Acoustic Phonetics

Lesson 6 - Prof. M. Grazia Busà

1. Vowel reduction in English
2. The schwa sound
3. The IPA phonetic symbols
4. Narrow and broad transcription

Vowel reduction

- The phonological process accounting for the weakening and reduction of (unstressed) vowels which come to take an undistinguished quality

English reduction to schwa

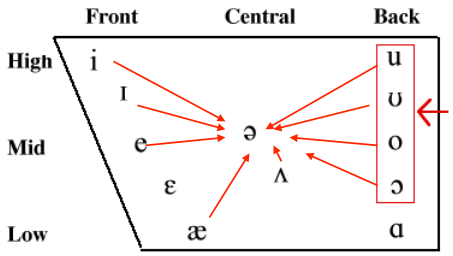
- English exhibits a pattern of vowel reduction whereby vowel quality contrasts are neutralized in unstressed syllables.
- The resulting vowel is usually transcribed as schwa [ə]

atom	ˈætəm
atomic	əˈtɒm.ɪk

Vowel reduction in English

- This process explains the progressive reduction of English vowels in words and sentences
- Extremely reduced vowels may disappear completely

English Vowels



Source:
http://www.utexas.edu/courses/linguistics/resources/phonetics/vowelmap/vowelmap2.html

Schwa

Schwa is called the *neutral vowel*:

- produced in a central (called *neutral*) position
- symbol: /ə/
- occurs only in unstressed position
- brief and unstressed

English word stress alternation

- pòlicy: ['pɒləsɪ]
- polìce: [pə'li:s]
- + man [mæn]
  [pə'li:smən] [p'l̩i:smn̩]
- pòlitics: ['pɒlətɪks]
- political: [pə'lɪtɪkl̩]

Only an English phonological process?

Phonological vowel reduction*

- In many languages vowel contrasts are neutralized in unstressed syllables
- Some examples are reported in the next slide

* The following slides are from Ed. Flemming's ppt: *Contrast and the realization of schwa vowels in English.* They will be noted with **EF.**

Examples of Phonological vowel reduction (from Ed. Flemming 2005-2009)*

Common patterns of vowel reduction:

a)

i u
e o
ɛ ɔ

b)

i u
e o

c)

i
a

a) reduces to (b): e.g. Standard Italian, Br. Portuguese, Slovene
b) reduces to (c): e.g. Standard Russian, Catalan
c) reduces to (c): e.g. Standard Russian, Catalan
Reduction to a single vowel: e.g. English, Dutch, Salish

Primarily neutralization of height contrasts

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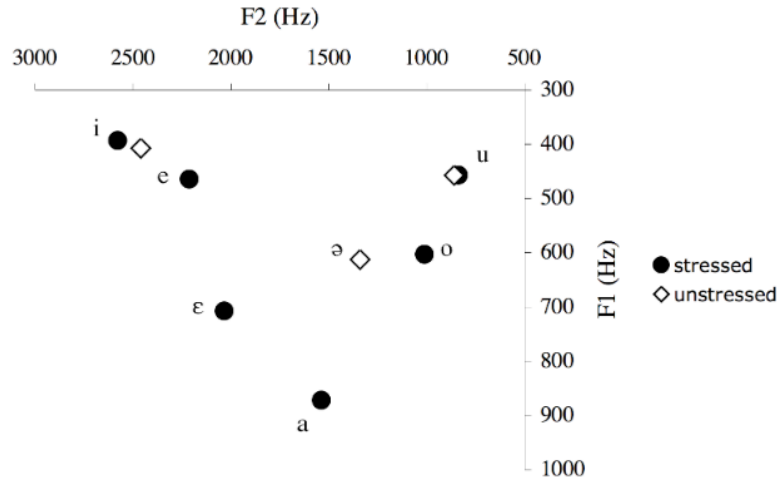

Fig. 7. Mean formant frequencies of Girona Catalan stressed and unstressed vowels. 3 speakers (data from Herrick 2003).

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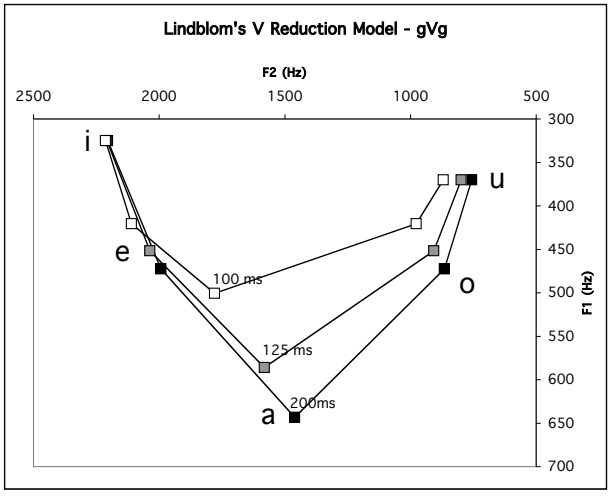
- Vowel reduction is fundamentally motivated by undershoot in short unstressed syllables.

