Phonological regularity, perceptual biases, and the role of grammar in speech error analysis

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Speech errors

Speech errors are unintended and non-habitual deviations from a speech plan.

Sound error: … what’s in each pixel /run row at a time. (one → run, 27)

Word error: This side has green Vs, I mean red Vs (797)

Syntactic error: I’m not staying all up night. (1817) ( #'s = SFUSED record ID)

Speech errors are common occurrences in human talkers, generally thought to be the by-product of normal production processes (not pathological)

Speech errors are patterned, and exhibit a host of psycholinguistic biases, like the lexical bias (sound errors more likely to result in actual word than they would by chance)

Speech errors tell us something about the nature of language production processes

Some themes in speech error research

**Interactivity of linguistic levels**
Examines how the outcomes of specific production processes are affected by the processing at other levels (Dell 1986, Rapp & Goldrick 2000, Stemberger 1985, Vigliocco & Hartsuiker 2002)

**Speech errors and serial order**

**Structure of speech errors and statistical structure of language**
Speech errors are affected by output biases that stem from the statistical structure of language (Dell 1986, Dell et al. 2000, Frisch 1996, cf. Stemberger 1991)

**Speech errors and linguistic structure**
Probes the psychological reality of linguistic structure by studying the structure of speech errors (Berg 1987, Fromkin 1971, Kubozono 1989, Stemberger 1983)
Speech errors tend to respect grammar

“First law” of tongue slips (due to Wells 1951)
Speech errors respect phonotactic constraints, only produce legal phonological combinations (Boomer & Laver 1968, Nooteboom 1967, Garrett 1980)

Phonological constraints active in repairs (Fromkin 1971: 41)

play the victor → flay the pictor (exchange of p and v, vl → fl)

Syntactic regularity in speech errors (Garrett 1980, Bock 2011)
• Category constraint (word substitutions respect part of speech labels), producing licit by unintended sentences.
• Sentence blends, role mis-assignments, and spurious agreement relations tend to respect grammar too.

Bock 2011: 332
“The most striking thing about attested syntactic errors is that, like other kinds of speech errors, they occur within a structural matrix that resists modification”
Regularity as a hard constraint

**Early models:** grammatical regularity not really explained, but the result of a built-in “structural matrix”

**Example: Spreading-interactive model: Dell 1986**
Mental lexicon: activation dynamics for selecting valid linguistic units

Tactic frames: productive capacity for language (builds sentence trees, word trees, and syllables. (a.k.a. ‘structural matrix’)

Result: speech errors respect grammar, e.g., syllable canons because of tactic frames and encoding of sounds in the mental lexicon are ‘hard-wired’ into the system.

**Intended word: play**

Tactic frame for syllables       Sound selected by activation dynamics
Onset  Peak  Coda                  Options for Onset: *pl fl kl gl*

____  ____  ____                  Non-options: *ŋ vl tl bw*
**But regularity is not a hard constraint**

Stemberger 1983: phonological regularity is very high, but speech errors do violate English phonotactics, approx. 1% of the time (37 violations/6,300 examples); supports standard of 99% phonological regularity

... in the first floor /dlorm — dorm room

I /sthough—- thought I said ‘moff’

... knowledge of the cooperative /rpin—- principle

**Issue** (Stemberger): the dominance of phonological regularity in speech errors does not entail that speech errors are controlled directly by phonotactic constraints—other independently need mechanisms sensitive to frequency could be at work ... so still don’t know precise role of grammar here.

**Dell, Juliano, Govindjee (1993)**
Develop a model of phonological encoding (simple recurrent network) that learns sequences, show that it accounts for phonological regularity (sometimes to lower standards) without tactic frames.
Empirical challenges

Provocative question: Just how regular are speech errors?

Syntactic errors: very rare (approx. 2%), not exhaustively studied
Pilot study in SFUSED
  • Majority word shifts are rampantly ungrammatical
    Example: *I'm not staying all up night.* (*… staying up all night*, 1817)
  • Many other types (blends, agreement errors) are also frequently ungrammatical
    Example: … *in life I'd never will understand* (348)
  • Conjecture: perhaps assumed syntactic regularity is due to a talker’s commitments to the message, and not structural requirements.

