Analysis based on report-v4.csv file from Paul's email of 13.09.2022

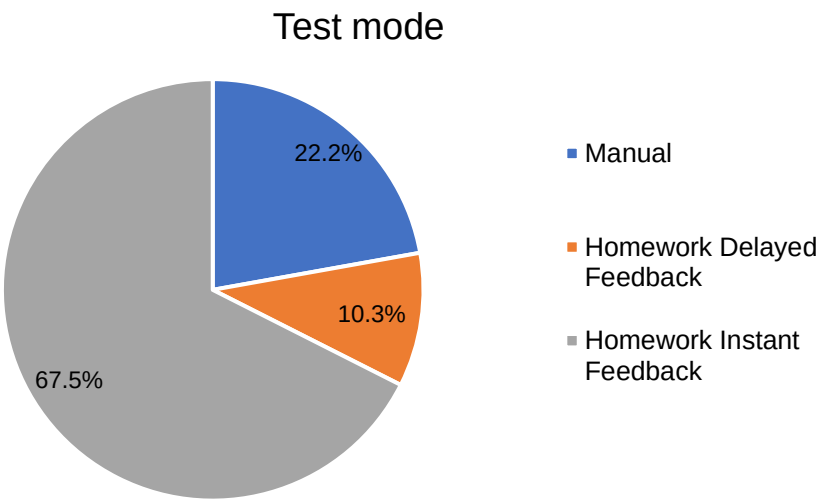
I excluded the records coming from Paul's testing account (school name: Fradgley High, School ID: 5) leaving 212,258 observations with 18 variables. On such a cleaned file, I tried to find regular users of the platform based on Julia's division.

Characteristics of the entire participants' sample:

N = 2,555

- Number of questions: During the entire period of usage of the GCSE Prepper, an average student attempted to responded to about **67.75** (*SD* = 107.32) unique questions. When I included all the questions students tried to answer, including the repetition of questions in subsequent sessions, they practiced about **83.07** (*SD* = 225.98) questions.
- Testing Mode:

  The percentages of questions practiced in each mode:



- Time Spent with the GSCE Prepper: An average period of usage of the GCSE Prepper was about **12 weeks –** the time between the first log in and the last log in. However, when I considered weeks of active usage of the platform – weeks at which a given participant tried to answer at least one question – that was on average **4 active weeks** per student. In total, students spent approximately **119 minutes** (about 2 hours) on trying to answer questions (including repetitions), and **246 minutes** (about 4 hours) to read feedback.

Group A – students who are actively and regularly engaged with the platform

N = 566

CONDITIONS

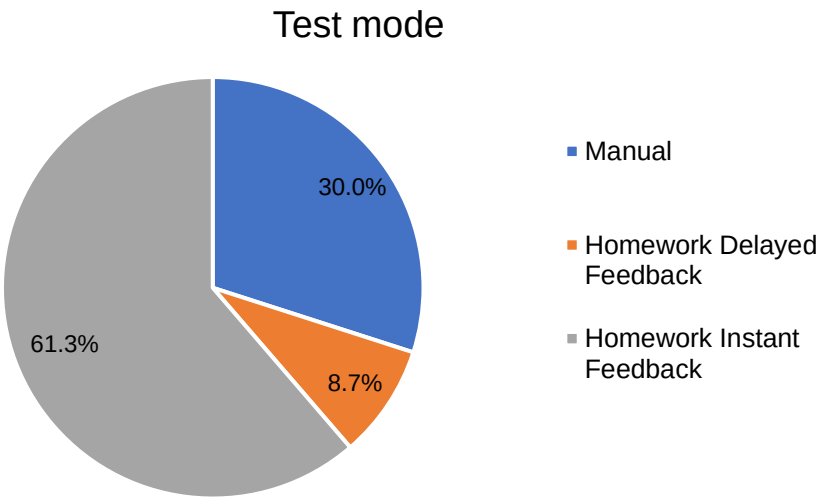
Necessary conditions:

1. 8 weeks period of usage of the GCSE Prepper (week of last log in minus week of first log in)
2. Practiced at least 50 unique questions (not included reptations)

Additional conditions (it is enough to meet one of them):

3. During the period of usage of the platform, they had at least 50% active weeks (active week – they did some activity with the program that week)
4. Practiced with at least 100 unique questions

- Number of questions: An average student in Group A attempted to respond to about **196.50** (*SD* = 167.35) unique questions, and **256.40** (*SD* = 434.25) questions with repetitions.
- Testing Mode:
- The percentages of questions practiced in each mode:



- Time Spent with the GSCE Prepper: The average period of usage of the GCSE Prepper was about **25 weeks**, including about **10 active weeks**. In total, in Group A, students spent about **5 hours 40 minutes** trying to answer questions (including repetitions), and about **9 hours 20 minutes** to read feedback.

Group B – students who accessed the platform once (and did not use it thereafter)

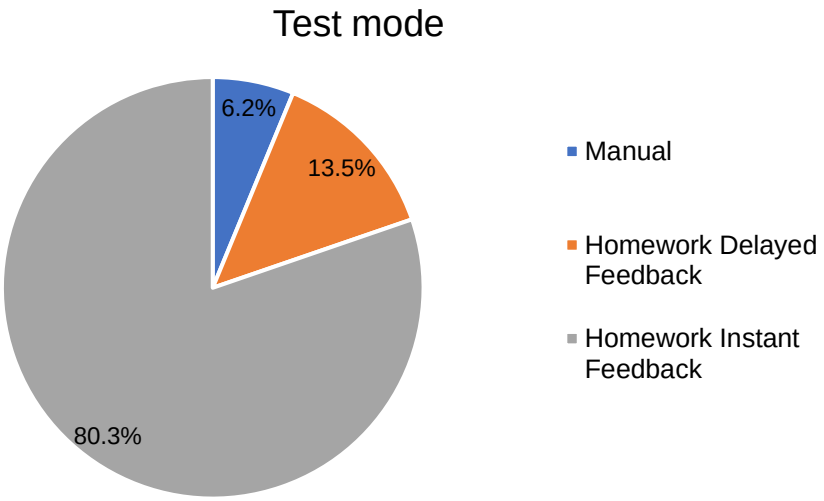
N = 681

CONDITION

Students who used the GSCE Prepper for only one day.

- Number of questions: In Group B, students attempted to respond about **9.41** (*SD* = 9.47) unique questions, and **9.78** (*SD* = 10.29) questions including repetitions.
- Testing Mode:

  The percentages of questions practiced in each mode:

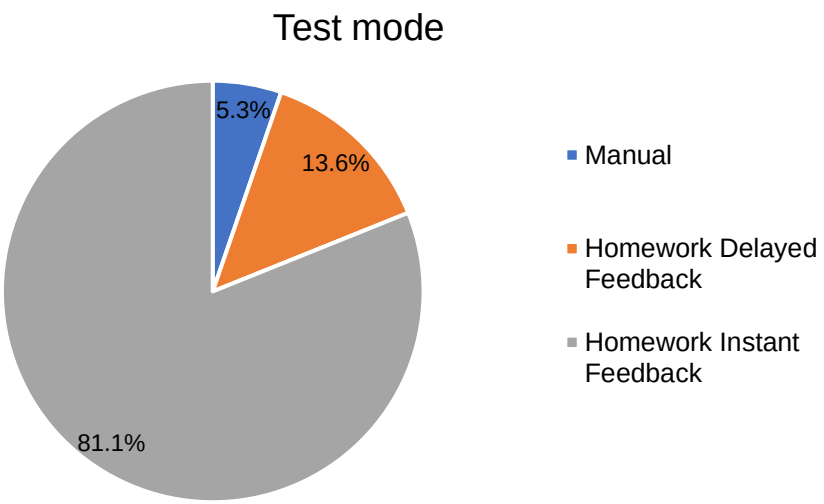


- Time Spent with the GSCE Prepper: In Group B, students spent about **15 min** trying to answer questions (including repetitions), and about **2 minutes** to read feedback.

Group C – students who use the platform sporadically

N = 1,308

- Number of questions: In Group C, on average, students attempted to respond about **42.42** (*SD* = 27.55) unique questions, and **46.22** (*SD* = 32.34) questions including repetitions (for comparison, Group A: 196.50 and 256.40, respectively).
- Testing Mode:
- The percentages of questions practiced in each mode:



- Time Spending with the GSCE Prepper: The average period of usage of the GCSE Prepper was about **12 weeks**, including about **3 active weeks** (Group A: 25 weeks, 10 active weeks). In Group C, participants spent in total about **1 hours 17 minutes** on trying to answer questions (including repetitions), and in total about **3 hours 56 minutes** to read feedback. (Group A: 5 hours 40 answering questions, 9 hours 20 minutes for feedback).

Group D – students who never accessed the platform (despite being invited to).

No data so far.

Additional Information

All	Min.	Max.	Median	Mean	Standard Dev.
number of unique questions	1	1,633	34	67.75	107.32
number of questions including repetitions in subsequent sessions	1	8,295	38	83.07	225.98
total time spent on responding answers (sec.)	4	456,356	3,173	7,153.00	15,622.62
total time spent on reading feedback (sec.)	0	6,182,584	333	14,748.00	224,903.40
total number of days (from firts to last log in)	1	729	49	77.47	87.36
total number of weeks (from first to last log in)	1	105	8	11.88	12.47
active weeks	1	44	3	4.20	4.03

Group A					
number of unique questions	51	1633	150	196.50	167.35
number of questions including repetitions in subsequent sessions	51	8295	169	256.40	434.25
total time spent on responding answers (sec.)	1,705	456,356	15,073	20,463.00	25,056.56
total time spent on reading feedback (sec.)	0	4,457,340	1,608	33,682.00	297,587.20
total number of days (from firts to last log in)	47	729	154	171.10	90.23
total number of weeks (from first to last log in)	8	105	23	25.24	12.91
active weeks	2	44	9	9.80	4.56

Group B					
number of unique questions	1	86	7	9.41	9.47
number of questions including repetitions in subsequent sessions	1	90	7	9.78	10.29
total time spent on responding answers (sec.)	4	8,396	629	903.90	936.64
total time spent on reading feedback (sec.)	0	2,039	56	110.70	182.92

Group C	Min.	Max.	Median	Mean	Standard Dev.

number of unique questions	2	276	37	42.42	27.55
number of questions including repetitions in subsequent sessions	2	278	40	46.22	32.34
total time spent on responding answers (sec.)	40	346,328	3,374	4,647.00	10,085.48
total time spent on reading feedback (sec.)	0	6,182,584	355	14,176.00	245,542.60
total number of days (from firts to last log in)	2	655	56	76.77	67.43
total number of weeks (from first to last log in)	1	94	9	11.77	9.63
active weeks	1	13	3	3.44	1.81

Analysis of Questions Repeated Three Times

Graph from Cepeda et al. (2008).

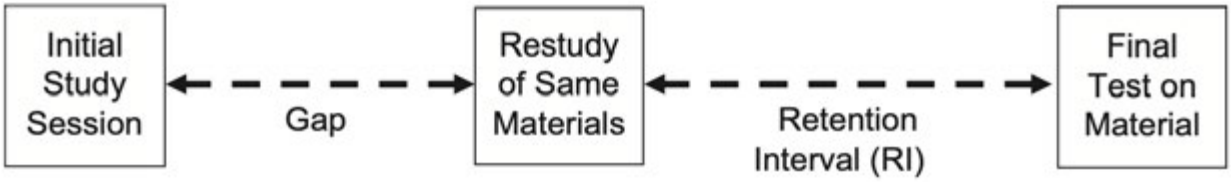


Fig. 1. Structure of a typical study of spacing effects on learning. Study episodes are separated by a varying gap, and the final study episode and test are separated by a fixed retention interval.

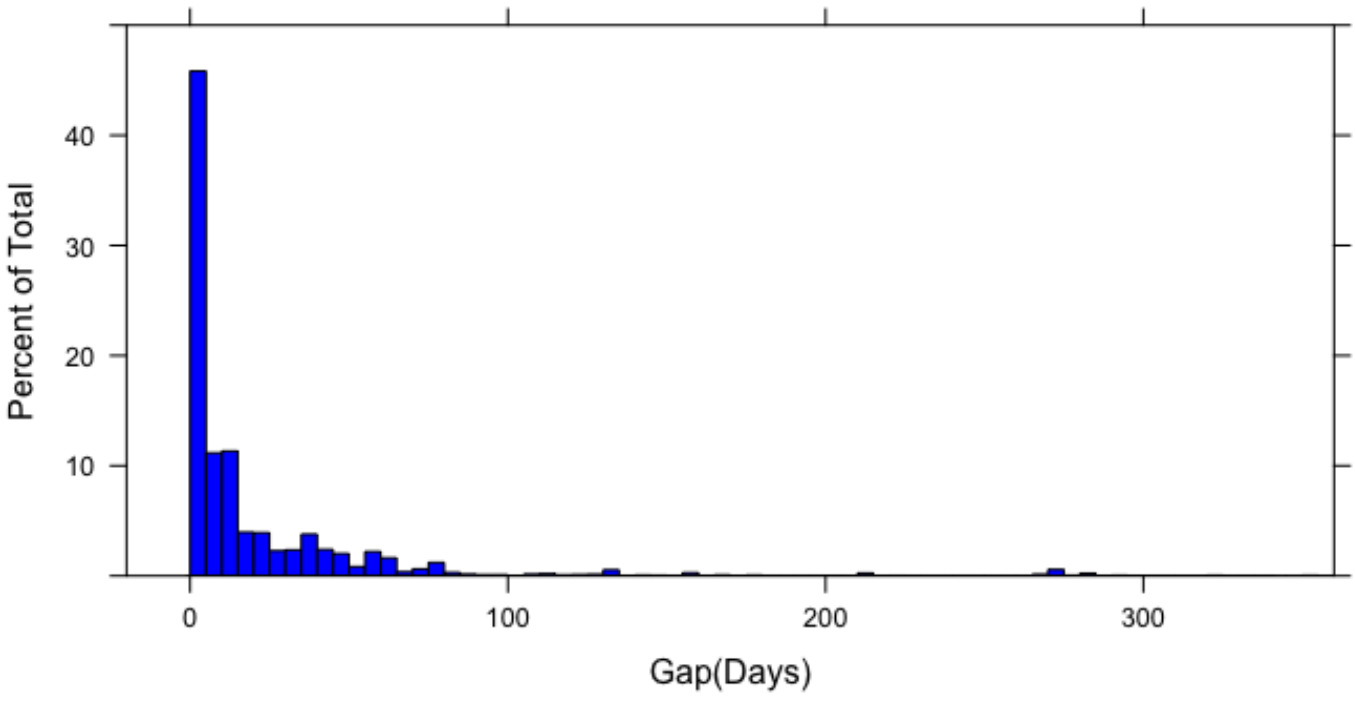
ALL QUESTIONS INCLUDED

The total number of questions in each session and a test: 7,175

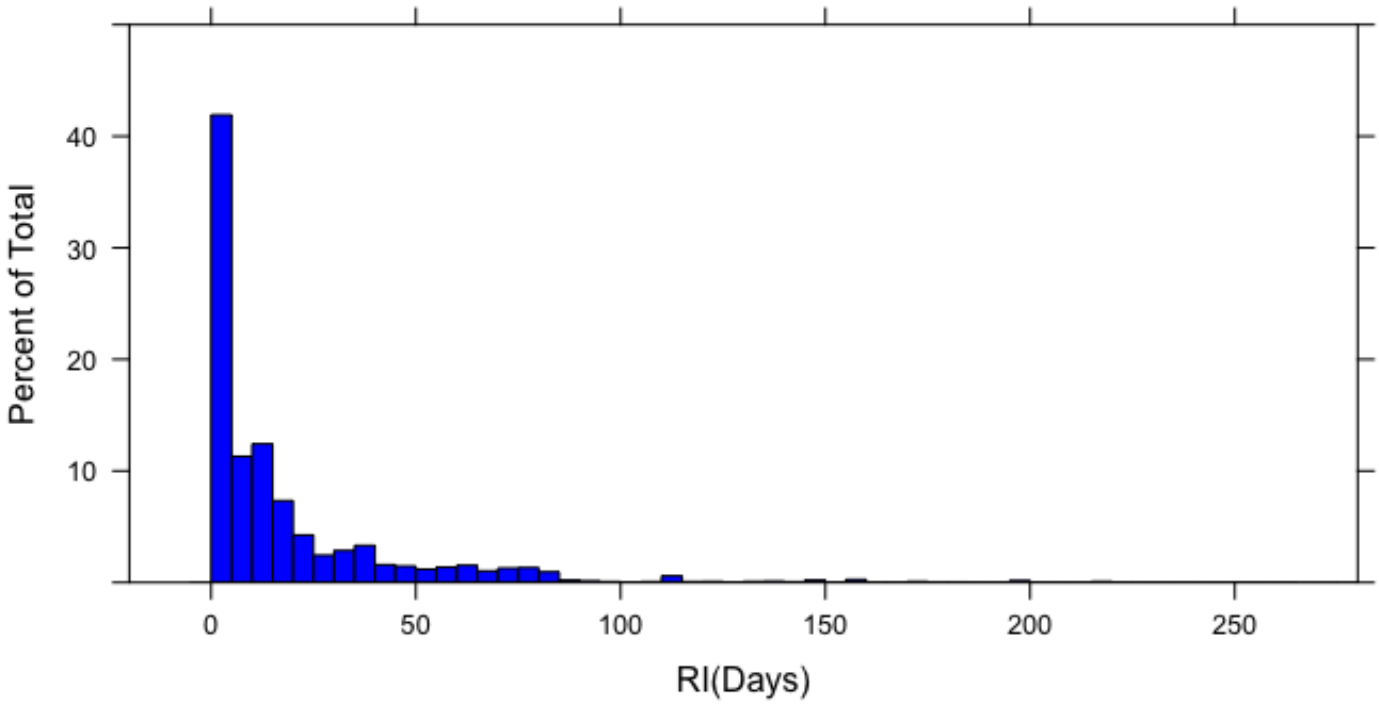
The number of unique questions: 1,833s

	Median	Mean	SD	1st Qu.	3rd Qu.	Min.	Max.
Initial Session Accuracy	100.00	64.93	41.76	20.00	100.00	0.00	100.00
Restudy Session Accuracy	100.00	70.06	40.27	50.00	100.00	0.00	100.00
Final Test Accuracy	100.00	72.16	39.81	50.00	100.00	0.00	100.00
Gap (days)	7.00	21.12	39.92	1.00	24.00	0.00	352.00
RI (days)	8.0	18.7	27.73	1.0	22.0	0.0	227.0

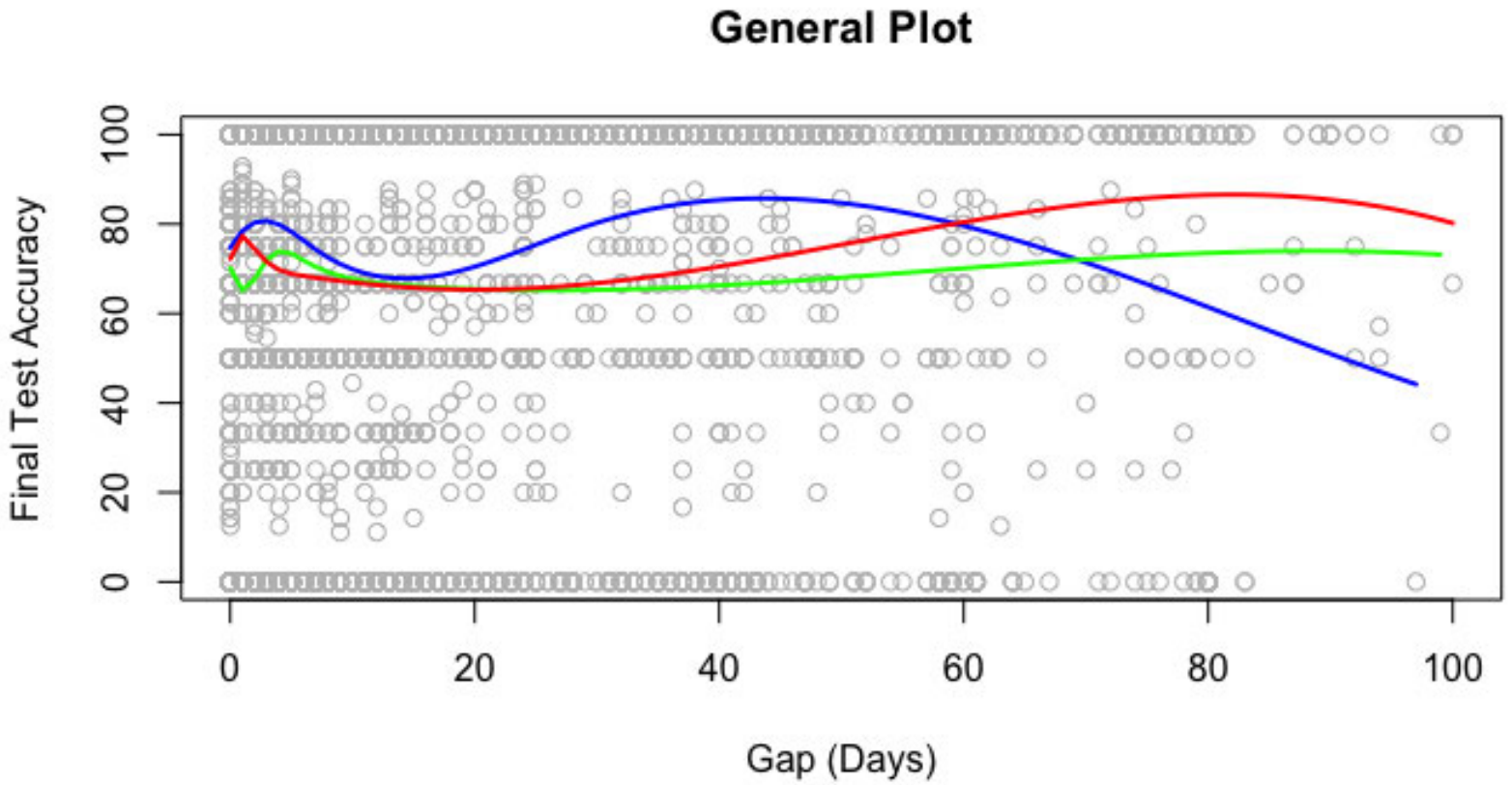
28% of questions were restudied the same day



