- Anaphoric Encapsulation -
Reading time & Discourse particle analysis

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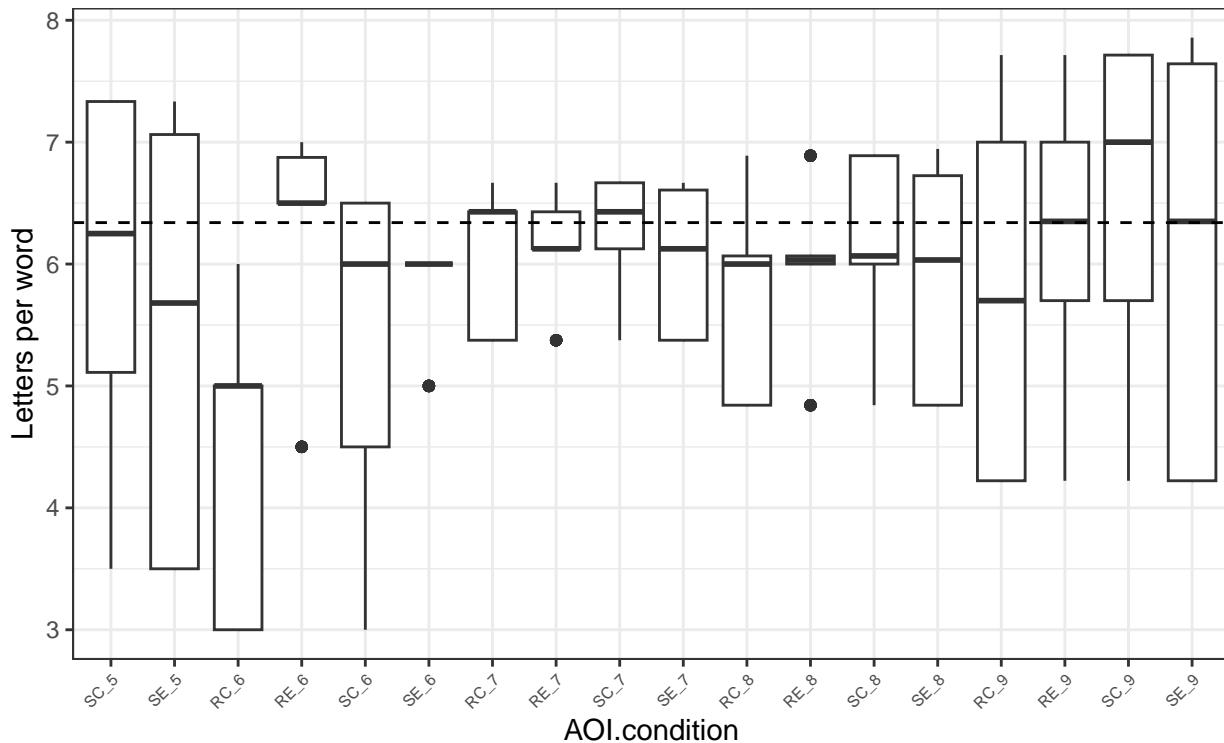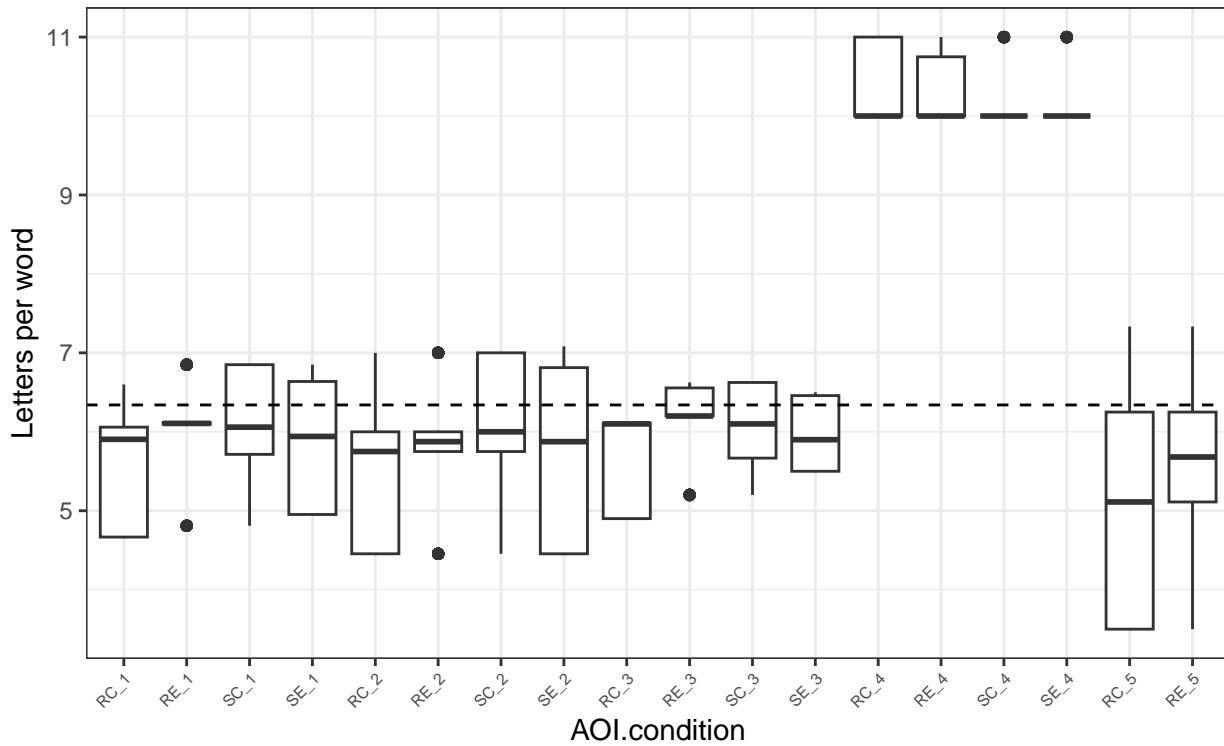
For the second type of models, analysis was performed using generalized additive mixed models (GAMM) as well using the following alternative parametrization:

- 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
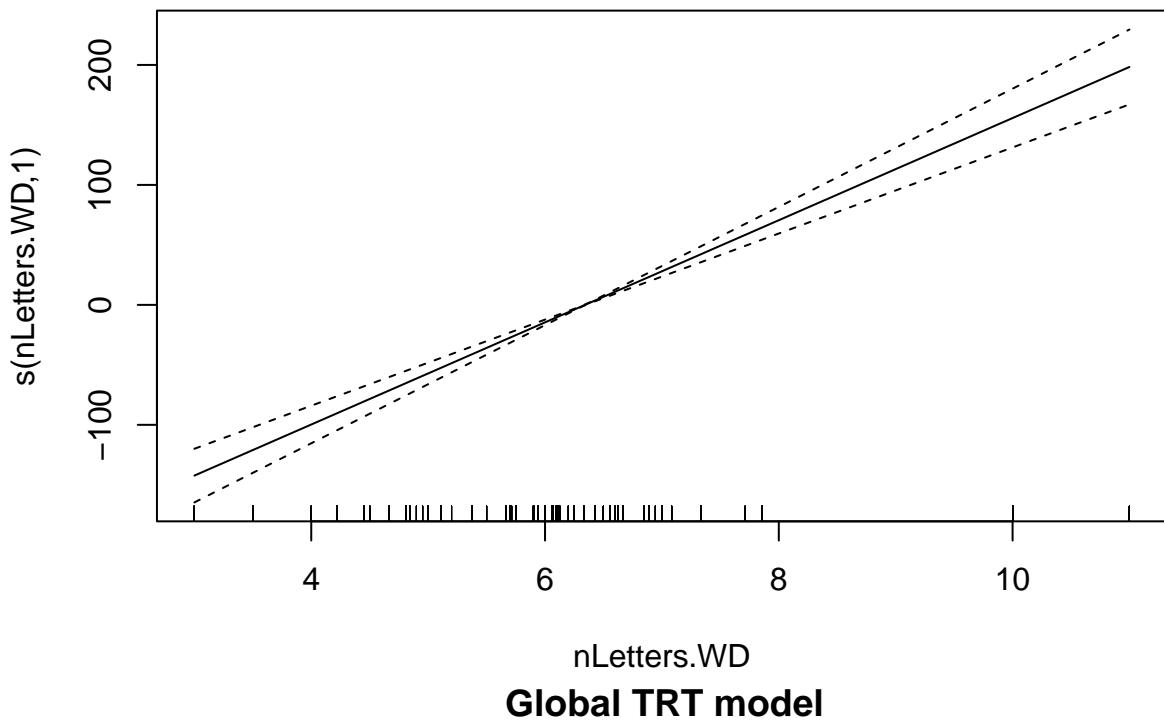
# Letters per word (with the average letters per word as horizontal line)
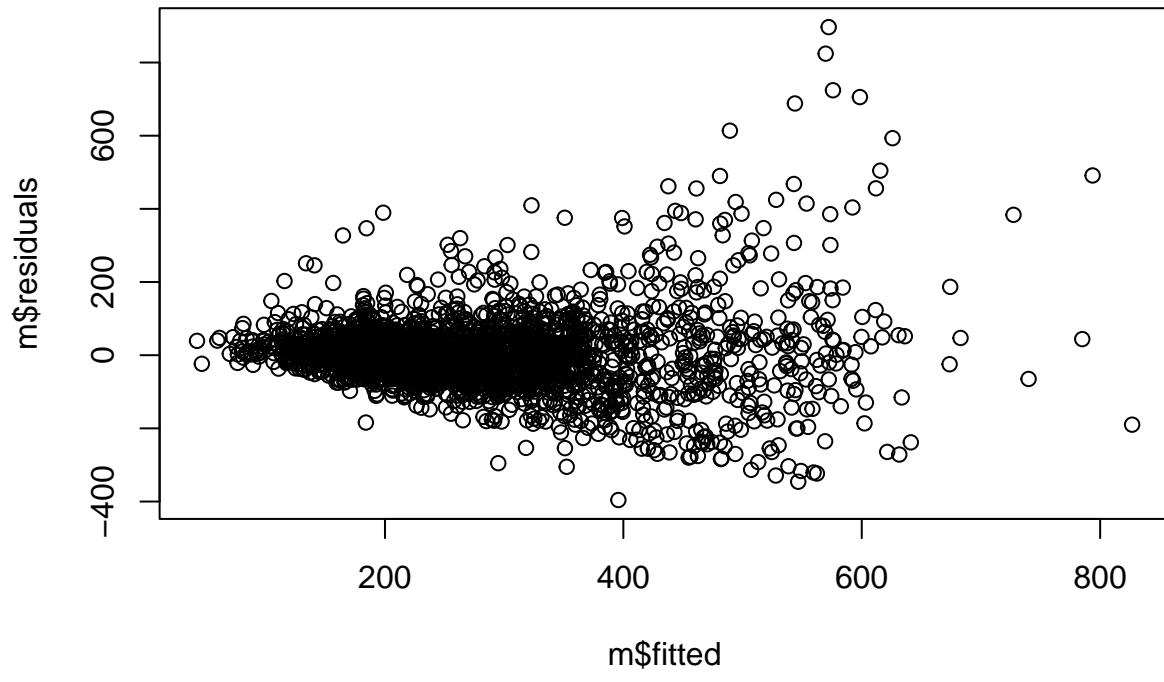
Observations per AOI.condition

