Supplemental Material 1: Exploring effects of Age of First Fitting and Vocabulary

Age of first fitting

       To check whether possible differences in length of (aided) auditory exposure affected our main conclusions about the effects of Age, Group, and WordType, we investigated the effects of Age of First Fitting (AoFF) (see Table 1) on performance. Firstly, there was no evidence that AoFF correlated with subject-averaged proportion of post-naming target looking in the DHH group ($r(16)$, 0.02, $p = 0.917$, 95% CI [-.44,.48]). We then added AoFF (z-transformed) as a covariate to our first "all trial" model in the average proportion of looks analysis[1], assigning an AoFF of 0 to all children with NH, reflecting that their (post-natal) auditory exposure started at birth. This analysis rendered no significant effect of AoFF ($\beta = -0.05$, $SE = 0.07$, $t = -0.69$, $p = .488$) and a result pattern identical to that obtained with the model without AoFF (see Table A). As can be observed in Table 1 (main text), one child was not fitted with a device and two were diagnosed with HL at 4.5 and 6.1 years of age. For these children, age of first fitting probably does not reliably capture their listening experience. To check whether these children skewed our analysis, we performed another analysis excluding them, and again obtained identical result patterns (see Table B)[2].

Table A

Analysis Age of First Fitting (z-transformed) with all children included

Predictors	Log-Odds	SE	z	p
Age of First Fitting	-0.05	0.07	-0.69	0.488
Age z-score	0.22	0.07	3.41	0.001
Group (NH vs. DHH)	-0.19	0.17	-1.14	0.254
WordType (Control vs. Min Pair)	-0.33	0.16	-2.12	0.034
Age * Group	0.06	0.13	0.44	0.658
Age * WordType	0.05	0.07	0.66	0.507
Group * WordType	-0.03	0.21	-0.17	0.867
Age * Group * WordType	0.25	0.14	1.80	0.072

Note. DHH = Deaf and Hard of Hearing, NH = Normal-Hearing, Min Pair = Minimal pair.

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[1] With the following model structure in R: glmer(cbind(SamplesInAOI.post, SamplesInDistractor.post)~
1+AoFFzscore+Agezscore*Group*WordType+(1 + WordType|Subject) + (1 + Group|Audioname))

[2] Prior to fitting AoFF + Age * WordType * Group, a model with AoFF * Age * WordType * Group was checked for interactions with AoFF that might explain variance (model was rank-deficient so dropped 4 terms). No significant interactions with AoFF were found and thus AoFF was included as a covariate (see online materials: OSF | Real-time Spoken Word Recognition in Deaf and Hard of Hearing Preschoolers: Effects of Phonological Competition).

Table B

Analysis Age of First Fitting (z-transformed) excluding three children

Predictors	Log-Odds	SE	z	p
Age of First Fitting	0.00	0.08	0.02	0.982
Age z-score	0.20	0.07	2.80	0.005
Group (NH vs. DHH)	-0.22	0.19	-1.13	0.257
WordType (Control vs. Min Pair)	-0.32	0.16	-1.98	0.048
Age * Group	-0.00	0.14	-0.00	0.998
Age * WordType	0.06	0.08	0.80	0.424
Group * WordType	-0.02	0.22	-0.09	0.925
Age * Group * WordType	0.29	0.16	1.83	0.068

Note. DHH = Deaf and Hard of Hearing, NH = Normal-Hearing, Min Pair = Minimal pair

Vocabulary scores

Vocabulary scores were present for 15 of the 18 DHH children. To better understand the relationship between vocabulary scores and word- and minimal pair recognition (Word Type) for this group, we investigated the effects of PPVT (standard) scores (see Table 1 in main text) on performance. Age (z-transformed) was included in the model to observe effects over and above age.

There was evidence that PPVT standard scores correlated with subject-averaged proportion of post-naming target looking in the DHH group (r(13), 0.58, p = 0.022, 95% CI [.10,.84]). We then added PPVT standard scores (z-transformed) as a covariate to our first "all trial" model in the average proportion of looks analysis[3], deleting the factor Group and the NH data entries as there were only PPVT scores for DHH children. This analysis rendered an effect of WordType (β = -.43, SE = .21, t = -2.07, p = .038) and an effect of PPVT * WordType (β = .20, SE = .09, t = 2.30, p = .021), suggesting increased difficulty with minimal pair recognition (defined as an increased difference between non-minimal and minimal pair recognition) as vocabulary scores lowered.

