

Acoustic Phonetics

Lesson 13

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Stress

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STRESS

- In linguistics, **stress** is the relative emphasis that may be given to certain syllables in a word.
- The term is also used to indicate phonetic prominence inside syllables.

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Prominence:

A syllable might be more **prominent** by **differing from the surrounding syllables** in terms of:

- loudness
- pitch
- length

Prominence is relative to the surrounding syllables, **not absolute**

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TYPES OF STRESS:

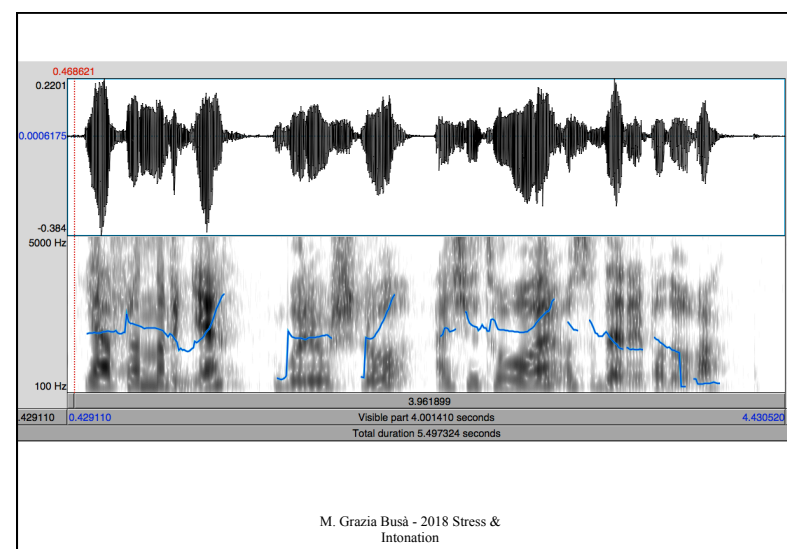
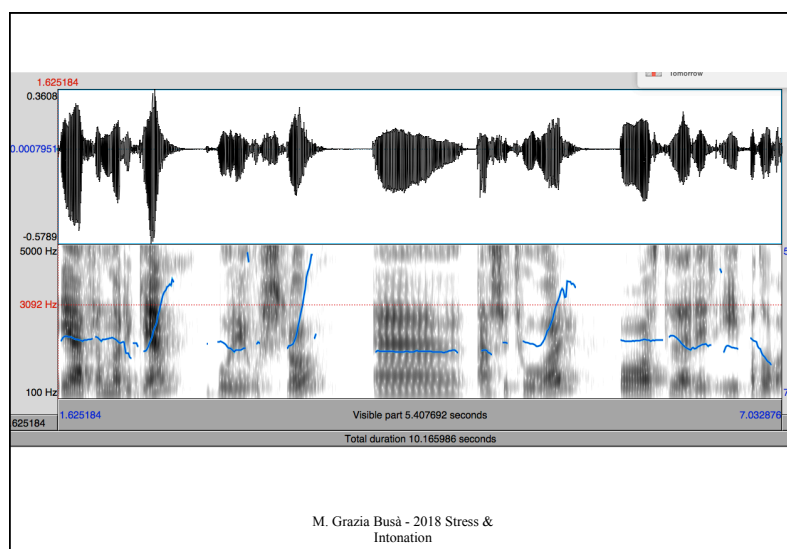
The realization of stress is language dependent.

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Pitch accent languages

- Stressed syllables have a **higher or lower pitch** than non-stressed syllables
 - Prominence is realized only by means of pitch
 - Tone contours on the prominent syllables are always the same

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Stress languages

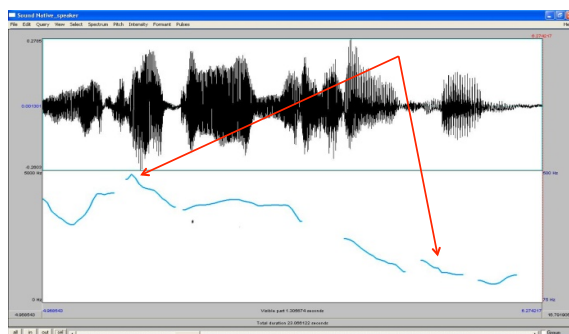
- Stressed syllables have a **higher or lower pitch** than non-stressed syllables (pitch excursion)
 - There may be varying degrees of high vs. low pitch
 - Loudness, vowel quality and/or quantity may also contribute to stress

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- Stressed syllables are often perceived as being more forceful than non-stressed syllables.
- Research has shown, however, that although dynamic stress is accompanied by greater respiratory force, **it does not mean a more forceful articulation** in the vocal tract.

