- Anaphoric Encapsulation - Reading time & Discourse particle analysis

In cooperation with

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This report contains the results of the analysis of the experiment 'Anaphoric Encapsulation'. Hypothesis tests may have been performed and, if so, are reported at the very end of this report. One model was fitted per reading time parameter, each including all AOI.conditions from the different experiments. Another model per reading time parameter was fitted, solely with respect to the reading times of the whole critical item (AOI 1).

The models were computed using the software for statistical computing R (to cite as: R Core Team (2018). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/). The models were estimated using the R function "gam" from the package "mgcv" (to cite as: Wood, S.N. (2017) Generalized Additive Models: An Introduction with R (2nd edition). Chapman and Hall/CRC).

As of the high number of hypothesis tests over all models all p-values per model were corrected using the Holm method (to cite as: Holm, S. (1979). A simple sequentially rejective multiple test procedure. Scandinavian Journal of Statistics 6, 65–70).

The report contains for the models of the first type tables with the estimates, the predicted values calculated for the average number of characters per word as well as the corresponding standard errors. The predicted values and the average number of characters per word for every AOI.condition are visualized in boxplots. For the second type of models, solely the estimates, the corresponding standard errors and the p-values are given.

Comments on the analysis

For the first type of model, the numbers are interpretable as reading times per word in milliseconds (ms). Each model comprises 3 reading time parameters:

- Total reading time per word (TRT.WD)
- First pass reading time per word (FRT.WD)
- Total dwell time/Re-reading time per word (RRT.WD)

The analysis was performed using generalized additive mixed models (GAMM) using the following parametrization:

- Fixed effects:
  - Areas of Interest (AOIs) per condition
- Random effects (specifically, random intercepts):
  - Participants
  - Items
- (Non)linear effect for average word length (see following report for in which models the effect was estimated as a linear or nonlinear effect)

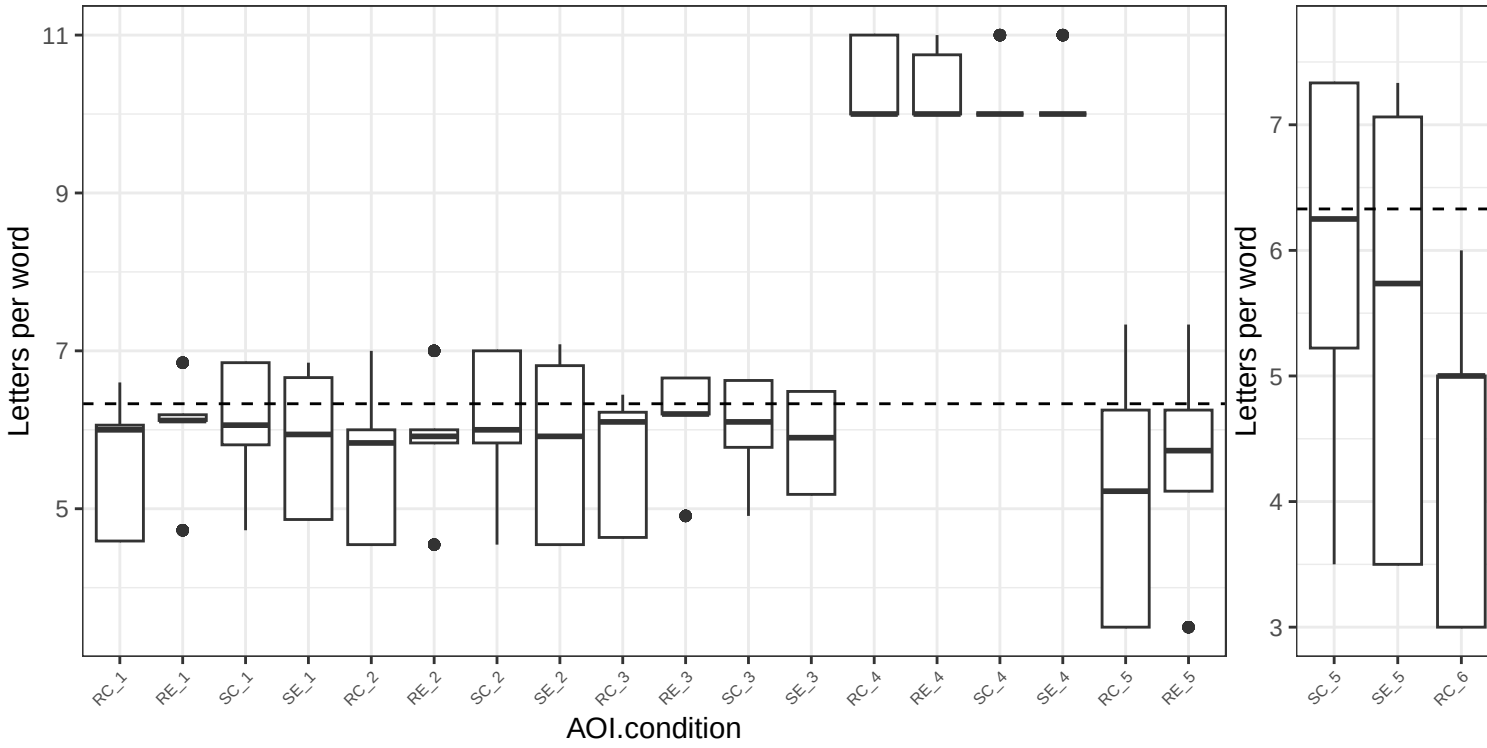
For the second type of models, analysis was performed using generalized additive mixed models (GAMM) as well using the following alternative parametrization:

- Target variables:
  - Total reading time, first pass reading time, re-reading time (each per letter)
- Fixed effects:
  - Variable 1 (with two levels, synonym and repetition)
  - Variable 2 (with two levels, encapsulation and coreference)
- Random effects (specifically, random intercepts):
  - Participants
  - Topics

Comments on data interpretation

1. Estimates are not interpretable as absolute values, i.e. they do not reflect absolute reading times in milliseconds.
   - The first value in the estimate column is the intercept, i.e. the reference AOI.condition for calculating all other values
   - Further values reflect reading time differences [in milliseconds] to the intercept
   - Estimate values take into account potential length differences between AOIs, i.e. the estimate value can be described as "difference of both AOIs that remains having controlled for possible differences in the number of characters per word"
   - The difference between the intercept and the estimate values cannot be expressed in percentages as the estimates themselves do not reflect absolute reading times
   - By controlling for differences in number of characters per word negative intercepts are possible. This is again due to the fact that the intercept (as all estimates) does not reflect absolute values.
2. Predicted values: interpretable as absolute values in milliseconds.
   - Predicted values reflect the absolute value in milliseconds for the AOI.condition assuming a fixed, average number of characters per word indicated in the column ‚nLetters.WD_fix'.
   - Differences between predicted values can be expressed in percentages
3. Plots
   - Boxplot of average number of characters per word for each AOI
     - Interpretation: check for differences in the average number of characters per word (predictions are only valid if the used average number of characters per word is realistic for each AOI)
   - Boxplot of predicted values
     - Visualization of predicted values

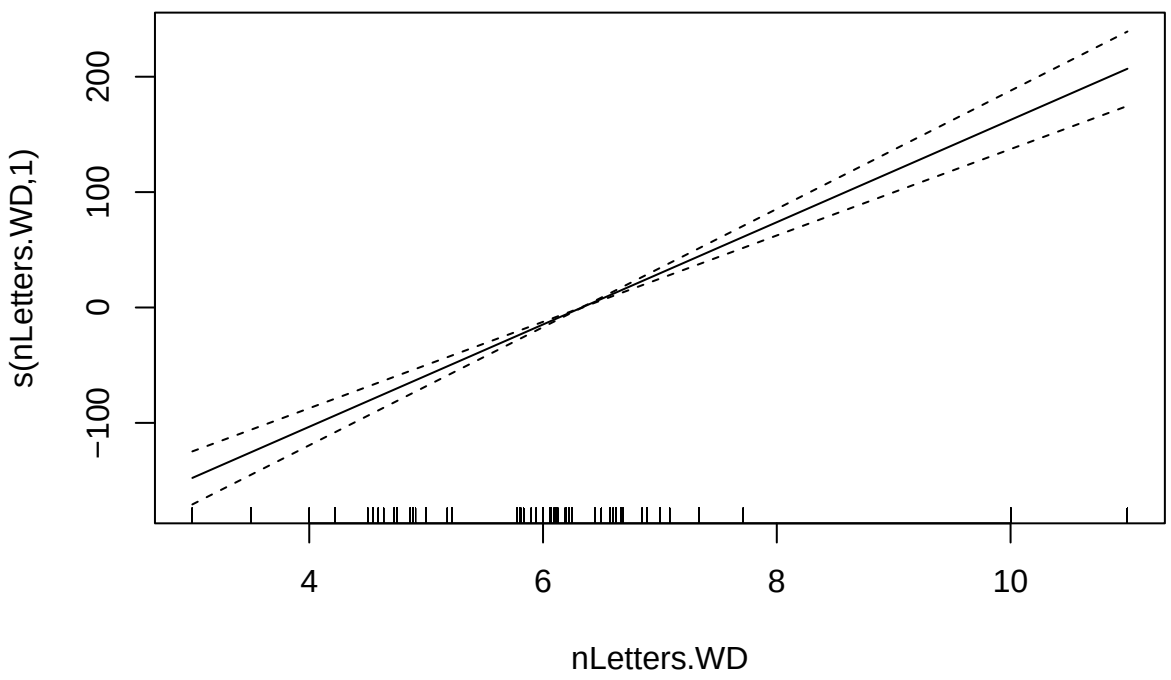
Letters per word (with the average letters per word as horizontal line)