Predictors	Log-Odds	SE	Statistic	p
PPVT (standard score) z-score	0.15	0.10	1.52	0.128
Age z-score	0.04	0.10	0.39	0.695
WordType (Control vs. Min Pair)	-0.43	0.21	-2.07	0.038
PPVT * Age	-0.08	0.11	-0.75	0.452
PPVT * WordType	0.20	0.09	2.30	0.021
Age * WordType	0.17	0.09	1.93	0.054
PPVT * Age * WordType	-0.02	0.09	-0.22	0.828

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[3] With the following model structure in R: glmer(cbind(SamplesInAOI.post, SamplesInDistractor.post)~
1+PPVTzscore*Agezscore*WordType+(1 + WordType|Subject) + (1|Audioname), data=DataModel_ppvt, family = binomial, control=ctrl_glmer)

As DHH children with smaller vocabularies have increased difficulty with minimal pair (as opposed to non-minimal pair) recognition, this suggests that children with smaller vocabularies may experience greater phonological competition. This might theoretically be explained by the lexical restructuring hypothesis, in which properties of the developing lexicon influence phonological processing (Walley, 1993). However, we cannot draw any conclusion about the directionality of this effect. For example, the degraded input DHH children receive may lead to smaller vocabularies and thus greater phonological competition, or increased phonological competition may be detrimental for word learning in DHH children, leading to smaller vocabularies.

References

Walley, A. C. (1993). The role of vocabulary development in children's spoken word recognition and segmentation ability. *Developmental Review*, *13*(3), 286-350. https://doi.org/10.1006/drev.1993.1015

Supplemental Material 2: Minimal pairs (Word 1 and Word 2) for the LWL task and corresponding phonemic contrasts

Segment Position	Type of Contrast	PoA	Contrast	Word 1	Word 2
Onset					
	Voicing	Bilabial	b/p	Bin	Pin
			b/p	Bath	Path
		Alveolar	d/t	Dough	Toe
			d/t	Deer	Tear
		Velar	g/k	Goat	Coat
			g/k	Gold	Cold
	PoA	Bilabial-velar	b/g	Boat	Goat
			p/k	Pearl	Curl
			p/k	Page	Cage
			p/k	Pea	Key
		Bilabial-alveolar	b/d	Bow	Dough
			b/d	B*	D*
			p/t	Pool	Tool
			p/t	Pen	Ten
		Alveolar-velar	d/g	Date	Gate
			t/k	Tape	Cape
			t/k	Tea	Key
			t/k	Toast	Coast
Coda					
	Voicing	Alveolar	d/t	Seed	Seat
			d/t	Pod	Pot
		Velar	g/k	Log	Lock
			g/k	Bag	Back
	PoA	Bilabial-velar	b/g	Rub	Rug
			b/g	Mud	Mug
			p/k	Cape	Cake
		Bilabial-alveolar	p/t	Map	Mat
			p/t	Cup	Cut
		Alveolar-velar	t/k	Net	Neck
			t/k	Bite	Bike
			t/k	Bat	Back

Note. PoA = Place of Articulation. * the letters 'B' and 'D'

