

**Can native Japanese listeners learn to differentiate /r-l/ on the basis of F3 onset frequency?**

ERIN M. INGVALSON &amp; LORI L. HOLT

*Carnegie Mellon University*

JAMES L. McCLELLAND

*Stanford University****Bilingualism: Language and Cognition,***<http://journals.cambridge.org/action/displayJournal?jid=BIL>**Supplementary Materials**

Here we report on individual participant performance in Experiment 1. We first consider identification and discrimination of the synthetic speech stimuli from Experiment 1, followed by natural speech identification.

***Identification***

We assessed individual identification performance via logistic regression slopes, which provide an estimate of the degree of separation between /r-l/ categories along the F3 dimension.

A single z-score quantified the difference between the pre- and post-test slopes:

$$\frac{(Slope_{post-test} - Slope_{pre-test})}{\sqrt{(SE_{post-test}^2 + SE_{pre-test}^2)}}$$

Comparing these z-scores to the normal distribution tested for significant performance changes at the .05 level. Pre- and post-test slopes, standard errors, and z-scores are shown in Table S.1.

No participant improved in identifying the trained vowel context. However, some listeners showed significant improvements on untrained contexts. Listeners Trained-1a.2 and Untrained-1b.2 both showed more separation between /ræ-læ/ categories at post-test. Listener Trained-1b.1 showed significant improvement on the /u/ series at post-test. This failure to learn the trained context following extensive exposure is unprecedented in earlier training attempts

(McCandliss et al., 2002; Strange & Dittman, 1984) and suggests the effects seen in the untrained contexts are unlikely to be a result of training.

### ***Discrimination***

Native listeners' discrimination is typically poor between tokens that are identified as the same speech sound but more accurate for sounds that straddle the identification boundary (Liberman et al., 1957). We identified the NE controls' /ra-la/ category boundary (/ra-la/ curves being the steepest) as a means of determining if NJ listeners' discrimination was akin to anticipated NE performance. A proportion /r/ response difference of .50 or greater between two members of a discrimination pair was indicative of a category boundary and called the SERIES MIDDLE (stimuli pairings 6-10 and 7-11). The remaining pairings were classified as the SERIES END. Position assignment from the /ra-la/ series was extrapolated to the other vowel contexts.

We assessed differences in pre- and post-test discrimination performance at the NE category boundary via pairwise t-tests. Individual accuracy can be seen in Table S.2. Listener Trained-1a.1 showed significant improvement on the /i/ series, as did listeners Untrained-1a.1 and Untrained-1a.2. Listener Untrained-1b.2 improved on the /ra-la/ and /ræ-læ/ series.

We compared series middle and end post-test discrimination accuracy to determine the NE-like nature of the discrimination curves following training (Liberman et al., 1957). Individual accuracy is presented in Table S.3. Listener Untrained-1a.1 better discriminated the /ri-li/ series middle than end. Listener Untrained-1b.2 showed the same pattern for /ræ-læ/. Untrained listeners' more NE-like performance and better post-test performance suggests these effects are not a result of training.

### ***Identification of Natural Speech***

Untrained-1a.1 was excluded from these analyses because of consistent use of invalid response keys at the post-test, which resulted in no usable data.

For each listener, we compared accuracy identifying natural speech at the pre- and post-tests using pairwise t-tests, collapsing across consonant position to maximize the number of points per cell. Listeners' pre- and post-test proportion correct identification for each consonant position can be seen in Table S.4, noting that high word final (e.g., mile-mire) accuracy is typical (Lively et al., 1993, 1994; Logan et al., 1991). No listeners showed significant pre- to post-test improvement.

Table S.1

*Logistic Regression Slopes and Standard Errors for All Vowel Contexts for All Listeners in Experiments 1a and 1b. Pre- and Post-Test Slopes were Converted to a Single Z-Score, Also Shown*

Listener	/ra-la/					/ræ-læ/					/ri-li/					/ru-lu/				
	Pre-Test		Post-Test		Z-Score	Pre-Test		Post-Test		Z-Score	Pre-Test		Post-Test		Z-Score	Pre-Test		Post-Test		Z-Score
	Slope	SE	Slope	SE		Slope	SE	Slope	SE		Slope	SE	Slope	SE		Slope	SE	Slope	SE	
Trained-1a.1	0.13	0.27	-0.07	0.14	-0.69	0.08	0.14	0.16	0.10	0.49	0.07	0.11	-0.24	0.19	-1.43	0.12	0.10	0.00	**	0.00
Trained-1a.2	-0.32	0.11	-0.43	0.12	-0.66	0.27	0.11	-0.34	0.11	-3.98 *	-0.07	0.09	-0.03	0.09	0.25	0.05	0.12	-0.32	0.23	-1.43
Trained-1b.1	0.00	0.04	0.03	0.04	0.54	0.01	0.04	-0.04	0.04	-0.90	-0.04	0.04	0.02	0.04	1.00	0.00	0.04	-0.19	0.06	-2.84 *
Trained-1b.2	-0.08	0.04	-0.02	0.04	0.97	-0.02	0.04	-0.02	0.04	-0.09	0.00	**	0.00	0.04	0.00	0.00	**	-0.03	0.04	0.00
Untrained-1a.1	-0.30	0.25	0.07	0.09	1.36	-0.32	0.19	-0.16	0.10	0.77	-0.29	0.31	-0.42	0.12	-0.39	-0.01	0.12	-0.05	0.09	-0.31
Untrained-1a.2	0.00	0.10	-0.19	0.13	-1.14	-0.11	0.17	-0.42	0.26	-1.00	-0.13	0.27	-0.58	0.32	-1.08	-0.22	0.13	-0.09	0.21	0.54
Untrained-1b.1	-0.03	0.04	-0.01	0.04	0.32	0.00	**	0.18	0.17	0.00	-0.17	0.09	-0.29	0.06	-1.10	-0.02	0.04	0.19	0.05	3.32 *
Untrained-1b.2	-0.04	0.04	0.00	0.04	0.75	0.08	0.04	-0.11	0.04	-3.45 *	-0.08	0.04	-0.10	0.04	-0.28	-0.11	0.04	0.03	0.04	2.43 *