27-28% of questions were tested the same day as their last repetition

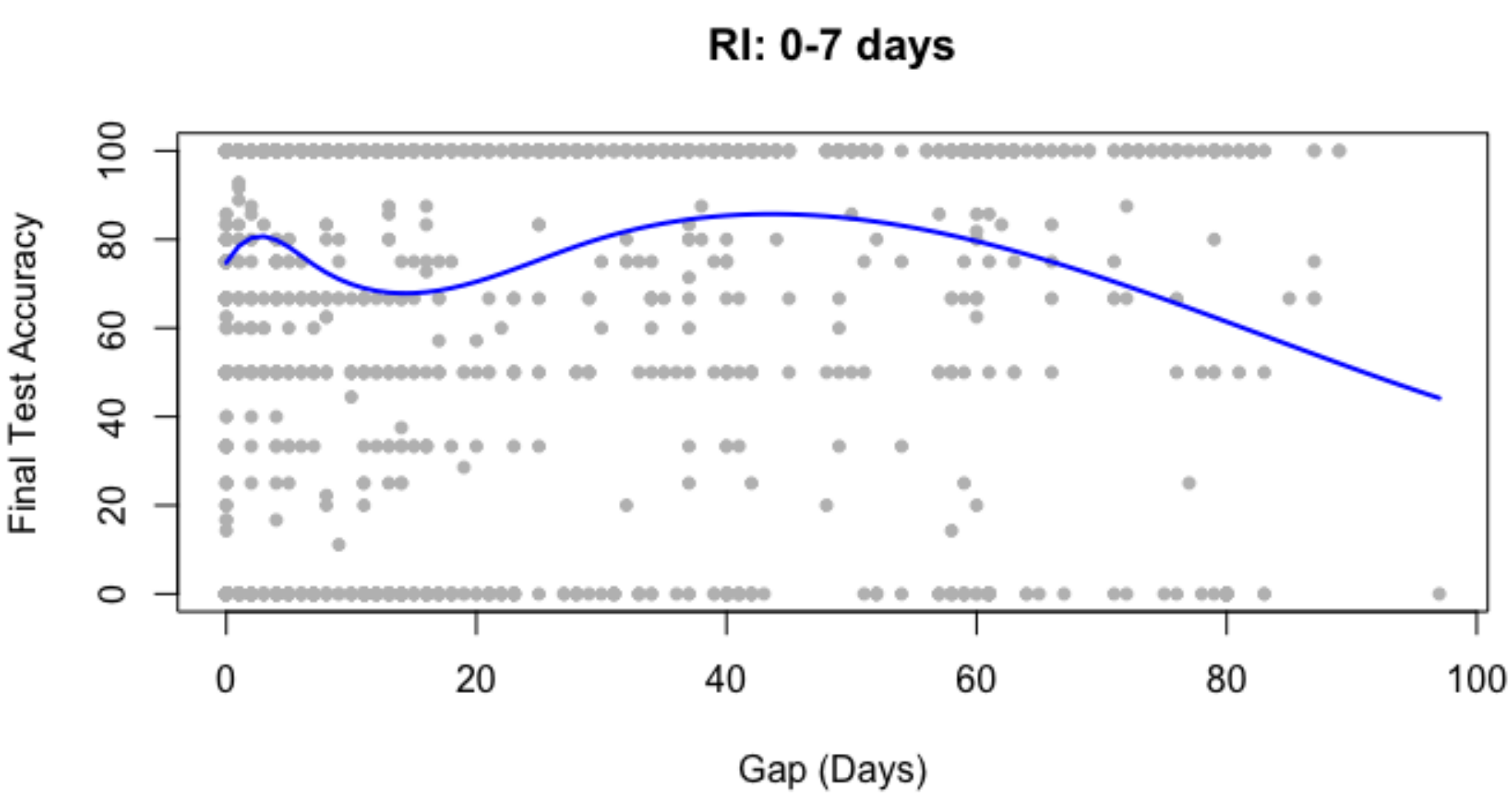


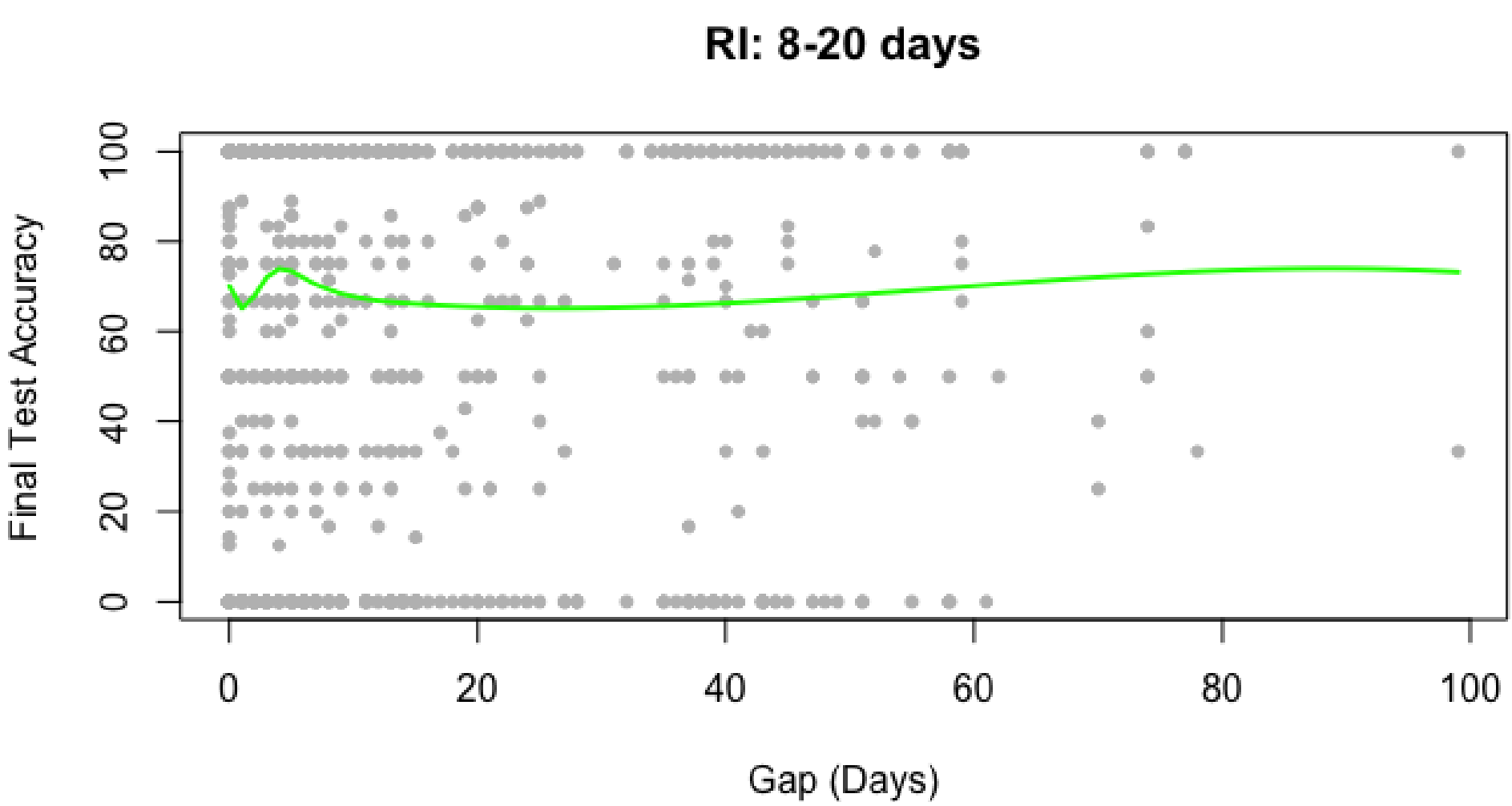
100-days gaps and RIs datapoints

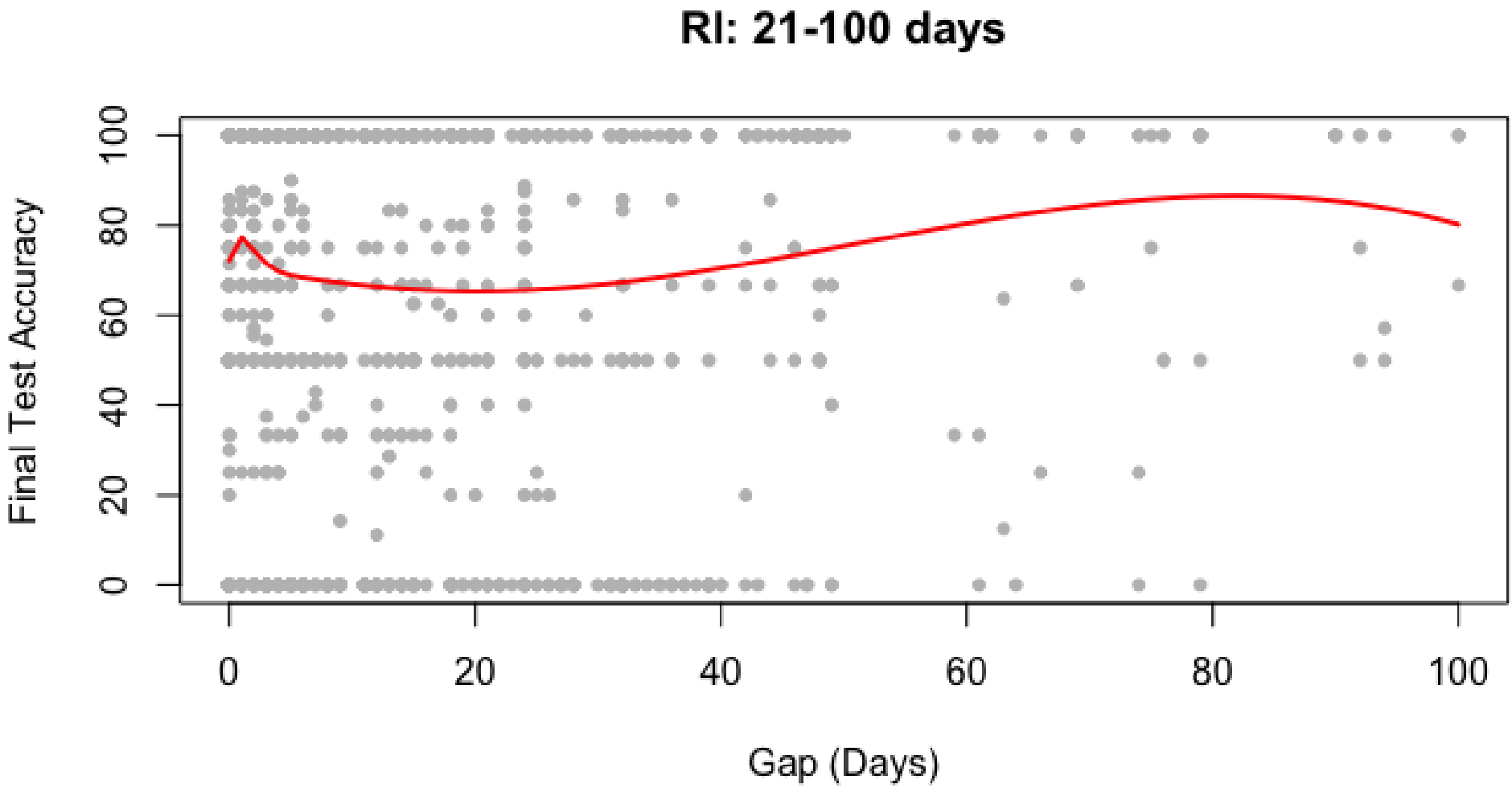


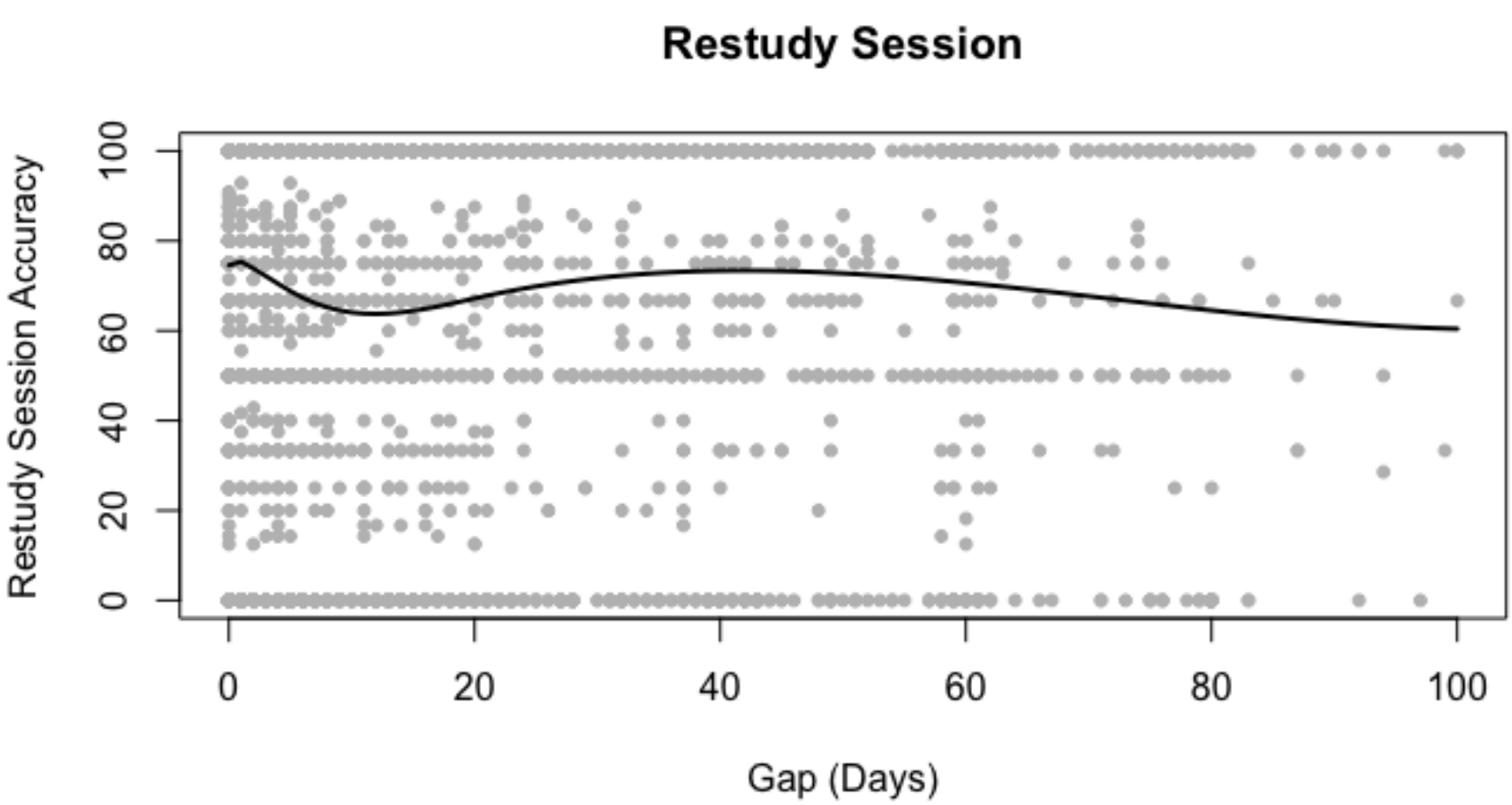
RI:

- 0-7 days
- 8-20 days
- 21-100 days


RI: 0-7 days
Final Test Accuracy
0
20
40
60
80
100
0
20
40
60
80
100
Gap (Days)


RI: 8-20 days
Final Test Accuracy
0
20
40
60
80
100
0
20
40
60
80
100
Gap (Days)


RI: 21-100 days
Final Test Accuracy
0
20
40
60
80
100
Gap (Days)


Restudy Session
Restudy Session Accuracy
0
20
40
60
80
100
Gap (Days)

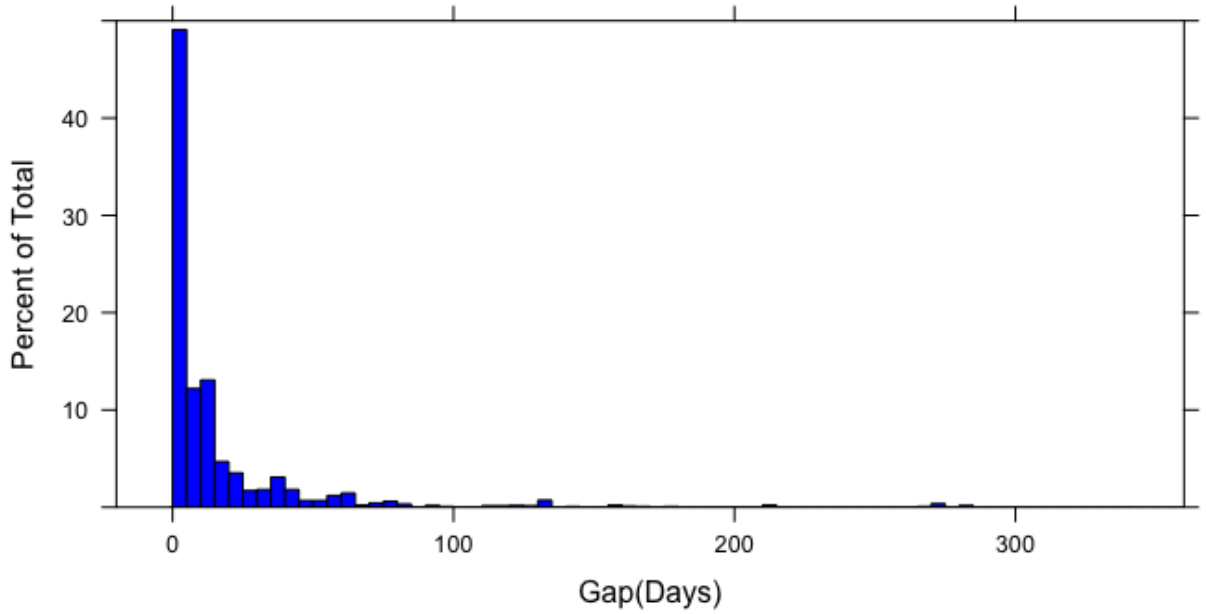
CONTROLLED ACCURACY ON THE INITIAL STUDY SESSION (deleted questions with more than 50% accuracy on the initial study session)

