Language

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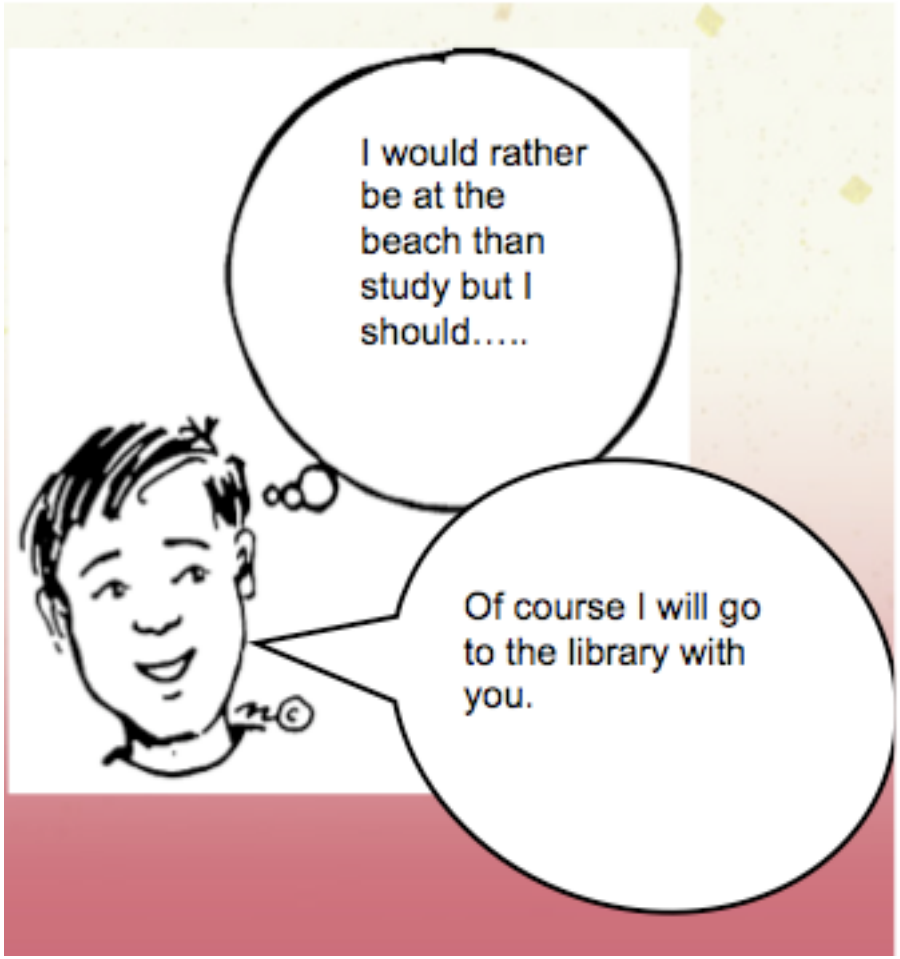
What is language ?

A code to translate

- **thoughts into output and input into thoughts**

- Communication with others

- Communication with self – reflect, understanding and decision making.



Components of language

Phonemes – Smallest acoustic unit that distinguishes meaning (eg - /t/ip and /d/ip)

Graphemes – Fundamental unit of written language

(alphabet, symbols of any writing system)

(eg - Ship – Four graphemes, three phonemes

Morphemes – Smallest linguistic unit that has meaning

(spoken language or speech – morphemes consist of phonemes)

(Written language – morphemes consist of graphemes)

Differ from words – many morphemes cannot stand as words on their own (un/break/able)

Lexicon – vocabulary

Semantics – meaning

Syntax – rules and principles that govern the construction of a sentence

Prosody – rhythm or stress in speech  

Pragmatics – the ability to communicate more than what is explicitly stated

(I could drink up the ocean)

Narrative – story, incident..

- How does the brain cope with spoken and written input to derive meaning?

- Primary question of interest – how are words represented in the brain ?

Mental Lexicon

- Mental store of information about words

- Semantic(word meanings)
- Syntactic (words combined to form sentences)
- Word forms (spellings and sounds)

Theories for a mental lexicon (two theories)

- Single mental lexicon for comprehension and production.
- Distinguished mental lexicons.(different input output lexica)

Mental lexicon differs from dictionary

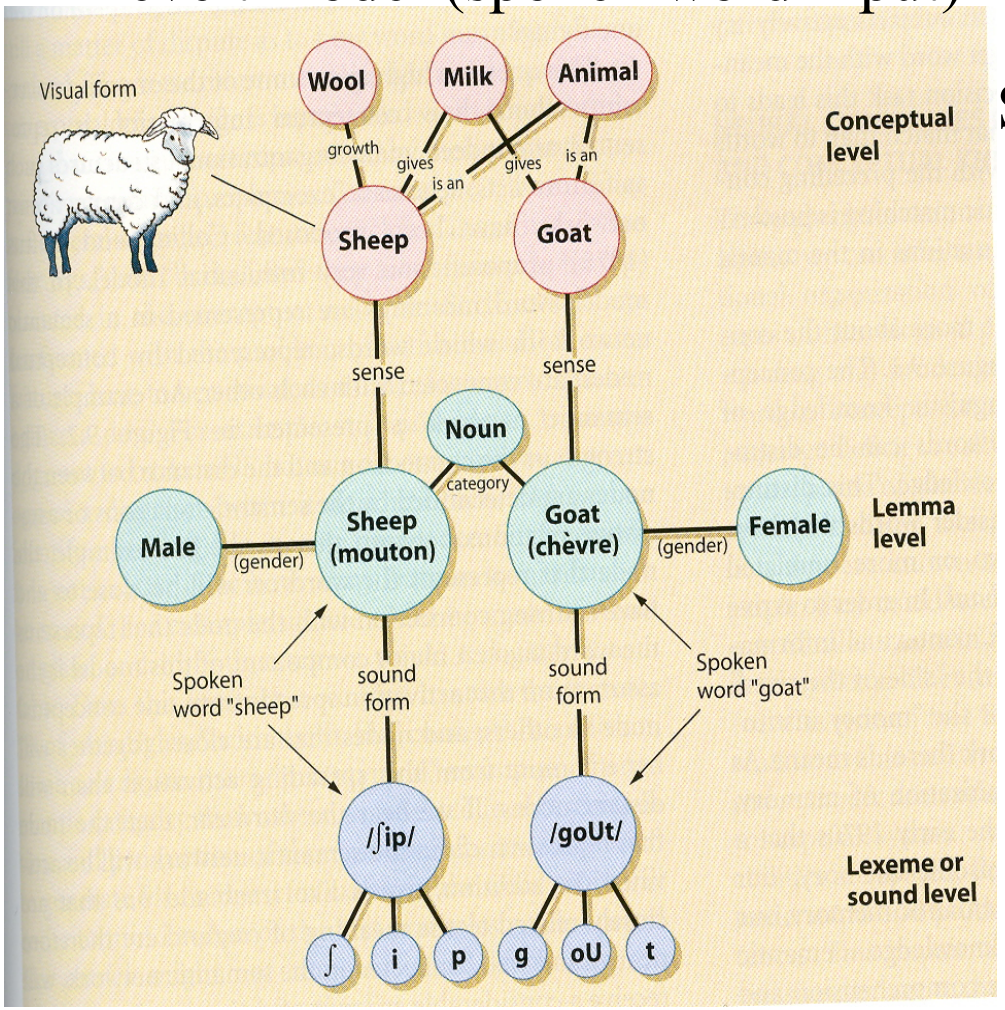
- Organized in highly efficient manner.
- Not alphabetical
- Has no fixed contents.
- More frequently used words are accessed more quickly (table, snail)
- Auditory Neighborhood effect – words that differ by only one phoneme are identified slowly. (late rate hate)

(competition between neighbours)

So how might the mental lexicon be organised ?

Mental lexicon – organized as information specific networks

Levelt model (spoken word input)



Semantic knowledge of words

Grammatical properties
Semantic information (living/nonliving)

Information for word forms

Organization involves the meaningful relations between words

Experimental evidence

Semantic priming studies – lexical decision task

Subjects presented with pairs of words – Prime & target

Prime Word

Target word/ nonword/pseudoword

Word - related / unrelated to prime

Subjects faster and more accurate when target is preceded by a related prime. (car/truck) as compared to (rose/truck)

Naming latencies are faster for related words than for unrelated ones.

