Behavior of homophones does not support irregular phonological change

Chelsea Sanker

Meaning in Flux
Yale University

12 October 2019

Influences of meaning on sound change

Meaning can have influences on sound change

- Minimal pairs have an effect on the likeliness of mergers occurring (Wedel et al. 2013); though the effect is small, it suggests a pressure of homophone avoidance
- Occasionally a word is deflected from the expected outcome when it would become homophonous with a vulgar word (e.g. OE *scyttan* 'shut' should have become /ʃɪt/)
- But the vast majority of changes are regular

Word-specific phonetics

- Most apparent examples of irregular changes can be attributed to:
  - changes with very specific environments
  - analogy
  - contact between languages or dialects
- But lexically specific patterns could in theory make irregular phonological developments possible
- Words can have phonetic differences based on factors like frequency (Bybee 1998), and listeners can be sensitive to acoustic details within categories (Liberman et al. 1957)

Lexical storage of homophones

- Homophones provide the clearest examples in which any phonetic differences must be lexical rather than phonologically regular.
- At least at the semantic level of representation, homophone mates are separate, which is reflected in various ways:
  - Distinct frequency effects in lexical access (e.g. Caramazza et al. 2001, Simpson & Burgess 1985, Grainger et al. 2001)
  - Weak or absent priming between homophone mates (e.g. Schvaneveldt et al. 1976, Masson & Freedman 1990)
  - Phonetic differences, based on frequency (Gahl 2008) and part of speech (e.g. Sorensen et al. 1978)
- However, phonetic differences are absent in frame sentences (Guion 1995) and might be due to prosodic position (Sorensen et al. 1978) and contextual predictability (Jurafsky et al. 2002).

Irregular splits?

- Given that homophones have distinct lexical entries at some level, it shouldn't a priori be impossible to associate them with distinct phonological forms
- But in cases of pernicious homophony, usually one item will simply fall out of use
- Once two items exist as homophones, do they ever split?

This study

To test whether listeners learn to associate acoustic details with individual homophone mates, I present two perception experiments:

- AX task deciding if pairs are the same or different, including pairs of the same word and pairs of homophone mates
- Identifying words in isolation by choosing between two written options, including trials with pairs of homophone mates

I also consider the role of production environment: Two conditions for each experiment, with stimulus words either (a) extracted from sentences or (b) produced in isolation

Tasks

Same-Different (AX) Task

- 48 native speakers of American English
- Listeners heard pairs of words and pressed a button to decide whether they were the **same** or **different**
- Stimuli were words taken from (a) definitional sentences or (b) production in isolation

Identification Task

- 48 native speakers of American English
- Listeners heard individual words and identified each by selecting one of two written options
- Stimuli were words taken from (a) definitional sentences or (b) production in isolation

Stimuli

AX Task

- Four types of pairs
  1. homophone-homophone pairs (e.g. *sun-son*)
  2. same pairs for a word with a homophone (e.g. *sun-sun*)
  3. same pairs for a word with no homophone (e.g. *cat-cat*)
  4. different pairs, with a single segmental contrast (e.g. *pat-cat*)
- Two speakers; in all word-pairs, the two words were from different speakers

Identification Task

- Individual items from the AX task, deciding between two written options:
  1. item matching one of two homophones (e.g. *sun-son*)
  2. item matching one of different pairs (e.g. *pat-cat*)

Hypotheses

AX Task

- Hypothesis 1: Homophone mates have distinct acoustic characteristics, and will be perceived as different
- Counter-Hypothesis 1: Homophone mates do not have any distinguishing characteristics, and will be perceived as the same

Identification Task

- Hypothesis 2: Homophone mates have distinct acoustic characteristics, and will be identified with above chance accuracy
- Counter-Hypothesis 2: Homophone mates do not have any distinguishing characteristics, and identifications choosing between homophone mates will be at chance

Homophone mates: Same or different?