Phonetic vowel reduction - Undershoot

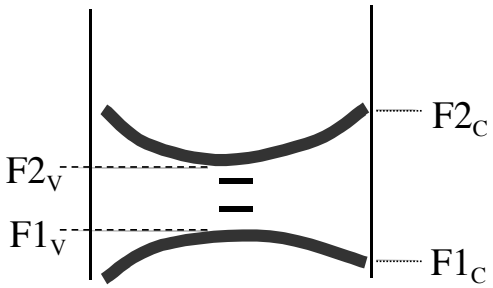


The phonetics of a schwa

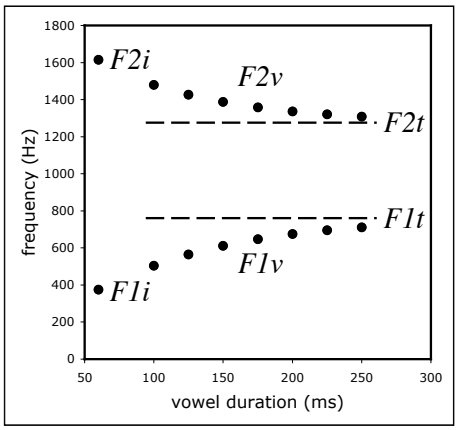
- Short duration of unstressed vowels increases the effort required to achieve distinct vowel qualities, particularly low vowels (Lindblom 1963).

Undershoot as a consequence of effort minimization

- Faster movements are more effortful (Nelson 1983, Perkell et al 2002).
- In a CVC sequence, the articulators have to move to and from the position for the vowel.
- Undershoot results from avoiding fast movements.



Formant undershoot as a function of duration and distance



More undershoot where:

- Vowel is shorter
- Distance between C and V is greater

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Implementation of the model of vowel reduction

- Stressed and unstressed inventories of contrasting vowel categories are selected from a space of possible vowels so as to best satisfy constraints on contrasts:
  - Maximize distinctiveness of contrasts.
  - Maximize number of contrasts.
  - Minimize articulatory effort.

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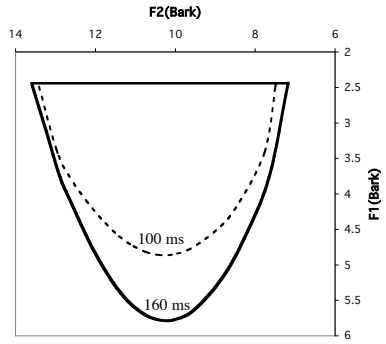
- Effort minimization implies undershoot.

Reduction of the vowel space

- The space of possible vowels contracts as vowel duration is reduced, following the undershoot functions proposed by Lindblom (1963)
- Consonants are assumed to assimilate partially to the vowel target in F2, but not in F1.

Reduction of the vowel space



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Reduction to 'schwa'

Predictions of the undershoot model:

- Reduction to a single vowel should be most likely where vowels are very short.
- Effort minimization should dominate when distinctiveness of vowel quality contrasts is irrelevant (e.g., there is a single vowel)
- Schwa should be a transitional vowel, maximally assimilated to the surrounding context → 'targetless schwa'

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Minimum effort vowels

- Minimal deviation from the narrow constrictions for surrounding consonants results in low F1 (a high vowel) because any constriction above the pharynx lowers F1.
- Minimal deviation from the tongue body and lip positions for surrounding consonants and vowels results in contextually variable F2.
- But schwa is often said to be a mid central vowel.

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Experiment 1: English schwa vowels

- Materials

final	non-final
Rosa	*rhapsody*
Lisa	*suggest*
Russia	*suspend*
asia	*prejudice*
ninja	*today*
sofa	*begin*
vodka	*report*
soda	*compare*
alpha	*probable*
umbrella	*suffocate*

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Experiment 1

- Also recorded full vowels for comparison.

  heed [i], *hid* [ɪ], *head* [ɛ], *had* [æ], *odd* [ɑ], *hood* [ʊ], *who* [u]
- Spoken in carrier phrase ‘Say ___ to me’.
- 9 female speakers of American English.
- Measured first two formants at the mid point of the vowels.
- *compare* frequently lacked any voiced vowel in the first syllable, so it was excluded from analysis.

