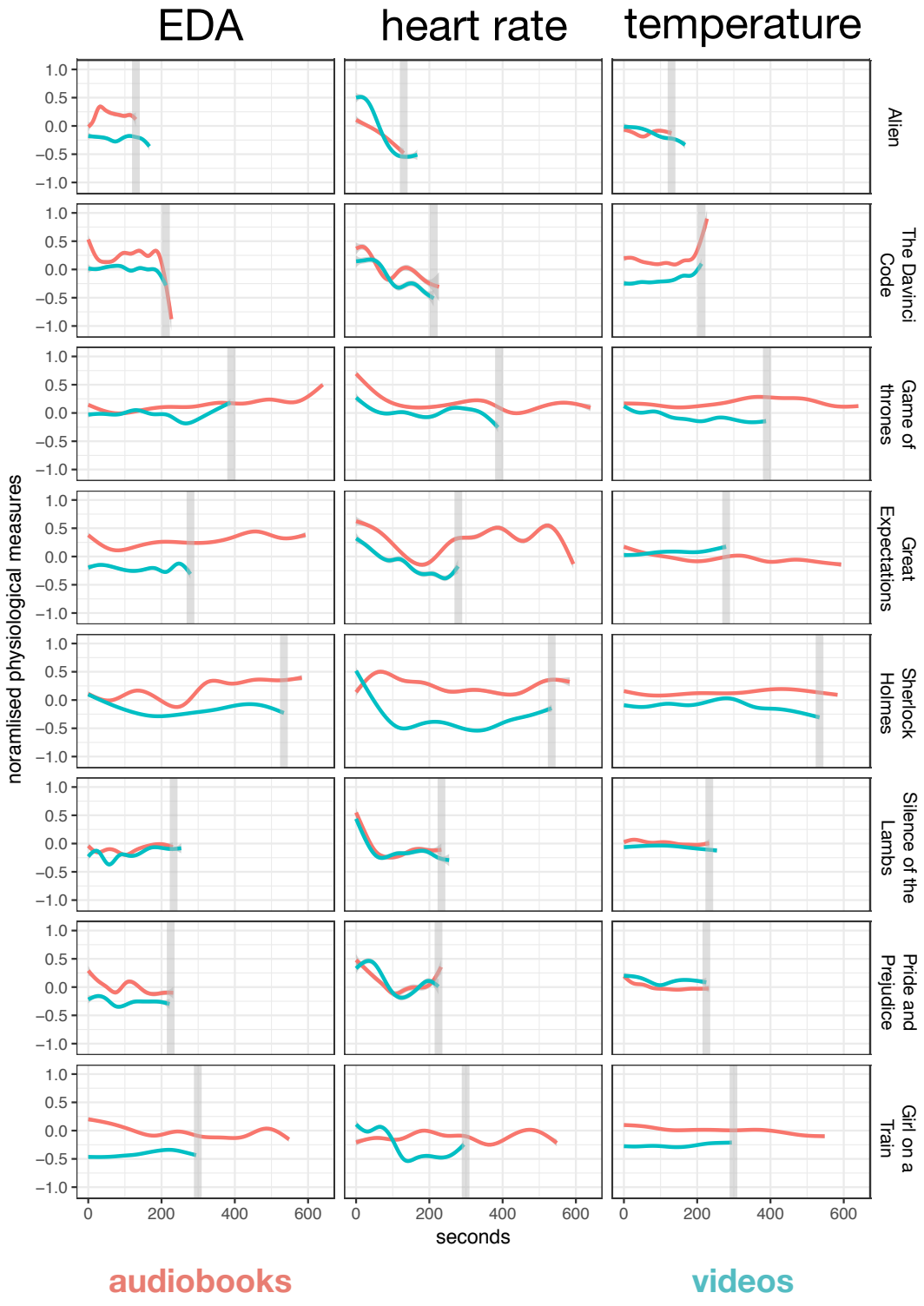
Measuring Narrative Engagement: The Heart Tells the Story

Supplementary Information



SI Figure 1. Timecourse of physiological measures for each story. Grey lines show the point stories were truncated to be equal length, in secondary analysis

Analyses

We employed Bayesian Mixed Models for our analyses. In the main text, we report the probabilities that the model parameter for modality is non-zero, and the odds that modality influenced our measures. This information was dervived by fitting, for each dependent variable, a Markov Chain Monte Carlo model. Weakly informative priors from the Gaussian family were used that were scaled by the rstanarm package. We used random effects for the participant, the story and the trial number, and fixed effects for the modality, the modality order and the stimulus order, specified as:

Dependent variable ~ modality + modality order + stimulus order +
(1 | participant) + (1 | story) + (1 | trial number)

In the tables below, we report information on the priors and detailed statistics for each models' parameters, including the 95% credibility intervals that are depicted in figures 2 and 3.

