Effects of consonantal context on pronunciation of vowels by humans and models

Rebecca Treiman

Brett Kessler

Washington University in St. Louis

Suzanne Bick

Wayne State University

ea as /i/

steam

dream

leap

lean

ea as /ɛ/

stead

bread

bead

Do readers use the following consonant(s) to help specify the pronunciation of the vowel?

MOST YES

"body [vowel + final consonant] units appear to play a role in pronunciation over and above effects due to the consistency of individual graphemes" (Andrews & Scarratt, 1998, p. 1067)

"our results clearly show that readers and spellers use vowel-final consonant units" (Treiman & Zukowski, 1988, p. 475)

BUT

"We have argued that there is not yet any convincing evidence that the orthographic body is a level of representation in the human reading system" (Coltheart et al., 2001)

Do readers use the preceding consonant(s) to help specify the pronunciation of the vowel?

MAYBE

Kay, 1987: Preliminary evidence that readers sometimes use initial consonants in pronouncing vowels

BUT REPORT IS INCOMPLETE

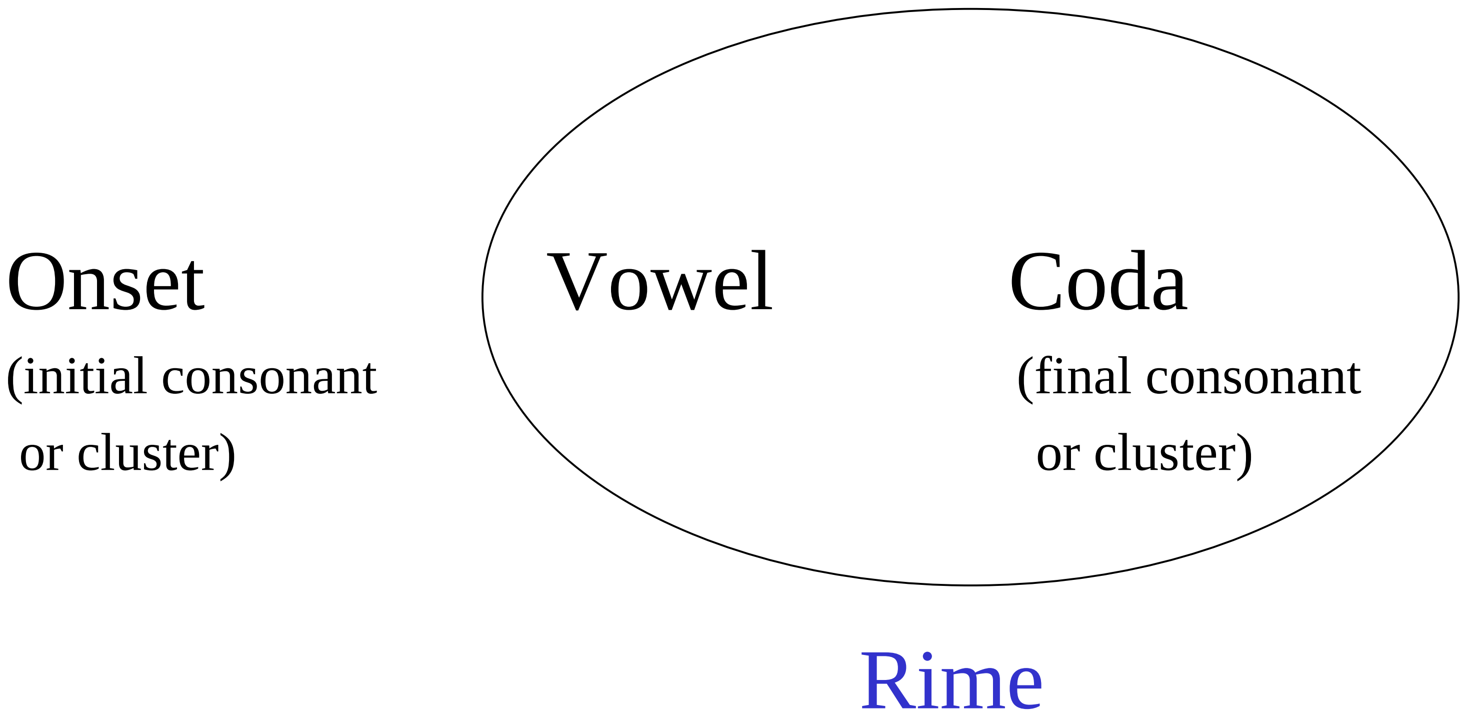
Treiman, Kessler, & Bick, 2002: Initial consonant influences choice of spelling for vowel