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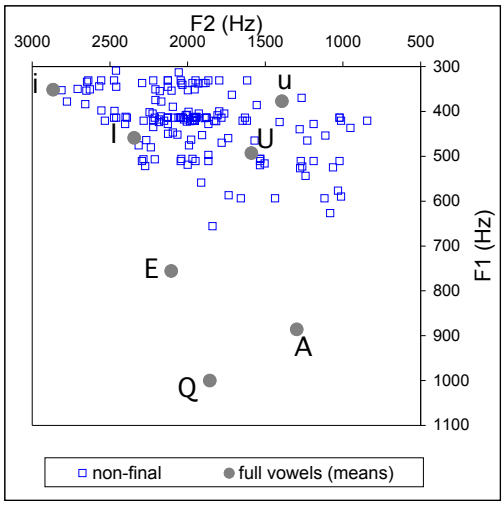
Results

Non-final schwa:

- Low F1 (mean 425 Hz)
- F2 is contextually variable.



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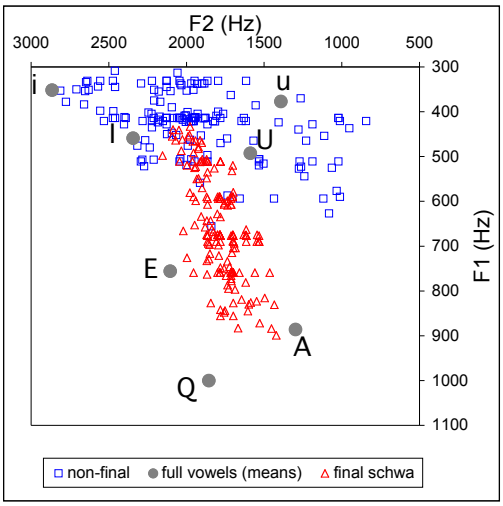
Results

Non-final schwa:

- Low F1 (mean 425 Hz)
- F2 is contextually variable.

Final schwa:

- F1 shows wide range (mean 665 Hz).
- Much of this is between-speaker variation.
- Central F2 (mean 1772 Hz)



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Two patterns of vowel reduction

- The difference between final and non-final schwa vowels can interpreted in terms of the undershoot model of vowel reduction.
- There are two degrees of unstressed vowel reduction, depending on characteristic vowel duration.

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Schwa variability

- There are two types of schwa vowels
  - Word-final schwas Word-medial schwas

Word-final schwas

- Longer vowels (153 ms vs. 64 ms.)
  - allows for vowel quality contrasts
- Schwa is realized as a mid central vowel, distinct from /i, ou/.

Word-medial schwas

- The quality of medial schwa vowels is highly variable
- The F2 trajectory of schwa depends on the consonantal context (assimilation)
- F1 of schwa varies with surrounding vowel context, but deviates from the vowel context

Thus…

- Non-final schwa vowels are short
- Vowel quality contrasts are neutralized
- Medial schwas show wide variation in F2 and in F1.
- This variation is systematically conditioned by context.

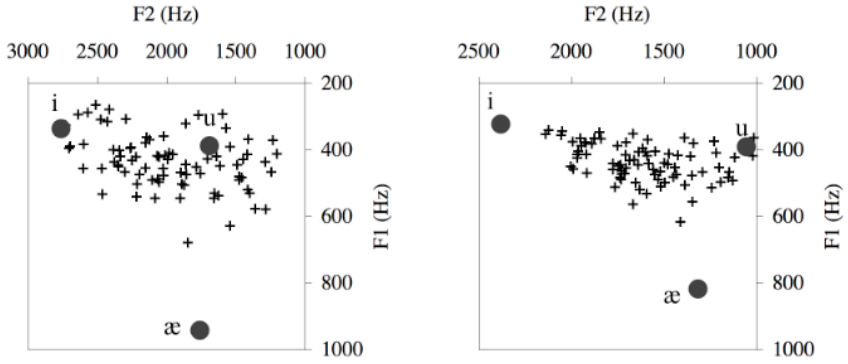

Fig. 4. Formant frequencies of schwa vowels from all contexts, two speakers.

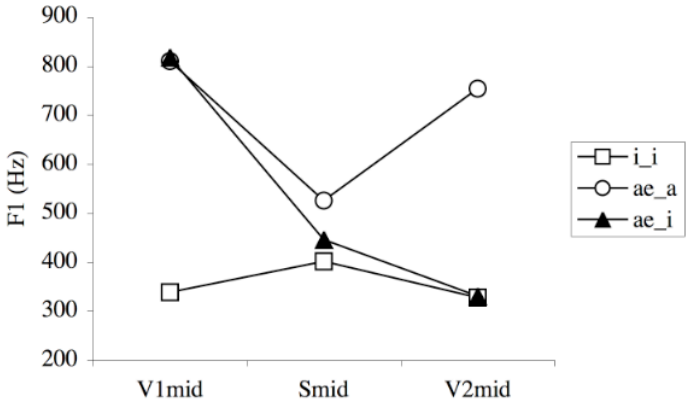

Fig. 6. Mean F1 at the midpoints of V1, schwa, and V2 in selected classes of words.