The total number of questions in each session and a test: 2,746

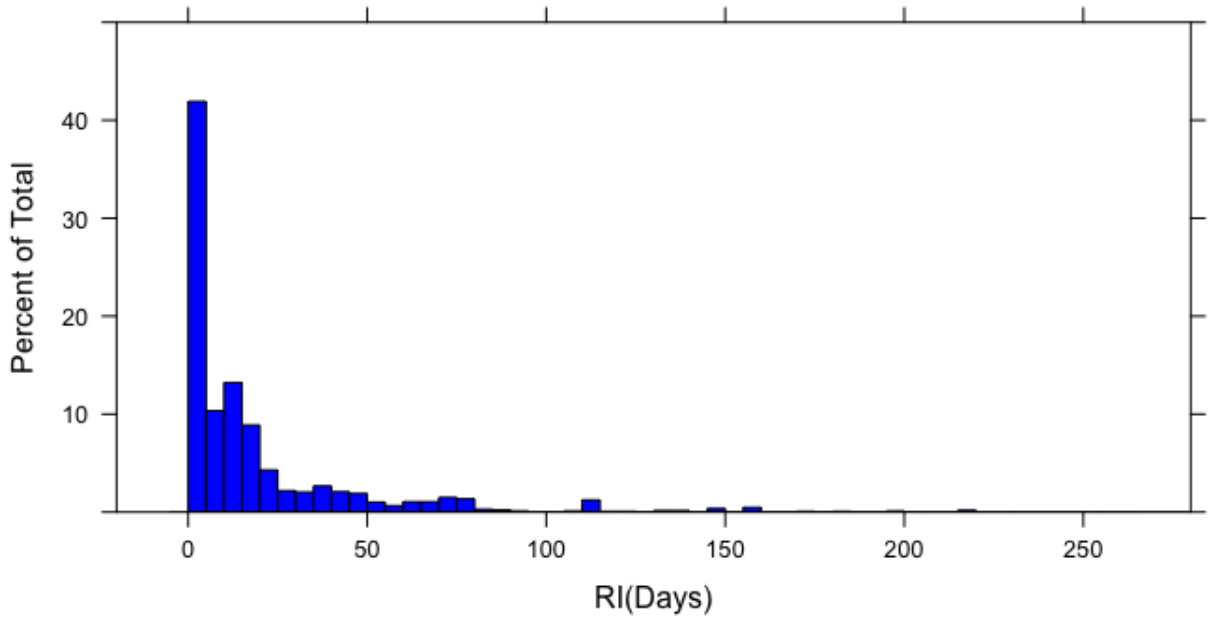
The number of unique questions: 1,079

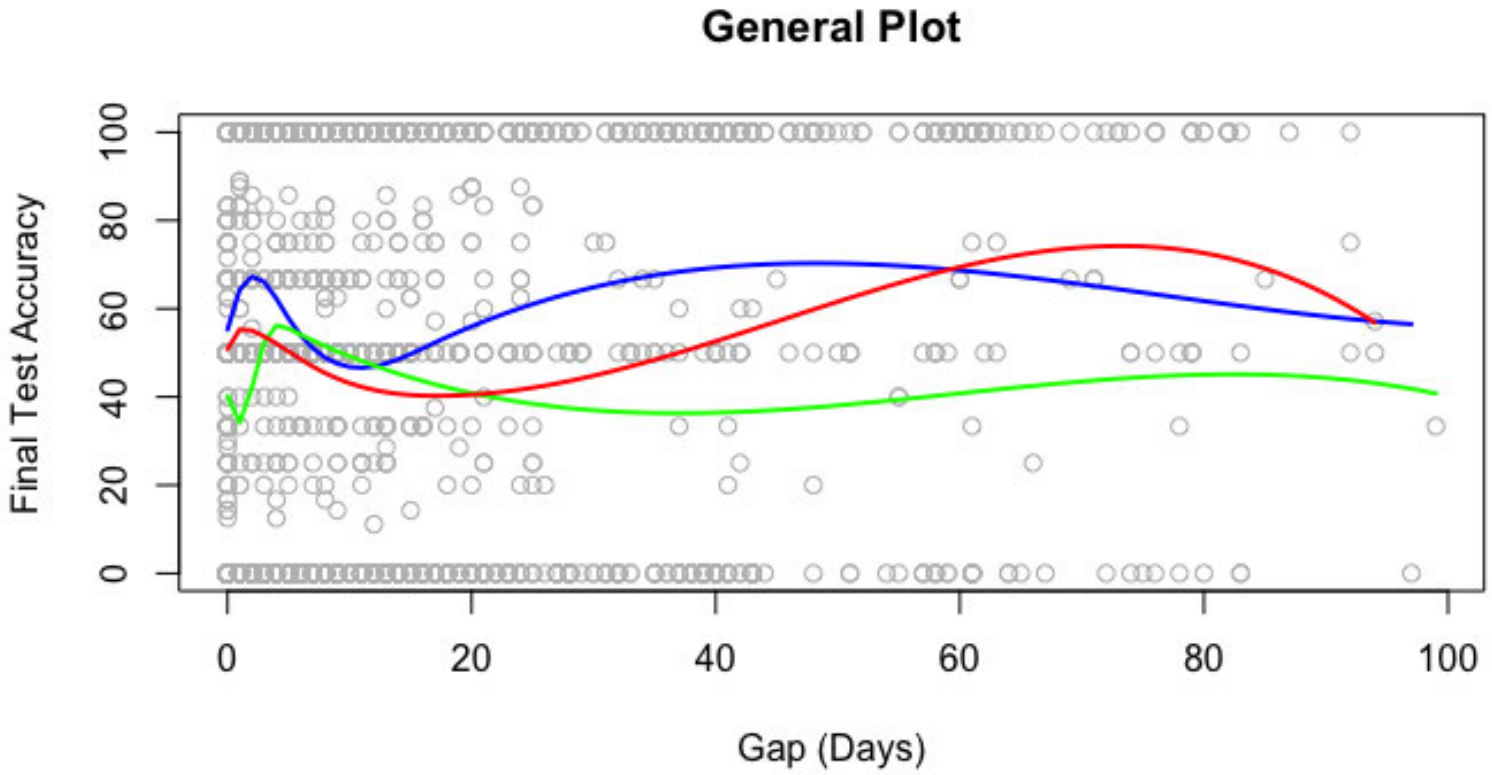
	Median	Mean	SD	1st Qu.	3rd Qu.	Min.	Max.
Initial Session Accuracy	0.00	15.96	21.81	0.00	40.00	0.00	50.00
Restudy Session Accuracy	50.00	47.85	43.27	0.00	100.00	0.00	100.00
Final Test Accuracy	50.00	51.96	44.13	0.00	100.00	0.00	100.00
Gap (days)	6.00	17.16	34.54	1.00	16.00	0.00	325.00
RI (days)	9.00	19.14	29.85	1.00	21.00	0.0	227.0

32% of questions were restudied the same day



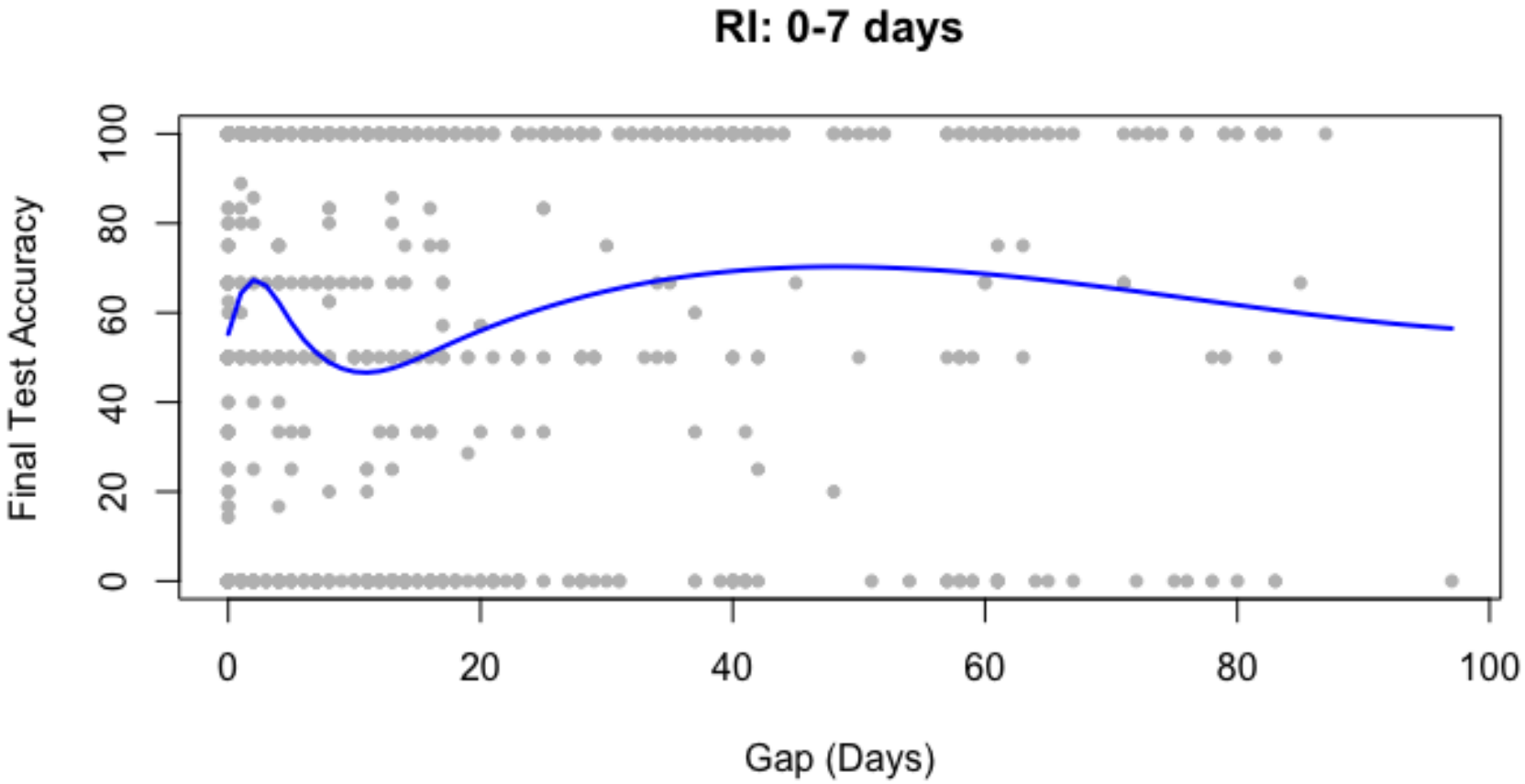
28% of questions were tested the same day as their last repetition

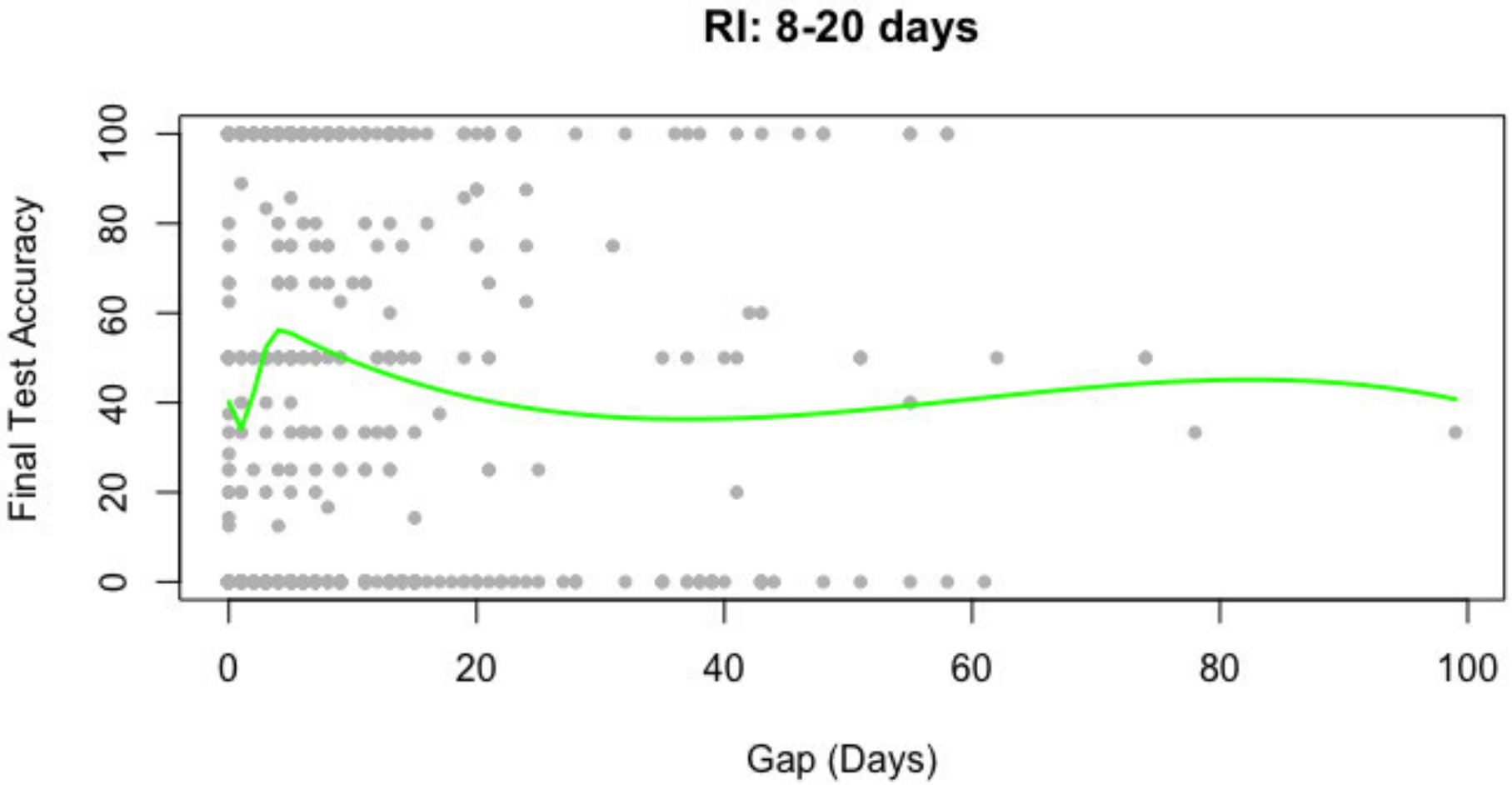


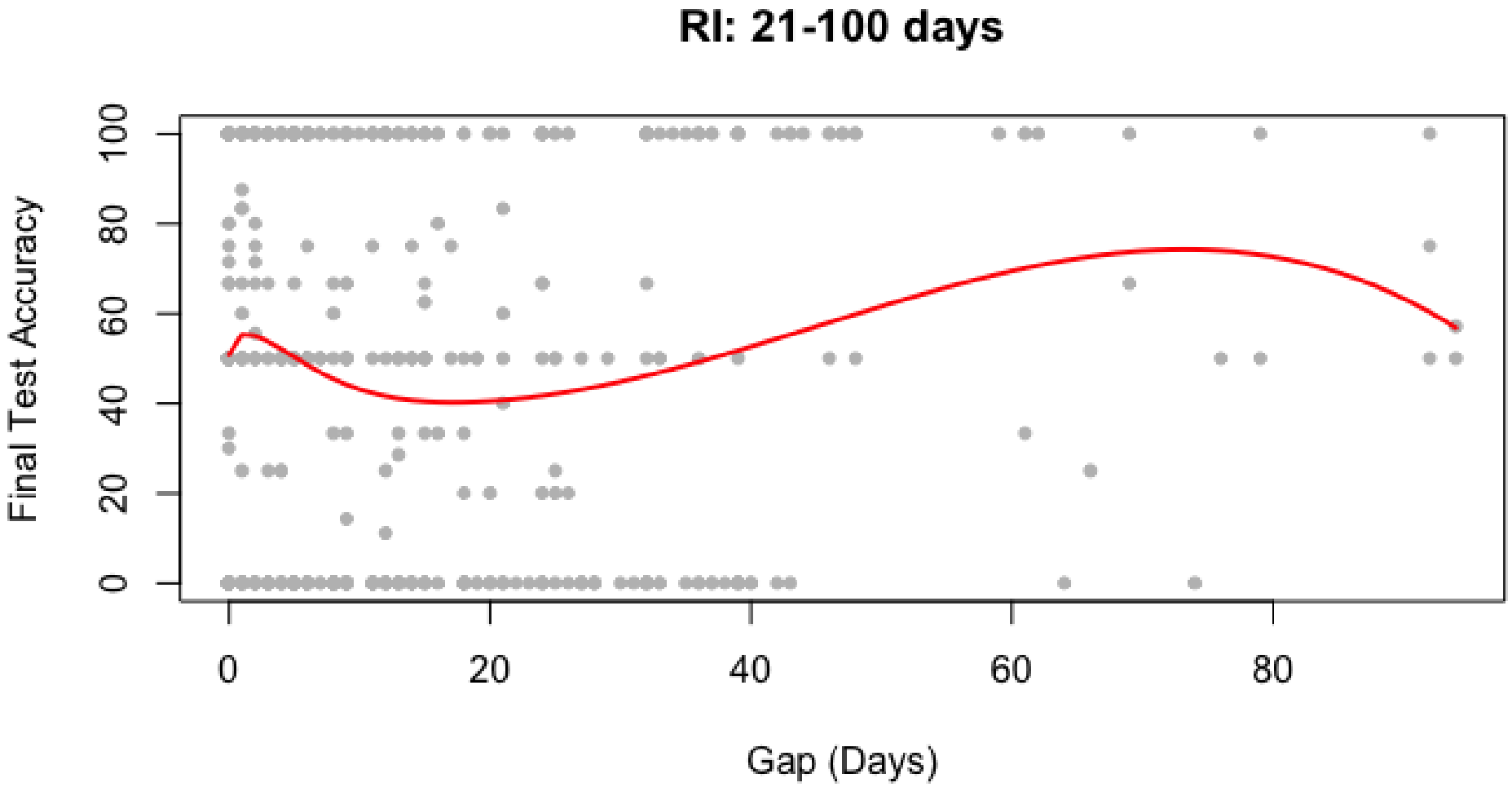


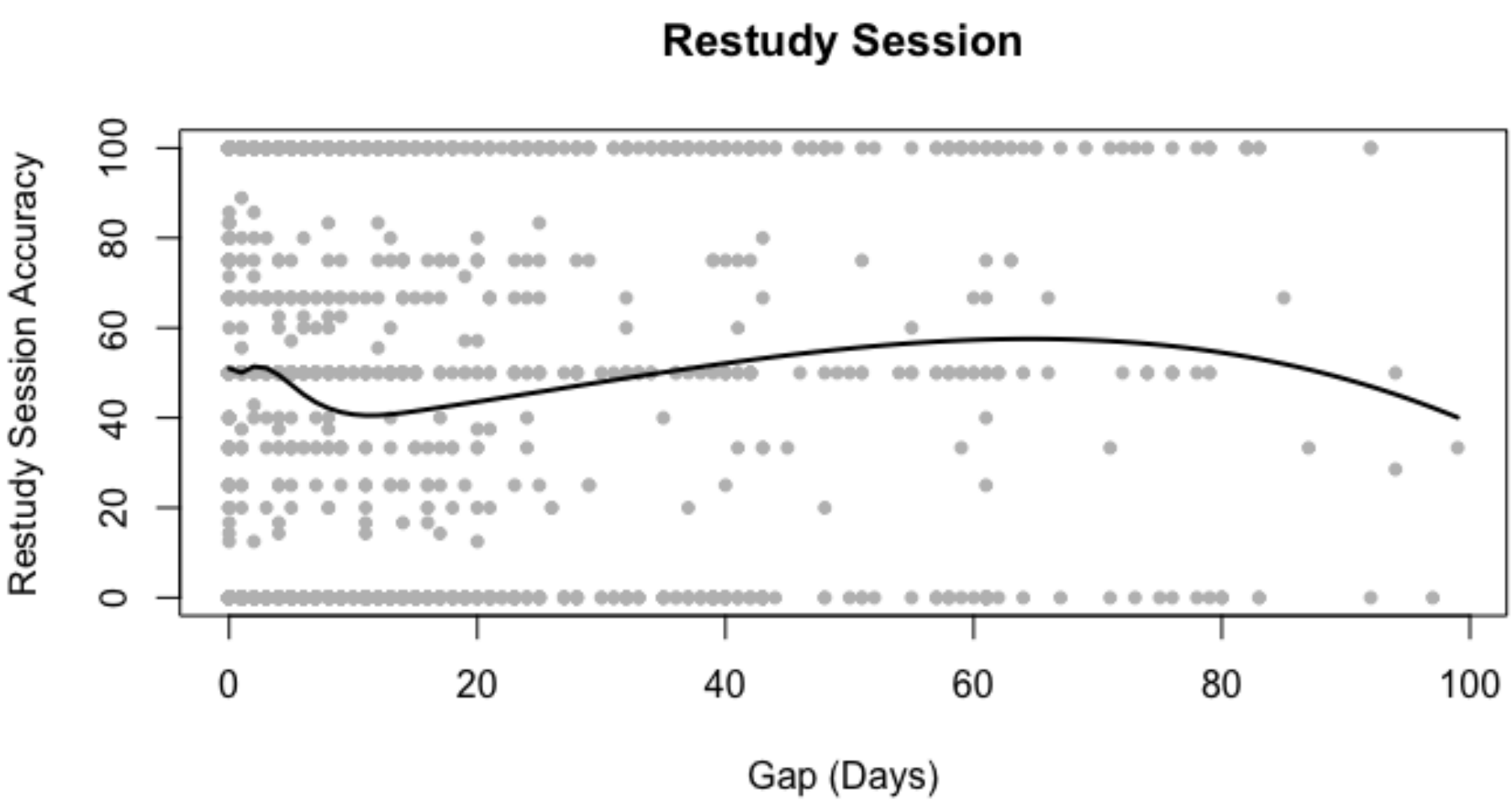
RI:

- 0-7 days
- 8-20 days
- 21-100 days


RI: 0-7 days
Final Test Accuracy
0
20
40
60
80
100
Gap (Days)


RI: 8-20 days
Final Test Accuracy
0
20
40
60
80
100
Gap (Days)


RI: 21-100 days
Final Test Accuracy
0
20
40
60
80
100
0
20
40
60
80
Gap (Days)


Restudy Session
Restudy Session Accuracy
0
20
40
60
80
100
Gap (Days)

CONTROLLED ACCURACY ON THE INITIAL STUDY SESSION (deleted questions with more than 50% accuracy on the initial study session) AND DELETED 0-SEC. QUESTIONS