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
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
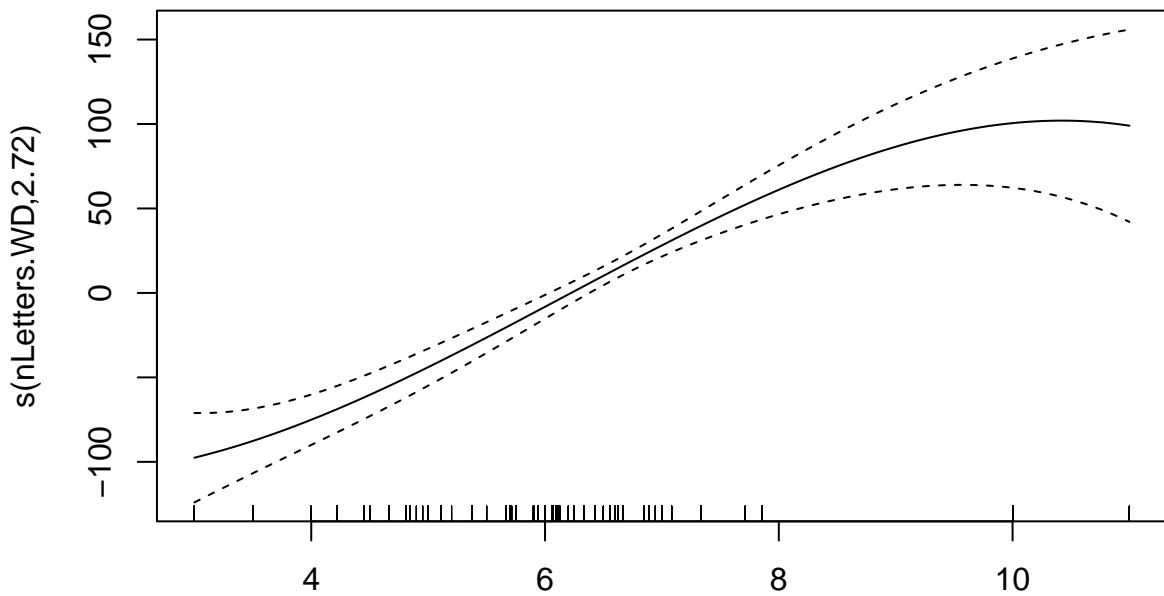
Global TRT model
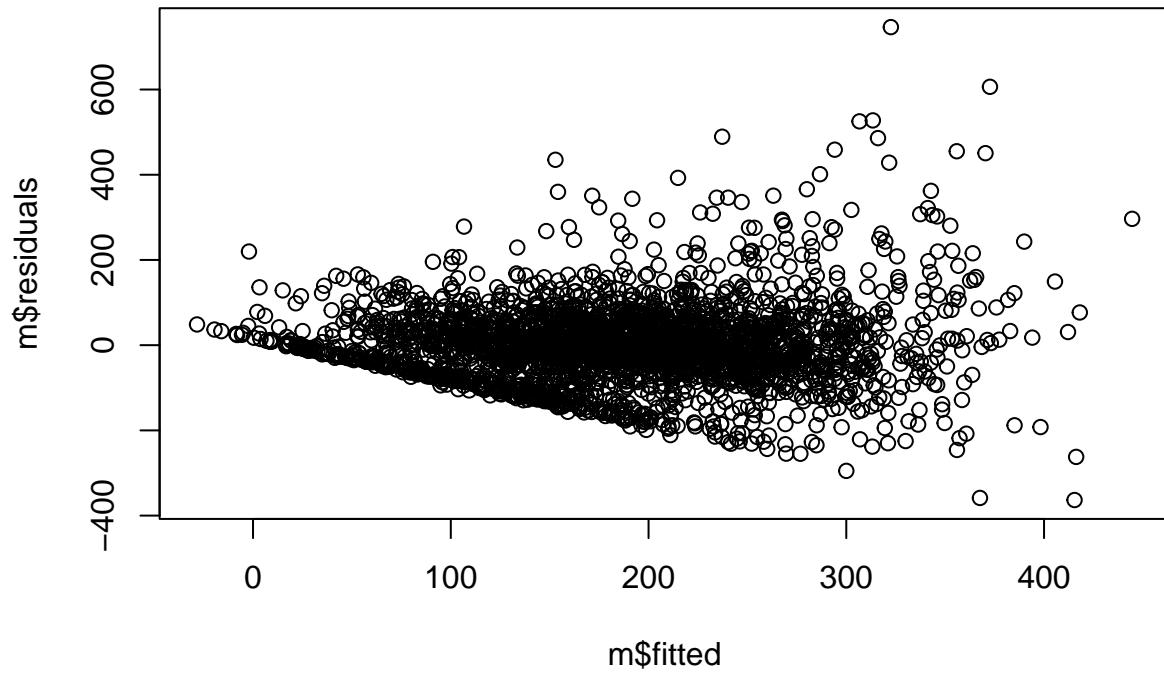
Global TRT model
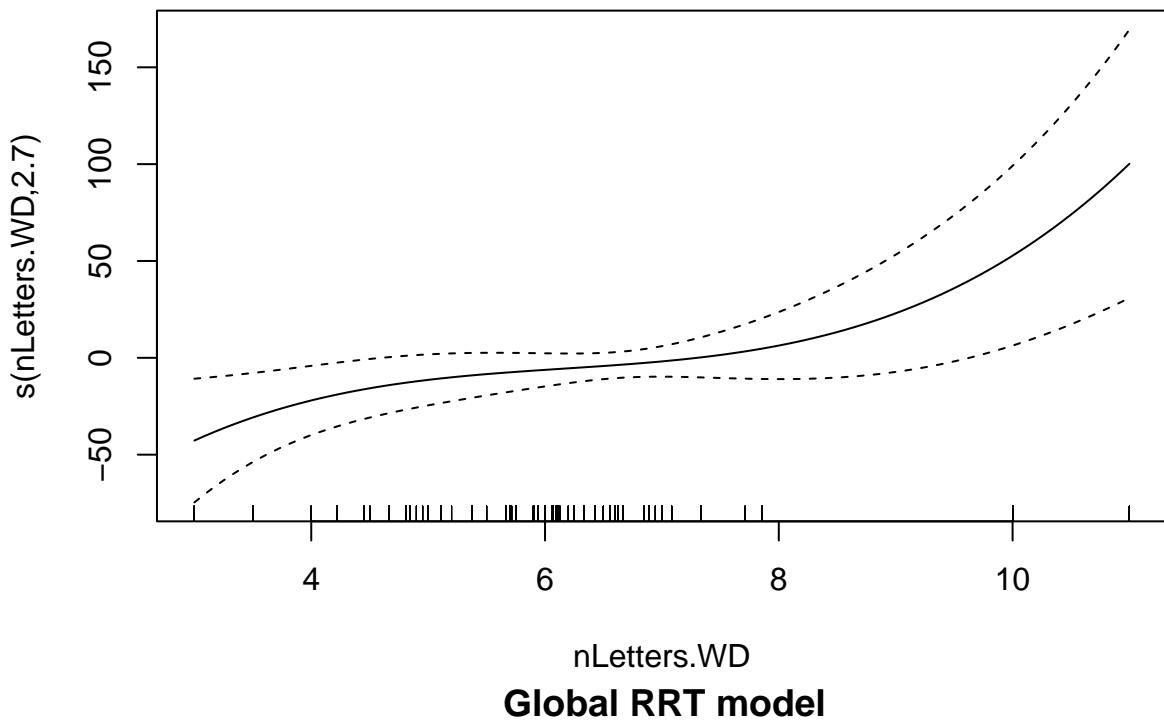
Global FRT model
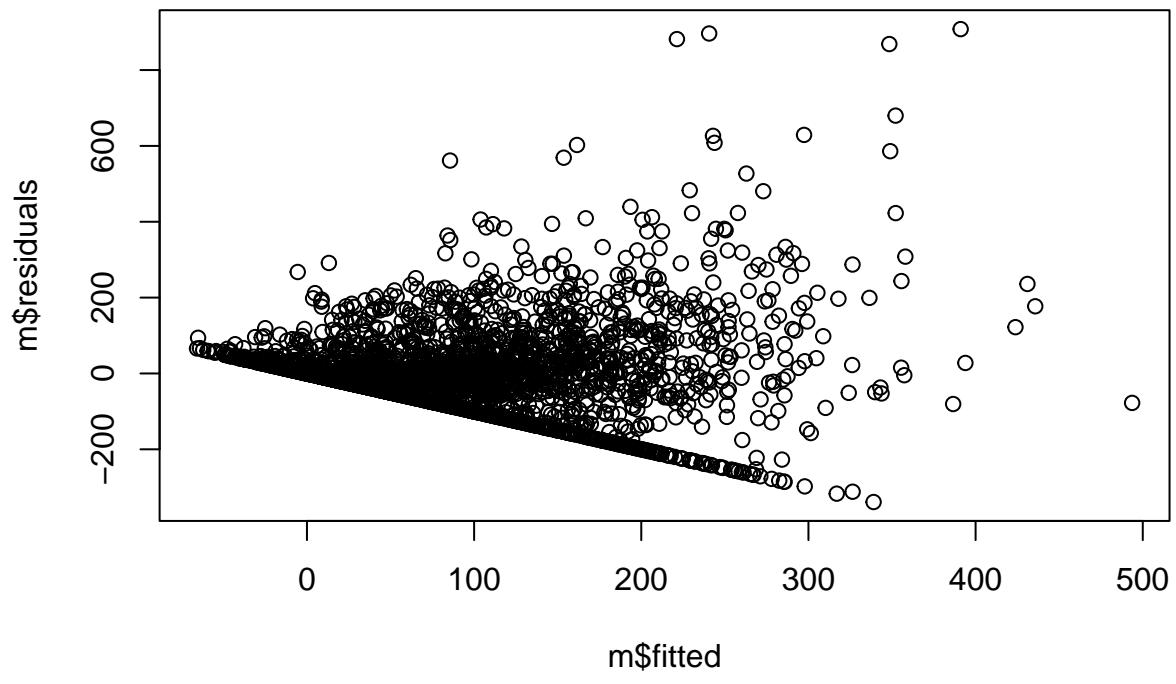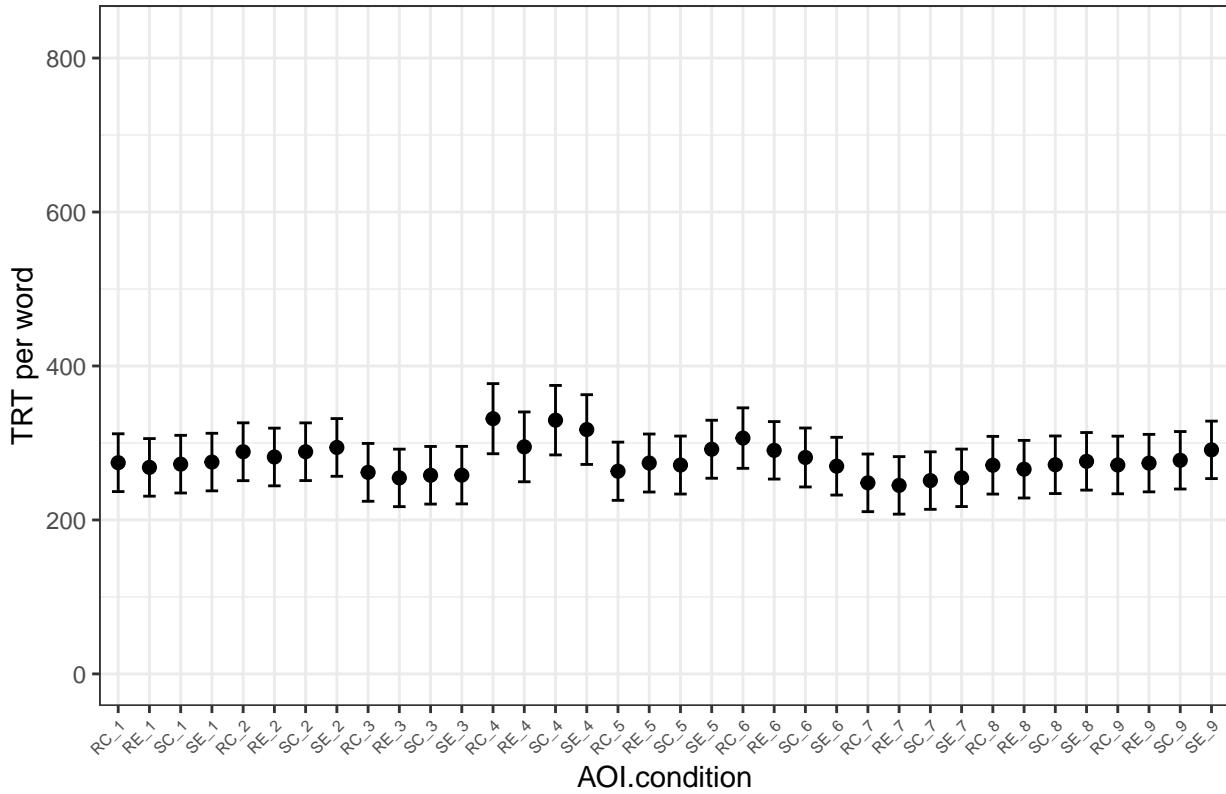
Global FRT model

Global RRT model

Global RRT model
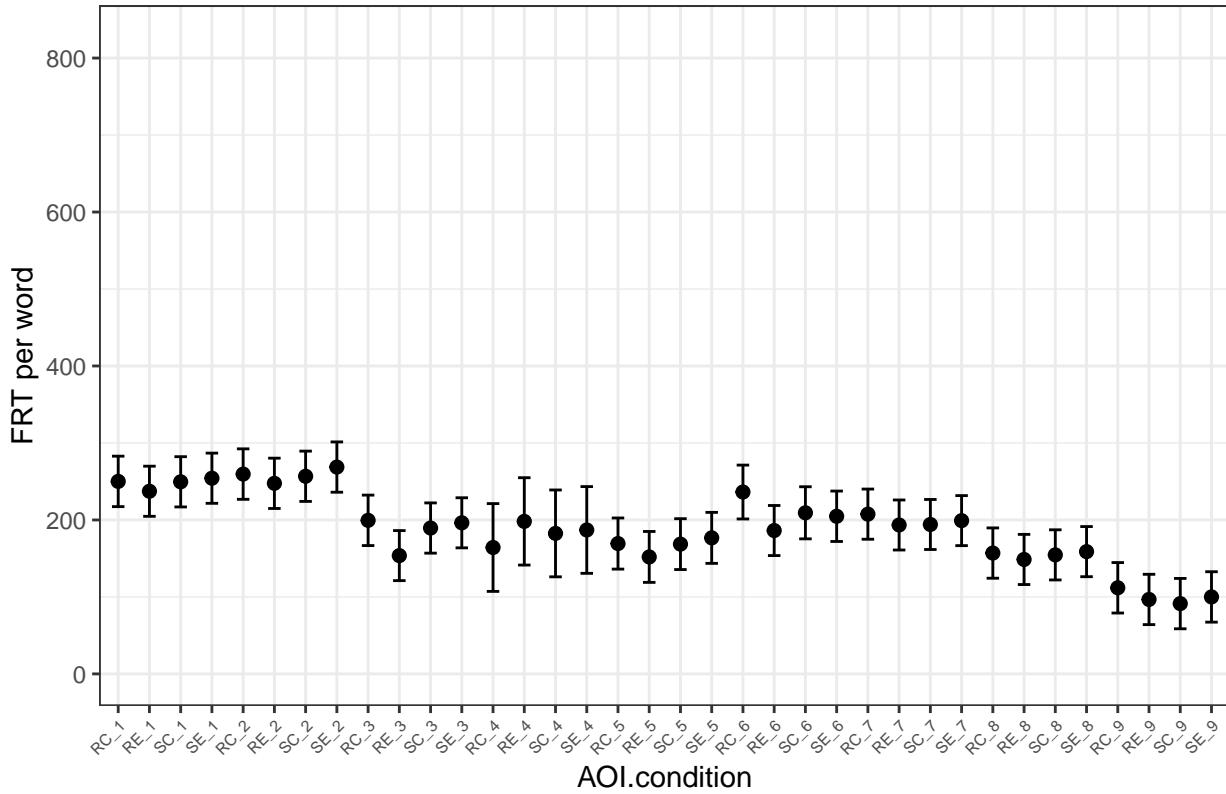
Model 1 – TRT

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	TRT.Pred	TRT.Pred.StdErr
RC_1	274.47	19.17	5.78	6.34	274.36	19.16
RE_1	-6.06	15.85	5.96	6.34	268.30	19.08
SC_1	-1.89	15.84	5.90	6.34	272.48	19.10
SE_1	0.81	15.85	5.92	6.34	275.18	19.08
RC_2	14.22	15.89	5.76	6.34	288.58	19.17
RE_2	7.41	15.84	5.79	6.34	281.77	19.12
SC_2	14.24	15.84	5.85	6.34	288.61	19.12
SE_2	19.82	15.84	5.80	6.34	294.18	19.12
RC_3	-12.53	15.89	5.77	6.34	261.83	19.17
RE_3	-19.74	15.88	6.15	6.34	254.63	19.05
SC_3	-16.32	15.85	5.93	6.34	258.05	19.10
SE_3	-16.16	15.87	6.05	6.34	258.20	19.06
RC_4	57.17	21.88	10.27	6.34	331.54	23.24
RE_4	20.58	21.76	10.26	6.34	294.94	23.13
SC_4	55.24	21.63	10.24	6.34	329.60	23.02
SE_4	43.04	21.73	10.23	6.34	317.41	23.11
RC_5	-11.07	15.92	5.48	6.34	263.29	19.29
RE_5	-0.42	15.87	5.54	6.34	273.95	19.22
SC_5	-3.05	15.86	5.63	6.34	271.31	19.20
SE_5	17.48	15.87	5.52	6.34	291.84	19.22
RC_6	32.00	16.48	4.48	6.34	306.36	20.04
RE_6	16.05	15.88	6.14	6.34	290.42	19.05
SC_6	6.78	16.06	5.06	6.34	281.15	19.54
SE_6	-4.53	15.84	5.76	6.34	269.84	19.13
RC_7	-26.17	15.94	6.14	6.34	248.20	19.09
RE_7	-29.47	15.88	6.15	6.34	244.89	19.05
SC_7	-23.24	15.88	6.17	6.34	251.13	19.05
SE_7	-19.65	15.88	6.13	6.34	254.71	19.05

