

Deictic Gestures Modulate Attentional Shifts and Cognitive Load in Simultaneous Interpreting

Dongpeng Pan^{1*}, Kilian G. Seeber¹

¹Faculty of Translation and Interpreting, University of Geneva, Geneva, Switzerland

*Corresponding author: Dongpeng.Pan@unige.ch

1. Stimulus List and Condition Assignment

Table S1. Complete Stimulus List

No.	Critical Sentence	Object A	Object B	Filler Sentence
1	In science fiction novels, robots predict future [markets/weather patterns].	markets	weather patterns	There are 5 novels in the new series.
2	At the laboratory, scientists experiment with unique [flies/rats].	flies	rats	There are 7 laboratories at the secret facility.
3	At the office, the man reads an interesting [book/report].	book	report	There are 10 offices in the tall building.
4	In the desert, the explorer sees a large [camel/cactus].	camel	cactus	There are 2 deserts on the vast continent.
5	At the resort, the children climb on a steep [hill/staircase].	hill	staircase	There are 3 resorts on the tropical island.
6	On the island, the man saves a little [girl/bird].	girl	bird	There are 2 islands in the remote region.
7	In the kitchen, the chef cooks delicious [potatoes/chicken].	potatoes	chicken	There are 6 kitchens in the famous restaurant.
8	At the pastry shop, the woman bakes a wonderful [roll/cookie].	roll	cookie	There are 3 pastry shops in the narrow street.
9	In the book, knights defeat the evil [king/dragon].	king	dragon	There are 4 books in the popular series.
10	At the summit, the minister visits a local [school/restaurant].	school	restaurant	There are 2 summits at the modern conference center.
11	In the front yard, the boy repairs the broken [lawnmower/bike].	lawnmower	bike	There are 3 yards around the stately home.

12	At the breakfast table, the girl smells the fresh [coffee/croissant].	coffee	croissant	There are 10 breakfast tables in the dining hall.
13	In the suburb, the restaurant serves the best [ribs/waffles].	ribs	waffles	There are 5 suburbs in the metropolitan area.
14	At the camp, the woman packs a heavy [tent/sleeping bag].	tent	sleeping bag	There are 4 camps in the national park.
15	In the orchard, the girl picks a ripe [apple/cherry].	apple	cherry	There are 7 orchards on the vast estate.
16	In the dining room, the little boy breaks an expensive [bowl/vase].	bowl	vase	There are 3 dining rooms in the luxurious mansion.
17	At the inauguration, the artist unveils an enormous [statue/painting].	statue	painting	There are 2 inaugurations at the annual event.
18	At the zoo, the ranger catches the mischievous [monkey/otter].	monkey	otter	There are 3 zoos in the big city.
19	On the stairs, the girl loses her beautiful [earrings/necklace].	earrings	necklace	There are 5 stairs in the tall building.
20	At the club, the owner plans the clandestine [meeting/game].	meeting	game	There are 8 clubs in the redlight district.
21	In the story, the dragon destroys the ancient [castle/church].	castle	church	There are 4 stories in the medieval saga.
22	By the river, the man abandons his loyal [dog/horse].	dog	horse	There are 2 rivers in the wide valley.
23	In the bedroom, the boy throws away his ugly [sweater/sandals].	sweater	sandals	There are 3 bedrooms in the cozy house.
24	In the shopping mall, the man buys a comfortable [chair/bed].	chair	bed	There are 3 shopping malls in the urban area.
25	At the street market, the collector finds a rare [coin/record].	coin	record	There are 4 street markets in the bustling city.
26	In the garden, the boy examines an injured [bunny/cat].	bunny	cat	There are 7 gardens in the peaceful neighborhood.

27	In his dream, the boy kills a scary [dinosaur/lion].	dinosaur	lion	There are 2 dreams in the boy's restless night.
28	In the town centre, the couple opens a fantastic [bar/shop].	bar	shop	There are 2 town centres in the unique city.
29	In the concert hall, the musician tunes an old [piano/harp].	piano	harp	There are 3 concert halls in the populous area.
30	At the party, the girl meets a handsome [doctor/judge].	doctor	judge	There are 4 parties in the official calendar.
P1	In the field, the girl plants a beautiful [tree/flower].	tree	flower	There are 2 fields in the remote countryside.
P2	For lunch, the man eats a whole [sandwich/steak].	sandwich	steak	There are 5 lunches in the weekly meal plan.

Note. Items 1–30: experimental trials; P1–P2: practice trials. Each item appeared in three gestural conditions: congruent (point to target), incongruent (point to competitor), and neutral (no gesture). Object position (top/bottom) was counterbalanced. Condition assignment followed a Latin square design across three experimental lists, with 10 items per condition per participant.

2. Condition Comparison Analysis

This section provides supplementary materials for the fixation analysis comparing target fixation probabilities across gestural conditions (congruent, incongruent, neutral). All models were fitted using binomial generalised additive mixed models (GAMMs) with a logit link function, estimated via fast restricted maximum likelihood (fREML) using `mgcv::bam()` in R. The reference level for condition is congruent. Full parametric and smooth term results are reported in the main text.

The model formula applied to each analytical window was:

Target ~ Condition + Lagged Target Fixation + s(Time, by = Lagged Target Fixation) + s(Time, by = Lagged Distance to Target) + s(Time, by = Lagged Distance to Competitor) + s(Time) + s(Trial) + ti(Trial, Time) + s(Participant, bs = "re") + s(Item, bs = "re") + s(Time, by = Condition)