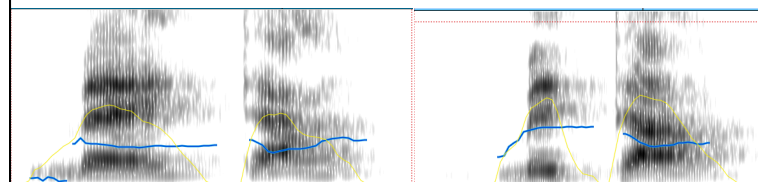
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Prominence in English



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Stress in Italian



meta



metà



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Stress in English

- an essential feature of word identity in English
 - Strong contrast between *stressed* and *unstressed syllables*
 - polysyllabic words have a *primary stress*, *secondary*, and *tertiary stress* or have *weak syllables* (with reduced vowels)

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- In English, stress is most dramatically realized on *focussed or accented words*. E.g.
 - "Is it brunch tomorrow?"
 - "No, it's *dinner* tomorrow."

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Information and Stress in English

- Words that carry **higher information** content in the utterance are given **higher stress**
 - One word is generally stressed more than any other
- '**content**' words, as opposed to 'function' words, generally **carry stress**.
 - **Content words**: nouns, verbs, adjectives, adverbs
 - **Function words**: articles, prepositions, conjunctions, and modal auxiliaries.

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Stress and prominence in Italian and English

- Italian stress:
 - Pitch loudness and intensity
- English stress:
 - Pitch loudness and intensity
 - Full vs. reduced vowels (leading to complex consonant clusters)

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What is the difference between stress and intonation?

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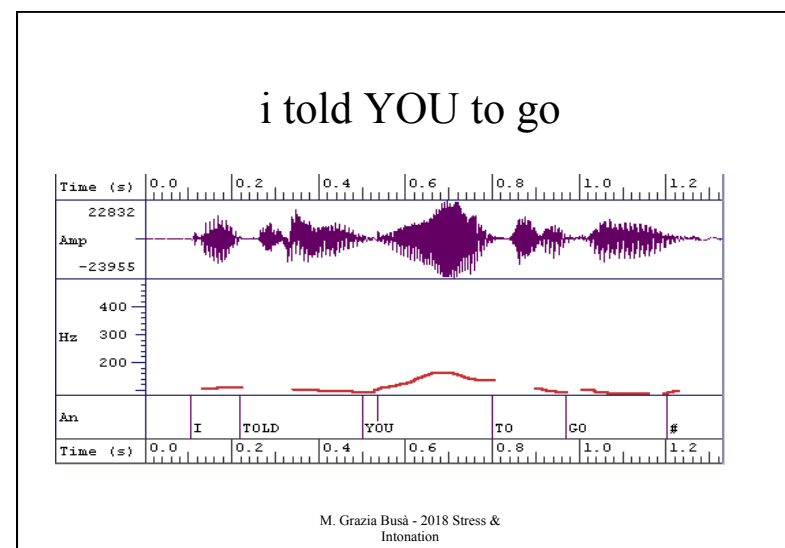
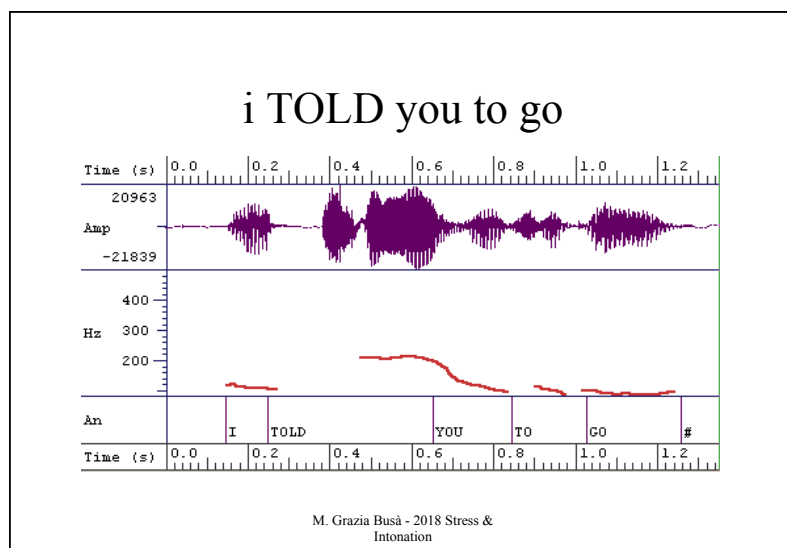
Stress:

- Involves variations in pitch, loudness and duration
- Domain of application is the word
- Makes one syllable in the word stand out from the rest of the word.

Intonation:

- Involves variations in pitch, loudness and duration
- Domain of application is the phrase or the utterance
- Gives certain syllables prominence over the others.

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Tonic Stress (1)

- The peak of stress in an intonation unit is called '**tonic stress**', or '**nucleus**'.
 - the syllable that receives the tonic stress is called 'tonic syllable'.

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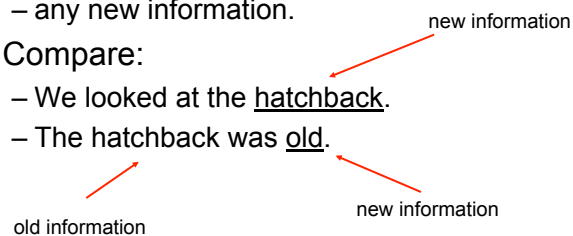
Tonic Stress (2)

- In a sequence of stressed syllables, these get stressed, but not as much as the tonic syllable, producing different degrees of stress in the utterance.