Priming can also result from

- Expectancy induced priming time duration(> 500 ms)
  (prime cat…..) (Reaction times faster for related words
- Semantic matching (Match target meaning with meaning of prime)
  Lexical decision task – faster yes responses

Support for mental lexicon organised according to meaningful relationships

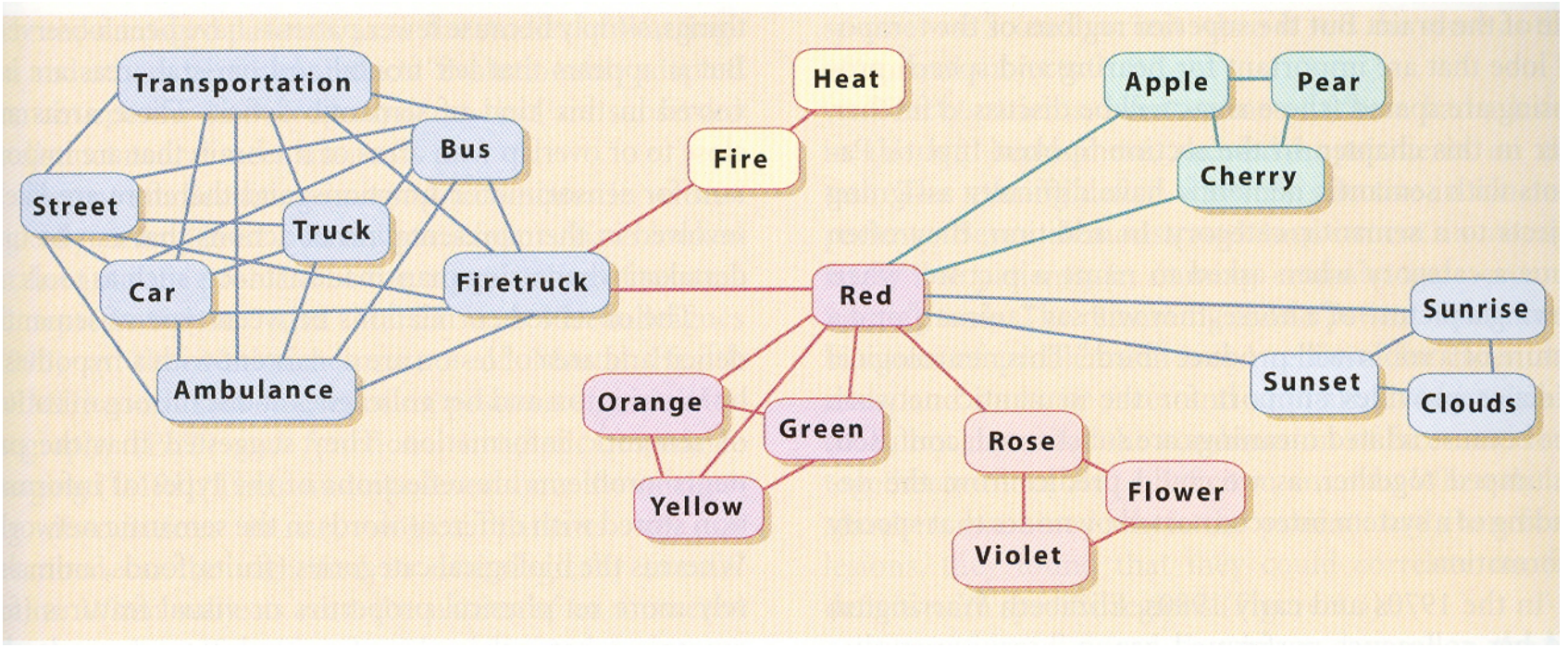
Difference between conceptual and linguistic level

- Semantic knowledge can be distinguished from linguistic knowledge (bank e.g.) (Contextual information required)
- Semantic/conceptual representations reflect knowledge of the real world
- Are conceptual systems single or multiple ?

  (dog eg)

Continues to be debated

Semantic Network proposed by Collins and Loftus



Word meanings represented in a semantic network and words represented by conceptual nodes are connected with each other. Strength of the connection & distance between the nodes determined by associative relations between the words.

Neural correlates of the mental lexicon

- Observations of deficits in patients' language ability
- Wernicke's aphasia - brain lesions in posterior part of LH - semantic paraphasia (horse…cow)
- Semantic dementia - difficulty in categorising objects
- Strong support for semantic network

- 1970's Warrington et al - (patients with category specific deficits) – conceptual knowledge

  (semantic dementia)
- Difficulty in pointing and naming for food and living things
- Performance with man-made things - better.

- Damasio and colleagues in 1996

30 patients – 29 had LH lesions

Naming famous faces (7)

Naming animals (5)

Naming tools

To dissociate conceptual representations from word retrieval – descriptions were permitted.

They could correlate naming with specific regions.

(word retrieval)

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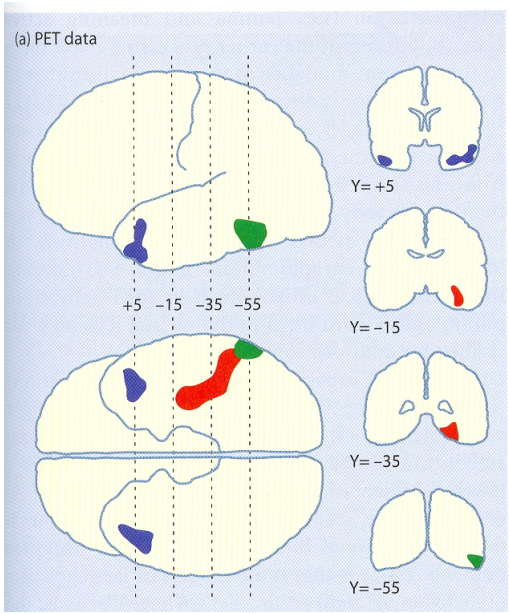
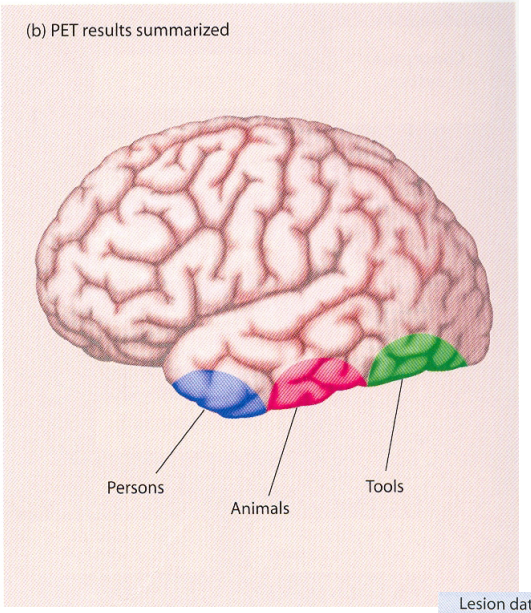
Neural substrates of the mental lexicon





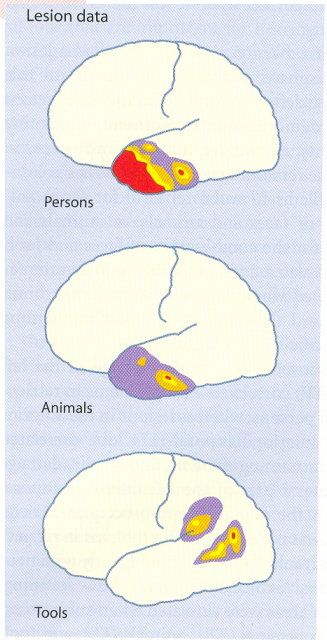
Category specific (Damasio et al)

