

Cognitive Foundations

Lecture 3: Lexical Processing (2)

Foundations of Language Science and Technology

Garance PARIS

14 November 2008

Overview

- What lexical processing consists of in comprehension
- What the stages of lexical processing are
- What influences the process of spoken-word recognition
- Models of word recognition

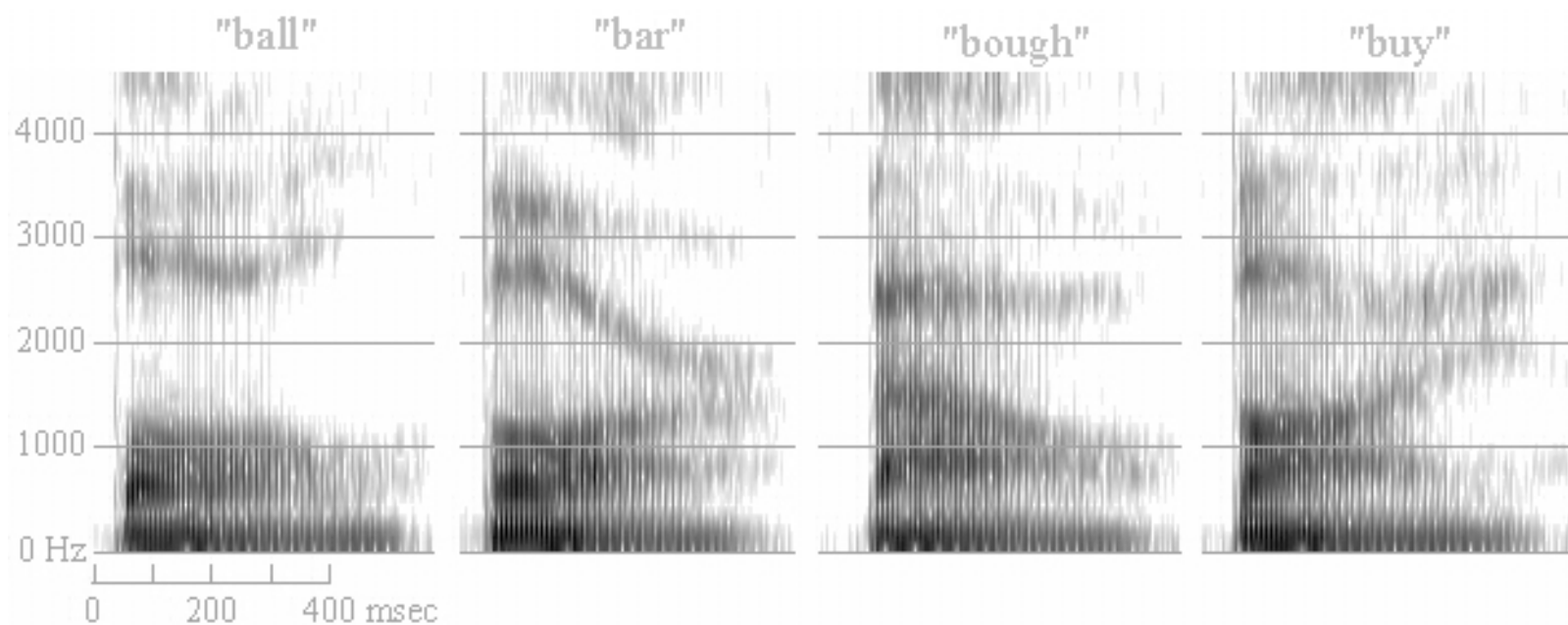
Auditory Lexical Processing

- Def.: Process by which people recognize words
 - ◆ Mapping of auditory signal onto representations of known words in the listener's mental lexicon
 - ◆ Representations contain conceptual information + lexical properties (spelling, morphological information, ...)
- Some characteristics:
 - ◆ Very fast: It takes people only 250ms to identify a word among a lexicon of 50 000 to 75 000 words
 - ◆ Error rate: approximately 2/1000 words
 - ◆ Automatic and robust, although a very difficult task

What is a “*word*”?

