

**Phonological neighborhood density, phonetic categorization, and vocabulary size
differentially affect the phonolexical encoding of easy and difficult L2 segmental contrasts**
by Rocca, Llompart, & Darcy

Supplementary materials

Appendix A

Debrief questions and results

Participants returned to the conference call twice to debrief: once after the auditory LDT and once after they completed the vocabulary test. The experimenter asked the following questions (both orally and in the chat box) and recorded participant responses:

1. On a scale of 1-5, how noisy was your testing environment (1= no noise, 5 = very noisy)?
2. On a scale of 1-5, how concentrated were you? (1 = not concentrated, 5 = very concentrated)
3. Did you find the task difficult? (*If they respond yes, follow-up with “Why?”*)
4. Did you experience any of the following?
 - a. *I got interrupted,*
 - b. *my phone rang,*
 - c. *I was distracted (texts or emails),*
 - d. *there was a loud noise,*
 - e. *or anything else that may have taken away from your concentration on the task?*

Results of debrief questions 1-2

Debrief session	Question	Mean response (SD)
	<u>English</u>	
1	1	1.3 (0.5)
1	2	4.6 (0.6)
2	1	1.3 (0.5)
2	2	4.4 (0.6)
	<u>Korean</u>	
1	1	1.3 (0.5)
1	2	4.3 (0.6)
2	1	1.3 (0.5)
2	2	4.5 (0.5)

Note: English participants = 15, Korean participants = 35

Appendix B

Stimuli lists

Test stimuli

Segment	Word	PND	Syllables	Neighbors	Lexical frequency
æ	match	Dense	1	29	49.4
æ	stack	Dense	1	25	6.1
æ	clap	Dense	1	18	4.7
æ	trap	Dense	1	16	23.8
æ	rapper	Dense	2	17	1.8
æ	battle	Dense	2	13	42.3
æ	ally	Dense	2	12	32.7
æ	castle	Dense	2	12	21.5
æ	draft	Sparse	1	9	7.3
æ	glass	Sparse	1	9	60.7
æ	smash	Sparse	1	6	8.3
æ	scratch	Sparse	1	5	18.8
æ	apple	Sparse	2	6	23.7
æ	shadow	Sparse	2	6	21.2
æ	jacket	Sparse	2	5	33.4
æ	travel	Sparse	2	5	33.4
ɛ	jet	Dense	1	23	14.1
ɛ	test	Dense	1	22	84.1
ɛ	spell	Dense	1	16	36.6
ɛ	egg	Dense	1	14	26.0
ɛ	seller	Dense	2	20	2.2
ɛ	setting	Dense	2	16	21.5
ɛ	metal	Dense	2	14	19.5
ɛ	pepper	Dense	2	10	8.8
ɛ	shelf	Sparse	1	8	7.0
ɛ	desk	Sparse	1	6	43.9
ɛ	fresh	Sparse	1	4	54.5
ɛ	stress	Sparse	1	4	15.6
ɛ	sweater	Sparse	2	7	13.8
ɛ	heavy	Sparse	2	5	47.3
ɛ	devil	Sparse	2	5	41.3
ɛ	essay	Sparse	2	2	6.1
f	force	Dense	1	28	70.7
f	flat	Dense	1	17	26.2
f	fish	Dense	1	16	83.5
f	faith	Dense	1	15	46.3
f	fighter	Dense	2	14	12.8
f	follow	Dense	2	13	123.2
f	feather	Dense	2	12	6.6
f	final	Dense	2	10	49.7
f	flame	Sparse	1	9	9.0

Segment	Word	PND	Syllables	Neighbors	Lexical frequency
f	front	Sparse	1	6	181.5
f	fuel	Sparse	1	5	17.2
f	French	Sparse	1	3	69.4
f	formal	Sparse	2	5	8.3
f	fiction	Sparse	2	4	6.1
f	finger	Sparse	2	4	36.7
f	flavor	Sparse	2	2	5.0
p	park	Dense	1	29	72.1
p	plane	Dense	1	22	95.5
p	page	Dense	1	21	37.5
p	path	Dense	1	17	49.4
p	penny	Dense	2	16	6.1
p	poker	Dense	2	13	4.7
p	power	Dense	2	10	23.8
p	prayer	Dense	2	10	1.8
p	prove	Sparse	1	7	42.3
p	push	Sparse	1	8	32.7
p	plant	Sparse	1	9	21.5
p	print	Sparse	1	4	7.3
p	pencil	Sparse	2	4	60.7
p	picture	Sparse	2	4	8.3
p	password	Sparse	2	1	18.8