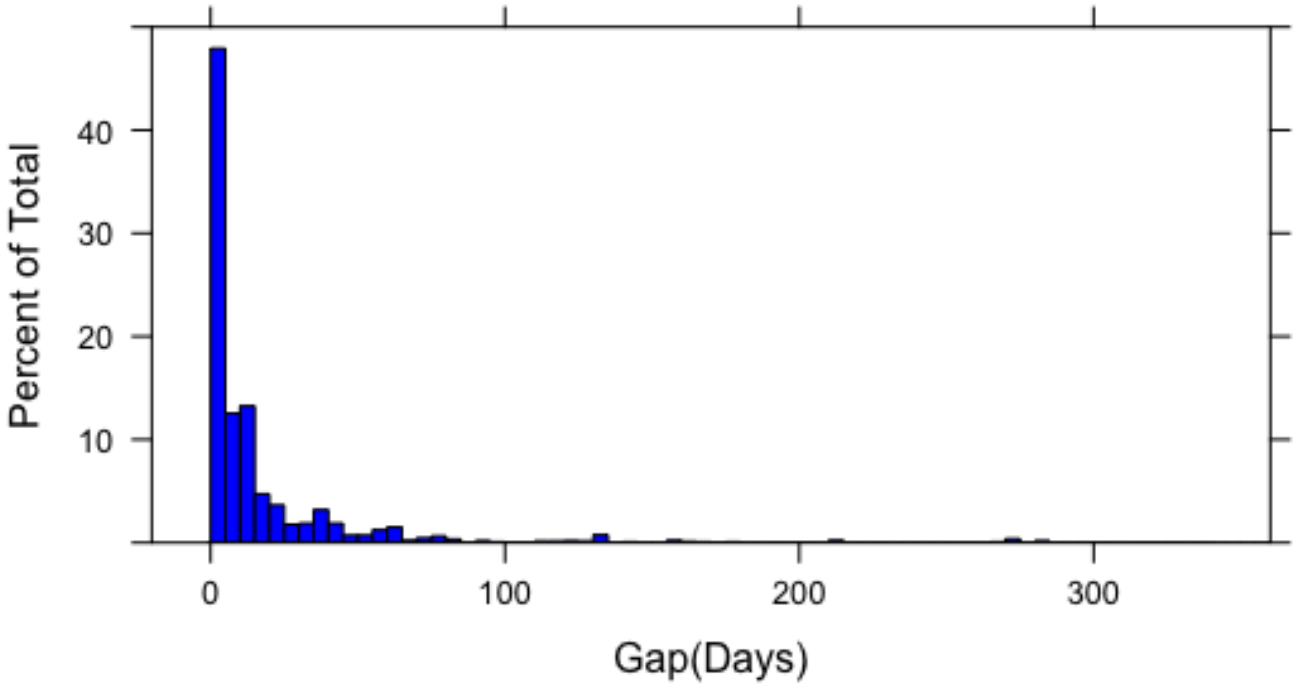
Subjects: 277

The total number of questions in each session and a test: 2,665

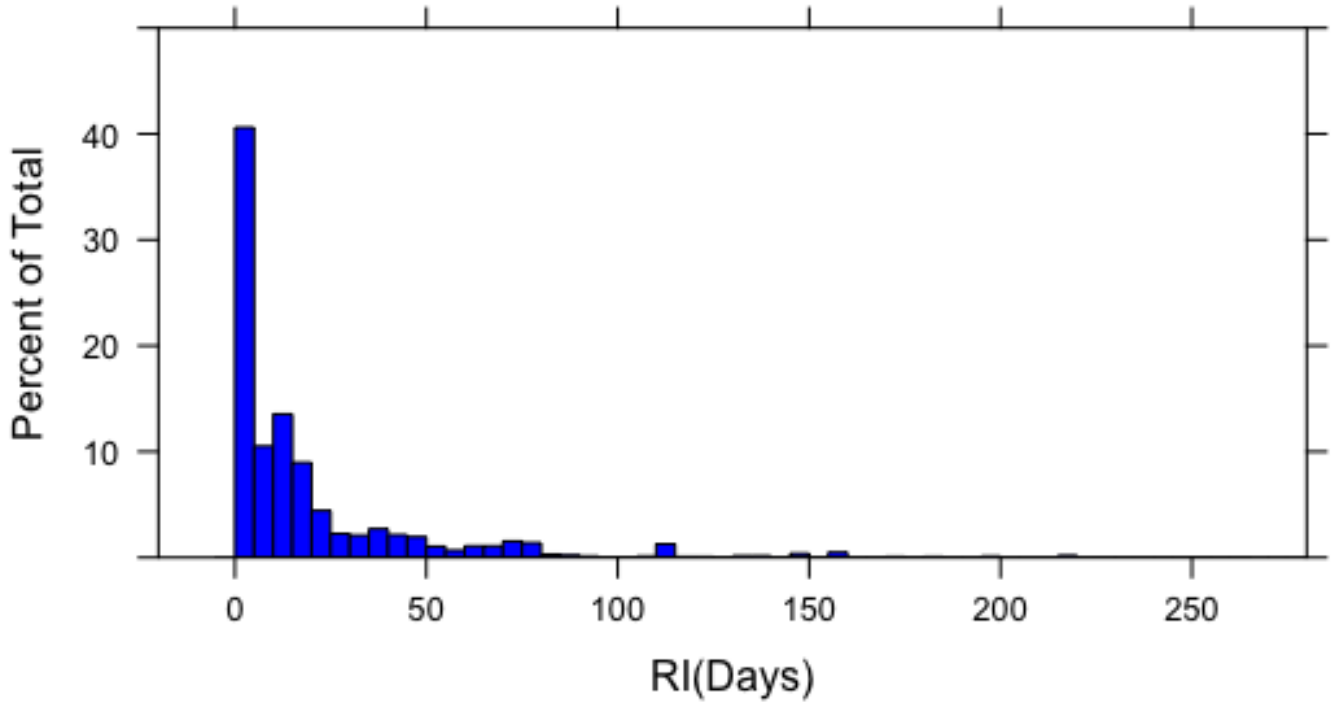
The number of unique questions: 1,040

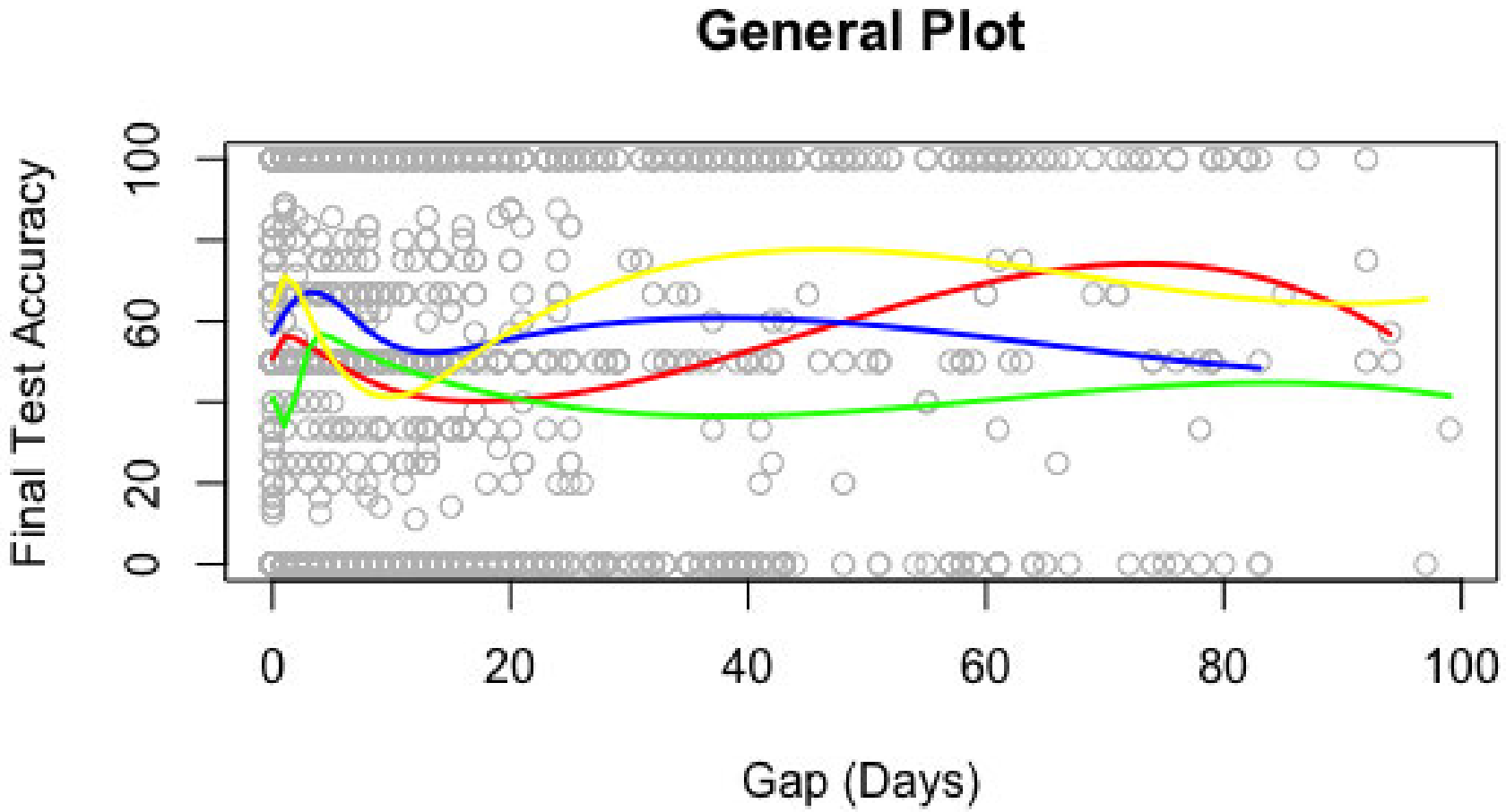
	Median	Mean	SD	1st Qu.	3rd Qu.	Min.	Max.
Initial Session Accuracy	0.00	16.40	21.94	0.00	50.00	0.00	50.00
Restudy Session Accuracy	50.00	48.15	43.13	0.00	100.00	0.00	100.00
Final Test Accuracy	50.00	53.16	43.91	0.00	100.00	0.00	100.00
Gap (days)	6.00	17.62	34.96	1.00	17.00	0.00	325.00
RI (days)	10.00	19.61	30.15	1.00	22.00	0.00	227.00

29% of questions were restudied the same day



27% of questions were tested the same day as their last repetition

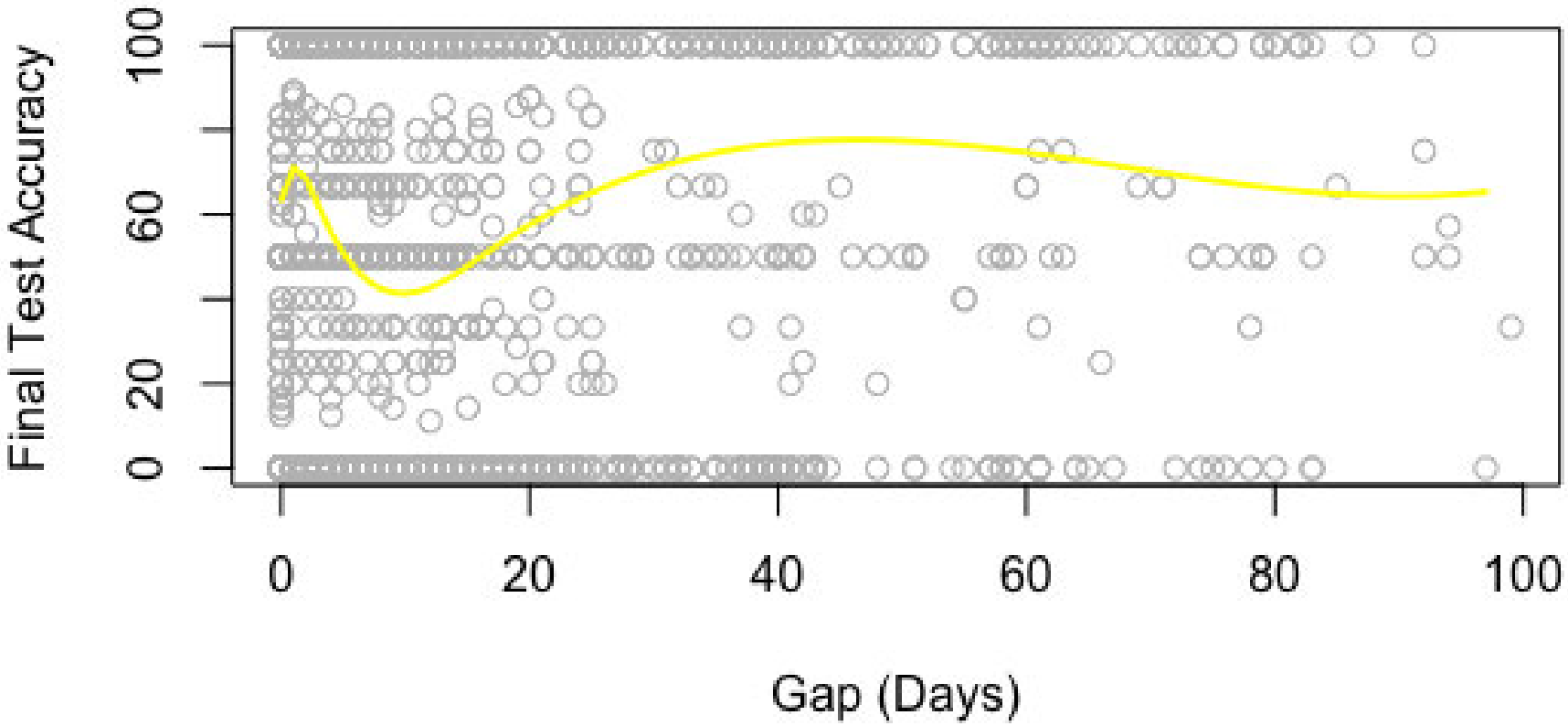




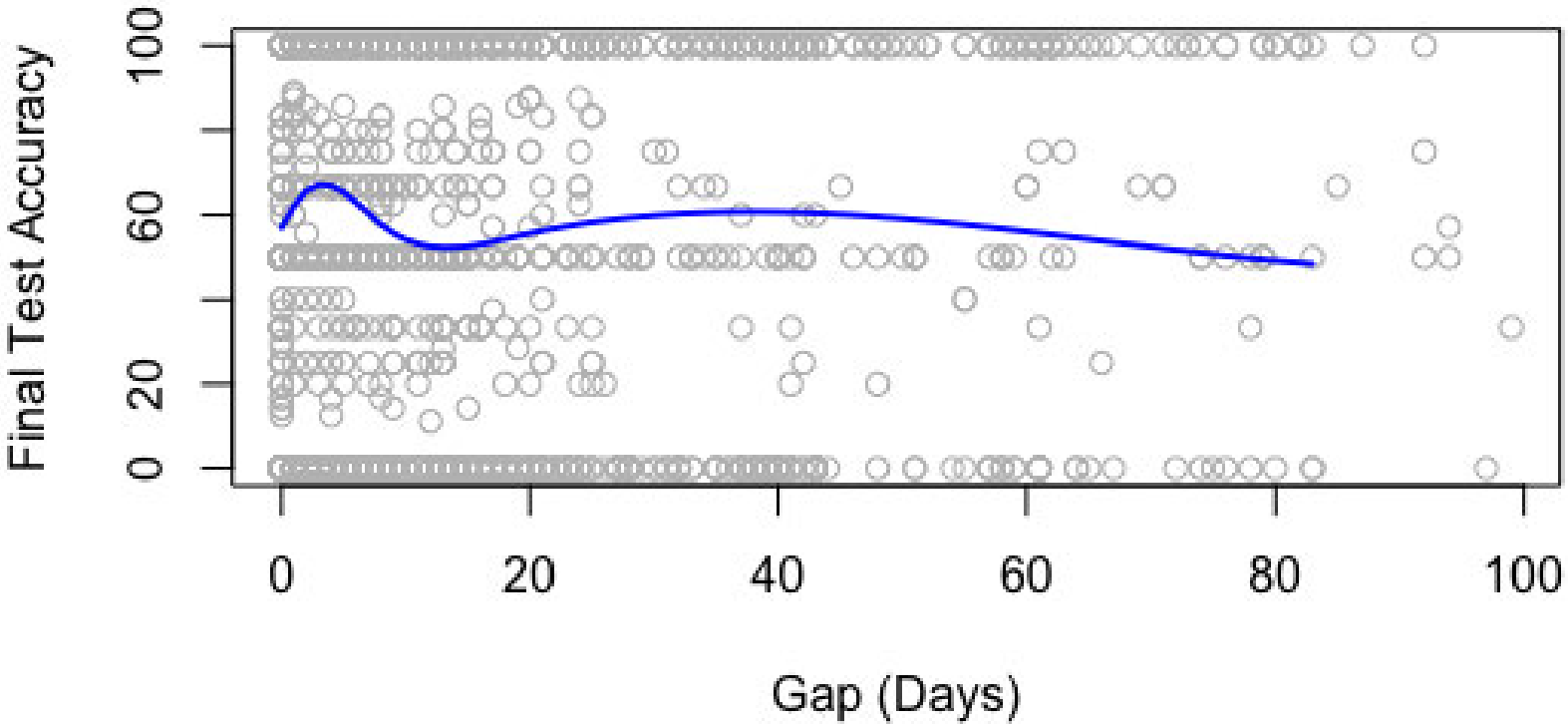
RI:

- 1 day
- 2-7 days
- 8-20 days
- 21-100 days

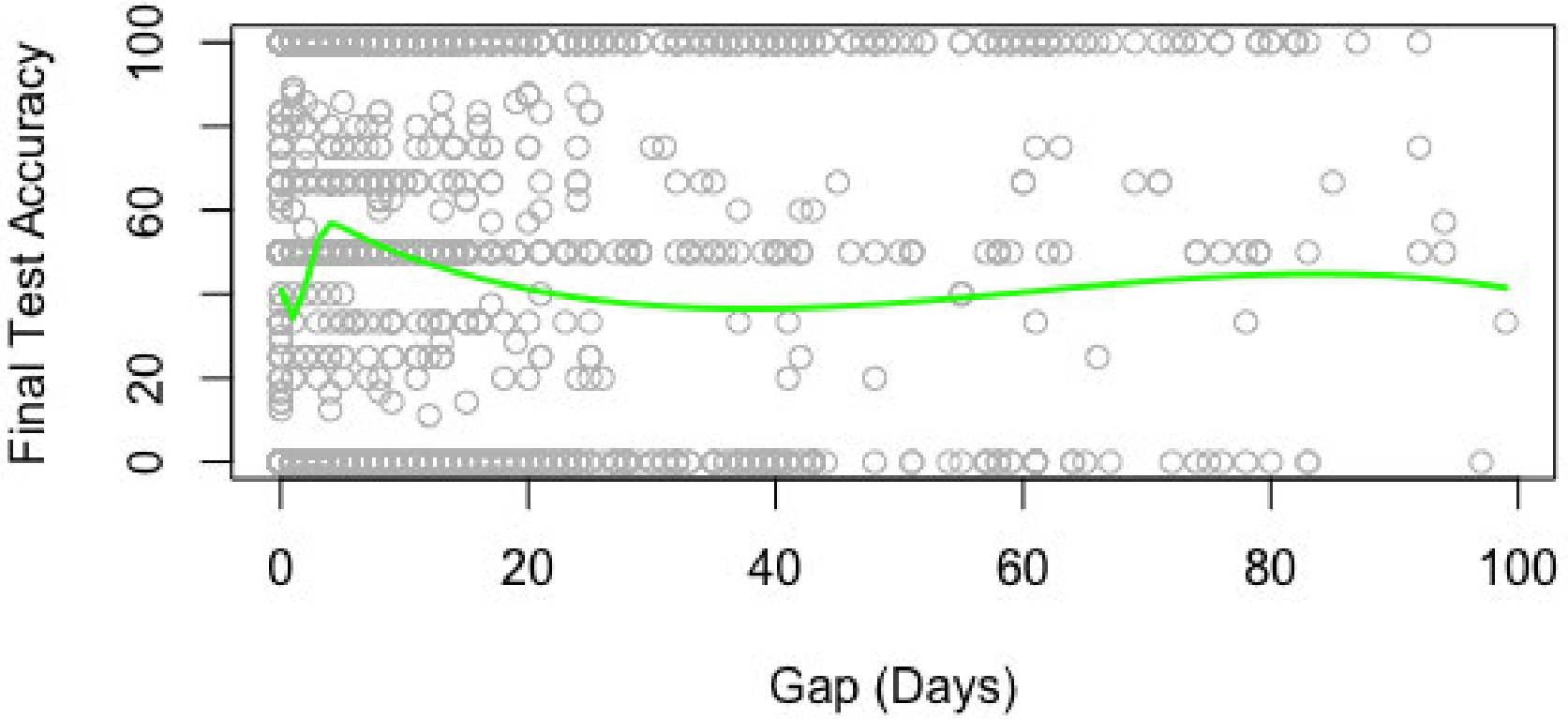
RI: 1 day



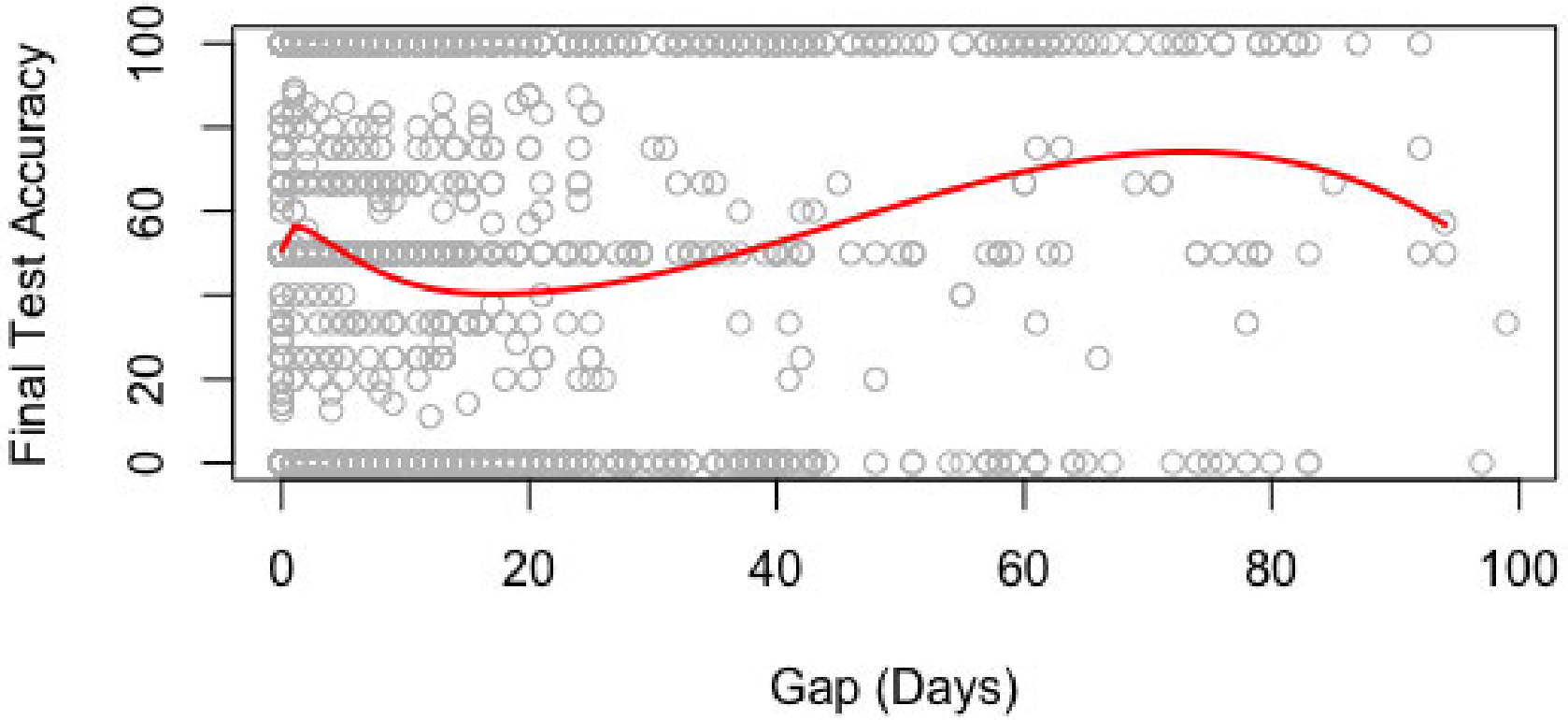
RI: 2-7 days



RI: 8-20 days



RI: 21-100 days



ALL QUESTIONS INCLUDED

Intact dataset:

```
> summary(lmer(accuracy_session_3 ~ GAP*RI + (GAP*RI|Student_ID), data = report))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAP * RI + (GAP * RI | Student_ID)
   Data: report

REML criterion at convergence: 73551.9

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.9247 -0.4699  0.3402  0.6154  2.6855

Random effects:
 Groups     Name        Variance  Std.Dev. Corr
 Student_ID (Intercept) 1214.1327 34.8444
            GAP          268.0455 16.3721  -0.01
            RI           267.7851 16.3641   0.00  0.00
            GAP:RI         0.4514  0.6719   0.00 -0.69 -0.72
 Residual               1094.6718 33.0858
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
             Estimate Std. Error t value
(Intercept) 66.359014   3.198576  20.746
GAP         -0.001084   1.120366  -0.001
RI          -0.307924   1.145013  -0.269
GAP:RI       0.007343   0.045918   0.160

Correlation of Fixed Effects:
       (Intr) GAP    RI
GAP    -0.114
RI     -0.123 -0.028
GAP:RI  0.159 -0.672 -0.721
fit warnings:
Some predictor variables are on very different scales: consider rescaling
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

Logarithmic transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPlog*RIlog + (GAPlog*RIlog|Student_ID), data = report))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPlog * RIlog + (GAPlog * RIlog | Student_ID)
   Data: report

REML criterion at convergence: 71689.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.7029 -0.5306  0.3609  0.6240  2.5810

Random effects:
 Groups     Name         Variance Std.Dev. Corr
 Student_ID (Intercept)   896.633 29.944
            GAPlog         22.267  4.719   -0.61
            RIlog          29.003  5.385   -0.37  0.89
            GAPlog:RIlog    1.184  1.088   -0.03 -0.59 -0.89
 Residual                1171.865 34.233
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
             Estimate Std. Error t value
(Intercept)   67.8965     2.7905  24.331
GAPlog         0.4839     0.7687   0.630
RIlog         -1.6577     0.8993  -1.843
GAPlog:RIlog  -0.2825     0.2766  -1.021

Correlation of Fixed Effects:
            (Intr) GAPlog RIlog
GAPlog      -0.748
RIlog       -0.668  0.737
GAPlog:RIlg  0.429 -0.691 -0.819
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

Square-root transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPsqrt*RIsqrt + (GAPsqrt*RIsqrt|Student_ID), data = report))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPsqrt * RIsqrt + (GAPsqrt * RIsqrt | Student_ID)
   Data: report

REML criterion at convergence: 71693.2

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.7235 -0.5291  0.3469  0.6313  2.4973

Random effects:
 Groups     Name           Variance  Std.Dev. Corr
 Student_ID (Intercept)    8.559e+02 29.2557
            GAPsqrt        6.049e+00  2.4594  -0.67
            RIsqrt         6.892e+00  2.6252  -0.34  0.92
            GAPsqrt:RIsqrt 3.739e-02  0.1934  -0.19 -0.57 -0.85
 Residual                  1.172e+03 34.2371
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
             Estimate Std. Error t value
(Intercept)  67.79615    2.46276  27.529
GAPsqrt       0.11869    0.36165   0.328
RIsqrt       -1.05019    0.39667  -2.647
GAPsqrt:RIsqrt -0.05118    0.06106  -0.838

Correlation of Fixed Effects:
            (Intr) GAPsqr RIsqrt
GAPsqrt     -0.726
RIsqrt      -0.621  0.768
GAPsqrt:RIs  0.307 -0.639 -0.684
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

Intact dataset:

```
> summary(lmer(accuracy_session_3 ~ GAP*RI + GAPx2 +(GAP*RI|Student_ID), data = report))
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAP * RI + GAPx2 + (GAP * RI | Student_ID)
   Data: report

REML criterion at convergence: 73579.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.9315 -0.4695  0.3419  0.6217  2.6873

Random effects:
 Groups     Name        Variance  Std.Dev. Corr
 Student_ID (Intercept) 1226.1777 35.0168
            GAP          274.6257 16.5718  -0.02
            RI           277.5433 16.6596  -0.05  0.02
            GAP:RI         0.6268  0.7917   0.04 -0.66 -0.76
 Residual               1094.8265 33.0882
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
             Estimate Std. Error t value
(Intercept) 65.8979553  3.2099339  20.529
GAP          0.0264930  1.1353488   0.023
RI          -0.1200095  1.1588361  -0.104
GAPx2        0.0001297  0.0001490   0.871
GAP:RI       0.0010173  0.0541911   0.019

Correlation of Fixed Effects:
       (Intr) GAP    RI     GAPx2
GAP    -0.120
RI     -0.139  0.006
GAPx2   0.042 -0.012 -0.001
GAP:RI  0.170 -0.650 -0.763 -0.007
fit warnings:
Some predictor variables are on very different scales: consider rescaling
optimizer (nloptwrap) convergence code: 0 (OK)
unable to evaluate scaled gradient
Model failed to converge: degenerate  Hessian with 4 negative eigenvalues
```

Logarithmic transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPlog*RIlog + GAPlogx2 +(GAPlog*RIlog|Student_ID), data = repor
t))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPlog * RIlog + GAPlogx2 + (GAPlog * RIlog |      Student_ID)
   Data: report

REML criterion at convergence: 71685.8

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.7024 -0.5357  0.3650  0.6238  2.5977

Random effects:
 Groups     Name         Variance Std.Dev. Corr
 Student_ID (Intercept)   894.261 29.904
            GAPlog         21.583  4.646   -0.60
            RIlog          28.423  5.331   -0.39  0.90
            GAPlog:RIlog    1.122  1.059   -0.05 -0.55 -0.86
 Residual                1170.671 34.215
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
             Estimate Std. Error t value
(Intercept)   67.1812     2.8036  23.962
GAPlog         2.6750     1.2553   2.131
RIlog         -1.8434     0.9027  -2.042
GAPlogx2      -0.5436     0.2430  -2.238
GAPlog:RIlog  -0.2735     0.2776  -0.985

Correlation of Fixed Effects:
            (Intr) GAPlog RIlog  GAPlg2
GAPlog      -0.543
RIlog       -0.646  0.353
GAPlogx2     0.122 -0.794  0.111
GAPlog:RIlg  0.409 -0.387 -0.809 -0.030
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

Square-root transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPsqrt*RIsqrt + GAPsqrtx2 +(GAPsqrt*RIsqrt|Student_ID), data = r
eport))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPsqrt * RIsqrt + GAPsqrtx2 + (GAPsqrt *
    RIsqrt | Student_ID)
   Data: report

REML criterion at convergence: 71696.6

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.7226 -0.5351  0.3488  0.6352  2.5091

Random effects:
 Groups     Name           Variance  Std.Dev. Corr
 Student_ID (Intercept)     881.1180 29.6836
            GAPsqrt           6.4455  2.5388  -0.68
            RIsqrt            6.5991  2.5689  -0.35  0.92
            GAPsqrt:RIsqrt    0.0319  0.1786  -0.17 -0.60 -0.86
 Residual                  1171.8389 34.2321
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
              Estimate Std. Error t value
(Intercept)    67.24751    2.49706  26.931
GAPsqrt         0.51976    0.46246   1.124
RIsqrt         -1.07200    0.38851  -2.759
GAPsqrtx2      -0.04249    0.03011  -1.412
GAPsqrt:RIsqrt -0.04360    0.05998  -0.727

Correlation of Fixed Effects:
            (Intr) GAPsqr RIsqrt GAPsq2
GAPsqrt     -0.646
RIsqrt      -0.601  0.540
GAPsqrtx2    0.112 -0.614  0.136
GAPsqrt:RIs  0.288 -0.424 -0.681 -0.137
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

CONTROLLED ACCURACY ON THE INITIAL STUDY SESSION (deleted questions with more than 50% accuracy on the initial study session) AND DELETED 0-SEC. QUESTIONS

Intact dataset:

```
> summary(lmer(accuracy_session_3 ~ GAP*RI + (GAP*RI|Student_ID), data = report))
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAP * RI + (GAP * RI | Student_ID)
   Data: report

REML criterion at convergence: 28634.7

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.38948 -0.68397  0.00413  0.83093  2.56955

Random effects:
 Groups     Name        Variance  Std.Dev. Corr
 Student_ID (Intercept) 1231.0207 35.0859
            GAP          236.0023 15.3624  -0.07
            RI           288.4559 16.9840  -0.09  0.00
            GAP:RI         0.7067  0.8407   0.10 -0.56 -0.82
 Residual               1248.9539 35.3405
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
            Estimate Std. Error t value
(Intercept) 53.79296    4.03532  13.331
GAP          0.46939    1.21759   0.386
RI          -0.14557    1.32518  -0.110
GAP:RI      -0.01366    0.06596  -0.207

Correlation of Fixed Effects:
       (Intr) GAP    RI
GAP    -0.181
RI     -0.176  0.004
GAP:RI  0.227 -0.571 -0.822
```

Logarithmic transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPlog*RIlog + (GAPlog*RIlog|Student_ID), data = repor
t))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPlog * RIlog + (GAPlog * RIlog | Student_ID)
   Data: report

REML criterion at convergence: 27274.3

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.26765 -0.83137  0.04067  0.82925  2.17881

Random effects:
 Groups     Name         Variance Std.Dev. Corr
 Student_ID (Intercept)   840.464 28.991
            GAPlog         18.011  4.244   -0.51
            RIlog          51.877  7.203   -0.61  0.95
            GAPlog:RIlog    1.973  1.405   -0.08 -0.70 -0.73
 Residual                1455.332 38.149
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
             Estimate Std. Error t value
(Intercept)   52.8630     3.7895  13.950
GAPlog         1.5552     1.1753   1.323
RIlog         -1.6038     1.3713  -1.170
GAPlog:RIlog  -0.7367     0.4667  -1.579

Correlation of Fixed Effects:
            (Intr) GAPlog RIlog
GAPlog      -0.705
RIlog       -0.768  0.681
GAPlog:RIlg  0.476 -0.774 -0.770
```

Square-root transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPsqrt*RIsqrt + (GAPsqrt*RIsqrt|Student_ID), data = report))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPsqrt * RIsqrt + (GAPsqrt * RIsqrt | Student_ID)
   Data: report

REML criterion at convergence: 27281.5

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.29629 -0.82675  0.03268  0.82920  2.22578

Random effects:
 Groups     Name           Variance  Std.Dev. Corr
 Student_ID (Intercept)    7.669e+02 27.6932
            GAPsqrt        3.459e+00  1.8597  -0.60
            RIsqrt         1.091e+01  3.3035  -0.58  0.98
            GAPsqrt:RIsqrt 6.645e-02  0.2578  -0.28 -0.53 -0.61
 Residual                  1.458e+03 38.1791
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
              Estimate Std. Error t value
(Intercept)    52.6882     3.1678  16.632
GAPsqrt         0.5710     0.5183   1.102
RIsqrt         -1.0195     0.6107  -1.670
GAPsqrt:RIsqrt -0.1577     0.1111  -1.419

Correlation of Fixed Effects:
            (Intr) GAPsqr RIsqrt
GAPsqrt     -0.654
RIsqrt      -0.723  0.638
GAPsqrt:RIs  0.361 -0.728 -0.652
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

Intact dataset:

```
> summary(lmer(accuracy_session_3 ~ GAP*RI + GAPx2 +(GAP*RI|Student_ID), data = report))
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAP * RI + GAPx2 + (GAP * RI | Student_ID)
   Data: report

REML criterion at convergence: 28690.5

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.39018 -0.68324  0.00463  0.82209  2.57298

Random effects:
 Groups     Name        Variance Std.Dev. Corr
 Student_ID (Intercept) 1219.561 34.9222
            GAP          349.818 18.7034  -0.07
            RI           250.655 15.8321   0.00  0.01
            GAP:RI         0.744  0.8625   0.03 -0.65 -0.76
 Residual               1247.633 35.3219
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
             Estimate Std. Error t value
(Intercept) 53.8134008  4.0510841  13.284
GAP          0.5170211  1.4510928   0.356
RI          -0.1875454  1.2565781  -0.149
GAPx2        0.0002195  0.0003230   0.680
GAP:RI      -0.0145829  0.0673886  -0.216

Correlation of Fixed Effects:
       (Intr) GAP    RI     GAPx2
GAP    -0.166
RI     -0.141  0.003
GAPx2   0.071 -0.021 -0.007
GAP:RI  0.192 -0.639 -0.768 -0.007
```

Logarithmic transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPlog*RIlog + GAPlogx2 +(GAPlog*RIlog|Student_ID), data = report))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPlog * RIlog + GAPlogx2 + (GAPlog * RIlog |      Student_ID)
   Data: report

REML criterion at convergence: 27271.8

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.23107 -0.84025  0.02583  0.83012  2.20002

Random effects:
 Groups     Name         Variance Std.Dev. Corr
 Student_ID (Intercept)   845.973 29.086
            GAPlog         20.188  4.493   -0.47
            RIlog          53.165  7.291   -0.63  0.94
            GAPlog:RIlog    2.111  1.453   -0.05 -0.71 -0.72
 Residual                1451.676 38.101
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
             Estimate Std. Error t value
(Intercept)   51.8660     3.8721  13.395
GAPlog         4.3912     2.1843   2.010
RIlog         -1.9310     1.3919  -1.387
GAPlogx2      -0.7135     0.4451  -1.603
GAPlog:RIlog  -0.6720     0.4743  -1.417

Correlation of Fixed Effects:
            (Intr) GAPlog RIlog  GAPlg2
GAPlog      -0.531
RIlog       -0.727  0.252
GAPlogx2     0.185 -0.838  0.138
GAPlog:RIlg  0.456 -0.369 -0.770 -0.059
```

Square-root transformation:

```
> summary(lmer(accuracy_session_3 ~ GAPsqrt*RIsqrt + GAPsqrtx2 +(GAPsqrt*RIsqrt|Student_ID), data = report))
boundary (singular) fit: see help('isSingular')
Linear mixed model fit by REML ['lmerMod']
Formula: accuracy_session_3 ~ GAPsqrt * RIsqrt + GAPsqrtx2 + (GAPsqrt *      RIsqrt | Student_ID)
   Data: report

REML criterion at convergence: 27285

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.28847 -0.83077  0.03255  0.83334  2.22551

Random effects:
 Groups     Name           Variance  Std.Dev. Corr
 Student_ID (Intercept)    7.829e+02 27.9798
            GAPsqrt        3.668e+00  1.9151  -0.61
            RIsqrt         1.131e+01  3.3633  -0.59  0.98
            GAPsqrt:RIsqrt 6.558e-02  0.2561  -0.23 -0.57 -0.64
 Residual                  1.457e+03 38.1690
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
               Estimate Std. Error t value
(Intercept)    52.35890    3.25331  16.094
GAPsqrt         0.86461    0.77826   1.111
RIsqrt         -1.05637    0.61986  -1.704
GAPsqrtx2      -0.03162    0.05892  -0.537
GAPsqrt:RIsqrt -0.14841    0.11247  -1.320

Correlation of Fixed Effects:
            (Intr) GAPsqr RIsqrt GAPsq2
GAPsqrt     -0.578
RIsqrt      -0.677  0.316
GAPsqrtx2    0.198 -0.743  0.148
GAPsqrt:RIs  0.322 -0.358 -0.662 -0.168
```

The most promising model on all questions:

```
> summary(lmer(accuracy_session_3_new ~ GAPlog*RIlog + GAPlogx2 + RIlogx2+ (1|Student_ID), data = report))
Linear mixed model fit by REML. t-tests use Satterthwaite's method ['lmerModLmerTest']
Formula: accuracy_session_3_new ~ GAPlog * RIlog + GAPlogx2 + RIlogx2 +      (1 | Student_ID)
   Data: report

REML criterion at convergence: 5736.4

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.7069 -0.5345  0.3953  0.6179  2.7716

Random effects:
 Groups     Name        Variance Std.Dev.
 Student_ID (Intercept) 0.06339  0.2518
 Residual               0.11991  0.3463
Number of obs: 7175, groups:  Student_ID, 345

Fixed effects:
              Estimate Std. Error         df t value Pr(>|t|)
(Intercept)   6.619e-01  2.066e-02  7.274e+02  32.039  < 2e-16 ***
GAPlog        2.302e-02  1.061e-02  7.061e+03   2.168  0.03016 *
RIlog         1.080e-02  1.218e-02  6.946e+03   0.887  0.37517
GAPlogx2     -5.798e-03  2.247e-03  7.107e+03  -2.581  0.00988 **
RIlogx2      -6.163e-03  2.643e-03  7.010e+03  -2.332  0.01971 *
GAPlog:RIlog -2.669e-03  1.979e-03  7.158e+03  -1.348  0.17761
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) GAPlog RIlog  GAPlg2 RIlgx2
GAPlog      -0.349
RIlog       -0.367 -0.022
GAPlogx2     0.167 -0.886  0.117
RIlogx2      0.200  0.067 -0.899 -0.031
GAPlog:RIlg  0.298 -0.232 -0.313 -0.128 -0.020
```

CONTROLLED ACCURACY ON THE INITIAL STUDY SESSION (deleted questions with more than 50% accuracy on the initial study session) AND DELETED 0-SEC. QUESTIONS

```
> summary(lmer(accuracy_session_3_new ~ GAPlog*RIlog + GAPlogx2 + RIlogx2+ (1|Student_ID), data = report))
Linear mixed model fit by REML. t-tests use Satterthwaite's method [
lmerModLmerTest]
Formula: accuracy_session_3_new ~ GAPlog * RIlog + GAPlogx2 + RIlogx2 +
    (1 | Student_ID)
   Data: report

REML criterion at convergence: 2809.9

Scaled residuals:
     Min       1Q   Median       3Q      Max
-2.25484 -0.82954  0.04115  0.85902  2.67513

Random effects:
 Groups     Name        Variance Std.Dev.
 Student_ID (Intercept) 0.04926  0.2219
 Residual               0.14940  0.3865
Number of obs: 2665, groups:  Student_ID, 277

Fixed effects:
               Estimate Std. Error         df t value Pr(>|t|)
(Intercept)   5.267e-01  2.983e-02  8.681e+02  17.655   <2e-16 ***
GAPlog        3.478e-02  1.991e-02  2.438e+03   1.747   0.0808 .
RIlog        -1.493e-02  2.228e-02  2.304e+03  -0.670   0.5029
GAPlogx2     -5.602e-03  4.259e-03  2.464e+03  -1.315   0.1885
RIlogx2      -9.972e-04  4.829e-03  2.283e+03  -0.206   0.8364
GAPlog:RIlog -6.656e-03  3.748e-03  2.595e+03  -1.776   0.0759 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:
            (Intr) GAPlog RIlog  GAPlg2 RIlgx2
GAPlog      -0.439
RIlog       -0.450 -0.068
GAPlogx2     0.207 -0.881  0.160
RIlogx2      0.238  0.115 -0.902 -0.084
GAPlog:RIlg  0.383 -0.259 -0.318 -0.105  0.001
```

Exploration of the additional data:

***N* = 240**

	GCSE results
the number of questions	0.43
the number of questions with repetitions	0.44
time spent on answering questions	0.44
time spent on answering questions - adjusted	0.50
time spent on reading feedback	0.22
the number of "active" weeks	0.45
the period of using GCSE prepper	0.43
accuracy of answered questions	0.32

***p* < .001**

