# WMD Analysis Results

Overall Process

- Replication of Luke, Darowksi, & Gale, 2018 (n= 102)
  - Three different tasks: reading, visual search, scene-viewing (aesthetic judgement)
- Splitting data by scene-viewing task: Aesthetic and Memorize
- Characterizing each subject's fixation duration distribution with Ex-Gaussian:
  - Mu - center of normal distribution
  - Sigma - standard deviation of normal
  - Tau- skewness of distribution
- Linear mixed effects model
  - WM factor (OSPAN) and fluid intelligence (RAPM) on the x-axis
  - Ex-Gauss parameters and mean saccade amplitude on the y-axis

Replication Goals

- In the original study:
  - WM span was negatively predictive of Tau across all three eye-movement tasks
  - In scene-viewing, WM span was predictive of Mu and Sigma of the fixation distribution
- Note: the original study had three different tasks (reading, visual search, scene-viewing), but we use two scene-viewing tasks so we are comparing to their results for scene-viewing

Ex-Gaussian Analysis

- Duration times tend to be skewed toward faster times
- Luke paper used quantile maximum probability estimation in QMPE
- We used continuous maximum likelihood estimation from package "retimes" from CRAN
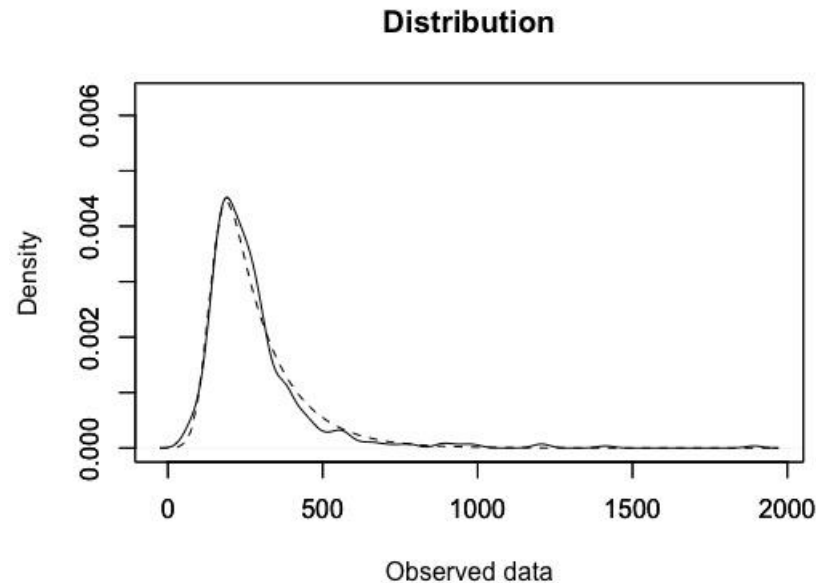
Distribution

Example: subject 1 distribution

Raw Fixation Duration Means and Fitted Means Comparison

	Luke Paper	Aesthetic Task	Memorize Task
Raw Mean	275	289	293
Mu	167	150	134
Sigma	49	52	49
Tau	102	142	164

Linear Mixed Effect Model

- Original Study:
  - Working Memory Factor (z-scored): OSPAN, symmetry span, reading span
  - Executive Control Factor (z-scored): antisaccade task, arrow flanker
  - Used scene-viewing task as baseline in model (intercept)
- Our Study:
  - Working Memory Factor (z-scored): OSPAN
  - Additional Fluid Intelligence Measure (z-scored): RAPM
  - In the discussion section of the Luke paper: "another limitation was the absence of any measure of fluid intelligence" (Luke, Darowski, & Gale, 2018)

Aesthetic: Mu

```
          Mixed Linear Model Regression Results
========================================================
Model:           MixedLM  Dependent Variable:  mu
No. Observations: 99      Method:              REML
No. Groups:       99      Scale:               464.6021
Min. group size:  1       Likelihood:          -471.1559
Max. group size:  1       Converged:           Yes
Mean group size:  1.0
--------------------------------------------------------
              Coef.  Std.Err.    z    P>|z|  [0.025  0.975]
--------------------------------------------------------
Intercept   150.662   0.859  175.437 0.000 148.979 152.345
OSPAN         4.438   2.953    1.503 0.133  -1.350  10.226
RAPM          4.883   3.070    1.590 0.112  -1.135  10.900
Group Var   464.602
========================================================
```