AX task, words extracted from sentences.

Hph-hph pairs patterned like same pairs:

- The majority of responses were 'same' (93.0%, vs. 93.9% for *same* pairs and 6.2% for *different* pairs)
- 'same' responses were significantly faster than 'different' responses (1145 ms vs. 1518 ms, $p < 0.001$), paralleling faster responses of 'same' for same pairs (1061 ms vs. 1474 ms, $p < 0.001$)

Decision patterns by pair type

- Lexically unambiguous *same* pairs were identified as 'same' more frequently (94.5%) than lexically ambiguous *same* pairs (92.8%) or hph-hph pairs (93%); the latter two did not differ

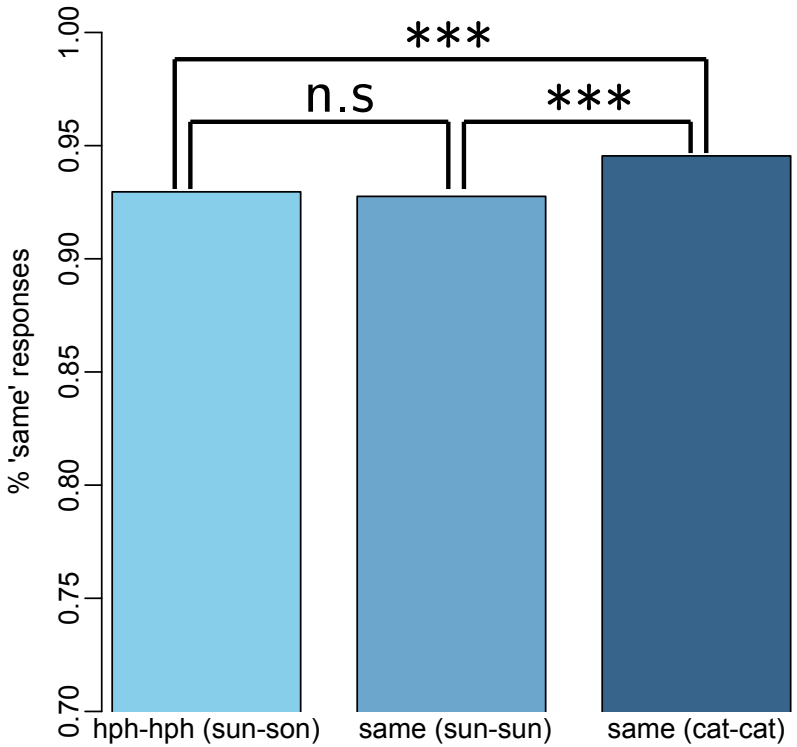

Figure: % 'same' Responses by Type

Response times by pair type

- But there were differences in hph-hph pairs in response time

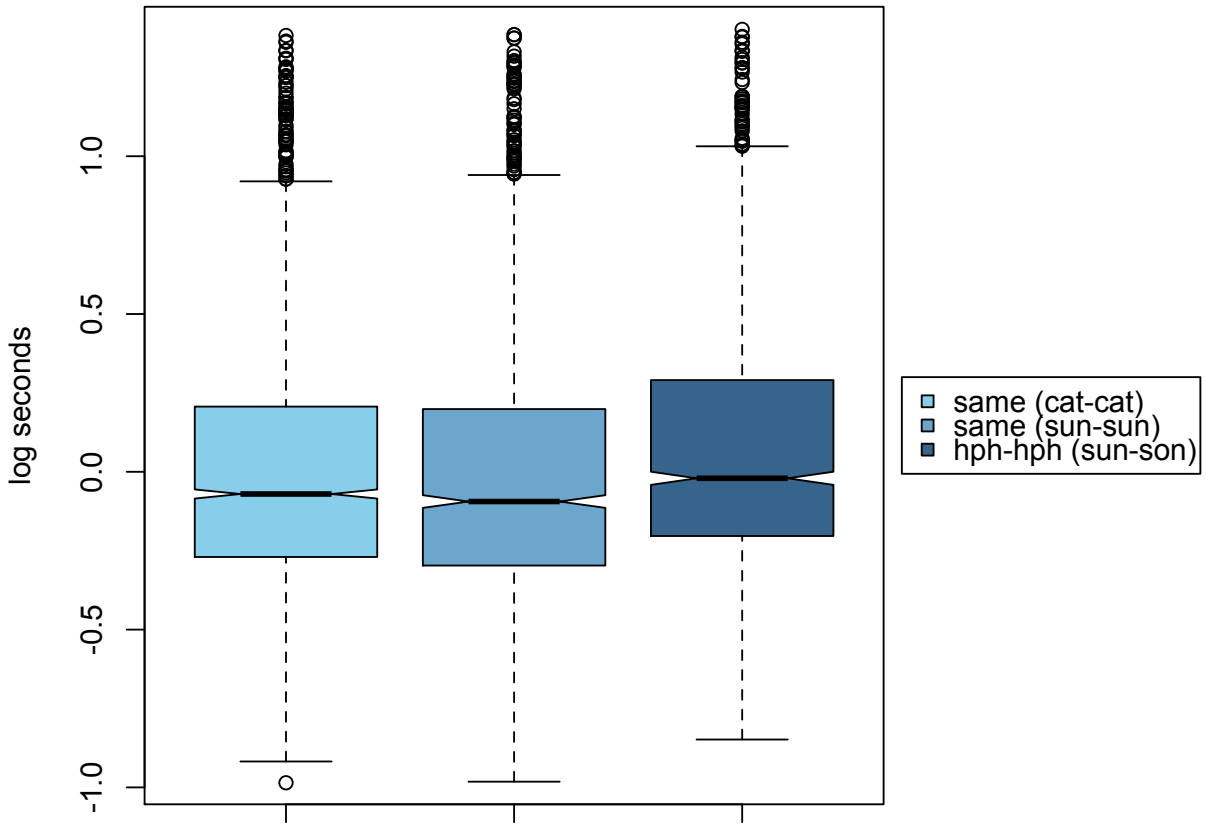

Figure: Response Time by Type and Response

Linear mixed effects model for log response times, excluding *different* pairs

	Estimate	Std. Error	t value	p value
(Intercept)	-0.042	0.033	-1.3	0.20
Type Hph-Hph	0.047	0.019	2.5	0.013*
Type Non-hom	0.0057	0.019	0.30	0.77
ContrastType C	0.093	0.012	8.0	< 0.001***
ContrastType O	-0.011	0.012	-0.92	0.36
Response 'different'	0.35	0.035	9.8	< 0.001***
TypeHph-Hph:ResponseDifferent	-0.14	0.051	-2.7	0.0065**
TypeNon-hom:ResponseDifferent	-0.15	0.047	-3.2	0.0013**

Intercept: Type = Same hom; ContrastType = N; Response = 'same'

Acoustic details

- For words produced in sentences, there were greater differences between the items in hph-hph pairs than between the items in same pairs in several characteristics, though the differences did not reach significance.
- Listeners are sensitive to acoustic distance; across pair types, longer response times were predicted by greater distance:

	β	t	p-value
vowel duration	0.85	3.08	0.0025**
Euclidean distance	0.00013	2.09	0.037*
F0 maximum	0.000039	0.20	0.84
spectral tilt	-0.0017	-1.4	0.18

Table: Contributions of acoustic characteristics to models of response time

- Acoustic distance had a similar but weaker effect on responses

Homophone mates: Same or different?

AX task, words from isolation.