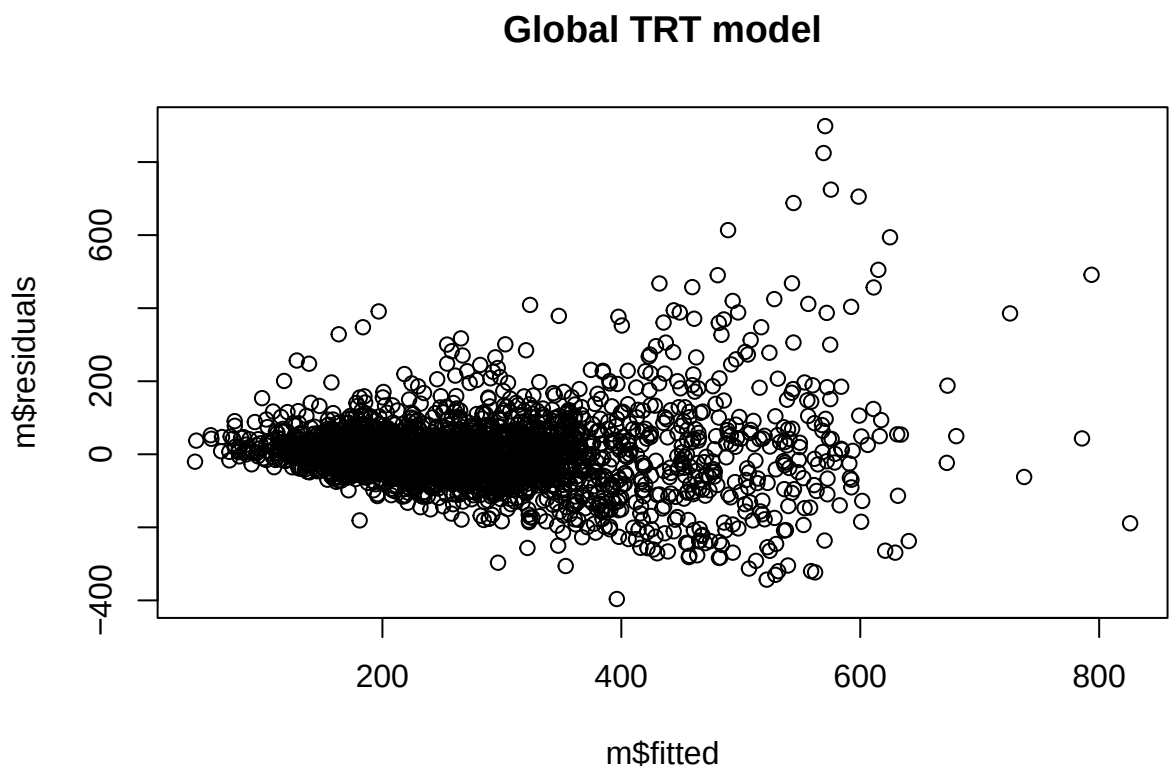


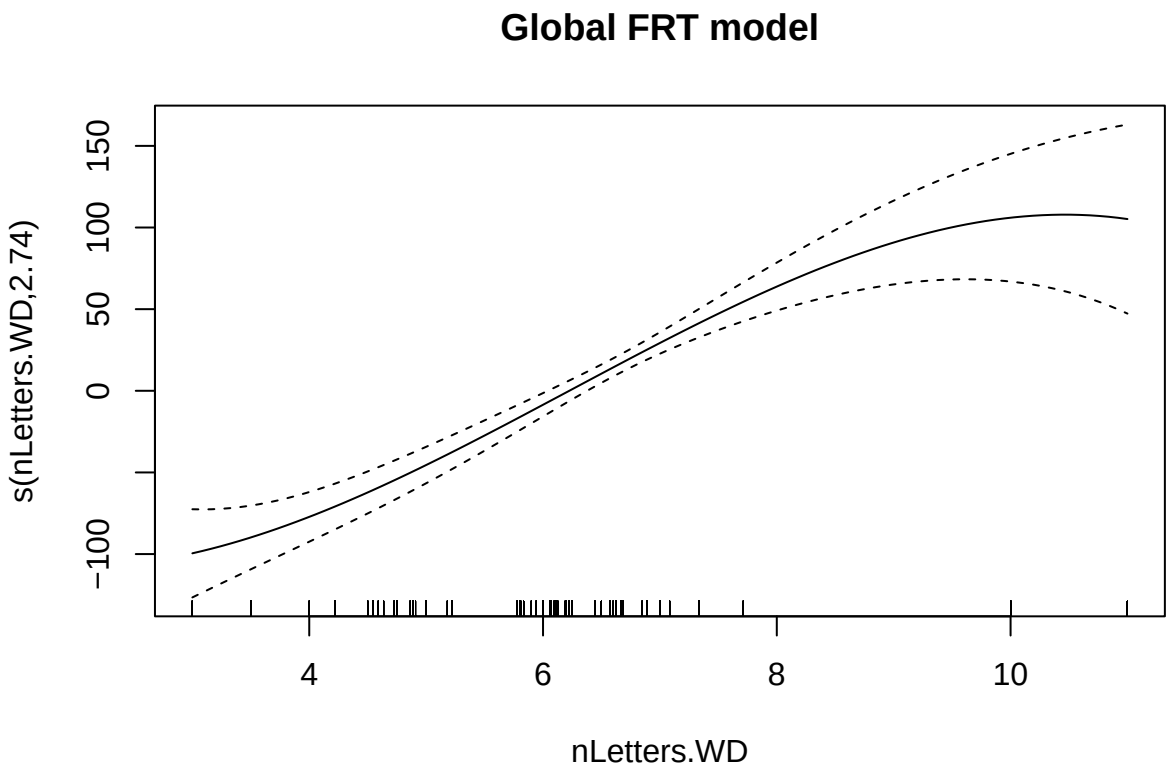
Observations per AOI.condition

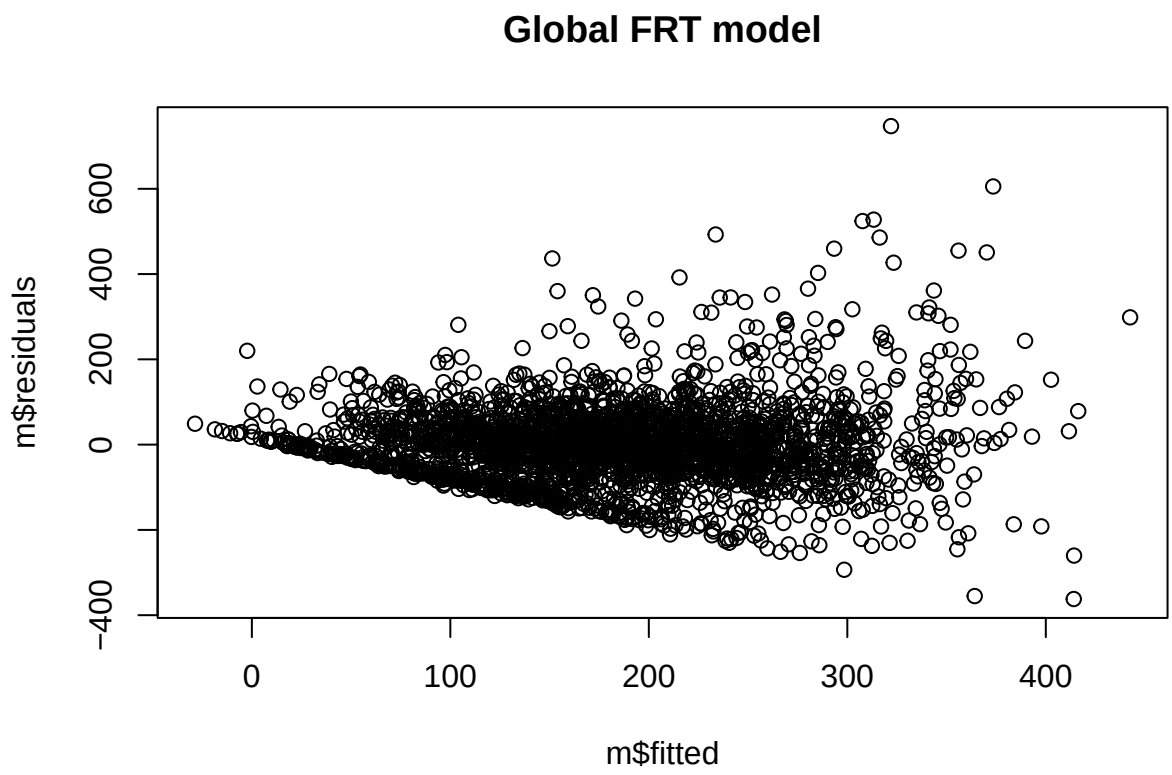
AOI.condition	Freq
RC_1	77
RE_1	78
SC_1	78
SE_1	78
RC_2	77
RE_2	78
SC_2	78
SE_2	78
RC_3	77
RE_3	78
SC_3	78
SE_3	78
RC_4	77
RE_4	78
SC_4	78
SE_4	78
RC_5	77
RE_5	78
SC_5	78
SE_5	78
RC_6	77
RE_6	78
SC_6	78
SE_6	78
RC_7	77
RE_7	78
SC_7	78

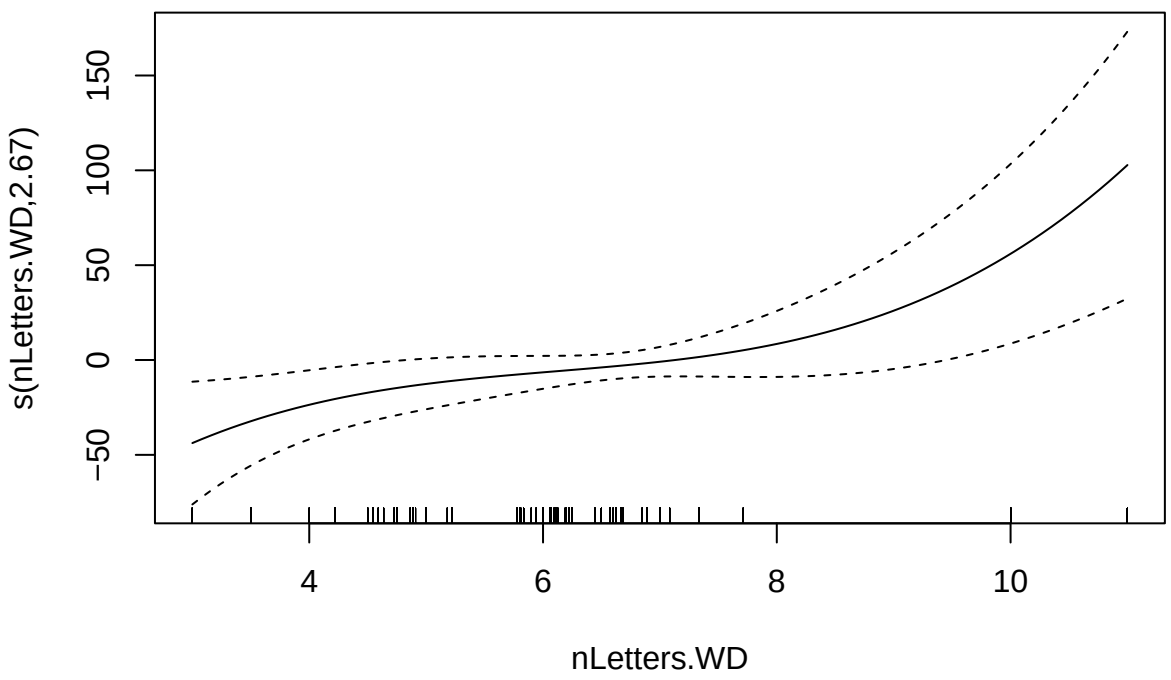
AOI.condition	Freq
SE_7	78
RC_8	77
RE_8	78
SC_8	78
SE_8	78
RC_9	77
RE_9	78
SC_9	78
SE_9	78

