Phonology **38** (2021). Supplementary materials

The dynamical landscape: phonological acquisition and the phonology–phonetics link

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Supplementary materials

These supplementary materials contain three appendices. Acoustic illustrations of Voice Assimilation in adult Polish, a boxplot for voicing percentage in fricatives in the speech of J's caregiver and waveform illustrations of positive VOTs in J's realisations of stops (§2.2 and §3.1) are provided in Appendix A, SPSS codes for statistical analyses, statistical results and goodness-of-fit measures (§3.2) are given in Appendix B and a summary of mathematical formulas (§4.2) appears in Appendix C.

A postprocessed data file, DynamicalLandscapeData.zip, is available at https://doi.org/10.1017/S0952675721000051. It contains two Excel files:

(i) AdultData.xlsx, which includes:
- voicing percentage measurements in obstruent clusters in adult Polish (Voice Assimilation contexts; §2.2);
- voicing percentage measurements in voiced fricatives in adult Polish (prevocalic contrastive contexts; Appendix A2).

(ii) ChildData.xlsx, which includes:
- a list of symbols used;
- voicing percentage measurements in fricatives and stops (presonorant contrastive contexts; §3.1–§3.2), as well as positive VOT measurements in stops (presonorant contrastive contexts; §3.1–§3.2, Appendix A3). Measurements for each of the seven stages of development are given in a separate sheet;
- voicing percentage measurements in obstruent clusters (Voice Assimilation contexts; §3.1–§3.2). Measurements for each of the seven stages of development are given in a single sheet.

Appendix A

1 Acoustic illustrations of Voice Assimilation effects in the speech of J's caregiver (§2.2)

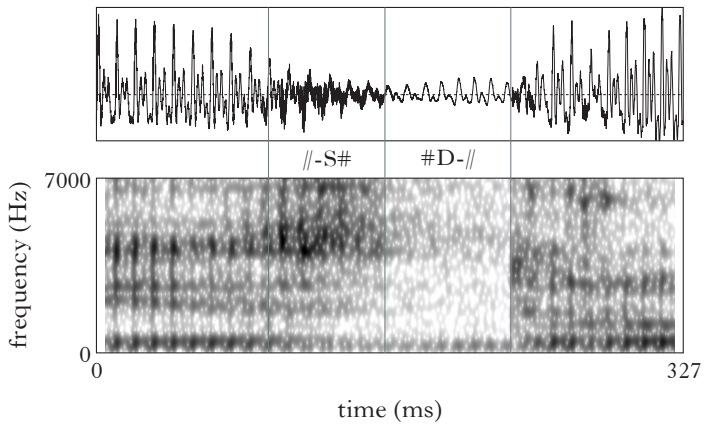

Figure 18

Waveform and spectrogram of surface /-z# #d-/ corresponding to underlying //-s# #d-// in the utterance *jest drugim* (*pieskiem*) 'is another dog (DIM)'; voicing measurement: $O_1 = 100\%$, $O_2 = 100\%$.

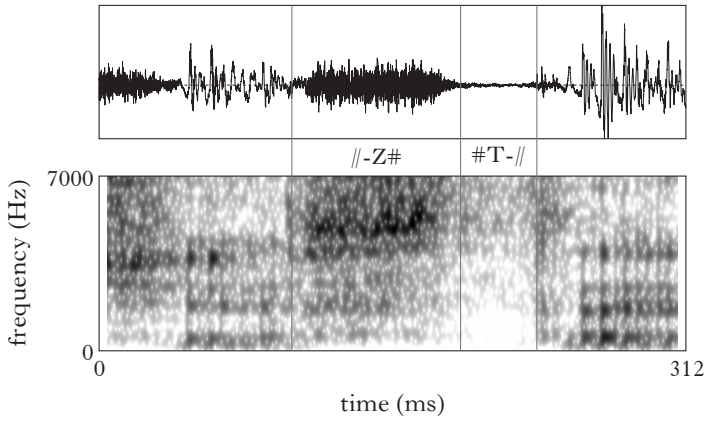

Figure 19

Waveform and spectrogram of surface /-s# #t-/ corresponding to underlying //-z# #t-// in the utterance *się z tego* (*wyplączemy*) '(we will get) out of this'; voicing measurement: $O_1 = 0\%$, $O_2 = 0\%$.