Control stimuli

Segment	Word	PND	Syllables	Neighbors	Lexical frequency
eɪ	waste	Dense	1	19	53.3
eɪ	babe	Dense	1	18	35.6
eɪ	paint	Dense	1	18	36.8
eɪ	shape	Dense	1	18	30.2
eɪ	waiter	Dense	2	18	13.2
eɪ	racing	Dense	2	17	11.9
eɪ	player	Dense	2	14	37.8
eɪ	laser	Dense	2	12	8.5
eɪ	space	Sparse	1	8	66.1
eɪ	snake	Sparse	1	8	22.4
eɪ	sprain	Sparse	1	6	0.8
eɪ	strange	Sparse	1	4	86.4
eɪ	bacon	Sparse	2	5	11.9
eɪ	danger	Sparse	2	4	43.7
eɪ	basic	Sparse	2	3	15.6
eɪ	payment	Sparse	2	3	10.5
oʊ	soap	Dense	1	25	15.2
oʊ	throw	Dense	1	19	128.8
oʊ	tone	Dense	1	39	16.9

Segment	Word	PND	Syllables	Neighbors	Lexical frequency
ou	ghost	Dense	1	14	36.6
ou	donor	Dense	2	10	4.1
ou	coma	Dense	2	13	12.3
ou	solo	Dense	2	12	8.5
ou	odor	Dense	2	11	2.3
ou	growth	Sparse	1	7	6.5
ou	stroke	Sparse	1	7	13.1
ou	globe	Sparse	1	7	5.2
ou	clothes	Sparse	1	4	101.1
ou	social	Sparse	2	4	33.4
ou	bonus	Sparse	2	3	9.2
ou	notice	Sparse	2	3	59.3
ou	photo	Sparse	2	2	22.8
s	sink	Dense	1	27	16.9
s	serve	Dense	1	16	37.9
s	swim	Dense	1	14	31.8
s	salt	Dense	1	12	19.5
s	silly	Dense	2	25	57.1
s	scissor	Dense	2	14	0.4
s	sunny	Dense	2	14	7.7
s	summer	Dense	2	17	78.7
s	swipe	Sparse	1	7	1.6
s	swept	Sparse	1	7	4.8
s	solve	Sparse	1	5	19.5
s	South	Sparse	1	4	64.5
s	season	Sparse	2	7	31.5
s	section	Sparse	2	3	27.3
s	someday	Sparse	2	3	33.8
s	science	Sparse	2	1	37.3
t	tool	Dense	1	30	10.7
t	type	Dense	1	27	60.6
t	tough	Dense	1	23	90.5
t	tab	Dense	1	22	5.8
t	traitor	Dense	2	13	10.6
t	title	Dense	2	11	18.6
t	timer	Dense	2	11	6.3
t	temper	Dense	2	10	11.4
t	task	Sparse	1	8	12.7
t	tenth	Sparse	1	6	4.2
t	twist	Sparse	1	6	12.6
t	twice	Sparse	1	1	62.6
t	tiny	Sparse	2	7	32.2
t	turtle	Sparse	2	5	17.0
t	teacher	Sparse	2	5	55.7
t	topic	Sparse	2	5	5.3

Appendix C

Comparisons of LDT stimuli: Phonological neighborhood density

PND of target sounds in sparse and dense conditions

	<u>Test stimuli</u>					
	mean sparse (SD)	mean dense (SD)	p	t	conf low	conf high
ε	5.1 (1.9)	16.9 (4.5)	< .001	-6.87	-15.6	-7.9
æ	6.4, (1.7)	17.8 (6.2)	.003	-4.99	-16.6	-6.1
f	4.8, (2.1)	15.6 (5.5)	.003	-5.24	-15.6	-6.2
p	4.8 (3)	17.2 (6.5)	.003	-4.91	-18.2	-6.8
	<u>Control stimuli</u>					
	mean sparse (SD)	mean dense (SD)	p	t	conf low	conf high
eɪ	5.1 (2)	16.8 (2.4)	< .001	-10.3	-14	-9.2
oʊ	4.6 (2.1)	17.9 (9.9)	.006	-3.72	-21.5	-5
s	4.6 (2.3)	17.4 (5.6)	.001	-6.01	-17.5	-8
t	5.4 (2.1)	18.4 (8)	.004	-4.43	-19.8	-6.2

Note: This table shows the results of Welch two sample t-tests examining PND for Critical and Control stimuli. Each row shows a comparison of the target sound in the sparse condition and the dense condition. P-values have been corrected for multiple comparisons (Holm-Bonferroni method), and p-values < .05 indicate significance.