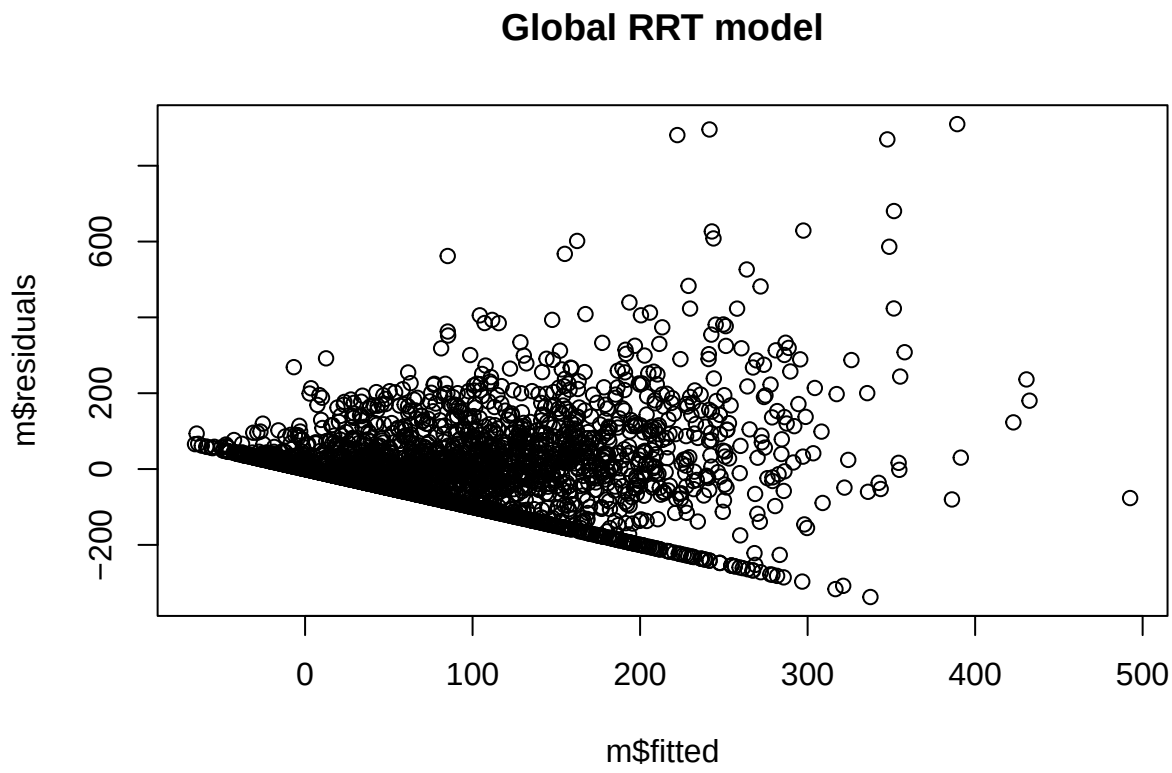

Global TRT model
s(nLetters.WD,1)
200
100
0
−100
4
6
8
10
nLetters.WD

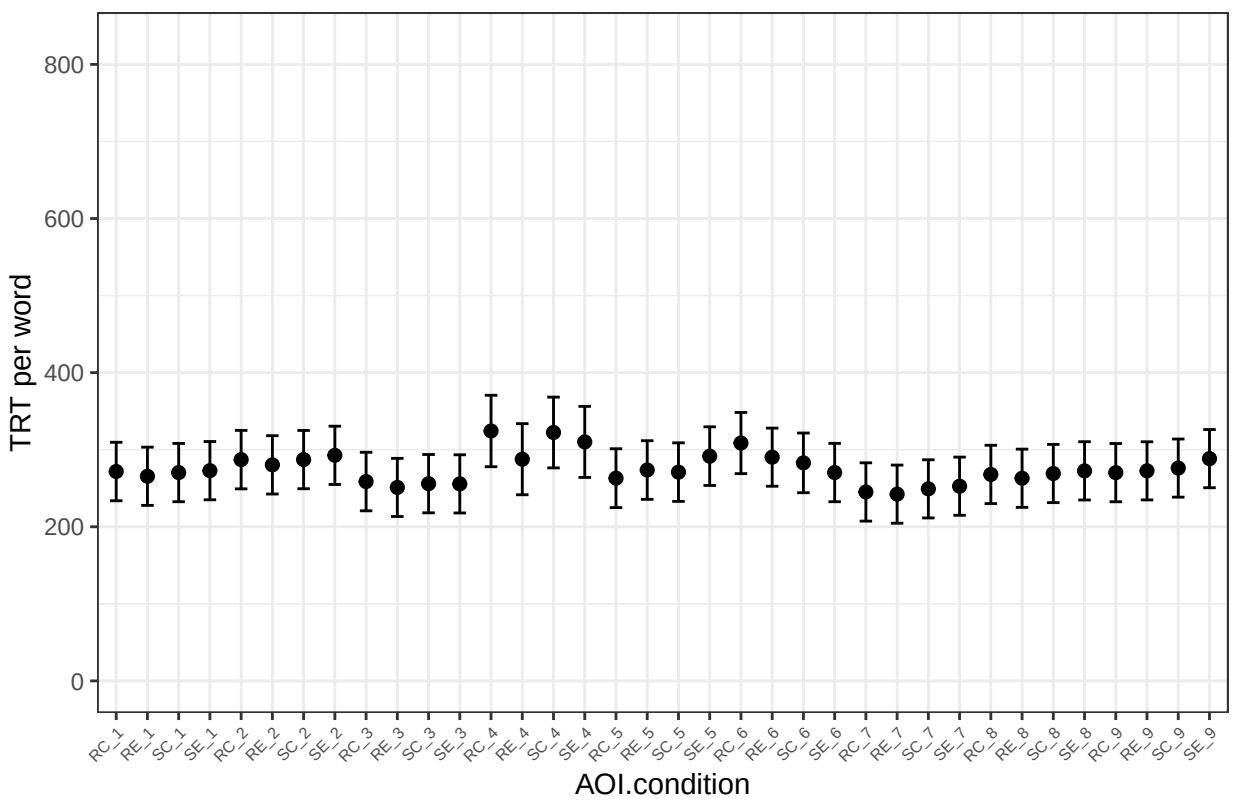

Global TRT model
m$residuals
600
200
0
−400
200
400
600
800
m$fitted


Global FRT model
s(nLetters.WD,2.74)
150
100
50
0
−100
4
6
8
10
nLetters.WD


Global FRT model
m$residuals
600
400
200
0
−400
0
100
200
300
400
m$fitted

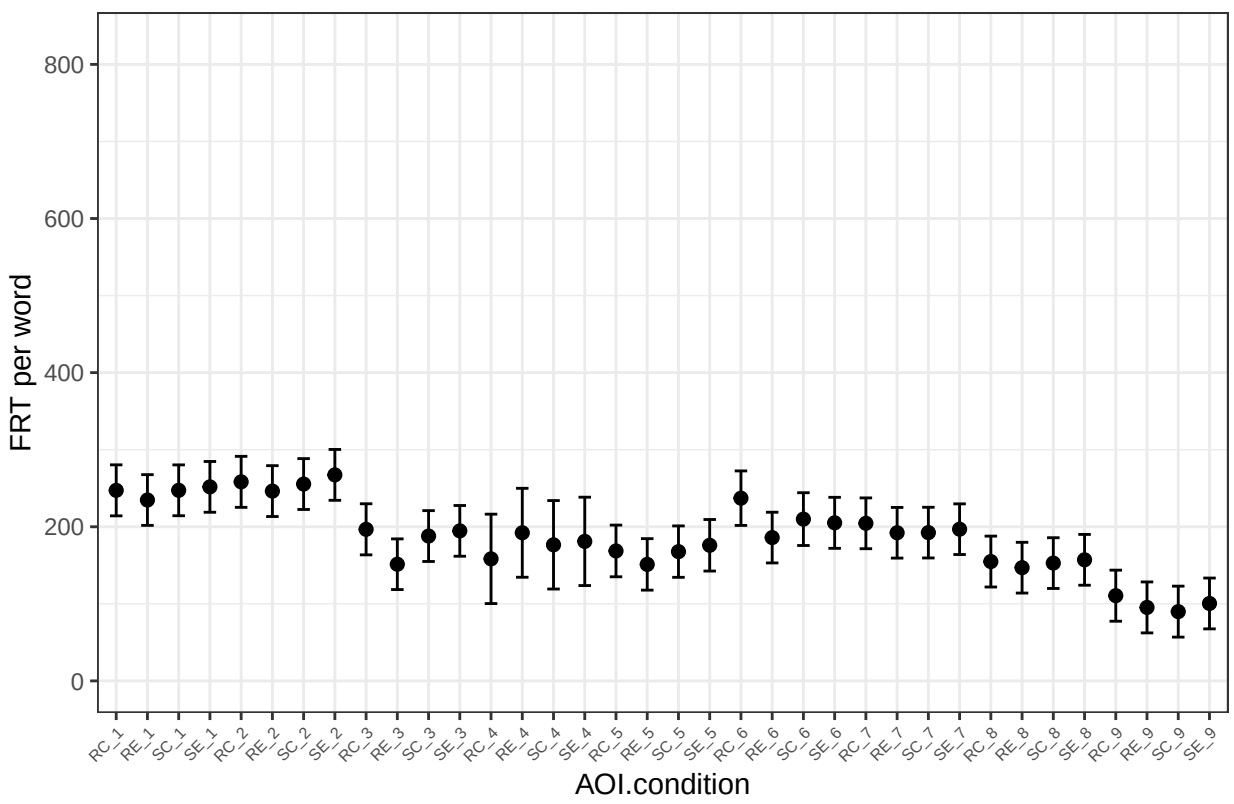

Global RRT model
s(nLetters.WD,2.67)
150
100
50
0
−50
4
6
8
10
nLetters.WD


Global RRT model
m$residuals
600
200
0
−200
0
100
200
300
400
500
m$fitted



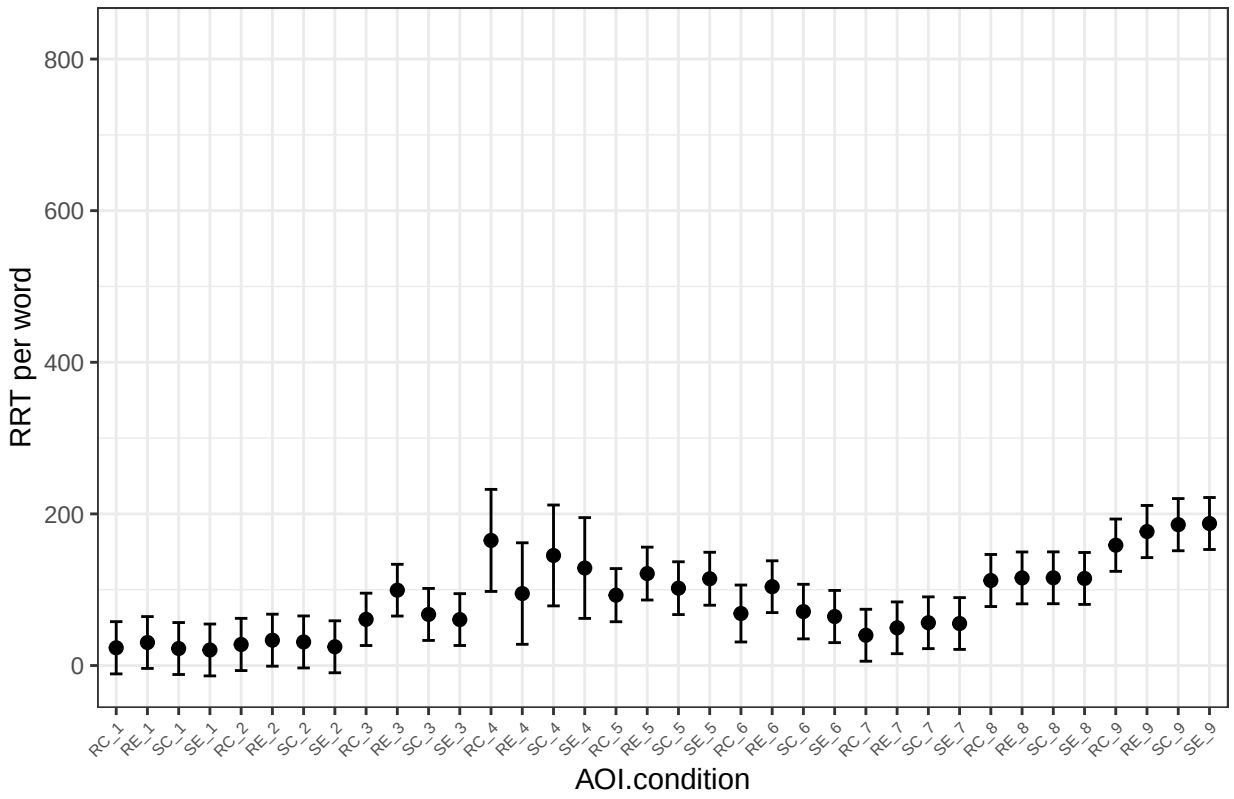
	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	TRT.Pred	TRT.Pred.StdErr
RC_1	271.79	19.36	5.79	6.33	271.70	19.36
RE_1	-6.17	15.85	5.97	6.33	265.53	19.27
SC_1	-1.37	15.85	5.90	6.33	270.34	19.30
SE_1	1.11	15.85	5.92	6.33	272.82	19.28
RC_2	15.45	15.89	5.81	6.33	287.15	19.35
RE_2	8.65	15.85	5.83	6.33	280.35	19.31
SC_2	15.47	15.85	5.89	6.33	287.18	19.30
SE_2	20.99	15.85	5.85	6.33	292.70	19.30
RC_3	-13.01	15.89	5.73	6.33	258.69	19.37
RE_3	-20.64	15.88	6.10	6.33	251.06	19.25
SC_3	-15.76	15.85	5.89	6.33	255.95	19.30
SE_3	-16.04	15.86	5.99	6.33	255.67	19.26
RC_4	52.58	22.18	10.27	6.33	324.29	23.65
RE_4	15.95	22.06	10.26	6.33	287.65	23.54
SC_4	50.63	21.93	10.24	6.33	322.33	23.43
SE_4	38.42	22.04	10.23	6.33	310.13	23.52
RC_5	-8.63	15.92	5.51	6.33	263.07	19.47
RE_5	1.93	15.87	5.57	6.33	273.63	19.41
SC_5	-0.80	15.86	5.66	6.33	270.90	19.39
SE_5	19.94	15.87	5.55	6.33	291.64	19.41
RC_6	36.94	16.51	4.49	6.33	308.64	20.26
RE_6	18.61	15.89	6.14	6.33	290.31	19.24
SC_6	11.23	16.08	5.06	6.33	282.93	19.75
SE_6	-1.33	15.85	5.76	6.33	270.37	19.32
RC_7	-26.52	15.92	6.05	6.33	245.18	19.29
RE_7	-29.37	15.87	6.06	6.33	242.33	19.25
SC_7	-22.49	15.87	6.09	6.33	249.21	19.25
SE_7	-19.05	15.87	6.03	6.33	252.65	19.25

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	TRT.Pred	TRT.Pred.StdErr
RC_8	-3.80	15.90	5.93	6.33	267.91	19.32