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	TRT.Pred	TRT.Pred.StdErr
RC_8	-3.28	15.90	5.92	6.34	271.08	19.13
RE_8	-8.45	15.85	5.94	6.34	265.92	19.08
SC_8	-2.68	15.85	5.99	6.34	271.69	19.08
SE_8	1.79	15.85	5.95	6.34	276.16	19.08
RC_9	-2.96	15.92	6.09	6.34	271.40	19.10
RE_9	-0.54	15.89	6.15	6.34	273.83	19.05
SC_9	3.15	15.90	6.23	6.34	277.51	19.04
SE_9	16.68	15.89	6.17	6.34	291.04	19.04
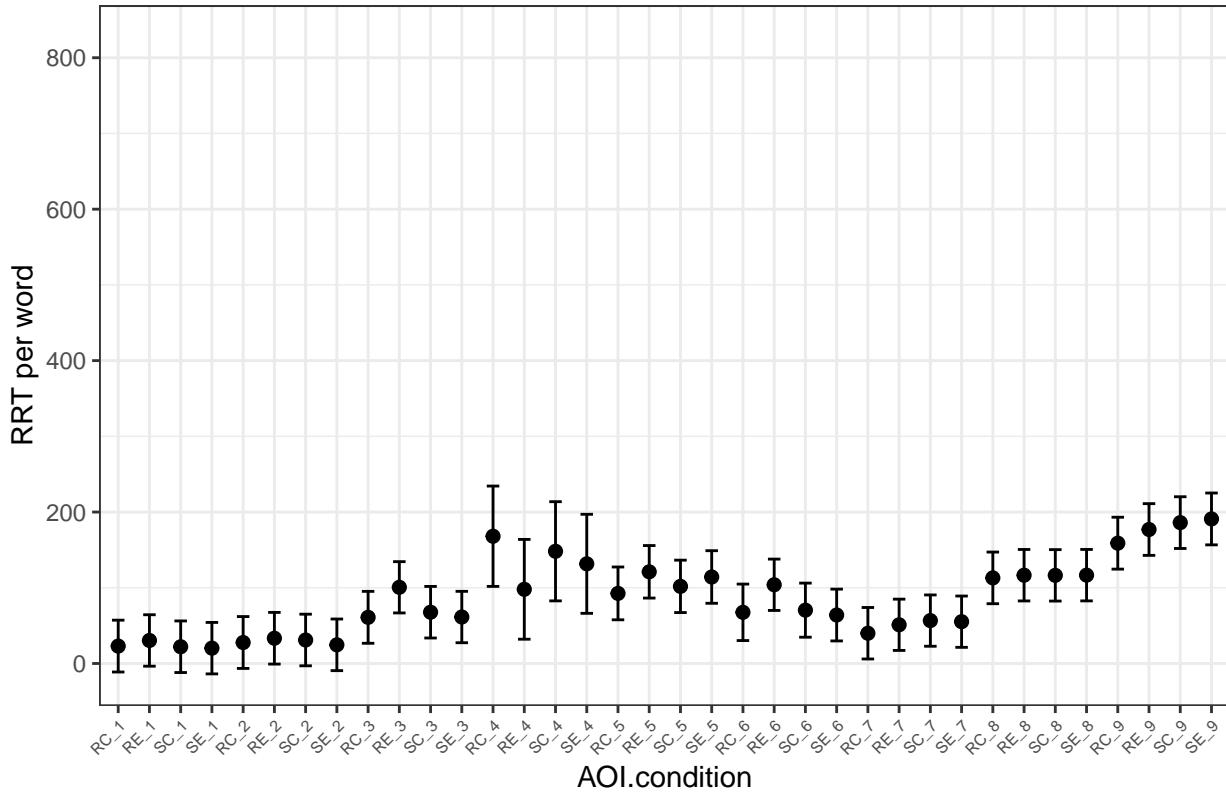
Model 1 – FRT

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	FRT.Pred	FRT.Pred.StdErr
RC_1	245.81	16.94	5.78	6.34	250.09	16.71
RE_1	-12.81	15.08	5.96	6.34	237.28	16.62
SC_1	-0.57	15.07	5.90	6.34	249.52	16.65
SE_1	4.12	15.07	5.92	6.34	254.21	16.63
RC_2	9.50	15.12	5.76	6.34	259.59	16.72
RE_2	-2.51	15.07	5.79	6.34	247.58	16.67
SC_2	6.65	15.07	5.85	6.34	256.74	16.66
SE_2	18.60	15.07	5.80	6.34	268.69	16.66
RC_3	-50.60	15.11	5.77	6.34	199.49	16.73
RE_3	-96.40	15.11	6.15	6.34	153.69	16.58
SC_3	-60.58	15.07	5.93	6.34	189.51	16.65
SE_3	-53.80	15.09	6.05	6.34	196.29	16.60
RC_4	-85.89	28.98	10.27	6.34	164.20	29.09
RE_4	-51.97	28.83	10.26	6.34	198.12	28.95
SC_4	-67.57	28.65	10.24	6.34	182.52	28.78
SE_4	-63.11	28.63	10.23	6.34	186.98	28.75
RC_5	-80.74	15.30	5.48	6.34	169.35	16.94
RE_5	-98.14	15.24	5.54	6.34	151.95	16.87
SC_5	-81.49	15.24	5.63	6.34	168.60	16.85
SE_5	-73.38	15.27	5.52	6.34	176.71	16.89
RC_6	-13.83	15.96	4.48	6.34	236.26	17.85
RE_6	-63.84	15.15	6.14	6.34	186.25	16.60
SC_6	-40.82	15.51	5.06	6.34	209.27	17.27
SE_6	-45.31	15.08	5.76	6.34	204.78	16.71
RC_7	-42.56	15.16	6.14	6.34	207.53	16.62
RE_7	-56.63	15.11	6.15	6.34	193.46	16.58
SC_7	-55.99	15.11	6.17	6.34	194.10	16.58
SE_7	-50.97	15.11	6.13	6.34	199.12	16.58

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	FRT.Pred	FRT.Pred.StdErr
RC_8	-93.12	15.12	5.92	6.34	156.97	16.67
RE_8	-101.43	15.07	5.94	6.34	148.66	16.62
SC_8	-95.47	15.07	5.99	6.34	154.62	16.62
SE_8	-91.25	15.08	5.95	6.34	158.84	16.62
RC_9	-138.22	15.28	6.09	6.34	111.87	16.72
RE_9	-153.37	15.26	6.15	6.34	96.72	16.68
SC_9	-158.76	15.29	6.23	6.34	91.33	16.69
SE_9	-150.10	15.30	6.17	6.34	99.99	16.70

Model 1 – RRT

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	RRT.Pred	RRT.Pred.StdErr
RC_1	27.86	17.79	5.78	6.34	22.99	17.47
RE_1	7.43	18.44	5.96	6.34	30.42	17.33
SC_1	-0.85	18.43	5.90	6.34	22.14	17.38
SE_1	-2.73	18.43	5.92	6.34	20.25	17.35
RC_2	4.74	18.49	5.76	6.34	27.73	17.47
RE_2	10.36	18.43	5.79	6.34	33.35	17.41
SC_2	8.04	18.43	5.85	6.34	31.02	17.40
SE_2	1.67	18.44	5.80	6.34	24.66	17.40
RC_3	38.00	18.49	5.77	6.34	60.99	17.49
RE_3	77.64	18.48	6.15	6.34	100.63	17.28
SC_3	44.74	18.43	5.93	6.34	67.73	17.37
SE_3	38.39	18.46	6.05	6.34	61.38	17.31
RC_4	145.08	35.25	10.27	6.34	168.06	33.81
RE_4	75.00	35.07	10.26	6.34	97.99	33.62
SC_4	125.20	34.86	10.24	6.34	148.19	33.42
SE_4	108.67	34.83	10.23	6.34	131.66	33.37
RC_5	69.60	18.71	5.48	6.34	92.59	17.79
RE_5	98.11	18.64	5.54	6.34	121.10	17.69
SC_5	78.87	18.63	5.63	6.34	101.86	17.66
SE_5	91.25	18.67	5.52	6.34	114.24	17.72
RC_6	44.59	19.49	4.48	6.34	67.58	19.03
RE_6	80.98	18.53	6.14	6.34	103.97	17.31
SC_6	47.46	18.96	5.06	6.34	70.45	18.23
SE_6	41.03	18.44	5.76	6.34	64.02	17.45
RC_7	16.97	18.54	6.14	6.34	39.96	17.34
RE_7	28.13	18.48	6.15	6.34	51.11	17.28
SC_7	33.67	18.48	6.17	6.34	56.66	17.28
SE_7	32.24	18.48	6.13	6.34	55.23	17.28

	Estimate	StdErr	nLetters.WD_obs	nLetters.WD_fix	RRT.Pred	RRT.Pred.StdErr
RC_8	90.07	18.49	5.92	6.34	113.06	17.40
RE_8	93.62	18.43	5.94	6.34	116.61	17.34
SC_8	93.42	18.44	5.99	6.34	116.41	17.34
SE_8	93.67	18.44	5.95	6.34	116.66	17.33
RC_9	135.91	18.69	6.09	6.34	158.90	17.48
RE_9	153.96	18.66	6.15	6.34	176.95	17.42
SC_9	163.07	18.69	6.23	6.34	186.06	17.43
SE_9	167.92	18.71	6.17	6.34	190.91	17.46

Separate models for p-value comparison

Model for AOI 1

TRT model
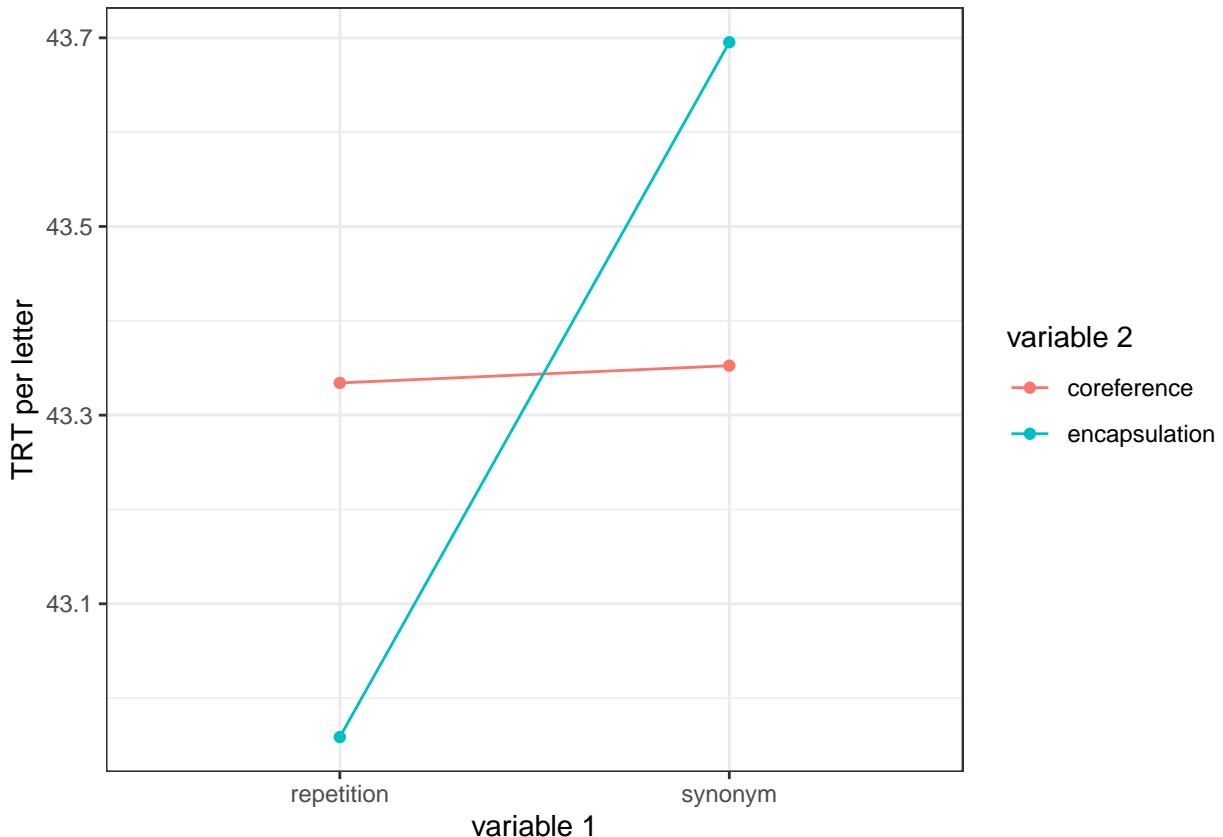
| TRT per Letter	Estimates	Std.Error	p.value
(Intercept)	43.9065	2.5779	0.0000
var1synonym	-0.4022	1.2789	0.7534
var2encapsulation	-1.0084	1.2783	0.4310
var1synonym:var2encapsulation	1.0995	1.8044	0.5429
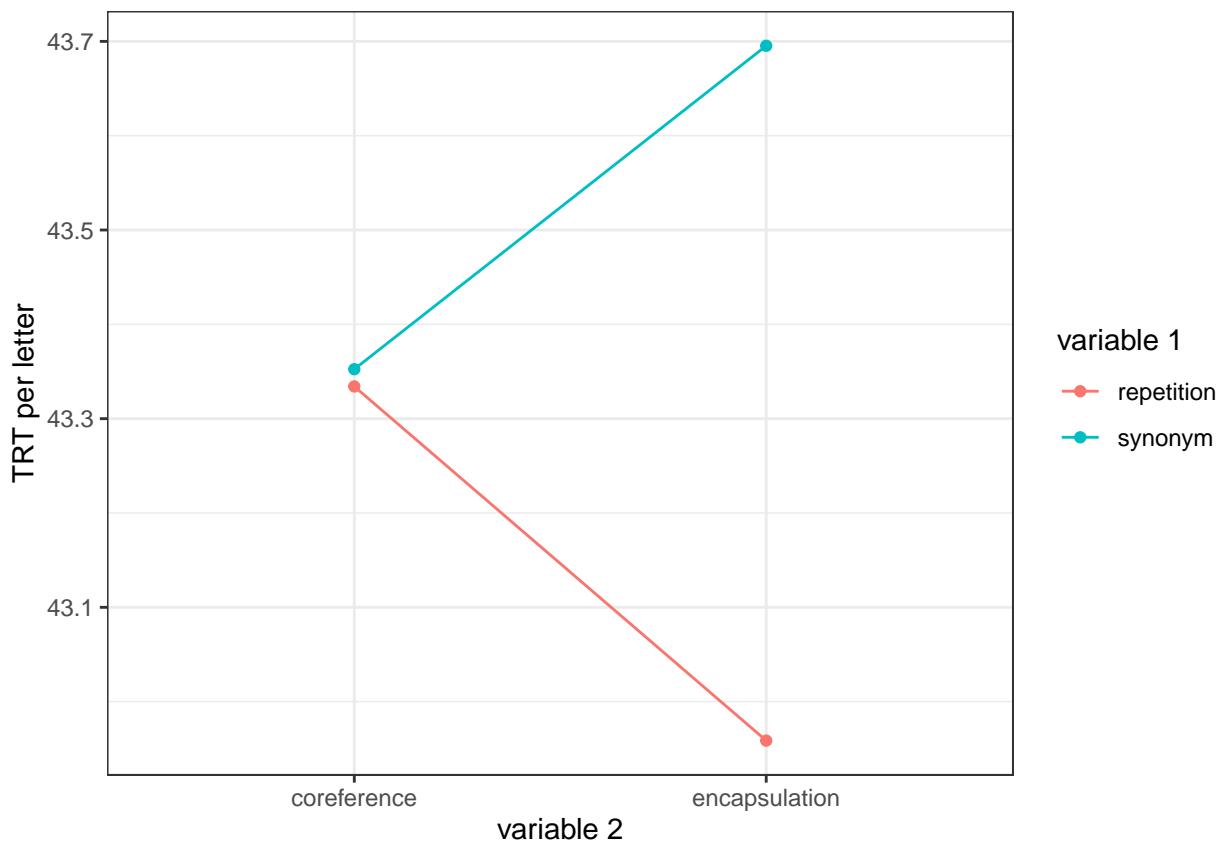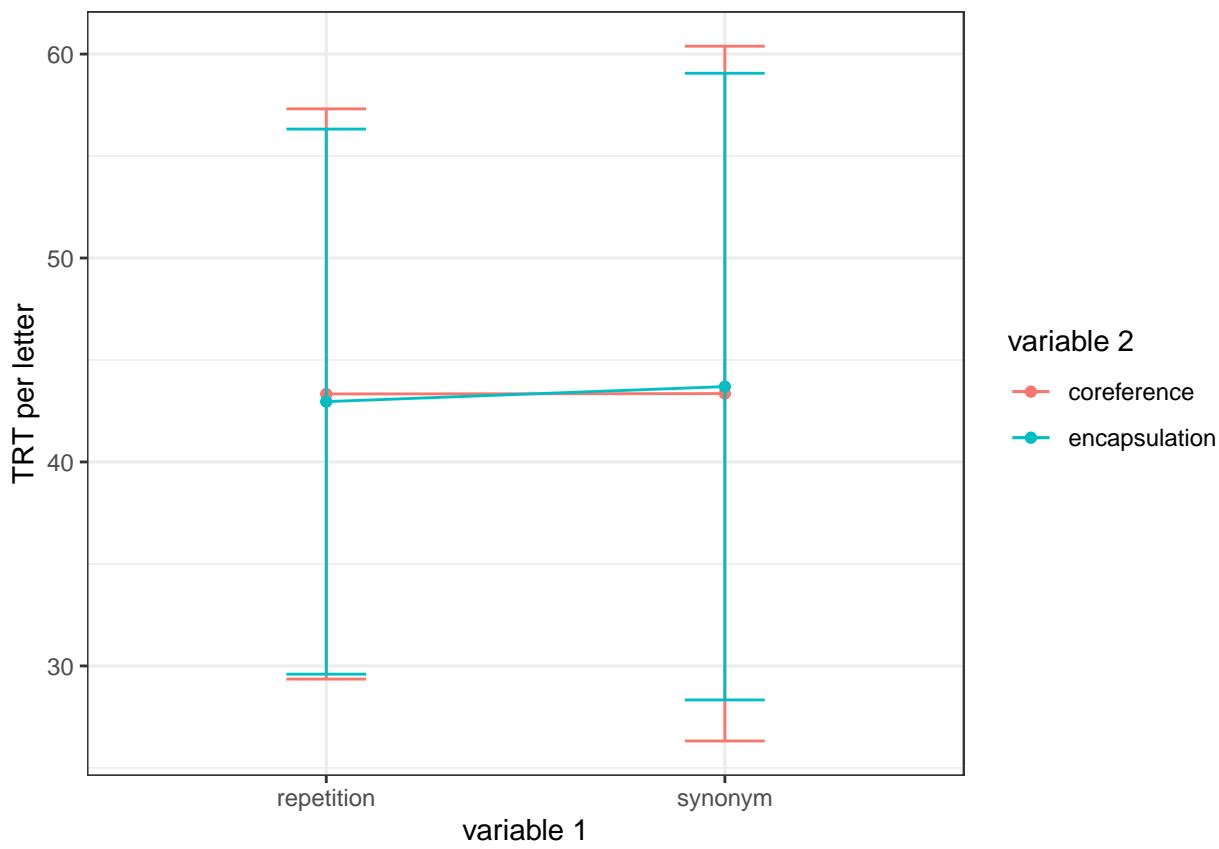
For the TRT model: Both random effects, for Participant and Topic, are significant w.r.t alpha = 0.05.
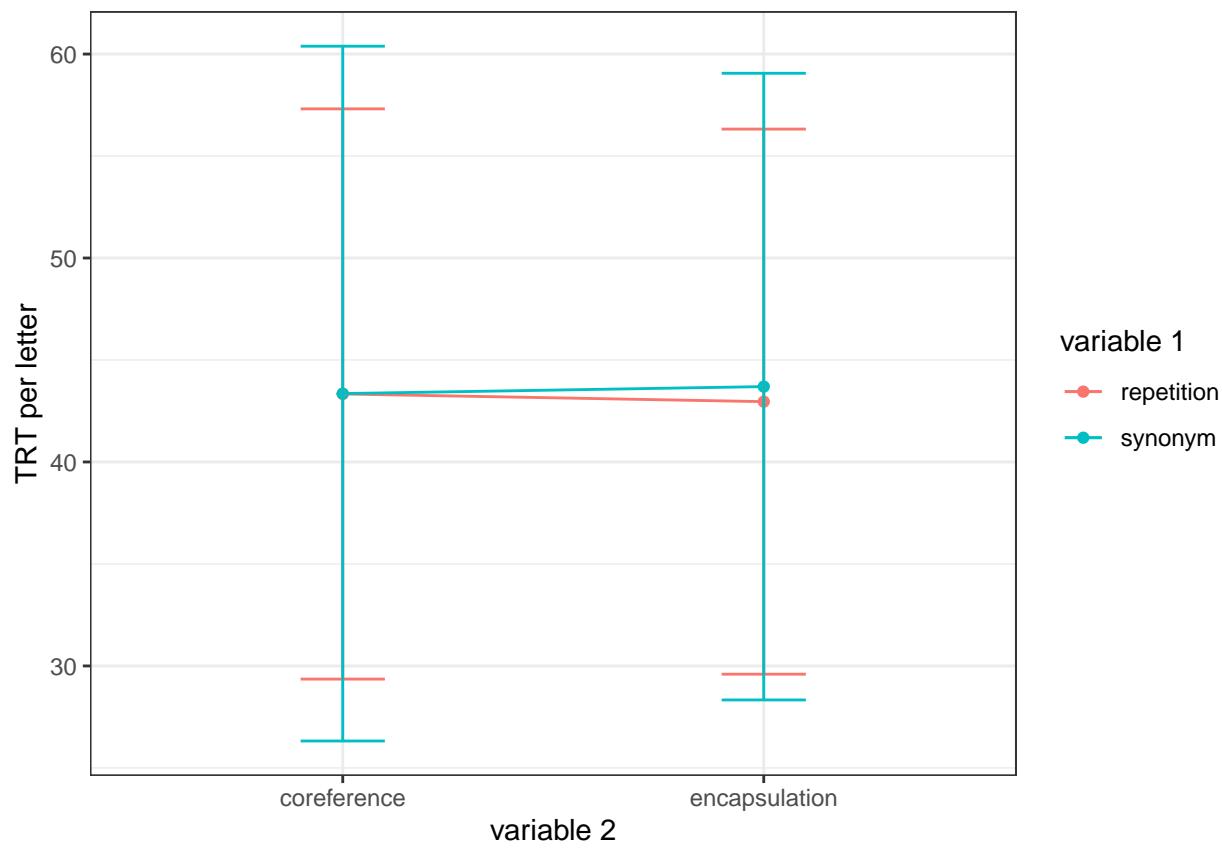
Pairwise comparisons