PND of phoneme contrasts in sparse and dense conditions

	<u>Sparse</u>					
	mean x (SD)	mean y (SD)	p	t	conf low	conf high
ε-æ	5.1 (1.9)	6.4 (1.7)	.180	-1.4	-3.2	0.7
f-p	4.8 (2.1)	4.8 (3)	1.00	0	-2.8	2.8
eɪ-oʊ	5.1 (2)	4.6 (2.1)	.630	0.49	-1.7	2.7
s-t	4.6 (2.3)	5.4 (2.1)	.500	-0.69	-3.1	1.6
	<u>Dense</u>					
	mean x (SD)	mean y (SD)	p	t	conf low	conf high
ε-æ	16.9, (4.5)	17.8, 6.2	.750	-0.32	-6.7	5
f-p	15.6, (5.5)	17.2, 6.5	.600	-0.54	-8.1	4.9
eɪ-oʊ	16.8, (2.4)	17.9, 9.9	.760	-0.31	-9.4	7.2
s-t	17.4, (5.6)	18.4, 8	.780	-0.29	-8.5	6.5

Note: This table shows the results of Welch two sample t-tests comparing the PND of contrasts in sparse and dense conditions. The column “mean x” is the first phone in the contrast and “mean y” is the second phone in the contrast. For example, in the first row of the sparse condition, the mean PND of /ε/ words is 5.1 and the mean frequency of /æ/ words is 6.4.

Appendix D

Comparisons of LDT stimuli: Frequency

Frequency of target sounds in sparse and dense conditions

	<u>Test stimuli</u>					
	mean sparse (SD)	mean dense (SD)	df	p	t	conf low
ε	28.7 (19.9)	26.6 (25.5)	13.2	.860	0.18	-22.6
æ	25.8 (17.2)	22.8, (17.9)	14	.730	0.35	-15.7
f	41.7 (60.7)	52.4, (39.1)	12	.680	-0.42	-66.3
p	48.8 (43.8)	54.4, (47.8)	13.9	.810	-0.24	-54.8

	<u>Control stimuli</u>					
	mean sparse (SD)	mean dense (SD)	df	p	t	conf low
eɪ	32.2 (30.4)	28.4 (15.7)	10.5	.760	0.31	-23
oʊ	31.3 (33.5)	28.1 (42.1)	13.3	.870	0.17	-37.7
s	27.5 (19.9)	31.2 (26.2)	13.1	.750	-0.32	-28.8
t	25.3 (22.7)	26.8 (31.4)	12.7	.910	-0.11	-31.1

Note: This table shows the results of Welch two sample t-tests examining frequency for Critical and Control stimuli. Each row compares the target sound in the sparse condition and the dense condition. The estimate column is the difference between the mean sparse and mean dense value. Frequencies are computed in words per million, and p-values < .05 indicate significance.

Frequency of phoneme contrasts in sparse and dense conditions

	<u>Sparse</u>						
	mean x (SD)	mean y (SD)	df	p	t	conf low	conf high
ε-æ	28.7 (19.9)	25.8 (17.2)	13.7	.760	0.31	-17.1	22.8
f-p	41.7 (60.7)	48.8 (43.8)	12.7	.790	-0.27	-64.4	50.1
eɪ-oʊ	32.2 (30.4)	31.3 (33.5)	13.9	.960	0.05	-33.5	35.2
s-t	27.5 (19.9)	25.3 (22.7)	13.8	.840	0.21	-20.7	25.1

	<u>Dense</u>						
	mean x (SD)	mean y (SD)	df	p	t	conf low	conf high
ε-æ	26.6 (25.5)	22.8 (17.9)	12.5	.730	0.35	-20	27.7
f-p	52.4 (39.1)	54.4 (47.8)	13.5	.930	-0.09	-49	45
eɪ-oʊ	28.4 (15.7)	28.1 (42.1)	8.9	.980	0.02	-35.7	36.3
s-t	31.2 (26.2)	26.8 (31.4)	13.6	.760	0.31	-26.7	35.5

Note: This table shows the results of Welch two sample t-tests comparing the frequency of contrasts in sparse and dense conditions. The column “mean x” is the first phone in the contrast and “mean y” is the second phone in the contrast. For example, in the first row of the sparse condition, the mean frequency of /ε/ is 28.7 and the mean frequency of /æ/ is 25.8.