We also report the results of 2 (modality) x2 (modality order) x2 (stimulus order) ANOVAs for readers who prefer frequentist analyses.

Analyses were run in R (v3.4.3) using the packages afex, rstanarm and psycho.

Makowski, D. (2017). Efficient and Publishing-Oriented Workflow for Psychological Science with the R Package 'psycho'. Available from https://github.com/neuropsychology/psycho.R

R Core Team (2017). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Singmann, H., Bolker, B., Westfall, J., & Aust, F. (2018). afex: Analysis of Factorial Experiments. R package version 0.19-1. https://CRAN.R-project.org/package=afex

Stan Development Team (2016). rstanarm: Bayesian applied regression modeling via Stan. R package version 2.13.1. http://mc-stan.org/.

Engagement Ratings
Attention

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 46.32

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [11.58,11.58,11.58]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 4.63 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	100	12.47	0.63	12.47	0.64	11.15	13.67
modality	100	3.53	0.22	3.53	0.22	3.09	3.95
modality order	99.18	-1.29	0.55	-1.29	0.55	-2.32	-0.18
stimuli order	92.45	0.78	0.55	0.79	0.55	-0.26	1.89

Anova table:

Effect	df	MSE	F	p
stim_order	1,98	6.41	0.74	0.39
mod_order	1,98	6.41	2.33	0.13
stim_order:mod_order	1,98	6.41	0.08	0.78
modality	1,98	2.24	2.99	0.09
stim_order:modality	1,98	2.24	0.13	0.72
mod_order:modality	1,98	2.24	1.08	0.3
stim_order:mod_order:modality	1,98	2.24	6.89	0.01

Character

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 28.56

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [7.14,7.14,7.14]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 2.86 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	100	11.34	0.38	11.35	0.39	10.58	12.1
modality	98.15	0.34	0.15	0.34	0.16	0.01	0.66
modality order	92.13	-0.48	0.34	-0.48	0.35	-1.21	0.14
stimuli order	78.73	-0.26	0.33	-0.26	0.34	-0.89	0.44

Anova table:

Effect	df	MSE	F	p
stim_order	1,98	15.69	3.7	0.06
mod_order	1,98	15.69	6.33	0.01
stim_order:mod_order	1,98	15.69	0.09	0.76
modality	1,98	6.13	107.07	<.0001
stim_order:modality	1,98	6.13	0.02	0.9
mod_order:modality	1,98	6.13	0.07	0.79
stim_order:mod_order:modality	1,98	6.13	0	0.96

Narrative

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 43.19

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [10.80,10.80,10.80]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 4.32 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	100	14.03	0.58	14.03	0.59	12.82	15.13
modality	100	1.67	0.22	1.67	0.22	1.23	2.11
modality order	95.38	-0.93	0.56	-0.94	0.56	-1.99	0.16
stimuli order	96.8	1.06	0.57	1.05	0.56	-0.1	2.11

Anova table:

Effect	df	MSE	F	p
stim_order	1,98	15.5	6.42	0.01
mod_order	1,98	15.5	3.45	0.07
stim_order:mod_order	1,98	15.5	0.57	0.45
modality	1,98	5.14	28.94	<.0001
stim_order:modality	1,98	5.14	0.04	0.83
mod_order:modality	1,98	5.14	0.02	0.88
stim_order:mod_order:modality	1,98	5.14	0.12	0.73

Presence

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 41.96

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [10.49,10.49,10.49]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 4.20 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	100	12.32	0.59	12.32	0.58	11.14	13.42
modality	100	1.88	0.19	1.88	0.19	1.51	2.26
modality order	88.45	-0.73	0.6	-0.72	0.6	-1.89	0.44
stimuli order	66.05	-0.24	0.6	-0.24	0.6	-1.41	0.94

Anova table:

Effect	df	MSE	F	p
stim_order	1,98	18.84	0.03	0.87
mod_order	1,98	18.84	1.4	0.24
stim_order:mod_order	1,98	18.84	1.51	0.22
modality	1,98	4.89	39.17	<.0001
stim_order:modality	1,98	4.89	0.58	0.45
mod_order:modality	1,98	4.89	4.29	0.04
stim_order:mod_order:modality	1,98	4.89	1.12	0.29

Physiological Measures
Heart Rate

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 6.73

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [1.68,1.68,1.68]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 0.67 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	79.08	0.06	0.07	0.05	0.07	-0.09	0.2
modality	100	-0.17	0.05	-0.17	0.05	-0.27	-0.08
modality order	56	-0.01	0.05	-0.01	0.05	-0.1	0.09
stimuli order	75.05	0.03	0.05	0.03	0.05	-0.06	0.12