Table 7

Mu

	b	SE	t value	p value
(Intercept)	167.13	1.65	100.99	<.0001
Task = Reading	−26.65	1.56	−17.14	<.0001
Task = Search	−30.97	1.56	−19.91	<.0001
WM span factor	4.82	1.66	2.91	0.0041
Executive control factor	0.044	1.39	0.032	0.97
Task = Reading × WM Span	−4.58	1.56	−2.94	0.0037
Task = Search × WM Span	−4.43	1.56	−2.844	0.0049

Aesthetic: Sigma

Mixed Linear Model Regression Results

```
=========================================================
Model:              MixedLM  Dependent Variable:  sig
No. Observations:   99       Method:              REML
No. Groups:         99       Scale:               97.0660
Min. group size:    1        Likelihood:          -395.9979
Max. group size:    1        Converged:           Yes
Mean group size:    1.0
---------------------------------------------------------
              Coef.   Std.Err.    z    P>|z|  [0.025 0.975]
---------------------------------------------------------
Intercept    52.789   0.477  110.569  0.000  51.853 53.724
OSPAN         2.024   1.382    1.465  0.143  -0.684  4.732
RAPM          1.580   1.338    1.181  0.238  -1.042  4.203
Group Var    97.066
=========================================================
```

Table 8
Sigma

	b	SE	t value	p value
(Intercept)	49.15	1.34	36.72	<.0001
Task = Reading	−16.94	1.65	−10.26	<.0001
Task = Search	−10.17	1.65	−6.16	<.0001
WM span factor	3.58	1.34	2.67	0.0081
Executive control factor	−0.082	0.94	−0.087	0.93
Task = Reading × WM Span	−5.036	1.65	−3.043	0.0027
Task = Search × WM Span	−3.61	1.65	−2.18	0.03

Aesthetic: Tau

```
         Mixed Linear Model Regression Results
=============================================================
Model:              MixedLM  Dependent Variable:  tau
No. Observations:   99       Method:              REML
No. Groups:         99       Scale:               1137.0704
Min. group size:    1        Likelihood:          -514.1173
Max. group size:    1        Converged:           Yes
Mean group size:    1.0
-------------------------------------------------------------
             Coef.   Std.Err.    z     P>|z|  [0.025   0.975]
-------------------------------------------------------------
Intercept   143.181    1.338 106.987 0.000 140.558 145.804
OSPAN        -4.201    4.615  -0.910 0.363 -13.246   4.843
RAPM         -5.516    4.805  -1.148 0.251 -14.934   3.902
Group Var  1137.070
=============================================================
```

Table 9

Tau

	b	SE	t value	p value
(Intercept)	101.61	1.98	51.34	<.0001
Task = Reading	-37.3	2.32	-16.056	<.0001
Task = Search	-8.1	2.32	-3.49	0.0006
WM span factor	-3.64	1.46	-2.5	0.014
Executive control factor	-0.41	1.46	-0.28	0.78

Aesthetic: Mean Saccade Amplitude

```
      Mixed Linear Model Regression Results
=======================================================
Model:             MixedLM Dependent Variable: SCamp
No. Observations:  99      Method:             REML
No. Groups:        99      Scale:              0.2656
Min. group size:   1       Likelihood:         -112.7504
Max. group size:   1       Converged:          Yes
Mean group size:   1.0
-------------------------------------------------------
           Coef. Std.Err.    z    P>|z| [0.025 0.975]
-------------------------------------------------------
Intercept  4.612  0.015 313.224 0.000  4.583  4.641
OSPAN      0.123  0.072   1.702 0.089 -0.019  0.265
RAPM       0.050  0.073   0.685 0.493 -0.093  0.194
Group Var  0.266
=======================================================
```

Table 5

Mean saccade amplitude

	b	SE	t value	p value
(Intercept)	4.49	0.055	80.95	<.0001
Task = Reading	−1.25	0.06	−20.7	<.0001
Task = Search	−0.11	0.06	−1.75	0.082
WM span factor	0.04	0.056	0.73	0.47
Executive control factor	−0.0038	0.043	−0.088	0.93
Task = Reading × WM Span	0.15	0.061	−2.5	0.013
Task = Search × WM Span	−0.019	0.061	0.32	0.75

Memorize: Mu

```
          Mixed Linear Model Regression Results
=============================================================
Model:              MixedLM  Dependent Variable:  mu
No. Observations:   99       Method:              REML
No. Groups:         99       Scale:               854.7963
Min. group size:    1        Likelihood:          -500.4206
Max. group size:    1        Converged:           Yes
Mean group size:    1.0
-------------------------------------------------------------
            Coef.   Std.Err.    z    P>|z|  [0.025   0.975]
-------------------------------------------------------------
Intercept 133.926    1.205  111.115 0.000 131.563 136.288
OSPAN       5.042     4.012    1.257 0.209  -2.822  12.906
RAPM        6.264     4.151    1.509 0.131  -1.872  14.400
Group Var 854.796
=============================================================
```