S2.1 Plots of fitted smooth functions

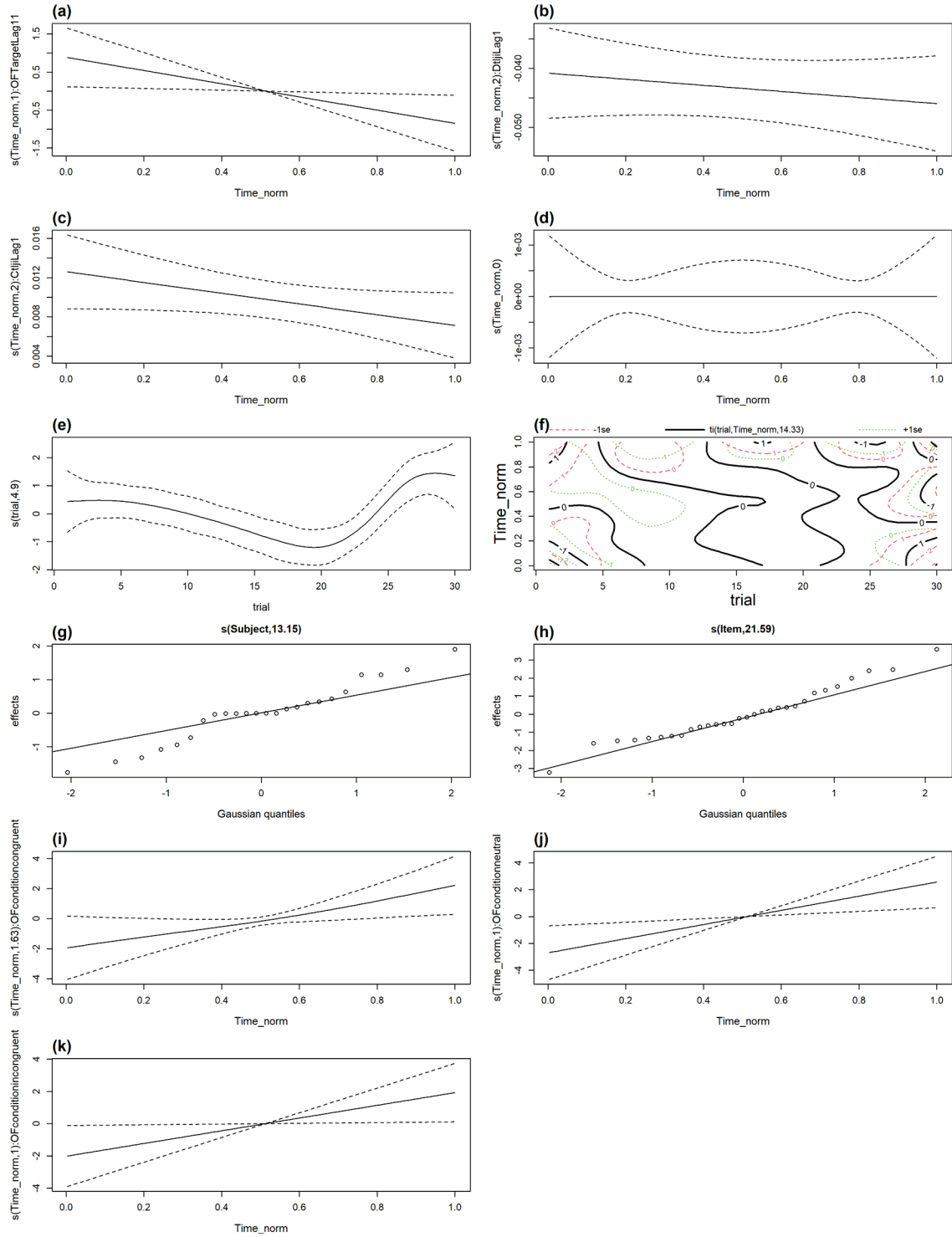


Figure S1. Fitted smooth functions of the condition comparison GAMM in the Modifier window: (a) $s(\text{Time})$:Prior Target Fixation, (b) $s(\text{Time})$:Lagged Distance to Target, (c) $s(\text{Time})$:Lagged Distance to Competitor, (d) $s(\text{Time})$ overall trend, (e) $s(\text{Trial})$, (f) $ti(\text{Trial}, \text{Time})$, (g) $s(\text{Participant})$, (h) $s(\text{Item})$, (i) $s(\text{Time})$:Condition[Congruent], (j) $s(\text{Time})$:Condition[Neutral], (k) $s(\text{Time})$:Condition[Incongruent]. Shaded regions represent 95% confidence intervals. The neutral (j) and incongruent (k) conditions show

significant time-varying effects (edf = 1.00, $\chi^2 = 7.22$, $p = .007$ and edf = 1.00, $\chi^2 = 4.51$, $p = .034$, respectively); the congruent condition (i) is marginally significant (edf = 1.63, $\chi^2 = 5.36$, $p = .062$).

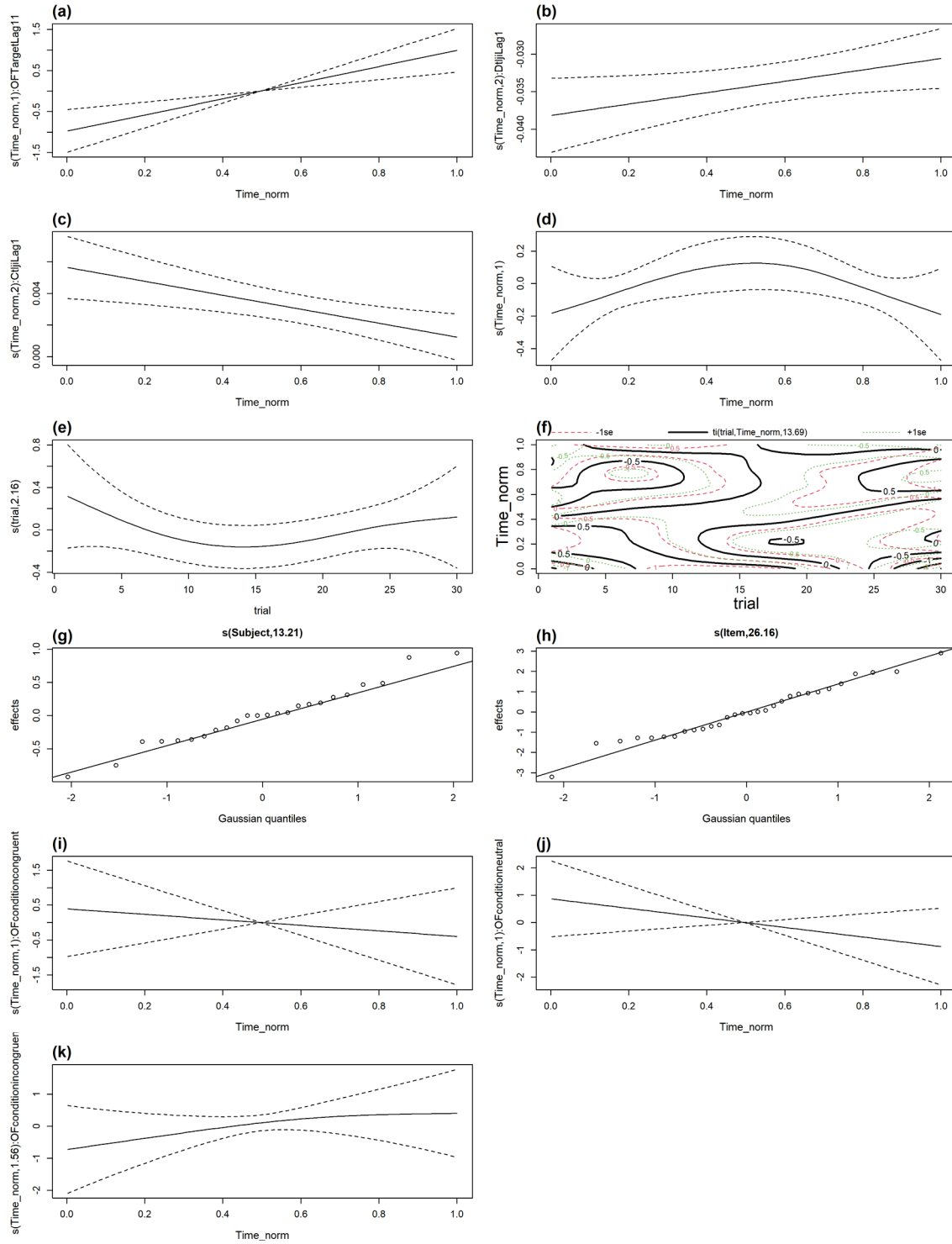


Figure S2. Fitted smooth functions of the condition comparison GAMM in the Object window. Layout as in Figure S1. None of the condition-specific smooth terms reach significance.