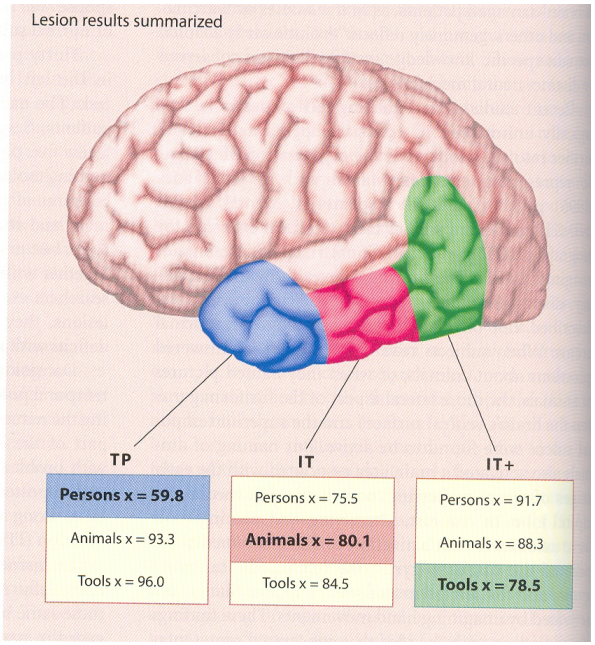
TP- difficulty naming persons

Inferior IT - naming animals

Posterio-lateral IT - naming tools

Lesions and PET





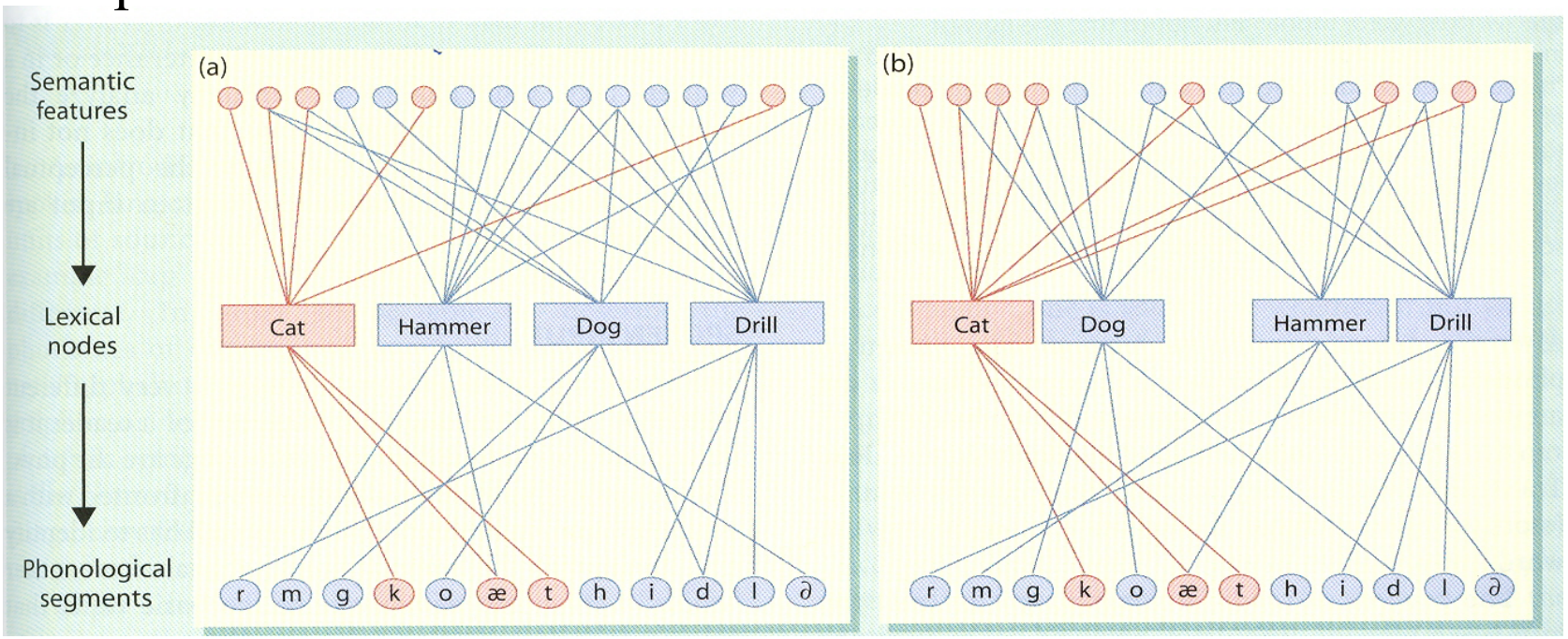
TP temporal pole

IT inferotemporal region

IT+ posterior part of inferior temporal lobe.

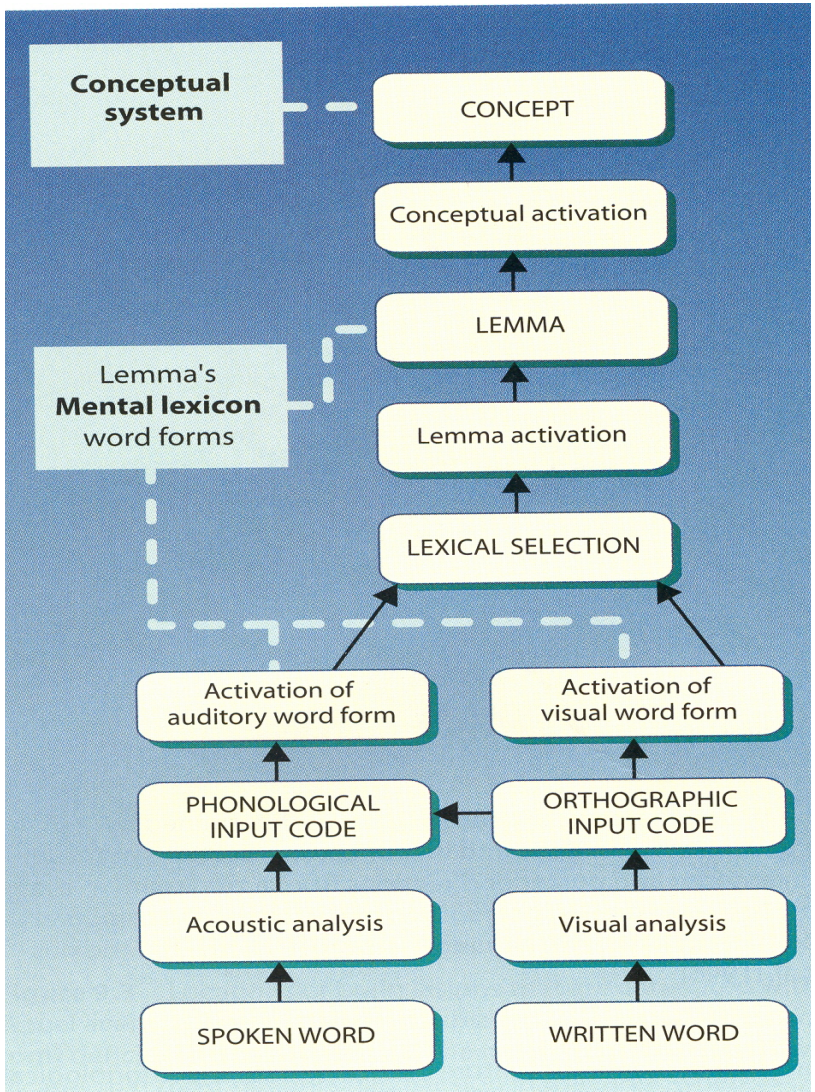
Damasio et al did not assume organisation of a conceptual network but reflected word retrieval - three levels of representation for word knowledge.

These were predicted by cognitive models of word production



b) Model that fits data of Damasio and colleagues

Perceptual analysis of linguistic input



Schematic representation of the components involved in spoken and written language