2 Voicing percentage in voiced fricatives (adult Polish) (§2.2)

Apart from measurements in Voice Assimilation contexts, I also measured the extent of voicing in voiced fricatives in non-assimilatory contrastive contexts in the speech of J's caregiver (based on 41 tokens): Median = 100% voicing, Mean = 91% voicing.

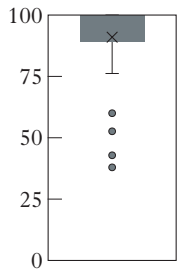

Figure 20
Voicing percentage in voiced fricatives in the caregiver's speech.

3 An illustration of positive VOTs in J's realisations of target stops (§3.1)

For J's realisations of stops, apart from voicing percentage, I also measured the portion of the speech signal corresponding to the release burst plus any subsequent aspiration, i.e. positive VOT. As illustrated in Fig. 21, most voiced stops had a burst superimposed on a continuing voicing pattern (a), while some showed a gradual reduction of voicing amplitude during the closure, with voicing clearly interrupted before the stop burst and reappearing right (or soon) after the burst (b); in voiceless stops there were usually small but clearly discernible positive VOTs (c).

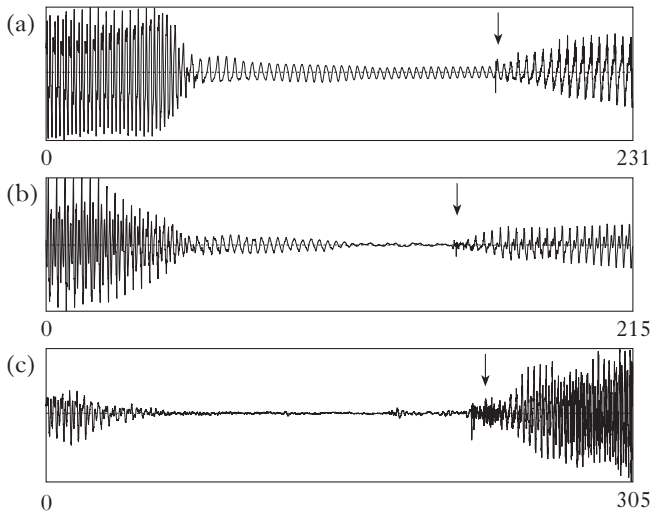

Figure 21

Positive VOTs in: (a) /b/ in *się robi* /ɕɛ rɔbi/ 'you do' (J 2;7.19); (b) /d/ in *za dużo* /za duʐo/ 'too much' (J 2;7.19); (c) /p/ in *taka pyszna* /taka pɨʂna/ 'so delicious' (J 2;5.10).

Appendix B: Statistical analyses (§3.2)

1 Procedure and SPSS codes

(a) Open SPSS and import the data from the .xlsx file (ChildData.xlsx), selecting the relevant sheet (in the syntax below it is 'pre-son (contrast)_Stage 1').

```
GET DATA
  /TYPE=XLSX
  /FILE='ChildData.xlsx'
  /SHEET=name 'pre-son (contrast)_Stage 1'
  /CELLRANGE=FULL
  /READNAMES=ON
  /DATATYPEMIN PERCENTAGE=95.0
  /HIDDEN IGNORE=YES.
EXECUTE.
DATASET NAME DataSet1 WINDOW=FRONT.
```

(b) Remove manually the datapoints marked as 'affricate-like realisation of the target fricative (removed from the GLM analysis reported in the paper)' from the SPSS data file.