S2.2 Model Diagnostics and ACF Plots

Each figure presents a combined five-panel display: (a) Q-Q plot of deviance residuals, (b) residuals versus linear predictor, (c) histogram of residuals, (d) response versus fitted values, and (e) autocorrelation function (ACF) of model residuals. The 2×2 diagnostic panels (a–d) appear on the left, with the ACF panel (e) on the right spanning both rows.

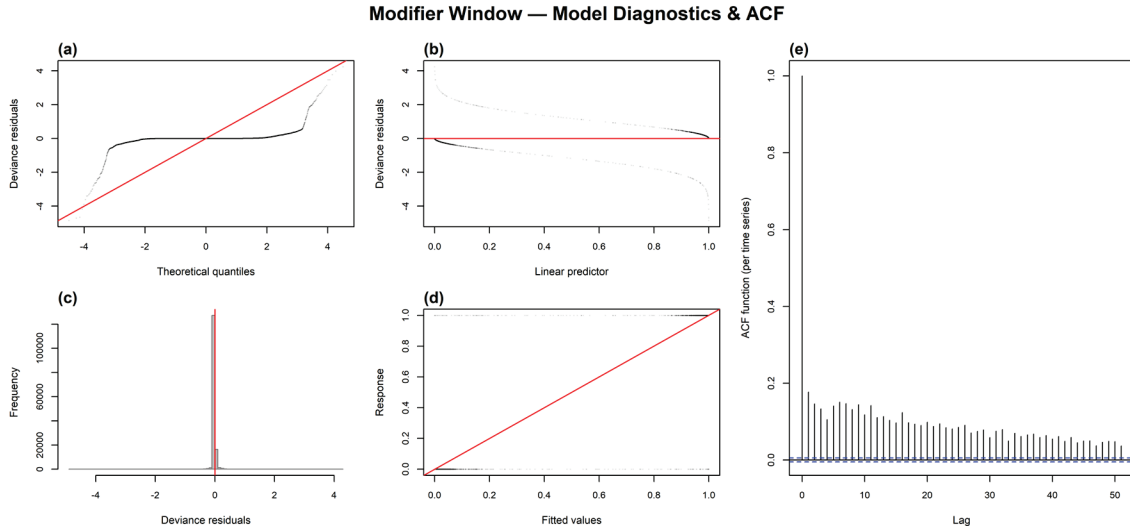


Figure S4. Model diagnostics and ACF for the condition comparison GAMM (Modifier window): (a) Q-Q plot of deviance residuals, (b) residuals vs. linear predictor, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals confirming negligible temporal autocorrelation after incorporating lag-1 predictors.

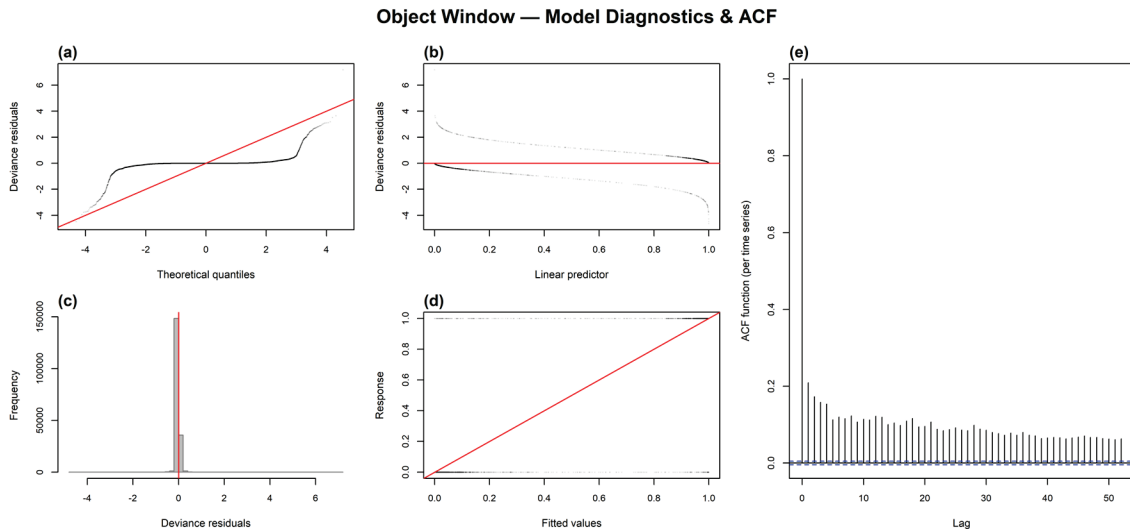


Figure S5. Model diagnostics and ACF for the condition comparison GAMM (Object window). Layout as in Figure S4.

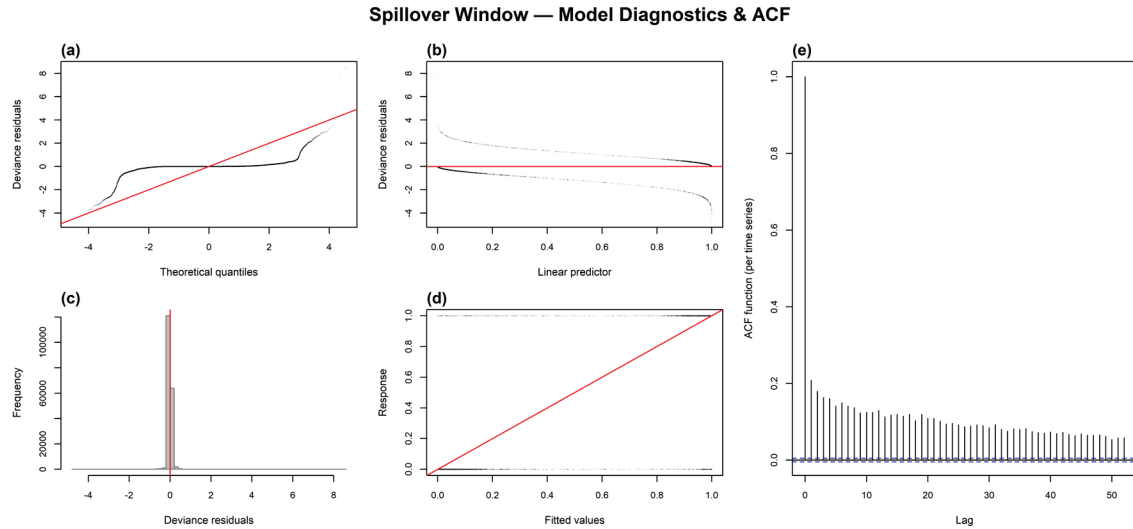


Figure S6. Model diagnostics and ACF for the condition comparison GAMM (Spillover window). Layout as in Figure S4.

S3. AOI Comparison Analysis

This section provides model specifications, full GAMM results, and diagnostic plots for all nine target–competitor divergence models (3 windows $\times$ 3 conditions). These models follow the framework outlined by Stone et al. (2021) for deriving divergence points in Visual World Paradigm research.