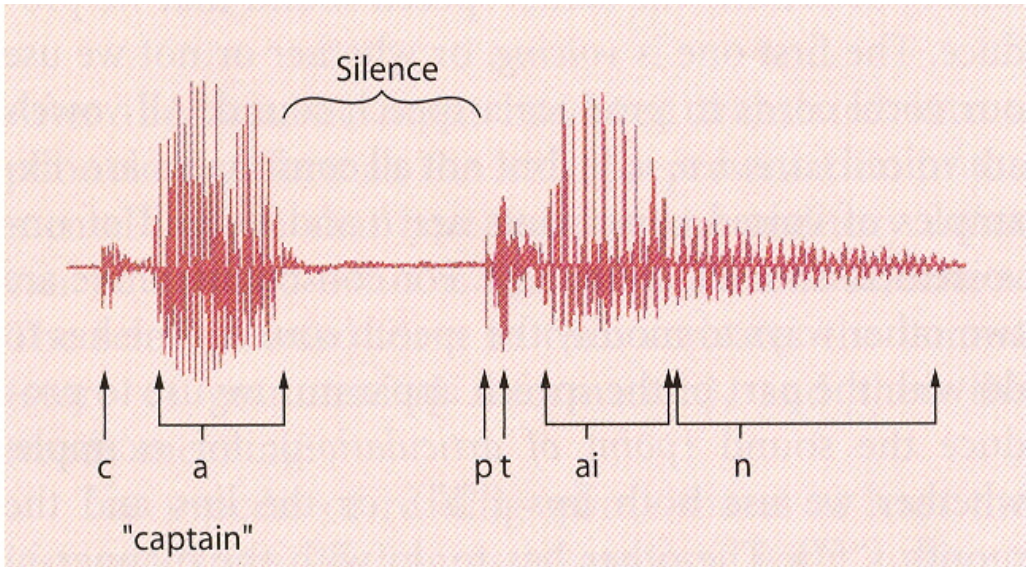
Speech input

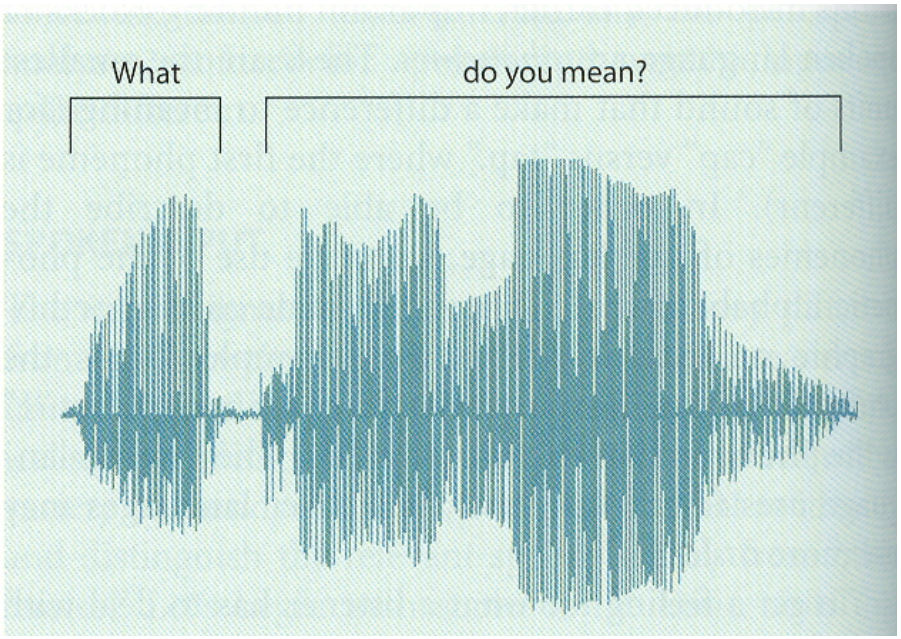
- Listeners confronted with a variety of sounds.
- Phonemes building blocks of spoken language.
- Different speech sounds are produced using different features of our vocal apparatus.
- 3 main features determine actual speech sound
- Voicing (vocal cords) a,e,i,o,u,b,m
- Point of articulation (lips “b”or lips & mouth “f”)
- Manner in which airstream is changed

“p” produced by blocking airstream

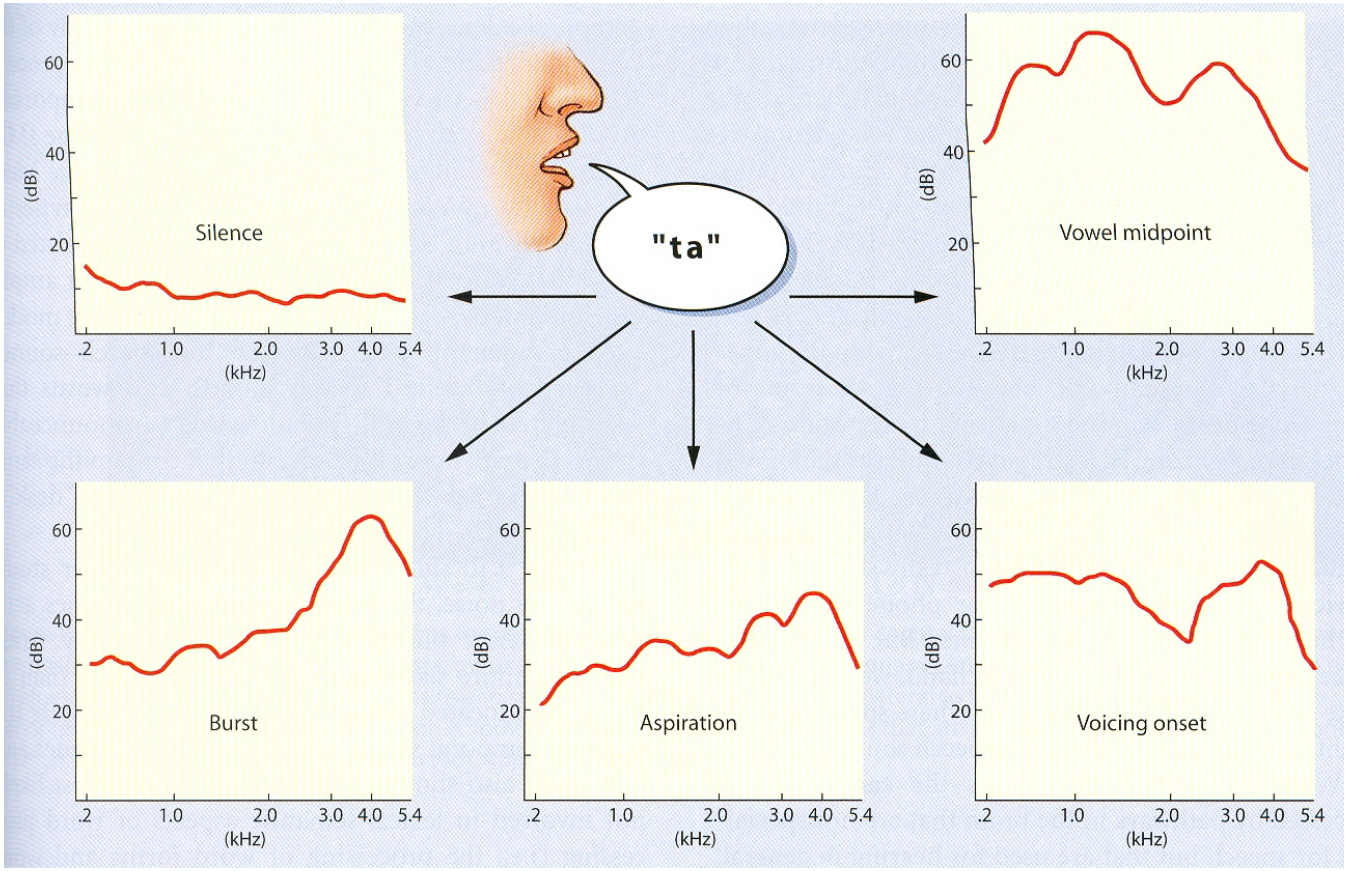
“I” hardly obstructs airflow.

Problems of unclear boundaries – segmentation problem





Spectral properties vary according to sounds

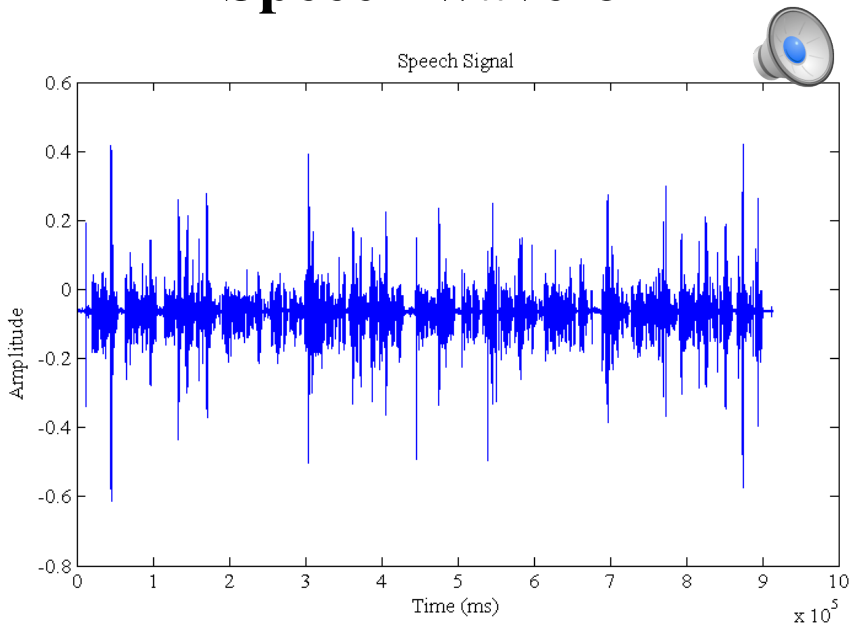


'ta' can be analysed to give 5 different critical band spectra.

