- Anaphoric Encapsulation - Reading time & Discourse particle analysis

In cooperation with

Óscar Loureda and Research group DPKog

Statistical Consulting Unit StaBLab

Department of Statistics

Ludwig-Maximilians-Universität München

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Marie Scherzer
Lona Koers

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)

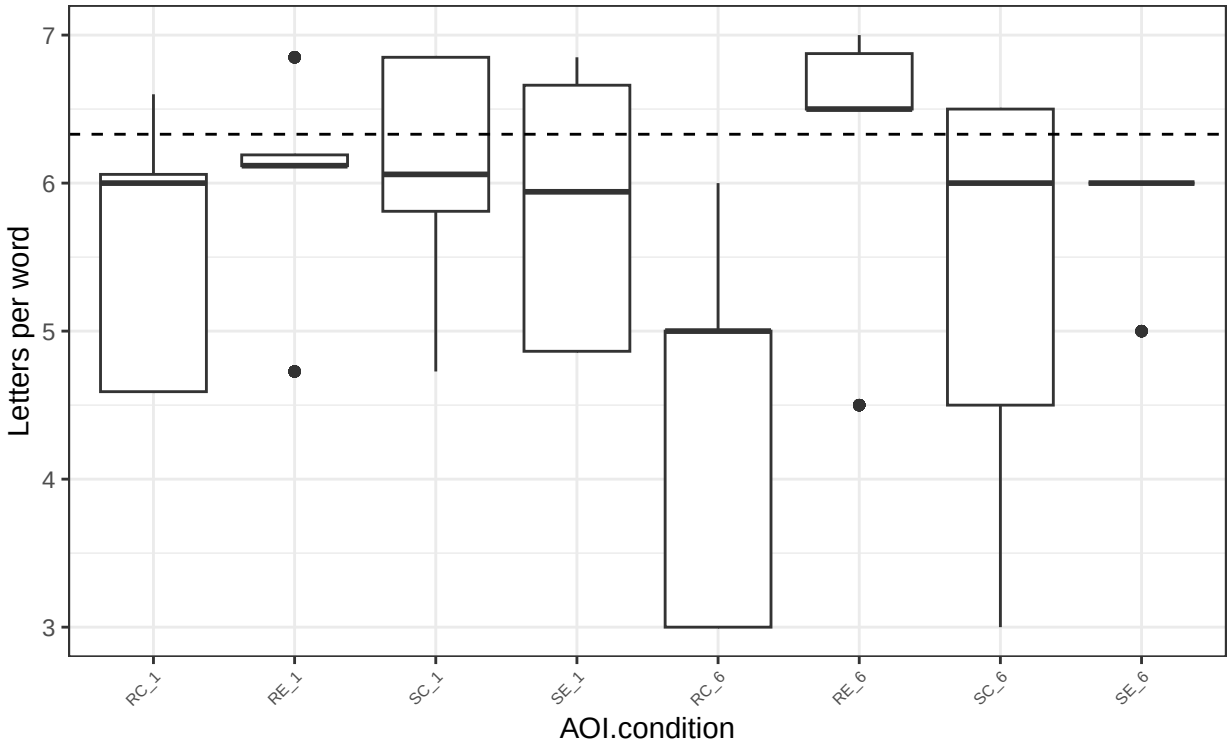
For the second type of models, analysis was performed using generalized additive mixed models (GAMM) as well using the following alternative parametrization:

- 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

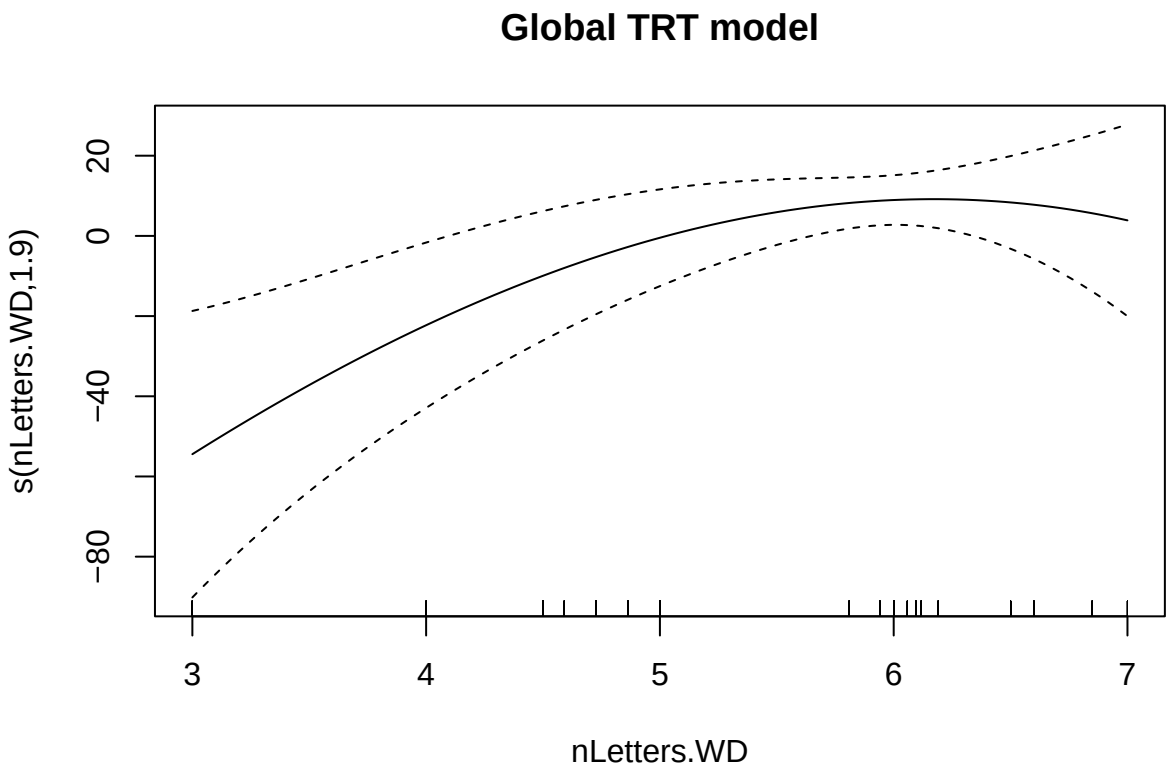
1. Estimates are not interpretable as absolute values, i.e. they do not reflect absolute reading times in milliseconds.
   - The first value in the estimate column is the intercept, i.e. the reference AOI.condition for calculating all other values
   - Further values reflect reading time differences [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

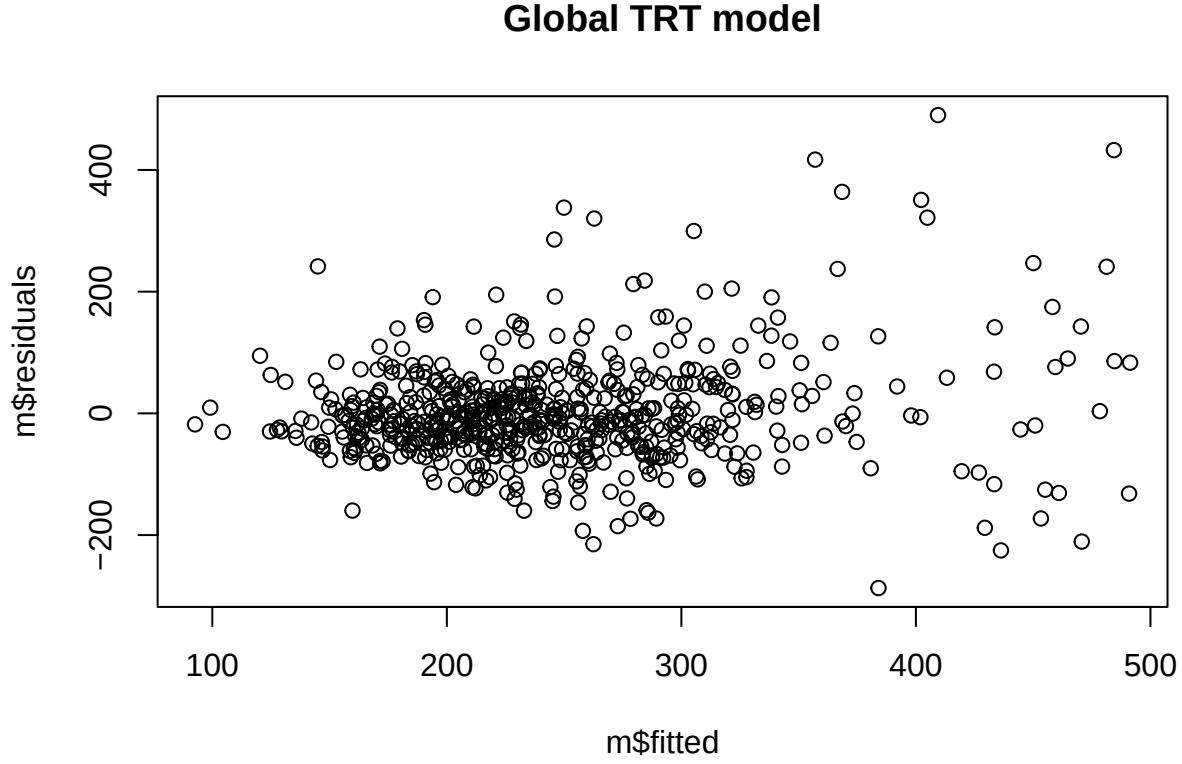
Letters per word (with the average letters per word as horizontal line)