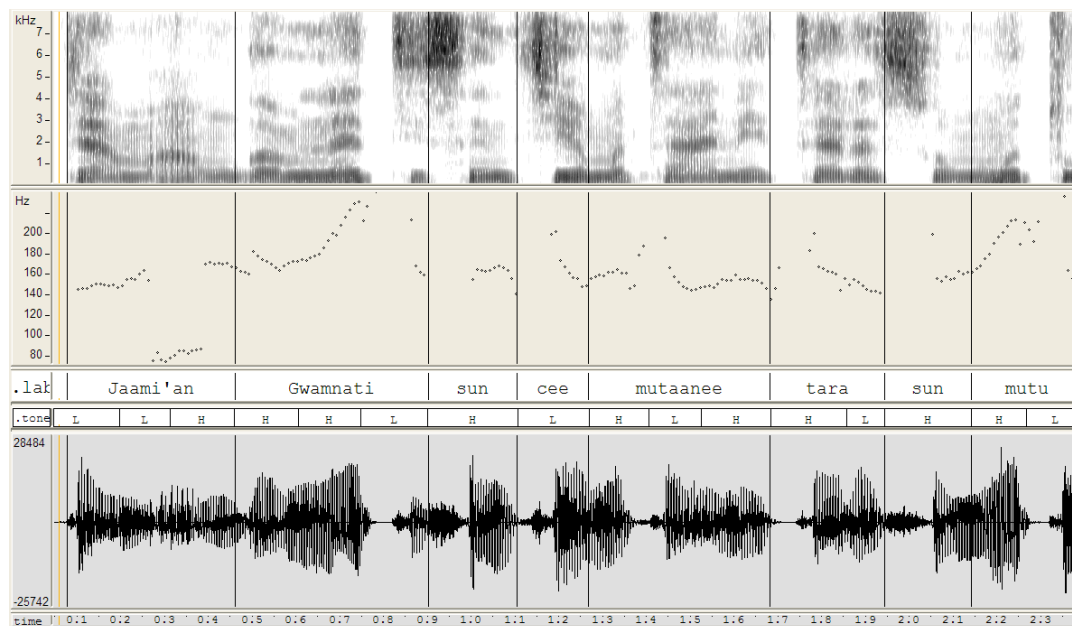
- Phonemes and words overlap without any clear boundaries
- Words may have other words embedded within them: /stɛɪ/ could be “stay”, but also the onset of steak, ...
- Most often words are embedded themselves in longer sequences
- Compare “recognize speech” with “wreck a nice beach”

Continuous Speech



- What continuous speech does NOT look like, with neat boundaries between the words
- Note the variation in the sound /b/ at the start of each word

Continuous Speech



- What continuous speech DOES look like
- Of course, together, the oscillogram, spectrogram and the pitch contour give us cues as to where the boundaries between words are
- But this is not sufficient to identify words without the help from lexical knowledge (segmentation into words cannot be achieved without top-down information)

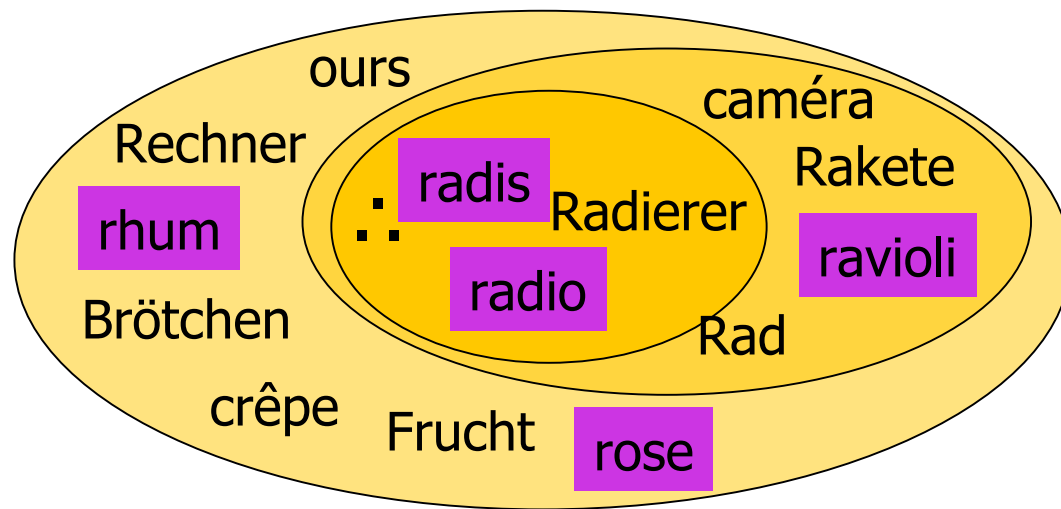
Spoken vs. written words

- Recognition takes place in time, one sound after the other
- Typically there is no chance to reconsider the spoken input
- Words form longer utterances, without reliable cues to mark boundaries
- Phonemes are realized differently in different contexts (coarticulation).
 - ◆ Compare /ki/ and /ku/
 - ◆ “Sweet girl” is often pronounced as “sweek girl”
- Written words are available to readers as a whole or at least several letters at a time
- Words can be re-scanned and passages re-read
- White space unambiguously mark word beginnings
- Not as much variability in printed text (although handwriting is another issue)