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Nuclear syllable and new information

- The nuclear syllable carries:
 - the main focus of information
 - any new information.
- Compare:
 - We looked at the hatchback.
 - The hatchback was old.



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Emphatic Stress

- The tonic stress can be moved from its utterance final position for emphasis.

Ex.:

- It was very BOring. (unmarked)
- It was VEry boring. (emphatic)

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Contrastive Stress

- Any lexical item can receive the tonic stress if it contrasts with some other lexical element in the utterance (even function words)
- Examples:
 - Do you like this one or THAT one?
I like THIS one.
 - She played the piano yesterday. (It was her who...)
 - She played the piano yesterday. (Not the violin). It was the piano that...)

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Intonation

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Meaning and intonation

- Language conveys meaning non only through words
- Emotions, emphasis, irony, contextual relevance, etc. can be conveyed through modulations of the tone of voice (what we hear as the voice going up and down)

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Meaning and intonation

- These modulations are commonly referred to **intonation patterns**.
 - Intonation is only poorly represented in the written language (through full stops, commas, question marks, exclamation marks).

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Meanings in intonation

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Intonation and Discourse

- Information status
 - Given/new information
 - S: Do you need a return **ticket**.
 - U: No, thanks, I don't need a **return**.
 - Contrast (narrow focus)
 - U: No, thanks, I don't need a **RETURN**.... (I need a time schedule, receipt,...)
 - Emphasis
 - U: No, thanks, I don't **NEED** a return.... (I need a time schedule, receipt,...)

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Intonation and Discourse (2)

- Speech acts (statements, questions, requests)

That'll be credit card

Can you open that window?

- Discourse/topic structure

I'm afraid we don't have time to finish the experiment today.

The man I saw at the train station was my uncle

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'Paralinguistic' Information

- Emotion (anger, happiness, love)
- Propositional attitude (uncertainty)

Did you feed the animals?

I fed the goldfish (Rise/Fall/Rise)

- Level of speaker engagement

Really

REALLY

- Personality

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Prosodic Disambiguation of Syntactic and Semantic Ambiguity

- Bill *doesn't* drink because he's unhappy.
- The presence of *none* of the professors will embarrass her.
- He *only* wounded Anne.
- He managed to find the woman *with the binoculars*.

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Language specific strategies for meaning beyond the word

- All languages express meaning through intonation
- However, in some languages, grammar may allow variations in word order, with differences in meaning depending on intonation.

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Language specific strategies for meaning beyond the word

In the Romance languages and in Italian, changes in word order may signal changes in meaning:

Ex.: **Piero viene** ~ **Viene Piero**

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Meaning through intonation in English

- English has a fairly strictly fixed word order
- Words cannot be freely re-arranged to make a point about something.
- Intonation in English provides the means to convey a range of meanings, emotions or situations, within the confines of standard grammar and fixed word order.

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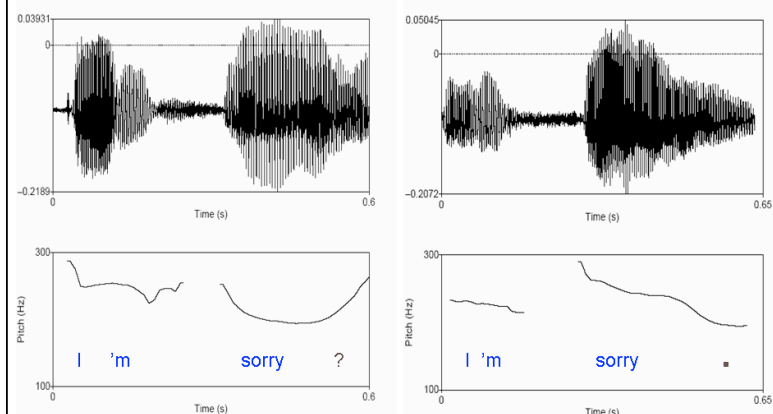
How is intonation studied?

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- The modulations in the tone of voice (or pitch) in speech (what we hear as the voice going up and down) are referred to **pitch patterns** or **intonation patterns**.

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Example: rising and falling contours



Pitch

- Pitch refers to the movements of the tone of voice
 - From a physiological point of view, pitch depends on the rate of vibration and/or alteration of the tension of the vocal cords.
 - When the vocal cords are stretched, the pitch of the voice increases.