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	-0.0911308	1.272977	233.9293	-0.0715887	0.9429904
RC vs RE	1.0083887	1.278260	233.9293	0.7888760	0.4309832
SC vs RC	-0.4022152	1.278858	233.9293	-0.3145113	0.7534131
SE vs RE	0.6973043	1.273178	233.9293	0.5476878	0.5844285

Plots

FRT model
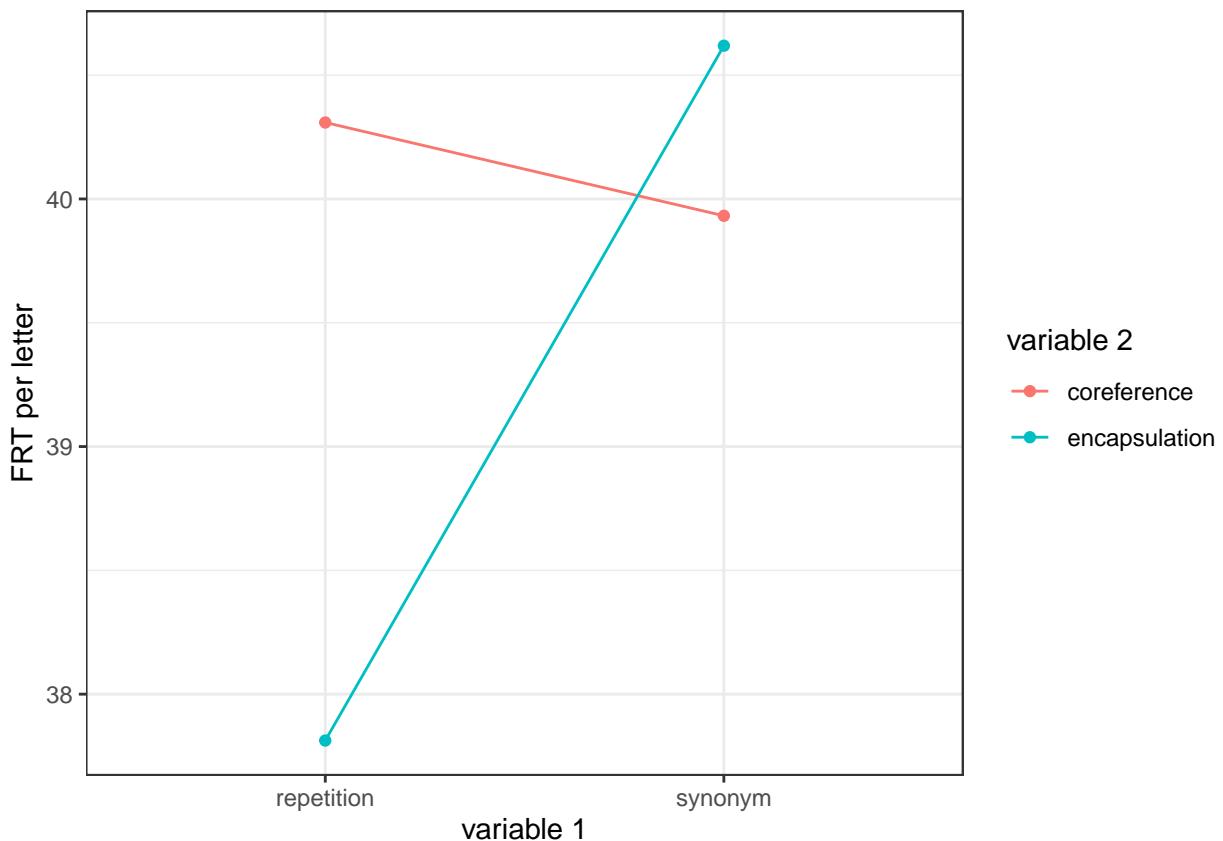
FRT per Letter	Estimates	Std.Error	p.value
(Intercept)	40.4851	2.3102	0.0000
var1synonym	-0.4383	1.3930	0.7533
var2encapsulation	-2.6955	1.3923	0.0541
var1synonym:var2encapsulation	3.1581	1.9655	0.1094
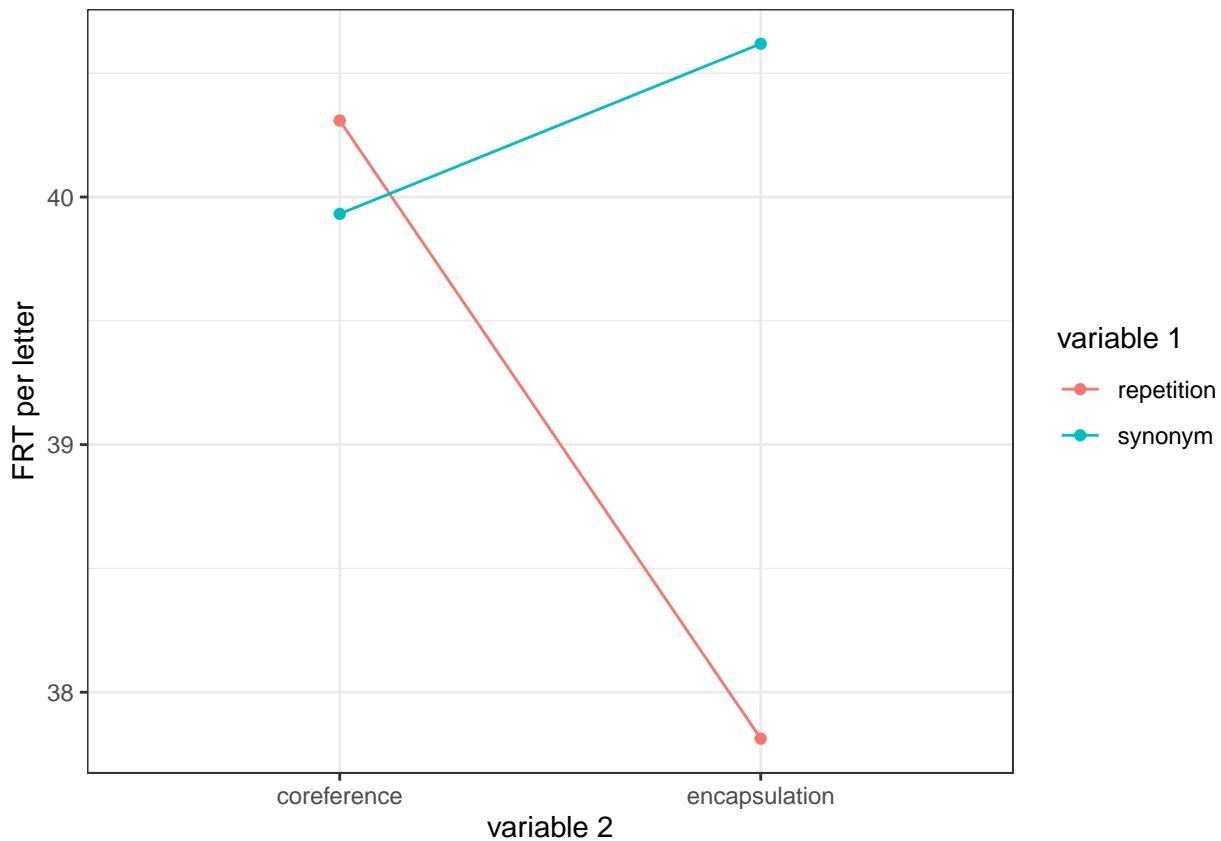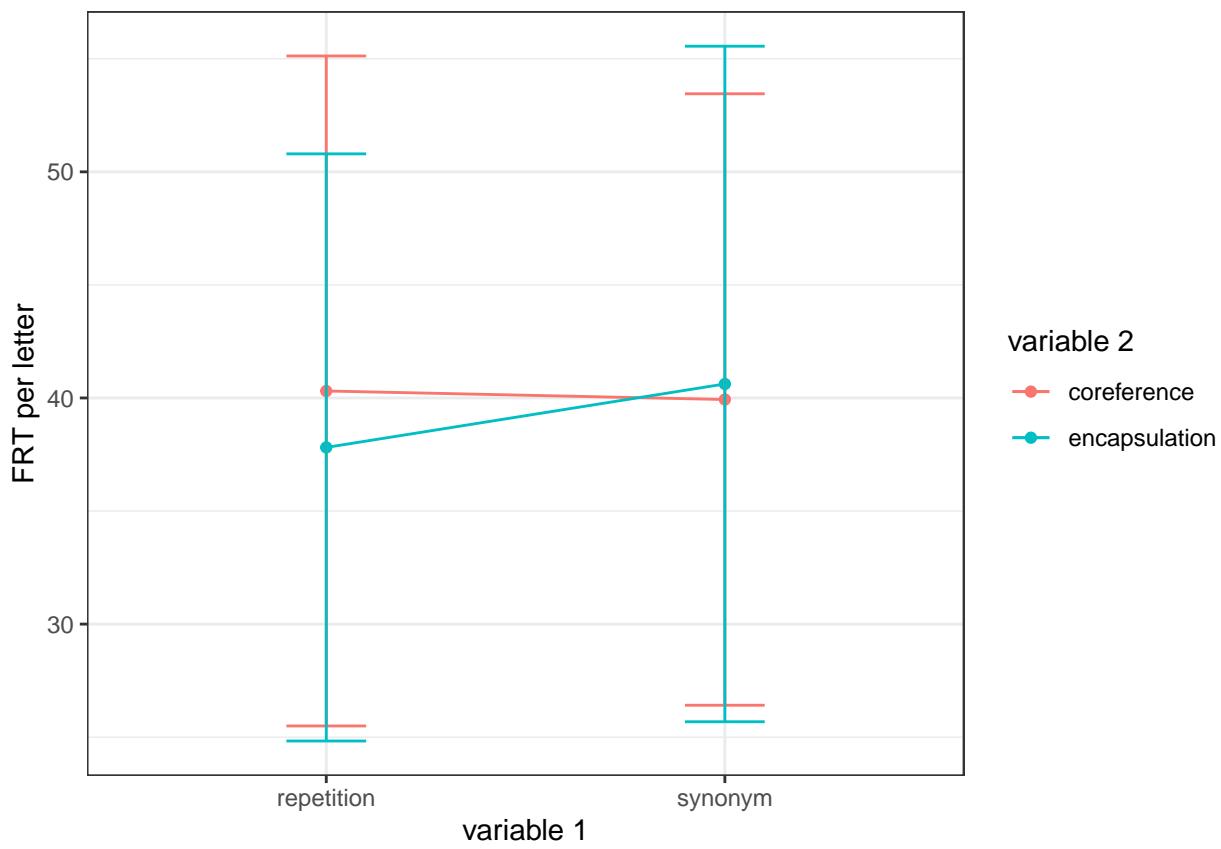
For the FRT model: Both random effects, for Participant and Topic, are significant w.r.t alpha = 0.05.
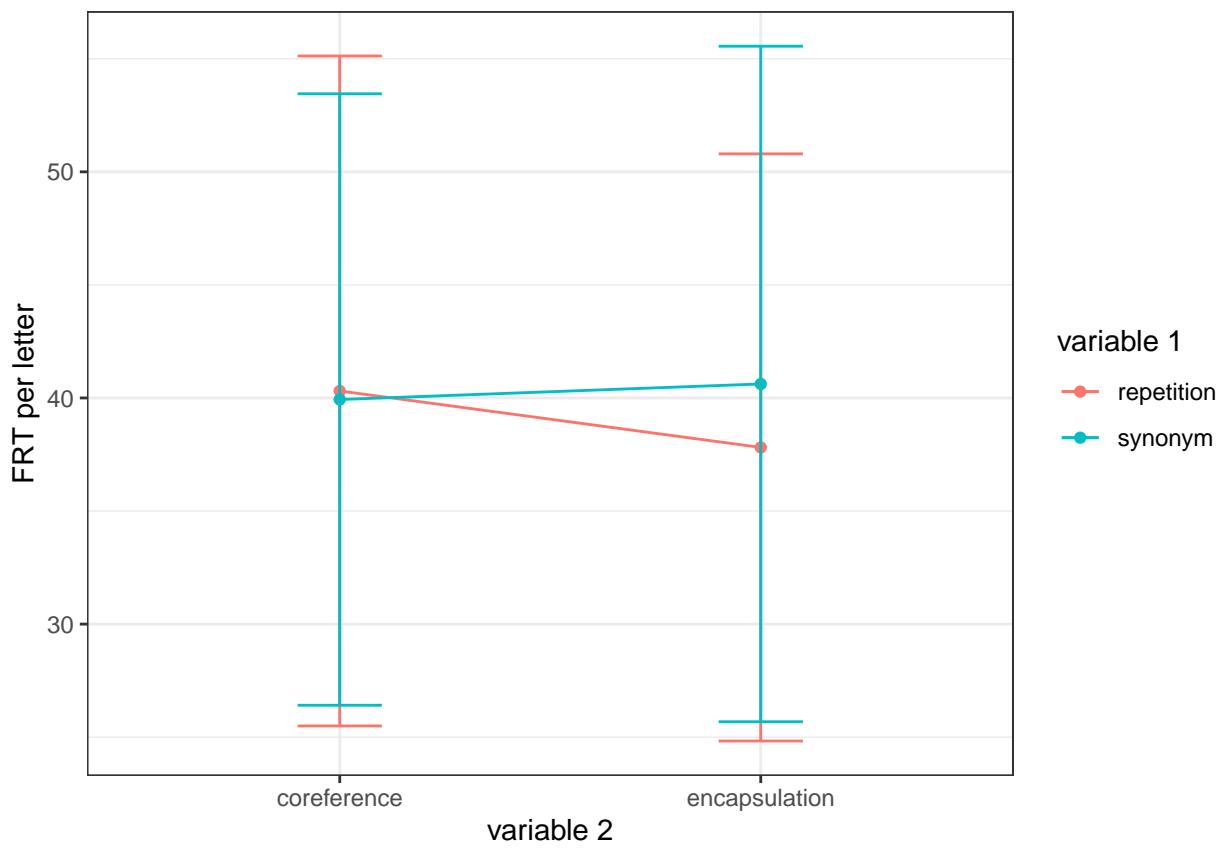
Pairwise comparisons