Table 7

Mu

	b	SE	t value	p value
(Intercept)	167.13	1.65	100.99	<.0001
Task = Reading	−26.65	1.56	−17.14	<.0001
Task = Search	−30.97	1.56	−19.91	<.0001
WM span factor	4.82	1.66	2.91	0.0041
Executive control factor	0.044	1.39	0.032	0.97
Task = Reading × WM Span	−4.58	1.56	−2.94	0.0037
Task = Search × WM Span	−4.43	1.56	−2.844	0.0049

Memorize: Sigma

```
              Mixed Linear Model Regression Results
==========================================================
Model:              MixedLM  Dependent Variable:  sig
No. Observations:   99       Method:              REML
No. Groups:         99       Scale:               162.8552
Min. group size:    1        Likelihood:          -420.8365
Max. group size:    1        Converged:           Yes
Mean group size:    1.0
----------------------------------------------------------
             Coef.   Std.Err.    z     P>|z|  [0.025  0.975]
----------------------------------------------------------
Intercept   49.084   0.857   57.293  0.000  47.405  50.763
OSPAN        0.843   1.604    0.525  0.599  -2.301   3.987
RAPM         3.803   1.815    2.096  0.036   0.247   7.360
Group Var  162.855
==========================================================
```

Table 8

Sigma

	b	SE	t value	p value
(Intercept)	49.15	1.34	36.72	<.0001
Task = Reading	−16.94	1.65	−10.26	<.0001
Task = Search	−10.17	1.65	−6.16	<.0001
WM span factor	3.58	1.34	2.67	0.0081
Executive control factor	−0.082	0.94	−0.087	0.93
Task = Reading × WM Span	−5.036	1.65	−3.043	0.0027
Task = Search × WM Span	−3.61	1.65	−2.18	0.03

Memorize: Tau

```
      Mixed Linear Model Regression Results
==========================================================
Model:              MixedLM Dependent Variable: tau
No. Observations:   99      Method:              REML
No. Groups:         99      Scale:               2327.2919
Min. group size:    1       Likelihood:          -548.4973
Max. group size:    1       Converged:           Yes
Mean group size:    1.0

             Coef.   Std.Err.    z     P>|z|   [0.025  0.975]
----------------------------------------------------------
Intercept  164.719     1.541 106.883 0.000 161.698 167.739
OSPAN        -8.100     6.709  -1.207 0.227 -21.249   5.050
RAPM         -8.824     6.859  -1.286 0.198 -22.268   4.621
Group Var 2327.292
==========================================================
```

Table 9

Tau

	b	SE	t value	p value
(Intercept)	101.61	1.98	51.34	<.0001
Task = Reading	−37.3	2.32	−16.056	<.0001
Task = Search	−8.1	2.32	−3.49	0.0006
WM span factor	−3.64	1.46	−2.5	0.014
Executive control factor	−0.41	1.46	−0.28	0.78

Memorize: Mean Saccade Amplitude

```
         Mixed Linear Model Regression Results
=================================================================
Model:              MixedLM Dependent Variable: SCamp
No. Observations:   99      Method:             REML
No. Groups:         99      Scale:              0.2984
Min. group size:    1       Likelihood:         -118.3261
Max. group size:    1       Converged:          Yes
Mean group size:    1.0
-----------------------------------------------------------------
            Coef.  Std.Err.    z     P>|z|  [0.025  0.975]
-----------------------------------------------------------------
Intercept   4.475   0.014  313.303  0.000   4.447   4.503
OSPAN       0.080   0.077    1.041  0.298  -0.070   0.230
RAPM        0.033   0.078    0.427  0.669  -0.119   0.186
Group Var   0.298
=================================================================
```

Table 5

Mean saccade amplitude

	b	SE	t value	p value
(Intercept)	4.49	0.055	80.95	<.0001
Task = Reading	−1.25	0.06	−20.7	<.0001
Task = Search	−0.11	0.06	−1.75	0.082
WM span factor	0.04	0.056	0.73	0.47
Executive control factor	−0.0038	0.043	−0.088	0.93
Task = Reading × WM Span	0.15	0.061	−2.5	0.013
Task = Search × WM Span	−0.019	0.061	0.32	0.75

Summary

- WM span is not significantly predictive of Tau for either of the two tasks
- WM span is not significantly predictive of Mu and Sigma for either of the two task
- While some coefficients looked similar, our p-values were much higher and we are unable to replicate the results from the original paper