\*Indicates a significant difference between the pre- and post-test slopes at the 0.05 level

\*\*Indicates a value that is poorly defined by the model

Table S.2

*Proportion Correct Discrimination of /r-l/ Pairs that Spanned the NE Category Boundary (Series Middle) at Pre- and Post-Test for all Vowel Contexts by all Listeners in Experiments 1a and 1b.*

Listener	<i>/ra-la/</i>		<i>/ræ-læ/</i>		<i>/ri-li/</i>		<i>/ru-lu/</i>	
	Series Middle	Series Middle	Series Middle	Series Middle	Series Middle	Series Middle	Series Middle	Series Middle
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Trained-1a.1	0.53 (0.88)	0.63 (0.94)	0.41 (0.81)	0.47 (0.94)	0.56 (1.00)	0.75 (1.00) *	0.47 (0.87)	0.50 (0.80)
Trained-1a.2	0.38 (0.50)	0.56 (0.75)	0.44 (0.69)	0.56 (0.75)	0.44 (0.50)	0.63 (0.75)	0.41 (0.73)	0.53 (0.87)
Trained-1b.1	0.53 (0.81)	0.56 (0.63)	0.50 (0.63)	0.56 (0.63)	0.38 (0.63)	0.34 (0.38)	0.47 (0.94)	0.53 (0.69)
Trained-1b.2	0.59 (0.63)	0.44 (0.75)	0.50 (0.50)	0.50 (0.63)	0.63 (0.75)	0.69 (0.88)	0.47 (0.94)	0.53 (0.81)
Untrained-1a.1	0.50 (0.94)	0.50 (0.81)	0.50 (1.00)	0.66 (0.94)	0.50 (1.00)	0.94 (0.94) *	0.50 (1.00)	0.38 (0.67)
Untrained-1a.2	0.47 (0.94)	0.41 (0.69)	0.50 (0.94)	0.53 (0.81)	0.47 (1.00)	0.69 (0.88) *	0.50 (0.93)	0.53 (0.93)
Untrained-1b.1	0.53 (0.88)	0.53 (0.75)	0.50 (1.00)	0.53 (1.00)	0.63 (1.00)	0.44 (0.75) *	0.50 (1.00)	0.50 (1.00)
Untrained-1b.2	0.44 (0.56)	0.72 (0.75) *	0.50 (0.75)	0.75 (0.75) *	0.72 (0.69)	0.47 (0.38) *	0.50 (0.69)	0.50 (0.56)

\*Indicates a significant difference discriminating the series middle at pre- vs. post-test at the 0.05 level.

Hit rate is reported in parentheses.

Table S.3

*Proportion Correct Discrimination of /r-l/ Pairs that Spanned the NE Category Boundary (Series Middle) and Pairs that were Within One NE Category (Series End) at the Post-Test for all Vowel Contexts by all Listeners of Experiments 1a and 1b.*

Listener	/ra-la/		/ræ-læ/		/ri-li/		/ru-lu/	
	Series Middle	Series End	Series Middle	Series End	Series Middle	Series End	Series Middle	Series End
	Post-Test	Post-Test	Post-Test	Post-Test	Post-Test	Post-Test	Post-Test	Post-Test
Trained-1a.1	0.63 (0.94)	0.61 (0.91)	0.47 (0.94)	0.49 (0.93)	0.75 (1.00)	0.61 (0.63)	0.50 (0.80)	0.56 (0.84)
Trained-1a.2	0.56 (0.75)	0.59 (0.70)	0.56 (0.75)	0.60 (0.70)	0.63 (0.75)	0.61 (0.60)	0.53 (0.87)	0.49 (0.77)
Trained-1b.1	0.56 (0.63)	0.51 (0.64)	0.56 (0.63)	0.49 (0.55)	0.34 (0.38)	0.50 (0.54)	0.53 (0.69)	0.49 (0.58)
Trained-1b.2	0.44 (0.75)	0.59 (0.80)	0.50 (0.63)	0.58 (0.74)	0.69 (0.88)	0.55 (0.81)	0.53 (0.81)	0.53 (0.85)
Untrained-1a.1	0.50 (0.81)	0.55 (0.73)	0.66 (0.94)	0.61 (0.84)	0.94 (0.94)	0.65 (0.68) *	0.38 (0.67)	0.46 (0.80)
Untrained-1a.2	0.41 (0.69)	0.56 (0.75)	0.53 (0.81)	0.64 (0.86)	0.69 (0.88)	0.64 (0.65)	0.53 (0.93)	0.59 (0.95)
Untrained-1b.1	0.53 (0.75)	0.58 (0.69)	0.53 (1.00)	0.51 (1.00)	0.44 (0.75)	0.60 (0.75) *	0.50 (1.00)	0.50 (1.00)
Untrained-1b.2	0.72 (0.75)	0.64 (0.71)	0.75 (0.75)	0.57 (0.61) *	0.47 (0.38)	0.53 (0.54)	0.50 (0.56)	0.53 (0.50)

\*Indicates a significant differences in discrimination performance of the post-test series middle vs. the series end at the 0.05 level.

Hit rate is reported in parentheses.