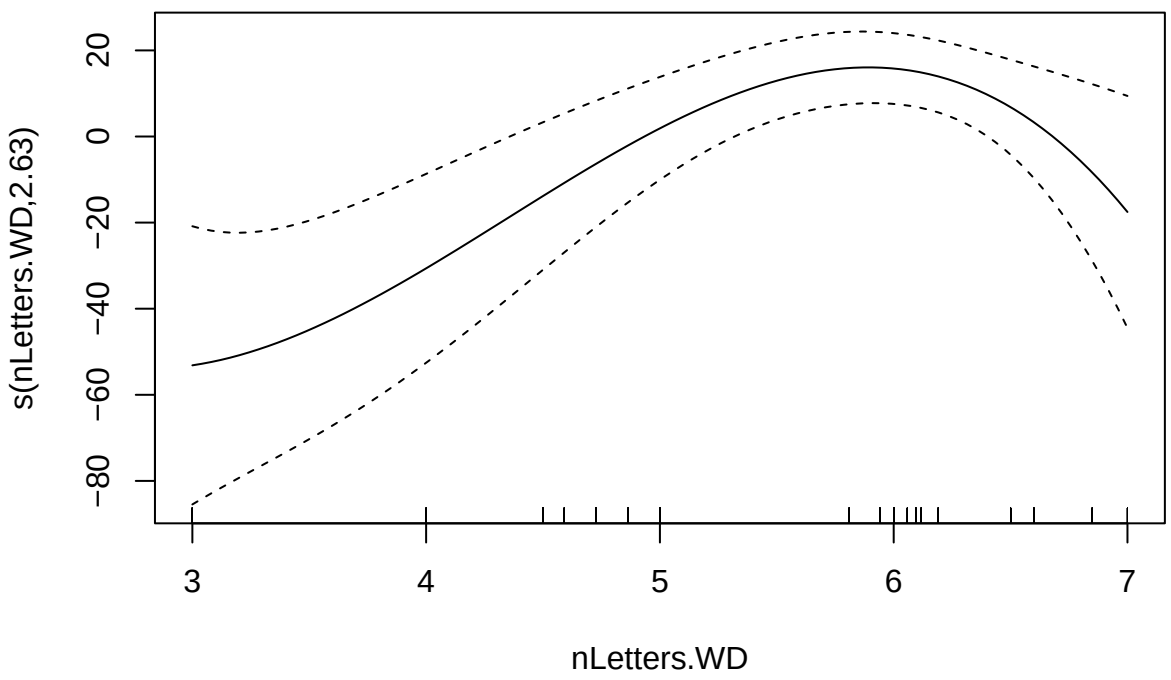


Observations per AOI.condition

AOI.condition	Freq
RC_1	77
RE_1	78
SC_1	78
SE_1	78
RC_6	77
RE_6	78
SC_6	78
SE_6	78


Global TRT model
s(nLetters.WD,1.9)
20
0
−40
−80
3
4
5
6
7
nLetters.WD


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


Global FRT model
s(nLetters.WD,2.63)
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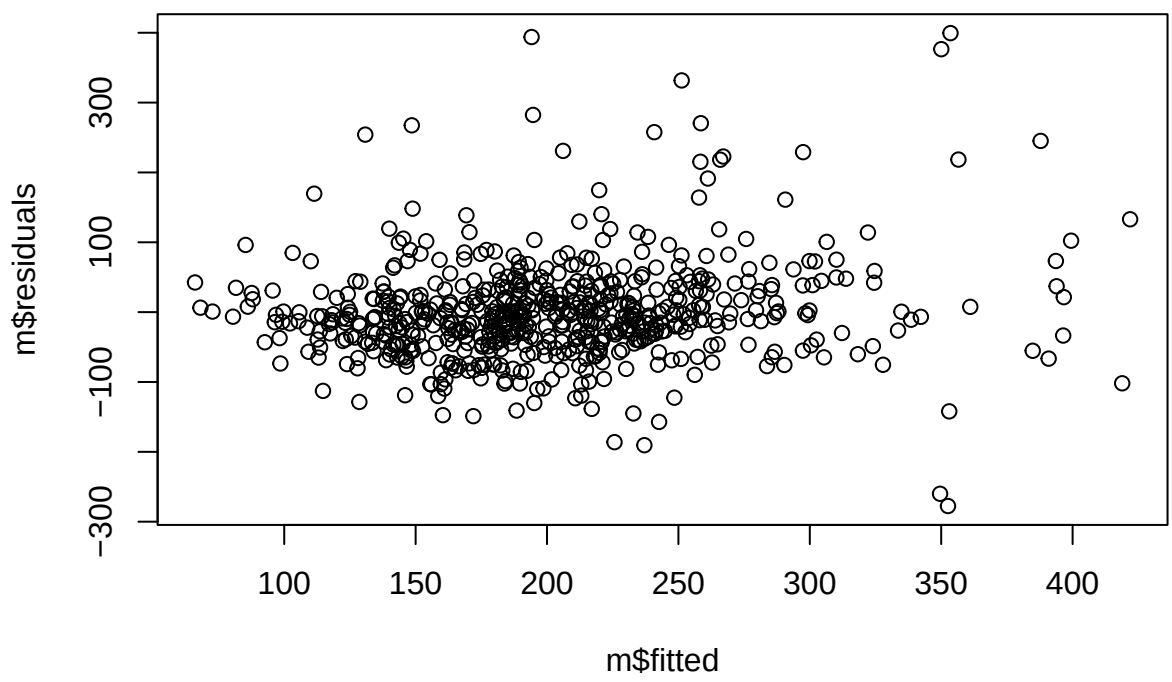
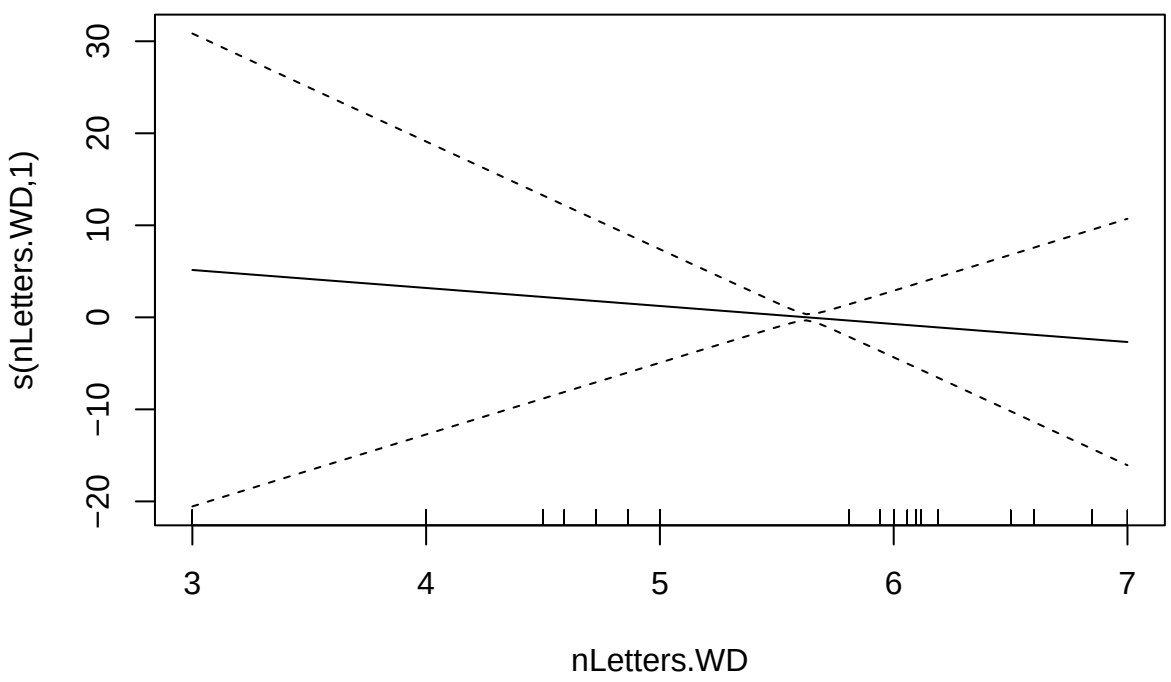
0
−20
−40
−60
−80
3
4
5
6
7
nLetters.WD