Stages of Lexical Processing

- Initial activation: Different theories assume different forms of contact
 - ◆ “LAFS” (lexical access from speech): Assumes direct contact between sound waves and the lexicon
 - ◆ Phonemic theories: Assume a prelexical representation level
- Lexical selection: Competition process
- Word recognition:
 - ◆ When only a single candidate remains in the pool
 - ◆ Possibly before the end of the word (uniqueness point)
 - ◆ Often after the end of the word
- Lexical access: Point at which lexically-stored information (phonological, morphological, semantic, etc.) becomes available
- Integration into the overall meaning of the sentence

Lexical Competition



(originally called the COHORT model, Marslen-Wilson & Welsch, 1978)



French: /R/... /Ra/... /Rad/... /Radi/

- In general, the more word candidates match the incoming speech signal, the more competition, the slower recognition
- Importantly, word candidates can get activated by any part of the speech input, not just the onset (explains recovery from early errors/noise)

Uniqueness Point

- “staple” could be identified by the /p/ because no other words in the English lexicon match that phoneme string
- However, often words do not become unique prior to word offset
 - ◆ /stɛɪ/ could not only be the word “stay”, it could also be the beginning of “steak”, “stage”, “staple”, “station”, “state”, “stale”, “stain”, “stable”, ...
 - ◆ More phonemic input and stored knowledge is needed to identify the word
e.g. the phonotactic rules of English allow very few words beginning with /u/, thus in /stɛɪku/ there must be a word boundary between // and /k/ (stay cool)

What Influences SPWR?

➤ Some factors at lexical level:

- ◆ Uniqueness point
- ◆ Word frequency
- ◆ Neighborhood size (dense/sparse)
- ◆ Phonological priming
- ◆ Semantic priming
- ◆ Concreteness

➤ Question:

When do these lexical properties come into play?

At activation, selection, recognition, lexical access, or integration stage?

➤ Note: Definition of stages does not mean they happen in serial order!

What Influences SPWR?

Some factors at other levels that restrict competition:

- Use of morphosyntactic information
e.g. gender information in preceding article
- Influence of preceding verb information
e.g. “*noch nie flog eine Fliege so hoch*”,
“never did a fly fly so high”
The lexical competitor *Fliese* (tile) is not considered during the onset of “*Fliege*” (fly) because of the previous context
- Context in its many forms: adjectives,...

SPWR in Bilinguals

- Eyetracking study: Stimuli from the irrelevant language are never presented (very strong proof)
- Bilinguals look at crosslinguistic competitors whose name is phonemically similar to the target
- E.g., when asked to pick up a *marker*, Russian-English bilinguals also briefly look at a stamp, */marka/* in Russian (Marian & Spivey, 2003)



Lexical Search Theory (Forster, 1976)