S3.1 Model Specifications

All AOI comparison models share the following formula:

$$\text{Value} \sim (\text{Intercept}) + \text{ValueLag1} + s(\text{Time}):\text{ValueLag1} + s(\text{Time}):\text{RegionBin} + s(\text{Time}) + s(\text{PartItem}, \text{bs} = \text{"re"}) + s(\text{RegionBin}, \text{PartItem}, \text{bs} = \text{"re"})$$

Model components:

- Value: binary outcome (1 = target fixation, 0 = competitor fixation)
- ValueLag1: lag-1 fixation value within participant–item–region groups
- RegionBin: binary indicator for target (1) vs. competitor (0)
- PartItem: participant–item interaction factor
- Estimation: binomial family with logit link; `mgecv::bam()`
- Divergence derived via `itsadug::plot_diff()`

S3.2 Full GAMM Results

Each table reports both the parametric coefficients and the approximate significance of smooth terms for a single model. Divergence intervals indicate the normalised time range where the 95% confidence interval of the target–competitor difference (estimated via `itsadug::plot_diff()`) excludes zero. Note: ValueLag1 shows NaN when the parametric term is undefined due to perfect prediction by the smooth.

Modifier Window

Table S2. Full GAMM results for the Modifier window, Congruent condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)

(Intercept)	−8.8170	0.3228	−27.31	< 2e-16 ***
ValueLag1	0.0000	0.0000	NaN	NaN
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	3.403	4.014	1990.675	< 2e-16 ***
s(Time):RegionBin	2.980	3.480	27.851	1.54e-05 ***
s(Time)	1.000	1.000	0.924	0.336
s(PartItem)	0.000	196.000	0.000	1.000
s(RegionBin, PartItem)	0.000	196.000	0.000	0.180

R-sq. (adj) = 0.996, Deviance explained = 98.9%, n = 81,088. Divergence: 0.034–0.849 (target > competitor)

Table S3. Full GAMM results for the Modifier window, Incongruent condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	−7.3095	0.2311	−31.64	< 2e-16 ***
ValueLag1	0.0000	0.0000	NaN	NaN
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	4.050	4.848	1052.230	< 2e-16 ***
s(Time):RegionBin	2.000	2.000	19.846	4.87e-05 ***
s(Time)	1.000	1.000	1.065	0.302
s(PartItem)	0.000	194.000	0.000	0.990
s(RegionBin, PartItem)	29.343	194.000	79.310	< 2e-16 ***

R-sq. (adj) = 0.997, Deviance explained = 99.3%, n = 80,978. Divergence: 0.004–0.950 (competitor > target)

Table S4. Full GAMM results for the Modifier window, Neutral condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	−9.0830	0.5784	−15.70	< 2e-16 ***
ValueLag1	17.4735	1.0694	16.34	< 2e-16 ***
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	2.180	2.722	10.550	0.015 *
s(Time):RegionBin	2.000	2.000	4.474	0.107
s(Time)	1.000	1.000	2.754	0.097 .
s(PartItem)	0.000	176.000	0.000	0.965
s(RegionBin, PartItem)	27.469	176.000	70.620	< 2e-16 ***

R-sq. (adj) = 0.998, Deviance explained = 99.7%, n = 76,718. Divergence: 0.708–0.970 (competitor > target; non-significant smooth for RegionBin)

Object Window

Table S5. Full GAMM results for the Object window, Congruent condition.

<i>Parametric coefficients</i>				
--------------------------------	--	--	--	--

Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-7.989	0.242	-33.02	< 2e-16 ***
ValueLag1	0.000	0.000	NaN	NaN
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	2.000	2.000	2423.183	< 2e-16 ***
s(Time):RegionBin	3.097	3.591	38.719	< 2e-16 ***
s(Time)	1.070	1.123	8.572	0.005 **
s(PartItem)	0.000	198.000	0.000	0.996
s(RegionBin, PartItem)	91.269	198.000	161.153	< 2e-16 ***

R-sq.(adj) = 0.995, Deviance explained = 99.0%, n = 99,012. Divergence: 0.164–1.000 (target > competitor)

Table S6. Full GAMM results for the Object window, Incongruent condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-7.2675	0.1992	-36.49	< 2e-16 ***
ValueLag1	0.0000	0.0000	NaN	NaN
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	2.000	2.000	2902.543	< 2e-16 ***
s(Time):RegionBin	2.459	2.773	28.500	1.39e-05 ***
s(Time)	1.000	1.000	0.068	0.794
s(PartItem)	0.000	198.000	0.000	1.000
s(RegionBin, PartItem)	76.113	198.000	116.834	5.51e-06 ***

R-sq.(adj) = 0.994, Deviance explained = 98.7%, n = 102,094. Divergence: 0.003–0.335 (competitor > target), 0.627–1.000 (target > competitor)

Table S7. Full GAMM results for the Object window, Neutral condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-8.2269	0.2811	-29.27	< 2e-16 ***
ValueLag1	0.0000	0.0000	NaN	NaN
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	2.000	2.000	1806.833	< 2e-16 ***
s(Time):RegionBin	2.000	2.000	7.119	0.028 *
s(Time)	1.000	1.000	2.638	0.104
s(PartItem)	0.000	185.000	0.000	1.000
s(RegionBin, PartItem)	46.515	185.000	66.134	4.02e-04 ***

R-sq.(adj) = 0.996, Deviance explained = 99.0%, n = 95,884. Divergence: 0.486–1.000 (target > competitor)

Spillover Window

Table S8. Full GAMM results for the Spillover window, Congruent condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	−8.3003	0.2506	−33.12	< 2e-16 ***
ValueLag1	0.0000	0.0000	NaN	NaN
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	2.000	2.000	2757.741	< 2e-16 ***
s(Time):RegionBin	2.000	2.000	24.189	4.9e-06 ***
s(Time)	1.000	1.000	4.275	0.039 *
s(PartItem)	0.000	196.000	0.000	0.998
s(RegionBin, PartItem)	55.060	196.000	77.381	3.47e-04 ***

R-sq. (adj) = 0.996, Deviance explained = 99.1%, n = 100,952. Divergence: 0.003–0.930 (target > competitor throughout)

Table S9. Full GAMM results for the Spillover window, Incongruent condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	−8.4782	0.2564	−33.06	< 2e-16 ***
ValueLag1	13.6874	0.2640	51.84	< 2e-16 ***
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	0.999	1.000	3.291	0.070 .
s(Time):RegionBin	1.999	2.000	56.678	< 2e-16 ***
s(Time)	1.000	1.000	0.934	0.334
s(PartItem)	0.000	197.000	0.000	1.000
s(RegionBin, PartItem)	0.000	197.000	0.000	0.513

R-sq. (adj) = 0.995, Deviance explained = 98.8%, n = 100,924. Divergence: 0.003–1.000 (target > competitor throughout)

Table S10. Full GAMM results for the Spillover window, Neutral condition.