Global FRT model
m$residuals
300
100
−100
−300
100
150
200
250
300
350
400
m$fitted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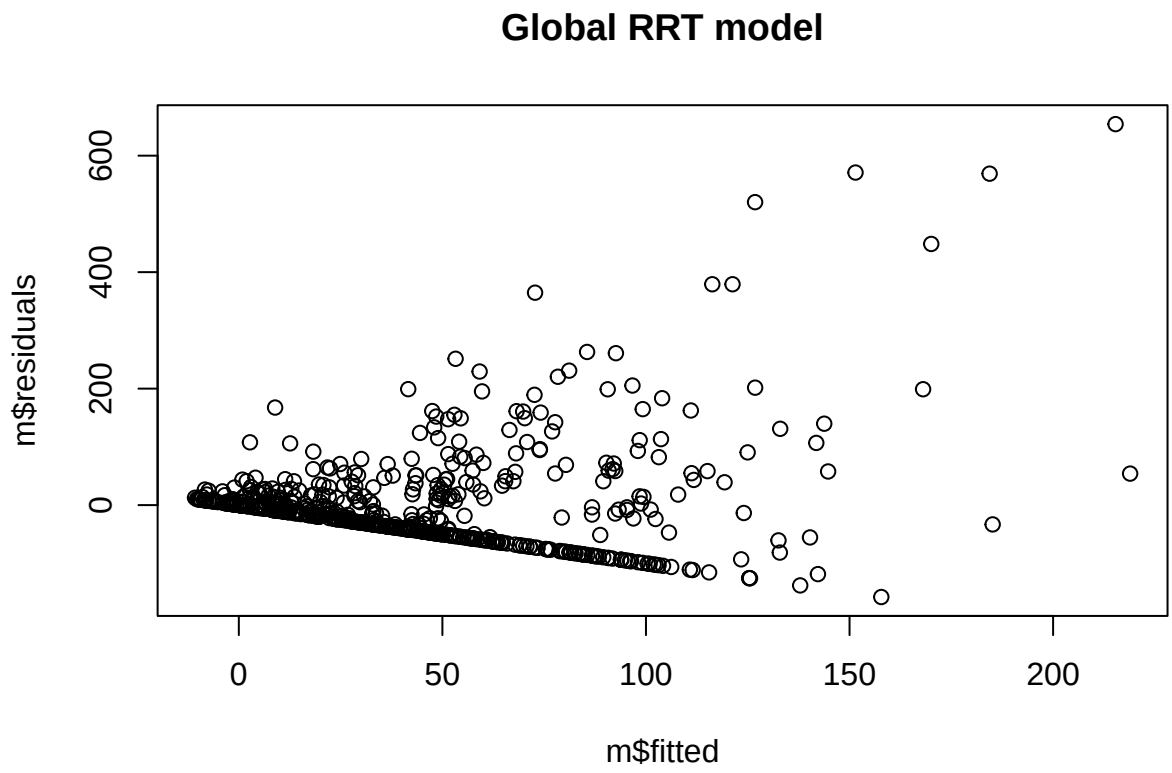
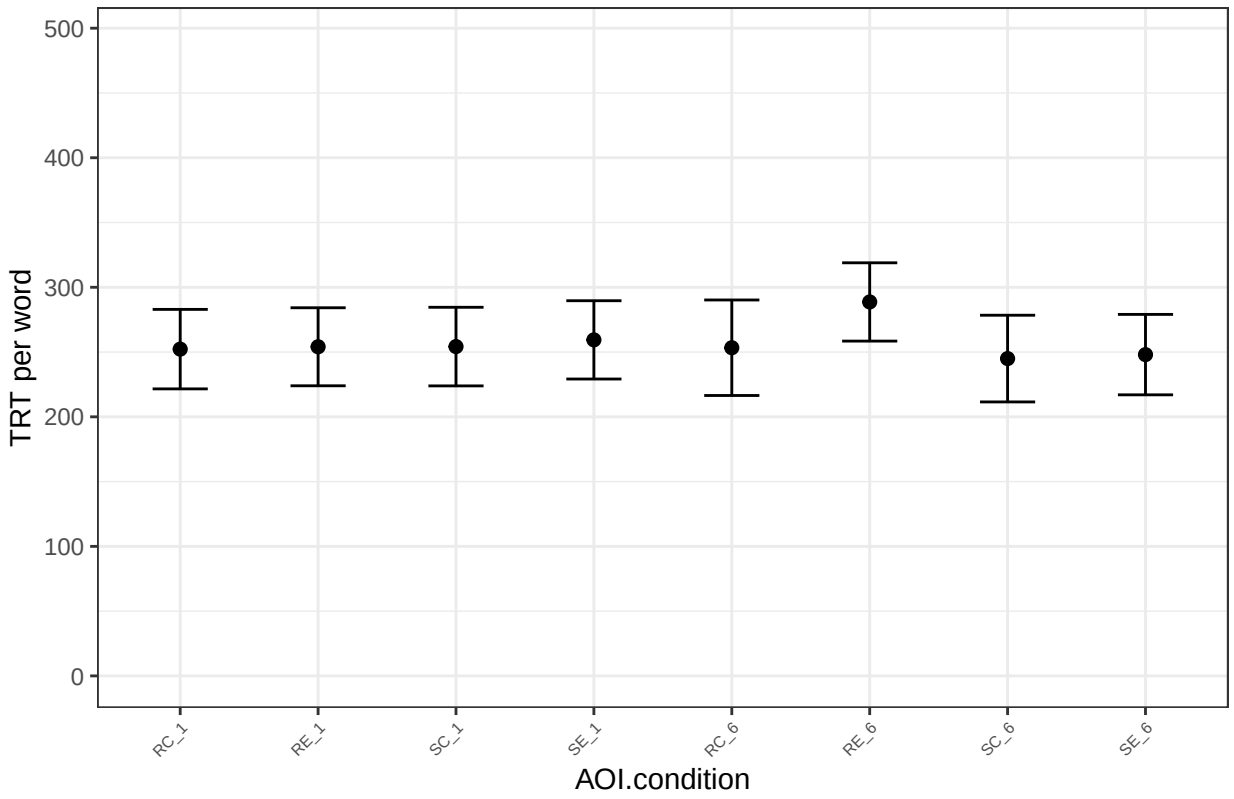
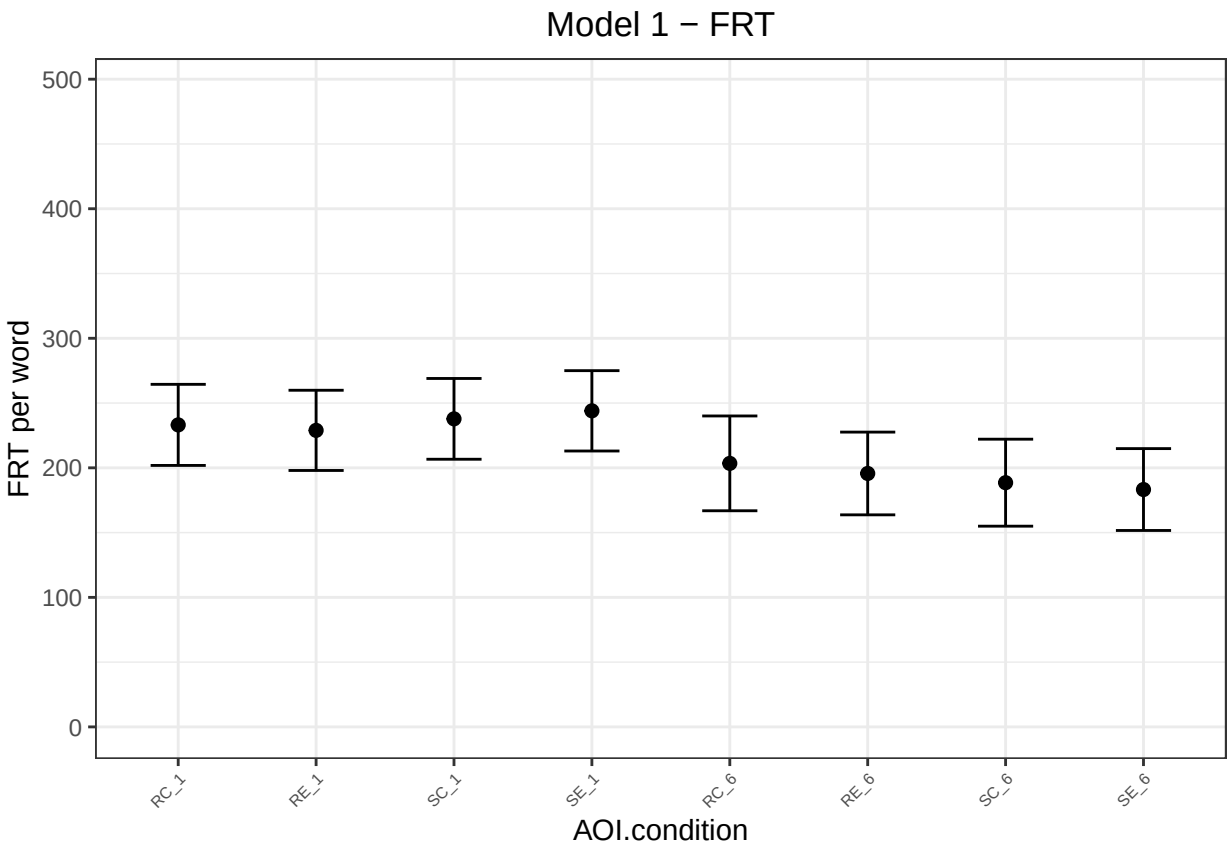
10
0
−10
−20
3
4
5
6
7
nLetters.WD

