Average speech rate is around 150 wpm; reading rate tends to be higher 180-200 wpm
In any given sentence, the listener may need to:
- identify words, e.g. dictionary-style look-up
- identify lexical categories (noun, verb, etc.)
- resolve syntactic ambiguities
- combine words with previous words (potentially over long spans)
- integrate visual information
- take into account speaker’s social status
- remember prior sentences & topic
- plan next utterance
Computational problem: how can humans complete the cognitive tasks necessary to communicate with one another given rapid, incremental nature of language?
BASIC FACTS

- Language processing is incremental.
- You don’t wait to process a word or sentence.
Computational problem is compounded by incrementality & uncertainty

That desert trains . . .
Computational problem is compounded by incrementality

- That desert trains . . .
- \[NP \text{That desert} \text{ trains young people to be tough.}\]
- \[S \text{That desert trains come irregularly} \text{ is well-known.}\]
WORD PROCESSING
How do we perceive sounds & words?

How do we perceive sound accurately given a noisy input?
Context plays an early role in perceptual processes
The state governors met with the respective legislatures convening in the capital city.
PHONEME RESTORATION

- Even when people know the phoneme is missing, they still hear it.
- Seems to be a very fast-acting & strong effect of context.
Or is it?

maybe you just think you heard it after the fact to make sense of the input
It was found that the *eal was on the TABLE
It was found that the *eel was on SHOE
Participants restored a phoneme based on evidence that came later!
What to make of these conflicting results?

- Sentence contexts may have post-lexical effects
- Word contexts may have earlier, even pre-lexical effects
How are words stored & accessed in the brain?
All words are not processed the same
- Some take a long time to process; others a short time
- If the mind just has a dictionary, why would it take longer to look up any word?
Several factors have been identified as being critical in the speed of word recognition:

- **Frequency**: how often has the word been experienced?
- **Age of acquisition**: when was the word first learned?
Whaley (1978): frequency is the most important factor in word recognition
- e.g. “abhor” named & recognized slower than “sleep”
- effects are measurable for very frequent vs. very infrequent, frequent vs. infrequent
predictability of frequency breaks down with extremely infrequent words

individuals differ in their experience

what’s common for me may be uncommon for you
Age of Acquisition

- Frequency is highly correlated with age of acquisition
- More frequent words are typically learned earlier, e.g. “go”, “see”, not “abhor”
- Words learned earlier named more quickly and accurately
In short, both factors suggest that personal experience plays a huge role in how we process words. Much of our experience is shared. Both AOA & frequency likely have independent effects (Morrison & Ellis, 2000). AOA particularly effects reading rate.
SENTENCE PROCESSING
Many strings contain some ambiguity of interpretation (although we typically don’t experience confusion)

- The boy saw the girl with the telescope
- I heard Liam say he saw the movie yesterday
Syntactic category ambiguity

That . . .

That is weird. = [deictic noun]
That show is weird. [=determiner]
That people like pole-vaulting is weird. [=complementizer]
Why is ambiguity so important?

- you don’t know how to interpret “that” immediately, and may have to wait a fairly long time before receiving disambiguating info
- ambiguity makes the computational problem harder
How do people deal with ambiguity?

Option #1: Select a default analysis based on syntactic principles and go with that
AMBIGUITY RESOLUTION

...that...

- Analyze as determiner
- Sets expectations for upcoming noun phrase
- Upside: parser always knows what to do
- Downside: it may be wrong!
Choose the simpler analysis
How do people deal with ambiguity?

- Option #2: The short-sightedness of the language processing system determines how ambiguity is dealt with
Tom said that Bill had taken the cleaning out yesterday.
John said that he heard Karen wrecked her car yesterday.

- Sentences get harder to process as the dependencies between arguments increase in length (Gibson 1998)
- Memory representations decay
- Discourse processing interferes with past discourse processing
AMBIGUITY RESOLUTION

- How do people deal with ambiguity?
- Option #3: The language system strategically uses multiple constraints, including context & probabilistic information to quickly resolve ambiguity
Brown corpus of English

- 77.5% of "that" are complementizers
- 11.1% are determiners
- 11.5% are demonstrative pronouns

= context-independent lexical frequencies
Sentence-initially, however, *that* is more likely to be a determiner than a complementizer.