Hph-hph pairs patterned like same pairs:

- The majority of responses were 'same' (89.3%, vs. 90.2% for *same* pairs and 4.0% for *different* pairs)
- 'same' responses were significantly faster than 'different' responses (1044 ms vs. 1469 ms, $p < 0.001$), paralleling faster responses of 'same' for same pairs (1058 ms vs. 1354 ms, $p < 0.001$)

Decision patterns by pair type

- Lexically unambiguous *same* pairs were identified as 'same' more frequently (91.1%) than lexically ambiguous *same* pairs (88.3%) or hph-hph pairs (89.3%); the latter two did not differ

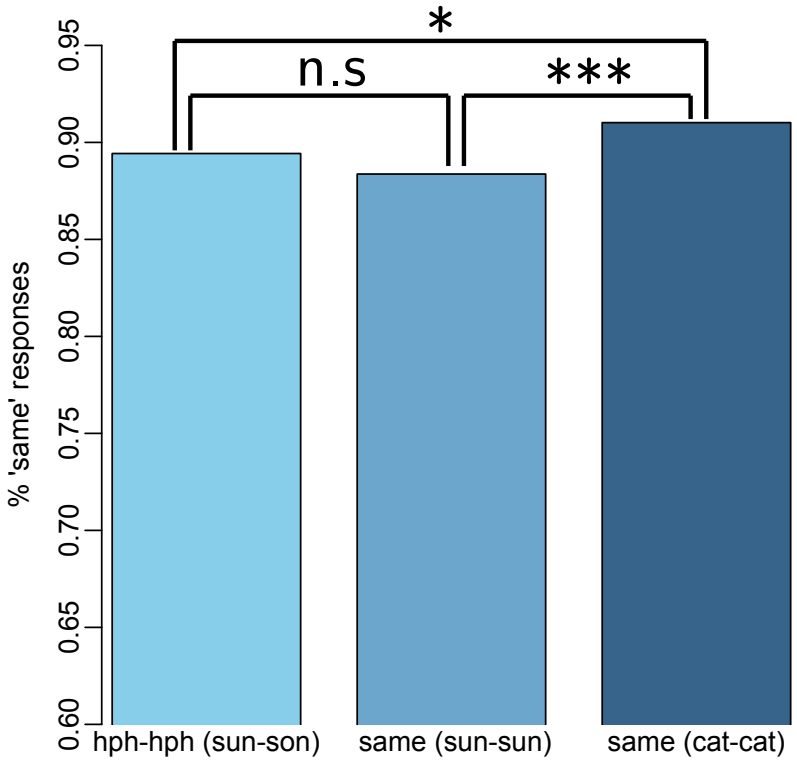

Figure: % 'same' Responses by Type

Response times by pair type

- Response times exhibited the same pattern as responses, largely due to speed of 'different' responses