Appendix E

Vowel formant measurements for LDT stimuli measured using Welch Two Sample t-test

Vowels in dense and sparse conditions

segment	mean sparse	mean dense	p	t	parameter	conf low	conf high
æ F1	1086	1034	.140	-1.60	9.37	-126.30	21.30
æ F2	1856	1851	.910	-0.11	12.82	-102.54	92.54
[æ] F1	1023	1026	.890	0.14	11.50	-51.37	58.37
[æ] F2	1816	1873	.080	1.96	11.42	-6.79	121.04
ε F1	850	834	.560	-0.61	13.37	-70.66	39.66
ε F2	1921	1995	.160	1.51	12.63	-31.73	178.73
[ε] F1	884	878	.830	-0.22	8.36	-70.28	57.78
[ε] F2	1931	1963	.540	0.64	13.98	-76.81	141.56

Note: Vowel measurements are taken at midpoint. Vowels in brackets are nonwords.

Vowels in real words vs. nonwords in dense and sparse conditions

segment	mean real word	mean nonword	p	t	parameter	conf low	conf high
æ F1 dense	1034	1026	.760	-0.32	11.33	-62.49	46.74
æ F2 dense	1851	1873	.490	0.72	11.02	-45.15	89.15
[æ] F1 sparse	1086	1023	.080	-1.94	9.48	-137.82	10.07
[æ] F2 sparse	1856	1816	.380	-0.91	12.42	-136.04	55.79
ε F1 dense	834	878	.080	1.99	9.38	-5.56	91.81
ε F2 dense	1995	1963	.560	-0.59	13.82	-145.43	82.43
[ε] F1 sparse	850	884	.300	1.09	11.46	-34.31	102.06
[ε] F2 sparse	1921	1931	.840	0.21	13.12	-90.10	109.35

Note: Vowel measurements are taken at midpoint. Vowels in brackets are nonwords.

Appendix F
Voice onset time /p/ and /t/ measured using Welch Two Sample t-test

VOT within segment measured

segment	mean sparse	mean dense	p	t	parameter	conf low	conf high
p real word	71.4	77.68	.500	0.69	13.21	-13.24	25.8
[p] nonword	71.57	72.25	.930	0.09	12.64	-15.36	16.73
t real word	81.7	92.18	.310	1.05	12.81	-11.05	32
[t] nonword	87.93	85.06	.740	-0.34	13.06	-20.91	15.15

Note: Closure onset is marked as where oscillation in the waveform begins. VOT onset is marked at closest zero-crossings just before the release burst. VOT ending is marked where the vowel's periodic wave begins. Vowels in brackets are nonwords.

VOT in dense vs. sparse conditions

segment	mean nonword	mean real word	p	t	parameter	conf low	conf high
[p]-p sparse	71.57	71.40	.990	0.02	13.62	-19.93	20.27
[p]-p dense	72.25	77.68	.450	-0.77	13.16	-20.59	9.73
[t]-t sparse	87.93	81.7	.550	0.61	13.71	-15.64	28.10
[t]-t dense	85.06	92.18	.400	-0.88	11.96	-24.71	10.47

Note: Closure onset is marked as where oscillation in the waveform begins. VOT onset is marked at closest zero-crossings just before the release burst. VOT ending is marked where the vowel's periodic wave begins. Vowels in brackets are nonwords.

Appendix G
Acoustics for /f/ and /s/ measured using Welch Two Sample t-test

Duration within segment measured using

segment	mean sparse	mean dense	p	t	parameter	conf low	conf high
f real word	165.31	178.83	.230	1.25	12.58	-9.9	36.94
[f] nonword	171.28	180.04	.530	0.64	14	-20.49	38
s real word	172.46	182.45	.30	1.07	13.98	-9.97	29.94
[s] nonword	180.46	184.81	.730	0.35	10.85	-22.8	31.52

Note: Vowels in brackets are nonwords.

