

Supplementary Materials

A. Acoustic and Articulatory Measurements of Perception Stimuli

This section includes the acoustic and articulatory measurements for all stimuli used in the study.

place order	position	stimID	word	PVR ¹	VRD ²	AcouLag ³	OnsLag ⁴	RelLag ⁵	Relative Overlap ⁶
front-to-back	initial	bge1	bgera	1	30.8	93.9	36	130	2.375
		bge2	bgera	1	32.1	95.3	34	130	1.800
		bge3	bgera	1	29.8	87.3	40	116	2.167
		bge4	bgera	0	NA	70.8	24	124	2.889
		bge5	bgera	0	NA	70.1	22	96	2.412
		dge6	dgeba	1	33.5	95.5	68	114	1.167
		dge7	dgeba	1	34.6	108.7	62	36	1.244
		dge8	dgeba	1	15.9	97.9	48	122	1.667
		dge9	dgeba	1	21.5	69.2	42	100	1.083
		dge10	dgeba	0	NA	90.3	48	108	0.875
		pti1	ptila	0	NA	85.2	120	202	-0.261
		pti2	ptila	0	NA	96.8	84	208	-1.429
		pti3	ptila	0	NA	89.6	94	160	-0.667
		pti4	ptila	0	NA	76.9	194	194	-7.750
		pti5	ptila	0	NA	78.2	86	136	-3.000
	medial	bga1	abga	1	35.8	67.0	14	96	4.857
		bga2	abga	1	37.7	68.2	38	74	3.600
		bga3	abga	1	39.3	76.2	48	96	2.000
		bga4	abga	1	38.6	87.3	70	98	1.000
		bga5	abga	1	38.1	57.6	10	62	4.625
		dge1	adgeba	1	35.9	99.2	84	-22	1.013
		dge2	adgeba	1	49.7	80.9	30	82	5.857
		dge3	adgeba	1	23.2	84.1	80	92	0.857
		dge4	adgeba	1	29.0	84.2	76	90	1.231
		dge5	adgeba	1	38.4	75.3	80	-44	1.129
pta1	aptari	0	NA	53.6	54	82	2.400		
pta2	aptari	0	NA	67.8	62	76	1.833		
pta3	aptari	0	NA	34.3	80	86	-0.333		
pta4	aptari	0	NA	59.2	66	90	0.500		
pta5	aptari	0	NA	37.3	16	74	4.500		

back-to-front	initial	gbe6	gberavs	1	39.9	132.8	132	102	-0.529
		gbe7	gberavs	1	59.4	117.5	96	74	0.500
		gbe8	gberavs	1	43.2	128.1	112	102	-0.700
		gbe9	gberavs	1	32.1	106.4	98	82	0.250
		gbe10	gberavs	1	33.9	104.2	100	74	0.286
		gde6	gdeba	1	36.7	116.9	140	232	-1.000
		gde7	gdeba	1	37.8	101.7	114	80	0.000
		gde8	gdeba	1	29.7	97.7	102	202	-0.667
		gde9	gdeba	1	29.0	96.2	124	88	-0.545
		gde10	gdeba	1	30.2	94.5	118	222	-1.444
		tbe1	tbeba	0	NA	109.6	64	88	-0.200
		tbe2	tbeba	0	NA	129.3	92	140	-1.333
		tbe3	tbeba	0	NA	131.7	80	128	-0.667
	medial	gbe1	dagbera	1	42.0	104.2	122	66	1.500
		gbe2	dagbera	1	55.4	113.1	116	74	1.333
		gbe3	dagbera	1	33.1	112.0	112	100	2.100
		gbe4	dagbera	1	44.4	104.4	108	58	1.818
		gbe5	dagbera	1	47.2	88.3	132	60	1.214
		gde1	agdeba	1	35.6	93.7	110	120	-0.444
		gde2	agdeba	1	19.0	88.9	118	104	-0.250
		gde3	agdeba	1	36.7	91.3	126	148	-0.833
		gde4	agdeba	1	57.0	83.0	158	92	-2.143
		gde5	agdeba	1	48.0	85.9	122	76	-0.750
		tba1	gatba	0	NA	103.3	70	50	1.091
		tba2	gatba	0	NA	104.6	66	34	1.000
		tba3	gatba	0	NA	118.9	72	34	1.118
tba4	gatba	0	NA	100.8	64	38	1.583		