Phonetic research in speech errors
  • Evidence for gradient errors, not simple mis-selection of one phonological category for another.
  • Mower & MacKay 1990: phonotactics is not a good way of assessing errors because most sublexical (sound errors) are not errors that make reference to symbolic categories.

A conjecture about perceptual bias (Dell et al. 1993)
It is possible that current assessments of regularity reflect a higher standard, because it is well know that speech error collection is subject to perceptual bias (see Bock 1996); possible that many errors that violate e.g., phonotactics are regularized or simple not detected
Research focus

**Just how regular are phonological speech errors?** (phonetic errors aside)
→ Quantitative assessment in SFUSED

**How does methodology affect phonological regularity?**
→ SFUSED designed to be robust to perceptual bias, can investigate Dell et al’s conjecture

**What is the role, if any, of phonological grammar in explaining the structure of speech errors?**
→ Given: phonotactics as hard constraints not valid (many violations)
→ Can we get by without frame constraints? (no explicit phonotactics, just frequency effects, à la Dell et al. 1993)
→ Are there more nuanced effects of phonological grammar, stochastic effects (Goldrick and Daland 2009, Goldbrick 2001)
The approach

**SFUSED (= Simon Fraser University Speech Error Database)**
Explain the methods used to collect and classify speech errors

**Phonotactics**
Need an account of English phonotactics in order to know when they are violated.

**Regularity and other grammatical effects**
- Can assess phonological regularity as a categorical effect (violates phonotactics or not), relates to prior research
- Can also investigate gradient effects of grammar, not an absolute but a trend
SFUSED

Current languages
-English (10,000 errors)
-Cantonese (2,200 errors)

Goals
-Build a multi-purpose database that documents the rich structure in spontaneous speech errors.
-Employ methods that are robust to problems found in other corpora.
-Examine how the structure of non-Indo-European languages impacts language production processes
-Partner with other labs to investigate new problems
Key methodological decisions

Offline collection from audio recordings (see Chen 1999 on Mandarin speech error database)
- errors collected from podcasts on different topics
- podcasts selected for having natural unscripted speech, usually Western Canada and U.S. (Midlands dialect ‘Standard American’)
- multiple podcasts (8 currently) with different talkers, approx. 50 hours of each podcast
- record dialectal and idiolectal features associated with speakers (because habitual, so not an error); listeners develop expectations about individuals

Multiple data collectors
- reduces collector bias, allows it to be studied (collector ID associated with all records)
- total of 13 data collectors

Training regime
- undergraduate students with introduction to formal linguistics, phonetics and phonology
- given phonetic training in transcription and tested for transcription accuracy
- introduction to speech errors, definition and illustration of all types
- training through listening tests: assigned pre-screened recordings, asked to find errors; learn by reviewing correct list of errors. Trainees that reach a certain level of accuracy continue.

Classification separate from data collection
- data collectors use established protocol for finding errors in audio recordings, submit errors in spreadsheet format
- data analysts (must be different than collector) verify the error, classify it using the SFUSED fields
## SFUSED Classification

### Example Fields
- **A:** I still use the laser comb.  
- **B:** Daily.  
- **A:** /[]s it the diet or is it the laser comb?

<table>
<thead>
<tr>
<th>Intended</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>[s]</td>
<td>[]s</td>
</tr>
</tbody>
</table>

### Orthographic Fields
- **Orthographic:** is
- **Error:** []s

### Phonetic Fields
- **Phonetic:** 'iz
- **Error:** 'iz

### Word Fields
- **Lexical Word:** N
- **Contextual:** Y
- **Right Lexeme:** Y
- **Open/Closed:** Open
- **Regular/Irregular:** Irreg
- **Error-Intended Semantic Relationship:** Same meaning (same lexeme)
- **Error-Intended Morphological Relationship:** Same Lexeme (differ only g. f.)