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	-0.4626605	1.386677	238.051	-0.3336470	0.7389397
RC vs RE	2.6954529	1.392336	238.051	1.9359213	0.0540614
SC vs RC	-0.4382764	1.392962	238.051	-0.3146362	0.7533135
SE vs RE	2.7198370	1.386890	238.051	1.9611055	0.0510326

Plots

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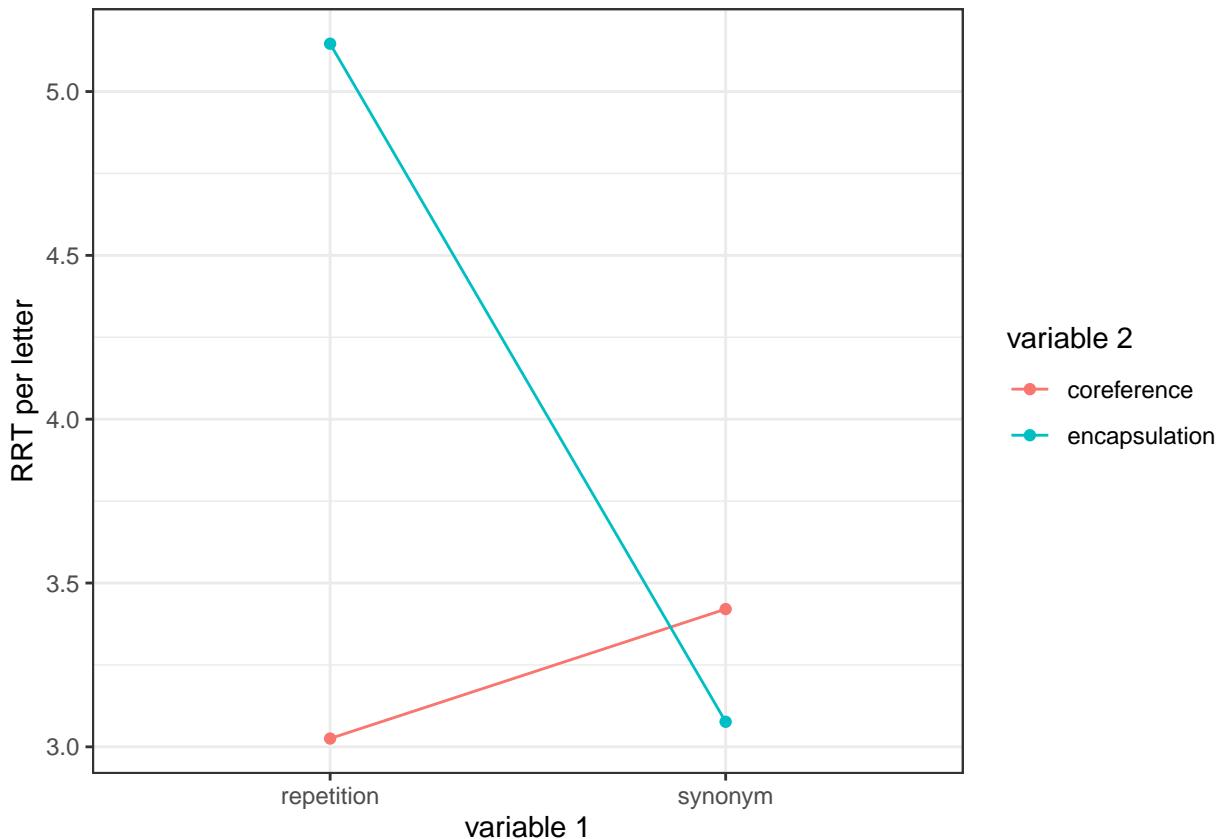
RRT model

| RRT per Letter	Estimates	Std.Error	p.value
(Intercept)	3.3116	0.9494	0.0006
var1synonym	0.1277	0.9821	0.8966
var2encapsulation	1.8138	0.9819	0.0659
var1synonym:var2encapsulation	-2.1698	1.3860	0.1187
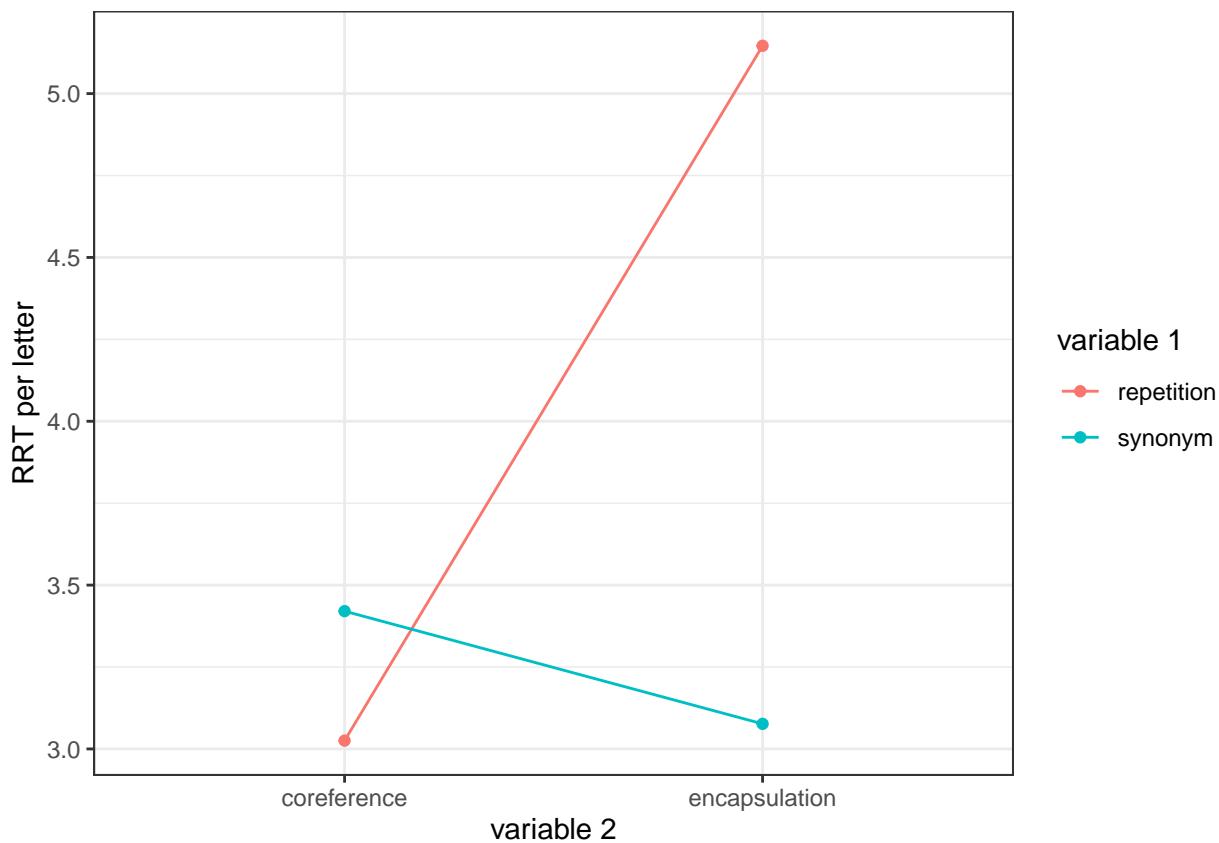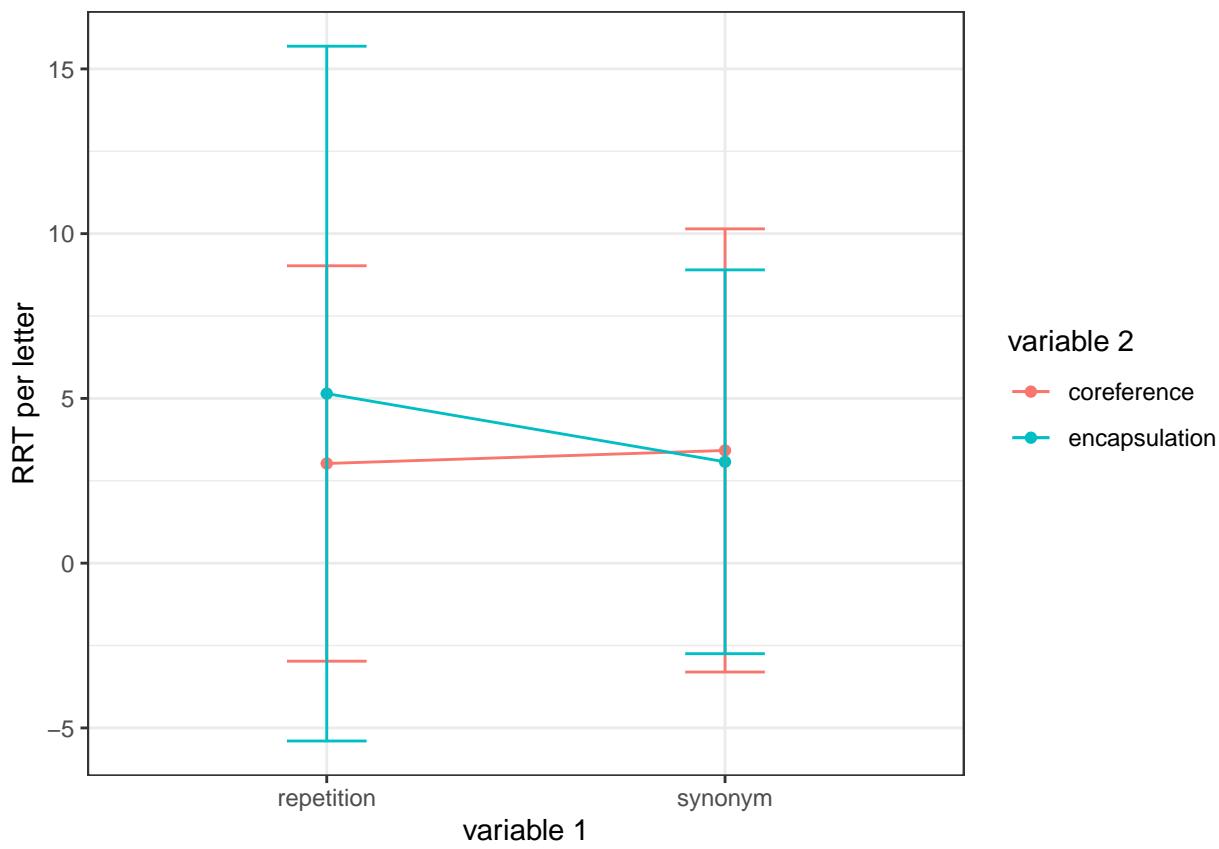
For the RRT model: The random effect s(Participant) is significant w.r.t alpha = 0.05.
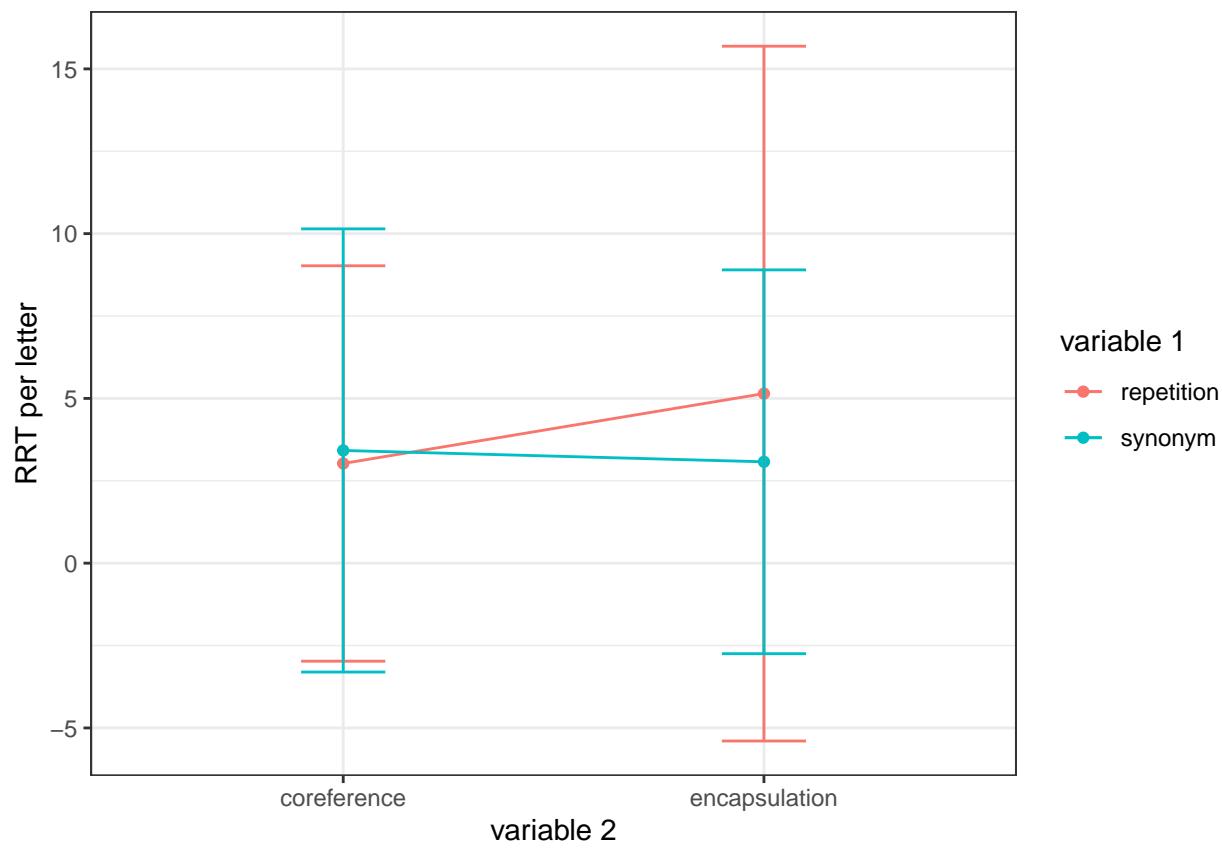
Pairwise comparisons