¹ PVR: Presence of Vocalic Release -- 1 (present), 0 (absent)

² VRD: Vocalic Release Duration (msec)

³ AcouLag: Acoustic Lag (C2 release burst – C1 release burst, in msec)

⁴ OnsLag: Onset Lag (C2 gesture onset – C1 gesture onset, in msec)

⁵ RelLag: Release Lag (C2 release – C1 release, in msec)

⁶ Relative Overlap: $1 - (C2 \text{ gesture onset} - C1 \text{ achievement}) / (C1 \text{ release} - C1 \text{ achievement})$

B. Statistical Model Output

This section provides the full output from the generalized mixed-effects models reported in the manuscript. For each model, we include:

- a. Model formula
- b. Model fit statistics
- c. Fixed effect estimates with standard errors, t-values, and p-values
- d. Random effects
- e. Variance inflation factors (VIF) for all fixed effects included in the final models

Data available from the corresponding author upon request.

1. Acoustic Lag

- a. Model formula:

C1 identification ~ Acoustic lag + Place Order * C1 Voicing
+ (1 + Place Order + C1 Voicing |Subject) + (1 |Item)

- b. Model fit statistics

AIC	BIC	logLik	deviance	df.resid
3192.2	3264.3	-1584.1	3168.2	3003

- c. Fixed effects table

	Estimate	Std.Error	z value	Pr(> z)
(Intercept)	0.157	0.804	0.195	0.845
Acoustic Lag	0.025	0.006	3.912	< 0.001
Place_Order(FB)	-1.501	0.584	-2.571	0.010
C1 Voicing	-1.939	0.533	-3.637	< 0.001
Place Order (FB): C1 Voicing	1.457	0.541	2.695	0.007

- d. Random effects table

Groups	Name	Variance	Std.Dev.
item	(Intercept)	1.178	1.085
subject	(Intercept)	2.761	1.662
	Place_Order	2.108	1.452
	C1 Voicing	3.410	1.847

- e. VIF table

Predictors	Acoustic Lag	Place Order	C1 Voicing	Place Order: C1 Voicing
VIF	1.240	2.698	1.518	3.056

2. Onset Lag

a. Model formula:

$$\text{C1 identification} \sim \text{Onset lag} + \text{Place Order} * \text{C1 Voicing} \\ + (1 + \text{Place Order} + \text{Onset Lag} + \text{C1 Voicing} | \text{Subject}) + (1 | \text{Item})$$

b. Model fit statistics

AIC	BIC	logLik	deviance	df.resid
3106.3	3202.5	-1537.1	3074.3	2999

c. Fixed effects table

	Estimate	Std.Error	z value	Pr(> z)
(Intercept)	0.784	0.640	1.225	0.221
Onset Lag	0.027	0.007	3.967	< 0.001
Place_Order(FB)	-2.288	0.596	-3.836	< 0.001
C1 Voicing	-3.203	0.630	-5.084	< 0.001
Place Order (FB): C1 Voicing	3.620	0.672	5.386	< 0.001

d. Random effects table

Groups	Name	Variance	Std.Dev.
item	(Intercept)	1.171	1.082
subject	(Intercept)	4.940	2.223
	Place_Order	3.850	1.962
	Onset Lag	0.001	0.024
	C1 Voicing	4.519	2.126

e. VIF table

Predictors	Onset Lag	Place Order	C1 Voicing	Place Order: C1 Voicing
VIF	2.160	2.655	1.964	4.044

