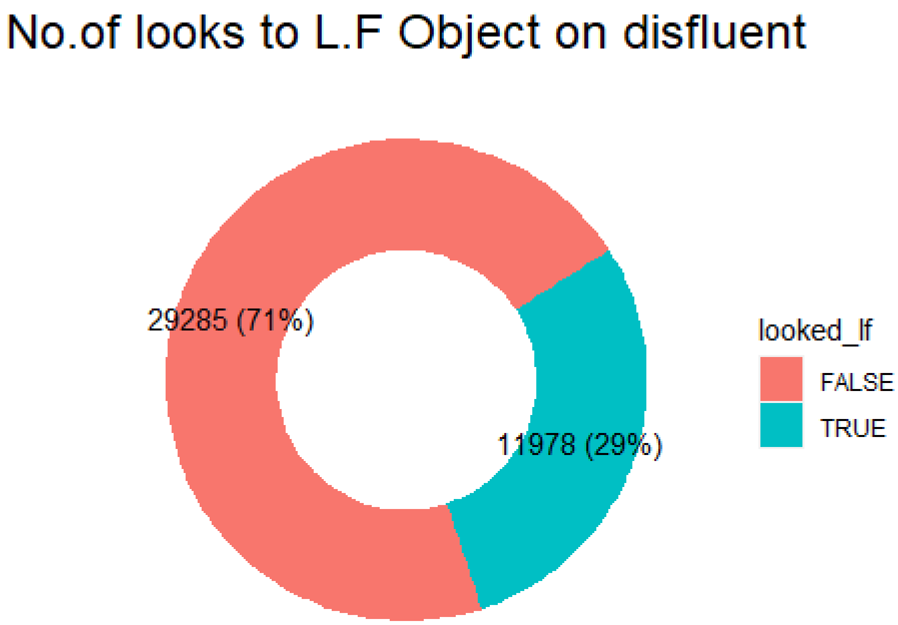


Figure 5 looks to l.f under dis-fluency

3.1.4. **Looks to high frequency object**

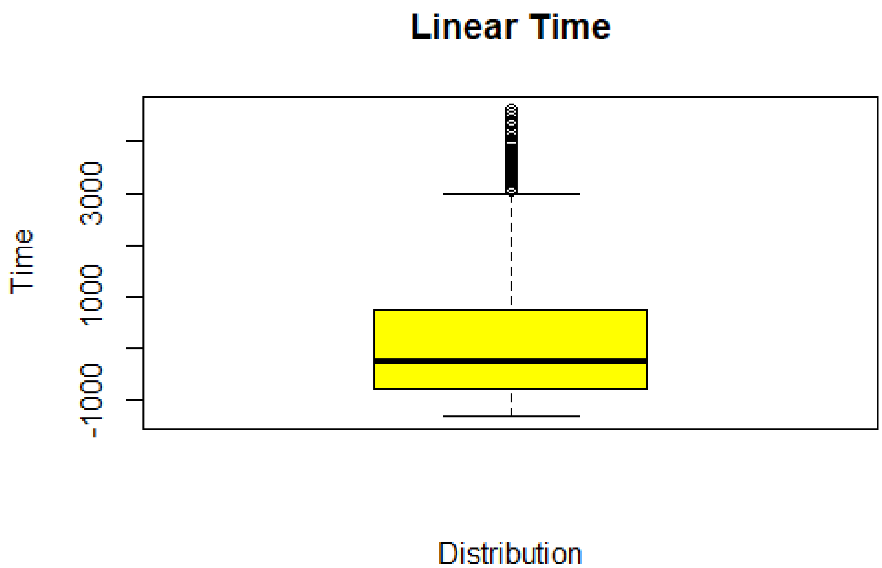
There were 11,641 looks to high frequency object.

Looks to HF	**Number**	**Percentage**
TRUE	14163	24.3%
FALSE	44209	75.7%

Among the 14163 looks to high frequency object 10,000 were under dis-fluent condition while 4163 were under fluent condition.