<i>Parametric coefficients</i>				
Term	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	−8.2849	0.2658	−31.17	< 2e-16 ***
ValueLag1	14.1435	0.3778	37.44	< 2e-16 ***
<i>Approximate significance of smooth terms</i>				
Smooth Term	edf	Ref.df	χ^2	p-value
s(Time):ValueLag1	2.874	3.604	12.426	0.013 *
s(Time):RegionBin	3.745	4.428	23.319	2.69e-04 ***
s(Time)	1.000	1.000	0.781	0.377
s(PartItem)	0.000	189.000	0.000	0.999
s(RegionBin, PartItem)	49.137	189.000	67.711	8.48e-04 ***

R-sq. (adj) = 0.997, Deviance explained = 99.2%, n = 97,930. Divergence: 0.164–0.738 (target > competitor)

S3.3 Model Diagnostics and ACF Plots

Each figure presents a combined five-panel display: (a) Q-Q plot of deviance residuals, (b) residuals versus fitted values, (c) histogram of residuals, (d) response versus fitted values, and (e) autocorrelation function (ACF) of model residuals. The 2×2 diagnostic panels (a–d) appear on the left, with the ACF panel (e) on the right spanning both rows. K-index checks confirm adequate basis dimensions for all smooth terms.

Modifier Window

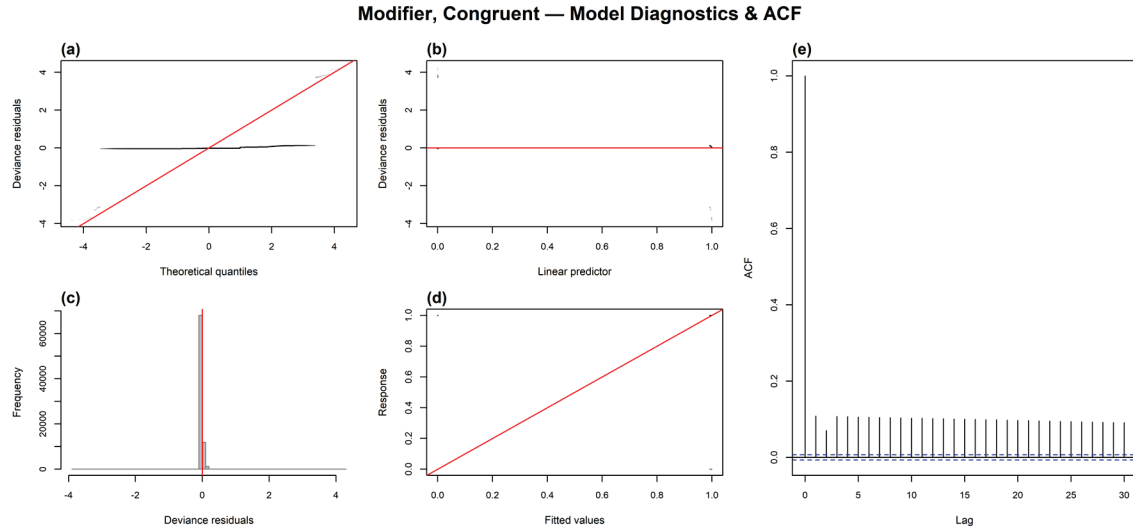


Figure S7. Model diagnostics and ACF for the AOI comparison GAMM, Modifier–Congruent condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

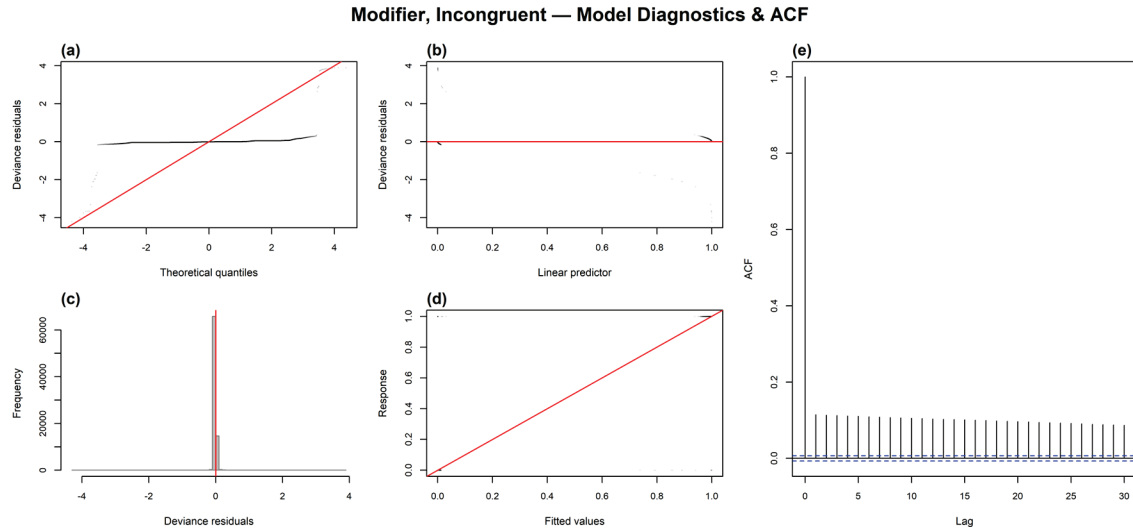


Figure S8. Model diagnostics and ACF for the AOI comparison GAMM, Modifier–Incongruent condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Modifier, Neutral — Model Diagnostics & ACF

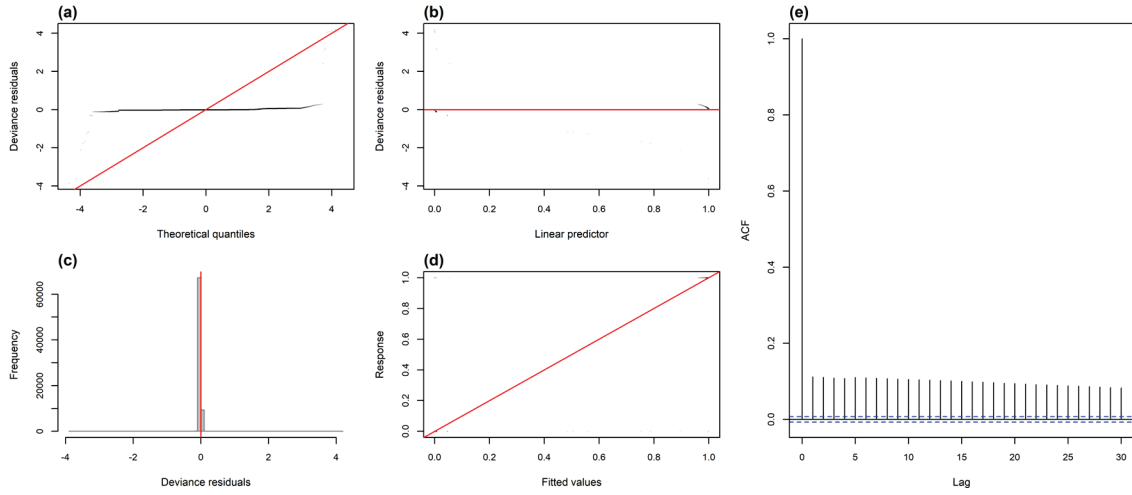


Figure S9. Model diagnostics and ACF for the AOI comparison GAMM, Modifier-Neutral condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Object Window