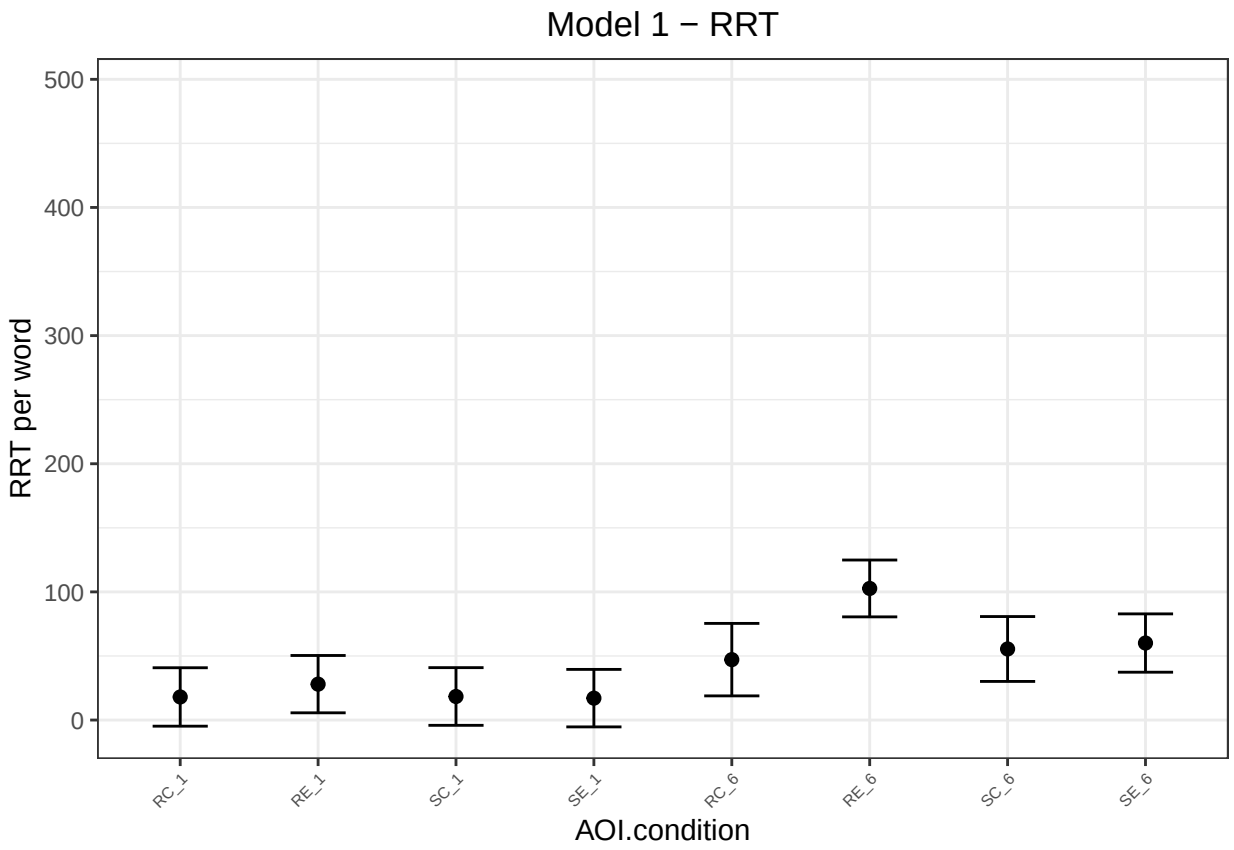

Global RRT model
m$residuals
600
400
200
0
0
50
100
150
200
m$fitted



	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	TRT.Pred	TRT.Pred.StdErr
RC_1	243.28	15.27	5.79	6.33	252.25	15.65
RE_1	1.82	14.71	5.97	6.33	254.07	15.36
SC_1	1.97	14.66	5.90	6.33	254.23	15.48
SE_1	7.15	14.67	5.92	6.33	259.40	15.41
RC_6	1.07	16.66	4.49	6.33	253.33	18.81
RE_6	36.42	15.21	6.14	6.33	288.67	15.42
SC_6	-7.29	15.51	5.06	6.33	244.96	17.07
SE_6	-4.24	14.72	5.76	6.33	248.01	15.84

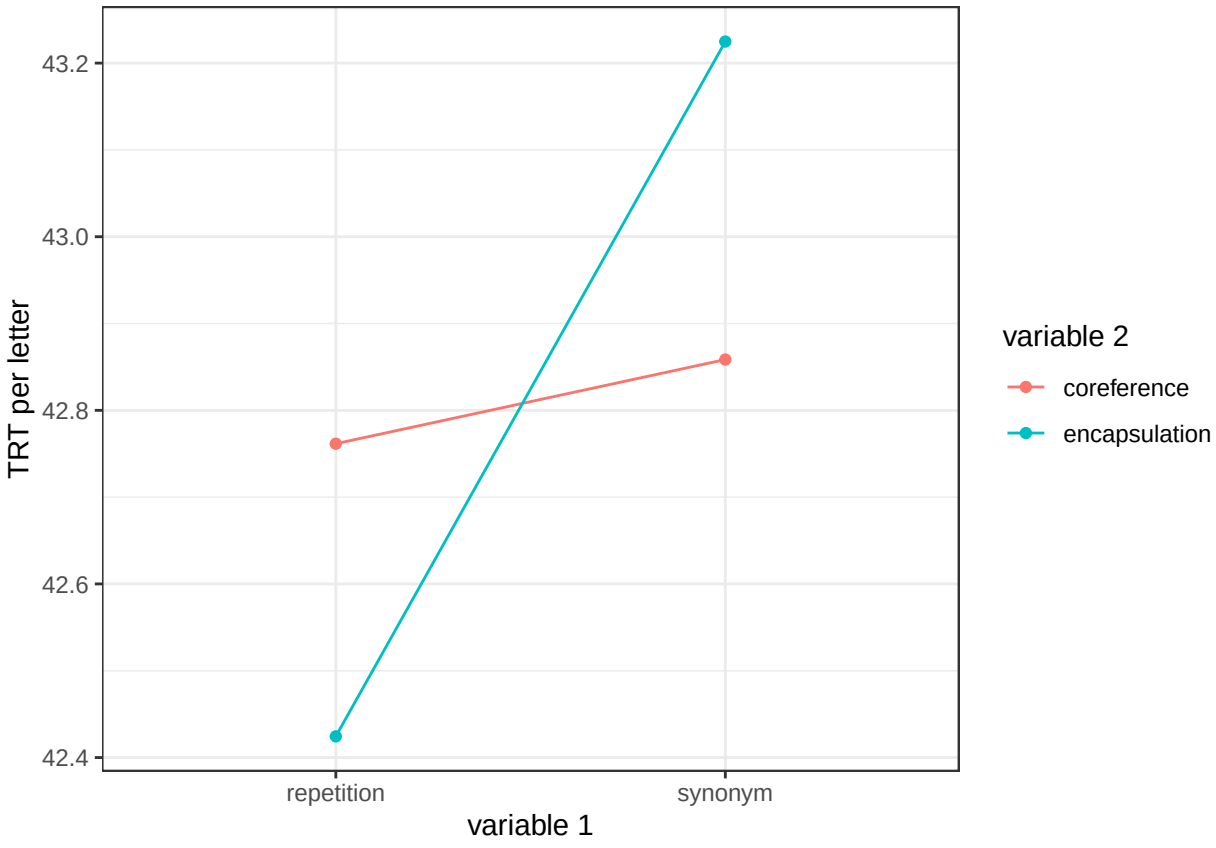


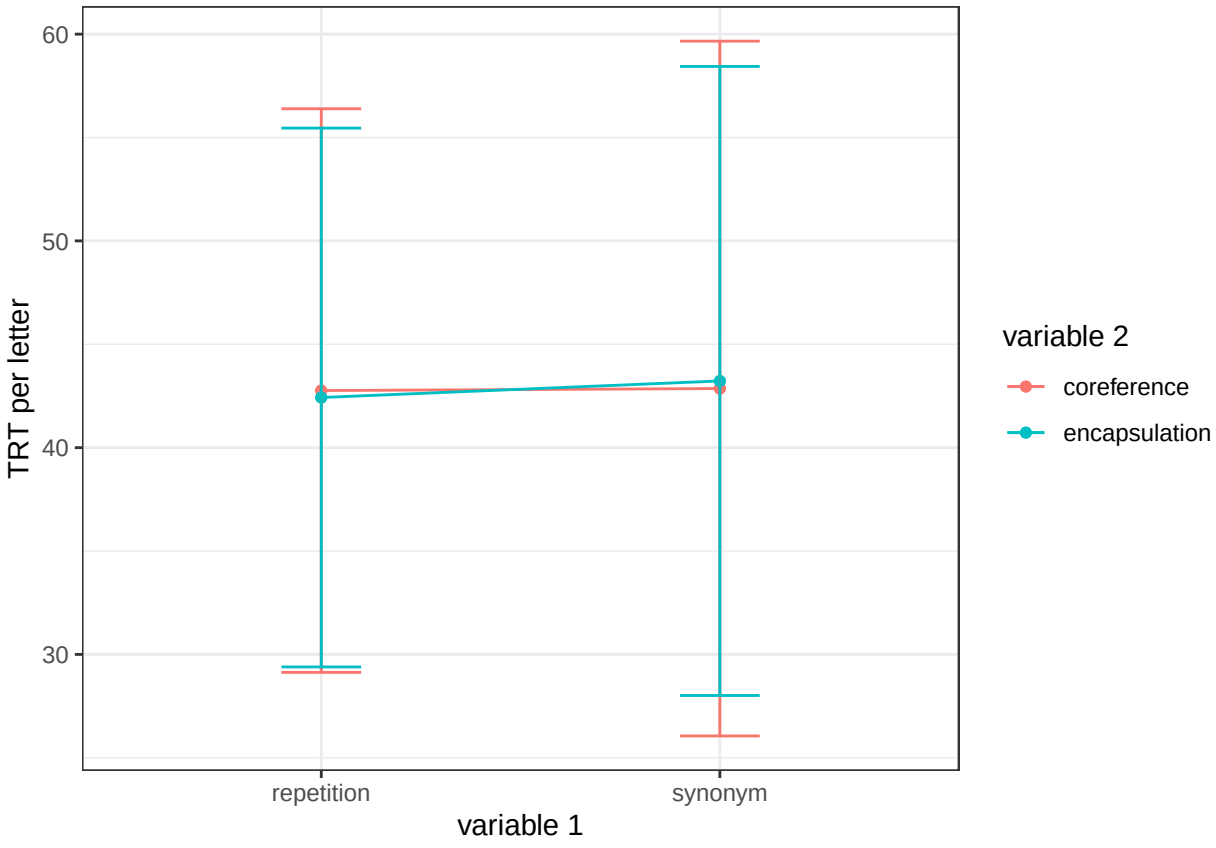
	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	FRT.Pred	FRT.Pred.StdErr
RC_1	221.73	15.58	5.79	6.33	233.14	15.97
RE_1	-4.23	12.59	5.97	6.33	228.92	15.80
SC_1	4.66	12.53	5.90	6.33	237.80	15.91
SE_1	10.85	12.53	5.92	6.33	244.00	15.82
RC_6	-29.70	14.44	4.49	6.33	203.44	18.67
RE_6	-37.50	13.46	6.14	6.33	195.64	16.29
SC_6	-44.62	13.33	5.06	6.33	188.53	17.13
SE_6	-49.90	12.68	5.76	6.33	183.24	16.12