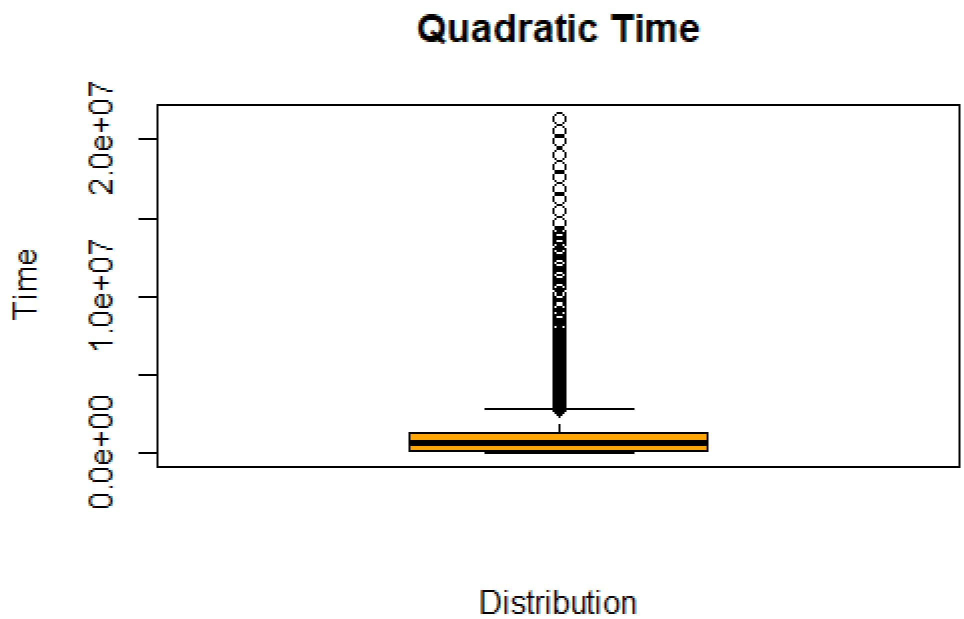
3.1.5.Linear Time

The linear had a standard deviation of 908.0202, mean of 0, a minimum value of -1306.1 and a maximum value of 4619.9. Linear time which was the centered duration between the onsets of the trial to time of dis-fluency was highly affected by outliers hence not normally distributed.



3.1.6.Quadratic time

The standard deviation of the quadratic time was 897977 and a mean of 824487. The quadratic time which is the square of linear time was too affected by outliers hence not normally distributed. The minimum and maximum of the quadratic time was o and 21343863 respectively.



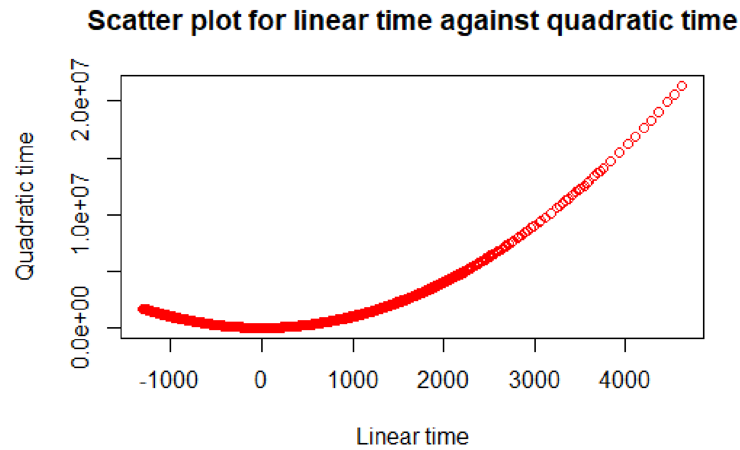
3.2. Determining whether fluency condition is significant predictor to looking at low frequency object.