RE_8	-8.73	15.85	5.95	6.33	262.97	19.28
SC_8	-2.59	15.85	5.99	6.33	269.11	19.27
SE_8	0.84	15.85	5.88	6.33	272.55	19.29
RC_9	-1.46	15.93	6.12	6.33	270.24	19.28
RE_9	0.86	15.90	6.18	6.33	272.56	19.24
SC_9	4.46	15.91	6.26	6.33	276.16	19.23
SE_9	16.73	15.86	5.98	6.33	288.43	19.26



	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	FRT.Pred	FRT.Pred.StdErr
RC_1	243.23	17.12	5.79	6.33	247.26	16.89
RE_1	-12.53	14.99	5.97	6.33	234.72	16.79
SC_1	0.05	14.98	5.90	6.33	247.31	16.83
SE_1	4.53	14.98	5.92	6.33	251.79	16.81
RC_2	11.04	15.03	5.81	6.33	258.30	16.88
RE_2	-0.97	14.98	5.83	6.33	246.29	16.84
SC_2	8.17	14.98	5.89	6.33	255.43	16.83
SE_2	20.07	14.99	5.85	6.33	267.33	16.83
RC_3	-50.56	15.03	5.73	6.33	196.69	16.92
RE_3	-95.86	15.02	6.10	6.33	151.40	16.77
SC_3	-59.30	14.98	5.89	6.33	187.96	16.84
SE_3	-52.59	14.99	5.99	6.33	194.67	16.79
RC_4	-88.92	29.30	10.27	6.33	158.34	29.59
RE_4	-55.05	29.15	10.26	6.33	192.21	29.44
SC_4	-70.66	28.98	10.24	6.33	176.59	29.28
SE_4	-66.22	28.96	10.23	6.33	181.04	29.25
RC_5	-78.62	15.20	5.51	6.33	168.64	17.11
RE_5	-96.07	15.14	5.57	6.33	151.18	17.04
SC_5	-79.51	15.14	5.66	6.33	167.75	17.02
SE_5	-71.28	15.17	5.55	6.33	175.98	17.06
RC_6	-10.15	15.89	4.49	6.33	237.11	18.04
RE_6	-61.27	15.06	6.14	6.33	185.99	16.78
SC_6	-37.34	15.43	5.06	6.33	209.92	17.47
SE_6	-42.13	14.99	5.76	6.33	205.12	16.88
RC_7	-42.75	15.05	6.05	6.33	204.51	16.82
RE_7	-55.03	15.01	6.06	6.33	192.23	16.77
SC_7	-54.84	15.00	6.09	6.33	192.42	16.78
SE_7	-50.39	15.00	6.03	6.33	196.87	16.78

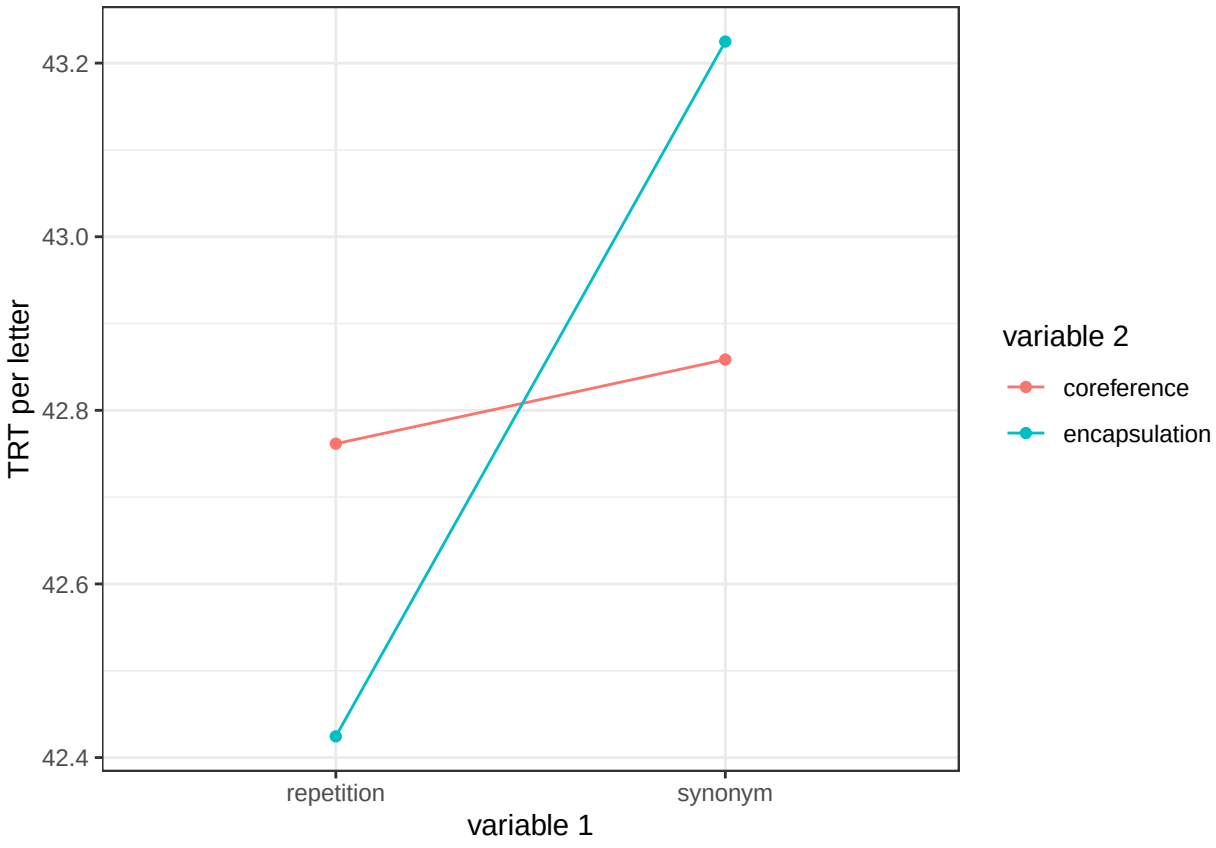
	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	FRT.Pred	FRT.Pred.StdErr
RC_8	-92.40	15.03	5.93	6.33	154.86	16.84
RE_8	-100.34	14.99	5.95	6.33	146.92	16.80
SC_8	-94.39	14.99	5.99	6.33	152.87	16.80
SE_8	-90.12	14.98	5.88	6.33	157.14	16.82
RC_9	-136.67	15.20	6.12	6.33	110.59	16.90
RE_9	-151.90	15.17	6.18	6.33	95.36	16.86
SC_9	-157.37	15.20	6.26	6.33	89.89	16.87
SE_9	-146.77	15.05	5.98	6.33	100.49	16.83

