Representational ambiguity and the phonetics of Dutch past tense formation

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Dutch past tense allomorphy

- 2 allomorphs for past tense weak verbs: *-de* /də/ and *-te* /tə/
- Choice between allomorphs determined by fortis/lenis specification of stem-final consonant of the verb
- Final devoicing obscures fortis/lenis contrast in many contexts

Inf.	1Sg.Pre	1Sg.Past	Inf.	1Sg.Pre	1Sg.Past
trappen	*ik trap*	*ik trapte*	*krabben*	*ik krab*	*ik krabde*
/trapə/	/trap/	/traptə/	/krabə/	/krab/	/krabdə/
[trapə]	[trap]	[traptə]	[krabə]	[krap]	[krabdə]
dansen	*ik dans*	*ik danste*	*glanzen*	*ik glans*	*ik glansde*
/dansə/	/dans/	/danstə/	/ɣlanzə/	/ɣlanz/	/ɣlanzdə/
[dansə]	[dans]	[danstə]	[ɣlanzə]	[ɣlans]	[ɣlanzdə]

Incongruous voicing

- Ernestus & Baayen (2001, 2003, 2004): standard account is oversimplification
- Speakers sometimes suffix the 'wrong' allomorph: *krabte*, *glanste*
- These deviations from the rule are correlated with token frequency and type similarity
  - More mismatches with infrequent verbs
  - More mismatches with verbs that have a large number of lexical neighbours with the opposite fortis/lenis specification
- Potential problem with E&B studies: spelling-based tasks
  - Influence of spelling unclear
  - Dutch spelling partially encodes fortis/lenis contrast
    - *(ik) krab*, *krabde* ∼ *glans*, *glansde*
  - How do speakers produce these forms?
- This study: audio-based task only

Method

- 8 speakers of Standard Dutch
  - Female, 19-24 years old, from western/central NL
  - 2nd year students of English at Utrecht University
- Stimuli: 3 x 36 verbs in frame sentence, read by male speaker
  - *Hij danst helemaal niet* 'He doesn't dance at all'
- Task: repeat frame sentence, change verb to past tense
- **-de**:
  - *Beven*, *Blieven*, *Bonzen*, *Deinzen*, *Draven*, *Durven*, *Grenzen*, *Hijgen*, *Hoeven*, *Huizen*, (*Jagen*), *Klagen*, *Leggen*, *Plagen*, *Plonzen*, *Pluizen*, *Reizen*, *Schroeven*, *Slagen*, *Turven*, *Vegen*
- **-te**:
  - *Blaffen*, *Dansen*, *Eisen*, *Fronsen*, *Juichen*, *Kruisen*, *Kuchen*, *Loensen*, *Pochen*, *Poffen*, *Schorsen*, *Sloffen*, *Surfen*, *Walsen*

Analysis

- Acoustic measurements of:
  - duration of vocal fold vibration during frication and closure
  - fricative duration
  - stop closure duration
  - burst duration
  - mean intensity of the burst
  - f_0 and f_1 at 10ms after the burst
- Emerging issues
  - Phonetic ambiguity
  - Absence of vocal fold vibration during frication/closure
  - Individual variation
- All tokens classified as pronounced with a *-te* or *-de* allophone based on two approaches
- Generalised linear mixed-effects regression used to model the likelihood of a mismatch between the classification and the prescriptively correct target
- Linear mixed-effects regression used to model the realisation of phonetics correlates of voicing

Linear Discriminant Analysis (LDA)

- Response variable: prescriptively correct target
- Phonetic predictors:
  - fricative duration
  - stop closure duration
  - burst duration
  - mean intensity of the burst
  - f_0 at 10ms after the burst
  - f_1 at 10ms after the burst
- Applied on a speaker-by-speaker basis for all data in the pool
- Results: 180 out of 786 (22.90%) verbs classified as involving a non-target pronunciation

Perceptual classification

- Materials:
  - tokens involving a mismatch between the LDA classification and the prescriptive target
  - matching tokens (based on the LDA) deemed as misclassified according to the perception of one of the authors
  - 310 tokens altogether
- Listeners:
  - 5 phonetically trained native Dutch speakers
- Response categories:
  - -t/-d
  - degree of certainly (definitely/probably)

Modelling the likelihood of a mismatch between the prescriptive target and the classification results