To determine significant predictors for fluency conditions I chose to use the logistic regression because my outcome variable was a categorical variable of two levels. There assumptions for logistic regression that should be met;

- No outliers should exist between continuous variables
- No multicollinearity between continuous variable
- The outcome variable should be categorical of two levels

Since the linear and quadratic time variables were highly affected by outliers I used square root and logarithmic functions to eliminate the outliers.

I also tested for multicollinearity effect between linear and quadratic time and obtained a correlation of 0.46 which indicated that there was a weak linear relationship between the two variables.



The above plot shows a scatter plot which appears to be curved upwards hence validating the correlation of 0.46. Having met the assumptions I carried the logistic regressions for both fluent and dis-fluent cases.

```
Coefficients: (1 not defined because of singularities)
                            Estimate Std. Error z value Pr(>|z|)    
(Intercept)               -3.484e+02  4.797e+01  -7.264 3.77e-13 ***
fluency_combineddisfluent  1.218e-01  8.133e-02   1.497    0.134    
sqrt(linear_time)          4.317e-03  4.765e-03   0.906    0.365    
log(quadratic_time)       -2.192e-02  1.721e-02  -1.274    0.203    
participant_id             3.286e-05  4.535e-06   7.245 4.33e-13 ***
`sentence template`D2      3.124e-02  4.501e-02   0.694    0.488    
`sentence template`D3      2.296e-02  4.258e-02   0.539    0.590    
`sentence template`F1     -6.932e-02  8.815e-02  -0.786    0.432    
`sentence template`F2     -1.352e-01  8.359e-02  -1.617    0.106    
`sentence template`F3             NA         NA      NA       NA    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 25927  on 22188  degrees of freedom
Residual deviance: 25828  on 22180  degrees of freedom
  (25676 observations deleted due to missingness)
AIC: 25846

Number of Fisher Scoring iterations: 4
```

```
Coefficients: (1 not defined because of singularities)
                          Estimate Std. Error z value Pr(>|z|)    
(Intercept)              9.400e+01  2.535e+01   3.708 0.000209 ***