Table S.4

*Proportion Correct Identification of Natural Speech /r-l/ at the Pre- and Post-Tests as a Function of Contrast Position\**

Listener	Initial Singleton		Initial Cluster		Intervocalic		Final Singleton	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Trained-1a.1	0.65	0.59	0.59	0.41	0.69	0.75	1.00	1.00
Trained-1a.2	0.72	0.44	0.56	0.44	0.56	0.81	1.00	1.00
Trained-1b.1	0.61	0.56	0.50	0.38	0.50	0.50	0.94	1.00
Trained-1b.2	0.72	0.67	0.75	0.56	0.71	0.71	1.00	1.00
Untrained-1a.2	0.44	0.50	0.44	0.19	0.81	0.50	1.00	1.00
Untrained-1b.1	0.94	0.94	0.94	0.94	0.86	0.93	1.00	1.00
Untrained-1b.2	0.50	0.61	0.44	0.56	0.79	0.64	0.94	1.00

\*No listener showed a significant pre- to post-test improvement when collapsing across contrast positions

Listener Untrained-1a.1 was not included in these analyses due to a consistent use of invalid response keys during the

Table S.5

Logistic Regression Slopes and Standard Errors for All Vowel Contexts for All Listeners in Experiment 2. Pre- and Post-Test Slopes were Converted to a Single Z-Score, Also Shown.

Listener	/ra-la/						/ræ-læ/						/ri-li/						/ru-lu/					
	Pre-Test		Post-Test		Z-Score	$\chi^2$	Pre-Test		Post-Test		Z-Score	$\chi^2$	Pre-Test		Post-Test		Z-Score	$\chi^2$	Pre-Test		Post-Test		Z-Score	$\chi^2$
	Slope	SE	Slope	SE			Slope	SE	Slope	SE			Slope	SE	Slope	SE			Slope	SE	Slope	SE		
Feedback-1	-0.09	0.05	-0.31	0.06	-2.86 *	63.13 ***	-0.09	0.06	-0.34	0.06	-2.79 *	37.33 **	4.94E-16 §	0.09	0.07	1.17E-06	210.42 ***	-0.06	0.07	-0.02	0.04	0.48	42.84	
Feedback-2	-0.27	0.05	-0.61	0.11	-2.64 *	9.48	-0.30	0.06	-0.29	0.06	0.16	6.01	-0.24	0.06	-0.30	0.06	-0.76	40.98 **	-0.16	0.05	-0.36	0.07	-2.27 *	54.46 *
Feedback-3	-0.01	0.04	-0.45	0.08	-4.94 *	43.13 ***	0.01	0.04	-0.34	0.07	-4.34 *	24.19	-0.18	0.05	-0.37	0.10	-1.67	5.59	0.04	0.04	-0.23	0.07	-3.48 *	86.74 *
Feedback-4	0.35	0.37	-0.13	0.05	-1.29	32.38 *	-3.49E-16 §	-0.14	0.05	-1.72E-06	35.60 **	0.35	0.37	§	§	-0.01	4.75	3.27E-30 §	-0.35	0.10	-4.34E-06	211.96		
Feedback-5	-0.12	0.05	-0.47	0.09	-3.58 *	30.96 *	-0.07	0.05	-0.10	0.06	-0.47	102.72 ***	8.37E-17 §	0.03	0.11	3.19E-07	1.48	-0.08	0.04	-0.57	0.42	-1.15	102.53	
Feedback-6	-0.18	0.06	-0.08	0.04	1.45	37.09 **	-0.21	0.05	-0.13	0.04	1.17	7.24	-0.17	0.06	-0.05	0.06	1.39	3.31	-3.46E-03	0.04	-0.13	0.04	-2.15 *	46.39 *
No Feedback-1	-0.30	0.06	-0.41	0.07	-1.14	7.22	0.11	0.04	-0.20	0.05	-4.99 *	108.93 ***	0.11	0.04	0.09	0.04	-0.40	6.18	0.13	0.04	-0.17	0.05	-4.46 *	108.09 *
No Feedback-2	-0.02	0.04	-0.05	0.04	-0.50	47.92 ***	0.01	0.04	-0.06	0.04	-1.38	13.42	0.39	0.14	-0.32	0.10	-4.20 *	19.52	-0.07	0.04	§	§	0.01	118.40
No Feedback-3	0.02	0.04	4.18E-18	0.04	-0.36	18.48	0.12	0.04	0.05	0.04	-1.09	17.16	-0.03	0.04	-0.02	0.04	0.26	24.58	-0.04	0.04	0.11	0.04	2.74 *	29.51 *
No Feedback-4	-0.13	0.04	-1.00	0.23	-3.77 *	32.86 *	-0.12	0.04	-0.13	0.04	-0.10	98.78 ***	0.04	0.04	0.10	0.04	1.06	12.24	0.01	0.06	-0.03	0.04	-0.46	63.60
No Feedback-5	-0.07	0.04	-0.19	0.05	-1.90	14.84	-0.05	0.05	-0.50	0.09	-4.39 *	79.34 ***	0.03	0.05	0.01	0.04	-0.36	20.96	-0.18	0.06	-0.15	0.04	0.38	24.05
No Feedback-6	-0.17	0.05	-0.48	0.09	-3.08 *	52.70 ***	-0.18	0.05	-0.34	0.08	-1.67	16.19	0.08	0.20	-0.01	0.04	-0.42	105.36 ***	0.01	0.04	1.85	0.57	3.18 *	40.67 *
Untrained-1	-0.03	0.04	-0.01	0.04	0.32	4.73	-5.59E-16 §	0.18	0.17	2.19E-06	0.00	-0.17	0.09	-0.29	0.06	-1.10	27.05	-0.02	0.04	0.19	0.05	3.32 *	27.37 *	
Untrained-2	-0.04	0.04	8.56E-18	0.04	0.75	6.38	0.08	0.04	-0.11	0.04	-3.45 *	32.78 *	-0.08	0.04	-0.10	0.04	-0.28	31.50 *	-0.11	0.04	0.03	0.04	2.43 *	22.76 *
Untrained-3	-0.23	0.05	-0.32	0.06	-1.07	6.61	-0.38	0.07	-0.48	0.09	-0.88	22.11	-0.07	0.07	-0.24	0.09	-1.43	6.36	-0.04	0.04	-0.06	0.04	-0.42	30.16
Untrained-4	-0.18	0.04	-0.67	0.13	-3.49 *	21.54	-0.09	0.05	-0.13	0.04	-0.73	14.66	-0.05	0.04	-0.06	0.04	-0.27	53.15 ***	0.01	0.04	0.19	0.06	2.60 *	34.25 *
Untrained-5	-0.20	0.05	-0.10	0.04	1.70	8.15	-0.15	0.04	-0.17	0.04	-0.43	11.89	-0.07	0.04	-0.12	0.04	-0.82	17.76	-0.05	0.04	-0.16	0.04	-1.81	20.95
Untrained-6	-0.21	0.05	-0.24	0.05	-0.38	4.14	-0.23	0.05	-0.34	0.07	-1.29	7.27	-0.09	0.05	-0.12	0.04	-0.39	35.87 **	-0.18	0.12	-0.13	0.05	0.39	29.13