Duration in dense vs. sparse conditions

segment	mean real word	mean nonword	p	t	parameter	conf low	conf high
[f]-f sparse	171.28	165.31	.660	0.46	13.88	-22.15	34.1
[f]-f dense	180.04	178.83	.920	0.11	11.99	-23.72	26.15
[s]-s sparse	180.46	172.46	.380	0.91	13.89	-10.80	26.79
[s]-s dense	184.81	182.45	.860	0.19	11.69	-25.41	30.15

Note: Vowels in brackets are nonwords.

Center of gravity

segment	mean sparse	mean dense	p	t	parameter	conf low	conf high
f real word	5899.72	5683.7	.640	-0.48	13.77	-1191.84	759.81
[f] nonword	5981.56	5976.23	.990	-0.02	10.35	-785.95	775.29
s real word	6873.64	6726.86	.720	-0.37	12.99	-995.36	701.81
[s] nonword	6797.78	6838.32	.940	0.08	12.98	-1015.32	1096.4

Note: Vowels in brackets are nonwords.

Center of gravity in sparse vs. dense conditions

segment	mean nonword	mean real word	p	t	parameter	conf low	conf high
[f]-f sparse	5981.56	5899.72	.860	0.18	13.9	-914.01	1077.71
[f]-f dense	5976.23	5683.7	.410	0.86	10.64	-456.66	1041.72
[s]-s sparse	6797.78	6873.64	.860	-0.18	13.93	-997.99	846.28
[s]-s dense	6838.32	6726.86	.810	0.24	11.5	-887.98	1110.89

Note: Vowels in brackets are nonwords.

Appendix H
Diphthong measurements compared using Welch Two-sample t-test

When measuring the formant values, we followed Wright and Nichols (2015), who suggest measuring the vowel nucleus at the 20% point and the offglide at the 80%. Vowels in brackets are nonwords.

Comparing nucleus formants in dense and sparse conditions

segment	mean sparse	mean dense	p	t	parameter	conf low	conf high
eɪ F1	581.88	571	.750	-0.33	13.98	-82.64	60.89
eɪ F2	2284.38	2186.75	.360	-0.95	13.13	-320.44	125.19
[eɪ] F1	605.38	583.88	.580	-0.57	12.37	-102.98	59.98
[eɪ] F2	2170.38	2333.75	.090	1.84	13.12	-28.18	354.93
oʊ F1	679.38	663.62	.600	-0.54	12.34	-78.95	47.45
oʊ F2	1519.88	1535.12	.810	0.25	13.16	-115.92	146.42
[oʊ] F1	655.38	617.5	.380	-0.94	7.33	-132.18	56.43
[oʊ] F2	1539.25	1397.38	.160	-1.49	12.86	-348.11	64.36

Comparing off-glide formants in dense and sparse conditions

segment	mean sparse	mean dense	p	t	parameter	conf low	conf high
eɪ F1	545.00	478.38	.370	-0.93	12.92	-221.61	88.36
eɪ F2	2696.5	2663.88	.600	-0.54	13.31	-162.8	97.55
[eɪ] F1	479.75	575.38	.240	1.24	9.81	-76.31	267.56
[eɪ] F2	2558.5	2636.25	.500	0.69	13.63	-163.25	318.75
oʊ F1	589.12	658.75	.480	0.74	8.27	-146.61	285.86
oʊ F2	1290.12	1303.88	.910	0.11	8.24	-260.81	288.31
[oʊ] F1	619.62	487.12	.140	-1.63	7.92	-320.72	55.72
[oʊ] F2	1342.62	1219.12	.180	-1.46	9.66	-312.50	65.50

Comparing nucleus formants in real words and nonwords

segment	mean real word	mean nonword	p	t	parameter	conf low	conf high
eɪ F1 dense	571.00	583.88	.750	0.33	13.21	-71.84	97.59
eɪ F2 dense	2186.75	2333.75	.200	1.36	13.69	-85.05	379.05
eɪ F1 sparse	581.88	605.38	.470	0.75	13.89	-43.84	90.84
eɪ F2 sparse	2284.38	2170.38	.190	-1.37	13.69	-292.27	64.27
oʊ F1 dense	663.62	617.5	.100	-1.86	7.91	-103.49	11.24
oʊ F2 dense	1535.12	1397.38	.060	-2.04	12.1	-284.91	9.41
oʊ F1 sparse	679.38	655.38	.590	-0.56	9.3	-120.82	72.82
oʊ F2 sparse	1519.88	1539.25	.830	0.21	11.76	-178.58	217.33