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sqrt(linear_time)        9.632e-03  3.849e-03   2.503 0.012325 *  
log(quadratic_time)     -5.383e-02  1.912e-02  -2.815 0.004879 ** 
participant_id          -8.906e-06  2.389e-06  -3.728 0.000193 ***
`sentence template`D3    5.199e-02  2.836e-02   1.833 0.066813 .  
`sentence template`F3           NA         NA      NA       NA    
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 30215  on 25292  degrees of freedom
Residual deviance: 30159  on 25287  degrees of freedom
  (33079 observations deleted due to missingness)
AIC: 30171

Number of Fisher Scoring iterations: 4
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From the above results fluency condition in either fluent or dis-fluent conditions is a significant predictor of looks on low frequency objects. Participant id is also a significant predictor for both conditions however, linear time, quadratic time and sentence templates are not significant predictors for dis-fluent condition but are significant for fluent condition.

3.3. Comparing the looks to both high and low frequency conditions under fluent and dis-fluent conditions and proving our hypothesis

Since we have determined that fluency condition is significant predictor to anticipated reference object, we would like to check whether it is true that incase a non-native speaker with strong foreign accent experiences dis-fluency then native speakers will not reference to a low frequency object.

We will achieve our comparison by checking whether, under dis-fluency condition the numbers of looks were different between low frequency objects to high frequency objects and if they are different, looks to low frequency object are less than the looks to high frequency object hence we shall accept our hypothesis that; incase a non-native speaker experiences dis-fluency then native speakers will not reference to a low frequency object.

Since the two variables under consideration that is fluency condition and looks to frequency object are categorical variables I employed Chi-square to check the comparison

Chi-square					
			fluency condition		
Variable	**N**	**Overall**, N = 58,372[1]	**disfluent**, N = 41,263[1]	**fluent**, N = 17,109[1]	**p-value**[2]