\*Indicates a significant difference at the 0.05 level

\*\*Indicates a significant difference at the 0.01 level

\*\*\*Indicates a significant difference at the 0.001 level

§Indicates a value that is poorly defined by the model



Table S.6

*Proportion Correct Discrimination of /r-l/ Pairs that Spanned the NE Category Boundary (Series Middle) at Pre- and Post-Test for all Vowel Contexts by all Listeners in Experiment 2.*

Listener	/ra-la/		/ræ-læ/		/ri-li/		/ru-lu/	
	Series Middle Pre-Test	Series Middle Post-Test	Series Middle Pre-Test	Series Middle Post-Test	Series Middle Pre-Test	Series Middle Post-Test	Series Middle Pre-Test	Series Middle Post-Test
Feedback-1	0.50 (0.81)	0.59 (0.88)	0.44 (0.50)	0.47 (0.81)	0.53 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)
Feedback-2	0.53 (0.75)	0.75 (1.00) *	0.63 (0.75)	0.59 (0.81)	0.50 (0.75)	0.50 (0.88)	0.53 (0.75)	0.56 (1.00)
Feedback-3	0.38 (0.50)	0.66 (0.94) *	0.59 (0.81)	0.38 (0.63) *	0.63 (0.81)	0.72 (1.00)	0.53 (0.81)	0.53 (0.75)
Feedback-4	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)
Feedback-5	0.50 (0.94)	0.81 (0.81) *	0.38 (0.50)	0.53 (0.94)	0.53 (1.00)	0.50 (0.81)	0.50 (1.00)	0.50 (1.00)
Feedback-6	0.41 (0.75)	0.56 (0.75)	0.53 (0.88)	0.66 (0.81)	0.44 (0.88)	0.53 (0.81)	0.53 (1.00)	0.50 (0.88)
No Feedback-1	0.41 (0.56)	0.59 (0.50)	0.56 (0.81)	0.63 (0.88)	0.66 (0.69)	0.69 (0.63)	0.47 (0.69)	0.63 (0.69)
No Feedback-2	0.44 (0.88)	0.50 (1.00)	0.56 (1.00)	0.53 (0.94)	0.56 (1.00)	0.50 (1.00)	0.56 (1.00)	0.44 (0.75)
No Feedback-3	0.56 (0.75)	0.47 (0.63)	0.53 (0.75)	0.63 (0.63)	0.47 (0.63)	0.56 (0.56)	0.50 (0.81)	0.53 (0.75)
No Feedback-4	0.47 (0.63)	0.97 (0.94) *	0.63 (0.94)	0.69 (0.81)	0.44 (0.63)	0.44 (0.44)	0.50 (1.00)	0.44 (0.50)
No Feedback-5	0.38 (0.69)	0.69 (0.81) *	0.53 (0.81)	0.53 (0.81)	0.53 (0.56)	0.59 (0.69)	0.50 (0.75)	0.53 (0.69)
No Feedback-6	0.50 (1.00)	0.50 (1.00)	0.59 (1.00)	0.50 (0.94)	0.59 (1.00)	0.50 (1.00) *	0.53 (1.00)	0.50 (1.00)
Untrained-1	0.53 (0.88)	0.53 (0.75)	0.50 (1.00)	0.53 (1.00)	0.63 (1.00)	0.44 (0.75) *	0.50 (1.00)	0.50 (1.00)
Untrained-2	0.44 (0.56)	0.72 (0.75) *	0.50 (0.75)	0.75 (0.75) *	0.72 (0.69)	0.47 (0.38) *	0.50 (0.69)	0.50 (0.56)
Untrained-3	0.66 (0.81)	0.56 (0.75)	0.63 (0.63)	0.50 (0.94)	0.53 (0.75)	0.53 (0.81)	0.47 (0.38)	0.50 (0.88)
Untrained-4	0.56 (0.63)	0.59 (0.56)	0.56 (0.81)	0.41 (0.50)	0.50 (0.63)	0.50 (0.63)	0.44 (0.81)	0.53 (0.50)
Untrained-5	0.50 (0.63)	0.53 (0.56)	0.56 (0.56)	0.66 (0.81)	0.56 (0.50)	0.53 (0.63)	0.41 (0.25)	0.47 (0.56)
Untrained-6	0.50 (0.75)	0.66 (0.81)	0.50 (0.47)	0.56 (0.56)	NA	NA	0.53 (0.56)	NA

Note: There were insufficient data points to estimate pre-test accuracy at the series middle for listener Untrained-6

\*Indicates a significant difference discriminating the series middle at pre- vs. post-test at the 0.05 level.

Hit rate is reported in parentheses.