### Sound Fields
- **Supplanted Intended:** i
- **Intruder:** i
- **Source Sound:** NotAppl

### Given Record Fields
- **Record ID no.:** 7879
- **Last Modified:** 2017-04-26
- **Total Completed:** 4207
- **Researcher:** gf
- **Found Date:** 2015-09-28
- **File:** whc131_2015-05-07
- **Podcast:** whc
- **Time stamp:** 0:06:18
- **Online/offline:** off
- **Speaker:** ac
- **Sex:** m
- **Conference Transcript:**
- **Personal Info:**
- **Record Complete:** Y
- **Record Confirmed By:** X

### Complex Processes
- [ ] Sub
- [ ] Del
- [ ] Stress
- [ ] Exch
- [ ] Add
- [ ] Shift
- [ ] Grad
- [ ] Blend

---

### Table

<table>
<thead>
<tr>
<th>Obvious Malapropism</th>
<th>Y</th>
<th>N</th>
<th>NotAppl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prosody Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Form Rules Type</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morpho Cats</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two Term Intervener</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transformation Type</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Methods matter!

**Online data collection** (most prior research): requires on-the-spot observation, only collect errors with high degree of confidence.

**Offline** (SFUSED): collection from audio recordings, can replay and listen to slow speech

**Result**: speech error patterns in SFUSED more diffuse, less concentrated in highly salient errors like blends or exchanges.

**Exchanges in SFUSED** Ex. *We can just wrap mine in a /torn /korkilla* (corn tortilla, 1495)

<table>
<thead>
<tr>
<th></th>
<th>Offline</th>
<th>Online</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphemes</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Phrases</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Sounds</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Words</td>
<td>1</td>
<td>15</td>
</tr>
<tr>
<td>Totals</td>
<td>2 (0.38% of 533)</td>
<td>47 (5.6% of 839)</td>
</tr>
</tbody>
</table>

From Alderete and Davis 2016
Methods matter!  

**Sound errors**

- Online errors have more corrected errors than offline errors.
- Online has a stronger repeated phoneme effect than offline errors.*
- Online errors have a stronger lexical bias than offline errors.(*)
- Online errors have a weaker word-onset effect than offline errors.*
- Online errors are more likely to be contextual than offline errors.*
- Online errors have more perseverations and exchanges than offline errors.*
- Online sound substitutions are more symmetric and more concentrated in a small number of substitutions than offline errors, which are more diffuse and asymmetrical.*

**Word errors**

- Online errors have less additions and deletions and more blends than offline errors.*
- Online word substitutions are much more likely to be in nouns than offline errors, which are more diffuse across lexical and function categories.*
- Online errors tend to respect the category constraint more than offline errors.

* = significant association from chi square test
Methods matter! Estimating error frequency

**Prior assumption:** speech errors are rare in general (error every 5-6 minutes), motivates focus on normal language production

**Problem:** prior estimates of error frequency based on different methods, and failed to address the fact of missed errors (though all studies concede they miss them).

**Capture-recapture:** common tool in ecology for estimating a population when exhaustive is impossible or impractical

**Take home:** speech errors occur much more commonly than enumerated in prior research, at least as often as 48.5 seconds (upper bound because of non-homogeneity)

<table>
<thead>
<tr>
<th>Second</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>AB</th>
<th>AC</th>
<th>BC</th>
<th>ABC</th>
<th>n</th>
<th>Ŧ̂</th>
<th>Ū̂</th>
<th>SPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,100</td>
<td>2</td>
<td>18</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>33</td>
<td>16.3</td>
<td>49.3</td>
<td>42.60</td>
</tr>
<tr>
<td>1,690</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>2</td>
<td>9</td>
<td>31</td>
<td>13.48</td>
<td>44.48</td>
<td>38.00</td>
</tr>
<tr>
<td>1,993</td>
<td>2</td>
<td>9</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>5</td>
<td>23</td>
<td>20.08</td>
<td>43.08</td>
<td>46.26</td>
</tr>
<tr>
<td>2,385</td>
<td>6</td>
<td>6</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>33</td>
<td>11.7</td>
<td>44.70</td>
<td>53.36</td>
</tr>
<tr>
<td>4,143</td>
<td>24</td>
<td>9</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>44</td>
<td>21.84</td>
<td>65.84</td>
<td>62.93</td>
</tr>
<tr>
<td>3,000</td>
<td>9</td>
<td>2</td>
<td>7</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>29</td>
<td>10.63</td>
<td>39.63</td>
<td>75.70</td>
</tr>
<tr>
<td>1,800</td>
<td>9</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>25</td>
<td>29.87</td>
<td>54.87</td>
<td>32.81</td>
</tr>
<tr>
<td>2,377</td>
<td>15</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>30</td>
<td>13.39</td>
<td>43.39</td>
<td>54.78</td>
</tr>
<tr>
<td>2,400</td>
<td>18</td>
<td>4</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>38</td>
<td>41.93</td>
<td>79.93</td>
<td>30.03</td>
</tr>
</tbody>
</table>