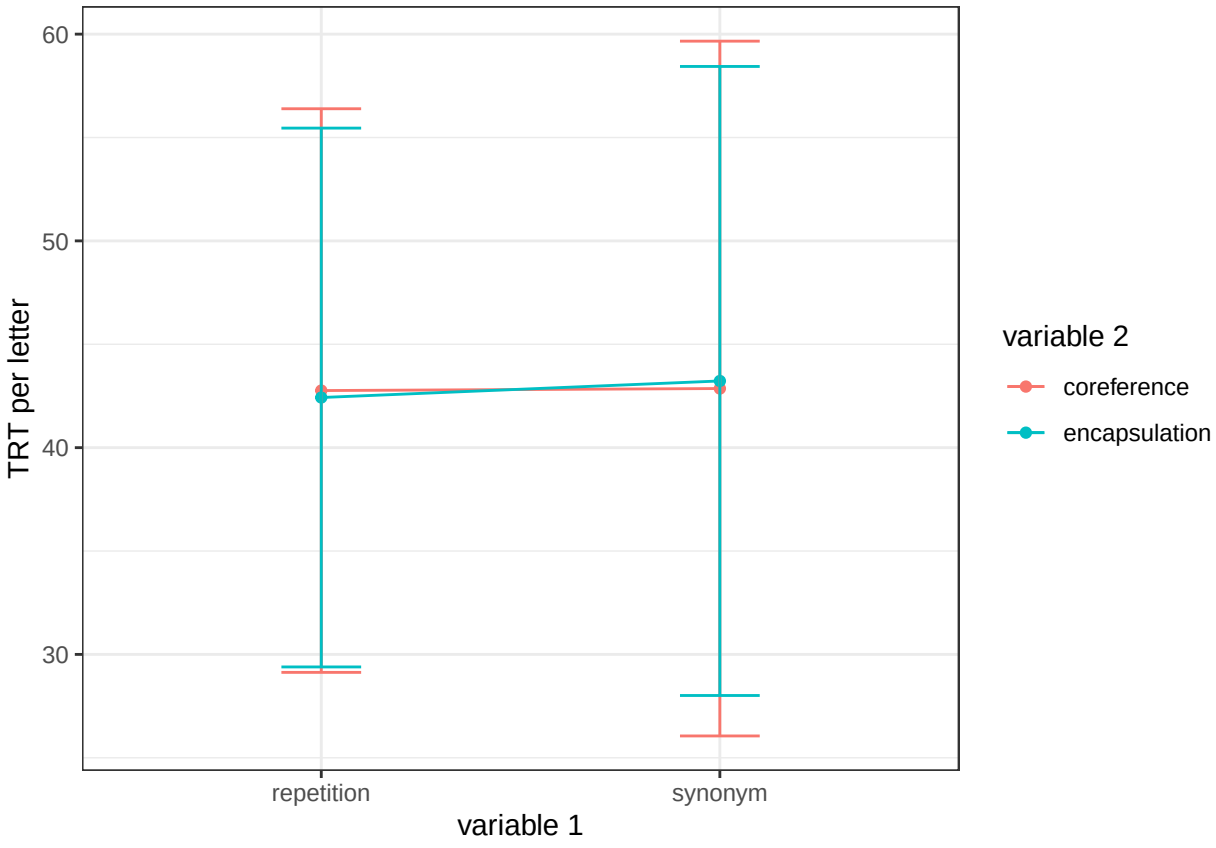


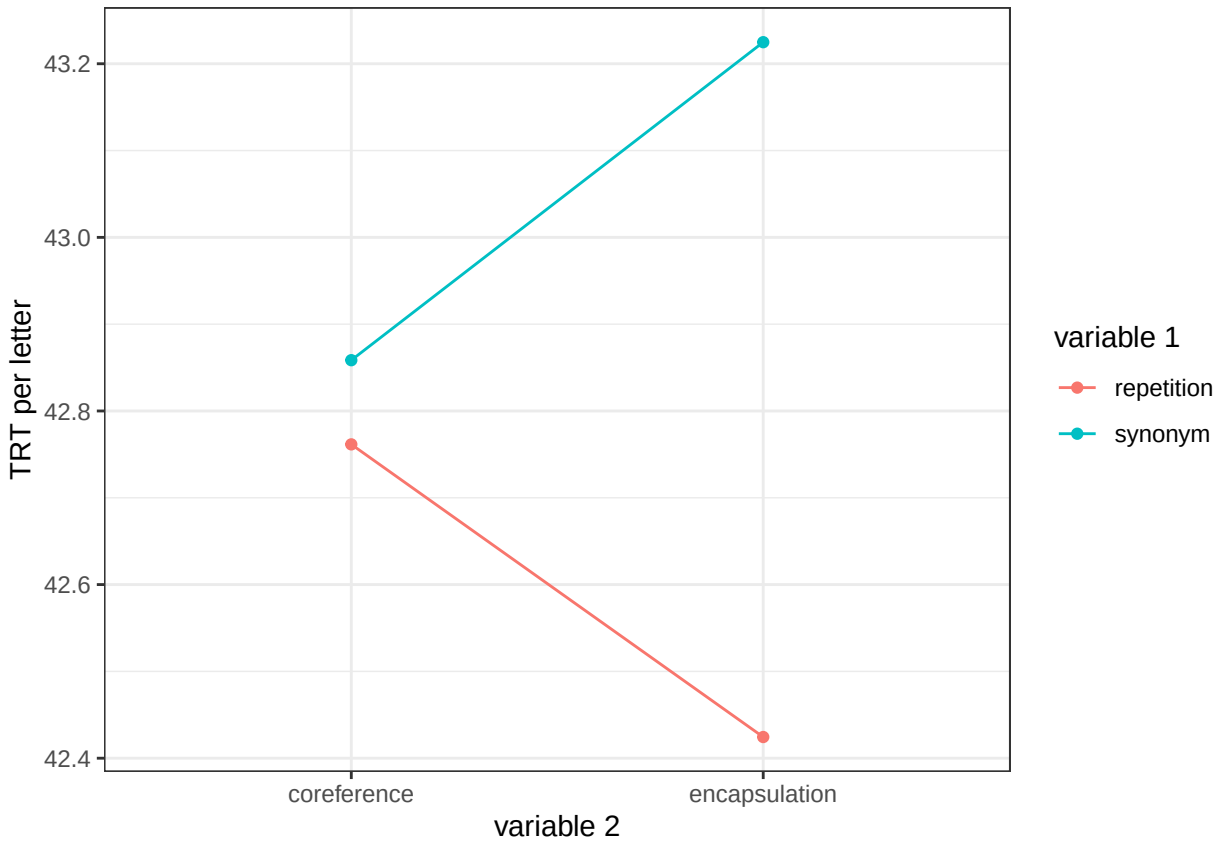
	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	RRT.Pred	RRT.Pred.StdErr
RC_1	28.19	17.90	5.79	6.33	23.38	17.58
RE_1	6.94	18.36	5.97	6.33	30.33	17.44
SC_1	-0.97	18.35	5.90	6.33	22.42	17.49
SE_1	-2.88	18.35	5.92	6.33	20.51	17.46
RC_2	4.39	18.40	5.81	6.33	27.78	17.57
RE_2	10.02	18.35	5.83	6.33	33.41	17.50
SC_2	7.70	18.35	5.89	6.33	31.08	17.49
SE_2	1.32	18.35	5.85	6.33	24.70	17.49
RC_3	37.51	18.41	5.73	6.33	60.90	17.61
RE_3	75.96	18.39	6.10	6.33	99.35	17.41
SC_3	44.00	18.35	5.89	6.33	67.39	17.50
SE_3	37.21	18.36	5.99	6.33	60.60	17.44
RC_4	141.63	35.63	10.27	6.33	165.01	34.34
RE_4	71.54	35.44	10.26	6.33	94.93	34.15
SC_4	121.79	35.24	10.24	6.33	145.17	33.95
SE_4	105.22	35.21	10.23	6.33	128.61	33.90
RC_5	69.40	18.61	5.51	6.33	92.78	17.88
RE_5	97.89	18.54	5.57	6.33	121.27	17.79
SC_5	78.62	18.53	5.66	6.33	102.00	17.76
SE_5	91.05	18.57	5.55	6.33	114.44	17.82
RC_6	45.20	19.42	4.49	6.33	68.59	19.16
RE_6	80.59	18.44	6.14	6.33	103.98	17.43
SC_6	47.75	18.88	5.06	6.33	71.13	18.37
SE_6	41.22	18.36	5.76	6.33	64.61	17.56
RC_7	16.53	18.44	6.05	6.33	39.92	17.48
RE_7	26.36	18.38	6.06	6.33	49.75	17.41
SC_7	33.02	18.38	6.09	6.33	56.40	17.42
SE_7	32.01	18.37	6.03	6.33	55.40	17.42