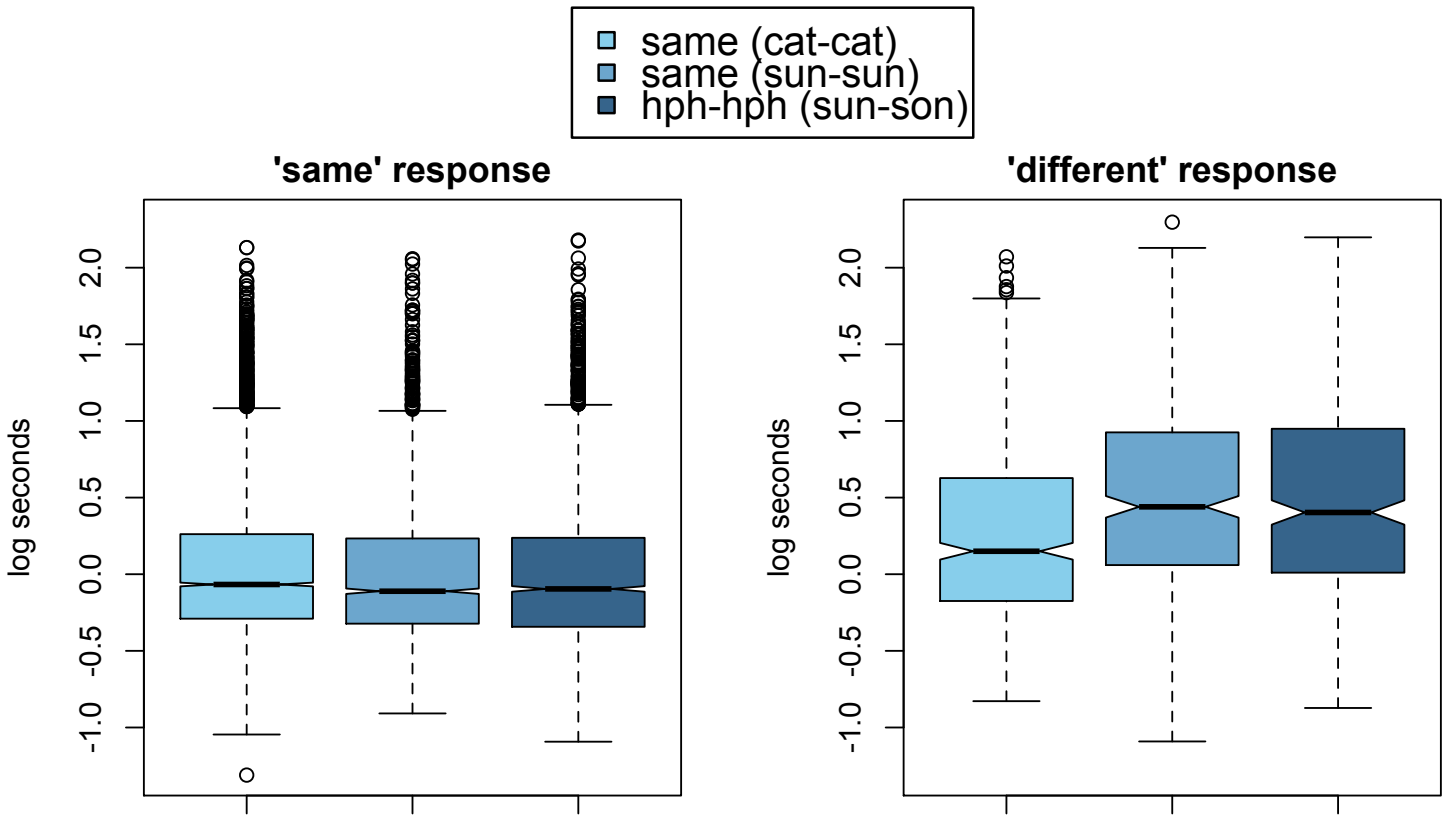

Figure: Response Time by Type and Response

Linear mixed effects model for log response times, excluding *different* pairs

	Estimate	Std. Error	t value	p value
(Intercept)	0.21	0.076	2.8	0.0089**
Type Hph-Hph	-0.045	0.066	-0.69	0.50
Type Non-hom	-0.1	0.028	-3.7	< 0.001***
ContrastType C	0.044	0.0094	4.7	< 0.001***
ContrastType O	-0.0086	0.0094	-0.92	0.36
Response 'different'	0.2	0.024	8.4	< 0.001***
TypeHph-Hph:ResponseDifferent	-0.052	0.033	-1.6	0.12
TypeNon-hom:ResponseDifferent	-0.012	0.03	-4.0	< 0.001***

Intercept: Type = Same hom; ContrastType = N; Response = 'same'

Acoustic details

- There was no larger difference between the members of hph-hph pairs than between members of *same* pairs.
- Though as before, listeners were sensitive to acoustic distance:

	β	t	p-value
vowel duration	0.15	1.2	0.23
Euclidean distance	0.000032	0.99	0.32
F0 maximum	0.00048	2.9	0.0033**
spectral tilt	0.0018	3.291	0.001**

Table: Contributions of acoustic characteristics to models of response time

Identification Task

Identifying individual words by identifying which of two written items matched the stimulus.