Object, Congruent — Model Diagnostics & ACF

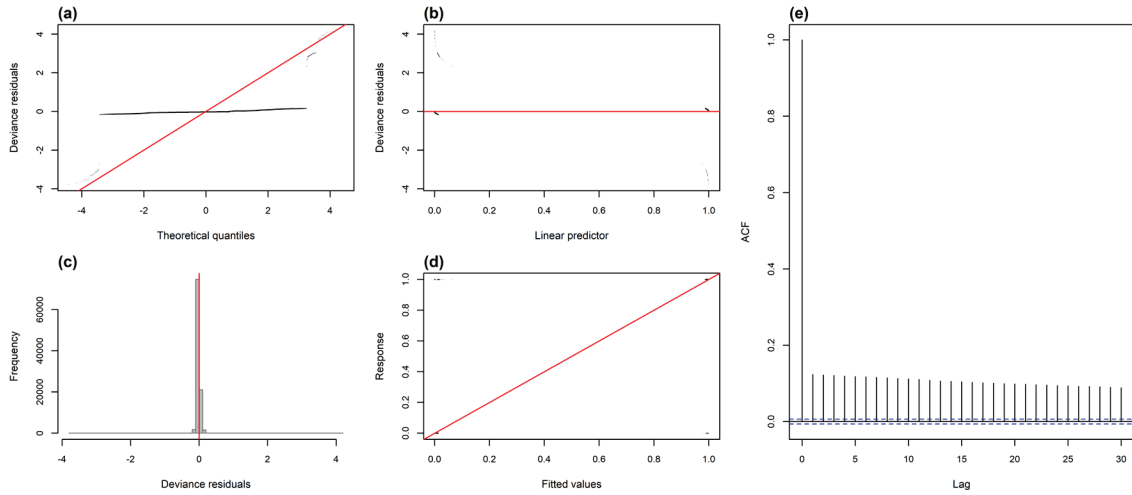


Figure S10. Model diagnostics and ACF for the AOI comparison GAMM, Object-Congruent condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Object, Incongruent — Model Diagnostics & ACF

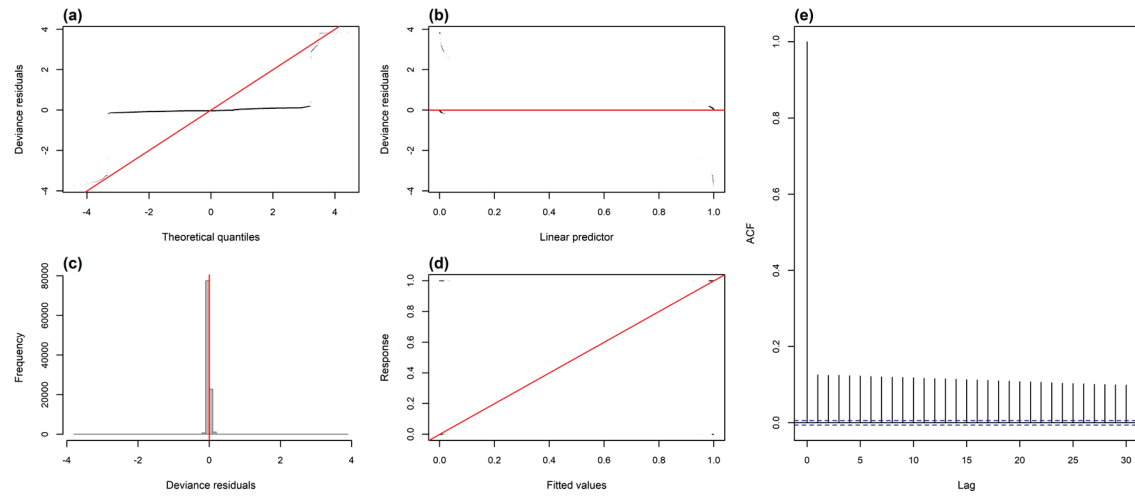


Figure S11. Model diagnostics and ACF for the AOI comparison GAMM, Object-Incongruent condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Object, Neutral — Model Diagnostics & ACF

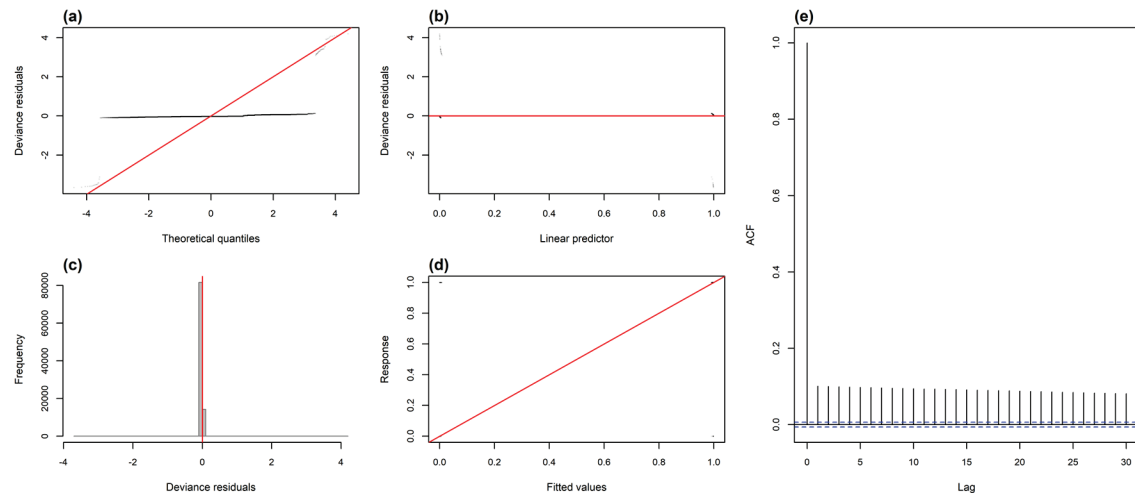


Figure S12. Model diagnostics and ACF for the AOI comparison GAMM, Object-Neutral condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Spillover Window