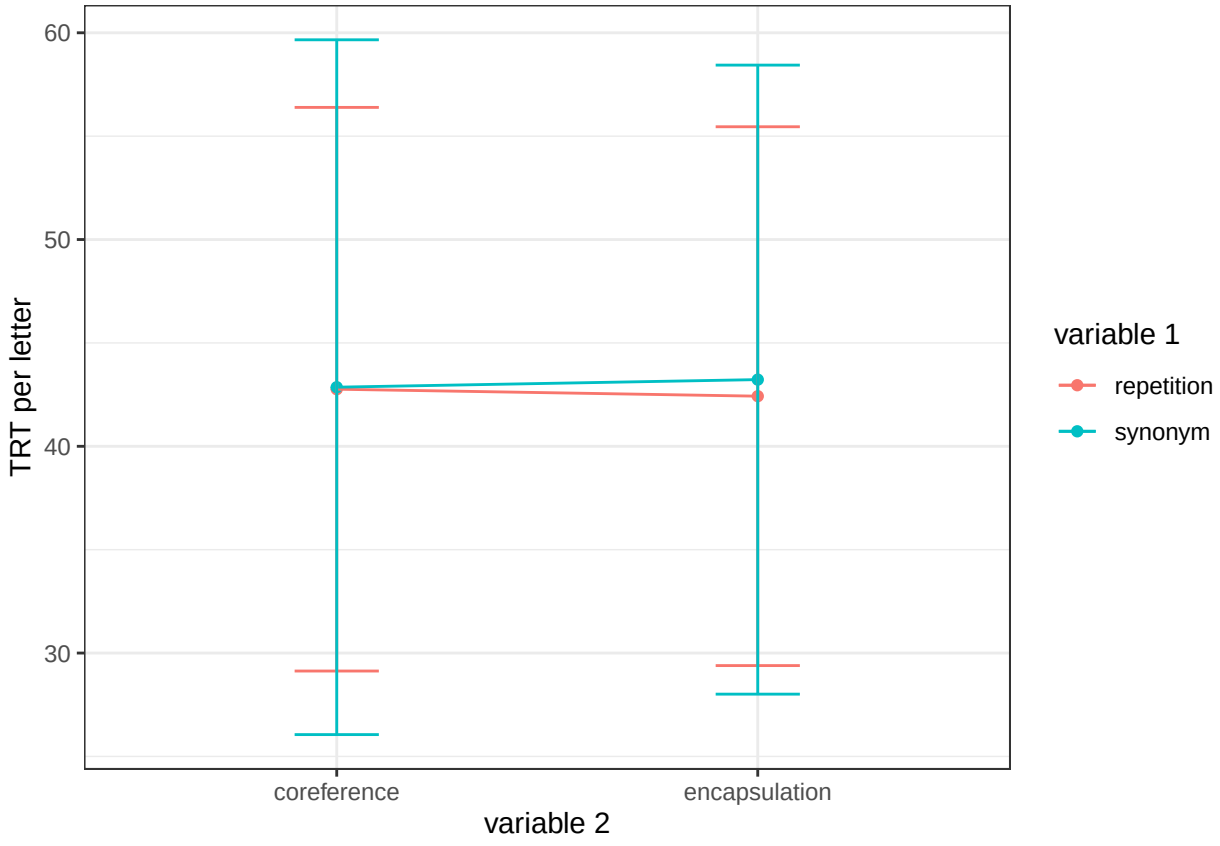
	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	RRT.Pred	RRT.Pred.StdErr
RC_8	88.76	18.41	5.93	6.33	112.14	17.52
RE_8	92.17	18.36	5.95	6.33	115.55	17.45
SC_8	92.34	18.36	5.99	6.33	115.72	17.45
SE_8	91.46	18.35	5.88	6.33	114.85	17.47
RC_9	135.33	18.60	6.12	6.33	158.71	17.60
RE_9	153.34	18.57	6.18	6.33	176.72	17.54
SC_9	162.42	18.61	6.26	6.33	185.80	17.56
SE_9	163.94	18.43	5.98	6.33	187.33	17.49

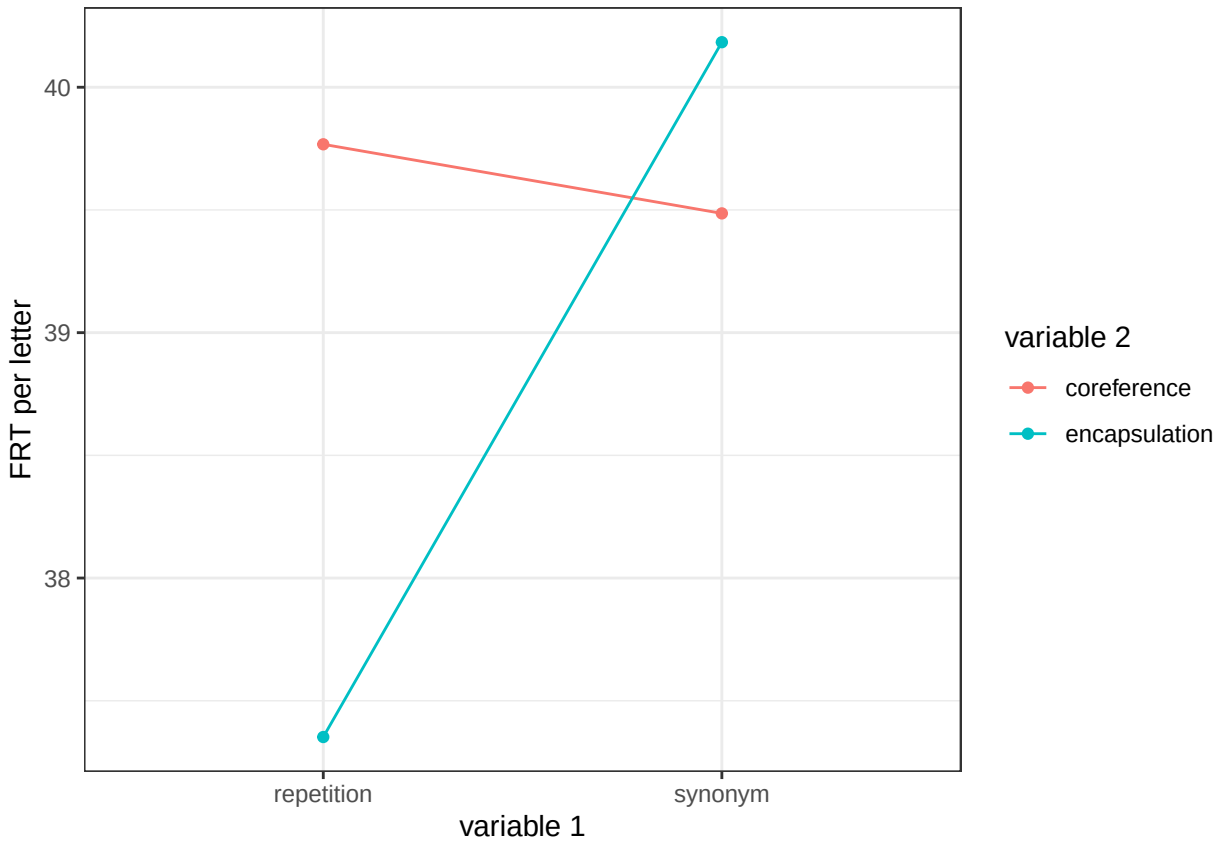
Second Model (for AOI 1)