Some researchers have proposed that spoken input representations are built on spectral properties (frequency content) of the incoming signal.

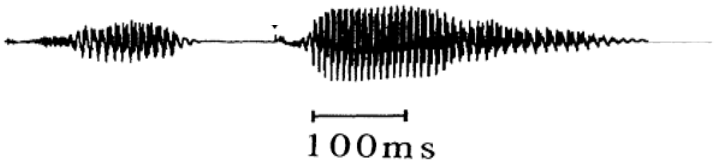
Speech and Language Laboratory at NBRC

Speech waveform

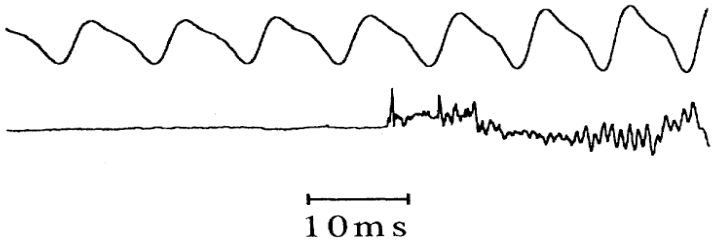


Phonological features

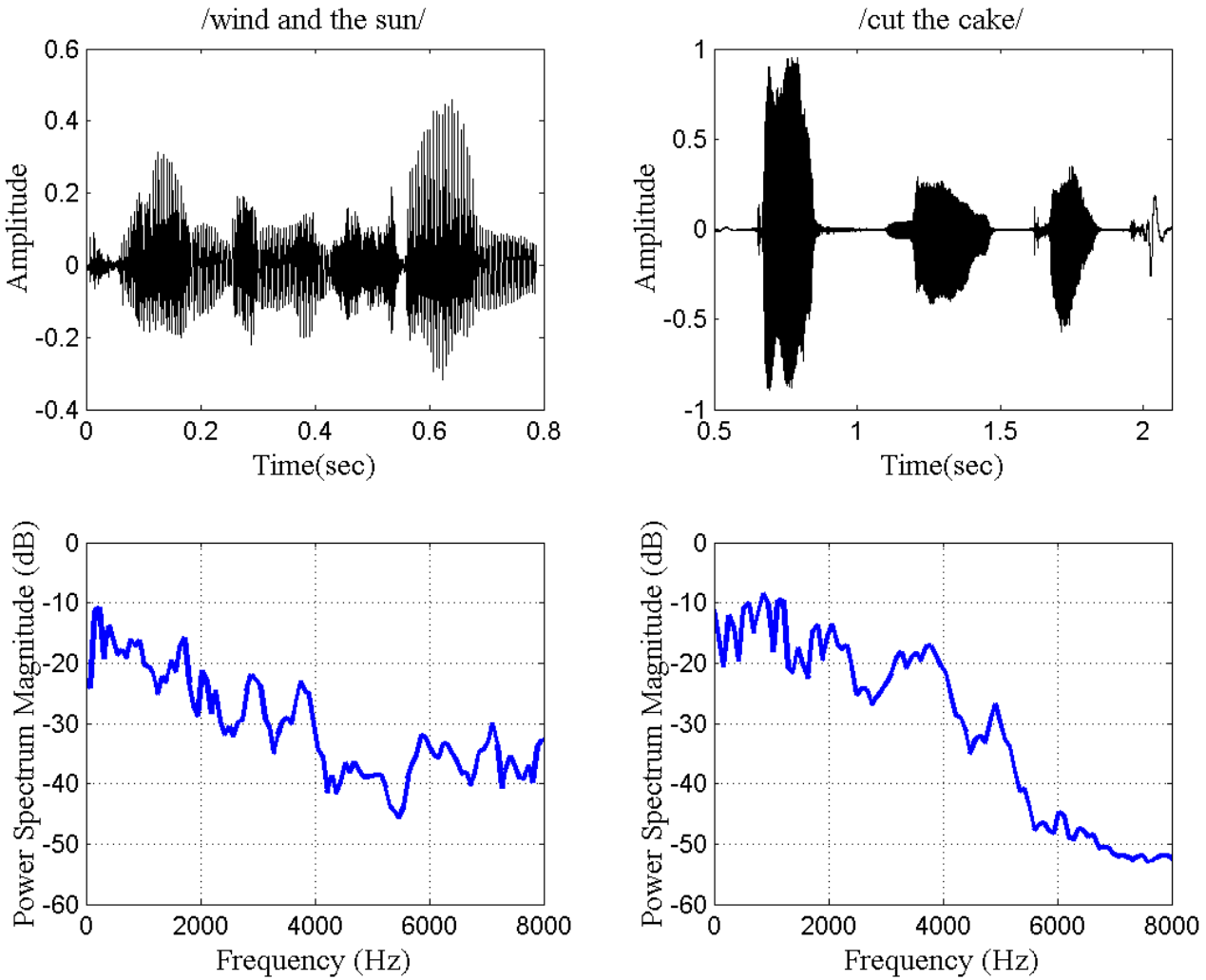
Long time scale information



Short time scale information



Time or frequency domain ?



Time

Frequency

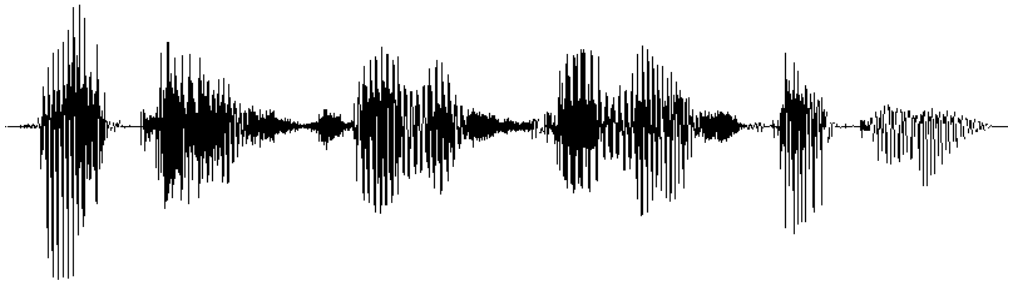
Difficult to identify articulatory units in either domain

Calculating the Spectrogram

Speech is a complex non-stationary signal in which structure as well as dynamics of harmonics encodes linguistic information. A good estimation of the speech signal can be obtained by assuming it to be stationary in small time windows and can be studied using either the STFT or the wavelet transform