- LDA-based classification

Term	Level	β	*SE*	*t*	*p*
(Intercept)		-19.49	3.86	-5.05	<0.001
Prescriptive target	-te	35.68	5.07	7.04	<0.001
Analogy index		-0.02	0.006	-3.58	<0.001
Fricative duration		0.08	0.01	6.70	<0.001
Closure duration		0.022	0.02	1.50	0.135
Burst duration		0.16	0.02	6.54	<0.001
Burst intensity		0.17	0.05	3.86	<0.001
f_0		-0.02	0.005	-3.68	<0.001
Pr. target: Analogy index	-te	0.042	0.008	4.76	<0.001
Pr. target: Fricative duration	-te	-0.15	0.02	-9.48	<0.001
Pr. target: Closure duration	-te	-0.07	0.02	-3.28	0.001
Pr. target: Burst duration	-te	-0.33	0.03	-9.63	<0.001
Pr. target: Burst intensity	-te	-0.26	0.06	-4.53	<0.001
Pr. target: f_0	-te	0.02	0.008	3.03	0.002

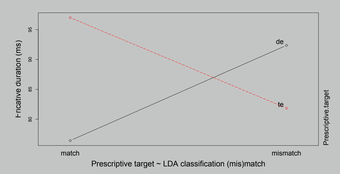
- Perception-based classification

Term	Level	β	*SE*	*t*	*p*
(Intercept)		-20.04	4.05	- 4.94	<0.001
Token frequency		-0.30	0.07	-4.49	<0.001
Prescriptive target	-te	39.39	5.73	6.87	<0.001
Analogy index		-0.03	0.007	-4.66	<0.001
Fricative duration		0.05	0.009	5.22	<0.001
Closure duration		0.02	0.01	1.63	0.104
Burst duration		0.16	0.02	7.13	<0.001
Burst intensity		0.13	0.04	3.18	0.001
f_1		0.008	0.003	2.52	0.012
Pr. target: Analogy index	-te	0.04	0.01	4.32	<0.001
Pr. target: Fricative duration	-te	-0.08	0.01	-6.02	<0.001
Pr. target: Closure duration	-te	-0.07	0.02	-3.20	0.001
Pr. target: Burst duration	-te	-0.33	0.04	-9.134	<0.001
Pr. target: Burst intensity	-te	-0.20	0.06	-3.26	0.001
Pr. target: f_1	-te	-0.021	0.005	-4.52	<0.001

Modelling fricative duration

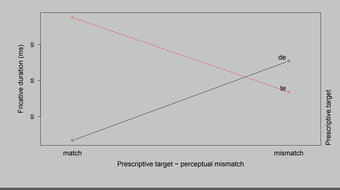
- LDA-based classification

Term	Level	β	*SE*	*t*	*p*
(Intercept)		76.43	5.57	13.74	0.001
Place of articulation	coronal	12.40	2.63	4.71	0.001
Place of articulation	velar	5.02	2.84	1.77	0.048
Prescriptive target	-te	20.57	2.36	8.71	0.001
Pr. target ∼ LDA (mis)match	mismatch	15.93	1.70	9.36	0.001
Pr.target: (mis)match	-te: mismatch	-31.07	2.36	-13.16	0.001



- Perception-based classification

Term	Level	β	*SE*	*t*	*p*
(Intercept)		76.69	5.76	13.31	0.001
Place of articulation	coronal	12.62	2.96	4.26	0.001
Place of articulation	velar	5.76	3.21	1.80	0.050
Prescriptive target	-te	17.07	2.63	6.49	0.001
Pr. target ∼ perc. (mis)match	mismatch	11.03	1.82	6.06	0.001
Pr. target: (mis)match	-te: mismatch	-21.36	2.83	-7.56	0.001



Summary

- effect of target: *-te* voicing more likely than *-de* devoicing
- effect of neighbourhood density: probability of a *-de* classification increases with the number of *-de* verbs in the neighbourhood
- effect of token frequency (acc. to the perceptual classification only): incongruous voicing more likely in less frequent verbs
- effect on fricative duration: incongruous voicing in verbs involves more phonetic similarity between *-te* and *-de* words wrt. fricative duration

Main findings

- Selection of allomorph influenced by more than underlying fortis/lenis specification
- Similarity-based analogy (neighbourhood density)
- When conflicting: higher chance of mismatch
- Mismatch: phonetic blending

Implications

- Mismatches and phonetic blending: suggest interactive model of speech production
- Fully discrete feed-forward models cannot accommodate these results
- Spreading activation models, or cascading: competing representations
  - Partial activation of multiple representations (lexical or phonological) (Goldrick & Blumstein, 2006)
- Exemplar models (Pierrehumbert, 2001) : storage includes phonetic detail
  - Choice of non-central exemplar

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