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	0.3560039	0.9780270	250.7003	0.3640021	0.7161633
RC vs RE	-1.8138391	0.9818588	250.7003	-1.8473524	0.0658742
SC vs RC	0.1277395	0.9820892	250.7003	0.1300692	0.8966160
SE vs RE	-2.0421035	0.9781077	250.7003	-2.0878103	0.0378246

Plots

Model for AOI 6

TRT model
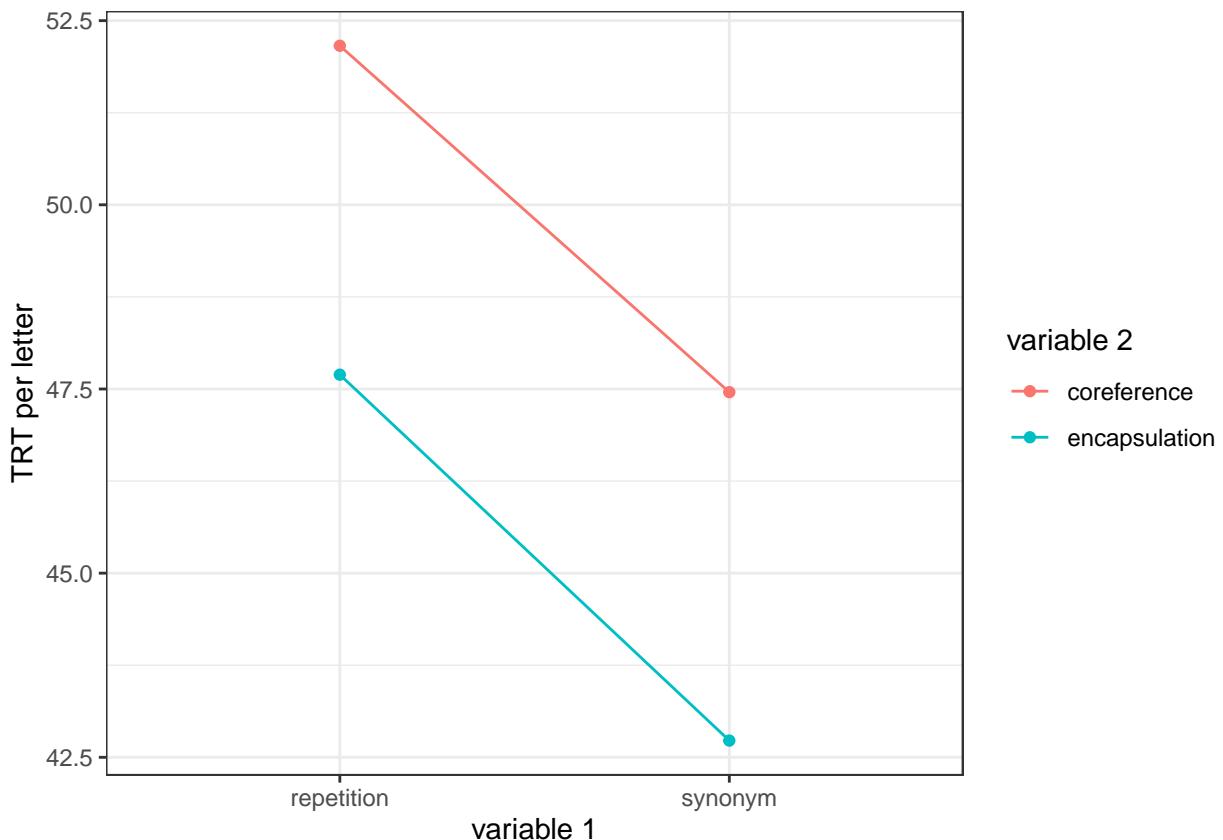
TRT per Letter	Estimates	Std.Error	p.value
(Intercept)	52.7739	3.9548	0.0000
var1synonym	-5.2827	4.1993	0.2095
var2encapsulation	-4.9574	4.1981	0.2387
var1synonym:var2encapsulation	0.1258	5.9266	0.9831
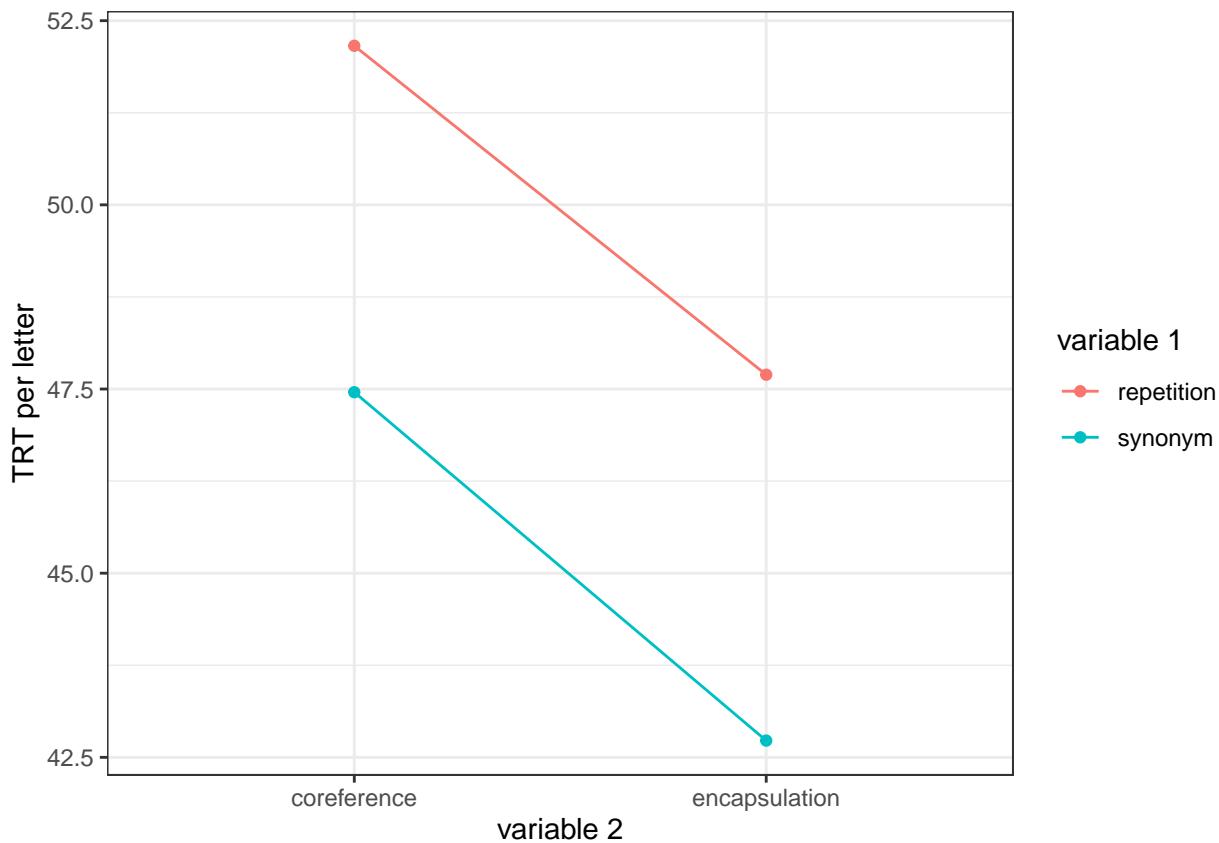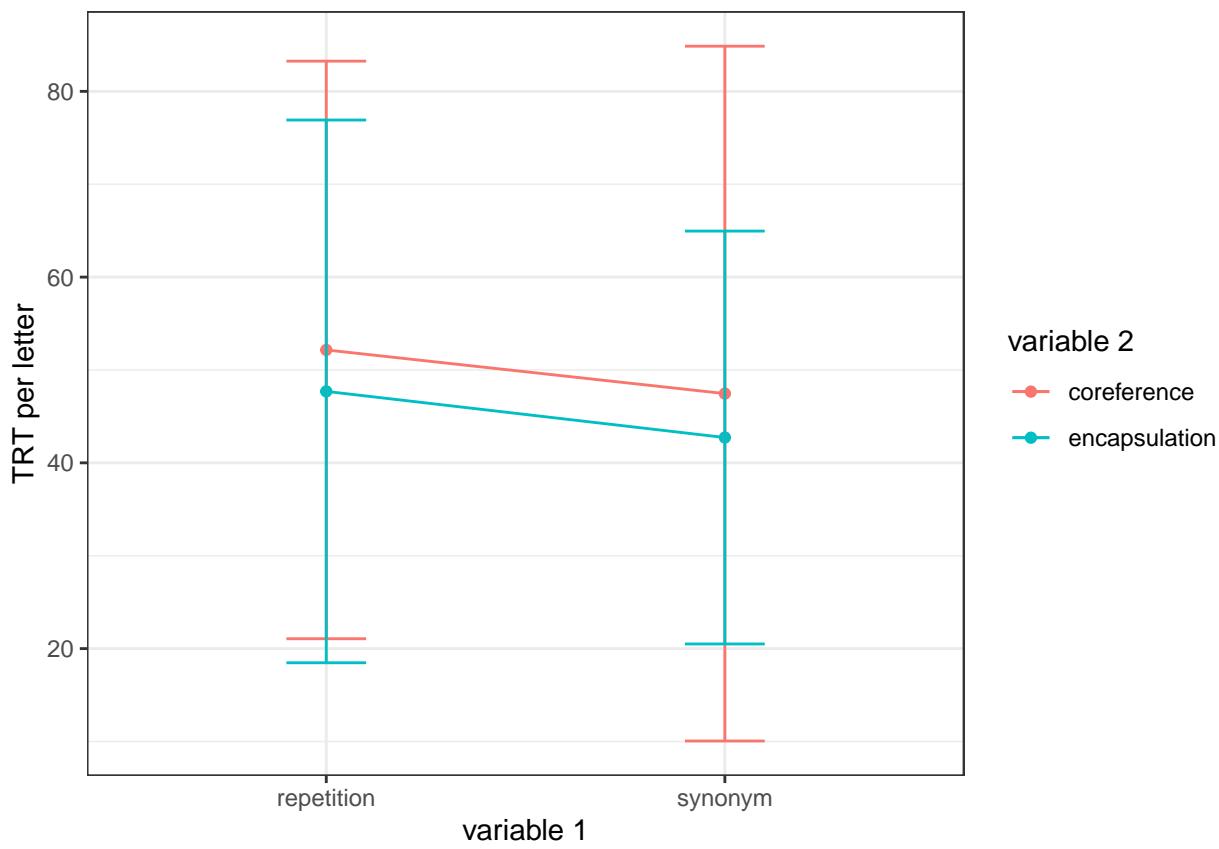
For the TRT model: The random effect s(Participant) is significant w.r.t alpha = 0.05.
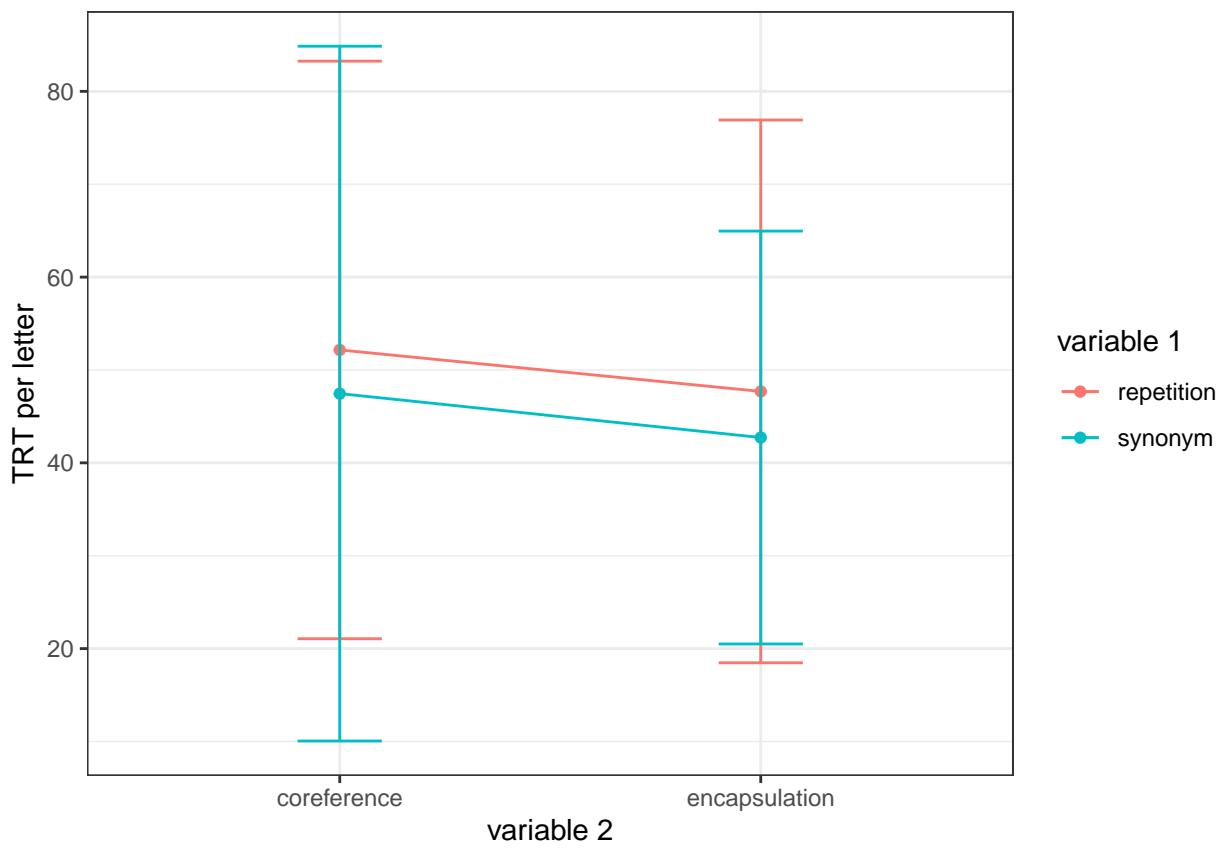
Pairwise comparisons