- Answers were presented on the left and right side of the screen; responses were given with the corresponding arrow keys
- Counterbalanced for which side of the screen the correct answer was on and for which homophone mate was the answer

Homophones from sentences: Barely distinguishable

Only slightly above chance accuracy for homophones (50.8%, p = 0.03). In contrast, accuracy for other pairs was 97.4%

Table: glmer model for accuracy in homophone identification

	β	SE	z value	p value
(Intercept)	0.45	0.21	2.17	**0.030***
ScreenSide right	-0.35	0.076	-4.63	< 0.001***
ContrastType C	-0.27	0.093	-2.92	0.0036**
ContrastType O	-0.049	0.093	-0.53	0.60
ResponseTime	-0.023	0.052	-0.46	0.65
Trial	-0.0019	0.00082	-2.33	0.020*
FreqCorr	0.090	0.021	4.37	< 0.001***
FreqIncorr	-0.049	0.020	-2.38	0.017*

Intercept: ScreenSide = left; ContrastType = N

Homophones produced in isolation: Not distinguishable

Listeners could not distinguish between homophones: Accuracy was 49.3%, p = 0.43. In contrast, accuracy for other pairs was 96.4%

Table: glmer model for accuracy in homophone identification

	β	SE	z value	p value
(Intercept)	0.25	0.21	1.21	0.23
ScreenSide right	-0.63	0.055	-11.48	$< 0.001^{***}$
ContrastType C	-0.045	0.067	-0.68	0.50
ContrastType O	0.047	0.067	0.70	0.49
ResponseTime	-0.021	0.039	-0.55	0.58
Trial	-0.000087	0.00040	-0.22	0.83
FreqCorr	0.14	0.015	9.58	$< 0.001^{***}$
FreqIncorr	-0.14	0.015	-9.61	$< 0.001^{***}$

Intercept: ScreenSide = left; ContrastType = N

By-Pair correlation across the tasks

- Accuracy was not above chance for any individual pair.
- No by-pair correlation in accuracy across the two experiments. Among the pairs that appeared in both experiments, $r(11) = 0.02$, $p = 0.95$

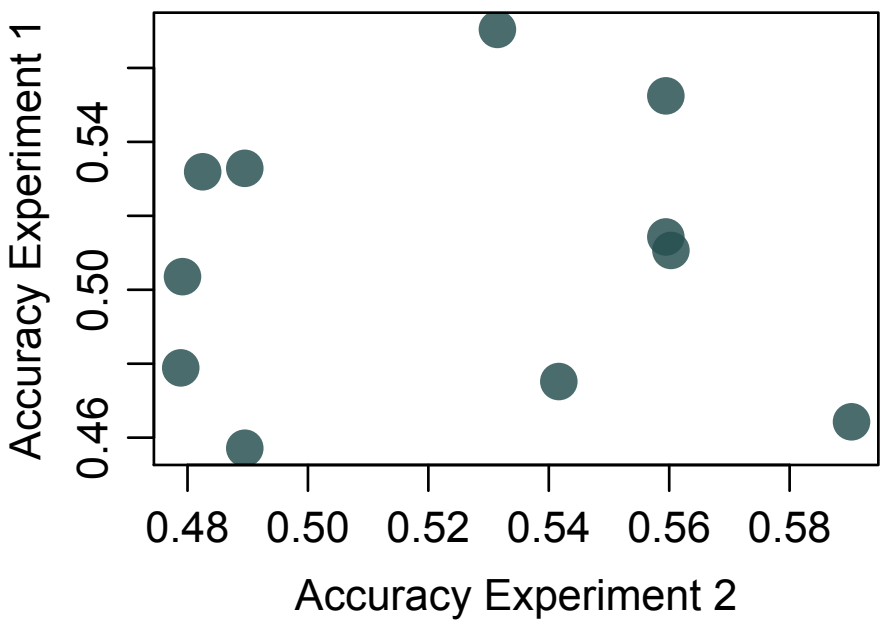

Figure: Accuracy by pair in each task

Summary of Results

Table: Results from each experiment and condition

	AX task	**identification**
Words extracted from sentences	slower responses for hph-hph pairs	slightly above chance
Words produced in isolation	hph-hph pairs don't differ	at chance