BUT SPELLING MAY NOT BEHAVE LIKE READING

NO

“there was little evidence that pronunciation is influenced by CV word neighbors” (Andrews & Scarratt, 1998, p. 1067)

“readers do not appear to use C_1V units” (Treiman, Mullennix, Bijeljac-Babic, & Richmond-Welty, 1995)


Onset
(initial consonant
or cluster)
Vowel
Coda
(final consonant
or cluster)
Rime

Present study

Assess effects of coda and onset on pronunciation of vowels in monosyllabic nonwords, using statistics about English from Kessler and Treiman (2001)

One test case for coda: Is *oo* pronounced differently when it occurs before *k* than when it occurs before *m* and *n?*

Experimental nonwords: *blook*, *glook*, *pook*, …

Control nonwords: *bloon*, *gloon*, *poom*, …

Critical pronunciation of vowel: /ʊ/ (as in *book*)

Typical pronunciation of vowel: /u/ (as in *boon*)

Do readers produce more critical pronunciations of the vowel for experimental nonwords than for control nonwords?

One test case for onset: Is *a* pronounced differently when it occurs after *w* and *u* than when it occurs after other consonants?

Experimental nonwords: *twamp*, *squant*, *wabs*, …

Control nonwords: *glamp*, *spant*, *trabs*, …

Critical pronunciation: /ɑ/ (as in *wad*)

Typical pronunciation: /æ/ (as in *pad*)

Do readers produce more critical pronunciations of the vowel for experimental nonwords than for control nonwords?

Experiment 1: participants pronounce nonwords, pronunciations transcribed by experimenter (and later checked for reliability); individual testing

Experiment 2: participants circle one of two real words that is most similar to their pronunciation of the nonword (e.g., *font* and *rant* for *squant*); group testing

Results for nonwords testing onset-to-vowel associations (Exp. 1)

	Case 1: *a* (followed by consonants other than *r* or velar)	**Case 2**: *ar*
Mean proportion critical vowel pronunciations, experimental nonwords (e.g., *squant*, *warge*)	.64*	.17*
Mean proportion critical vowel pronunciations, control nonwords (e.g., *spant*, *carge*)	.06	.01

* Significantly greater than for control nonwords by subjects and by items

Results for nonwords testing coda-to-vowel associations (Exp. 1)

	Case 1 (*ange* vs. *ance*)	**Case 2** (*ald*, *alt* vs. *and*, *ant*)	**Case 3** (*ead* vs. *ea* + other C)	**Case 4** (*ind*, *ild* vs. *int*, *ilt*)	**Case 5** (*old*, *olt* vs. *ond*, *ont*)	**Case 6** (*ook* vs. *oom*, *oon*)
Mean proportion critical vowel pronunciations, experimental nonwords	.59*	.94*	.13*	.35*	.88*	.70*
Mean proportion critical vowel pronunciations, control nonwords	.05	.08	.01	.02	.05	.00

* Significantly greater than for control nonwords by subjects and by items

Conclusions about human readers

College students’ pronunciations of vowels in nonwords are affected by **both** onset and coda

Rimes are not the only multi-grapheme units involved in reading. The role of rimes in English may reflect the fact that many patterns involving vowels and codas exist, not the fact that readers are insensitive to other patterns

Readers seem to be less sensitive to onset-to-vowel and coda-to-vowel associations than one would expect given the strength of the associations in the words they know

Difference between proportion of critical pronunciations of vowels in experimental and control nonwords in human readers and in English words

Case	Human readers	English words
CV1	.58	.80
CV2	.16	1.00
VC1	.55	1.00
VC2	.86	1.00
VC3	.12	.69
VC4	.33	.83
VC5	.83	.97
VC6	.70	.93

Models

- Dual-route models: Generative knowledge important for nonwords, case-specific knowledge important for known words

  Coltheart et al., 2001: Generative route uses spelling-to-sound rules at level of single graphemes and single phonemes, most rules not sensitive to context

  Zorzi et al., 1998: Generative knowledge induced by connectionist learning principles

- Single-route connectionist models: Similar procedures used with novel items and familiar items. These involve the spread of activation along connections, the weights of which change with experience.