Supplemental Material 3: Pixel and Luminance Values

Segment Position	Type of Contrast	Picture 1	Pixel	M lum bef. (HSV)	M lum after (HSV)	Picture 2	Pixel	M lum bef. (HSV)	M lum after (HSV)
Onset	Voicing	Bin	102334	0.857	0.881	Pin	100668	0.856	0.885
		Bath	101006	0.875	0.883	Path	104107	0.859	0.881
		Dough_toe	102545	0.943	0.885	Toe	102514	0.949	0.886
		Deer	101357	0.852	0.882	Tear	100941	0.905	0.883
		Goat_coat	106464	0.873	0.877	Coat	105277	0.879	0.879
		Gold	102985	0.882	0.880	Cold	102076	0.890	0.882
	PoA	Boat	106044	0.835	0.878	Goat_boat	103712	0.837	0.880
		Pearl	102845	0.898	0.881	Curl	103675	0.923	0.881
		Page	103001	0.897	0.884	Cage	100725	0.861	0.883
		Pea	101938	0.869	0.883	Key_pea	101734	0.877	0.885
		Bow	101787	0.927	0.886	Dough_bow	102545	0.943	0.885
		B	103262	0.893	0.887	D	100602	0.897	0.890
		Pool	102375	0.870	0.882	Tool_pool	100865	0.856	0.885
		Pen	101515	0.910	0.884	Ten	100237	0.888	0.886
		Date	102925	0.883	0.883	Gate	101163	0.857	0.881
		Tape	102262	0.929	0.885	Cape_tape	103447	0.888	0.880
		Tea	103849	0.874	0.879	Key_tea	103220	0.879	0.881
		Toast	102642	0.916	0.881	Coast	100664	0.926	0.886
Coda	Voicing	Seed	100575	0.837	0.885	Seat	101437	0.926	0.884
		Pod	101128	0.867	0.882	Pot_pod	102312	0.882	0.884
		Log	102937	0.851	0.883	Lock	103330	0.854	0.886
		Bag	105424	0.890	0.882	Back_bag	105534	0.858	0.879
	PoA	Rub	108032	0.921	0.874	Rug	109652	0.911	0.876
		Mud	101820	0.859	0.886	Mug	102616	0.858	0.885
		Cape_cake	101902	0.925	0.886	Cake	100104	0.921	0.883
		Map	103804	0.917	0.881	Mat	102713	0.900	0.880
		Cup	104493	0.894	0.884	Cut	102293	0.901	0.887
		Net	107392	0.843	0.875	Neck	106384	0.861	0.882
		Bite	103166	0.871	0.885	Bike	104860	0.829	0.879
		Bat	100329	0.853	0.887	Back_bat	104061	0.900	0.884
Non-MP		Book	101060	0.863	0.887	Tail	102065	0.861	0.885
		Comb	105619	0.880	0.878	Bib	104746	0.909	0.881
		Dice	101764	0.858	0.882	Pear	100911	0.876	0.888
		Toy	101387	0.906	0.883	Bed	101692	0.918	0.886
		Dog	102484	0.871	0.883	Cow	103741	0.860	0.880
		Ball	103576	0.864	0.883	Car	104414	0.861	0.879
		Bus	103688	0.893	0.879	Kite	100709	0.889	0.883
		Pan	103142	0.830	0.883	Door	103409	0.834	0.883

Supplemental Material 4: Intensity values

Position	Type of Contrast	Word 1	Mean intensity in dB	Word 2	Mean intensity in dB	Overall Mean (SD)
Onset	Voicing	Bin	47.02	Pin	45.67	
		Bath	46.16	Path	43.67	
		Dough_toe	47.67	Toe	48.97	
		Deer	48.02	Tear	47.45	
		Goat_coat	44.55	Coat	43.00	
		Gold	46.17	Cold	46.92	
						46.27 (1.8)
	PoA	boat	44.65	goat	44.55	
		pearl	50.88	curl	49.95	
		page	46.69	cage	45.36	
		pea	47.26	key	45.56	
		bow	49.70	dough	47.67	
		B	45.59	D	43.91	
		pool	47.80	tool	49.51	
		pen	45.34	ten	47.95	
		date	43.64	gate	43.80	
		tape	42.84	cape	41.66	
		tea	46.14	key	45.56	
		toast	48.19	coast	47.45	
						46.08 (2.48)
Coda	Voicing	seed	51.36	seat	47.11	
		pod	48.91	pot	44.66	
		log	52.98	lock	46.80	
		bag	48.46	back	41.44	
						43.03 (14.61)
	PoA	net	47.53	rug	51.23	
		rub	52.05	mug	50.08	
		mud	51.53	cake	41.74	
		cape	41.66	mat	47.18	
		map	46.36	cut	42.26	
		cup	42.38	neck	44.49	
		bite	44.12	bike	42.25	
		bat	44.42	back	41.44	
						44.83 (3.27)
Non-MP		book	40.84	tail	48.04	
		comb	49.84	bib	45.43	
		dice	46.70	pear	49.05	
		toy	46.81	bed	44.26	
		dog	48.35	cow	50.20	
		ball	47.11	car	51.57	
		bus	48.33	kite	43.86	
		pan	48.61	door	49.12	
						47.83 (2.31)

Note. Intensity was measured using the averaging method 'dB' in Praat (Boersma & Weenink, 2020)

Supplemental Material 5: Link to online scripts that show outcomes of the word familiarity analysis: [OSF | Real-time Spoken Word Recognition in Deaf and Hard of Hearing Preschoolers: Effects of Phonological Competition](#)