looked_lf	58,372	16,393 (28%)	11,978 (29%)	4,415 (26%)	<0.001
looked_hf	58,372	14,163 (24%)	10,000 (24%)	4,163 (24%)	0.80

[1] Median (IQR) or Frequency (%)

[2] Pearson's Chi-squared test

From the chi-square results under dis-fluent condition low frequency had 11,978 looks against 10,000 looks to high frequency object. The p-value was 0.8 which was greater than 0.001 hence signifying looks to low frequency object were not significantly different to looks to high frequency object. Hence we accept our hypothesis that incase a non-native speaker experiences dis-fluency then native speakers will not reference to a low frequency object. This is so because looks to both low frequency and high frequency objects are significantly equal.

4. <u>Experiment 3</u>

Experiment 3 data had a total of 54552 observations. There were 50 participants however; data from 4 participants was removed as the participants were observed to have a low frequency. The hypothesis for testing was; since the degree of foreign accent has not been considered in previous research, two possible effects might be observed, and as such, two hypotheses would be considered:

- Native English listeners' bias toward LF referents will be sensitive to the degree of foreign accent of the non-native speakers and, in turn, will increase more when processing the speech of the non-native speaker with a native-like accent when compared to non-native speakers with a strong foreign. So, listeners' looks at the LF object will increase in the dis-fluent condition.
- Native English listeners' bias toward LF referents will not be sensitive to the non-native speakers' degree of foreign accent, and the dis-fluencies from both non-native speakers will be processed in an identical manner. So, listeners' looks at the LF object will not increase in the dis-fluent condition.

4.1. Exploratory data analysis

4.1.1. Number of trials

Out of the 46 participants the experiment was repeated several times with interchange of points and recording of the eye tracks depending on zone looked to. The mean of the trials was 15.89 with a standard deviation of 8.81. The maximum number of trials was 30 with the lowest as 1. Below is visualization on the time number of trials