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F0 and Pitch

F0 (fundamental frequency)

- Indicates the number of glottal vibrations in a second

Pitch (tone height)

- Perceptual correlate of F0

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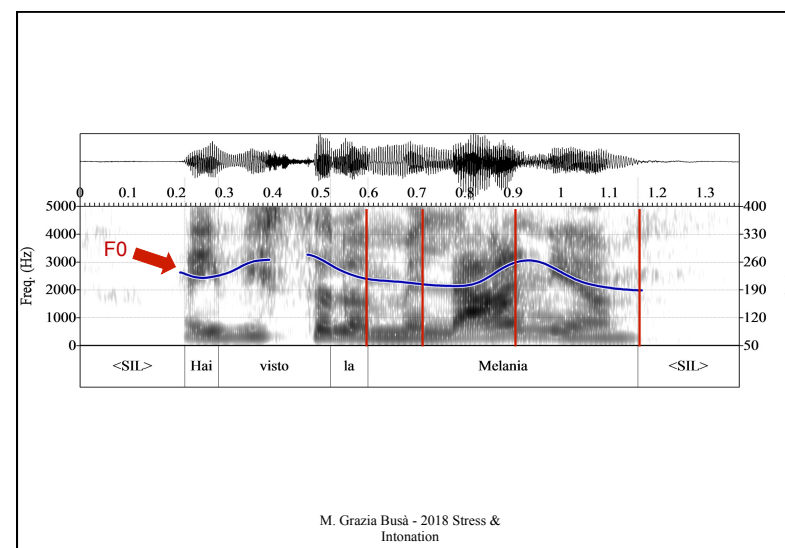
Pitch in the spectrogram

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Variations in Pitch

- pitch can vary from high to low (pitch levels/ range).
- higher pitch is heard louder than lower pitch.
- stressed syllables tend to have higher pitch

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The tone group

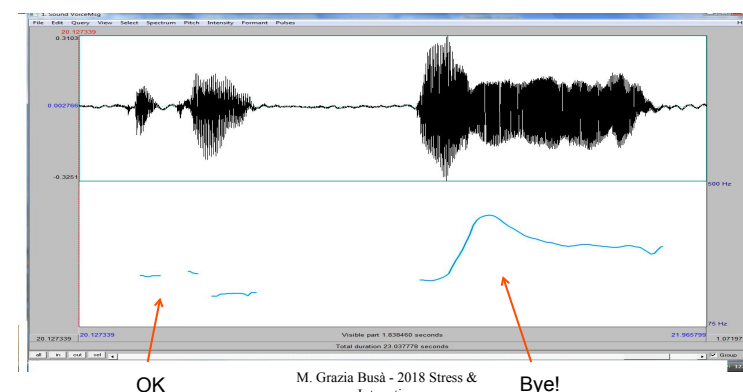
- By **tone group** we mean the stretch of speech on which intonation applies.
- Tone groups can contain only one word or as many as seven or eight.

Ex.:

/no / I really can't put up with it / good-bye/

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Ex.: Tone groups



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Tone units

- The division of a sentence into tone groups can affect the meaning in some cases.

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il maestro disse l'ispettore è un asino

il maestro disse // l'ispettore è un asino

il maestro // disse l'ispettore // è un asino

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– Do you take sugar?

– / I don't / no /

Meaning: I don't, no.

/ I don't no/

Meaning: I don't know.

– / The prince said / the princess had been unfaithful./

Meaning: The prince said (that) the princess had been unfaithful.

– / The prince / said the princess / had been unfaithful./

Meaning: "The prince," said the princess, "had been unfaithful."

http://english.unitecnology.ac.nz/resources/resources/exp_lang/how.html

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About intonation models

- Intonation is not a simple subject
- Many different theories present differing viewpoints and terminology on intonation
- Studying intonation is complicated by:
 - Individual variation
 - Variations due to speakers' intentions and paralinguistic information

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Tone sequence models

- General assumption: intonation is generated from sequences of (possibly) **categorically different and phonologically distinctive accents (tonic syllable)**

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Intonation models

- Two types of models within the group of tone sequence models:

Type 1: Intonation made up of sequences of **pitch movements**

Type 2: Intonation made up of sequences of **pitch levels or targets**

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Two types of tone-sequence model

Type 1: based on pitch movements

t a r g e t



The British School
The Dutch School

Type 2: based on pitch levels

H t a r g e t L



The American School

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The British School

- Based on auditory analysis
- Tone sequence model and pitch movement analysis (e.g. *falling* vs. *rising* intonation)

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Concepts in the British School

- Basic unit of intonational description: **intonation phrase (tone unit)**
 - Delimited by pauses, phrase-final lengthening, pitch movement
- Syllables within a tone unit can be **stressed** or **accented**
- **Accented** syllables are **stressed** and **pitch prominent**

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Accent

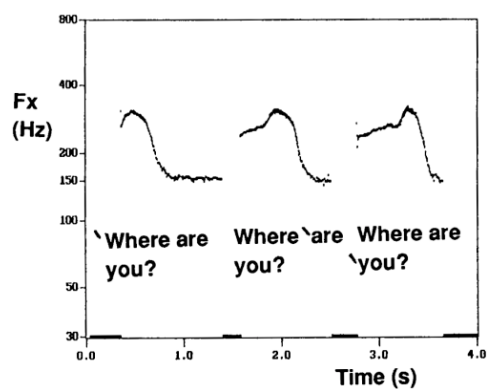
Stressed syllable has full vowel and is perceived as involving a rhythmic beat

Pitch prominence

- syllable produced with **moving pitch** or **pitch change**

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Example



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Intonation Phrase Structure

- Intonational phrases have an internal structure
 - Structure determined by location of accents in an IP
 - Each accent defines the **beginning** of a prosodic constituent