Please see: Analysis Code -> 'averageproportionanalyses_LWL_OSF_fixedknit' -> additional analyses -> Word Familiarity Analysis

Supplemental Material 6: Excluded trials in the LWL task

4A. *Mean (SD) % of excluded trials in the Looking-While-Listening Task per Group per Condition.*

| | Onset | | Coda | | Non-MP |
	Voicing (*n*=6)	PoA (*n*=12)	Voicing (*n*=4)	PoA (*n*=8)	(*n*=8)
NH group	9.9 % (16.2) %	16.7 % (19.4) %	15.7 % (18.5) %	19.3 % (17.9) %	15.2 % (13.3) %
DHH group	15.8 % (16.6) %	19.9 % (19.6) %	34.7 % (31.1) %	19.4 % (18.8) %	22.9 % (18.5) %

Note. The total *n* amount of trials in the experiment is given per condition. DHH = Deaf and Hard of Hearing, NH = Normal-Hearing, PoA = Place of Articulation, MP = Minimal Pair.

4B. *Number of trials each child contributed to each condition, with the number of total trials in each condition displayed in the header*

| | Subject | Onset | | Coda | | Non-MP (*n*=8) |
		Voicing (*n*=6)	PoA (*n*=12)	Voicing (*n*=4)	PoA (*n*=8)	
NH	101	6	12	4	6	7
	104	6	12	4	8	8
	105	6	11	4	8	8
	106	6	7	4	7	7
	107	6	8	3	7	6
	108	6	10	4	7	8
	109	6	12	4	5	7
	110	6	9	4	8	7
	111	4	11	4	7	6
	112	6	11	4	6	7
	113	6	12	3	7	7
	114	4	12	4	6	8
	115	4	8	3	5	8
	116	5	10	2	6	7
	117	6	7	2	6	6
	118	6	12	4	7	7
	119	6	12	3	7	7
	120	6	8	3	3	5
	121	5	12	4	7	8
	122	5	7	3	7	6
	123	6	12	2	7	6
	124	6	11	3	7	8
	125	3	10	4	8	5
	126	6	12	3	6	6
	127	5	6	2	2	5
	129	6	12	4	8	8
	130	3	4	3	6	5
DHH	202	5	10	1	4	4
	203	6	12	4	8	8
	204	6	12	4	8	8
	205	6	9	4	8	7
	206	4	7	1	6	5
	207	4	9	2	6	7

208	6	11	4	8	8
209	6	11	2	6	4
216	3	7	0	7	6
218	5	10	4	3	5
219	5	11	3	5	5
220	6	12	3	7	7
221	3	7	2	7	7
223	5	11	2	6	4
224	6	12	3	8	7
225	5	4	2	6	5
226	5	7	2	5	6
228	5	11	4	8	8

Note. PoA = Place of articulation, NH = normal-hearing, DHH = deaf and hard of hearing

Supplemental Material 7: Outcomes of Mixed Effects Logistic Regression on Pre-window Proportion of Looking Time to Target All-trial model (Group, Word Type)

Predictors	Estimate (log-odds)	SE	t-value	p	Estimate (odds-ratio)
	Dependent Variable				
Group: NH (-0.5) vs. DHH (+0.5)	-0.06	0.15	-0.42	0.678	0.94
WordType: Non-MP (-0.5) vs. Min Pair (+0.5)	-0.07	0.20	-0.37	0.708	0.93
NH vs. DHH * Non-MP vs. Min Pair	-0.00	0.30	-0.01	0.988	1.00

Supplemental Material 8: Outcomes of Mixed Effects Logistic Regression on Pre-window Proportion of Looking Time to Target Minimal Pair Trials (Group, Segment Position, Word Type)

Predictors	Dependent Variable				
	Estimate (log-odds)	SE	t-value	p	Estimate (odds-ratio)
Group: NH vs. DHH	-0.02	0.19	-0.12	0.907	0.98
SegPos: Onset vs. Coda	0.09	0.20	0.46	0.645	1.10
TypeCon: Voicing vs. PoA	-0.01	0.21	-0.03	0.976	0.99
NH vs. DHH * Onset vs. Coda	0.10	0.33	0.30	0.765	1.10
NH vs. DHH * Voicing vs. PoA	-0.07	0.35	-0.21	0.835	0.93
Onset vs. Coda * Voicing vs. PoA	0.02	0.41	0.05	0.958	1.02
NH vs. DHH * Onset vs. Coda * Voicing vs. PoA	-0.25	0.65	-0.39	0.700	0.78