Table S.7

*Proportion Correct Discrimination of /r-l/ Pairs that Spanned the NE Category Boundary (Series Middle) and Pairs that were Within One NE Category (Series End) at the Post-Test for all Vowel Contexts by all Listeners of Experiment 2.*

Listener	/ra-la/		/ræ-læ/		/ri-li/		/ru-lu/	
	Series Middle Post-Test	Series End Post-Test	Series Middle Post-Test	Series End Post-Test	Series Middle Post-Test	Series End Post-Test	Series Middle Post-Test	Series End Post-Test
Feedback-1	0.59 (0.88)	0.60 (0.83)	0.47 (0.81)	0.51 (0.81)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)
Feedback-2	0.75 (1.00)	0.69 (0.95)	0.59 (0.81)	0.68 (0.83)	0.50 (0.88)	0.63 (0.83)	0.56 (1.00)	0.63 (0.89)
Feedback-3	0.66 (0.94)	0.63 (0.94)	0.38 (0.63)	0.58 (0.79) *	0.72 (1.00)	0.54 (0.86) *	0.53 (0.75)	0.52 (0.81)
Feedback-4	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.55 (0.96)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)	0.50 (1.00)
Feedback-5	0.81 (0.81)	0.64 (0.91) *	0.53 (0.94)	0.51 (0.90)	0.50 (0.81)	0.50 (0.85)	0.50 (1.00)	0.50 (1.00)
Feedback-6	0.50 (0.75)	0.53 (0.74)	0.50 (0.81)	0.62 (0.80)	0.50 (0.81)	0.56 (0.91)	0.50 (0.88)	0.52 (0.88)
No Feedback-1	0.59 (0.50)	0.46 (0.53)	0.63 (0.88)	0.72 (0.90)	0.69 (0.63)	0.58 (0.71)	0.63 (0.69)	0.51 (0.61)
No Feedback-2	0.50 (1.00)	0.62 (0.91)	0.53 (0.94)	0.58 (0.88)	0.50 (1.00)	0.59 (0.98)	0.44 (0.75)	0.48 (0.80)
No Feedback-3	0.47 (0.63)	0.56 (0.64)	0.63 (0.63)	0.58 (0.61)	0.56 (0.56)	0.53 (0.79)	0.53 (0.75)	0.58 (0.73)
No Feedback-4	0.97 (0.94)	0.56 (0.88) *	0.69 (0.81)	0.74 (0.85)	0.44 (0.44)	0.55 (0.71)	0.44 (0.50)	0.53 (0.56)
No Feedback-5	0.69 (0.81)	0.58 (0.84)	0.53 (0.81)	0.61 (0.91)	0.59 (0.69)	0.48 (0.59)	0.53 (0.69)	0.41 (0.54)
No Feedback-6	0.50 (1.00)	0.49 (0.98)	0.50 (0.94)	0.54 (0.90)	0.50 (1.00)	0.51 (1.00)	0.50 (1.00)	0.51 (1.00)
Untrained-1	0.53 (0.75)	0.58 (0.69)	0.53 (1.00)	0.51 (1.00)	0.44 (0.75)	0.60 (0.75) *	0.50 (1.00)	0.50 (1.00)
Untrained-2	0.72 (0.75)	0.64 (0.71)	0.75 (0.75)	0.57 (0.61) *	0.47 (0.38)	0.53 (0.54)	0.50 (0.56)	0.53 (0.50)
Untrained-3	0.56 (0.75)	0.49 (0.74)	0.50 (0.94)	0.53 (0.90)	0.53 (0.81)	0.49 (0.81)	0.50 (0.88)	0.46 (0.70)
Untrained-4	0.59 (0.56)	0.61 (0.58)	0.41 (0.50)	0.68 (0.66) *	0.50 (0.63)	0.68 (0.59) *	0.53 (0.50)	0.63 (0.54)
Untrained-5	0.53 (0.56)	0.50 (0.55)	0.66 (0.81)	0.55 (0.56)	0.53 (0.63)	0.53 (0.60)	0.47 (0.56)	0.46 (0.54)
Untrained-6	0.66 (0.81)	0.48 (0.64) *	0.56 (0.56)	0.54 (0.61)	0.53 (0.56)	0.64 (0.60)	0.53 (0.63)	0.51 (0.64)

Note: There were insufficient data points to estimate pre-test accuracy at the series middle for listener Untrained-6

\*Indicates a significant differences in discrimination performance of the post-test series middle vs. the series end at the 0.05 level.

Hit rate is reported in parentheses.

Table S.8

*Proportion Correct Identification of Natural Speech /r-/ at the Pre- and Post-Tests as a Function of Contrast Position.*

Listener	Initial Singleton		Initial Cluster		Intervocalic		Final Singleton	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test
Feedback-1	0.59	1.00	0.47	0.53	0.56	0.75	1.00	1.00 *
Feedback-2	0.71	0.94	0.88	0.76	0.88	0.75	1.00	1.00
Feedback-3	0.59	0.59	0.53	0.35	0.63	0.50	0.36	0.71
Feedback-4	0.35	0.65	0.59	0.53	0.56	0.31	0.50	0.50
Feedback-5	0.76	0.71	0.35	0.76	0.38	0.75	1.00	1.00 *
Feedback-6	0.71	0.76	0.59	0.59	0.75	0.81	0.86	0.79
No Feedback-1	0.94	0.88	0.47	0.65	0.88	0.88	1.00	1.00
No Feedback-2	0.59	0.53	0.41	0.59	0.63	0.63	0.71	0.29
No Feedback-3	0.59	0.47	0.71	0.53	0.50	0.44	0.93	0.86
No Feedback-4	0.88	0.76	0.76	0.82	0.75	0.81	0.93	0.93
No Feedback-5	0.65	0.76	0.47	0.59	0.69	0.88	0.71	0.86 *
No Feedback-6	0.71	0.71	0.59	0.41	0.69	0.81	0.71	0.79
Untrained-1	1.00	1.00	0.76	1.00	1.00	1.00	0.86	0.93
Untrained-2	0.71	0.65	0.59	0.71	0.88	0.63	0.57	0.71
Untrained-3	0.76	0.94	0.65	0.65	0.63	0.88	1.00	1.00 *
Untrained-4	0.71	0.76	0.53	0.82	0.88	0.75	1.00	1.00
Untrained-5	0.65	0.53	0.53	0.53	0.56	0.56	0.50	0.71
Untrained-6	0.82	0.88	0.65	0.76	0.88	0.81	1.00	1.00

\*Showed a significant improvement from pre- to post-test when collapsing across contrast positions.