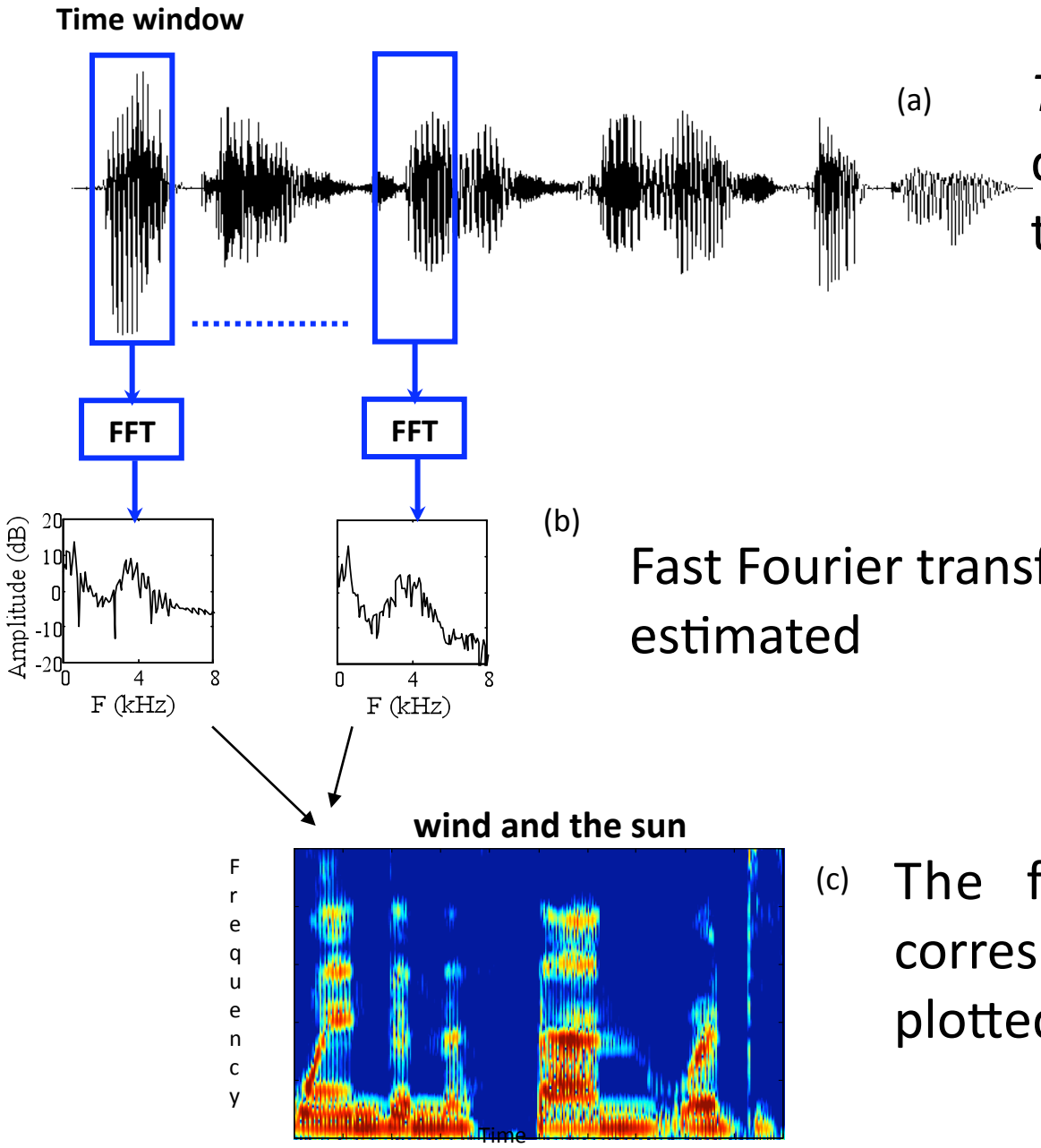
$$S(t, f) = \int_{-\infty}^{\infty} e^{-i2\pi f \tau} s(\tau) h(\tau - t) \mathrm{d}\tau$$

The STFT of a signal



The speech signal

Calculating the STFT

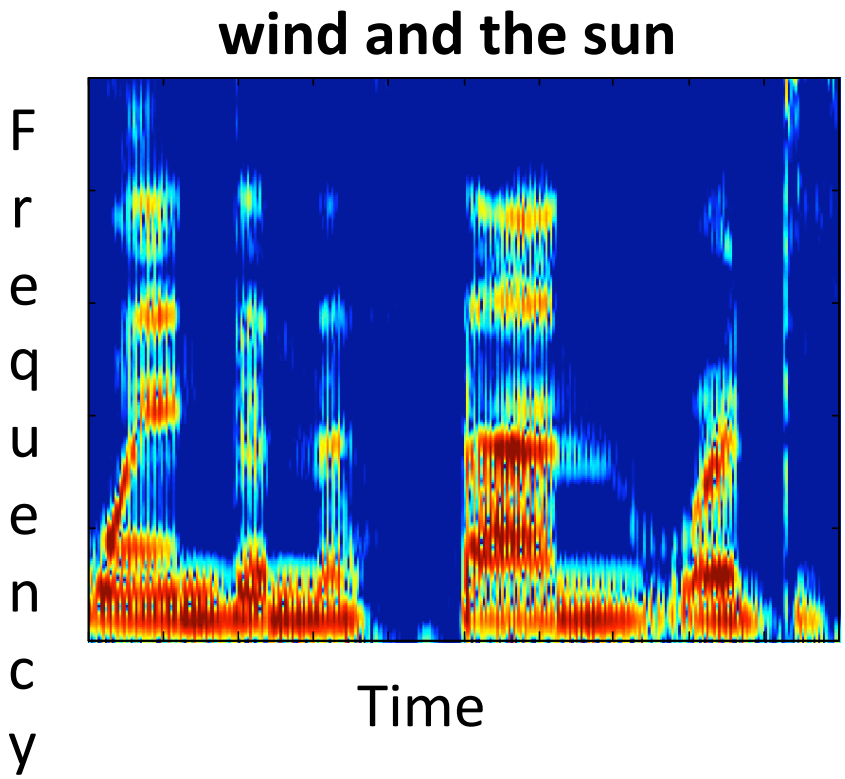


The sound waveform is divided in to overlapping time windows

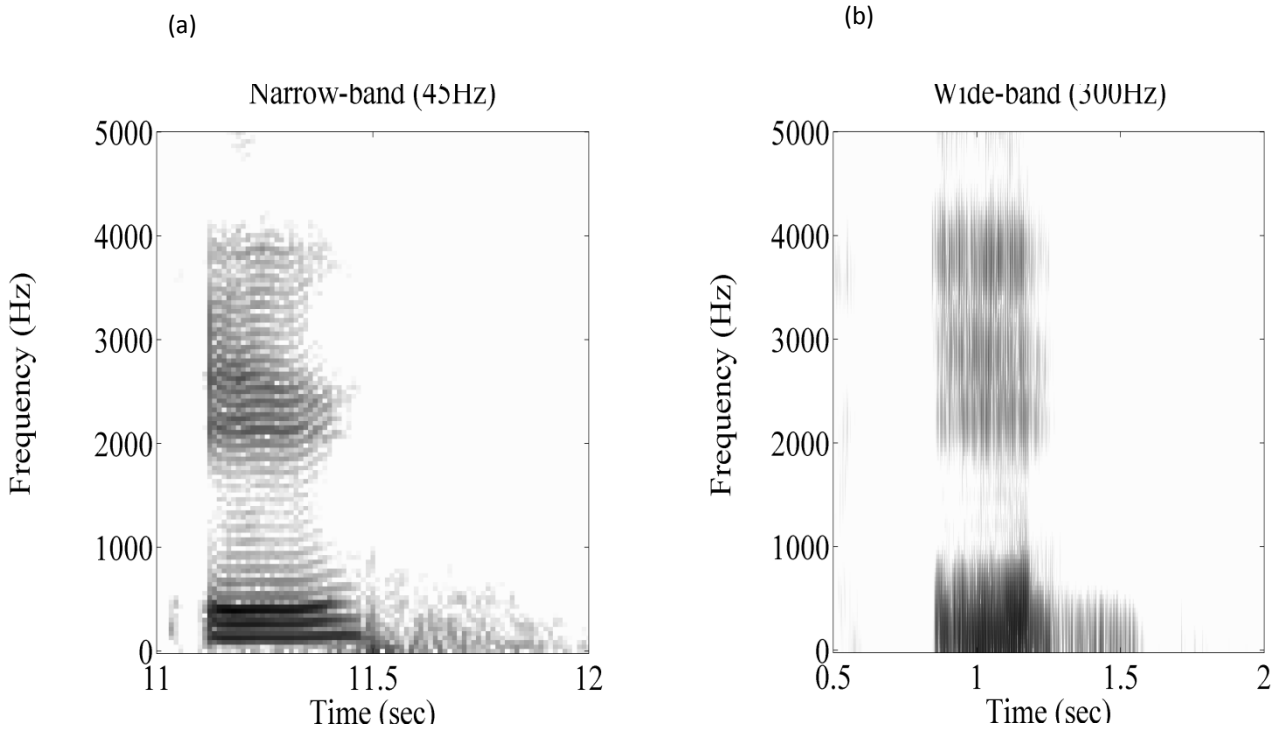
Fast Fourier transform in each window is estimated