Supplemental Material 9: Boxplots showing proportion of looking time averaged over the pre-naming window in A) All trial model and B) Minimal pair model. Diamonds indicate the mean. MP = minimal Pair, DHH = deaf and hard of hearing, NH = normal-hearing, PoA = place of articulation, prop. = proportion, avg. = average.
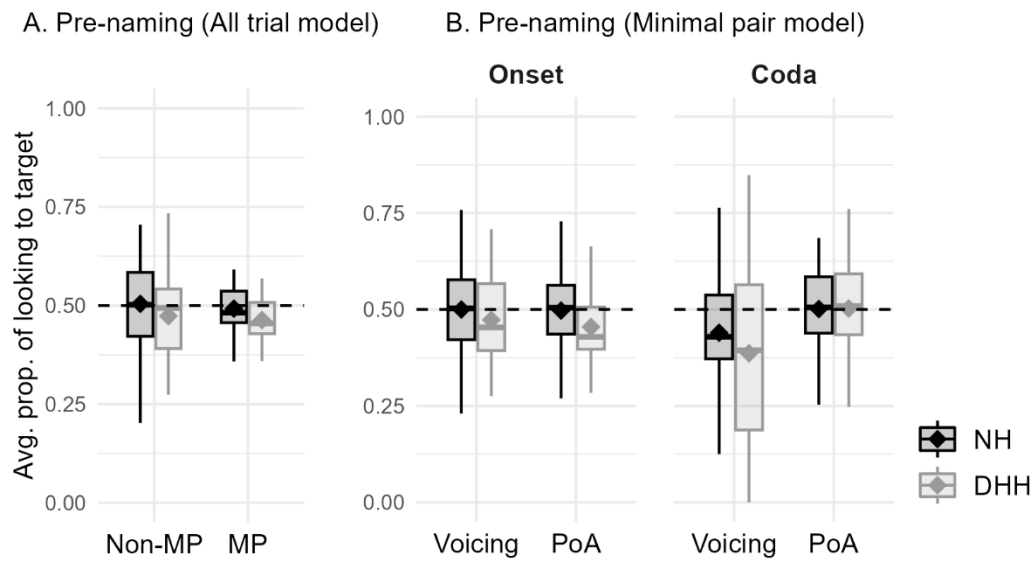
Supplemental Material 10: Results of the maximal minimal pair model (Age, Group, Segment Position, and Type Contrast), showing model estimates, standard errors (SE), t-values, p-values, and odds ratios.

Predictors	Est. (log-odds)	Est. (odds ratio)	SE (log-odds)	t-value	p
Age z-score	0.21	1.23	0.08	2.60	**0.009***
Group: NH (-0.5) vs. DHH (+0.5)	-0.46	0.63	0.18	-2.48	**0.013***
SegPos: Onset (-0.5) vs. Coda (+0.5)	-0.22	0.80	0.20	-1.10	0.271
TypeCon: Voicing (-0.5) vs. PoA (+0.5)	-0.11	0.89	0.19	-0.59	0.554
Age * Group	0.30	1.35	0.16	1.88	**0.059**
Age * Segment Position	-0.07	0.94	0.14	-0.48	0.631
Group * Segment Position	-0.52	0.59	0.33	-1.58	0.114
Age * Type Contrast	0.14	1.15	0.12	1.18	0.236
Group * Type Contrast	0.30	1.35	0.30	1.01	0.312
Segment Position * Type Contrast	-0.20	0.82	0.40	-0.50	0.616
Age * Group * Segment Position	0.43	1.53	0.28	1.54	0.124
Age * Group * Type Contrast	-0.09	0.91	0.24	-0.39	0.696
Age * Segment Position * Type Contrast	0.15	1.16	0.28	0.53	0.598
Group * Segment Position * Type Contrast	0.50	1.65	0.66	0.75	0.451
Age * Group * Segment Position * Type Contrast	-0.22	0.80	0.56	-0.40	0.691

Note. The log-odds model outputs are reported in-text, but the table also reports the Odds Ratios, i.e.,

exp(log-odds). Bold font with an asterisk indicates a *p*-value < 0.05. Bold font only indicates a *p*-value <0.10. NH = Normal Hearing, DHH = Deaf and Hard of Hearing, SegPos = Segment Position,

TypeCon = Type of Contrast, Est. = Estimate.