```
> rcorr(correlations)
              exam accuracy period active_weeks feedback_time time time_ad rep_questions questions
exam          1.00     0.32   0.43         0.45          0.22 0.44    0.50          0.44      0.43
accuracy      0.32     1.00   0.05        -0.03          0.10 0.16    0.17          0.03      0.01
period        0.43     0.05   1.00         0.75          0.45 0.56    0.61          0.66      0.67
active_weeks  0.45    -0.03   0.75         1.00          0.41 0.68    0.78          0.83      0.84
feedback_time 0.22     0.10   0.45         0.41          1.00 0.76    0.66          0.57      0.57
time          0.44     0.16   0.56         0.68          0.76 1.00    0.94          0.77      0.77
time_ad       0.50     0.17   0.61         0.78          0.66 0.94    1.00          0.90      0.90
rep_questions 0.44     0.03   0.66         0.83          0.57 0.77    0.90          1.00      1.00
questions     0.43     0.01   0.67         0.84          0.57 0.77    0.90          1.00      1.00

n= 240


P
              exam   accuracy period active_weeks feedback_time time   time_ad rep_questions questions
exam                 0.0000   0.0000 0.0000       0.0006        0.0000 0.0000  0.0000         0.0000
accuracy      0.0000         0.4776 0.6383       0.1350        0.0106 0.0094  0.6992         0.8248
period        0.0000 0.4776         0.0000       0.0000        0.0000 0.0000  0.0000         0.0000
active_weeks  0.0000 0.6383   0.0000               0.0000        0.0000 0.0000  0.0000         0.0000
feedback_time 0.0006 0.1350   0.0000 0.0000                      0.0000 0.0000  0.0000         0.0000
time          0.0000 0.0106   0.0000 0.0000       0.0000               0.0000  0.0000         0.0000
time_ad       0.0000 0.0094   0.0000 0.0000       0.0000        0.0000         0.0000         0.0000
rep_questions 0.0000 0.6992   0.0000 0.0000       0.0000        0.0000 0.0000                 0.0000
questions     0.0000 0.8248   0.0000 0.0000       0.0000        0.0000 0.0000  0.0000
>
```

N = 240

GCSE results: *M* = 5.16, *SD* = 1.80

time spent on answering questions – adjusted (min) *M* = 45.01, *SD* = 46.62

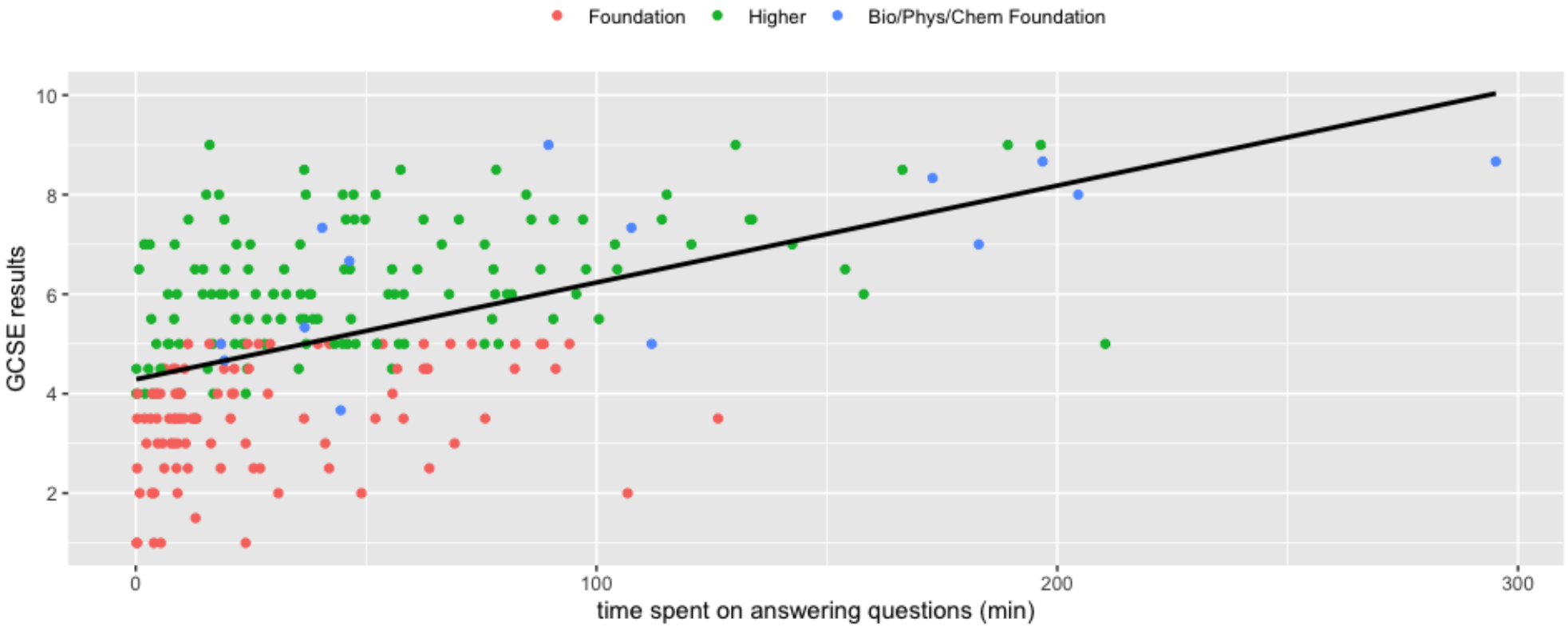
```
> exp1.lm = lm(exam ~ time_ad_min, data = GCSE_predictions)
> summary(exp1.lm)

Call:
lm(formula = exam ~ time_ad_min, data = GCSE_predictions)

Residuals:
    Min      1Q  Median      3Q     Max
-4.3654 -0.9514 -0.0321  0.9964  4.4010

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 4.286834   0.140029  30.614   <2e-16 ***
time_ad_min 0.019471   0.002163   9.001   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.559 on 238 degrees of freedom
Multiple R-squared:  0.254,     Adjusted R-squared:  0.2508
F-statistic: 81.02 on 1 and 238 DF,  p-value: < 2.2e-16
```

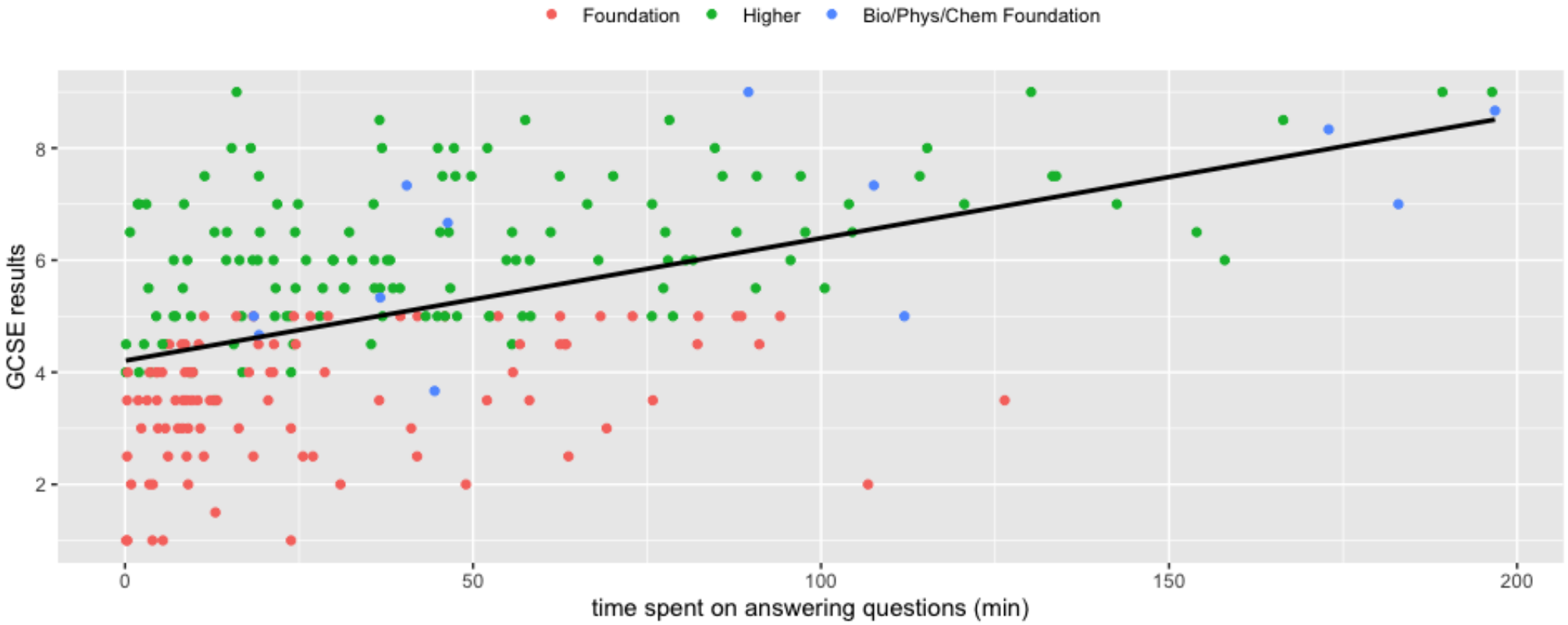
Foundation

```
> exp2.lm = lm(GCSE_Foundation$GCSE ~ GCSE_Foundation$sum_response_time_min_adjusted, data = GCSE_Foundation)
> summary(exp2.lm)

Call:
lm(formula = GCSE_Foundation$GCSE ~ GCSE_Foundation$sum_response_time_min_adjusted,
    data = GCSE_Foundation)

Residuals:
    Min      1Q  Median      3Q     Max
-2.5807 -0.7134  0.1973  0.7408  1.6581

Coefficients:
                                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                                 3.194525   0.152195  20.990  < 2e-16 ***
GCSE_Foundation$sum_response_time_min_adjusted 0.012985   0.003763   3.451 0.000842 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.057 on 93 degrees of freedom
Multiple R-squared:  0.1135,    Adjusted R-squared:  0.104
F-statistic: 11.91 on 1 and 93 DF,  p-value: 0.0008422

>
```

Higher

```
> exp3.lm = lm(GCSE_Higher$GCSE ~ GCSE_Higher$sum_response_time_min_adjusted, data = GCSE_Higher
> summary(exp3.lm)

Call:
lm(formula = GCSE_Higher$GCSE ~ GCSE_Higher$sum_response_time_min_adjusted,
    data = GCSE_Higher)

Residuals:
    Min      1Q  Median      3Q     Max
-3.1235 -0.9069 -0.0812  0.8239  3.2633

Coefficients:
                                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                               5.539883   0.153466   36.10  < 2e-16 ***
GCSE_Higher$sum_response_time_min_adjusted 0.012279   0.002308    5.32 4.44e-07 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.161 on 129 degrees of freedom
Multiple R-squared:  0.1799,    Adjusted R-squared:  0.1736
F-statistic: 28.31 on 1 and 129 DF,  p-value: 4.44e-07
```


Foundation
Higher
Bio/Phys/Chem Foundation
GCSE results
10
8
6
4
2
0
100
200
300
time spent on answering questions (min)


Foundation
Higher
Bio/Phys/Chem Foundation
GCSE results
8
6
4
2
0
50
100
150
200
time spent on answering questions (min)

GCSE results: $M = 5.16$, $SD = 1.80$

time spent on answering questions – adjusted (min), average $M = 0.95$, $SD = 0.37$

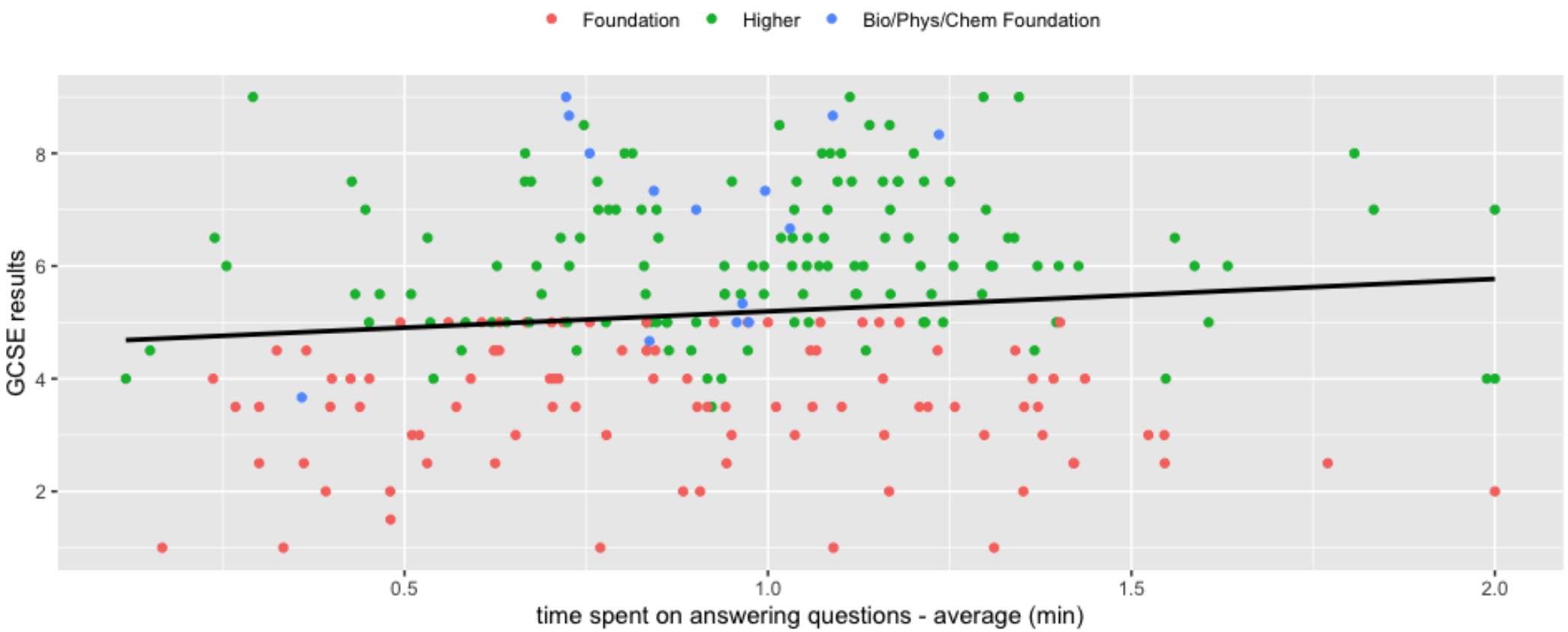
```
> exp4.lm = lm(exam ~ time_ad_average_min, data = GCSE_predictions)
> summary(exp4.lm)

Call:
lm(formula = exam ~ time_ad_average_min, data = GCSE_predictions)

Residuals:
    Min      1Q  Median      3Q     Max
-4.3737 -1.1573 -0.0816  1.2168  4.2148

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)          4.6170     0.3214  14.365   <2e-16 ***
time_ad_average_min  0.5772     0.3168   1.822   0.0698 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.793 on 238 degrees of freedom
Multiple R-squared:  0.01375,   Adjusted R-squared:  0.009607
F-statistic: 3.318 on 1 and 238 DF,  p-value: 0.06976

>
```

Foundation

```
> exp5.lm = lm(GCSE_Foundation$GCSE ~ GCSE_Foundation$mean_response_time_adjusted_min, data = GCSE_Foundation)
> summary(exp5.lm)

Call:
lm(formula = GCSE_Foundation$GCSE ~ GCSE_Foundation$mean_response_time_adjusted_min,
    data = GCSE_Foundation)

Residuals:
     Min       1Q   Median       3Q      Max
-2.68435 -0.61347 -0.00657  0.92530  1.52411

Coefficients:
                                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                                     3.7125     0.2882  12.881   <2e-16 ***
GCSE_Foundation$mean_response_time_adjusted_min -0.1688     0.2987  -0.565    0.573
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.12 on 93 degrees of freedom
Multiple R-squared:  0.003421,  Adjusted R-squared:  -0.007295
F-statistic: 0.3192 on 1 and 93 DF,  p-value: 0.5734
```

Higher

```
> exp6.lm = lm(GCSE_Higher$GCSE ~ GCSE_Higher$mean_response_time_adjusted_min, data = GCSE_Higher)
> summary(exp6.lm)

Call:
lm(formula = GCSE_Higher$GCSE ~ GCSE_Higher$mean_response_time_adjusted_min,
    data = GCSE_Higher)

Residuals:
    Min      1Q  Median      3Q     Max
-2.6313 -1.0483 -0.1685  0.9012  3.0481

Coefficients:
                                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                                 5.8690     0.3320  17.679   <2e-16 ***
GCSE_Higher$mean_response_time_adjusted_min  0.2843     0.3134   0.907    0.366
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.278 on 129 degrees of freedom
Multiple R-squared:  0.006339,  Adjusted R-squared:  -0.001364
F-statistic: 0.823 on 1 and 129 DF,  p-value: 0.366
```


Foundation
Higher
Bio/Phys/Chem Foundation
GCSE results
8
6
4
2
0.5
1.0
1.5
2.0
time spent on answering questions - average (min)

GCSE results: $M = 5.16$, $SD = 1.80$

accuracy of answered questions: $M = 0.45$, $SD = 0.20$

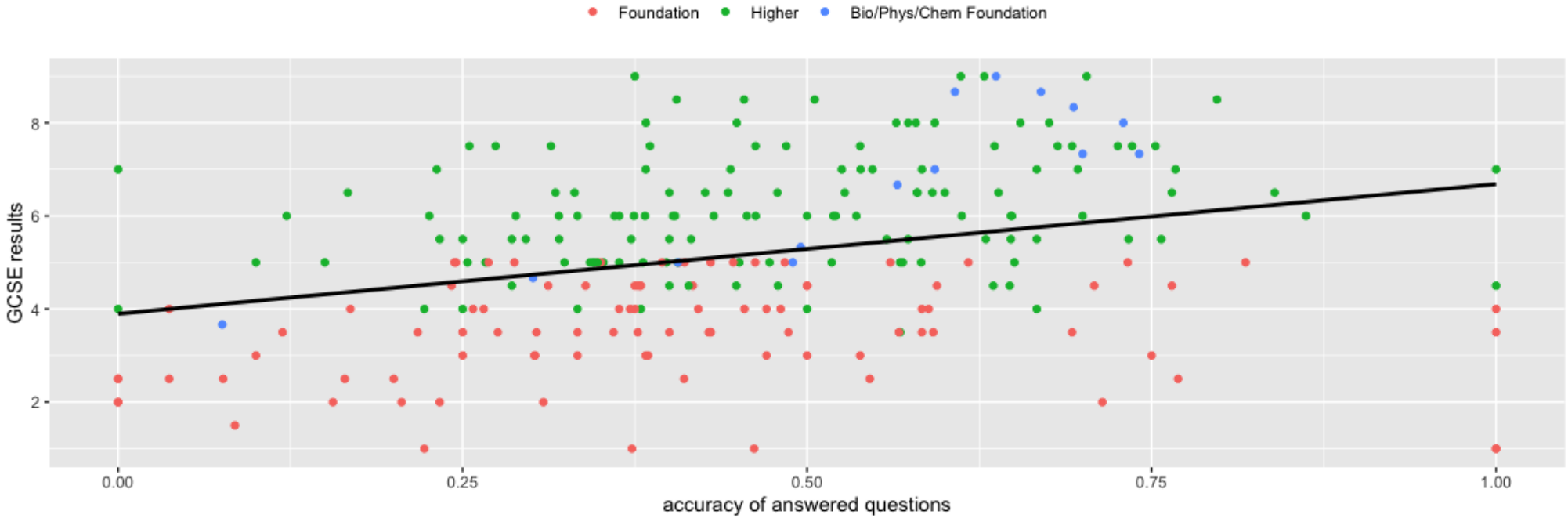
```
> ratings1.lm = lm(exam ~ accuracy, data = GCSE_predictions)
> summary(ratings1.lm)

Call:
lm(formula = exam ~ accuracy, data = GCSE_predictions)

Residuals:
    Min      1Q  Median      3Q     Max
-5.6849 -1.1693 -0.0171  1.1405  4.0581

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   3.8961     0.2696  14.452  < 2e-16 ***
accuracy      2.7888     0.5412   5.153 5.38e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.712 on 238 degrees of freedom
Multiple R-squared:  0.1004,    Adjusted R-squared:  0.09659
F-statistic: 26.55 on 1 and 238 DF,  p-value: 5.385e-07
```

Foundation

```
> exp7.lm = lm(GCSE_Foundation$GCSE ~ GCSE_Foundation$memory_accuracy, data = GCSE_Foundation)
> summary(exp7.lm)

Call:
lm(formula = GCSE_Foundation$GCSE ~ GCSE_Foundation$memory_accuracy,
    data = GCSE_Foundation)

Residuals:
     Min       1Q   Median       3Q      Max
-2.95137 -0.63836  0.02032  0.94042  1.54080

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                     3.3003     0.2370  13.928   <2e-16 ***
GCSE_Foundation$memory_accuracy   0.6511     0.5143   1.266    0.209
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.113 on 93 degrees of freedom
Multiple R-squared:  0.01694,   Adjusted R-squared:  0.006367
F-statistic: 1.602 on 1 and 93 DF,  p-value: 0.2087