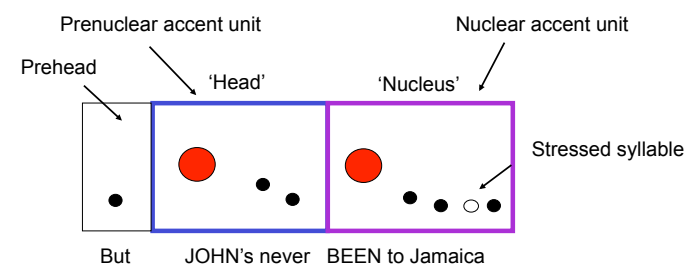
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Intonation phrase (IP) structure

- Two types of accent unit in the British School:
 - Prenuclear accent units; also called the **Head**
 - Nuclear accent units; also called the **Nucleus**
- The nuclear accent unit is the **last accent unit** in the IP
- The head comprises **all prenuclear accent units**

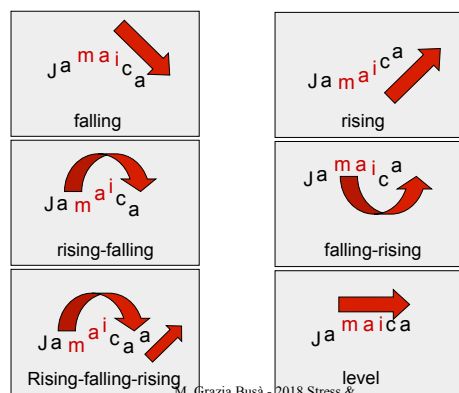
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Intonation phrase structure



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Six nuclear choices in English



Prosodic constituents

Each constituent consists of stressed (strong) and unstressed (weak) syllables.

It was the best car for them to buy.

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The Head

- The constituent that extends from the first stressed syllable up to (but not including) the next tonic syllable is called the **head**:

– John's never **been** to Jamaica

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The Nuclear Syllable

- Within the tone group, one syllable will be even more strongly stressed than the other stressed syllables. This is called the **nuclear syllable**.

– It was the best car for them to **buy**.



Nuclear
syllable

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Criticism

- How are accents, prominence defined? Related to segments? Too many options....
- Are prenuclear accents qualitatively different from nuclear accents? What is the evidence?
- Does each pitch accent begin a new 'prosodic unit' in the phrase? What is the evidence?



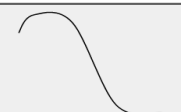
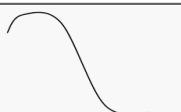
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The American School

- Based on instrumental + auditory analysis
- Analysis based on sequences of H and L levels

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Differences between the US and the British approach

Auto-segmental Metrical approach	British Nuclear Tone approach
	
L H	rise
	
H L	fall

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The American School and ToBI

The following slides are taken from Julia Hirschberg

www.cs.columbia.edu/~julia/ M. Grazia Busà - 2018 Stress &
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The American School

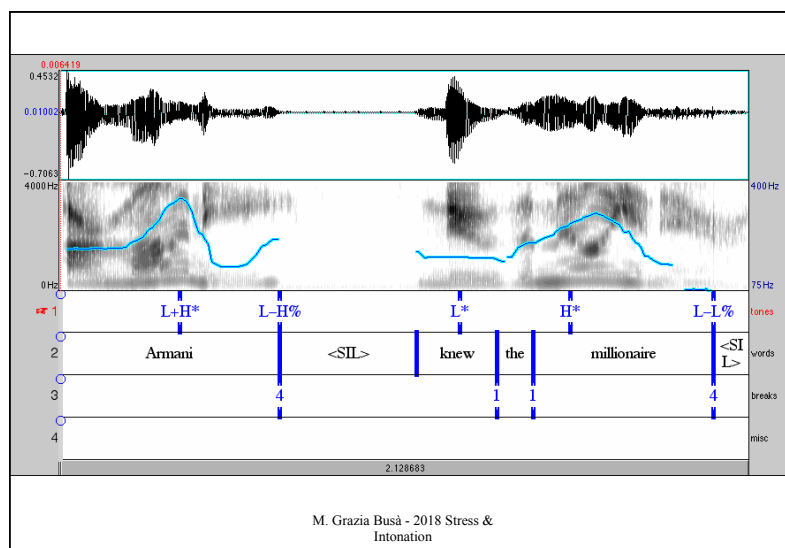
- American school-type models make a distinction between **accents** (what makes a particular word prominent) and **boundary tones** (how a phrase ends)
- **Autosegmental metrical or two-tone models**
- Only two tones, which may be combined
 - H = high target
 - L = low target

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Prominence and boundaries

- Prominence: accents, stress
 - John only introduced **MARY** to Sue
 - John only introduced Mary to **SUE**
- Boundaries: disjuncture between words
 - Bill doesn't drink | because he's unhappy
 - Bill doesn't drink because he's unhappy

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ToBI Goal

- Capture *enough* variation to explain similarities and differences in prosodic meaning

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ToBI Scheme

- ToBI annotation tiers:
 - Orthographic tier: Time-aligned words
 - Break-index tier: degrees of junction (0-4)
 - Tonal tier: pitch accents, phrase accents, boundary tones
 - Miscellaneous tier: disfluencies, non-speech sounds, etc.