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	4.831664	4.182262	258.6822	1.155275	0.2490437
RC vs RE	4.957432	4.198101	258.6822	1.180875	0.2387371
SC vs RC	-5.282664	4.199282	258.6822	-1.257992	0.2095289
SE vs RE	-5.156896	4.182684	258.6822	-1.232916	0.2187265

Plots

FRT model
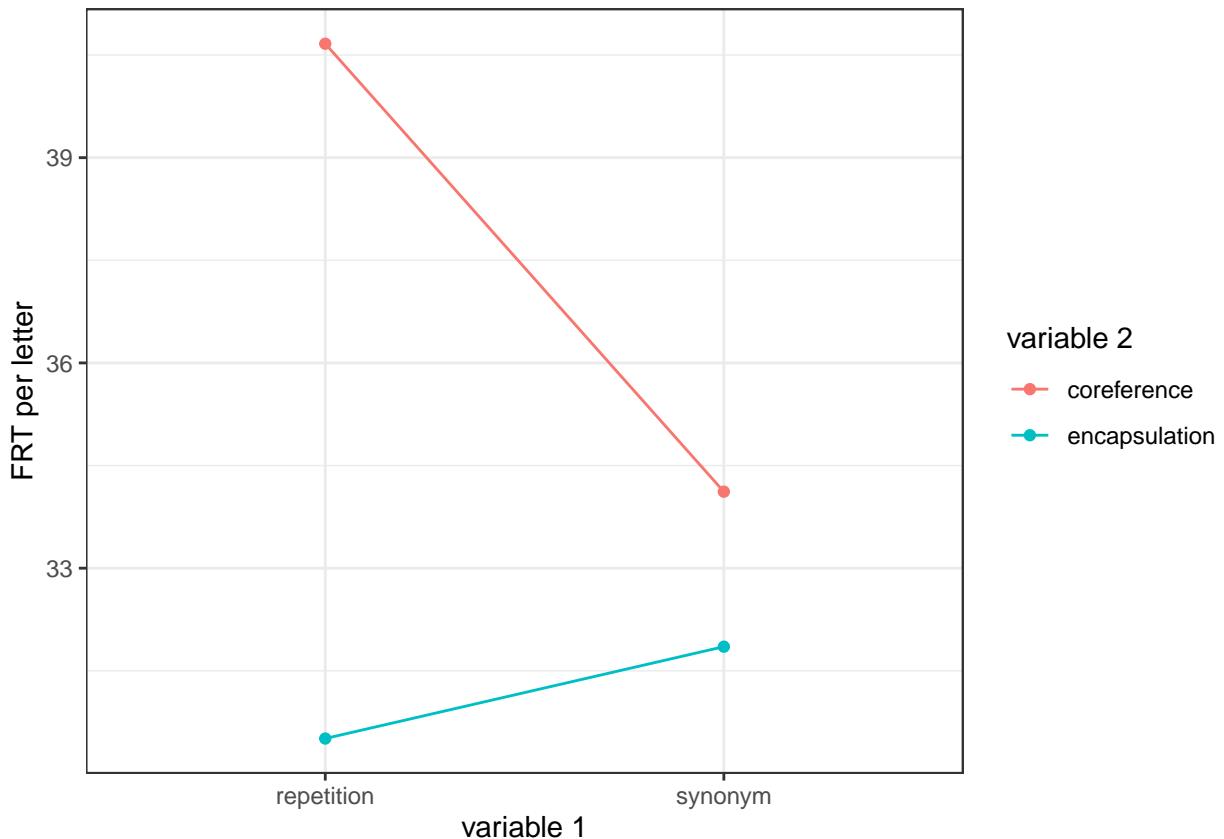
| FRT per Letter	Estimates	Std.Error	p.value
(Intercept)	40.6323	3.5707	0.0000
var1synonym	-6.4865	3.0511	0.0344
var2encapsulation	-9.8980	3.0499	0.0013
var1synonym:var2encapsulation	7.4282	4.3061	0.0857
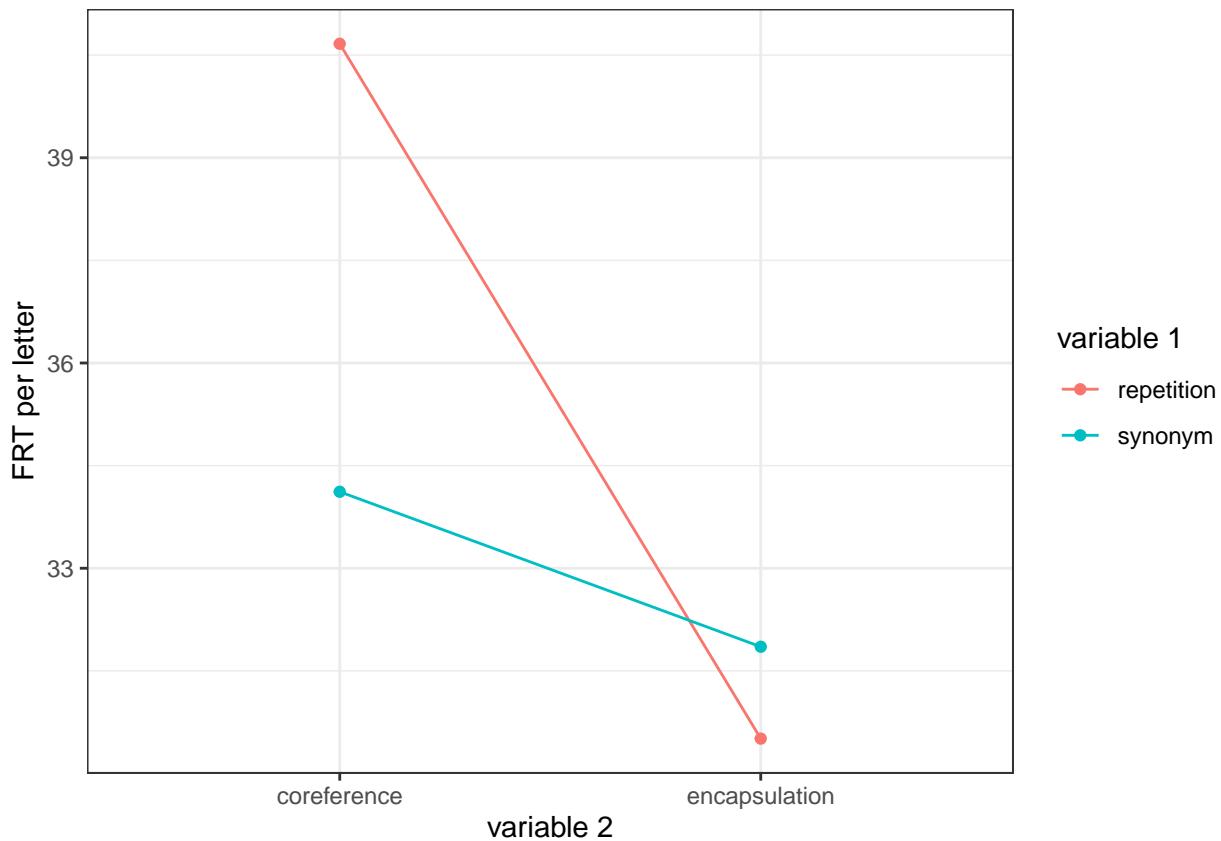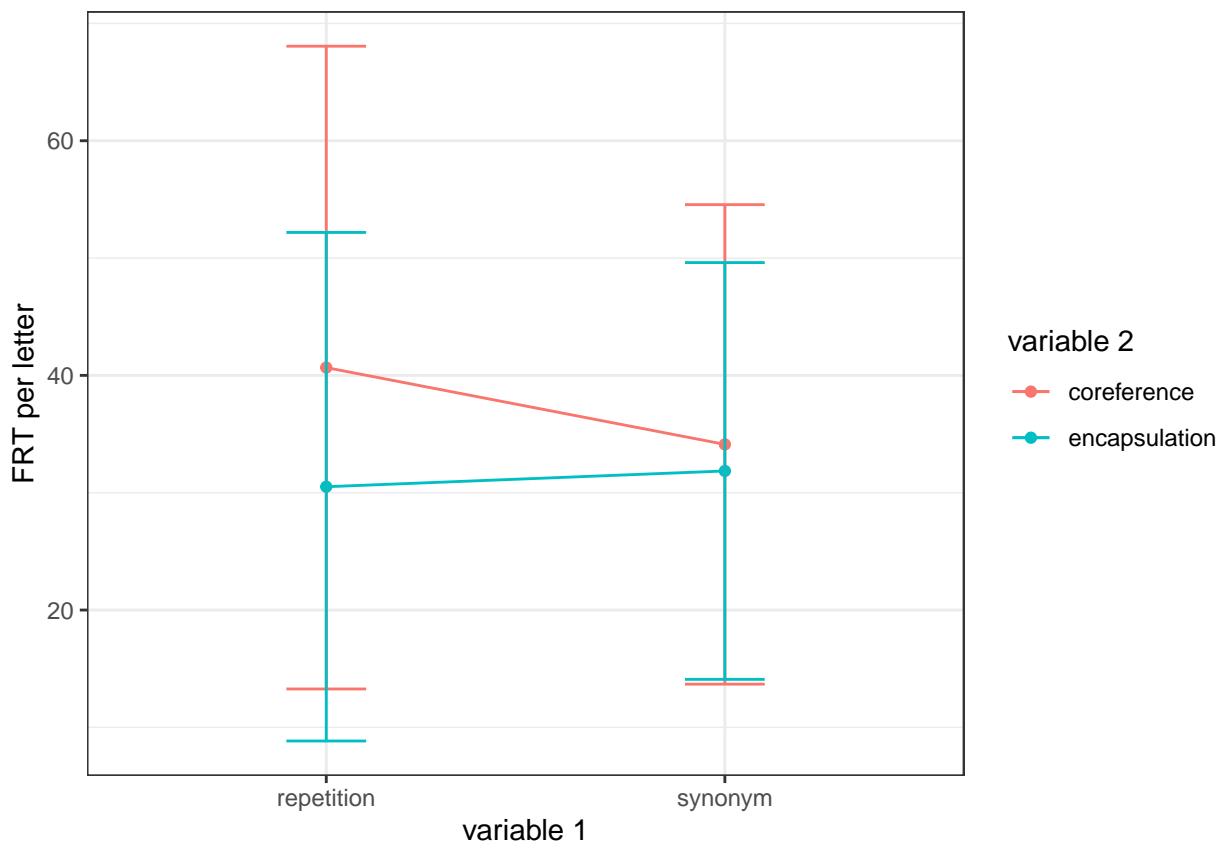
For the FRT model: Both random effects, for Participant and Topic, are significant w.r.t alpha = 0.05.
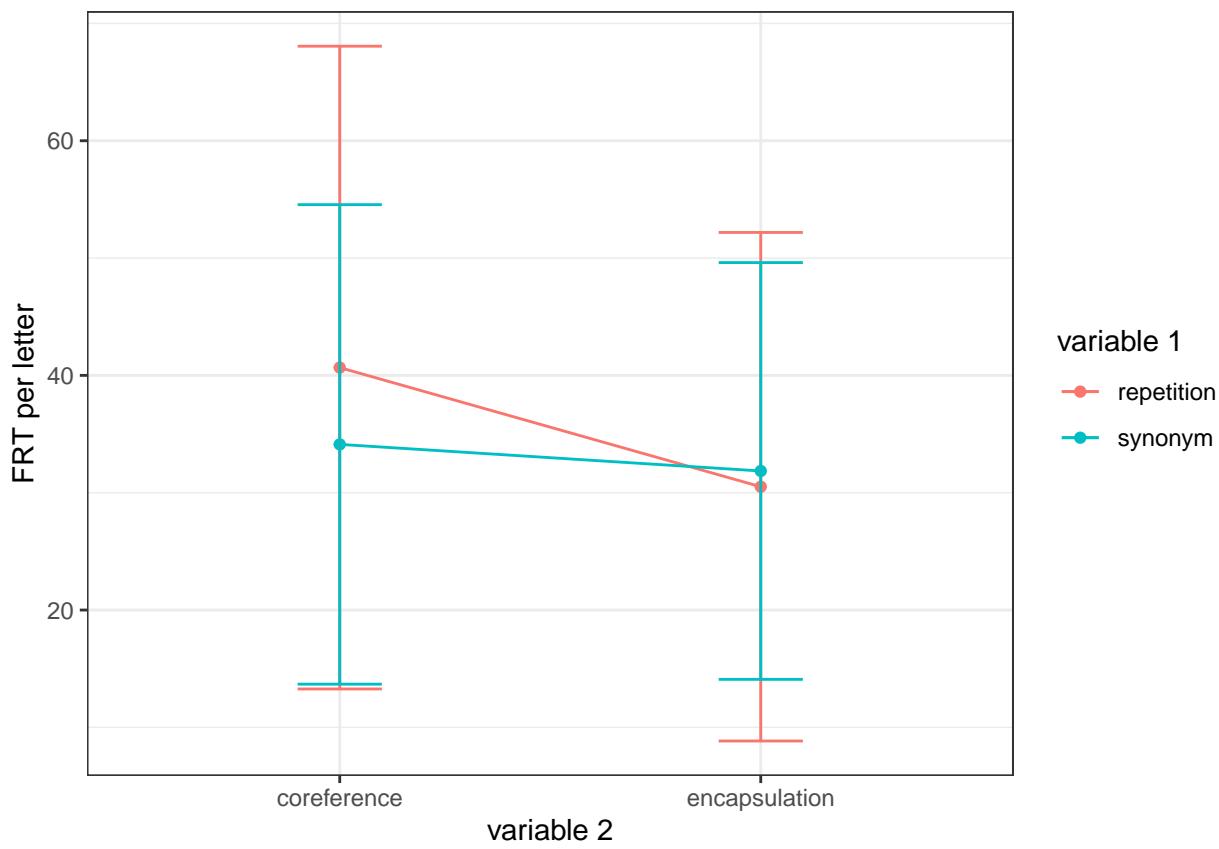
Pairwise comparisons