> #osobno dla higher
```

Higher

```
> exp8.lm = lm(GCSE_Higher$GCSE ~ GCSE_Higher$memory_accuracy, data = GCSE_Higher)
> summary(exp8.lm)

Call:
lm(formula = GCSE_Higher$GCSE ~ GCSE_Higher$memory_accuracy,
    data = GCSE_Higher)

Residuals:
     Min       1Q   Median       3Q      Max
-2.80959 -0.91597 -0.09183  0.87070  3.03875

Coefficients:
                            Estimate Std. Error t value Pr(>|t|)
(Intercept)                   5.2829     0.3032   17.42  < 2e-16 ***
GCSE_Higher$memory_accuracy   1.8089     0.5892    3.07  0.00261 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.237 on 129 degrees of freedom
Multiple R-squared:  0.0681,    Adjusted R-squared:  0.06088
F-statistic: 9.427 on 1 and 129 DF,  p-value: 0.002608

>
```


Foundation
Higher
Bio/Phys/Chem Foundation
GCSE results
8
6
4
2
0.00
0.25
0.50
0.75
1.00
accuracy of answered questions

GCSE results: $M = 5.16$, $SD = 1.80$

The number of questions: $M = 48.03$, $SD = 45.07$

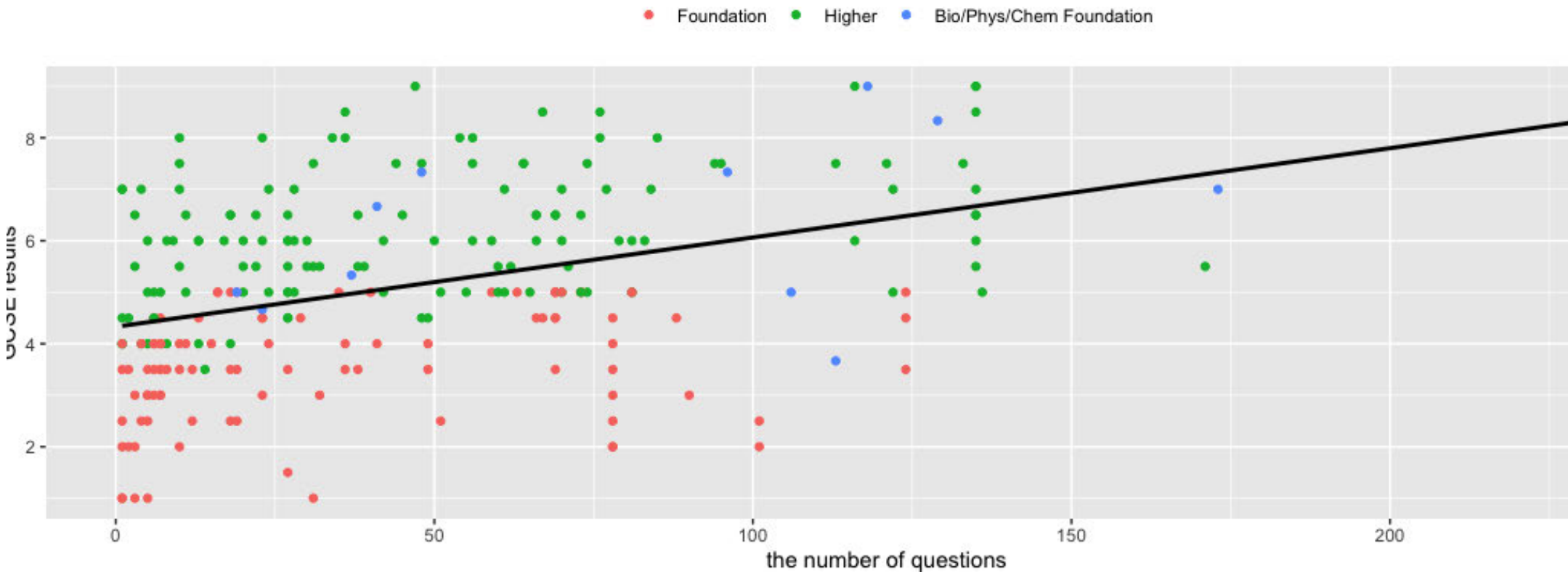
```
> ratings2.lm = lm(exam ~ questions, data = GCSE_predictions)
> summary(ratings2.lm)

Call:
lm(formula = exam ~ questions, data = GCSE_predictions)

Residuals:
    Min      1Q  Median      3Q     Max
-4.0815 -0.9950 -0.0619  1.1885  3.8547

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) 4.330408   0.153591  28.194  < 2e-16 ***
questions   0.017338   0.002334   7.428 1.96e-12 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.626 on 238 degrees of freedom
Multiple R-squared:  0.1882,    Adjusted R-squared:  0.1848
F-statistic: 55.18 on 1 and 238 DF,  p-value: 1.959e-12
```

Foundation

```
> exp9.lm = lm(GCSE_Foundation$GCSE ~ GCSE_Foundation$numeber_questions, data = GCSE_Foundation)
> summary(exp9.lm)

Call:
lm(formula = GCSE_Foundation$GCSE ~ GCSE_Foundation$numeber_questions,
    data = GCSE_Foundation)

Residuals:
    Min      1Q  Median      3Q     Max
-2.5219 -0.7381  0.2171  0.7370  1.6275

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)
(Intercept)                     3.213169   0.158523   20.27   <2e-16 ***
GCSE_Foundation$numeber_questions 0.009958   0.003255    3.06   0.0029 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.07 on 93 degrees of freedom
Multiple R-squared:  0.09145,   Adjusted R-squared:  0.08168
F-statistic: 9.361 on 1 and 93 DF,  p-value: 0.002896
```

Higher

```
> exp10.lm = lm(GCSE_Higher$GCSE ~ GCSE_Higher$numeber_questions, data = GCSE_Higher)
> summary(exp10.lm)

Call:
lm(formula = GCSE_Higher$GCSE ~ GCSE_Higher$numeber_questions,
    data = GCSE_Higher)

Residuals:
     Min       1Q   Median       3Q      Max
-2.23157 -0.89568 -0.05819  0.81349  2.88348

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                   5.568265   0.166573  33.428  < 2e-16 ***
GCSE_Higher$numeber_questions 0.011665   0.002595   4.495 1.53e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 1.192 on 129 degrees of freedom
Multiple R-squared:  0.1354,    Adjusted R-squared:  0.1287
F-statistic: 20.21 on 1 and 129 DF,  p-value: 1.53e-05
```


Foundation
Higher
Bio/Phys/Chem Foundation
GCSE results
8
6
4
2
0
50
100
150
200
the number of questions

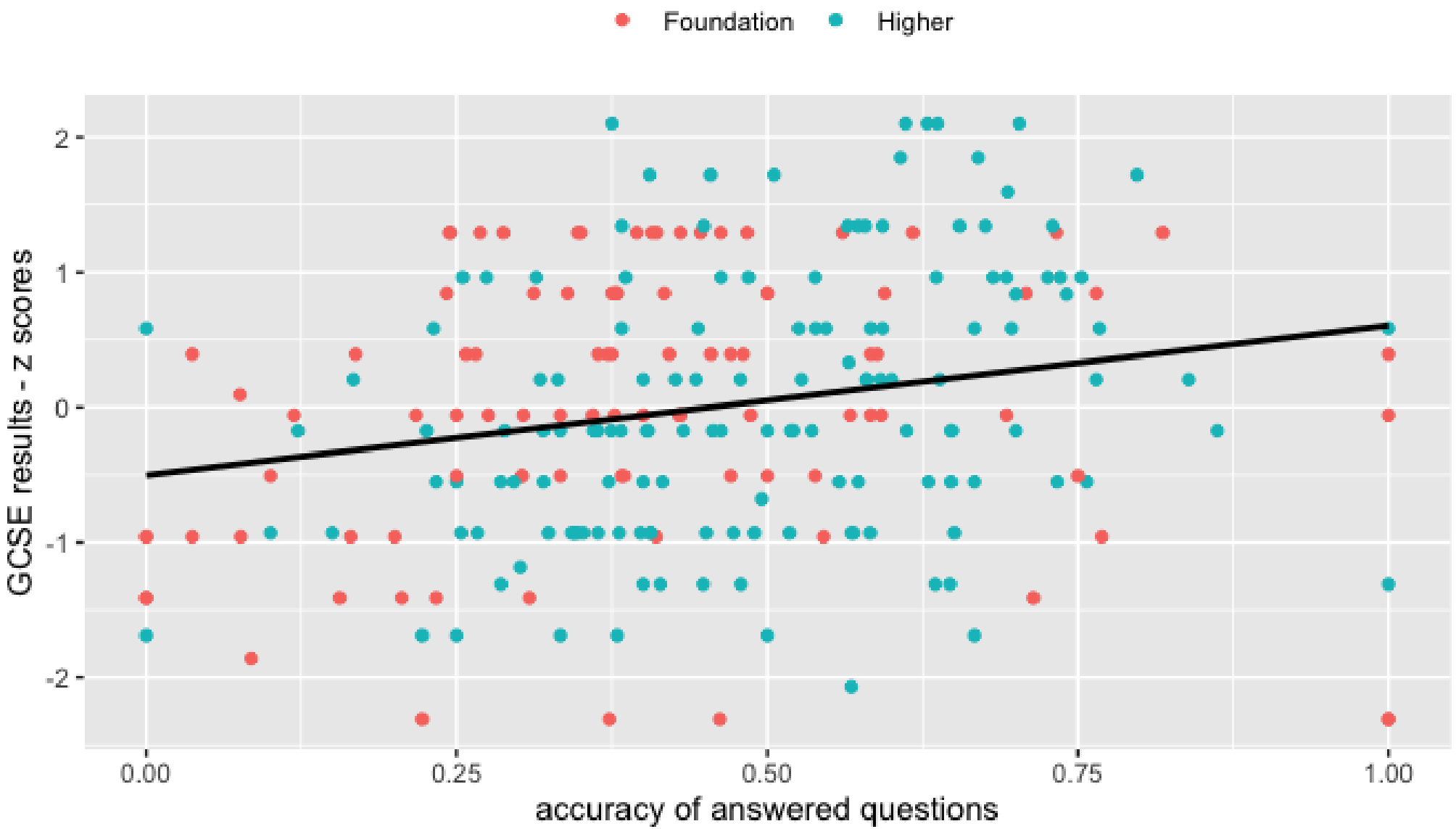
Interaction

```
> ratings.lm = lm(exam ~ accuracy * questions, data = GCSE_predictions)
> summary(ratings.lm)

Call:
lm(formula = exam ~ accuracy * questions, data = GCSE_predictions)

Residuals:
    Min      1Q  Median      3Q     Max
-4.2324 -0.9623 -0.0738  1.0292  4.1166

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)        3.825147   0.319187  11.984  < 2e-16 ***
accuracy           1.370481   0.592650   2.312 0.021613 *
questions         -0.003546   0.005871  -0.604 0.546436
accuracy:questions 0.040339   0.010654   3.786 0.000194 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.489 on 236 degrees of freedom
Multiple R-squared:  0.3257,    Adjusted R-squared:  0.3171
F-statistic: 37.99 on 3 and 236 DF,  p-value: < 2.2e-16

>
```

Model 1: GCSE – z scores

Predictor: accuracy of answered questions

```
> model1 = lm(report$GCSE_z ~ report$memory_accuracy, data = report)
> summary(model1)

Call:
lm(formula = report$GCSE_z ~ report$memory_accuracy, data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.91431 -0.71188 -0.02681  0.70957  2.18642

Coefficients:
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)             -0.5038     0.1533  -3.286 0.001171 **
report$memory_accuracy   1.1088     0.3078   3.602 0.000384 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9738 on 238 degrees of freedom
Multiple R-squared:  0.0517,    Adjusted R-squared:  0.04771
F-statistic: 12.98 on 1 and 238 DF,  p-value: 0.0003842
```


Foundation
Higher
GCSE results - z scores
2
1
0
-1
-2
0.00
0.25
0.50
0.75
1.00
accuracy of answered questions

Moderator: Exam Level (1 – Foundation, 2 – Higher)

```
Call:
lm(formula = GCSE_z ~ Level..1.Foundation..2.Higher. * memory_accuracy,
    data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.64932 -0.68998 -0.01088  0.71245  2.30189

Coefficients:
                                          Estimate Std. Error t value Pr(>|t|)
(Intercept)                                0.4108     0.4679   0.878   0.3809
Level..1.Foundation..2.Higher.            -0.6377     0.3087  -2.066   0.0399 *
memory_accuracy                           -0.6293     0.9912  -0.635   0.5261
Level..1.Foundation..2.Higher.:memory_accuracy   1.1963     0.6275   1.906   0.0578 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9692 on 236 degrees of freedom
Multiple R-squared:  0.06857,   Adjusted R-squared:  0.05673
F-statistic: 5.792 on 3 and 236 DF,  p-value: 0.0007767
```

SIMPLE SLOPES ANALYSIS

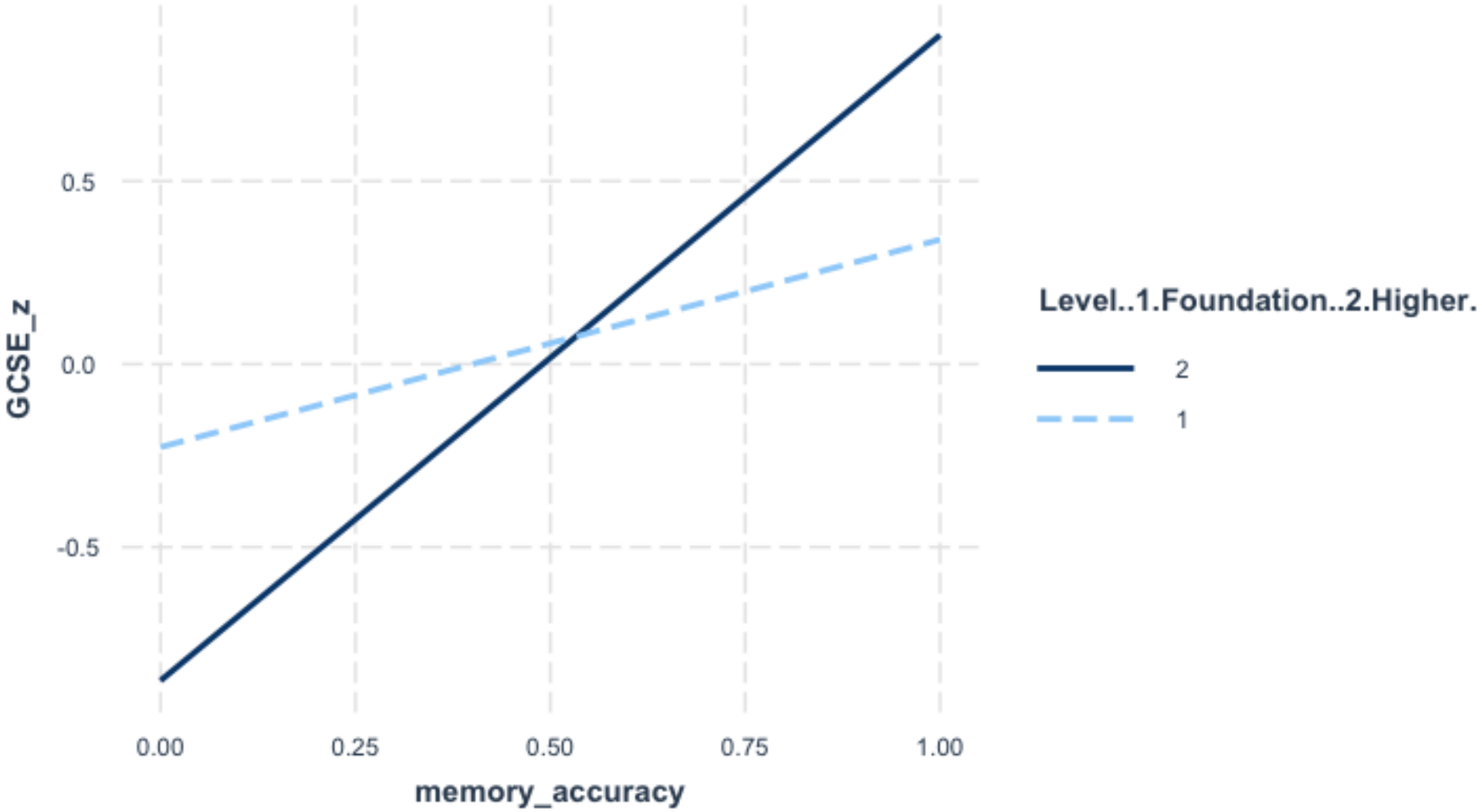
Slope of memory_accuracy when Level..1.Foundation..2.Higher. = 1.00 (1):

Est.	S.E.	t val.	p
0.57	0.44	1.28	0.20

Slope of memory_accuracy when Level..1.Foundation..2.Higher. = 2.00 (2):

Est.	S.E.	t val.	p
1.76	0.44	3.97	0.00

`


0.5
0.0
-0.5
GCSE_z
0.00
0.25
0.50
0.75
1.00
memory_accuracy
Level..1.Foundation..2.Higher.
2
1

Moderator: Gender (0 – Male, 1 - Female)

```
Call:
lm(formula = GCSE_z ~ Gender_n * memory_accuracy, data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.38525 -0.63856 -0.01219  0.76899  2.26595

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)              0.07852    0.25032   0.314  0.75405
Gender_n                -0.93072    0.31448  -2.960  0.00339 **
memory_accuracy         -0.01160    0.48240  -0.024  0.98084
Gender_n:memory_accuracy  1.83742    0.62109   2.958  0.00341 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9595 on 236 degrees of freedom
Multiple R-squared:  0.08715,   Adjusted R-squared:  0.07555
F-statistic: 7.511 on 3 and 236 DF,  p-value: 8.033e-05
```

SIMPLE SLOPES ANALYSIS

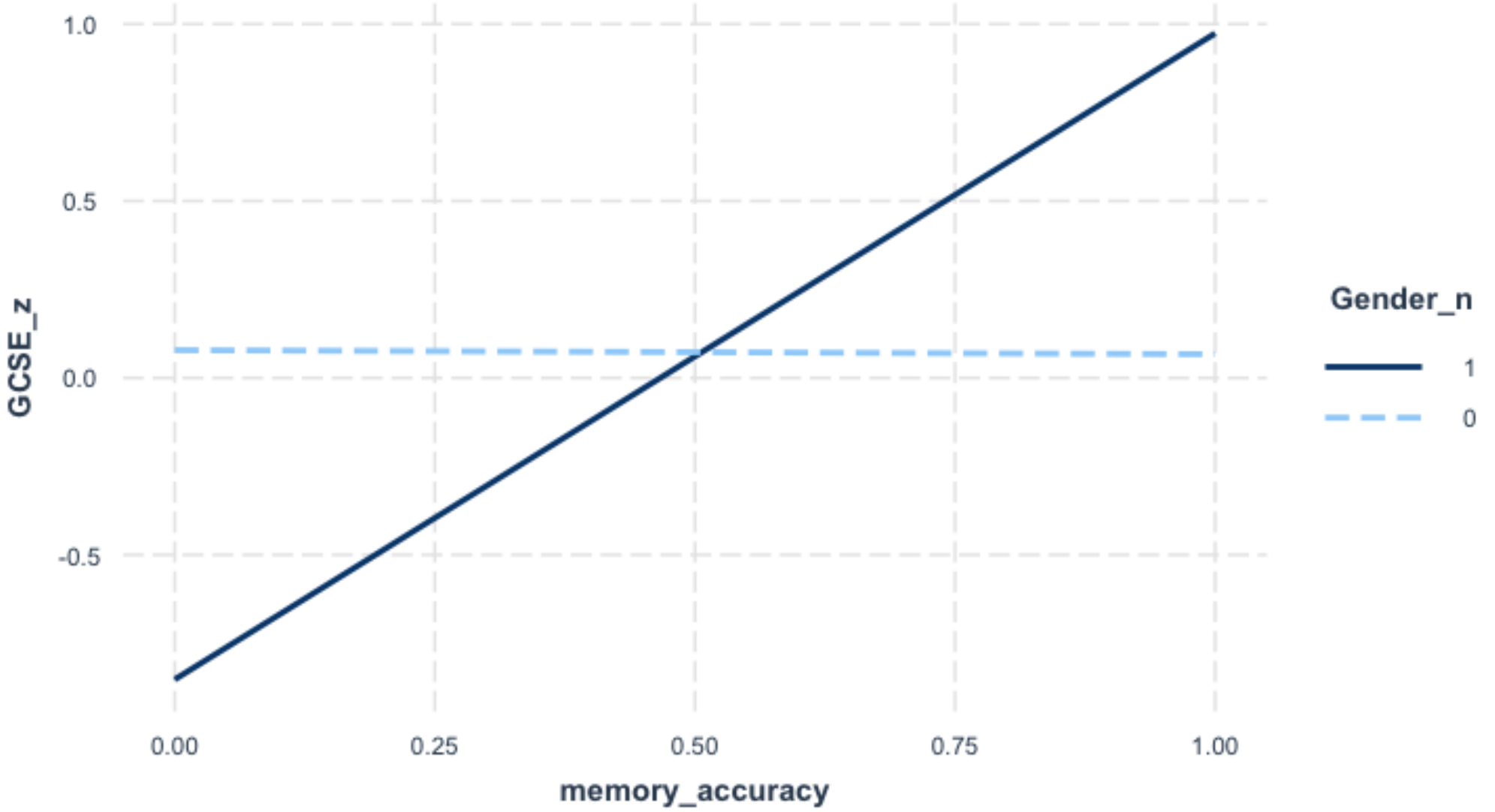
Slope of memory_accuracy when Gender_n = 0.00 (0):

Est.	S.E.	t val.	p
-0.01	0.48	-0.02	0.98

Slope of memory_accuracy when Gender_n = 1.00 (1):

Est.	S.E.	t val.	p
1.83	0.39	4.67	0.00

Moderator: Gender (0 – Male, 1 - Female)



Moderator: Pupil Premium (0 – no, 1 - yes)

