1. Introduction

• What is the connection between opacity, phonetic variation, and learning?
  • **Levantine Arabic** stress-epenthesis opacity:
    - **heavy penult stressed:** /ʔalif-na/ /ʔa.lif.na/ ‘our letter alif’
    - **except when epenthetic V:** /ʔal-fern/ /ʔa.l.fern/ ‘our thousand’
  • How is such a grammar learned?

• **Lebanese Arabic**: we show that epenthetic vowels are phonetically backer and/or shorter than lexical vowels. Extent of difference varies by speaker, as does the phonological context for epenthesis.
• We argue that learners use this phonetic variation as a crutch for learning the correct underlying representations.
• Some speakers of **Palestinian Arabic** can optionally stress epenthetic vowels.
• Do Palestinians distinguish these vowels phonetically?

2. Phonological variation

<table>
<thead>
<tr>
<th>Palestinian epenthesis</th>
<th>Lebanese epenthesis</th>
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• Modern Standard Arabic: no epenthesis in CC#.
• Epenthesis in Levantine CC#:
  - Rising sonority (dm, kl): almost obligatory
  - Flat/falling sonority (fs, nt): optional, variable
• Likelihood of epenthesis determined by:
  - Sonority profile: rising > falling
  - Voice: voiced > voiceless
  - Place constraints
  - Manner: sibilants, stops ok finally
    (Haddad 1984, Farwaneh 1995)

3. Phonetic study: design

**Participants:**
• 8 Lebanese speakers (from various locations in Lebanon, recorded in the US and UK)
• 8 Palestinian speakers (recorded in Haifa, Israel)
• 3 men, 5 women in each group
• All are at least bidialectal in Standard Modern Arabic, as is normal in the Arab world.

**Materials:** 30 minimal and near-minimal pairs, pseudo-randomized and embedded in a list of 50+ fillers. First vowel was always high.

\[
\begin{array}{ll}
/CVCC/ & /CVCVC/ \text{ verbs} \\
\text{bikr} & \text{‘first-born’} \\
\text{sikir} & \text{‘got drunk’} \\
\text{rikib} & \text{‘riding’} \\
\text{ximir} & \text{‘rose’} \\
\text{libis} & \text{‘clothes’} \\
\end{array}
\]

• Presented in consonantal Arabic script w/ English translations.
• To disambiguate minimal pairs, words were grouped in verb/non-verb blocks.
• **Analysis:** Spectrographic; measured duration, F1, F2, F3, and intensity.

4. Phonetic study: results

Lebanese duration: epenthetic < lexical, ep. F2 < lexical F2. F1 approached signif. for some speakers; Everything else n.s.
Palestinian duration: same trends but n.s.; F1, F2 and F3 n.s.

**Lebanese by speaker**

**Palestinian by speaker**

5. A theory of incomplete neutralization

• **Incomplete neutralization** is phonetics accessing a representation which is intermediate between input and output.
  • **Optimality Theory with Candidate Chains** (McCarthy 2007):
    - A candidate is a chain, e.g. /pada/ <pa.da, pad, pat> [pat]
    - **Gradualness**: one change (basic faith violation) at a time
    - **Harmonic improvement** required at each step
  • Sonorous epenthetic vowels = harmonic improvement but also greater unfaithfulness (Gouskova 2003, Howe and Pulleyblank 2004).
  "Dep-a>>Dep-e,o>>Dep-i, u>>Dep-e,o>>Dep-i"

Propose **incomplete neutralization**: phonetics can optionally access any part of the chain.

phonological representation

\[
\begin{array}{l}
/bikr/ \rightarrow <bikr, bikir, bikar, bikir>
\end{array}
\]

• The faithful candidate is part of the chain, so sometimes there is no epenthesis.
• **Prediction**: some speakers should have [a], not [i]. True for some Lebanese speakers, whose epenthetic vowels were significantly lower than lexical ones.

5. Learning

**Subset problem**: The learner must find the grammar that produces stress-epenthesis interactions but cannot assign stress freely, as in a lexical stress pattern.

• Alderete and Tesar (2002): Before positing underlying stress distinctions, learners must consider unfaithful origin of vowel as the explanation for opaque stress. This assumes that learners cannot distinguish surface epenthetic and lexical vowels.
• **Our proposal**: Learners posit a candidate chain based on surface phonetic variants. Each surface variant corresponds to step in chain. Phonetic variation requires longer chains.
• Positing correct derivations is easier for Lebanese speakers than for Palestinians, who don’t make drastic quality differences between epenthetic and lexical vowels.
• Over time, opaque stress is reanalyzed as predictable stress (cf. Labov, Karen and Miller 1991 and others).

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