Question 1: We could choose to exclude trials with an atypical pupil size in a similar fashion. Do you think this would be a good idea? Why so, or why not? (Note, there are no wrong answers per se!).

No, if we are measuring a change in pupil size, the measurement should be the rate of change, not the actual starting and finishing values that could vary with natural pupil size.

Question 2: What is our DV, and what are our FE(s) and RE(s)?

- DV: Pupil Size
- FE: target_background
- RE: subject, RT, target_side

Question 3: With the inclusion of random slopes, what possibility do we take into account? Make sure that your answer concretely involves the DV indicated in the previous question.

We take into account that some subjects might have better vision in one side of their frontal vision than another, so the target side should have a random slope, because its effect on the final value of pupil size might vary per subject.

Question 4: Please copy (either by means of a print screen or by copying the code manually) the results onto your answer sheet.

```
boundary (singular) fit: see help( isSingular )
> summary(model1)
Linear mixed model fit by REML ['lmerMod']
Formula: pupil_size ~ target_background + (1 | subject) + (1 | RT) + (1 |      target_side)
   Data: data

REML criterion at convergence: 12077.7

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.5443 -0.4902 -0.0309  0.5220  2.9681

Random effects:
 Groups      Name        Variance Std.Dev.
 RT          (Intercept) 23218.3  152.38
 subject     (Intercept)   174.6   13.21
 target_side (Intercept)   124.4   11.15
 Residual                54077.1  232.54
Number of obs: 858, groups:  RT, 852; subject, 24; target_side, 2

Fixed effects:
                    Estimate Std. Error t value
(Intercept)           901.92      15.82   57.02
target_backgroundwhite  -492.78      18.99  -25.95

Correlation of Fixed Effects:
            (Intr)
trgt_bckgrn -0.601
>
```

```
> summary(model2)
Linear mixed model fit by REML ['lmerMod']
Formula:
pupil_size ~ target_background * target_side + (1 + pupil_size |
    subject) + (1 | RT)
   Data: data

REML criterion at convergence: -17668.2

Scaled residuals:
       Min         1Q     Median         3Q        Max
-1.113e-05 -1.505e-06  0.000e+00  1.911e-06  1.175e-05

Random effects:
 Groups   Name        Variance  Std.Dev.  Corr
 RT       (Intercept) 0.000e+00 0.000e+00
 subject  (Intercept) 9.764e-08 3.125e-04
          pupil_size  2.810e-02 1.676e-01 -1.00
 Residual             2.045e-11 4.522e-06
Number of obs: 858, groups:  RT, 852; subject, 24

Fixed effects:
                                        Estimate Std. Error t value
(Intercept)                            1.864e-03  6.010e-07    3101
target_backgroundwhite                 3.556e-13  5.170e-07       0
target_sideright                       1.045e-12  4.382e-07       0
target_backgroundwhite:target_sideright 1.101e-13  6.191e-07       0

Correlation of Fixed Effects:
            (Intr) trgt_b trgt_s
trgt_bckgrn -0.764
trgt_sdrght -0.389  0.439
trgt_bckg:_  0.252 -0.596 -0.708
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

```
> summary(model3)
Linear mixed model fit by REML ['lmerMod']
Formula:
pupil_size ~ target_background * RT + (1 + pupil_size | subject) +
    (1 | target_side)
   Data: data

REML criterion at convergence: -19856.4

Scaled residuals:
       Min         1Q     Median         3Q        Max
-7.103e-05 -7.741e-06  2.900e-07  7.935e-06  7.969e-05

Random effects:
 Groups      Name        Variance  Std.Dev.  Corr
 subject     (Intercept) 1.604e-03 4.005e-02
             pupil_size  2.814e-02 1.678e-01 -1.00
 target_side (Intercept) 7.581e-03 8.707e-02
 Residual                1.380e-12 1.175e-06
Number of obs: 858, groups:  subject, 24; target_side, 2

Fixed effects:
                            Estimate Std. Error t value
(Intercept)                3.074e-01  6.037e-02   5.092
target_backgroundwhite    -2.240e-10  5.654e-07   0.000
RT                        -4.250e-13  8.188e-10  -0.001
target_backgroundwhite:RT  3.214e-13  7.890e-10   0.000

Correlation of Fixed Effects:
            (Intr) trgt_b RT
trgt_bckgrn  0.000
RT           0.000  0.708
trgt_bck:RT  0.000 -0.982 -0.725
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

```
> summary(model4)
Linear mixed model fit by REML ['lmerMod']
Formula: pupil_size ~ target_background + (1 + target_side | subject) +      (1 | RT) + (1 | target_side)
   Data: data

REML criterion at convergence: 12077.6

Scaled residuals:
    Min      1Q  Median      3Q     Max
-3.5713 -0.4943 -0.0328  0.5186  2.9889

Random effects:
 Groups      Name             Variance Std.Dev. Corr
 RT          (Intercept)      22431.2  149.77
 subject     (Intercept)        102.1   10.10
             target_sideright   129.7   11.39   1.00
 target_side (Intercept)        122.3   11.06
 Residual                     54757.0  234.00
Number of obs: 858, groups:  RT, 852; subject, 24; target_side, 2

Fixed effects:
                     Estimate Std. Error t value
(Intercept)            902.22      15.87   56.84
target_backgroundwhite -492.77      18.97  -25.97

Correlation of Fixed Effects:
            (Intr)
trgt_bckgrn -0.598
optimizer (nloptwrap) convergence code: 0 (OK)
boundary (singular) fit: see help('isSingular')
```

Question 5: Please provide a summary of the results (including the b-value, SE and tvalue) and, thus, an answer to the central research question.

Model	b-value	STD	t-value
Model1, no random slope for Target Side	-492.78	18.99	-25.95
Model 4, random slope for Target Side	-492.77	18.97	-25.97

- In both cases, the t-value was higher than |1.96|, therefore we accept the hypothesis that background color/brightness has a significant effect, or that the pupil responds to the brightness of memorized objects.
- For the test in interactions, both tvalues were not significant either.