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Pitch accents: Intonational Prominence

- Achieved through
 - Different tone targets
 - Differences in f0 height
 - Being louder and longer
- Hierarchy
 - Last accented word tends to be most prominent
 - Most prominent accent in intermediate phrase is called phrase's *nuclear accent* or *nuclear stress*

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Break Indices Differences

- Associated with
 - Variation in f_0
 - Phrase final lengthening
 - Glottalization
 - Some amount of pause

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Degrees of junction (Break indexes)

Level 0: word boundary apparently erased

Level 1: typical between-word disjuncture within a phrase

Level 2: Strong juncture with no tonal boundaries

Level 3: minor or **intermediate phrase**Level

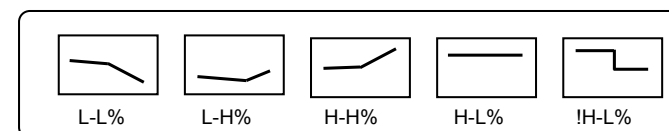
Level 4: end of an intonational phrase

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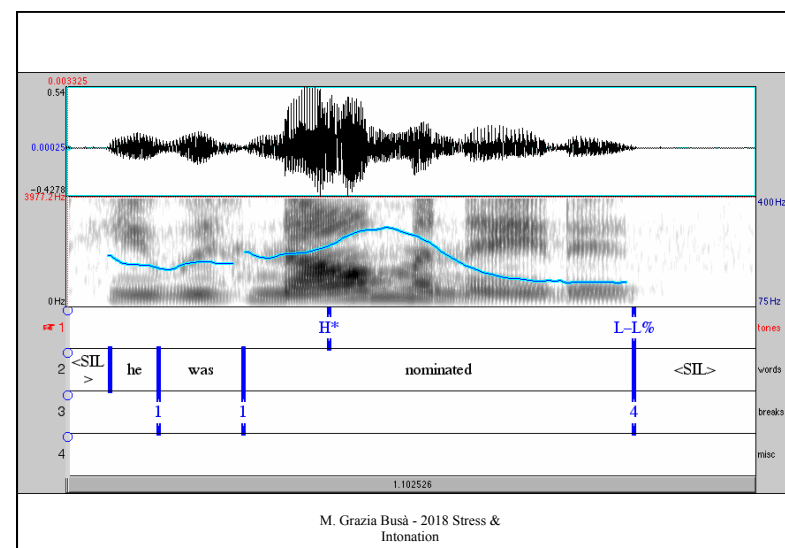
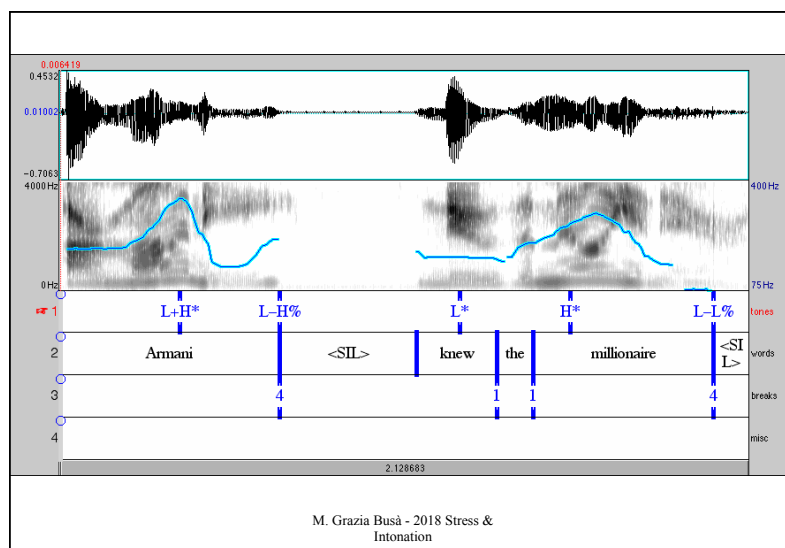
Accents			
Pitch Accent		Phrase Accent	Boundary tones
H*		L -	H %
L*			L %
L* + H			
L + H*		H -	H %
H + !H*			L %
H* !H*			