Anova table:

Effect	df	MSE	F	p
stim_order	1,91	0.02	0.02	0.9
mod_order	1,91	0.02	1.74	0.19
stim_order:mod_order	1,91	0.02	0.12	0.73
modality	1,91	0.2	9.16	0.003
stim_order:modality	1,91	0.2	1.85	0.18
mod_order:modality	1,91	0.2	13.87	0.0003
stim_order:mod_order:modality	1,91	0.2	0.87	0.35

Heart Rate Standard Deviation

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 3.78

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [0.95,0.95,0.95]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 0.38 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	100	0.66	0.04	0.66	0.04	0.58	0.75
modality	99.95	-0.08	0.03	-0.08	0.03	-0.13	-0.03
modality order	99.73	0.08	0.03	0.08	0.03	0.02	0.13
stimuli order	55.78	0	0.03	0	0.03	-0.06	0.05

Anova table:

Effect	df	MSE	F	p
stim_order	1,91	0.03	0.11	0.74
mod_order	1,91	0.03	5.75	0.02
stim_order:mod_order	1,91	0.03	0.21	0.65
modality	1,91	0.04	7.7	0.007
stim_order:modality	1,91	0.04	0.63	0.43
mod_order:modality	1,91	0.04	8.19	0.005
stim_order:mod_order:modality	1,91	0.04	4.78	0.03

EDA

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 8.86

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [2.21,2.21,2.21]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 0.89 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	80.03	0.12	0.15	0.13	0.15	-0.17	0.43
modality	100	-0.27	0.07	-0.27	0.07	-0.41	-0.12
modality order	68.55	-0.03	0.07	-0.03	0.07	-0.19	0.09
stimuli order	62.85	-0.02	0.08	-0.02	0.08	-0.17	0.13

Anova table:

Effect	df	MSE	F	p
stim_order	1,55	0.04	0.35	0.55
mod_order	1,55	0.04	0.89	0.35
stim_order:mod_order	1,55	0.04	0.06	0.81
modality	1,55	0.51	4.49	0.04
stim_order:modality	1,55	0.51	0.17	0.68
mod_order:modality	1,55	0.51	18.75	<.0001
stim_order:mod_order:modality	1,55	0.51	0.67	0.42

Temperature

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 9.48

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [2.37,2.37,2.37]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 0.95 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	58.3	0.03	0.16	0.03	0.18	-0.38	0.34
modality	99.2	-0.17	0.07	-0.17	0.07	-0.3	-0.03
modality order	88.28	0.09	0.07	0.09	0.07	-0.06	0.23
stimuli order	64.63	-0.03	0.07	-0.03	0.07	-0.17	0.11

Anova table:

Effect	df	MSE	F	p
stim_order	1,72	0.05	0.55	0.46
mod_order	1,72	0.05	6.99	0.01
stim_order:mod_order	1,72	0.05	0.51	0.48
modality	1,72	0.74	1.87	0.18
stim_order:modality	1,72	0.74	0.00	0.95
mod_order:modality	1,72	0.74	13.01	0.0006
stim_order:mod_order:modality	1,72	0.74	0.02	0.9

Acceleration

Priors:

```
Intercept (after predictors centered)
 ~ normal(location = 0, scale = 10)
     **adjusted scale = 3.20

Coefficients
 ~ normal(location = [0,0,0], scale = [2.5,2.5,2.5])
     **adjusted scale = [0.80,0.80,0.80]

Auxiliary (sigma)
 ~ exponential(rate = 1)
     **adjusted scale = 0.32 (adjusted rate = 1/adjusted scale)

Covariance
 ~ decov(reg. = 1, conc. = 1, shape = 1, scale = 1)
```

Estimates of model parameters:

Variable	MPE	Median	MAD	Mean	SD	CI low	CI high
Intercept	54.7	0	0.03	0	0.03	-0.05	0.05
modality	76.2	-0.02	0.02	-0.02	0.02	-0.06	0.03
modality order	55.68	0	0.02	0	0.02	-0.05	0.04
stimuli order	80.53	0.02	0.02	0.02	0.02	-0.02	0.06

Anova table:

Effect	df	MSE	F	p
stim_order	1,91	0.01	1.07	0.3
mod_order	1,91	0.01	0.03	0.87
stim_order:mod_order	1,91	0.01	2.19	0.14
modality	1,91	0.05	0.29	0.59
stim_order:modality	1,91	0.05	0.22	0.64
mod_order:modality	1,91	0.05	0	0.96
stim_order:mod_order:modality	1,91	0.05	0.04	0.85