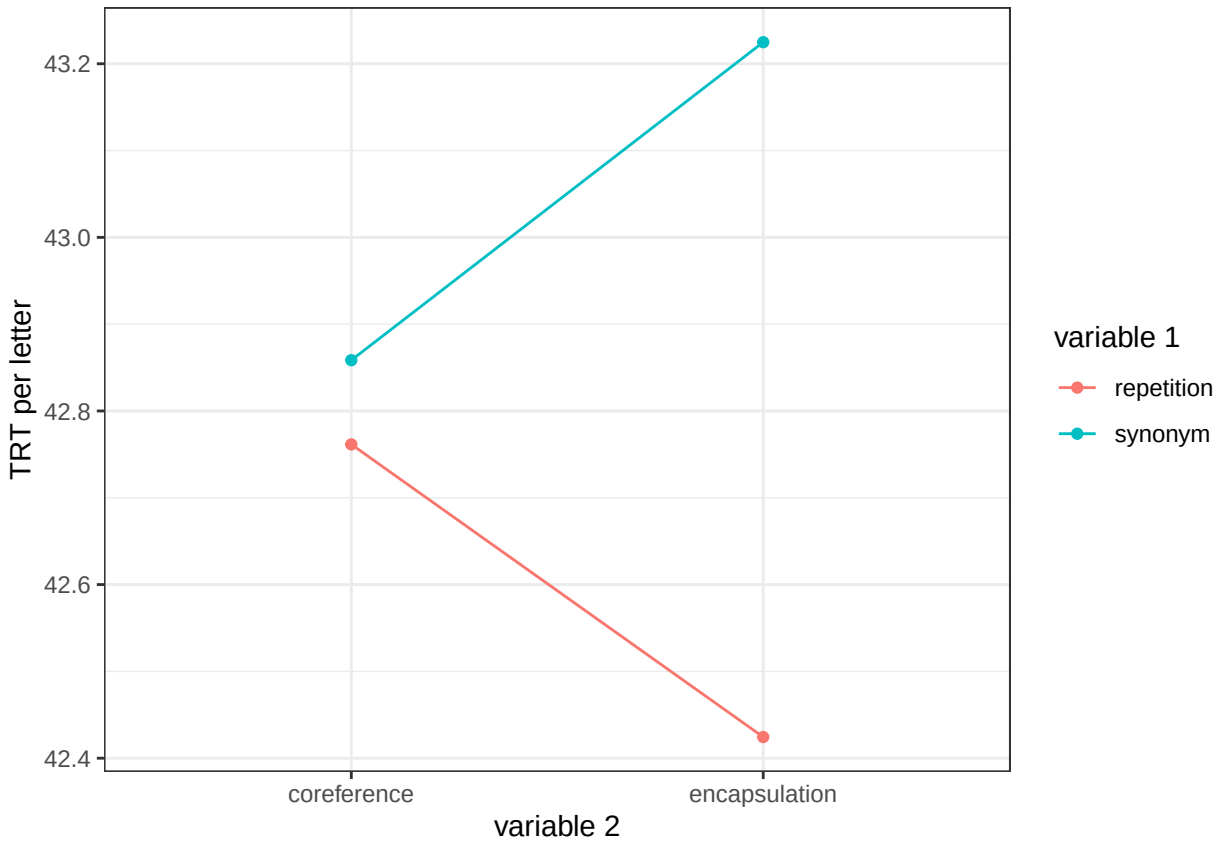


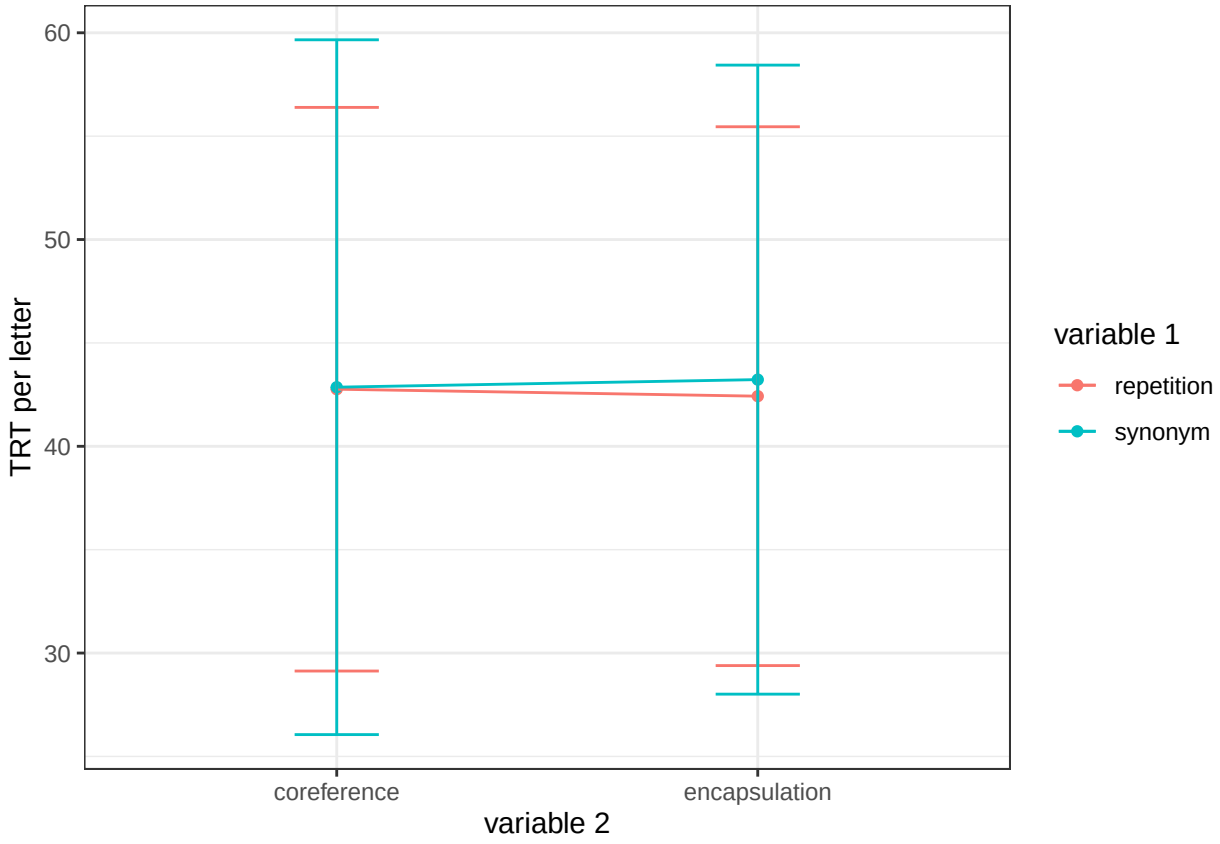
	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	RRT.Pred	RRT.Pred.StdErr
RC_1	19.38	11.37	5.79	6.33	18.01	11.63
RE_1	10.00	14.14	5.97	6.33	28.01	11.42
SC_1	0.37	14.12	5.90	6.33	18.38	11.48
SE_1	-0.93	14.13	5.92	6.33	17.07	11.45
RC_6	29.12	15.50	4.49	6.33	47.13	14.43
RE_6	84.69	14.21	6.14	6.33	102.70	11.31
SC_6	37.44	14.59	5.06	6.33	55.45	12.91
SE_6	42.08	14.11	5.76	6.33	60.09	11.61