From Alderete and Davis 2016
English phonotactics

**Guiding assumption:** a word is phonotactically licit if it can be syllabified within a well-formed syllable of English (Kahn 1976, Giegerich 1993, Jensen 1993)

<table>
<thead>
<tr>
<th>Onset</th>
<th>Peak</th>
<th>Coda</th>
</tr>
</thead>
<tbody>
<tr>
<td>(s)(C1)(C2)</td>
<td>X4</td>
<td>(X5) (C6)(C7)(C8)(C9)</td>
</tr>
</tbody>
</table>

**Conditions:**
All C positions are optional.
Banned C1: ɲ ʒ, Banned Codas: h, j, w.
Onset clusters: obstruent + sonorant
Appendix + C, C always a voiceless stop, sf rare/loans
Banned onset clusters: vd fric/affricate + sonorant, labial + w, coronal nonstrident + l,
θw ffV fw fl sr sh gw stw skl
Onglide j: part of peak because of limited distribution, but cannot occur in CCju cluster.
Coda clusters X5+C6: falling sonority (r > l > nasals > obstruents) and s + p t k; lg is banned.
C7-9 are appendices limited to coronal obstruents
Nasal + obstruent clusters agree in place and the obstruent is voiceless.
Tense vowels and diphthongs are bimoraic (fill X4 and X5), lax vowels are short fill X4.
Stressed and final syllables are bimoraic (lax vowels occur in closed syllables) and all syllables maximally trimoraic (syllables tense vowels only have simple codas)
Results by error type

**Observations:** % of phonotactic violation differs by type, but overall % if irregularity much higher than 1% found in Stemberger’s corpus.

<table>
<thead>
<tr>
<th>Error type</th>
<th>Example</th>
<th>$N$</th>
<th>Violations</th>
<th>% of $N$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitutions</td>
<td>pleep for <em>sleep</em></td>
<td>1,376</td>
<td>44</td>
<td>3.20</td>
</tr>
<tr>
<td>Additions</td>
<td>bluy for <em>buy</em></td>
<td>358</td>
<td>33</td>
<td>9.22</td>
</tr>
<tr>
<td>Deletions</td>
<td>pay for <em>play</em></td>
<td>169</td>
<td>3</td>
<td>1.78</td>
</tr>
<tr>
<td>Exchanges</td>
<td>heft lemisphere for <em>left hemisphere</em></td>
<td>37</td>
<td>2</td>
<td>5.41</td>
</tr>
<tr>
<td>Shifts</td>
<td>splare backforests for <em>spare blackforests</em></td>
<td>7</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>Sequential Blends</td>
<td>Tennedy for <em>Ted Kennedy</em></td>
<td>57</td>
<td>4</td>
<td>7.02</td>
</tr>
<tr>
<td>Word Blends</td>
<td>tab for <em>taxi/cab</em></td>
<td>72</td>
<td>4</td>
<td>5.56</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td></td>
<td>2,076</td>
<td>90</td>
<td><strong>4.34</strong></td>
</tr>
</tbody>
</table>
Examples of phonotactic violations

Substitutions

Illicit onsets/appendices
1500 … by the maps at the ^selection /ʃk rin] (screen)
5739 … they shoot, /ʒu] shoot The Thick of It … (you)

Illicit codas/rimes
1245 … Their HOV /ləŋ] xxx lane is like one driver (lane)
5898 Vin Diesel got kicked off of /Reiŋ]deer Games … (reindeer)

Nonnative sounds
5964 … first of all, Katrina /kly]= clearly defined (clearly)

Additions

Illicit onsets, appendix + onset
49 … get the Ferrari down a /ʃliŋ] xxx few ^floors? (few)
1278 I don't like the ^/vɛrɪl ^marketing. (viral)
5599 … talking a ^dream, what that ^dream /mɛn]eans … (means)

Illicit codas/rimes
1526 The ^person /kɛmp] ^up to the desk.