Comparing off-glide formants in real words and nonwords

segment	mean real word	mean nonword	p	t	parameter	conf low	conf high
ei F1 dense	478.38	575.38	.300	1.07	13.5	-98.02	292.02
ei F2 dense	2663.88	2636.25	.780	-0.28	10.92	-242.93	187.68
ei F1 sparse	545.00	479.75	.240	-1.22	12.98	-180.67	50.17
ei F2 sparse	2696.5	2558.5	.120	-1.69	10.5	-318.63	42.63
oo F1 dense	658.75	487.12	.100	-1.86	7.7	-386.39	43.14
oo F2 dense	1303.88	1219.12	.500	-0.71	8.24	-359.3	189.8
oo F1 sparse	589.12	619.62	.720	0.37	8.65	-159.58	220.58
oo F2 sparse	1290.12	1342.62	.550	0.62	9.67	-136.51	241.51

Comparing /ei/ to /oo/ nucleus formants in dense and sparse conditions

segment	mean ei	mean oo	p	t	parameter	conf low	conf high
ei-oo F1 dense	571.00	663.62	.050	-2.72	14	-165.73	-19.52
ei-oo F2 dense	2186.75	1535.12	< .001	7.25	9.77	450.69	852.56
ei-oo F1 sparse	581.88	679.38	.018	-3.44	12.6	-158.95	-36.05
ei-oo F2 sparse	2284.38	1519.88	< .001	9.65	13.1	593.52	935.48
[ei]-[oo] F1 dense	583.88	617.5	.583	-1.06	7.55	-107.22	39.97
[ei]-[oo] F2 dense	2333.75	1397.38	< .001	10.37	13.37	741.93	1130.82
[ei]-[oo] F1 sparse	605.38	655.38	.583	-1.11	10.67	-149.55	49.55
[ei]-[oo] F2 sparse	2170.38	1539.25	< .001	6.72	12.57	427.49	834.76

Note: Significant differences are important for F2 values. This means there is a large difference in front-back distinction. P-values have been corrected for multiple comparisons (Holm-Bonferroni method).

Comparing /ei/ to /oo/ off-glide formants in dense and sparse conditions

segment	mean ei	mean oo	p	t	parameter	conf low	conf high
ei-oo F1 dense	478.38	658.75	.472	-1.68	11.89	-413.89	53.14
ei-oo F2 dense	2663.88	1303.88	< .001	10.96	9.32	1080.87	1639.13
ei-oo F1 sparse	545	589.12	.513	-0.87	11.90	-154.7	66.45
ei-oo F2 sparse	2696.5	1290.12	< .001	27.66	13.89	1297.23	1515.52
[ei]-[oo] F1 dense	575.38	487.12	.513	1.21	8.16	-79.14	255.64
[ei]-[oo] F2 dense	2636.25	1219.12	< .001	15.38	9.19	1209.38	1624.87
[ei]-[oo] F1 sparse	479.75	619.62	.472	-1.64	9.25	-331.79	52.04
[ei]-[oo] F2 sparse	2558.5	1342.62	< .001	11.49	13.95	988.8	1442.95

Note: Significant differences are important for F2 values. This means there is a large difference in front-back distinction. P-values have been corrected for multiple comparisons (Holm-Bonferroni method).

Appendix I

Auditory LDT nonword item results: /ɛ/-/æ/

Results for /ɛ/-/æ/ nonword rejection in the auditory LDT by language group

Language group										Total
	<u>/æ/ dense nonwords</u>									
	ally	battle	castle	clap	match	rapper	stack	trap		
English	86%	79%	86%	93%	100%	86%	100%	93%		90%
Korean	39%	12%	12%	16%	18%	14%	12%	12%		17%
	<u>/æ/ sparse nonwords</u>									
	apple	glass	scratch	shadow	smash	travel	draft	jacket		
English	71%	100%	93%	100%	71%	64%	NA	NA		83%
Korean	9%	15%	6%	9%	3%	9%	NA	NA		9%
	<u>/ɛ/ dense nonwords</u>									
	egg	jet	metal	pepper	seller	setting	spell	test		
English	100%	79%	100%	79%	100%	100%	93%	93%		93%
Korean	24%	36%	36%	9%	21%	39%	48%	15%		29%
	<u>/ɛ/ sparse nonwords</u>									
	desk	devil	essay	fresh	heavy	shelf	stress	sweater		
English	86%	93%	86%	100%	100%	86%	93%	100%		93%
Korean	9%	21%	15%	30%	24%	64%	9%	15%		23%

Note: If “NA” is reported instead of a percentage, this means the item was removed because it was an outlier.