Table S.9  
*Average Level of Difficulty on Each Training Day for Each Listener in  
 Experiment 2.*

Training Day	Feedback-Trained Listeners						No Feedback-Trained Listeners					
	1	2	3	4	5	6	1	2	3	4	5	6
1	60	32	92	0	97	0	69	72	3	63	25	39
2	90	87	111	18	121	23	104	47	3	93	62	85
3	92	116	122	35	52	57	111	39	74	126	111	95
4	104	118	119	50	14	17	103	87	62	130	119	89
5	126	123	124	36	100	8	119	63	107	130	113	97
6	127	122	99	61	124	1	125	73	107	129	126	94
7	123	122	129	19	63	1	125	61	107	131	125	100
8	131	122	67	82	48	1	125	47	107	131	123	107

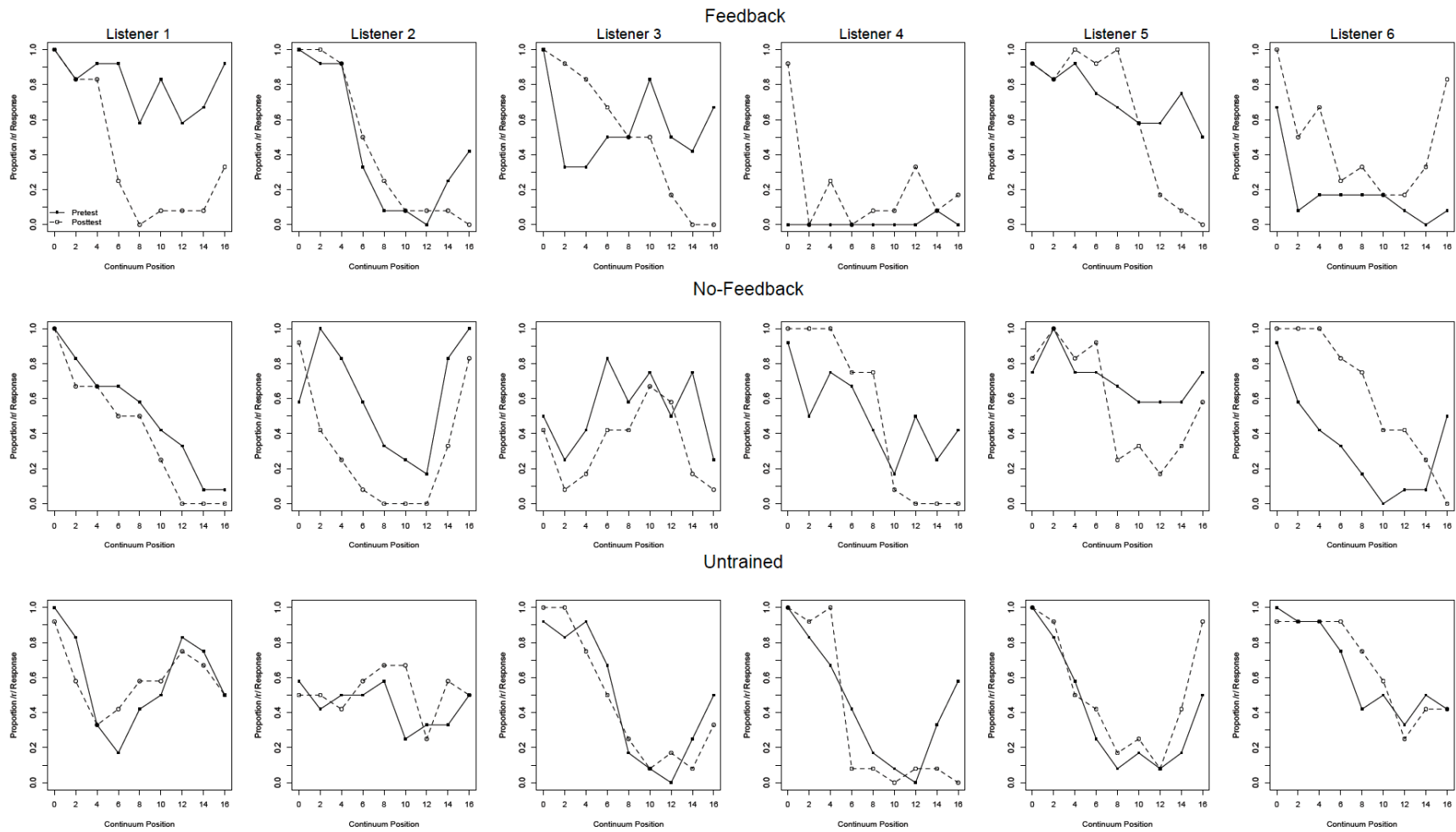


Figure S. 1. Pre- and post-test identification performance on the /ra-la/ continuum for all participants in Experiment 2.