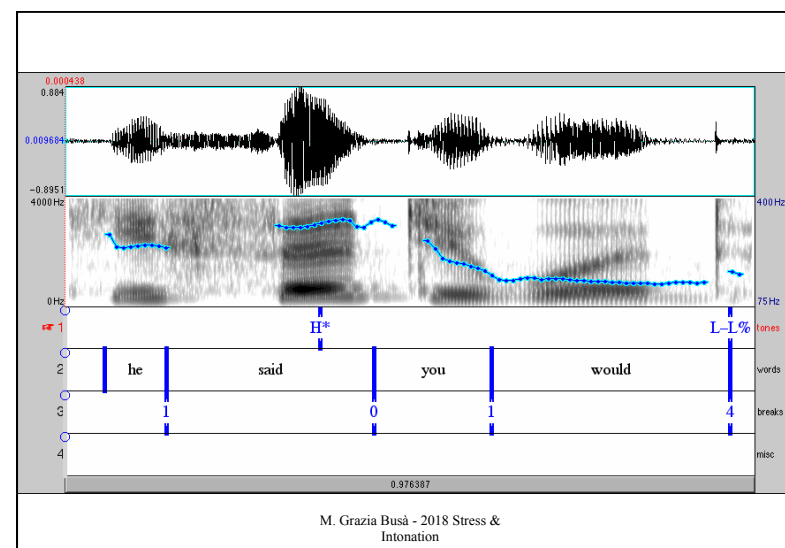
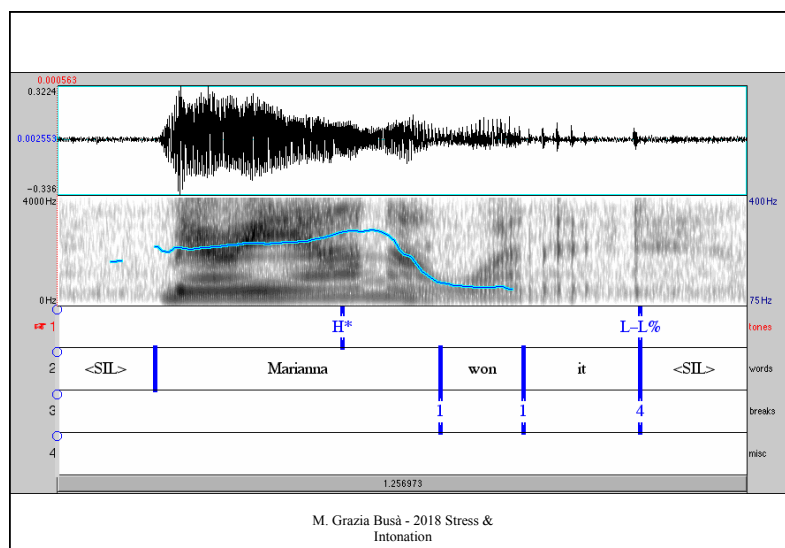
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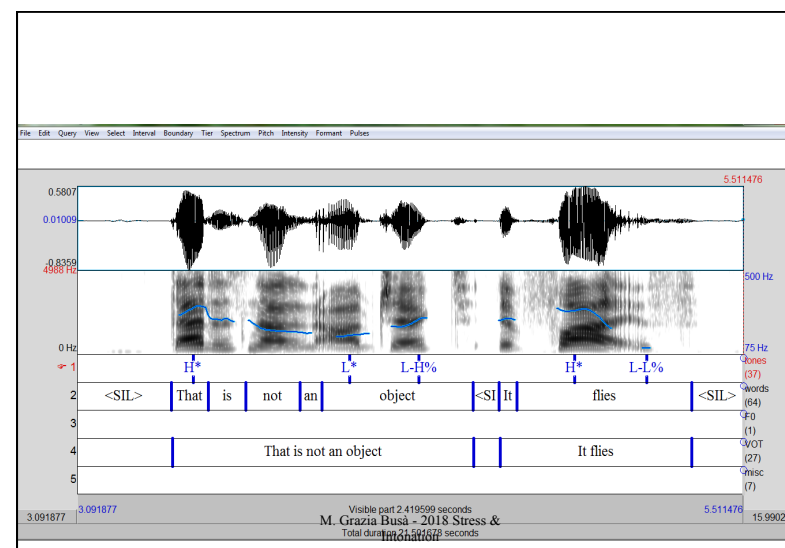
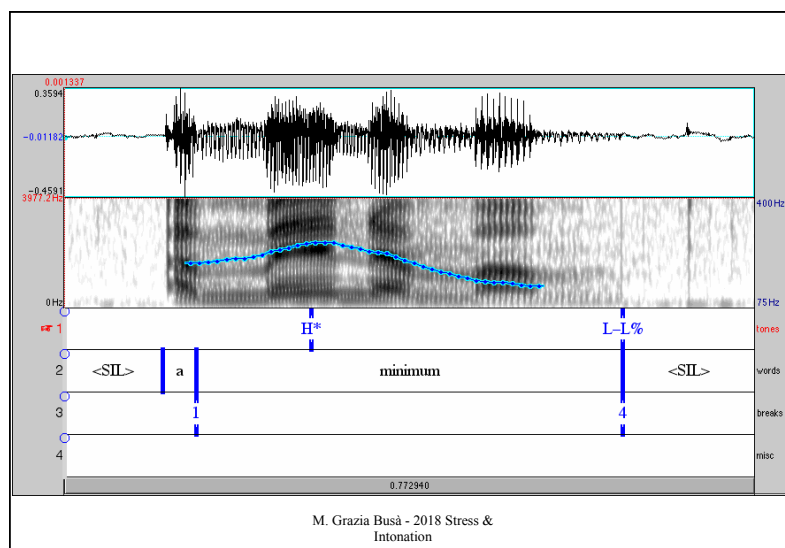
Phrase Ending Types