3. Release Lag

a. Model formula:

$$\text{C1 identification} \sim \text{Release lag} * \text{Place Order} + \text{Place Order} * \text{C1 Voicing} \\ + (1 + \text{Place Order} + \text{Release Lag} + \text{C1 Voicing} | \text{Subject}) + (1 | \text{Item})$$

b. Model fit statistics

AIC	BIC	logLik	deviance	df.resid
3185.9	3288.1	-1576	3151.9	2998

c. Fixed effects table

	Estimate	Std.Error	z value	Pr(> z)
(Intercept)	1.631	0.477	3.419	0.001
Place_Order(FB)	-0.915	0.694	-1.318	0.187
C1 Voicing	-2.358	0.547	-4.309	< 0.001
Release Lag	0.014	0.004	4.108	< 0.001
Place Order (FB): C1 Voicing	2.236	0.561	3.987	< 0.001
Place Order (FB): Release Lag	-0.019	0.005	-3.909	< 0.001

d. Random effects table

Groups	Name	Variance	Std.Dev.
item	(Intercept)	1.152	1.073
subject	(Intercept)	1.826	1.351
	Release Lag	0.000	0.005
	Place_Order	2.130	1.459
	C1 Voicing	3.251	1.803

e. VIF table

Predictors	Place Order	C1 Voicing	Release Lag	Place Order: C1 Voicing	Place Order: Release Lag
VIF	3.856	1.715	2.091	3.270	3.537

4. Relative Overlap

a. Model formula:

$$\text{C1 identification} \sim \text{Relative Overlap} + \text{Place Order} * \text{C1 Voicing} \\ + (1 + \text{Place Order} + \text{Relative Overlap} + \text{C1 Voicing} | \text{Subject}) + (1 | \text{Item})$$

b. Model fit statistics

AIC	BIC	logLik	deviance	df.resid
3164.2	3260.4	-1566.1	3132.2	2999

c. Fixed effects table

	Estimate	Std.Error	z value	Pr(> z)
(Intercept)	2.893	0.467	6.193	< 0.001
Place_Order(FB)	-2.436	0.526	-4.635	< 0.001
C1 Voicing	-2.126	0.528	-4.027	< 0.001
Relative Overlap	-0.393	0.084	-4.701	< 0.001
Place Order (FB): C1 Voicing	2.773	0.535	5.181	< 0.001

d. Random effects table

Groups	Name	Variance	Std.Dev.
item	(Intercept)	1.030	1.015
subject	(Intercept)	2.862	1.692
	Place_Order	2.347	1.532
	Onset Lag	0.059	0.242
	C1 Voicing	3.666	1.915

e. VIF table

Predictors	Place Order	C1 Voicing	Relative Overlap	Place Order: C1 Voicing
VIF	2.211	1.469	1.241	3.078

5. Presence of Vocalic Release

a. Model formula:

C1 identification ~ Presence of Vocalic Release (PVR) * Place Order
 + (1 + Place Order + Presence of Vocalic Release |Subject) + (1 |Item)

b. Model fit statistics

AIC	BIC	logLik	deviance	df.resid
3229.7	3295.8	-1603.8	3207.7	3004

c. Fixed effects table

	Estimate	Std.Error	z value	Pr(> z)
(Intercept)	2.839	0.486	5.836	< 0.001
Place_Order(FB)	-2.797	0.539	-5.192	< 0.001
PVR	-2.089	0.526	-3.969	< 0.001
Place Order (FB): PVR	2.360	0.545	4.331	< 0.001

d. Random effects table

Groups	Name	Variance	Std.Dev.
item	(Intercept)	1.319	1.148
subject	(Intercept)	2.529	1.59
	Place_Order	2.07	1.439
	PVR	2.673	1.635

e. VIF table

Predictors	Place Order	PVR	Place Order: PVR
VIF	2.163	1.680	2.785

6. Vocalic Release Duration

a. Model formula:

C1 identification ~ Vocalic Release Duration (VDR) + Place Order
 + (1+ Vocalic Release Duration + Place Order |Subject) + (1|Item)

b. Model fit statistics

AIC	BIC	logLik	deviance	df.resid
2265.3	2321.8	-1122.6	2245.3	2091

c. Fixed effects table

	Estimate	Std.Error	z value	Pr(> z)
(Intercept)	2.934	0.704	4.168	< 0.001
Place_Order(FB)	-0.752	0.446	-1.686	0.092
VRD	-0.056	0.016	-3.410	0.001

d. Random effects table

Groups	Name	Variance	Std.Dev.
item	(Intercept)	1.322	1.150
subject	(Intercept)	4.158	2.039
	Place_Order	3.033	1.742
	VRD	0.002	0.041

e. VIF table

Predictors	Place Order	VRD
VIF	1.022	1.022