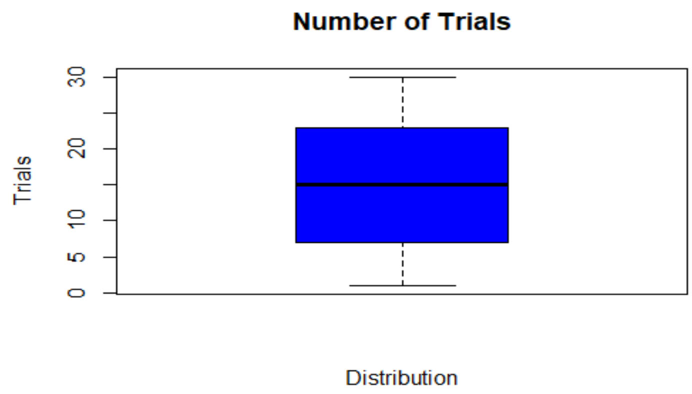


Figure 6

4.1.2. Fluency conditions

There were two fluency conditions that are fluent and dis-fluent. 63.4% that is (34,609) were on dis-fluent while 36.6% were on fluent condition.

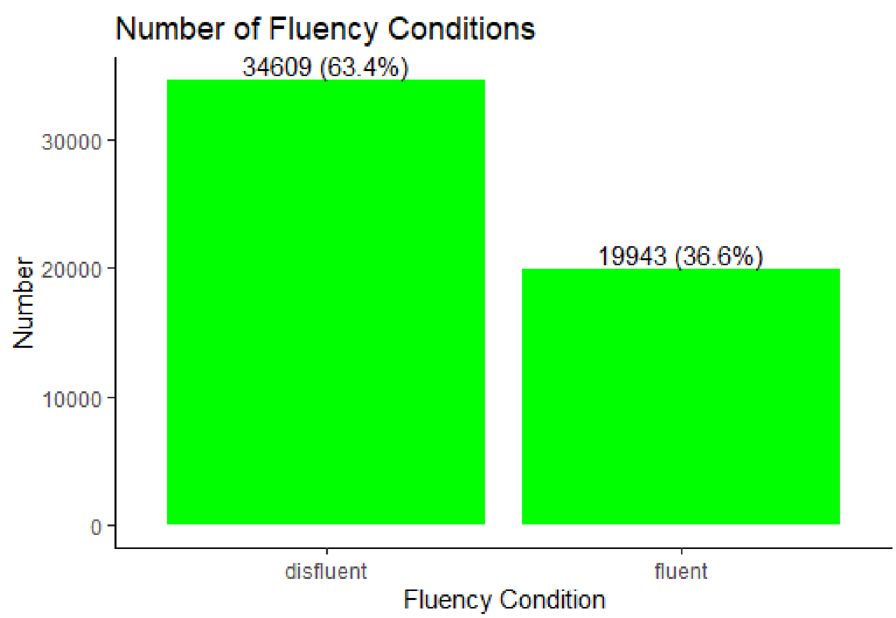


Figure 7 for fluency condition

4.1.3. Looks to low frequency object

There were 14900 (27.3%) looks to the low frequency object out of the 54552 total observations.

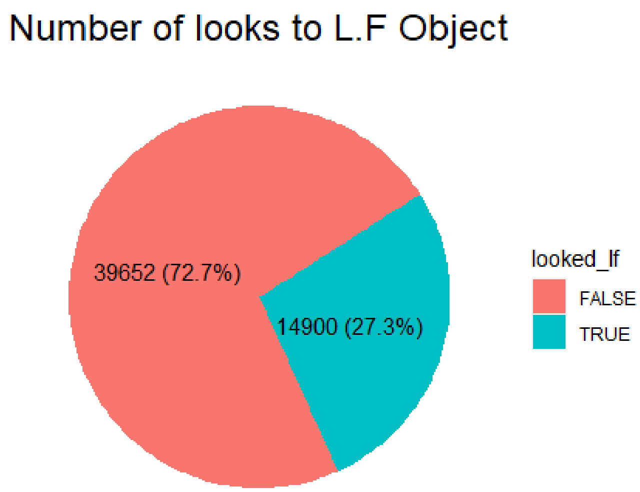


Figure 4 looks to low frequency object

Among the 14,900 looks, 9780 looks were under dis-fluent condition. This therefore implied that under fluent condition there were 5120 looks to low frequency object.

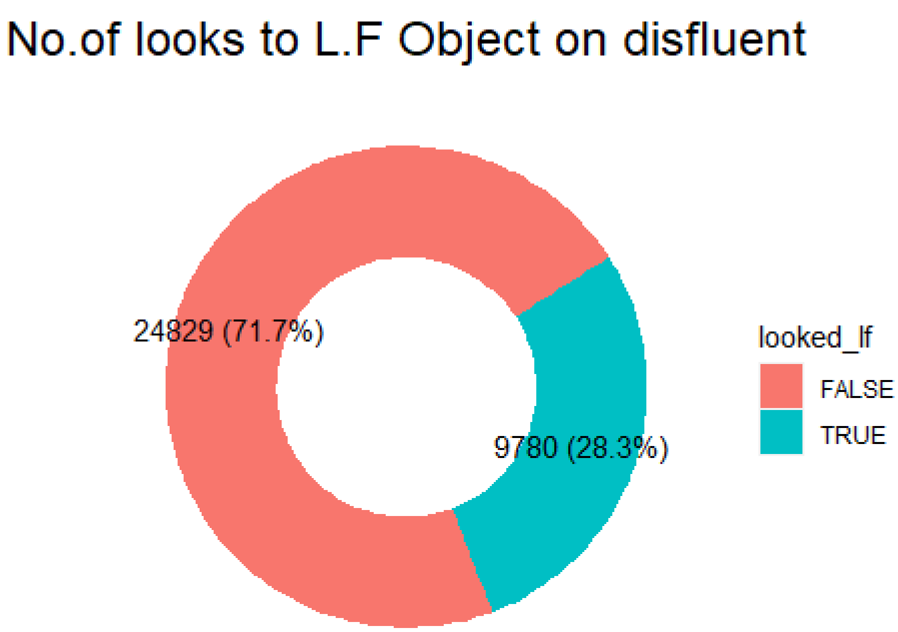


Figure 8 looks to l.f under dis-fluency

4.1.4. **Looks to high frequency object**

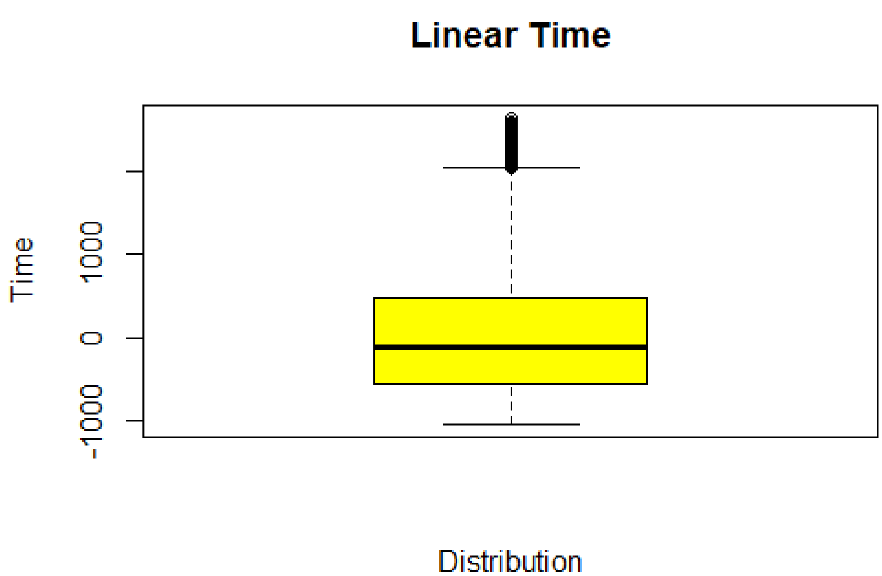
There were 13828 looks to high frequency object.

Looks to HF	Number	Percentage
TRUE	13828	25.3%
FALSE	40724	76.1%

Among the 13,828 looks to high frequency object 8254 were under dis-fluent condition while 5574 were under fluent condition.

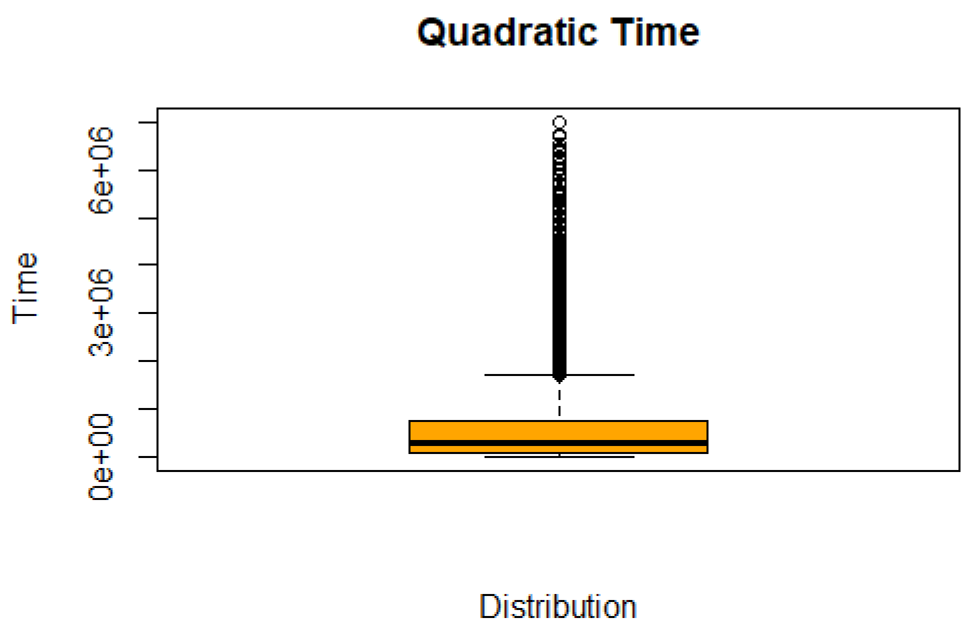
4.1.5.Linear Time

The linear had a standard deviation of 700.3136, mean of 0, a minimum value of -1047.5 and a maximum value of 2645.5. Linear time which was the centered duration between the onsets of the trial to time of dis-fluency was highly affected by outliers hence not normally distributed.



4.1.6. Quadratic time

The standard deviation of the quadratic time was 576542.8 and a mean of 490430. The quadratic time which is the square of linear time was too affected by outliers hence not normally distributed. The minimum and maximum of the quadratic time was 0 and 6998747 respectively.



4.2. Determining whether fluency condition is significant predictor to looking at low frequency object.

To determine significant predictors for fluency conditions I chose to use the logistic regression because my outcome variable was a categorical variable of two levels. There assumptions for logistic regression that should be met;

- No outliers should exist between continuous variables