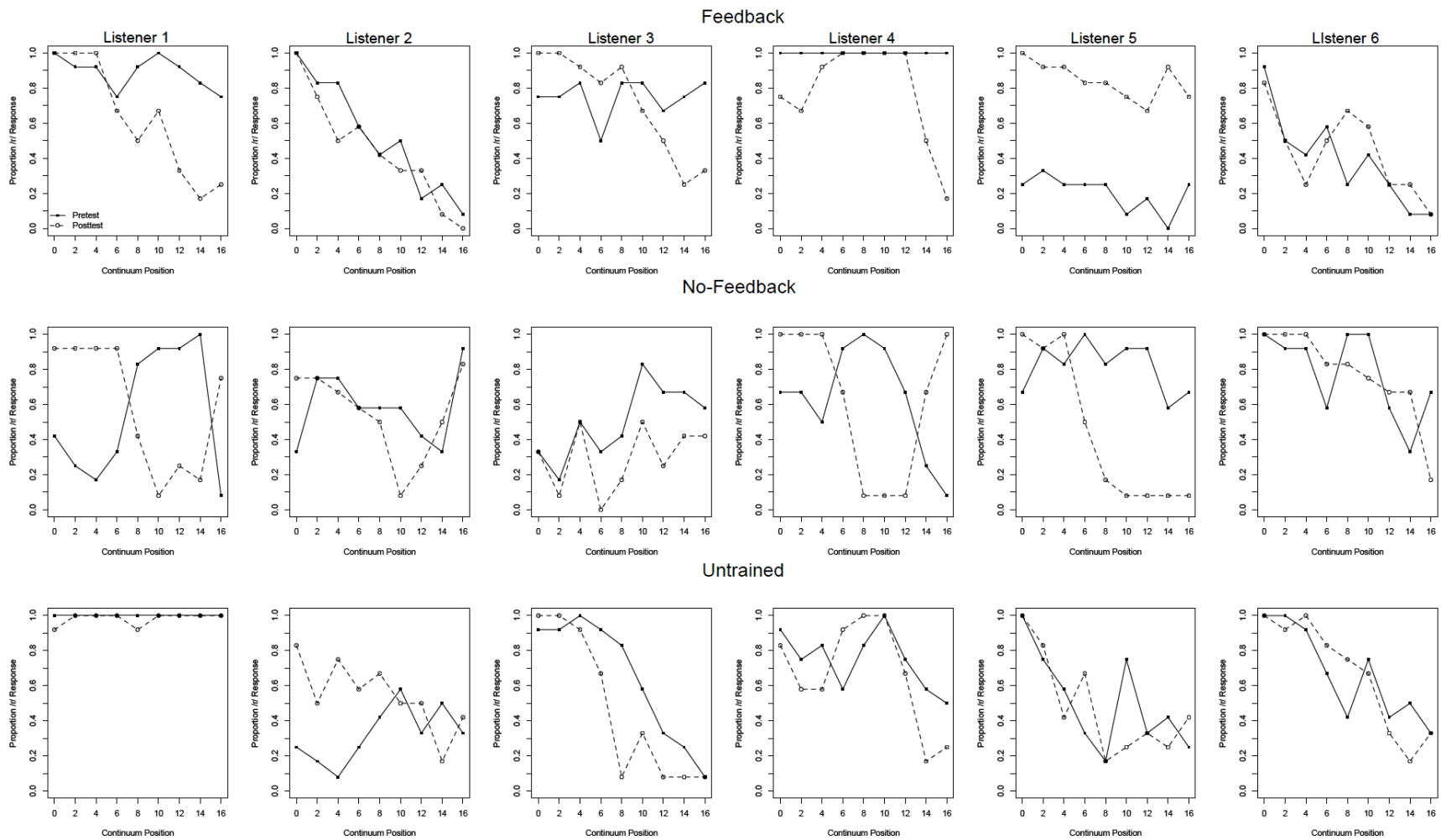


Figure S.2. Pre- and post-test identification performance on the /ræ-læ/ continuum for all participants in Experiment 2.