(c) Use the syntax below to compute statistics for the dependent variable voicing percentage (the first operation consists in adding 1 to all data points because the Gamma with Log link function model cannot work on data points = 0); the second operation separates analyses for stops *vs*. fricatives; the third operation computes the GLM).

```
DATASET NAME DataSet1 WINDOW=FRONT.
COMPUTE Voicingplusconstant=voicing + 1.
EXECUTE.

SORT CASES  BY frication1closure2.
SPLIT FILE SEPARATE BY frication1closure2.

* Generalised Linear Models.
GENLIN Voicingplusconstant BY voiceless1voiced2
(ORDER=ASCENDING)
  /MODEL voiceless1voiced2 INTERCEPT=YES
 DISTRIBUTION=GAMMA LINK=LOG
  /CRITERIA METHOD=FISHER(1) SCALE=MLE COVB=MODEL
MAXITERATIONS=100 MAXSTEPHALVING=5
    PCONVERGE=1E-006(ABSOLUTE) SINGULAR=1E-012
ANALYSISTYPE=3(WALD) CILEVEL=95 CITYPE=WALD
    LIKELIHOOD=FULL
  /MISSING CLASSMISSING=EXCLUDE
  /PRINT CPS DESCRIPTIVES MODELINFO FIT SUMMARY SOLUTION.
```

(d) The results will show in the SPSS 'output' window.

2 Statistical results and goodness-of-fit measures

(a)

stage	likelihood ratio χ^2	*df*	significance
1	0.034	1	0.853
2	1.861	1	0.173
3	5.633	1	0.018
4	5.511	1	0.019
5	6.048	1	0.014
6	17.032	1	0.000
7	24.643	1	0.000

(b)

	deviance			Pearson χ^2		
stage	value	*df*	value/*df*	value	*df*	value/*df*
1	7.413	29	0.256	5.333	29	0.184
2	10.976	14	0.784	6.655	14	0.475
3	14.362	25	0.574	10.236	25	0.409
4	23.738	32	0.742	14.112	32	0.441
5	13.366	26	0.514	10.502	26	0.404
6	26.355	65	0.405	26.540	65	0.408
7	15.854	43	0.369	18.027	43	0.419

Table I

Fricatives (dependent variable: voicing percentage): (a) comparison of the fitted model against the intercept-only model; (b) goodness of fit.

(a)

stage	likelihood ratio χ^2	*df*	significance
1	45.949	1	0.000
2	39.038	1	0.000
3	23.991	1	0.000
4	18.692	1	0.000
5	39.300	1	0.000
6	77.775	1	0.000
7	56.028	1	0.000

(b)

	deviance			Pearson χ^2		
stage	value	*df*	value/*df*	value	*df*	value/*df*
1	42.599	81	0.526	27.114	81	0.335
2	24.168	53	0.456	13.808	53	0.261
3	14.287	29	0.493	6.689	29	0.231
4	11.034	40	0.276	8.521	40	0.213
5	25.130	58	0.433	20.633	58	0.356
6	39.124	117	0.334	39.542	117	0.338
7	44.385	87	0.510	36.618	87	0.421

Table II

Stops (dependent variable: voicing percentage): (a) comparison of the fitted model against the intercept-only model; (b) goodness of fit.

Appendix C: A summary of mathematical formulas (§4.2)

The following potential functions and control parameter values were used in the dynamical modelling of the evolution of J's phonological system:

(a) General schema

Grammar	$V^G(x) = kx - \frac{1}{2}x^2 + \frac{1}{4}x^4$
$\alpha \times$ Intention	$V^I(x) = \alpha(\frac{1}{2}x^2 - x^{REQ} \times x)$
Combined	$V^G(x) + V^I(x)$

(b) Voiced–voiceless intentions

'voiced'	$x^{REQ} = -1$
'voiceless'	$x^{REQ} = 1$

(c) Shifting control parameters

	Fig. 17a	Fig. 17b	Fig. 17c
k	−0.5	−0.3	−0.1
α	0.15	0.2	0.25

Table III

The mathematical set-up of potential functions in Fig. 17.