Appendix J

Auditory LDT nonword item results: /f/-/p/

Results for /f/-/p/ nonword rejection in the auditory LDT by language group

Language group									Total avg
	<u>/f/ dense nonwords</u>								
	faith	feather	fighter	final	fish	flat	follow	force	
English	100%	100%	100%	100%	100%	100%	86%	93%	97%
Korean	78%	81%	97%	100%	94%	70%	85%	97%	88%
	<u>/f/ sparse nonwords</u>								
	fiction	finger	flavor	formal	French	front	fuel	flame	
English	100%	100%	100%	100%	100%	86%	93%	NA	97%
Korean	76%	94%	97%	97%	79%	76%	82%	NA	86%
	<u>/p/ dense nonwords</u>								
	page	park	path	penny	plane	poker	power	prayer	
English	100%	100%	93%	100%	86%	100%	100%	100%	97%
Korean	88%	97%	91%	100%	79%	86%	85%	48%	84%
	<u>/p/ sparse nonwords</u>								
	password	pencil	picture	plant	practice	print	prove	push	
English	86%	86%	100%	93%	86%	100%	100%	100%	94%
Korean	79%	94%	91%	85%	88%	88%	91%	91%	88%

Note: If “NA” is reported instead of a percentage, this means the item was removed because it was an outlier.

Appendix K

Mean results of LDT for control stimuli

For the /eɪ/-/oʊ/ contrast, accuracy is near ceiling for all participants, with slightly lower accuracy for the Korean group on /oʊ/ dense nonwords (see Figure 1). For the /s/-/t/ contrast, accuracy is again near ceiling for both groups, with slightly lower accuracy for the Korean group on /s/ dense nonwords (see Figure 2). The results for the control items should be treated cautiously and should not be overinterpreted because some of these words may have been unknown or unfamiliar to learners. These items were not included in the word familiarity questionnaire to keep the task shorter. Whiskers in plots represent 1.5 times the inter-quartile range.

Figure 1

Mean lexical decision accuracy (proportion correct) on vowel control items

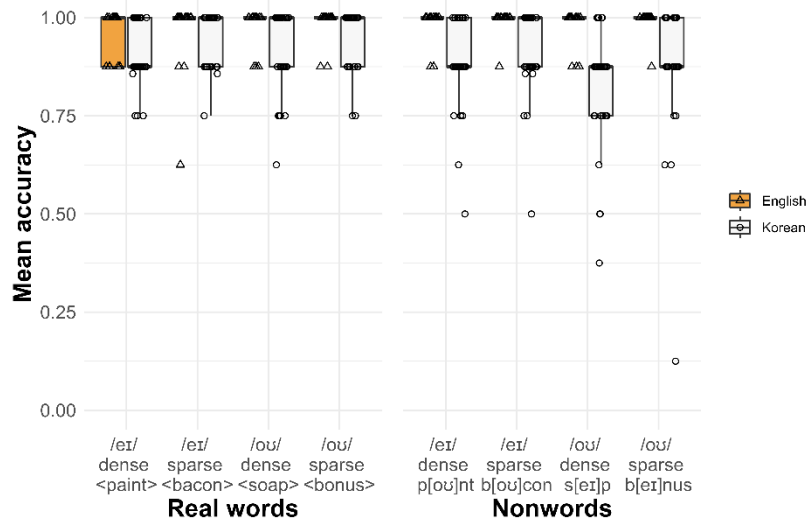
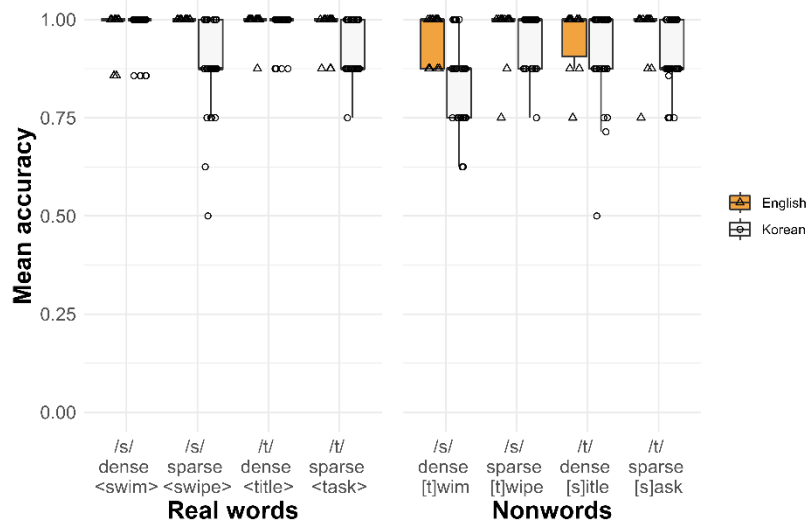