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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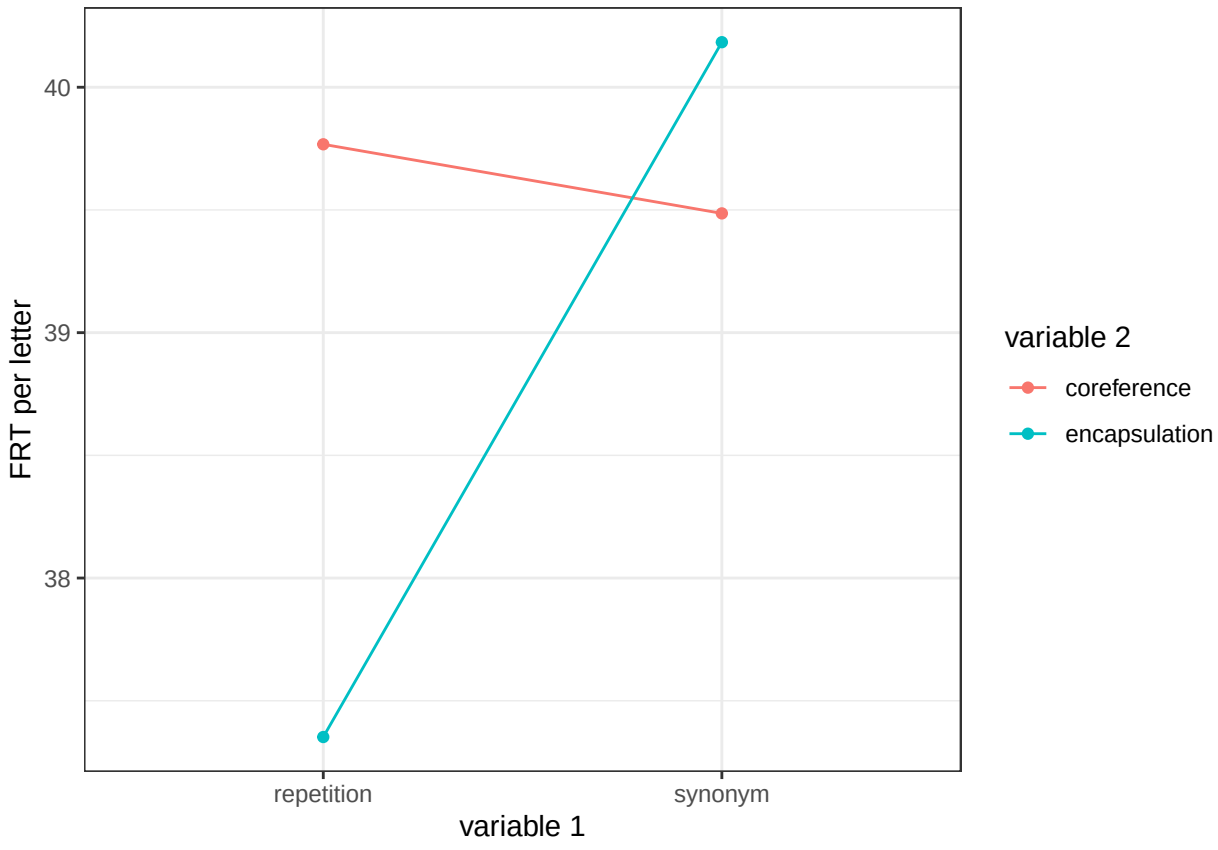
40
30
TRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym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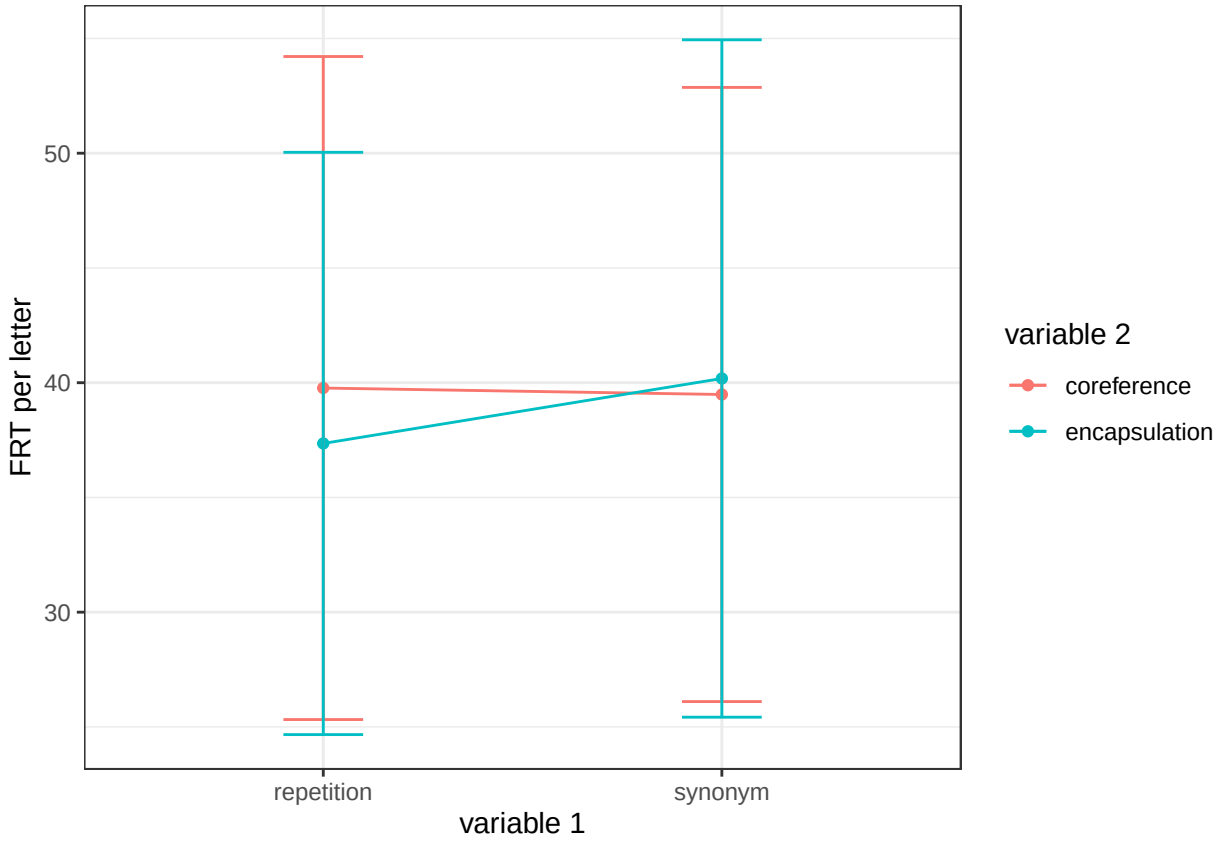
39
38
FRT per letter
repetition
synonym
variable 1
variable 2
coreference
encapsulation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FRT per letter
repetition
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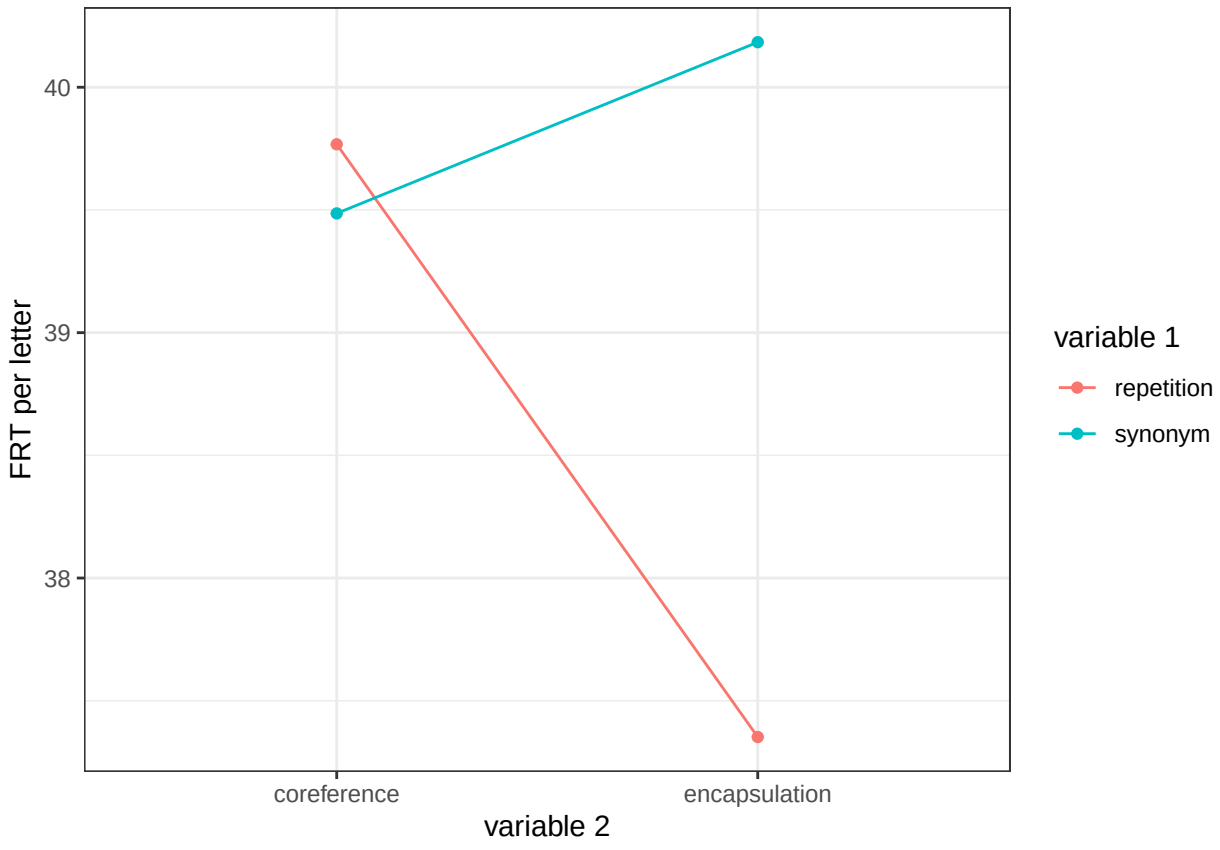
variable 2
coreference
encapsulation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39
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FRT per letter
coreference
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variable 1