Supplemental Material 11: Table with all detected time-clusters in the cluster-based permutation analyses.

Predictors	Time-window (ms)	$\sum t$	Monte Carlo p
Main effects			
Group (NH vs. DHH)	0-100	2.47	.350
	500-1800	-33.33	**.012***
Word Type (Non-MP vs. MP)	1000-2400	45.72	**.000***
Segment Position (Coda vs. Onset)	-200- -100	-2.11	.465
	2200-2400	-4.74	.260
	2500-2900	-9.43	.128
Type of Contrast (PoA vs. Voicing)	-300--200	2.21	.418
Interaction effects			
Group * Word Type (NH vs. DHH * Non-MP vs. MP)	1700-2400	-18.85	**.011***
Group * Segment Position (NH vs. DHH * Coda vs. Onset)	2500-2600	-2.07	.475
Group * Type of Contrast (NH vs. DHH * PoA vs. Voicing)	-	-	-
Type of Contrast * Segment Position (PoA vs. Voicing * Coda vs. Onset)	400-900	13.71	**.037***
NH: Type of Contrast * Segment Position	600-800	4.38	.358
DHH: Type of Contrast * Segment Position	500-700	5.56	.238
Age (z-transformed) effects			
Age ~ all trials	-500- -400	-2.18	.353
	100-1200	32.91	**.005***
	1700-1900	4.57	.218
	2400-3000	19.31	**.024***

Note. Bold font with an asterisk indicates a *p*-value < 0.05. Bold font only indicates a *p*-value <0.10. NH = Normal Hearing, DHH = Deaf and Hard of Hearing, non-MP = Non-Minimal pair, MP = Minimal Pair, PoA = Place of Articulation, $\sum t$ = cluster-level sum statistic
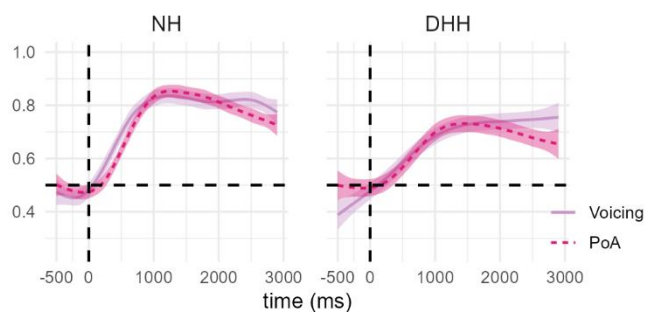
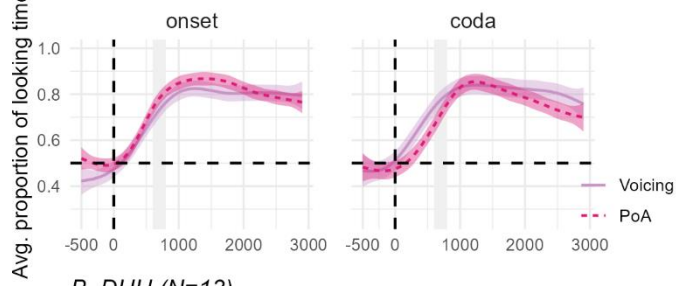Supplemental Material 12: Looking time courses for the Group * Segment Position and Group * Type Contrast and interactions
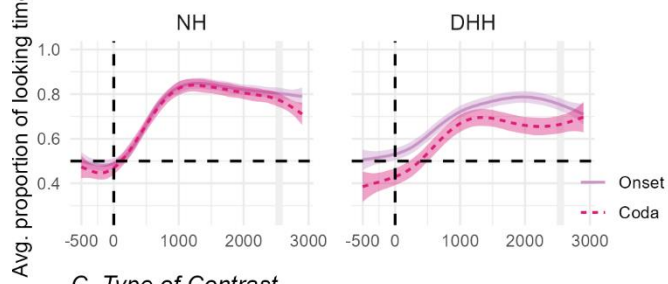
Supplemental Material 13. *Looking time courses for DHH: Segment Position * Type Contrast and NH: Segment Position * Type Contrast interactions. MP = Minimal Pair*

Segment Position * Type of Contrast (MP trials)

A. NH (N=25)

B. DHH (N=13)