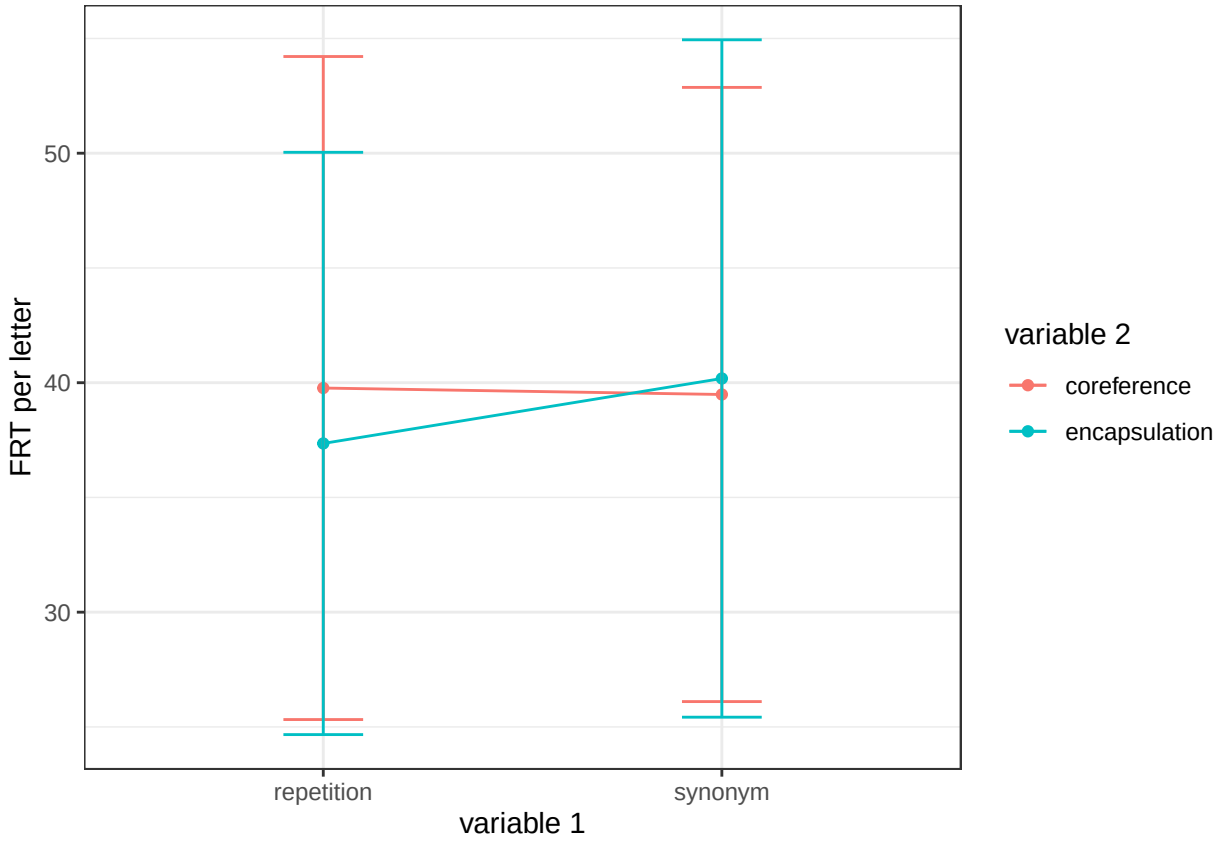


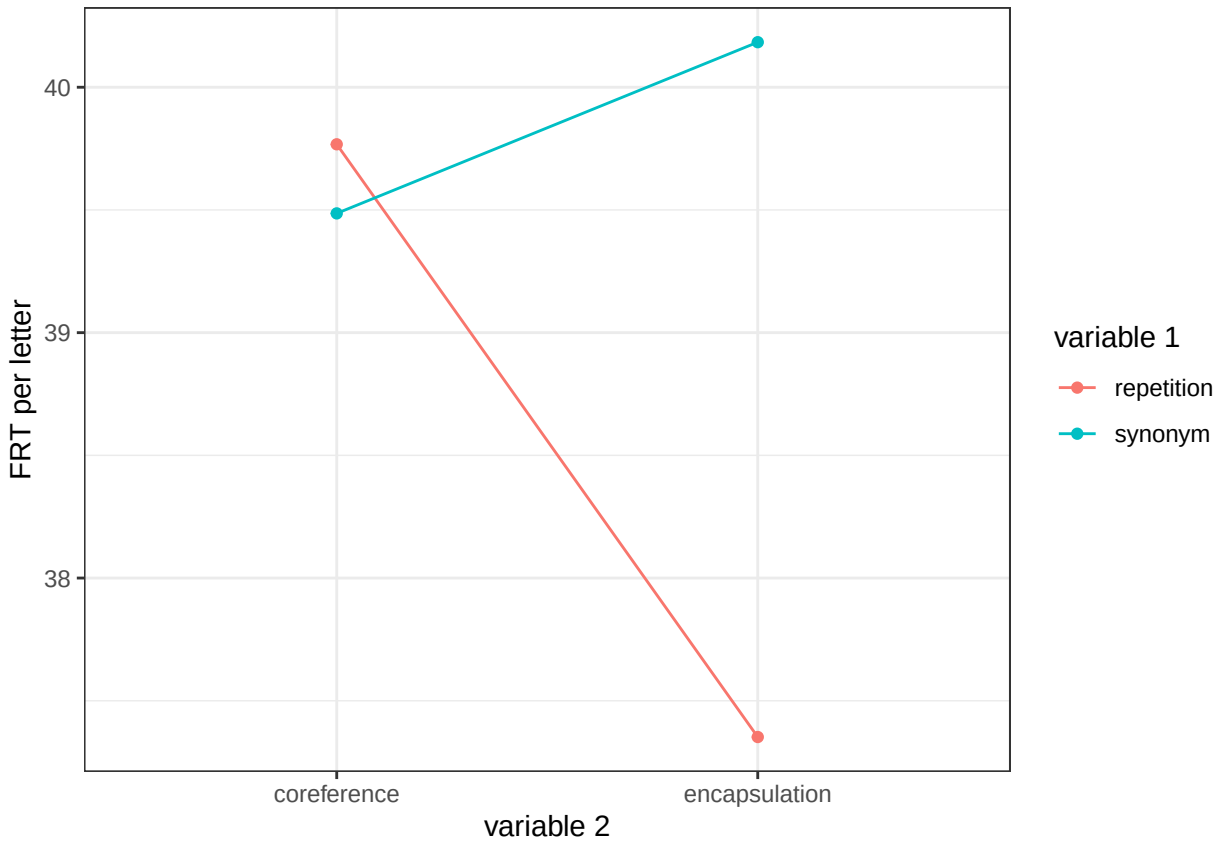


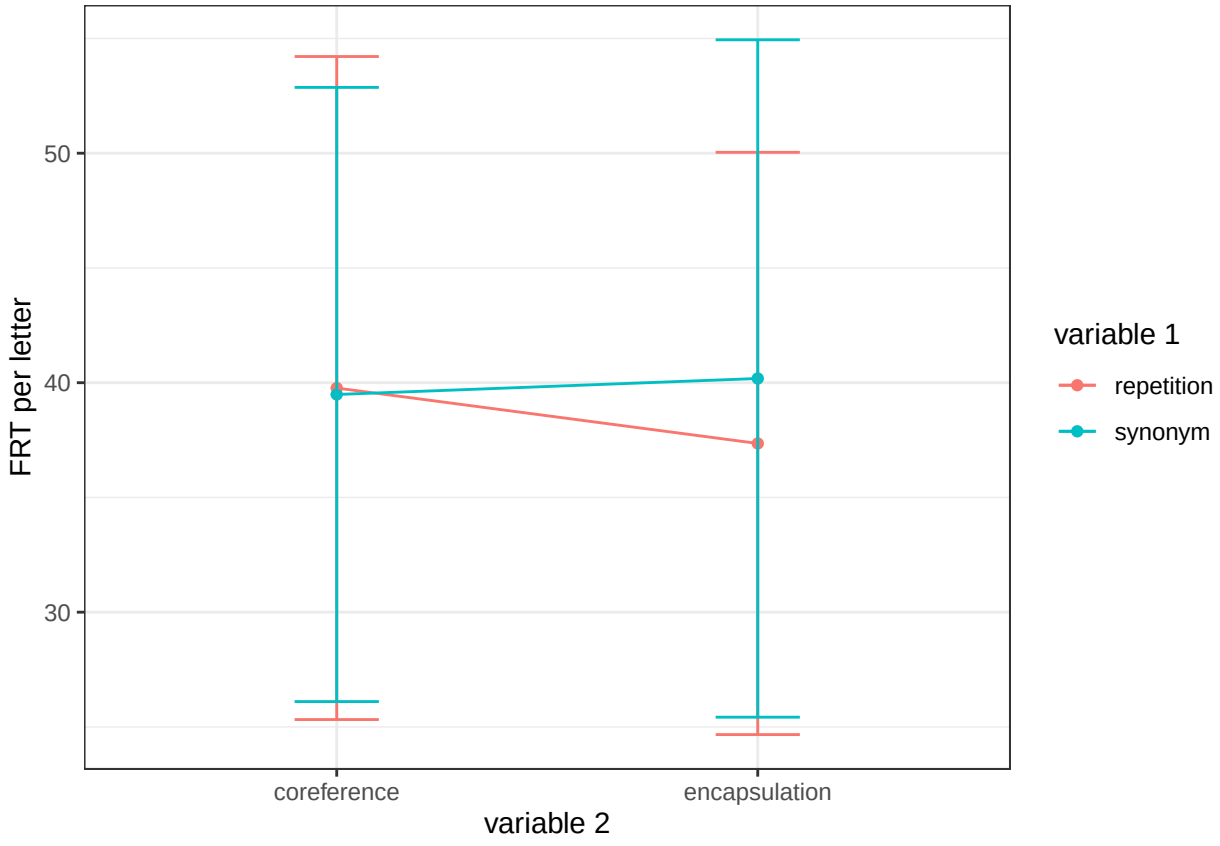

43.2
43.0
42.8
42.6
42.4
TRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym

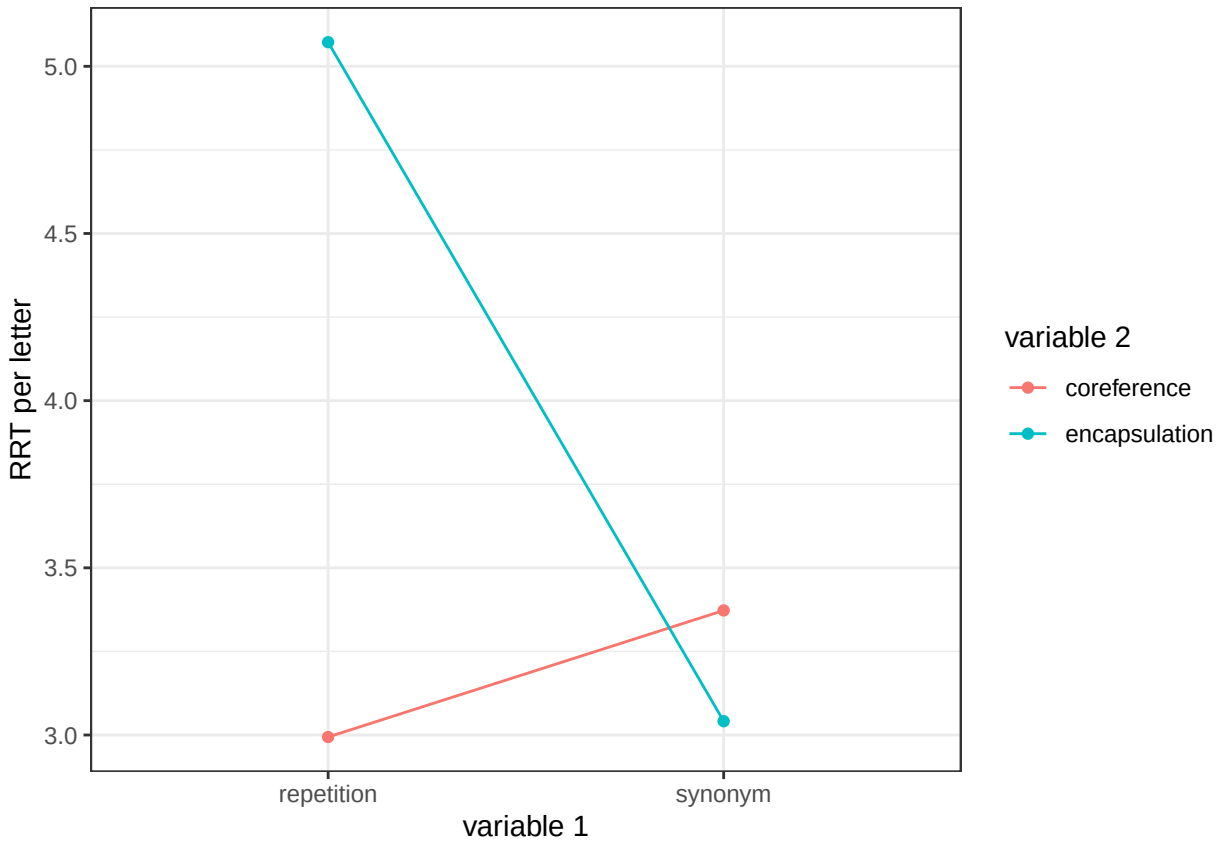

60
50
40
30
TRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym

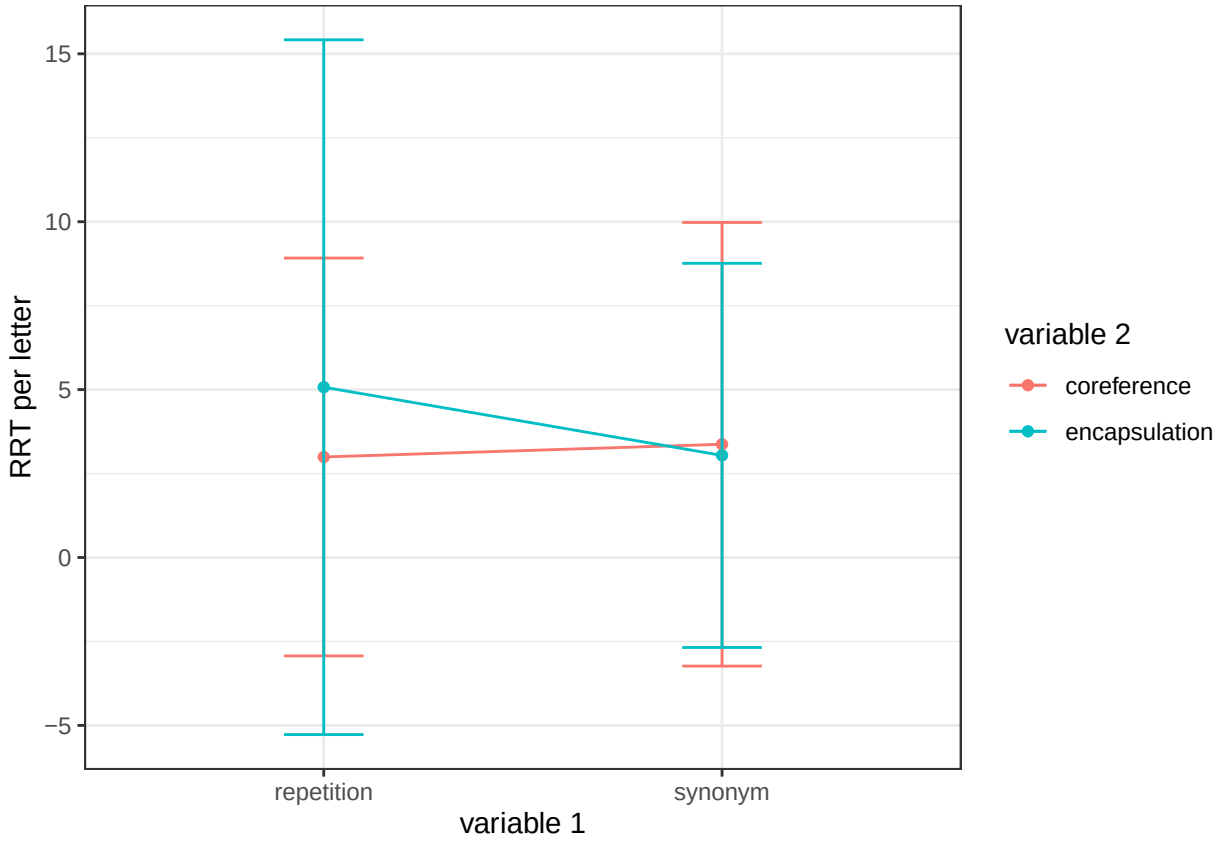

40
39
38
FRT per letter
repetition
synonym
variable 1
variable 2
coreference
encapsulation