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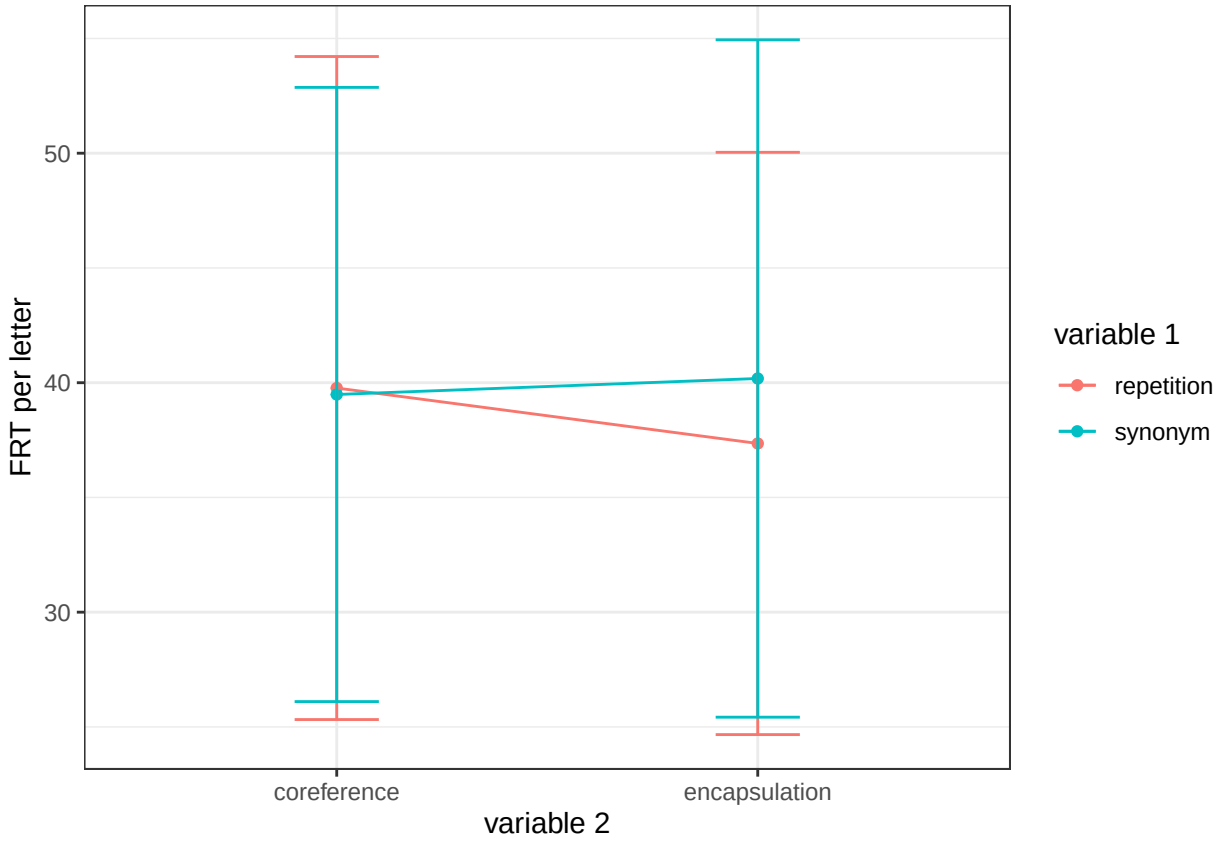
synonym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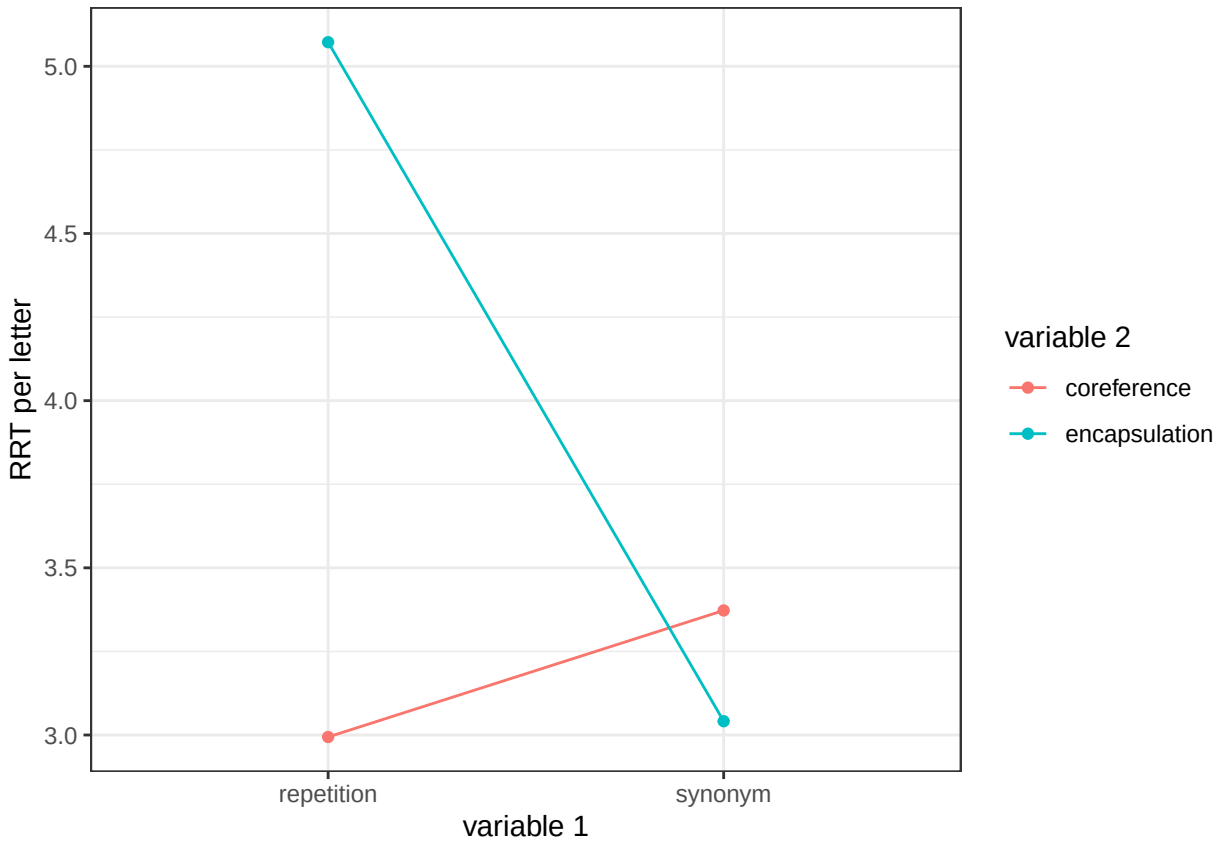
FRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym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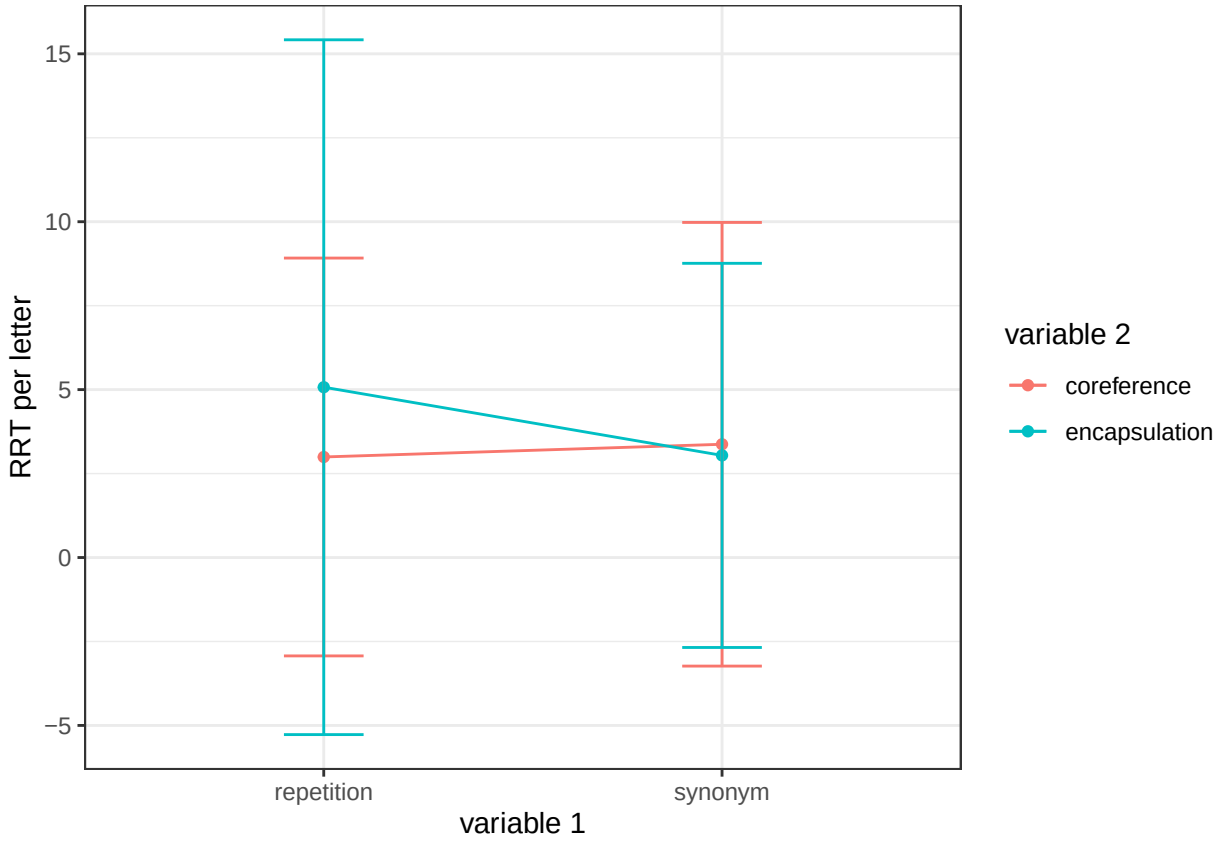
RRT per letter
repetition
synonym
variable 1
variable 2
coreference
encapsulation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10
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−5
RRT per letter
repetition
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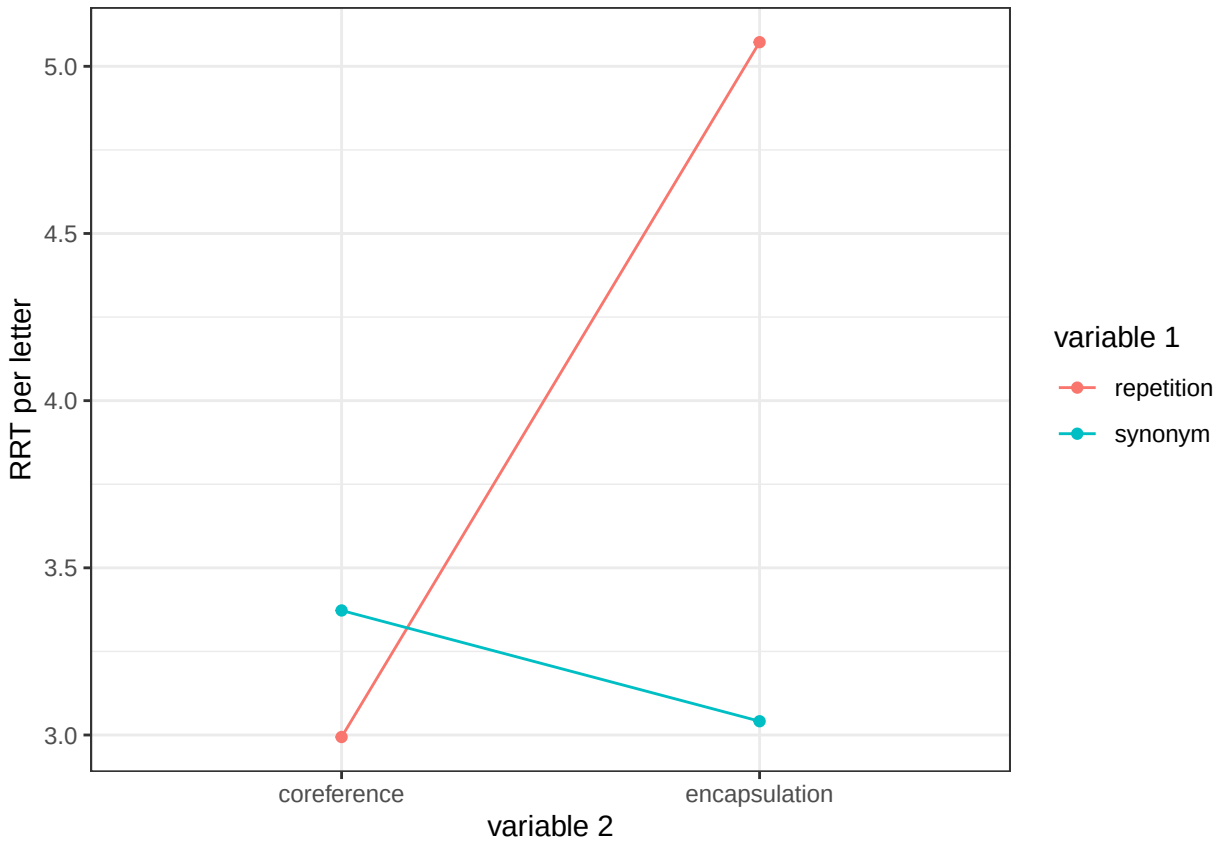
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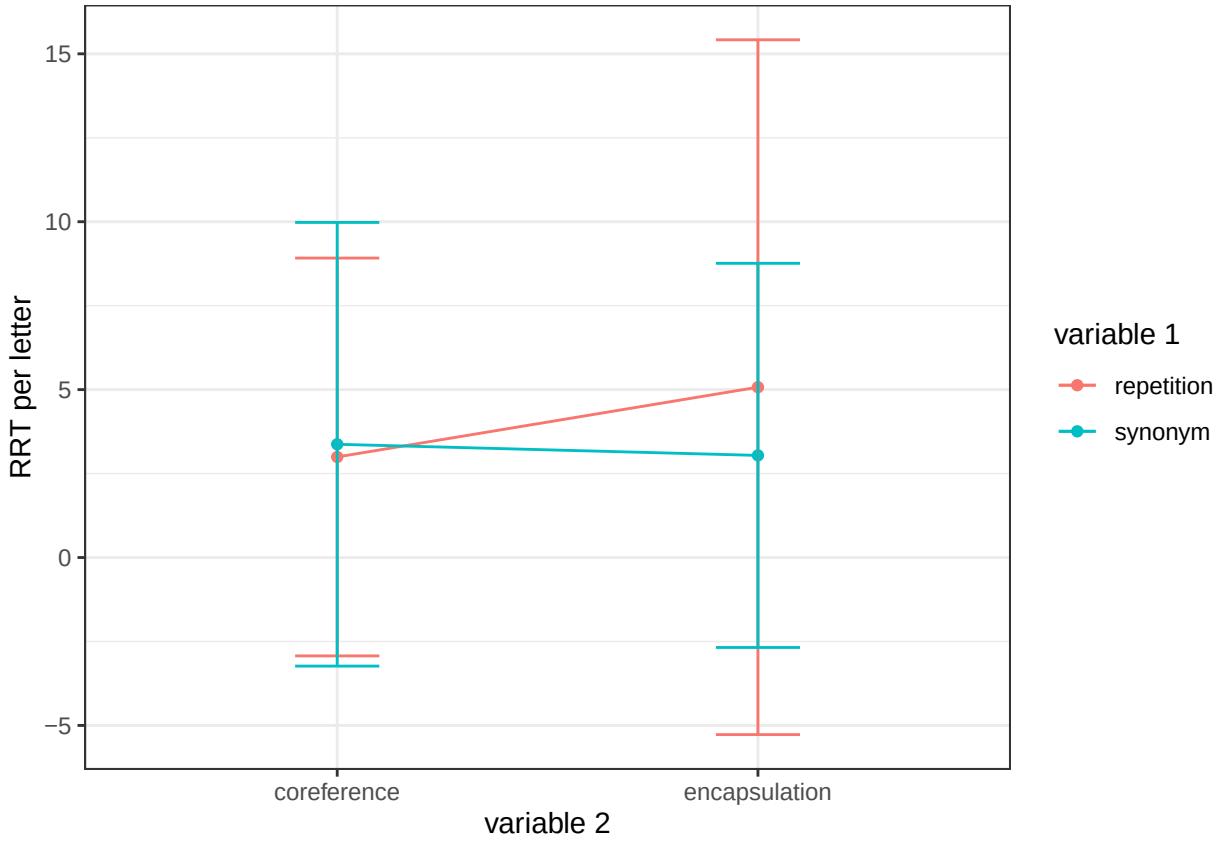
3.0
RRT per letter
coreference
encapsulation
variable 2
variable 1
repetition
synonym