In other words, your analysis of the ambiguous word *that* depends on where you see it.

GIBSON (2006)
On constraint-based views of language processing, humans solve the computational problem of language by utilizing a number of sources of information to make sense of the input.
Errors at different levels of language processing
- phonological, syntactic, and semantic
- Slips of the tongue
Speech Errors

- Anticipations: substitutions of upcoming units
  - sidewalk → widewalk
  - table of contents → cable of contents
- Perseverations: repetition of preceding unit
  - walk the beach → walk the beak
- Addition
  - spic and splan; TARGET: spic and span
- Deletion
  - his immoral soul; TARGET: his immortal soul
metathesis (aka exchanges / spoonerisms)
- fill the pool ➔ fool the pill
- chimichangas ➔ chichimangas
- slippery crags ➔ crippery slags
- Are my keys in the door ➔ Are my doors in the key?
evidence for the psychological reality of phones, morphemes, and syntactic units

substitution of words & phrases tells us about the organization of meaning

substituted words tend to be semantically related

* turn the lights off ➔ turn the lights on
SPEECH ERRORS

- Exchanges only seem to involve elements at the same level of processing.
- Sounds and words don’t exchange.
- Sounds and morphemes don’t exchange.
- "fill the bucket" → "bill the fucket"
- # "fill the bucket" → "buckill the fet"
- Speech errors exchanges only seem to involve elements at the same level of processing.
- Sound exchanges rarely (if ever) happen across different word position.
  - hit the ball → bit the hall
  - # hit the ball → hib the tall
- Phonemes in onsets exchange with other onset phonemes, nuclei exchange with other nuclei, etc.
How selfish are we as speakers?
Wardlow Lane & Ferreira (2008)

Q: Would speakers only use modifiers like *big* or *small* when listener could see both a big and small object?
Wardlow Lane & Ferreira (2008)

- some information was privileged
- e.g. only speaker could see two hearts mentioned
Results: Even if listener couldn’t see one element in the contrast set, speaker was more likely to use a modifier
Wardlow Lane & Ferreira (2008)

LOW SALIENCE CONDITION: experiment points to the relevant object to name

HIGH SALIENCE: reference to contrasting item
Wardlow Lane & Ferreira (2008)

Speakers more likely to use modifying descriptions when it’s highly salient to *them*, but not to listener
Speaker needs and sense of salience outweigh demands for communicative success.

Speakers were using terms such as “big heart” when listener only saw one heart.
At least in some circumstances, speakers ignore their listener(s) perspective.
LANGUAGE & MIND
In many western cultures, we talk of spatial relations with words like “to the left of”, “to the right of”, etc.

- Frame of reference: speaker or listener biased
- In other languages, spatial relations can be based on absolute (i.e. unchanging) features
- Object-centered coordinates: frame of reference based on items’ “perspective”
Relative: The fork is to the left of the spoon
Absolute: The fork is to the north of the spoon
Intrinsic: The fork is at the nose of the spoon
Bowerman, Levinson, and colleagues argue that many speakers not only don’t use relative frames of reference, they don’t *think* in terms of relative frames of reference.
Guguu Yimithirr (Australia): only use Absolute frame of reference

“There’s an ant on your south leg”

Tzeltal (Mexico): absolute frame of reference based on geographical landmarks
Figure 6.2. **Homing pigeons**: directions at vanishing point (after Batschelet 1981: 11?6).

Figure 6.3. **Guugu Yimithirr** speakers estimating the location of Laura at 80 km.
• Halligan (2003): all individuals have an egocentric view of space

• Alternative: individuals recruit different frames of reference and language capitalizes upon these different available systems
• Experiment showed participant a path a man traveled on Table 1
• Participant turned around and asked to show how the man traveled out of a maze
• Again, Tzeltal overwhelmingly Absolute FoR
Answering how language influences cognition turns out to be a very tricky question.

Very difficult to separate culture & experience from language.