The frequency spectrum of corresponding time windows is plotted side-by-side

The Spectrogram

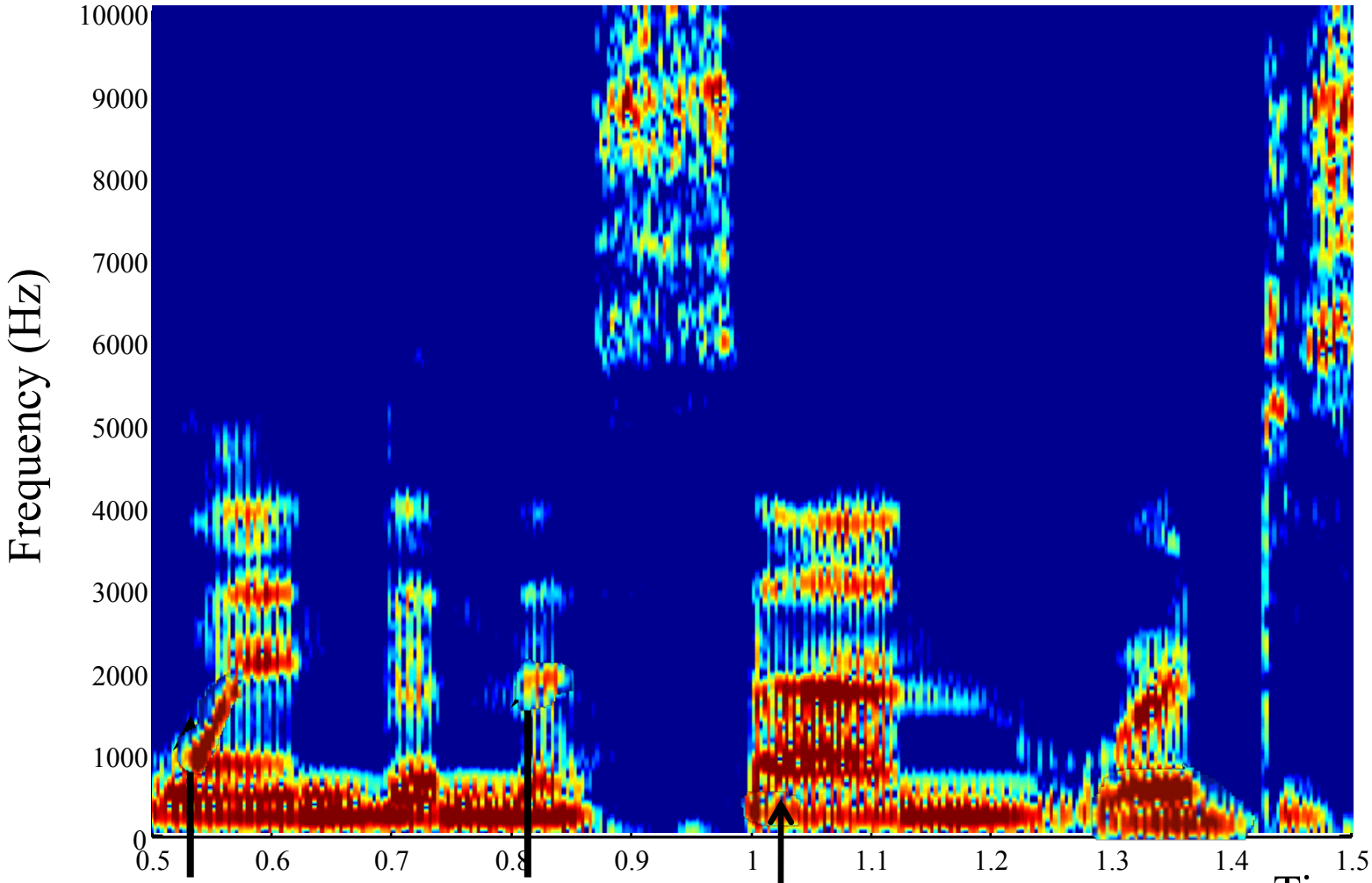


Narrowband and Wideband Spectrograms



(a) Narrow-band (45Hz) spectrogram (b) Wideband (300Hz) spectrogram of vowel “a”

Articulatory features in speech are encoded at different time scales



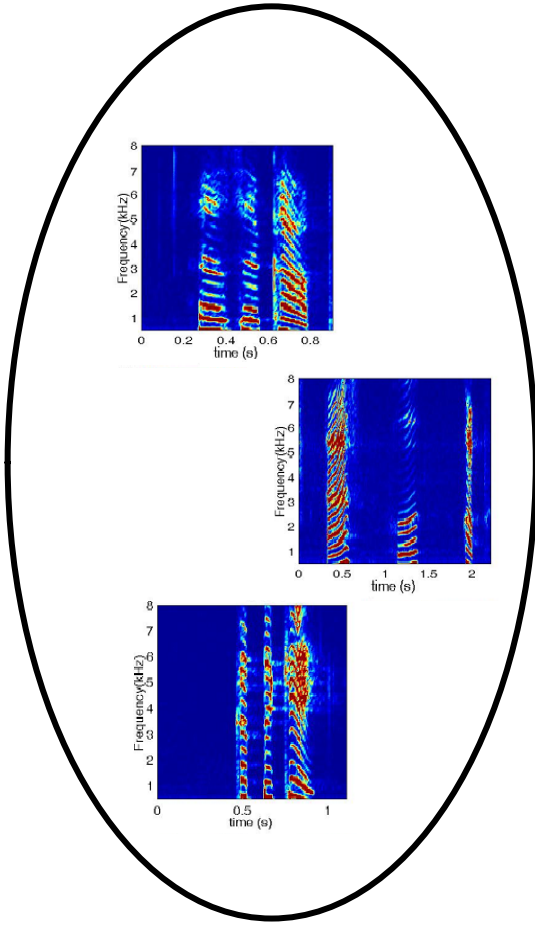
L. Singh and N. C. Singh et al., Developmental Science, 11, 2008

New biologically motivated approach time – frequency analysis

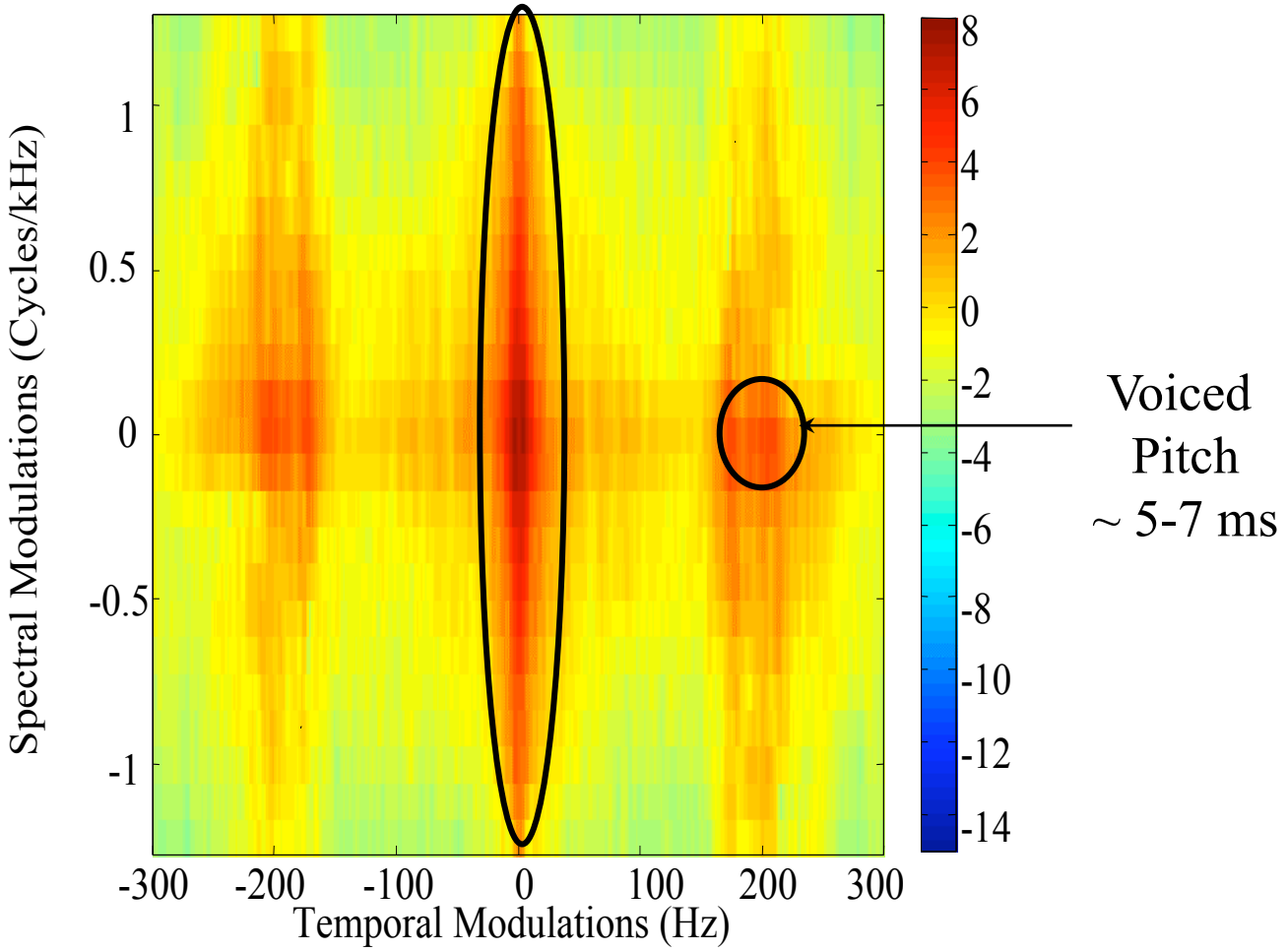
We propose digital analysis techniques using a spectro-temporal representation to study speech.