Some schwa acoustics

- From Ed Fleming's paper *Schwa Phonetics, 2007*

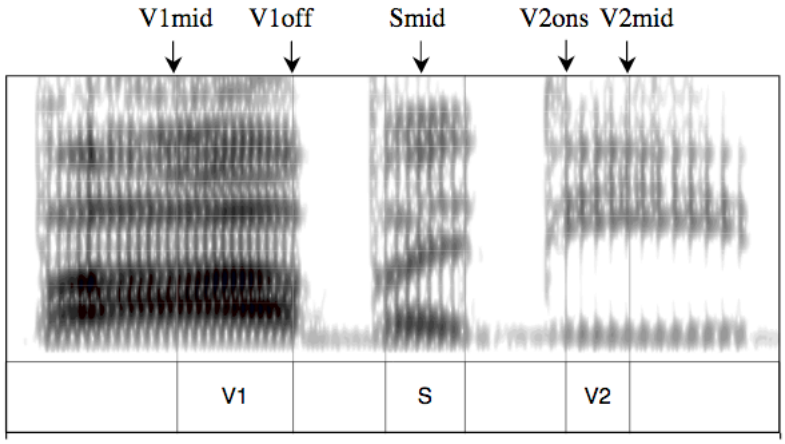

Fig. 3. Spectrogram of an utterance of [ˈbæbəˌdit], illustrating the points at which formant measurements were made.

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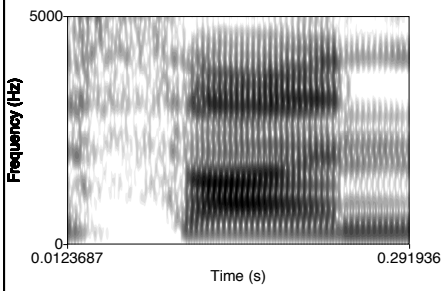
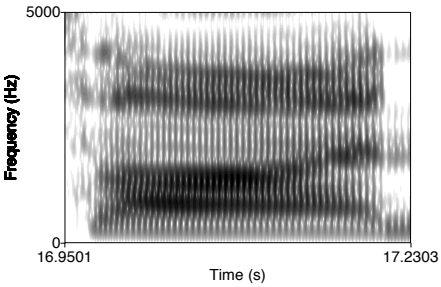
Schwa presence vs. absence



saw n(othing)



saw an(other)

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Undershoot and vowel reduction

- Relating phonological vowel reduction to undershoot helps to explain:
  - i. The tendency to neutralize vowel contrasts in short unstressed syllables.
  - ii. The generalization that vowel reduction primarily eliminates height contrasts.
  - iii. The generalization that neutralizing vowel reduction is accompanied by phonetic reduction.

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Correlation between contrast and reduced vowel quality

- Reduced vowel quality is observed across languages only when vowel contrast is irrelevant

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Back to English scwa

English schwa vowels

final	non-final
Rosa	*rhapsody*
Lisa	*suggest*
Russia	*suspend*
asia	*prejudice*
ninja	*today*
sofa	*begin*
vodka	*report*
soda	*compare*
alpha	*probable*
umbrella	*suffocate*

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Function and lexical words

- The English lexicon distinguishes between *lexical* (or *content*) words and *function* words (or *relational* words)
  - Lexical words: nouns, adjectives, adverbs and verbs
  - Function words: conjunctions, articles, pronouns, prepositions, auxiliaries, etc

  Ex.: a$_{(f)}$ cup $_{(l)}$ of $_{(f)}$ tea $_{(l)}$

Vowel reduction in function words

- Function words are more likely to be reduced in English.
  - Vowels in function words may disappear completely
  - This is at the basis of the so-called 'contracted forms' in English
    - I've, He's, etc.....

Some examples

a:	[ei]	[ə]
and:	[ænd]	[ənd], [ən], [n̩]
as:	[æz]	[əz]
at:	[æt]	[ət]
can:	[kæn]	[kən], [kn̩]
has:	[hæz]	[həz], [əz], [z], [s]
he:	[hi]	[hɪ], [ɪ]
must:	[mvst]	[məst], [məs], [ms]
to:	[tu]	[tʊ], [tə], [ə]
would:	[wud]	[wəd], [əd], [d]

Practice with English shwa

- Which of the words in the following slides contains a schwa, and where is it? (you may guess or check their pronunciation in an online dictionary)

Practice with English shwa

- *amazing* [əmeizɪŋ]
- *altogether* [ɔltəgɛðəɹ]
- *another*
- *habit*
- *vegetable*
- *feeder*
- *fascination*
- *buzz*
- *management*

basket
pasted
candies
basic
rabbit
faucet
attack
perfect
address

bunker
laboratory
elephant
development
sponsor
plus
blanket
synonym
liquify
laminate
support
sport

practice
busted
nationality
mustache
butter
gallop
instinct