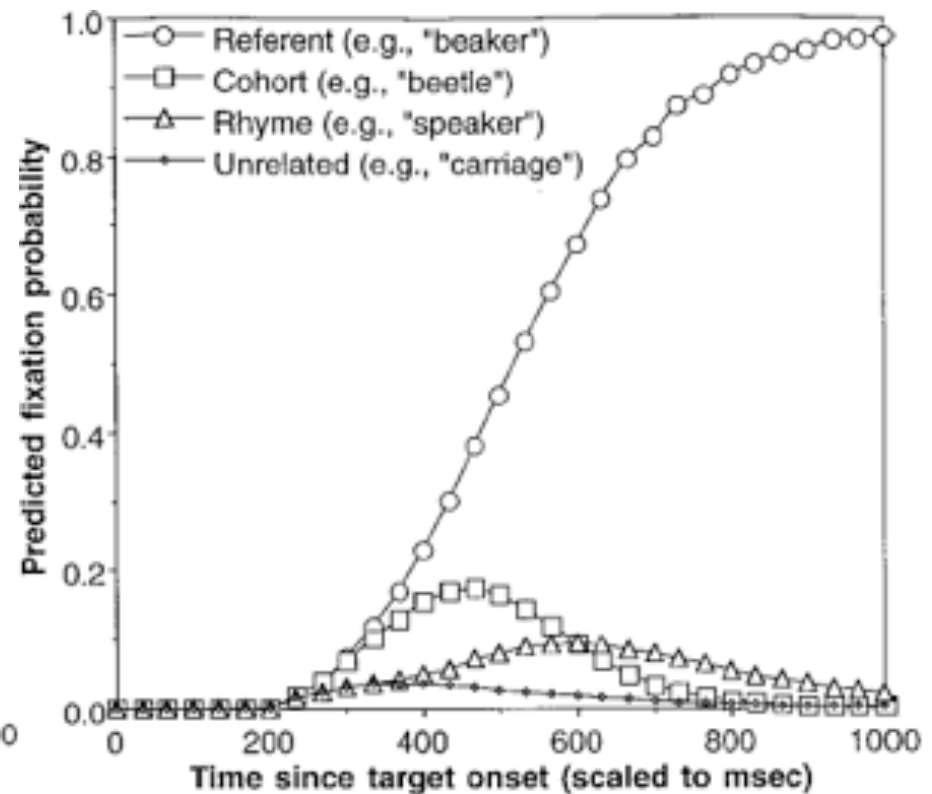
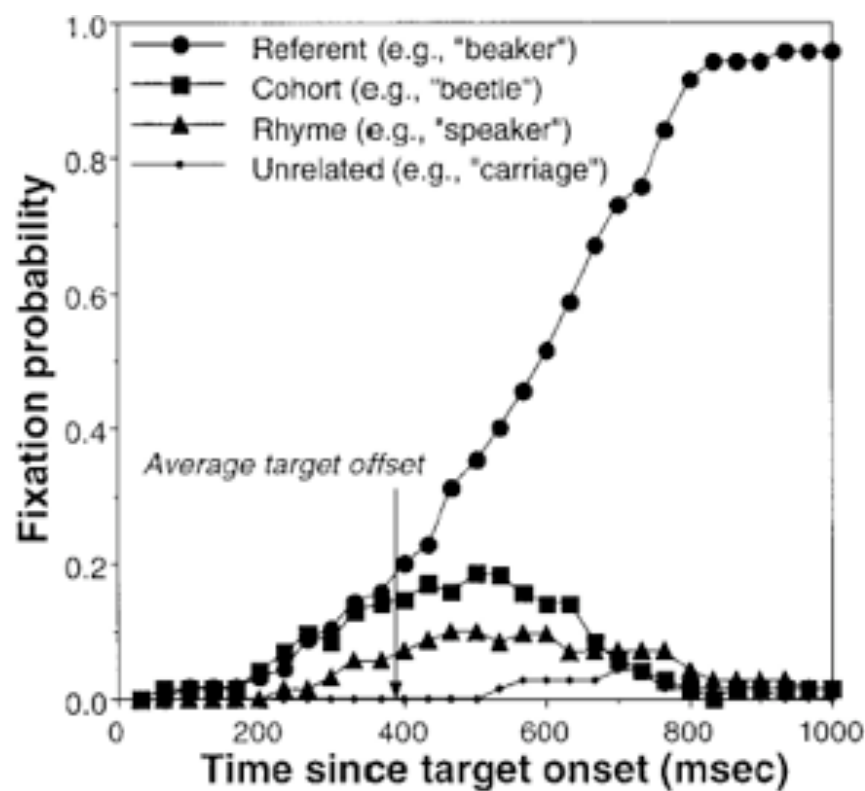
- A complete perceptual representation of the perceived stimulus is constructed
- The perceived stimulus is compared one-by-one against words in memory
- Words in memory are ordered by lexical frequency
- Similar to what computers do
- But: Today we know human processing is incremental

TRACE (McClelland & Elman, 1986)

- Implemented computer model
- 3 levels of processing
 - ◆ Features (e.g., [+voice], [+nasal])
 - ◆ Phonemes (e.g., /d/, /g/)
 - ◆ Lexical entries (words)
- At first, activation spreads from features to phonemes to words
- Later on, higher levels have a top-down influence on lower levels
- Inhibition between nodes of a level

Linking Hypothesis

TRACE simulations closely correspond to eye movements probabilities (Allopenna, Magnuson, & Tanenhaus, 1998)



Some Effects TRACE Accounts for

- Link btw. lexical activation and eye movements:
 - “The activation of the name of a picture determines the probability that a subject will shift attention to that picture and thus make an eye movement to fixate it.”
- Some effects TRACE accounts for:
 - ◆ Frequency effects: The more frequent, the stronger the connections
 - ◆ Phonological priming: Activation does not return to zero immediately between words, but decays over time
 - ◆ Semantic priming: Words activate related words
 - ◆ Feedback from lexical processing to phonetic processing