  Plaut et al., 1996

  Harm & Seidenberg, submitted

- Single-route non-connectionist (analogy) models: Deal with novel items based on their similarity to known items stored in memory

  Norris, 1994: Compute similarity at multiple levels (e.g., rime, vowel, …)

How well do models account for human nonword pronunciation?

WIDESPREAD VIEW

First-generation connectionist model (Seidenberg & McClelland, 1989) worse than people at pronouncing nonwords, as pointed out by Besner et al. (1990)

Current models said to be relatively good at pronouncing nonwords

"[the] new set of PDP models … read both words and nonwords about as accurately as intact humans do" (Besner, 1999, p. 419)"

BUT MAYBE THE MODELS HAVE NOT BEEN ASSESSED STRINGENTLY ENOUGH

Plaut et al., 1996: Model’s pronunciation of *glook* counted as correct if either /gluk/ or /glʊk/

Harm & Seidenberg, submitted: Similar way of assessing model

What if model produces one pronunciation and people predominantly produce the other?

Methods of assessing agreement between model and human pronunciations

Binary method: Score model as correct if its vowel pronunciation (critical, typical, or neither) agrees with the one produced by the majority of people

Proportional method: Determine the proportion of cases in which humans' vowel pronunciation falls into the same category (critical, typical, or neither) as that produced by model

Agreement between vowels produced by models and vowels produced by people using binary method (results using proportional method shown in parentheses)

	Control nonwords	Experimental nonwords
Coltheart et al., 2001	1.00 (.94)	.38 (.38)
Zorzi et al., 1998	.96 (.92)	.43 (.42)
Plaut et al., 1996	.95 (.91)	.63 (.56)
Harm & Seidenberg, submitted	.94 (.88)	.54 (.52)
Norris, 1994	.89 (.83)	.68 (.59)

1. Is *badge* a word?

2. Is *lodge* a word?

3. Is *wadge* a word?

Difficulties of existing models in accounting for human data

Coltheart et al: Vowel pronunciation in nonwords not influenced by context with current parameter set, but humans do use context

Zorzi et al.: Built to discourage use of onset context, but humans do sometimes use onsets in pronouncing vowels

Single-route connectionist models: Tend to show stronger contextual influences than people do

Norris: Treats clusters as single units and so can’t generalize on the basis of phonemes, but humans do

Might existing models be models of some readers only?

- Coltheart et al: Apparently not, as no human reader (of 47 in the two experiments) failed to show at least some contextual effects
- Other models: Perhaps, but a model that reproduced typical human behavior and modeled individual differences in a principled manner would be more satisfactory

Well, do we have a better model?

No, not yet

Building a better model

- Should be able to operate at level of phonemes
- Should recognize similarity between same segment in different positions
- Should take context into account
- Should be able to consider context on both sides of vowel, even simultaneously

Analogical model similar in some respects to that of Norris (1994)

Phenomena that models should be able to explain, from Coltheart et al., 2001

1. Reading aloud is faster for high-frequency words than for low-frequency words
2. Reading aloud is faster for regular words than for nonwords
3. Reading aloud is faster for regular words than for irregular words when these are low in frequency; when they are high in frequency the regularity effect is small or absent

(+ 4 more)

8. Specific pronunciations that people produce for nonwords (and words)

“a more detailed consideration of people’s nonword naming performance is necessary to allow proper evaluation of the compatibility of the human and network data” (Andrews & Scarratt, 1998, p. 1054)

What is a wadge, anyway?

Wadge: Some parts of the chimpanzee's meal are not swallowed (e.g. the skin and seeds of some fruits, leaves which may have been chewed up with meat or eggs, or pieces of bone, etc.). The chimp, after chewing such things, sometimes spits them out at once, but sometimes continues to express the juices by pressing the skin, leaves, etc., between his lower lip and teeth, or actually in his mouth between tongue and palate. Such wadges may be sucked for 20 minutes or so, but are finally spat out and discarded.