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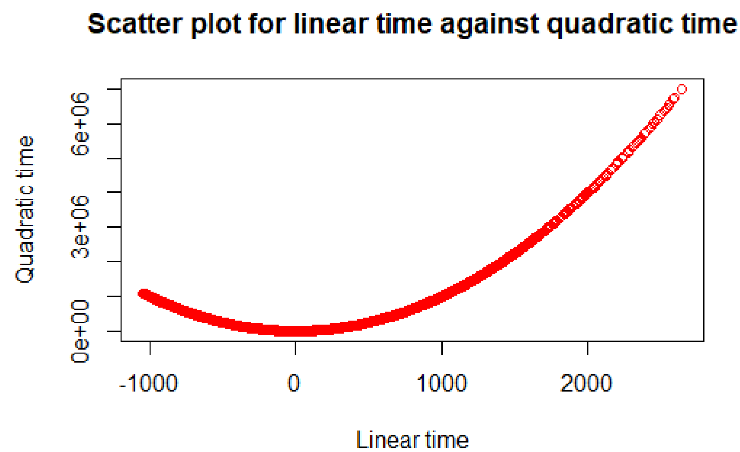
Since the linear and quadratic time variables were highly affected by outliers I used square root and logarithmic functions to eliminate the outliers.

I also tested for multicollinearity effect between linear and quadratic time and obtained a correlation of 0.46 which indicated that there was a weak linear relationship between the two variables.



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```
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(Intercept)             -3.484e+02  4.797e+01  -7.264 3.77e-13 ***
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participant_id           3.286e-05  4.535e-06   7.245 4.33e-13 ***
`sentence template`D2    3.124e-02  4.501e-02   0.694    0.488    
`sentence template`D3    2.296e-02  4.258e-02   0.539    0.590    
`sentence template`F1   -6.932e-02  8.815e-02  -0.786    0.432    
`sentence template`F2   -1.352e-01  8.359e-02  -1.617    0.106    
`sentence template`F3           NA         NA      NA       NA    
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Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

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Coefficients:
                            Estimate Std. Error z value Pr(>|z|)    
(Intercept)                5.417e+02  9.487e+01   5.710 1.13e-08 ***
`fluency condition`fluent  7.849e-02  7.925e-02   0.990   0.3220    
sqrt(linear_time)          1.040e-02  4.184e-03   2.484   0.0130 *  
log(quadratic_time)       -2.618e-02  1.830e-02  -1.431   0.1525    
participant_id            -5.126e-05  8.962e-06  -5.720 1.07e-08 ***
`sentence template`D2     -5.250e-02  4.160e-02  -1.262   0.2070    
`sentence template`D3      3.677e-01  5.330e-02   6.899 5.24e-12 ***
`sentence template`F1     -3.182e-01  1.469e-01  -2.166   0.0303 *  
`sentence template`F2     -6.847e-02  1.001e-01  -0.684   0.4938    
`sentence template`F3     -1.117e-01  6.748e-02  -1.656   0.0977 .  
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 28426  on 24067  degrees of freedom
Residual deviance: 28280  on 24058  degrees of freedom
  (30484 observations deleted due to missingness)
AIC: 28300

Number of Fisher Scoring iterations: 4
```