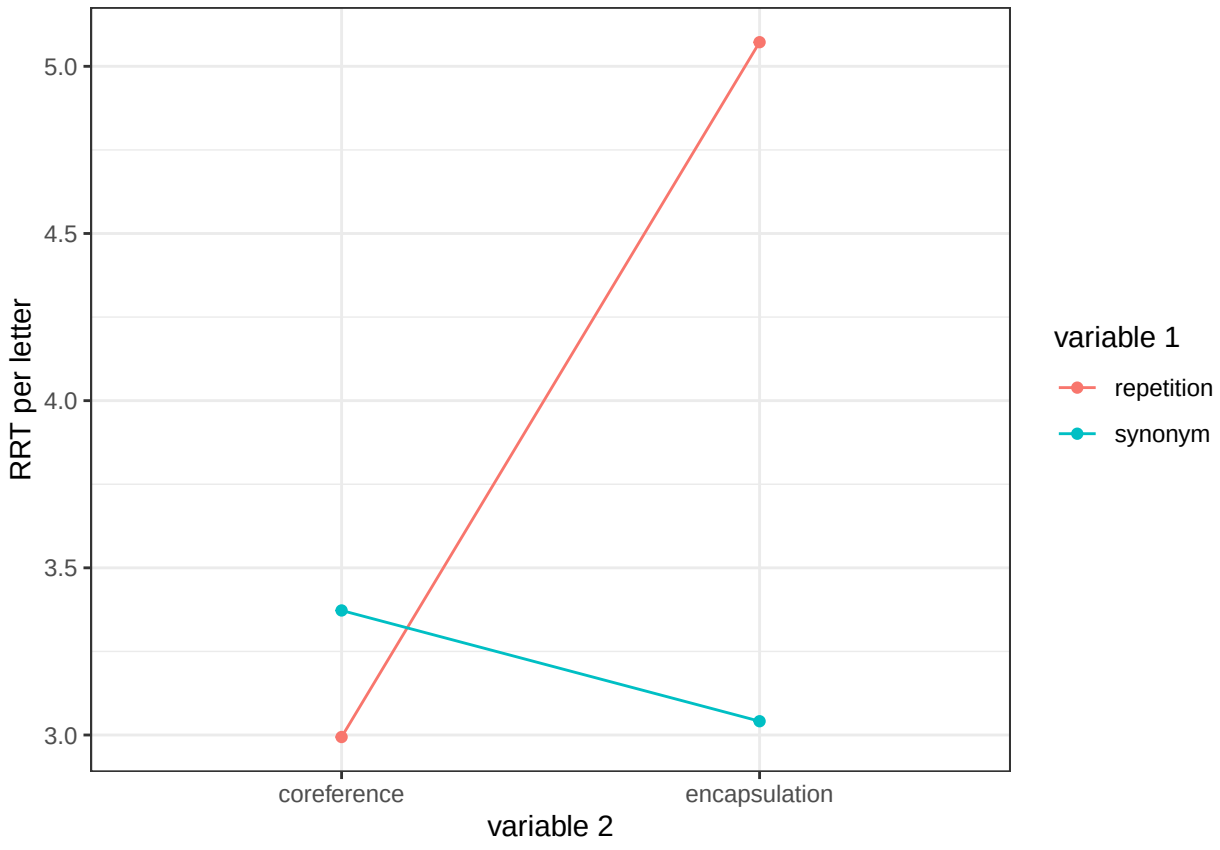

50
40
30
FRT per letter
repetition
synonym
variable 1
variable 2
coreference
encapsulation

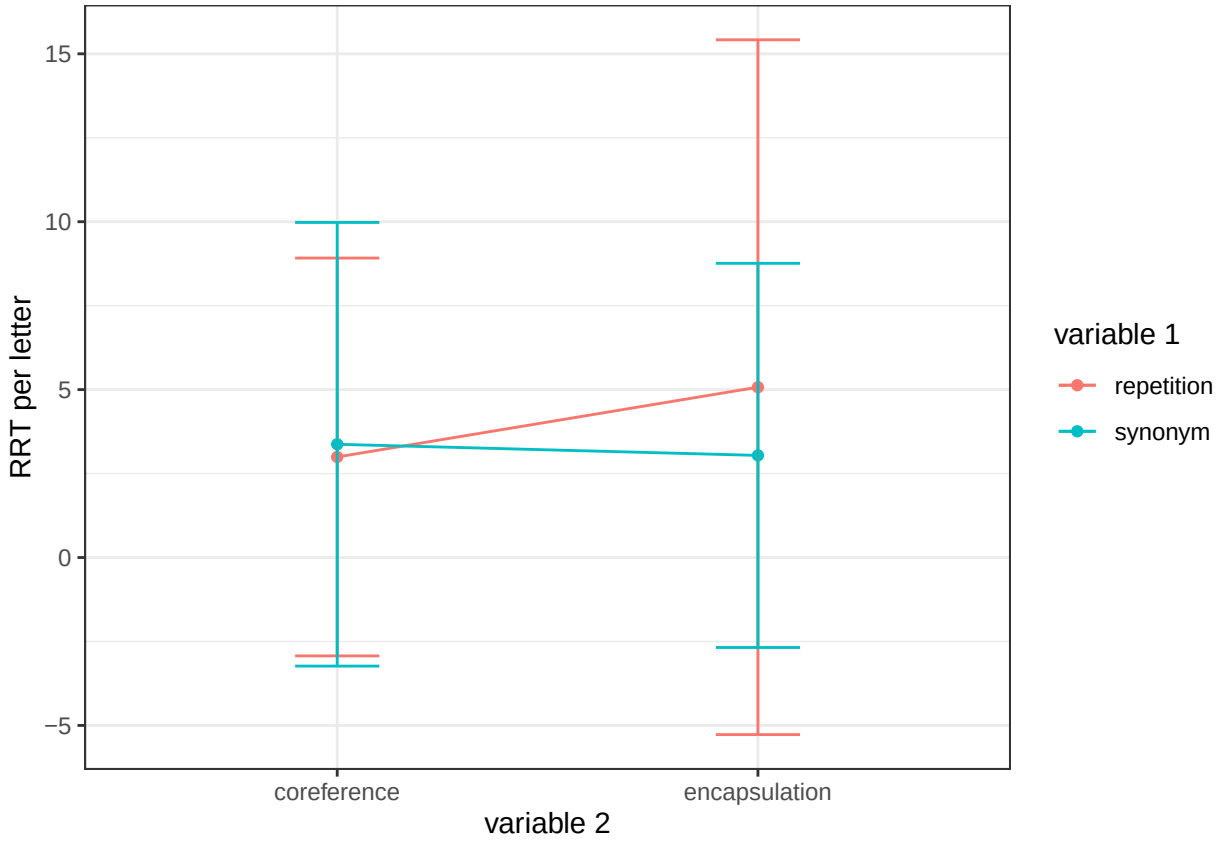

40
39
38
FRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym


50
40
30
FRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym


5.0
4.5
4.0
3.5
3.0
RRT per letter
repetition
synonym
variable 1
variable 2
coreference
encapsulation


15
10
5
0
−5
RRT per letter
repetition
synonym
variable 1
variable 2
coreference
encapsulation


5.0
4.5
4.0
3.5
3.0
RRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym


15
10
5
0
−5
RRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym

TRT per Letter	Estimates	Std.Error	p.value
(Intercept)	43.3532	2.4216	0.0000
var1synonym	-0.3736	1.2624	0.7675
var2encapsulation	-0.9934	1.2619	0.4319
var1synonym:var2encapsulation	1.1534	1.7812	0.5179

FRT per Letter	Estimates	Std.Error	p.value
(Intercept)	39.9688	2.1584	0.0000
var1synonym	-0.3957	1.3699	0.7729
var2encapsulation	-2.6431	1.3693	0.0548
var1synonym:var2encapsulation	3.1584	1.9329	0.1036

RRT per Letter	Estimates	Std.Error	p.value
(Intercept)	3.2754	0.9314	0.0005
var1synonym	0.1145	0.9645	0.9056
var2encapsulation	1.7762	0.9643	0.0667
var1synonym:var2encapsulation	-2.1175	1.3612	0.1211

For the TRT model: Both random effects, for Participant and Topic, are significant w.r.t alpha = 0.05.

For the FRT model: Both random effects, for Participant and Topic, are significant w.r.t alpha = 0.05.

For the RRT model: The random effect s(Participant) is significant w.r.t alpha = 0.05.

Model for AOI 6

TRT per Letter	Estimates	Std.Error	p.value
(Intercept)	52.7047	3.9556	0.0000
var1synonym	-5.2137	4.1994	0.2155
var2encapsulation	-4.8880	4.1982	0.2454
var1synonym:var2encapsulation	0.0558	5.9268	0.9925

FRT per Letter	Estimates	Std.Error	p.value
(Intercept)	40.5869	3.5740	0.0000
var1synonym	-6.4412	3.0510	0.0357
var2encapsulation	-9.8522	3.0498	0.0014
var1synonym:var2encapsulation	7.3817	4.3058	0.0876

RRT per Letter	Estimates	Std.Error	p.value
(Intercept)	12.0622	3.0005	0.0001
var1synonym	1.2765	3.7442	0.7334
var2encapsulation	5.1216	3.7442	0.1725
var1synonym:var2encapsulation	-7.5859	5.2853	0.1524

For the TRT model: The random effect s(Participant) is significant w.r.t alpha = 0.05.

For the FRT model: Both random effects, for Participant and Topic, are significant w.r.t alpha = 0.05.

For the RRT model: The random effect s(Participant) is significant w.r.t alpha = 0.05.

Hypothesis tests

No hypothesis tests were performed