```
Call:
lm(formula = GCSE_z ~ Pupil.premium_n * memory_accuracy, data = report)

Residuals:
    Min      1Q  Median      3Q     Max
-2.8466 -0.6603  0.0061  0.6970  2.1063

Coefficients:
                              Estimate Std. Error t value Pr(>|t|)
(Intercept)                    -0.3350     0.1812  -1.849   0.0658 .
Pupil.premium_n                -0.6233     0.3370  -1.849   0.0657 .
memory_accuracy                 0.8723     0.3660   2.383   0.0180 *
Pupil.premium_n:memory_accuracy  0.7584     0.6676   1.136   0.2571
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9683 on 236 degrees of freedom
Multiple R-squared:  0.07033,   Adjusted R-squared:  0.05852
F-statistic: 5.951 on 3 and 236 DF,  p-value: 0.0006286
```

SIMPLE SLOPES ANALYSIS

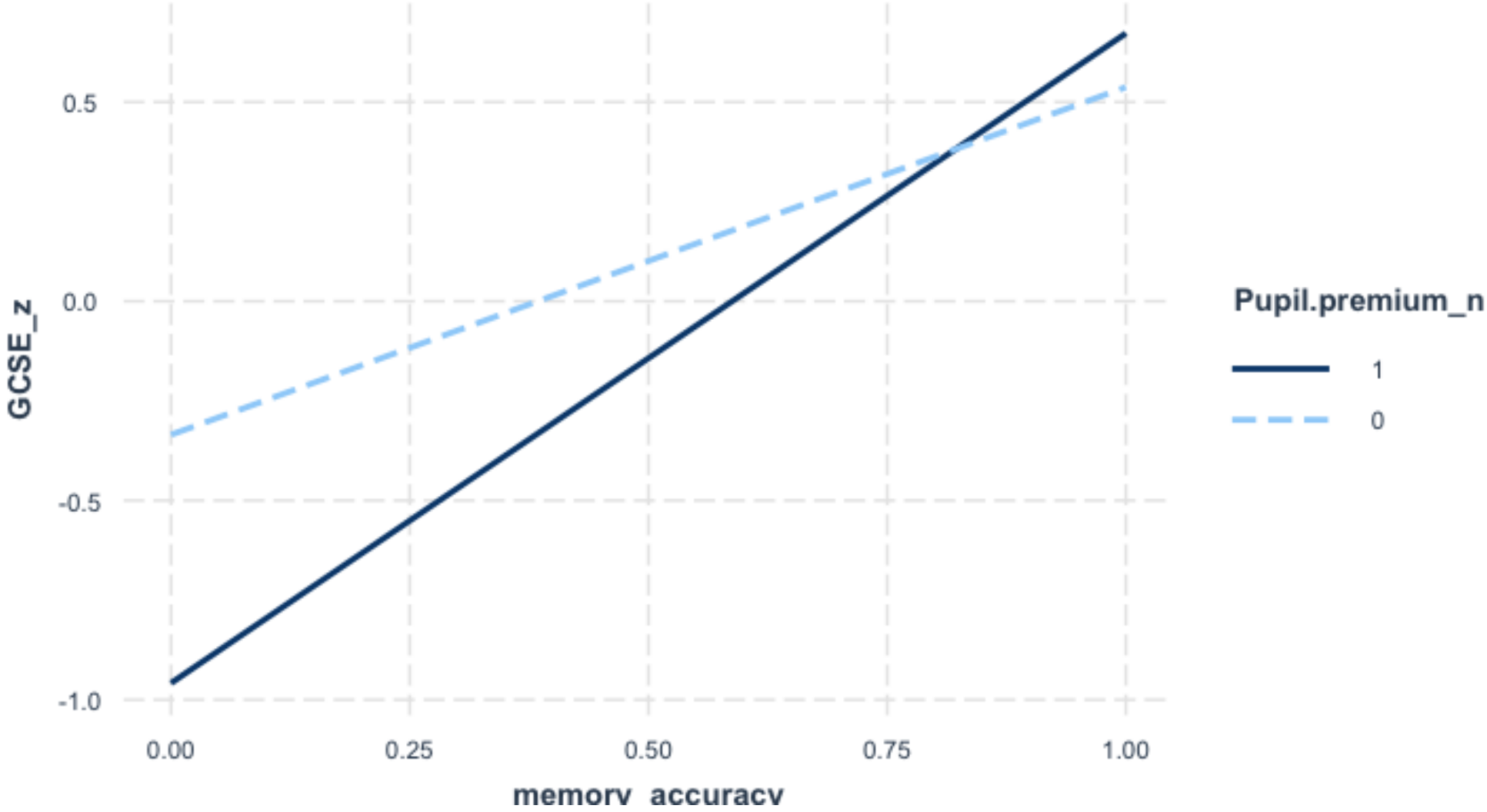
Slope of memory_accuracy when Pupil.premium_n = 0.00 (0):

Est.	S.E.	t val.	p
0.87	0.37	2.38	0.02

Slope of memory_accuracy when Pupil.premium_n = 1.00 (1):

Est.	S.E.	t val.	p
1.63	0.56	2.92	0.00

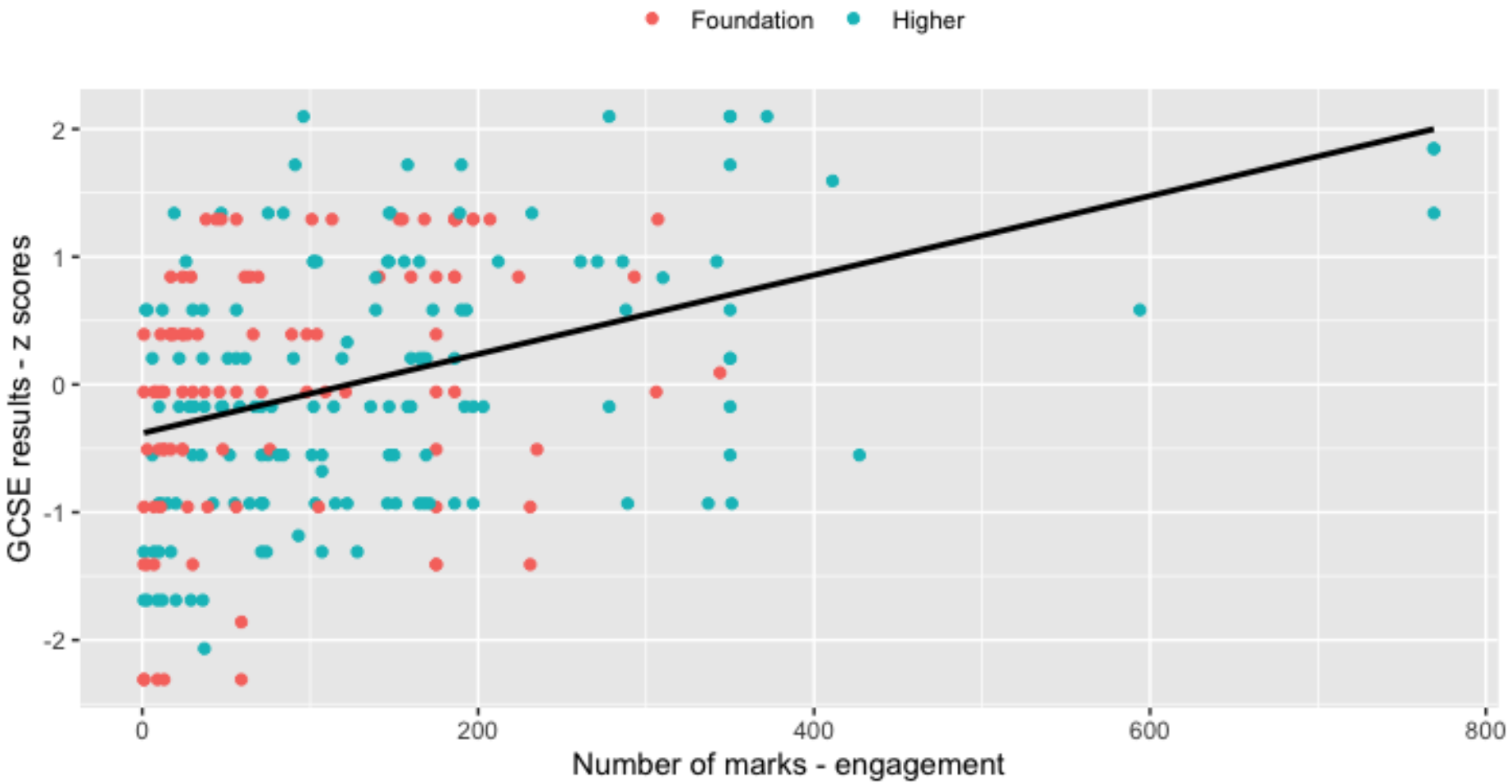
Moderator: Pupil Premium (0 – no, 1 - yes)



Model 2 – GCSE – z scores

Predictor: number of marks attempted

```
Call:
lm(formula = report$GCSE_z ~ report$Mark_max, data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.11081 -0.67148  0.06054  0.72095  2.18239

Coefficients:
                  Estimate Std. Error t value Pr(>|t|)
(Intercept)     -0.3811316  0.0825960  -4.614 6.45e-06 ***
report$Mark_max  0.0030955  0.0004669   6.630 2.23e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.9188 on 238 degrees of freedom
Multiple R-squared:  0.1559,    Adjusted R-squared:  0.1523
F-statistic: 43.95 on 1 and 238 DF,  p-value: 2.235e-10

>
```


Foundation
Higher
GCSE results - z scores
2
1
0
-1
-2
0
200
400
600
800
Number of marks - engagement

Moderator: Exam Level (1 – Foundation, 2 – Higher)

```
Call:
lm(formula = GCSE_z ~ Level..1.Foundation..2.Higher. * Mark_max,
    data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.19132 -0.68336  0.07097  0.66829  2.25229

Coefficients:
                                        Estimate Std. Error t value Pr(>|t|)
(Intercept)                           -0.2448268  0.2915277  -0.840   0.4019
Level..1.Foundation..2.Higher.        -0.1031349  0.1735632  -0.594   0.5529
Mark_max                               0.0046995  0.0022494   2.089   0.0378 *
Level..1.Foundation..2.Higher.:Mark_max -0.0008016  0.0012151  -0.660   0.5101
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9176 on 236 degrees of freedom
Multiple R-squared:  0.1652,    Adjusted R-squared:  0.1546
F-statistic: 15.56 on 3 and 236 DF,  p-value: 2.857e-09
```

SIMPLE SLOPES ANALYSIS

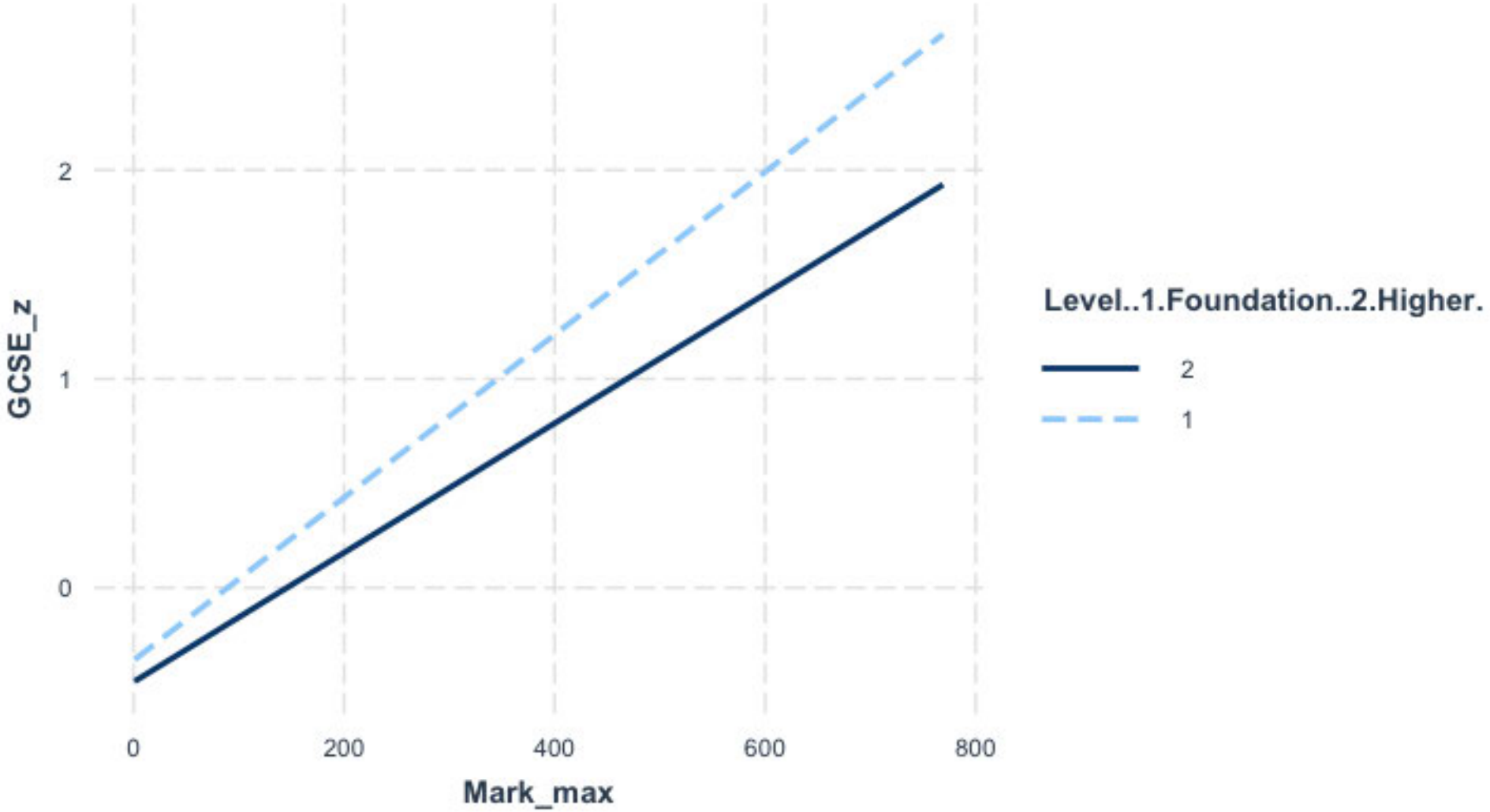
Slope of Mark_max when Level..1.Foundation..2.Higher. = 1.00 (1):

Est.	S.E.	t val.	p
0.00	0.00	3.57	0.00

Slope of Mark_max when Level..1.Foundation..2.Higher. = 2.00 (2):

Est.	S.E.	t val.	p
0.00	0.00	5.83	0.00

Moderator: Exam Level (1 – Foundation, 2 – Higher)



Moderator: Gender (0 – Male, 1 - Female)

```
Call:
lm(formula = GCSE_z ~ Gender_n * Mark_max, data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.08092 -0.67419  0.04996  0.70880  2.20659

Coefficients:
                   Estimate Std. Error t value Pr(>|t|)
(Intercept)       -0.3214235  0.1319315  -2.436   0.0156 *
Gender_n          -0.0987008  0.1717597  -0.575   0.5661
Mark_max           0.0029402  0.0006362   4.621 6.28e-06 ***
Gender_n:Mark_max  0.0003095  0.0009428   0.328   0.7430
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.922 on 236 degrees of freedom
Multiple R-squared:  0.1571,    Adjusted R-squared:  0.1464
F-statistic: 14.66 on 3 and 236 DF,  p-value: 8.694e-09
```

SIMPLE SLOPES ANALYSIS

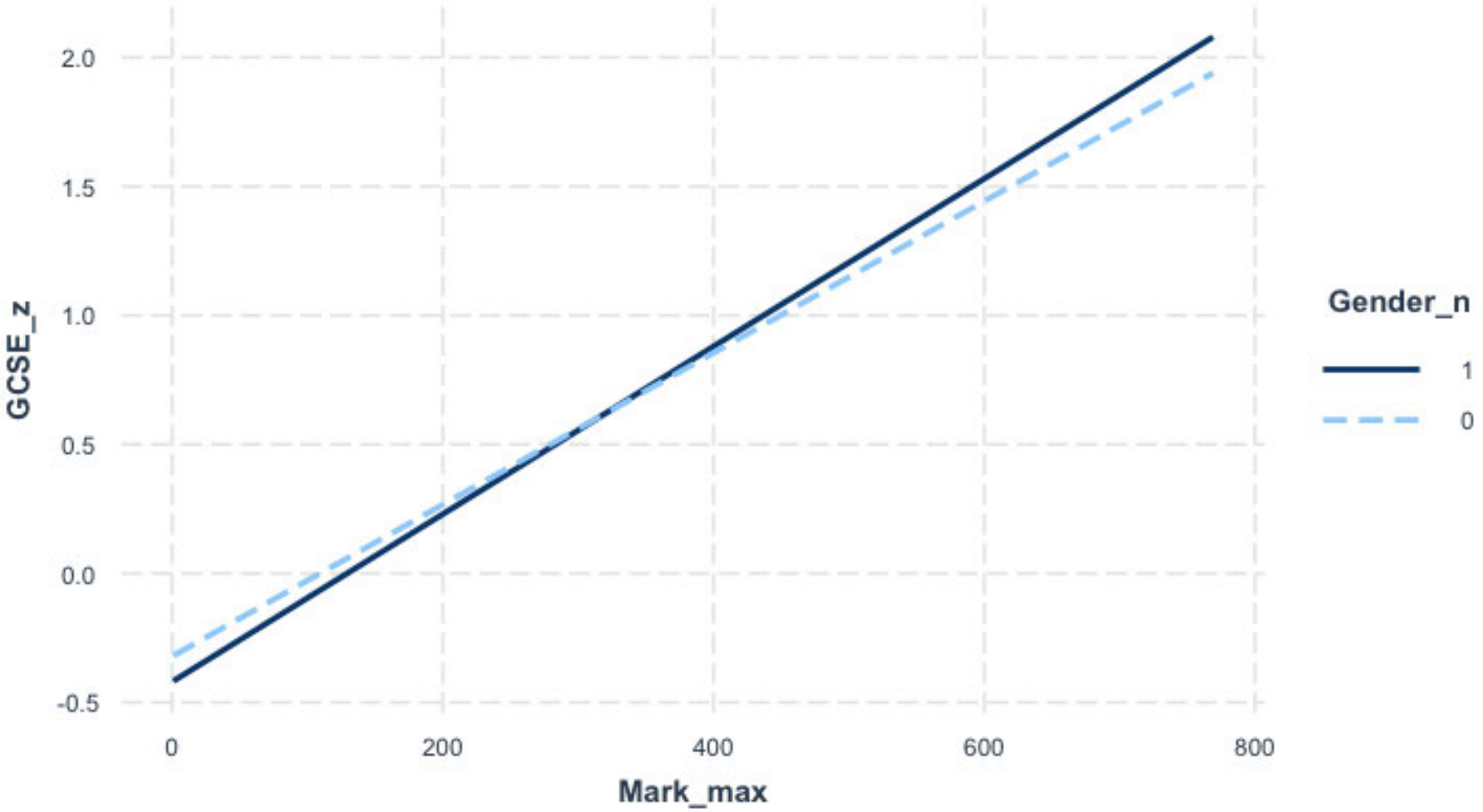
Slope of Mark_max when Gender_n = 0.00 (0):

Est.	S.E.	t val.	p
0.00	0.00	4.62	0.00

Slope of Mark_max when Gender_n = 1.00 (1):

Est.	S.E.	t val.	p
0.00	0.00	4.67	0.00

Moderator: Gender (0 – Male, 1 - Female)



Moderator: Pupil Premium (0 – no, 1 - yes)

```
Call:
lm(formula = GCSE_z ~ Pupil.premium_n * Mark_max, data = report)

Residuals:
     Min       1Q   Median       3Q      Max
-2.12693 -0.66642  0.04789  0.70512  2.16603

Coefficients:
                           Estimate Std. Error t value Pr(>|t|)
(Intercept)              -0.3654200  0.0962083  -3.798 0.000185 ***
Pupil.premium_n          -0.0136641  0.2023781  -0.068 0.946227
Mark_max                  0.0031023  0.0004988   6.220 2.24e-09 ***
Pupil.premium_n:Mark_max -0.0009053  0.0018569  -0.488 0.626336
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.9216 on 236 degrees of freedom
Multiple R-squared:  0.1578,    Adjusted R-squared:  0.1471
F-statistic: 14.74 on 3 and 236 DF,  p-value: 7.895e-09
```

SIMPLE SLOPES ANALYSIS

Slope of Mark_max when Pupil.premium_n = 0.00 (0):

Est.	S.E.	t val.	p
0.00	0.00	6.22	0.00

Slope of Mark_max when Pupil.premium_n = 1.00 (1):

Est.	S.E.	t val.	p
0.00	0.00	1.23	0.22

Moderator: Pupil Premium (0 – no, 1 - yes)