Deletions
3954 … Lisa, /Sr ee ch and Lisa. (Screech)
8943 … I think you're a /hʊŋə]= hunk-a-rama.
More examples

Exchanges
4581 ... the children in the trailer for /Moon[raɪŋ] /Keez= Moonrise Kingdom.

Sequential Blends
4453 ... A diary is a /[sb]ook xxx a very special book.
5278 ... you can't quite /[pjɜrt] xxx put your finger on.
7211 ... because we /[spɪlkf] xxx we, we speak film

Word Blends
870 ... ... /[sastæ] makes me frisky. (pasta, sauce)
7120 Top ten /thwaws to make me cry (things, ways)
7270 ... /so[m-bwʌn-di] xxx uh in the ... (someone, somebody)
Results by phonological pattern

Repair strategies: Additions
Onsetless syllables: large percentage of additions (approx. 40%)
repair onsetless syllables by filling an onset:

Example: 1170 … that [baɪ] ^basically wear all the time. (I)

Repair strategies: Deletions
Cluster reduction: the majority (73%) of deletions reduce CC clusters, and while they may also produce onsetless syllables, there is a strong tendency for such deletions to be contextual:

Example: 1398 Stress _errors _are really /[ɛr]. (rare)

Perhaps a role for markedness constraints (OT constraints: Onset, *Complex), even dominated constraints not active in the language (cf. Goldrick & Rapp 2007 on markedness asymmetries)
Results by phonological pattern, cont’d

Sonority sequencing in CC clusters

Onsets
21 of 176 (12%) substitutions and additions into CC onsets violated a sequencing constraint. Ex. means → mreans (5599)

Codas
4 of 44 (9%) substitutions/additions into CC codas violated sequencing. Higher incidence of irregularity in CC clusters (sensible, since most phonotactic restrictions apply to clusters)

Tense/lax phonology
Additions in C_CC syllables don’t seem to reflect the general avoidance of tense vowels in VCC rimes: of 14 relevant cases, 6 additions had lax vowels, 8 had tense vowels.

Lax vowel: 6  Tense vowel: 8
Eg. this[t]  cam[p] [kɛɪmp]
Effect of collection method on regularity

Summary statistics: 4.34% of errors violate phonotactics, which is far more than 1% reported in prior research. Likely due to robust methods of SFUSED.

SFUSED: collection method is coded for in SFUSED, so we can test for effect of method regularity.

Observation: there is a significant association between collection method and regularity—nearly three times as many phonotactic violations

<table>
<thead>
<tr>
<th></th>
<th>Regular</th>
<th>Irregular</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>660</td>
<td>11 (1.64%)</td>
</tr>
<tr>
<td>Offline</td>
<td>1,326</td>
<td>76 (5.55%)</td>
</tr>
</tbody>
</table>

$X^2 = 16.9618$, $p < .05$
Discussion: perceptual biases

Dell et al.’s conjecture: 99% standard for regularity too high, will be lower if factor in perceptual biases

SFUSED: offline method and verification protocols have been shown to be more representative of actual occurrence of speech errors, less prone to bias. Lower phonological regularity in SFUSED is direct confirmation of Dell’s conjecture.

Room for debate: what’s regular/irregular (θw, gw)

No room: method affects counts of regularity, same phonotactics used for both offline and online data.

Revised standard: 94-95% regularity
Discussion: new standard and models

Dell et al. (1993): simple recurrent network developed to model errors. Trained on a sample of English words and tested against a set of phonological patterns characteristic of speech error patterns (given below).

→ Tried to account for phonological effects, without tactic frames.
  • Phonological regularity effect (our focus here)
  • Consonant-vowel category effect
  • Syllabic constituent effect
  • Initialness effect (a.k.a. the word onset asymmetry)

Result: given certain parameters (trained on frequent vocabulary, internal and external input), the model produces errors that are phonotactically regular about 96.3% of the time, which compares with our findings in natural speech.

Limitations: model trained only on three segment words, designed to account for limited phonological structure, cf. many polysyllabic words in our database. Very likely that Dell et al. also used different phonotactics. Didn’t account for prosody (stress errors), non-native sounds (except maybe geminates), and other structures. However, many of the errors with phonotactic violations produced by the SRN resemble the phonotactically illicit errors we have found, with illegal clusters and initials.
Discussion: is there a role for grammar?