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An interesting course

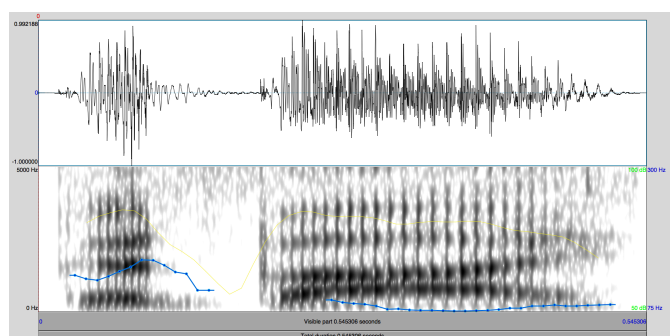
- https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-911-transcribing-prosodic-structure-of-spoken-utterances-with-tobi-january-iap-2006/lecture-notes/chapter2_6/

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Now you try!

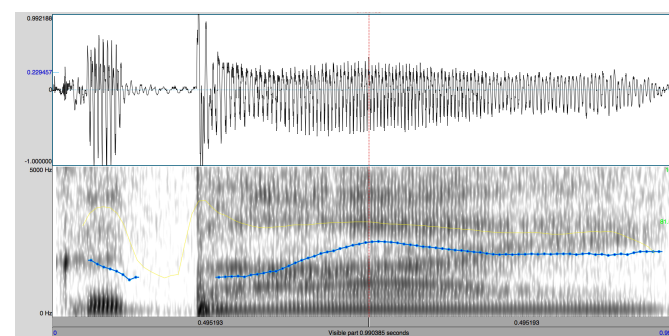
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Goodbye!



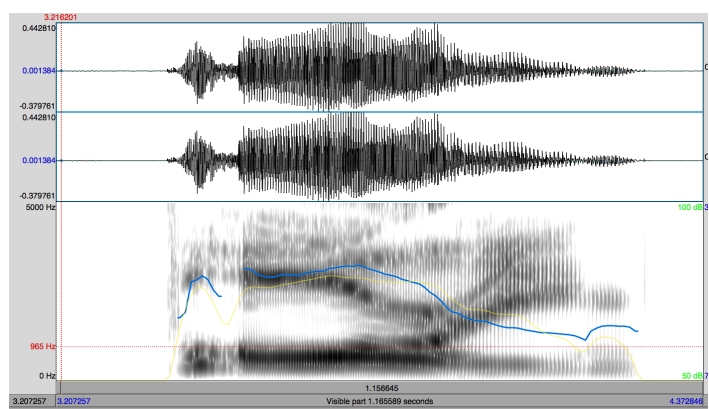
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Goodbye!

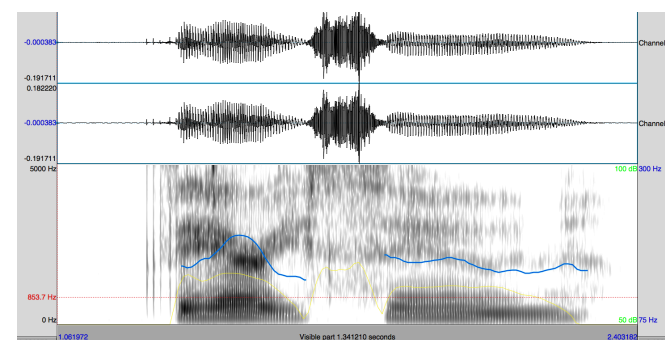


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(that was) boring!



(...) very soon



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Laboratory models

a number of laboratory techniques are used in the study of suprasegmentals

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Manual Annotation:

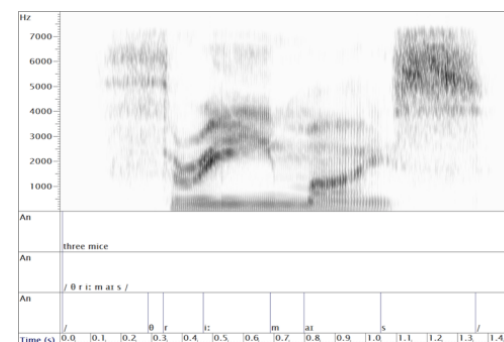
- accuracy of the human annotator
- time-consuming and error-prone

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Automatic Annotation:

- automatic "phoneme alignment" between a phonological transcription and the recorded signal
- locates segments, syllables and phrases
 - allows for [large-scale analysis](#)
 - basis for much experimental phonetics research and [technological applications](#) such as speech recognition and speech synthesis.

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Pitch track :

- a "pitch track" or fundamental frequency contour can be extracted from a recorded speech signal
 - shows how the pitch of the voice changes through an utterance: e.g.,
 - changes in fundamental frequency associated with pitch accents;
 - range of F₀ used by the speaker;
 - voiced and voiceless regions

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Stylised pitch:

- To extract parameters from the pitch track it is common practice to first model the shape of the contour. A common strategy is to stylise the changes in pitch with a sequence of simple shapes, e.g. straight lines

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