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.

Separate models for p-value comparison

Model for AOI 1

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.

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	-0.1600052	1.256637	233.944	-0.1273281	0.8987901
RC vs RE	0.9933810	1.261853	233.944	0.7872398	0.4319383
SC vs RC	-0.3735894	1.262437	233.944	-0.2959272	0.7675482
SE vs RE	0.7797968	1.256834	233.944	0.6204456	0.5355684

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	-0.5152805	1.363705	237.9759	-0.3778533	0.7058764
RC vs RE	2.6431473	1.369275	237.9759	1.9303267	0.0547547
SC vs RC	-0.3957478	1.369880	237.9759	-0.2888923	0.7729153
SE vs RE	2.7626801	1.363911	237.9759	2.0255576	0.0439263

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	0.3413152	0.9605149	250.6886	0.3553461	0.7226291
RC vs RE	-1.7761786	0.9642786	250.6886	-1.8419765	0.0666597
SC vs RC	0.1145456	0.9645028	250.6886	0.1187613	0.9055596
SE vs RE	-2.0029482	0.9605934	250.6886	-2.0851155	0.0380707

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.

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	4.832166	4.182375	258.6252	1.155364	0.2490076
RC vs RE	4.888011	4.198218	258.6252	1.164306	0.2453729
SC vs RC	-5.213734	4.199399	258.6252	-1.241543	0.2155300
SE vs RE	-5.157888	4.182797	258.6252	-1.233119	0.2186508

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	2.4704792	3.038493	262.6341	0.8130607	0.4169197
RC vs RE	9.8522017	3.049760	262.6341	3.2304841	0.0013933
SC vs RC	-6.4411875	3.050951	262.6341	-2.1112068	0.0356995
SE vs RE	0.9405351	3.038924	262.6341	0.3094961	0.7571896

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	2.464316	3.730320	266.4575	0.6606180	0.5094280
RC vs RE	-5.121585	3.744245	266.4575	-1.3678553	0.1725099
SC vs RC	1.276507	3.744245	266.4575	0.3409252	0.7334286
SE vs RE	-6.309394	3.730320	266.4575	-1.6913816	0.0919331

Hypothesis tests

No hypothesis tests were performed