Spillover, Congruent — Model Diagnostics & ACF

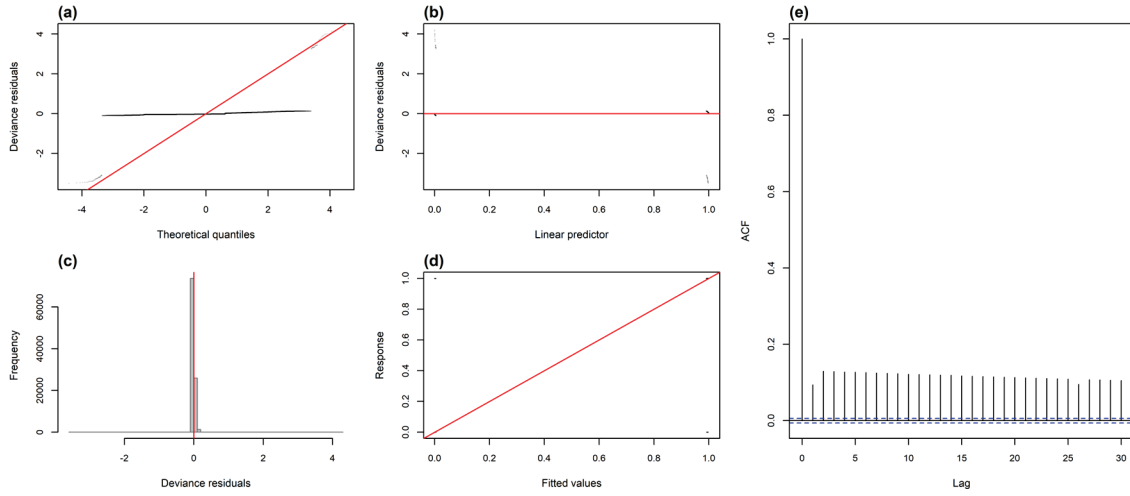


Figure S13. Model diagnostics and ACF for the AOI comparison GAMM, Spillover–Congruent condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Spillover, Incongruent — Model Diagnostics & ACF

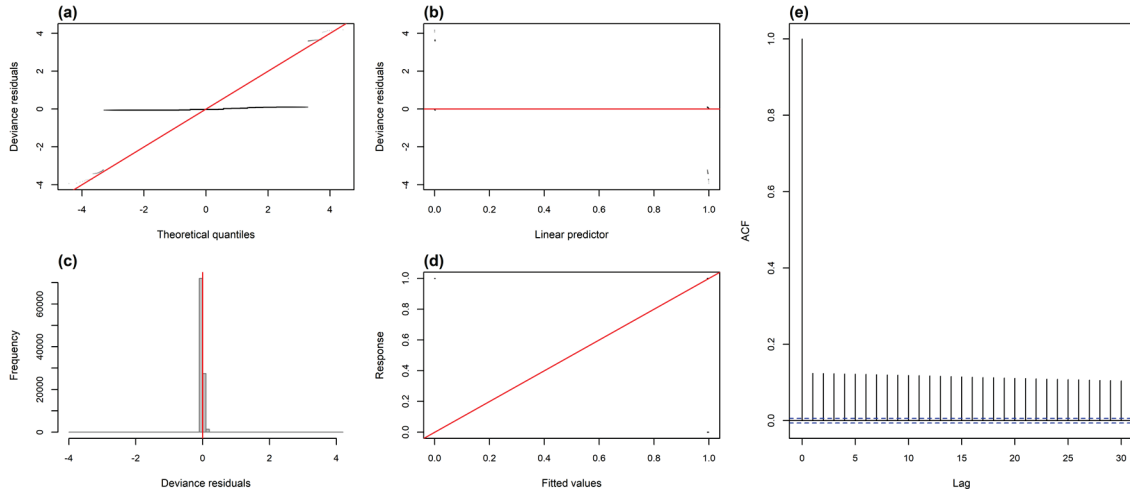


Figure S14. Model diagnostics and ACF for the AOI comparison GAMM, Spillover–Incongruent condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

Spillover, Neutral — Model Diagnostics & ACF

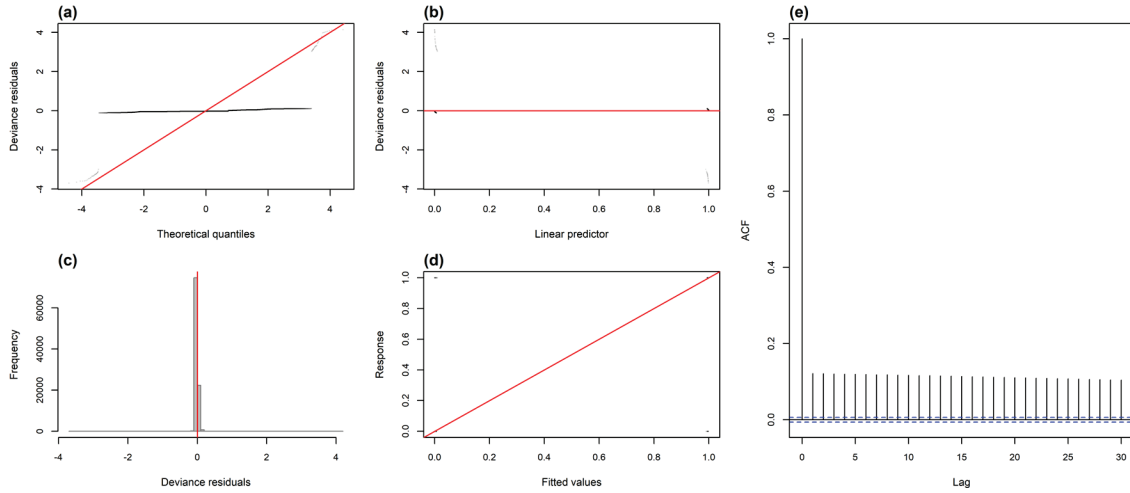


Figure S15. Model diagnostics and ACF for the AOI comparison GAMM, Spillover–Neutral condition: (a) Q-Q plot of deviance residuals, (b) residuals vs. fitted values, (c) histogram of residuals, (d) response vs. fitted values, (e) ACF of model residuals.

S4. Pupil Dilation Analysis

This section provides model specifications and diagnostic plots for the pupil dilation analysis across three analytical windows (Modifier, Object, Spillover). Full GAMM results, pairwise parametric contrasts, and smooth difference significance intervals are reported in the main text.

S4.1 Model Specifications

All pupil dilation models share the following formula:

Pupil ~ Condition + s(Time, by = Condition, k = 20) + s(Xgaze, Ygaze) + s(Time, Sub_Item, bs = “fs”, m = 1)

Model components:

- Pupil: baseline-corrected pupil size (arbitrary units)
- Condition: gestural condition factor (congruent [reference], incongruent, neutral)
- s(Time, by = Condition, k = 20): condition-specific temporal smooth with 20 basis functions
- s(Xgaze, Ygaze): bivariate smooth for gaze position
- s(Time, Sub_Item, bs = “fs”, m = 1): factor-smooth random effects for participant–item interactions
- Family: scaled t-distribution (scat) for robustness to outliers
- Estimation: mgcv::bam() with discrete = TRUE, nthreads = 32
- Temporal autocorrelation: AR1 error structure

AR1 autocorrelation parameters: $\rho_{\text{Modifier}} = 0.972$, $\rho_{\text{Object}} = 0.963$, $\rho_{\text{Spillover}} = 0.977$.

S4.2 Model Diagnostics and ACF Plots

Each figure presents a combined five-panel display: (a) residuals versus fitted values with LOESS smooth, (b) Q-Q plot of deviance residuals, (c) histogram of residuals, (d) residuals versus normalised time, and (e) autocorrelation function (ACF) of model residuals with AR1 ρ annotation. The 2×2 diagnostic panels (a–d) appear on the left, with the ACF panel (e) on the right spanning both rows. Models were fitted with a scaled t-distribution (scat) family.