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	2.4698744	3.038674	262.7219	0.8128132	0.4170611
RC vs RE	9.8980249	3.049938	262.7219	3.2453200	0.0013253
SC vs RC	-6.4864540	3.051128	262.7219	-2.1259202	0.0344426
SE vs RE	0.9416965	3.039104	262.7219	0.3098599	0.7569131

Plots

RRT model
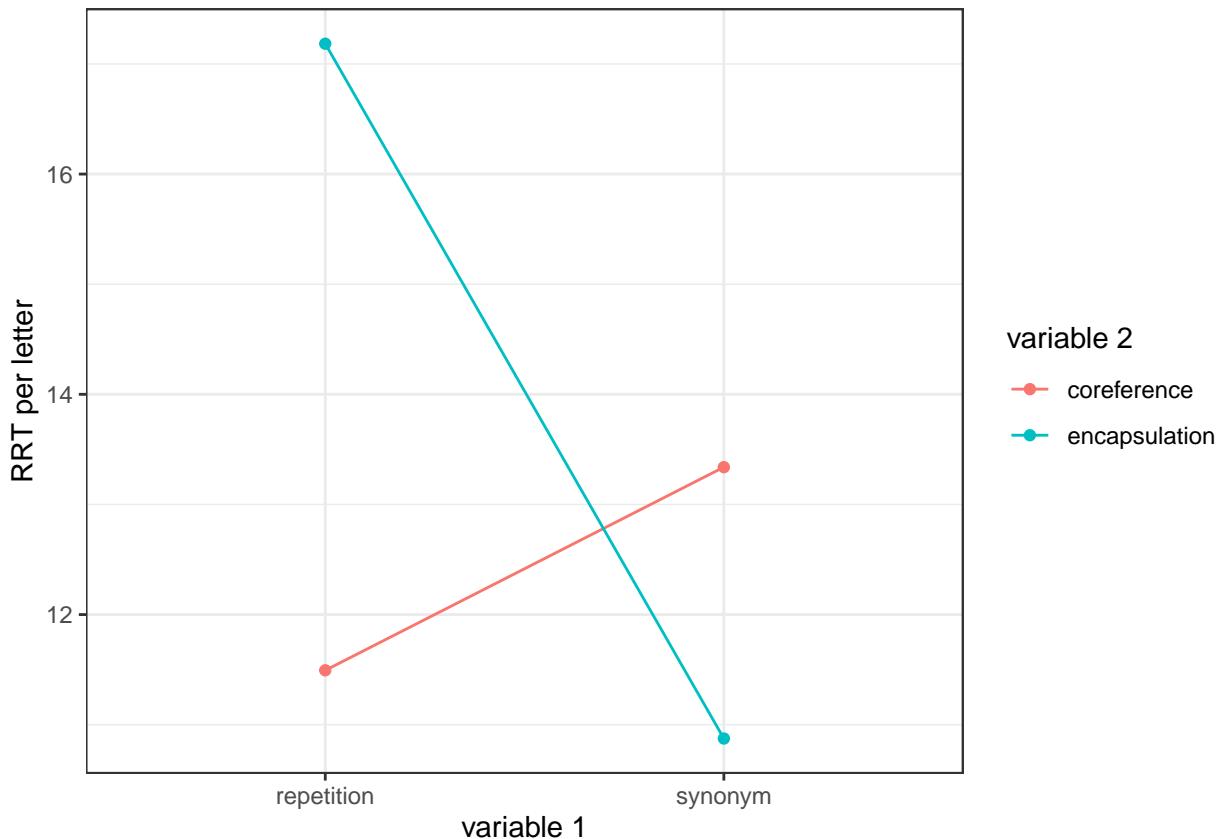
| RRT per Letter	Estimates	Std.Error	p.value
(Intercept)	12.0870	3.0005	0.0001
var1synonym	1.2517	3.7443	0.7384
var2encapsulation	5.0967	3.7443	0.1746
var1synonym:var2encapsulation	-7.5611	5.2854	0.1537
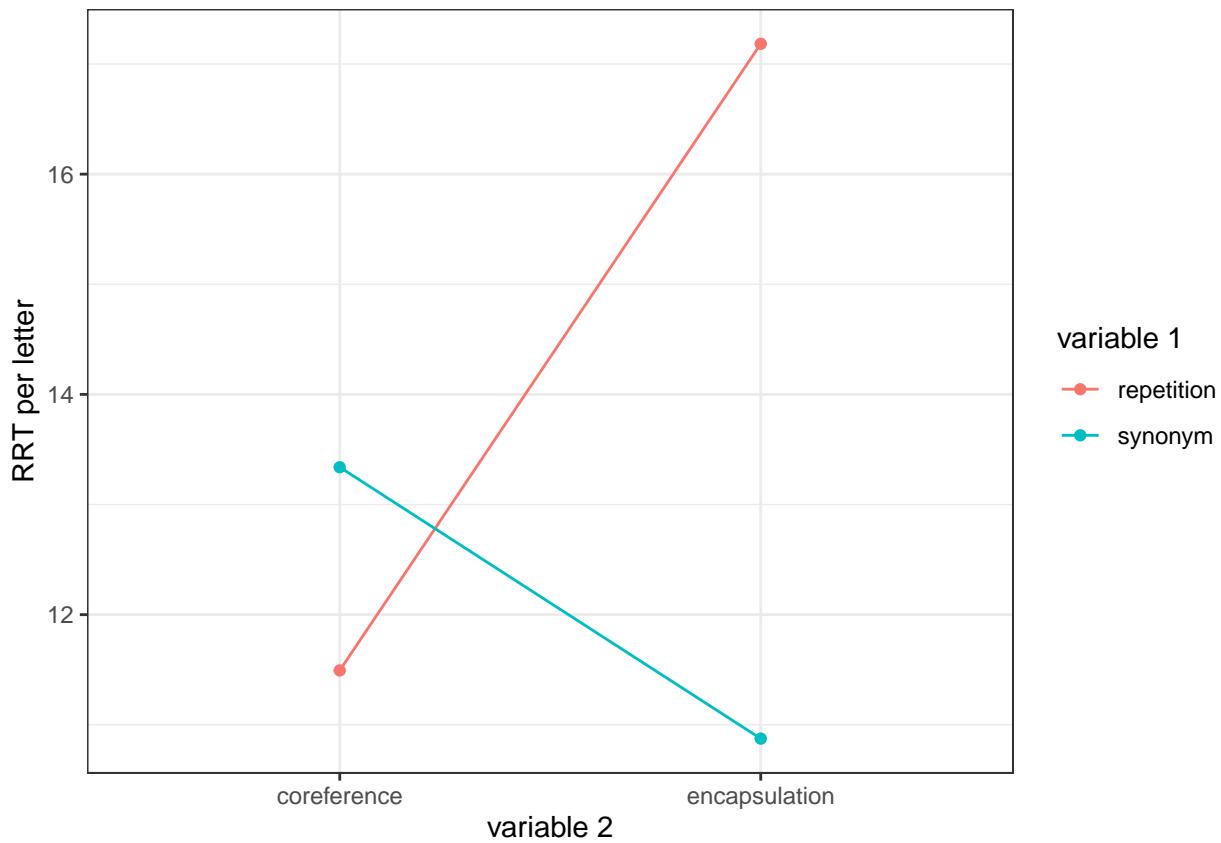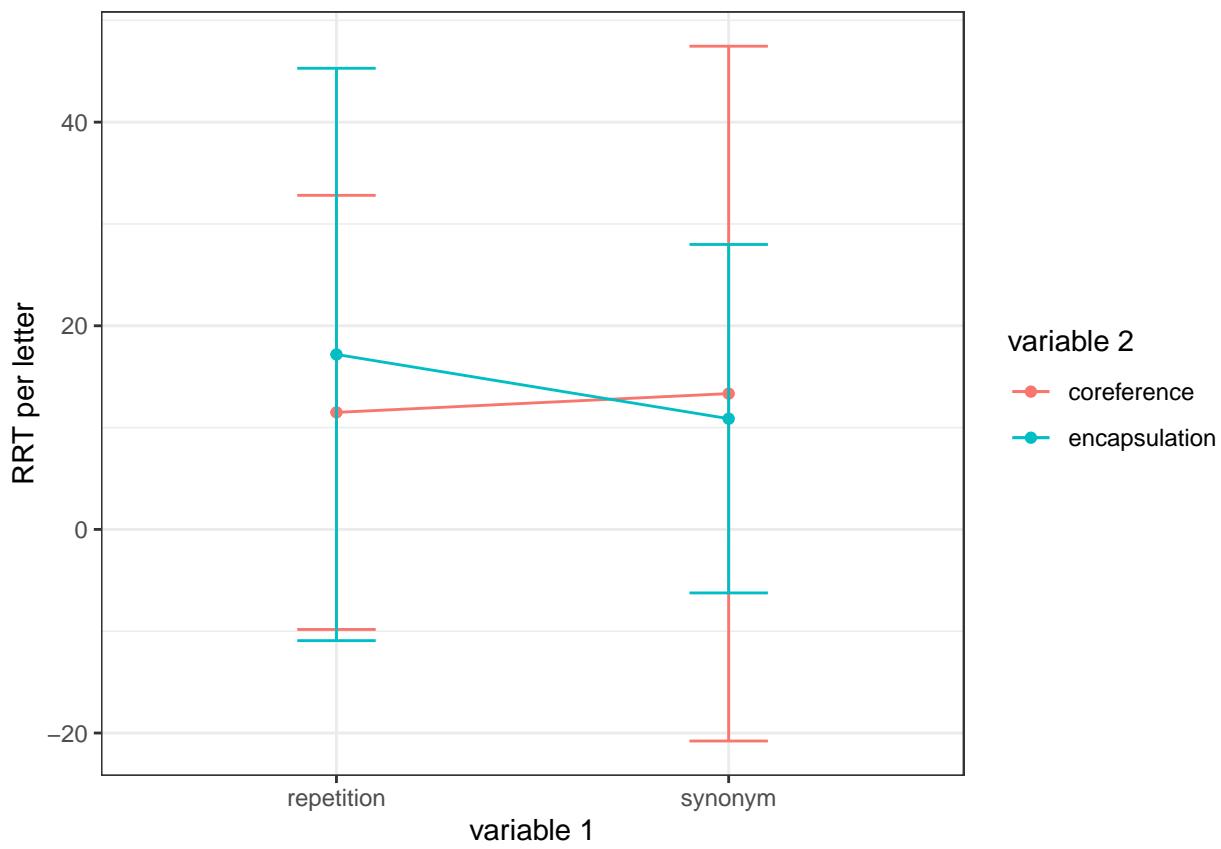
For the RRT model: The random effect s(Participant) is significant w.r.t alpha = 0.05.
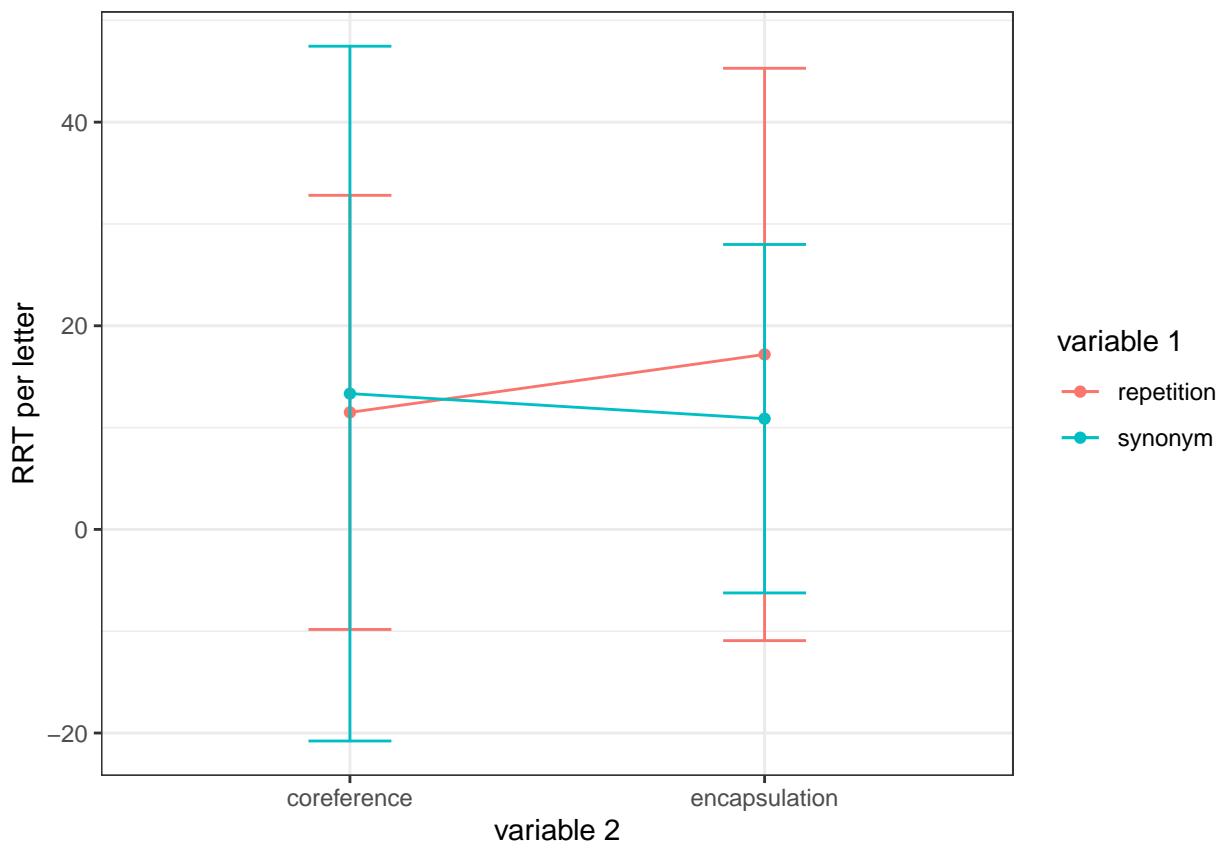
Pairwise comparisons

contrast	estimate	SE	df	t.ratio	p.value
SC vs SE	2.464316	3.730342	266.4604	0.6606141	0.5094305
RC vs RE	-5.096742	3.744267	266.4604	-1.3612122	0.1745966
SC vs RC	1.251664	3.744267	266.4604	0.3342881	0.7384251
SE vs RE	-6.309394	3.730342	266.4604	-1.6913716	0.0919350

Plots

Hypothesis tests

No hypothesis tests were performed