From the above results fluency condition in either fluent or dis-fluent conditions is a significant predictor of looks on low frequency objects. Participant id is also a significant predictor on both conditions however, linear time, quadratic time and sentence templates are not significant predictors for di-fluent conditions but are significant predictors for fluent conditions.

4.3. Comparing the looks to both high and low frequency conditions under fluent and dis-fluent conditions and proving our hypothesis

Since we have determined that fluency condition is significant predictor to anticipated reference object, we would like to check whether it is true that;

Native English listeners’ bias toward LF referents will be sensitive to the degree of foreign accent of the non-native speakers and, in turn, will increase more when processing the speech of the non-native speaker with a native-like accent when compared to non-native speakers with a strong foreign. So, listeners’ looks at the LF object will increase in the dis-fluent condition.

Native English listeners’ bias toward LF referents will not be sensitive to the non-native speakers’ degree of foreign accent, and the dis-fluencies from both non-native speakers will be processed in an identical manner. So, listeners' looks at the LF object will not increase in the dis-fluent condition.

We will achieve our comparison by checking whether, under dis-fluency condition the numbers of looks were different between low frequency objects to high frequency objects and if they are different and looks to low frequency object are more the we shall accept our hypothesis that; Native English listeners will more likely expect LF referents when they encounter a dis-fluency in native English speech. So, listeners' looks at the LF object will increase in the dis-fluent condition. Inversely, if looks to low frequency object are not significantly different to looks to high frequency object we shall accept the hypothesis that; native English listeners' bias toward LF referents will not be sensitive to the non-native speakers' degree of foreign accent, and the dis-fluencies from both non-native speakers will be processed in an identical manner. So, listeners' looks at the LF object will not increase in the dis-fluent condition.

Since the two variables under consideration that is fluency condition and looks to frequency object are categorical variables I employed Chi-square to check the comparison

Chi-square					
			fluency condition		
Variable	N	**Overall**, N = 54,552[1]	**disfluent**, N = 34,609[1]	**fluent**, N = 19,943[1]	p-value[2]
looked_lf	54,552	14,900 (27%)	9,780 (28%)	5,120 (26%)	<0.001
looked_hf	54,552	13,828 (25%)	8,254 (24%)	5,574 (28%)	<0.001

[1] Median (IQR) or Frequency (%)

[2] Pearson's Chi-squared test

From the chi-square results under dis-fluent condition low frequency had 9,780 looks against 8,254 looks to high frequency object. The p-value was less than 0.001 hence signifying looks to low frequency object were significantly different to looks to high frequency object. Since under dis-fluency condition low frequency object has the most looks then we accept our hypothesis that native English listeners' bias toward LF referents will be sensitive to the degree of foreign accent of the non-native speakers and, in turn, will increase more when processing the speech of the non-native speaker with a native-like accent when compared to non-native speakers with a strong foreign. So, listeners' looks at the LF object will increase in the dis-fluent condition.

5. Conclusion

From the three experiments native listeners tend to infer referent to a low frequency object when a native speaker experiences dis-fluency which similarly reflects to native listeners inferring referent to a low frequency object when a non-native speaker with a native-like accent undergoes lexical retrieval.

When a non-native speaker with a strong foreign accent experiences dis-fluency then anticipated referent is not on low-frequency object neither on high frequency object. It is true that here listeners will develop some adaptability mechanisms to predict the intended target.