**Issue:** while it appears Dell et al’s SRN is a good fit with the data, there still could be a role for grammar in explaining more subtle patterns than categorical regular/irregular combinations.

**Goldrick 2011, Goldrick & Daland 2009:** speech errors may produce marked structures, but statistically they **tend to reduce markedness**, and markedness is distinct from frequency.

**Example:** Goldrick & Rapp 2007
Case study of BON, brain-damaged subject with deficit in post-lexical phonological processes (sensitivity to prosody and features)
- More accurate with onsets (96%) than codas (91%)
- More accurate with coronals /t d/ (93%) than dorsals /k g/ (86%)

At least onset/coda difference could not be attributed to frequency effects.

**Conjecture:** markedness may account for asymmetries that can’t be accounted for with pure frequency; if so, supports a notion of gradient constraints now ubiquitous in phonological theory, e.g., Harmonic Grammar, MaxEnt Grammar, Gradient Symbol Processing
Discussion: Evidence for markedness asymmetries?

Warning: somewhat conjectural, numbers still a bit rough

Repairs — from before
High percentage of additions repair onsetless syllables (40%). Evidence for Onset?
Very high percentage of deletions reduce CC onsets or codas (73%). Evidence for *Complex?

Additions into onsets and codas, by position and context sensitivity

<table>
<thead>
<tr>
<th></th>
<th>Onsets</th>
<th></th>
<th>Codas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
<td>Simple</td>
</tr>
<tr>
<td>Contextual</td>
<td>15</td>
<td>61</td>
<td>91</td>
</tr>
<tr>
<td>Noncontextual</td>
<td>10</td>
<td>6</td>
<td>10</td>
</tr>
<tr>
<td>Total - All</td>
<td>193 (71.2%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Totals, N.C.</td>
<td>26</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Observation: many more additions into onset position than codas, which is expected if errors structured by markedness; weaker in noncontextual errors.
### Discussion: Evidence for markedness asymmetries?

**Warning:** somewhat conjectural, numbers still a bit rough

Deletions in onsets and codas, by position and context sensitivity

<table>
<thead>
<tr>
<th></th>
<th>Onsets</th>
<th>Codas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>C1</td>
<td>C2</td>
</tr>
<tr>
<td>Contextual</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>28</td>
</tr>
<tr>
<td>Noncontextual</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Total - All</td>
<td>83</td>
<td>(58.9%)</td>
</tr>
<tr>
<td>Totals, N.C.</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

**Observation:** still more errors in onsets, but magnitude is far less (cf. 71.2% vs. 28.8% with additions from above); noncontextual errors roughly equal. Expect a difference from additions, because deletions remove segments (good in codas, bad in simple onsets).
Future work: markedness asymmetries

Markedness asymmetries: assemble a range of potential markedness asymmetries and document their patterns in SFUSED

Check for output biases based in frequency: then try to determine if the asymmetry could be explained as an output bias of some kind: segment frequency, sequence frequency, onset/rime frequency, etc.

Anticipating outcomes
• If find markedness asymmetry that can’t be explained as an output bias, then we have evidence for a role for gradient constraints.
• Lacking markedness effects independent from frequency effects, then we can account for the speech error patterns with just a SRN like Dell et al’s model.
• What I think is likely: mixed bag, some markedness effects strong, others not. Syllabic effects seem strong, but pilot testing of segment markedness (e.g., coronals vs. dorsals) has shown no effect. (Stemberger 1991 explicitly argues for combining frequency effects with other structural patterns, so also has a mixed model.)
Take Homes

**New standard for regularity**: errors of phonological encoding are phonotactically regular about 94-95% of the time. Phonotactic violations are more common than reported in prior research.

**Methodology**: new standard is documented using different collection methods; so lower standard is likely the result of perceptual bias.

**Grammar in phonological encoding?** SRN does a relatively good job of accounting for the data, but markedness asymmetries may emerge that require a role for gradient constraints. *Stay tuned!*
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Future projects

SFUSED is designed as a multi-purpose database and we actively seek out new project proposals.

New projects can improve the data quality through data cleaning, and also extend the database by introducing new fields.

The database can be imported to Tableau and then explored much faster and deeper.

Projects can combine questions from linguistic theory (e.g., ‘psychological reality of X’) or experimental paradigms.

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