- Homophones were consistently perceived as being the same
- Though acoustic distance in phonologically identical words increases response time in AX tasks
- When produced in sentences, homophones have larger differences than pairs of the same word

Conclusions: Representations

- The perception results for homophones suggest that the acoustic differences that have been observed between homophone mates are due to context and are not part of the representation
  - These differences are not present for words in isolation
  - They influence response times in an AX task, but don't change category perception
  - But listeners' experience with words in context provides weak memories that may allow them to choose very slightly above chance in an identification task
- There is also an effect of knowledge of ambiguity – in the AX task, listeners are more likely to guess that a pair differs if they know that two words with that form exist

Conclusions: Implications for sound change

- There are observable phonetic differences between homophone mates in certain production contexts
- However, these differences do not enter the phonological representation; phonological representations are updated at the category level, not the word level
- So there is no pathway for irregular categorical splits of the same sound in different words

References

Bermúdez-Otero, R. 2007. Diachronic Phonology. In P. de Lacy (ed.) *The Cambridge Handbook of Phonology*. Cambridge: Cambridge University Press. 497–518.

Bybee, J. 1998. The phonology of the lexicon: Evidence from lexical diffusion. In M. Barlow & S. Kemmer (eds.) *Usage-based models of language*. Stanford: CSLI Publications. 65–85.

Caramazza, A., Costa, A., Miozzo, M., & Bi, Y. 2001. The specific-word frequency effect: Implications for the representation of homophones in speech production. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 27(6), 1430–1450.

Gahl, S. 2008. Time and thyme are not homophones: The effect of lemma frequency on word durations in spontaneous speech. *Language*, 84(3), 474–498.

Grainger, J., Van Kang, M., & Segui, J. Cross-modal repetition priming of heterographic homophones. *Memory & Cognition*, 29(1), 53–61.

Guion, S. 1995. Word frequency effects among homonyms. *Texas Linguistic Forum*, 35, 103–116.

Jescheniak, J., & Levelt, W. 1994. Word frequency effects in speech production: Retrieval of syntactic information and of phonological form. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 20(4), 824–843.

Jurafsky, D., Bell, A., & Girand, C. 2002. The role of the lemma in form variation. In C. Gussenhoven, & N. Warner (eds.), *Laboratory Phonology VII*. Berlin: Mouton de Gruyter. 3–34.

Liberman, A., Harris, K., Hoffman, H., & Griffith, B. 1957. The discrimination of speech sounds within and across phoneme boundaries. *Journal of Experimental Psychology*, 54, 358–368.

Masson, M., & Freedman, L. 1990. Fluent identification of repeated words. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 16(3), 355–373.

Schvaneveldt, R., Mayer, D., & Becker, C. 1976. Lexical ambiguity, semantic context, and visual word recognition. *Journal of Experimental Psychology: Human Perception and Performance*, 2(2), 243–256.

Simpson, G., & Burgess, C. 1985. Activation and selection processes in the recognition of ambiguous words. *Journal of Experimental Psychology: Human Perception and Performance*, 11(1), 28–39.

Sorensen, J., Cooper, W., & Paccia, J. 1978. Speech timing of grammatical categories. *Cognition*, 6(2), 135–153.

Wedel, A., Jackson, S., & Kaplan, A. 2013. Functional load and the lexicon: Evidence that syntactic category and frequency relationships in minimal lemma pairs predict the loss of phoneme contrasts. *Language and Speech*, 56(3), 395–417.