Modifier Window — Pupil Model Diagnostics & ACF

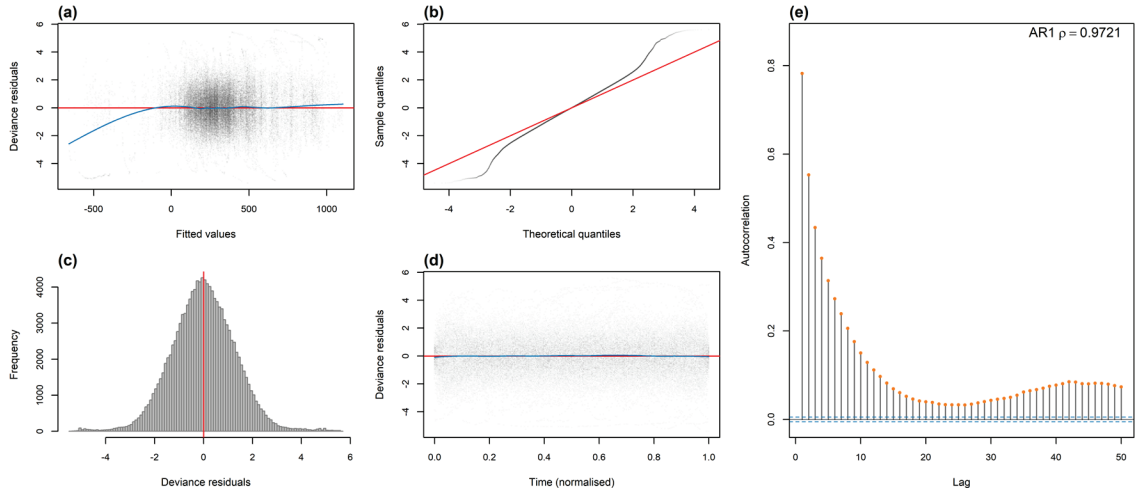


Figure S16. Model diagnostics and ACF for the pupil dilation GAMM (Modifier window, $AR1 \rho = 0.972$): (a) residuals vs. fitted values with LOESS smooth, (b) Q-Q plot of deviance residuals, (c) histogram of residuals, (d) residuals vs. normalised time, (e) ACF of model residuals. Dashed blue lines indicate 95% confidence bounds. Residual autocorrelation decays rapidly, confirming adequate temporal correction.

Object Window — Pupil Model Diagnostics & ACF

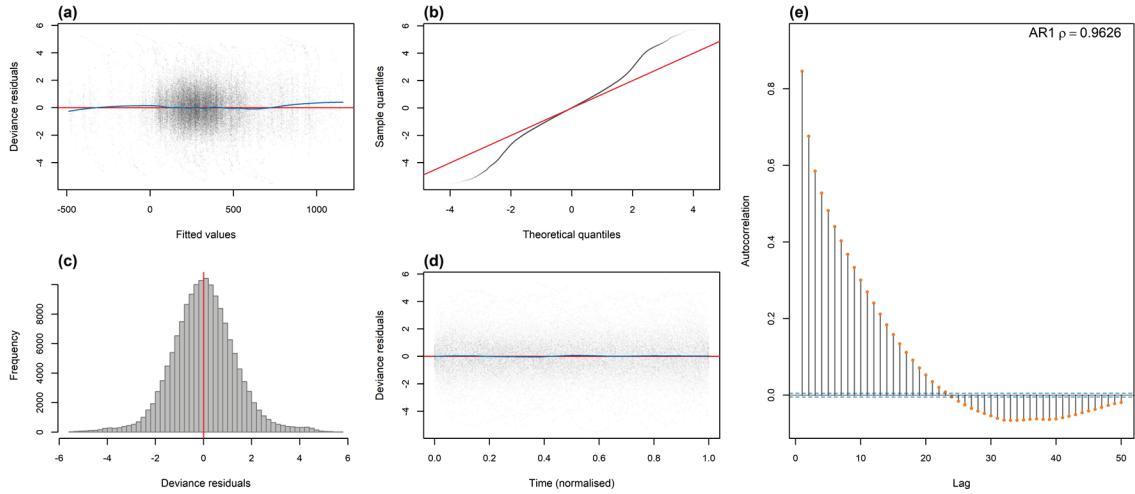


Figure S17. Model diagnostics and ACF for the pupil dilation GAMM (Object window, $AR1 \rho = 0.963$): (a) residuals vs. fitted values with LOESS smooth, (b) Q-Q plot of deviance residuals, (c) histogram of residuals, (d) residuals vs. normalised time, (e) ACF of model residuals. Dashed blue lines indicate 95% confidence bounds. Residual autocorrelation decays rapidly, confirming adequate temporal correction.

Spillover Window — Pupil Model Diagnostics & ACF

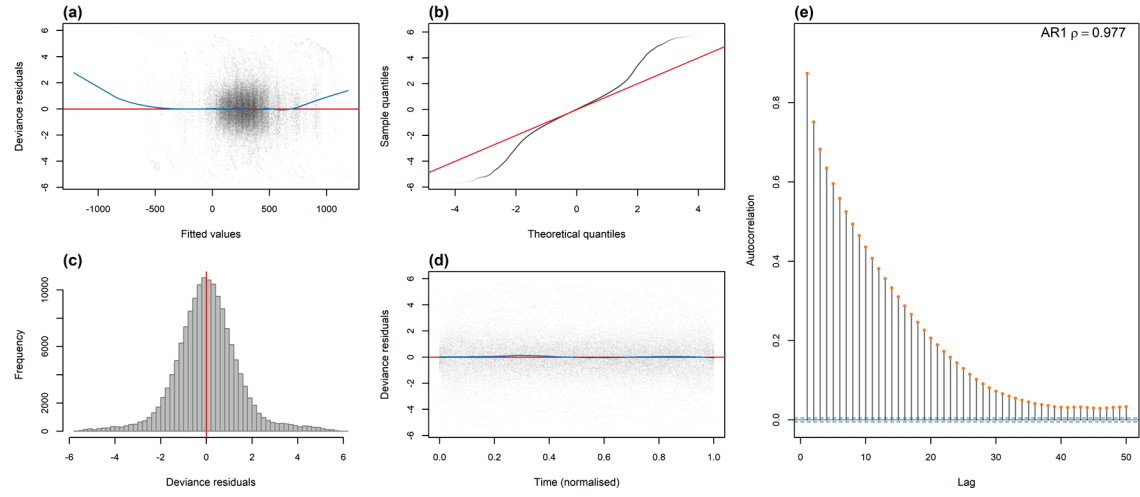


Figure S18. Model diagnostics and ACF for the pupil dilation GAMM (Spillover window, $AR1 \rho = 0.977$): (a) residuals vs. fitted values with LOESS smooth, (b) Q-Q plot of deviance residuals, (c) histogram of residuals, (d) residuals vs. normalised time, (e) ACF of model residuals. Dashed blue lines indicate 95% confidence bounds. Residual autocorrelation decays rapidly, confirming adequate temporal correction.