Figure 2

Mean lexical decision accuracy (proportion correct) on consonant control items



Appendix L

GLMM model comparisons and results

GLMM 1

Paper section: Lexical decision: Group differences and test vs. control contrasts

Model: Comparing LDT performance of groups among test and control contrasts

Model comparisons: Contrast type over Participants: $\chi^2(2) = 35.44, p < .001$; Segment type over Participants: $\chi^2(2) = 30.8, p < .001$; and Language group over Items: $\chi^2(2) = 19.15, p < .001$.

Results: See Table 2 in paper.

GLMM 2

Paper section: Effects of PND and segment type on Korean Participants nonword rejection accuracy

Model: Testing the effect of PND in the target vowel and consonant contrast.

Model comparisons: Segment type over Participants: $\chi^2(2) = 44.40, p < .001$; PND over Participants: $\chi^2(2) = 3.61, p = .16$

Results: The model reveals a main effect of Segment type ($b = 4.58, SE = 0.41, z = 11.21, p < 0.001$), showing that participants are more accurate on consonant items, but there is no main effect of PND ($b = 0.31, SE = 0.29, z = 1.09, p = .275$) nor an interaction between PND and segment type ($b = -0.55, SE = 0.58, z = -0.95, p = .342$).

GLMM 3

Paper section: Effects of PND and segment type on Korean Participants nonword rejection accuracy

Model: Exploratory analysis testing PND and Vowel in test vowel contrast

Model comparisons: Target over Participants: $\chi^2(2) = 3.86, p = .145$; PND over Participants: singular fit error.

Results: There is a main effect of PND ($b = 0.74, SE = 0.37, z = -2.03, p = 0.042$) and Vowel ($b = 1.3, SE = 0.37, z = 3.55, p < .001$) but no significant interaction of PND x Vowel, indicating that PND does not differentially affect the dominant and nondominant vowel ($b = -0.58, SE = 0.73, z = -0.79, p = 0.43$).

GLMM 4

Paper section: Lexical decision: Effects of perception, vocabulary size, and PND

Model: Testing the effect of PND, perception, and vocabulary size on test vowel and consonant nonword rejection.

Model comparisons: Perception over Item: model failed to converge; Segment type over Participants: $\chi^2 (2) = 5.85, p = .054$; PND over Participants: $\chi^2 (2) =$ singular fit error; Vocabulary size over Item: singular fit error.

Results: See Table 3.

GLMM 5

Paper section: Lexical decision: Effects of perception, vocabulary size, and PND

Model: Testing the effect of PND, perception, and vocabulary size on test consonant nonword rejection.

Model comparisons: Perception over Item: $\chi^2 (2) = 11.78, p < .001$; PND over Participant: $\chi^2 (2) = 0.24, p = .886$; Vocabulary size over Item: singular fit error.

Results: See Table 4.

GLMM 6

Paper section: Lexical decision: Effects of perception, vocabulary size, and PND

Model: Testing the effect of PND, perception, and vocabulary size on test vowel nonword rejection

Model comparisons: Perception over Item: singular fit error; PND over Participant: singular fit error; Vocabulary size over Item: $\chi^2 (2) = 2.35, p = .31$.

Results: See Table 5.