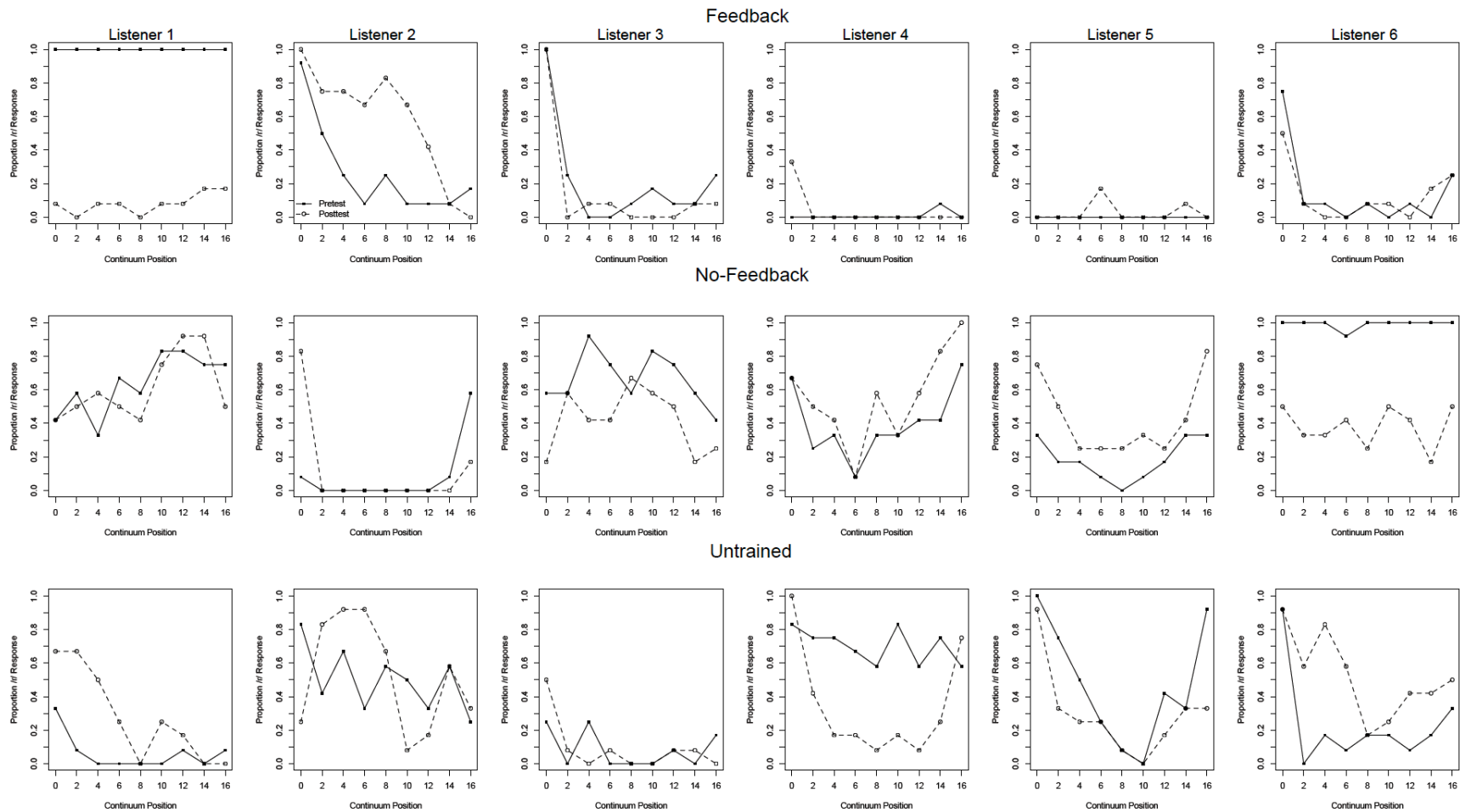


Figure S.3. Pre- and post-test identification performance on the /ri-li/ continuum for all participants in Experiment 2.

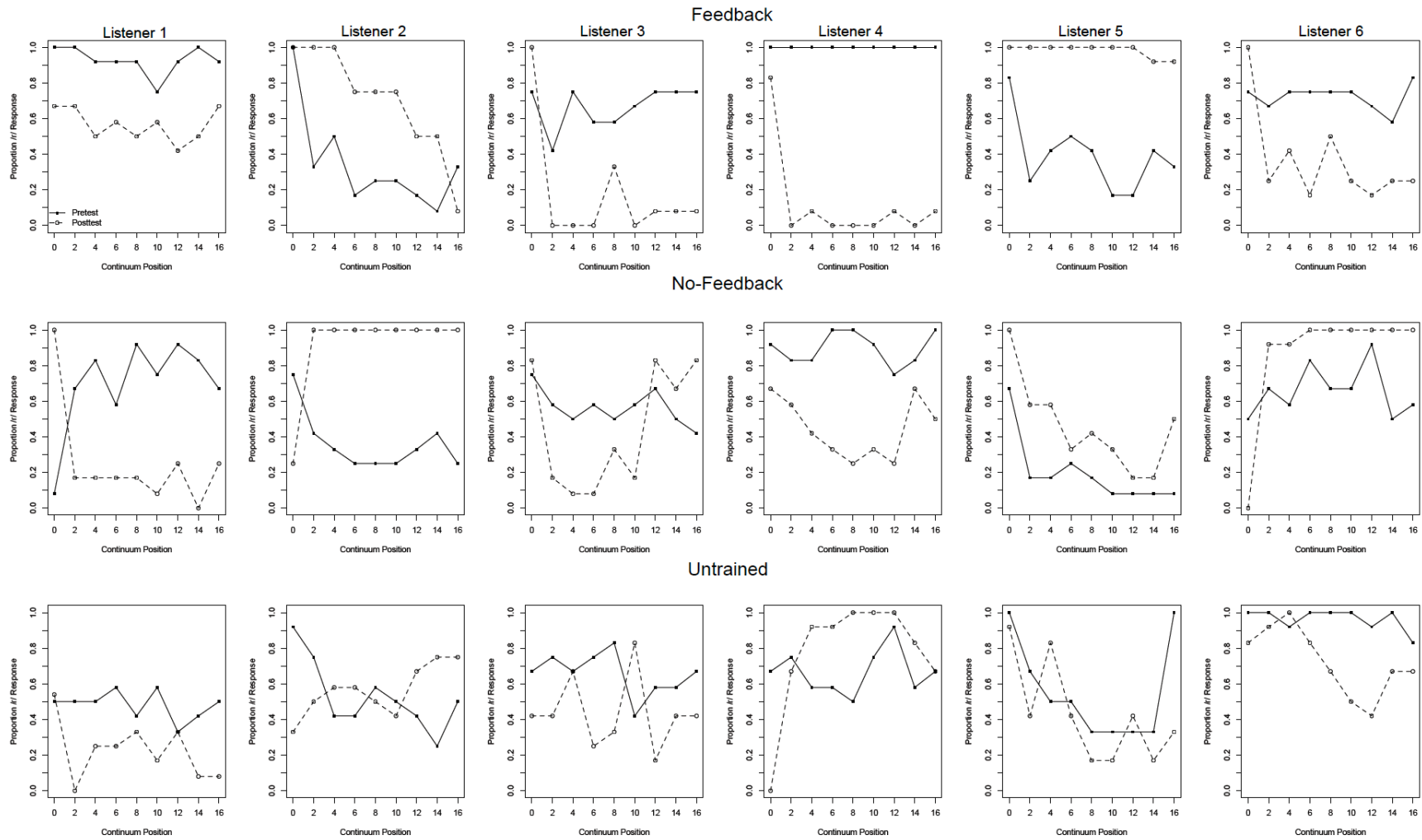


Figure S.4. Pre- and post-test identification performance on the /ru-lu/ continuum for all participants in Experiment 2.