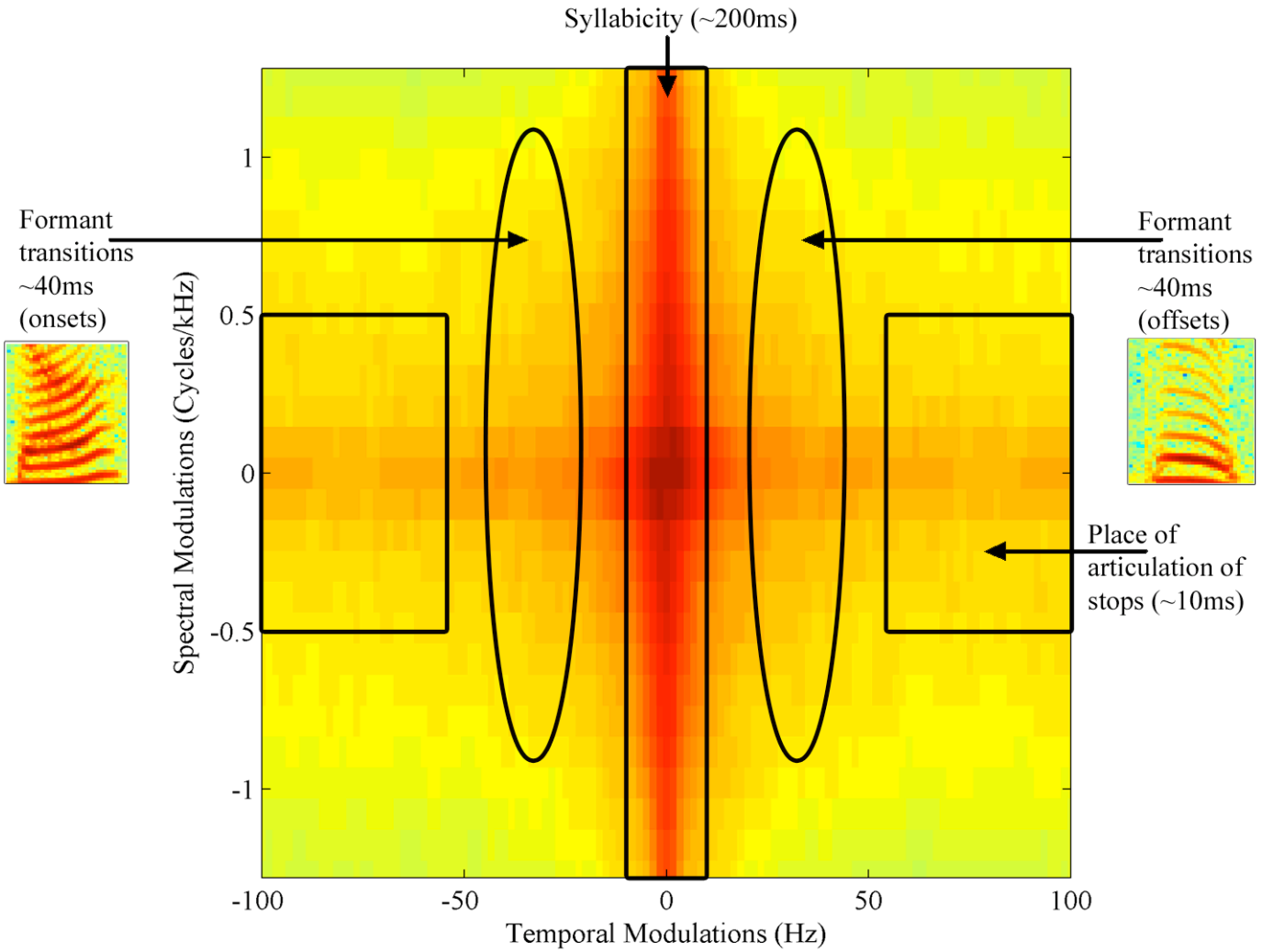
Focus on articulation and attempt to capture the articulatory features of speech ?

Articulation Map



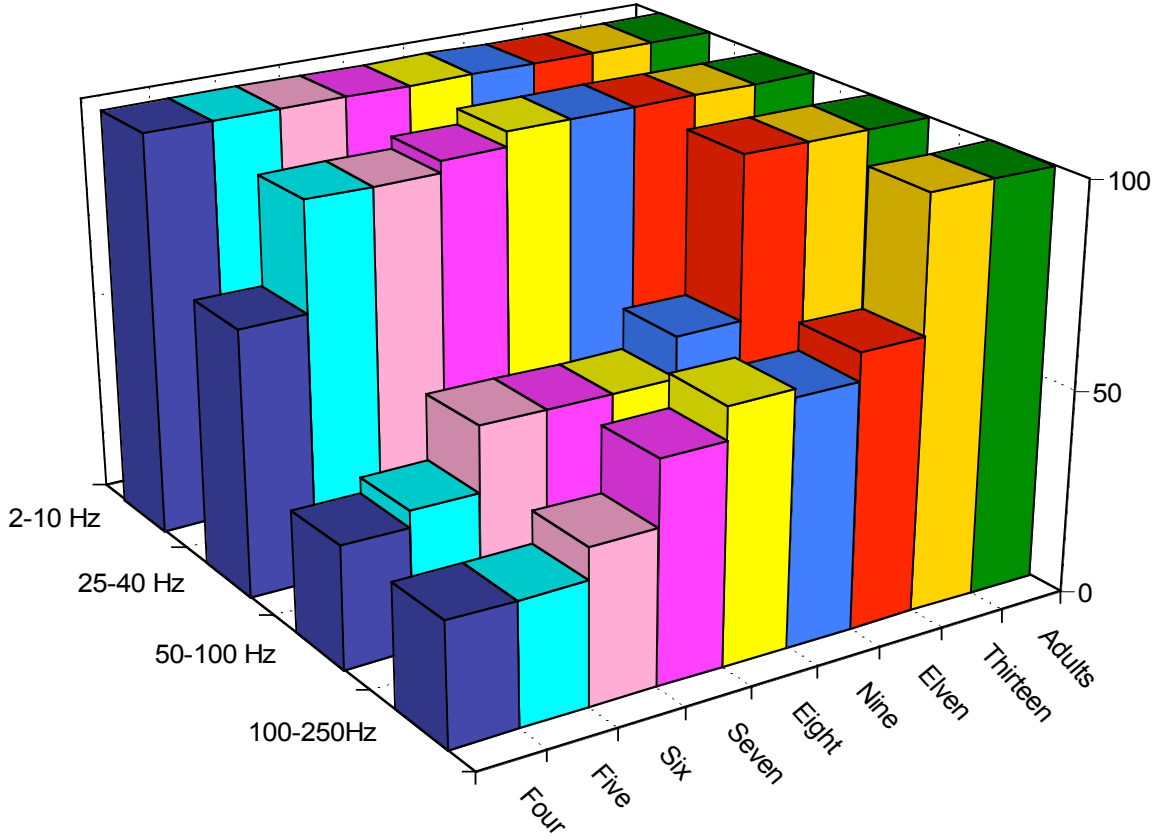
Adult speech





- Articulatory features encoded at different time scales.
- Energy distribution varies across articulatory features is not uniform.
- They provide information across different speech motor skills.

Distribution of articulatory features in a population of typically developing children



L.Singh and N. C. Singh, Developmental Science,11, 2008.

L. Singh and N.C. Singh, J. of App., Acoustics, 68 (2007) 260-269.

Open questions

- How good is this technique as a predictor for language development in children with ASD ?

- Can this be used for early screening for ASD ?