

# Language as communication

Ted Gibson  
9.59J/24.905J

# Overview

- Language information sources and constraints  
*Lexicon; syntax; world knowledge; working memory; context; pragmatics; prosody*
- Language as communication
  - Ambiguity?
  - Words
  - Sentences
  - Communication-based models of language evolution and processing

# Language information sources and constraints

- *Lexicon*
- *Syntax*
- *World knowledge*
- *Context*
- *Working memory*
- *Pragmatics*
- *Prosody*

# Language:

## Information sources and constraints

- Lexical (Word) information, e.g., frequency  
Unambiguous words: more frequent, faster access: “class” vs. “caste”
- Ambiguity: more frequent usages are preferred  
*# The old man the boats.*
- Syntactic argument structure frequencies  
*# I put the candy on the table into my mouth.*  
The verb “put” prefers to have a locative goal prepositional phrase (like “on ...”)  
The noun “candy” has no bias to have a locative prepositional phrase

# The existence of “garden-path” effects provides evidence:

- That the relevant information factor(s) play a role in human language processing (e.g., lexical frequency, syntactic phrase structure frequency, etc.)

And more generally:

That language is processed on-line, as it is heard or read

That the human parser is not unlimited parallel. Rather, it must be ranked parallel or serial.

# Language:

## Information sources and constraints

**Syntax** / word order / sentence structure: giving rise to the literal predicate-argument meaning of a phrase / sentence

*The cat is watching the mouse.*  
*?? mouse cat the is the watching.*

Compositional rules: meaning of the larger phrase is formed from the meaning of the parts: NP  $\rightarrow$  Det Noun; S  $\rightarrow$  NP VP; VP  $\rightarrow$  Verb NP

The syntax of a language makes some interpretations available:

*The dog bit the boy.* vs. *The boy bit the dog.*

Ambiguity: multiple syntactic interpretations  
*The boy saw the man with the telescope.*

# Language:

## Information sources and constraints

**Syntax** / word order / sentence structure, giving rise to the literal predicate-argument meaning of a phrase / sentence

The rules corresponding to assigning the meaning of a phrase like “The dog with the white fur” are **context-independent**: (so-called “context-free” rules)

Subject position of sentence (the noun phrase to the left of verb):

*The dog with the white fur chased the black squirrel into the home of the grey cat.*

Direct object position of sentence (first noun phrase to the right of verb):

*The grey cat chased the dog with the white fur into the home of the black squirrel.*

Direct object position of a preposition (first noun phrase to the right of a preposition):

*The grey cat chased the black squirrel into the home of the dog with the white fur.*

# Language:

## Information sources and constraints

More frequent phrase rules, easier processing (Jurafsky, 1996; Hale, 2001; Levy, 2008):

### **Ambiguity**

*The defendant examined ...*

$S \rightarrow NP VP$  vs.  $NP \rightarrow NP RC$

✓ *The defendant examined ... the evidence.*

?? *The defendant examined ... by the lawyer turned out to be unreliable.*

### **Unambiguous syntax**

*John was smoking.*

? *That John was smoking bothered me.*

?? *John's face needs washed.*

# Language: Information sources and constraints

## **World knowledge**

Unambiguous examples:

*The dog bit the boy. vs. The boy bit the dog.*

Ambiguity: (Trueswell, Tanenhaus & Garnsey, 1994)

*The defendant examined by the lawyer turned out to be unreliable.*

*The evidence examined by the lawyer turned out to be unreliable.*

Methods: (1) Eye-tracking during reading; (2) Self-paced reading

# Reading time studies

- Compare target to its control:

Temporary ambiguity:

*The defendant examined by the lawyer turned out to be unreliable.*

Unambiguous control:

*The defendant that was examined by the lawyer turned out to be unreliable.*

Target regions: “examined”, “by the lawyer”

# Information sources and constraints: **Modularity / Information-**

## **Two kinds of questions:**

**WHAT** are the information sources that people are sensitive to? (And how are they organized in the brain: we don't know this well yet)

**WHEN** are information constraints applied?

Fodor (1983) proposed “modularity” / “information-encapsulation” of words and syntax

One concrete idea: people compute the literal meanings of compositional language first, and then make inferences about what might have been meant

Non-literal language: inferences about the intended meaning: PRAGMATICS

**Some of the students passed the test.** → *Not all the students passed the test.*

**JOHN** went to the store. → *Only John went to the store.*

**Can you please pass the salt?** → *Pass the salt.*

**I am cold.** (next to an open window): → *Close the window.*

# Information sources and constraints: **Modularity / Information-**

**WHEN** are information constraints applied?

Fodor (1983) proposed “modularity” / “information-encapsulation” of words and syntax

Another idea: people use **syntactic disambiguation rules** to decide among choices, independent of their meaning: choose simplest syntactic choice, independent of meaning. E.g., most frequent syntax

Thus the choice between Main-Verb or Relative Clause structure of “the defendant / evidence examined” would not depend on the meanings

Thus people should favor the simpler structure, independent of meaning. This is what Ferreira & Clifton (1986) found for “the evidence examined” case. But there were serious confounds in their materials, which undermined their interpretation

# Language: Information sources and constraints

**Current Context** (Crain & Steedman, 1985; Altmann & Steedman, 1988; Tanenhaus et al., 1995): visual or linguistic

Ambiguity:

There were two defendants, one of whom the lawyer ignored entirely, and the other of whom the lawyer interrogated for two hours.

The defendant examined by the lawyer turned out to be unreliable.

Monitoring visual eye-movements while listening to spoken instructions  
(Tanenhaus et al., 1995; Trueswell et al., 1999)

I-referent context: “Put the hippo on the towel in the basket.”  
*Many looks to the incorrect target*



Monitoring visual eye-movements while listening to spoken instructions  
(Tanenhaus et al., 1995; Trueswell et al., 1999)

2-referent context: “Put the bear on the plate into the box.”  
*No looks to the incorrect target*



# Language:

## Information sources and constraints

**Working memory:** Longer distance dependencies are harder to process than more local ones

Dependencies between a verb and its post-verbal objects:

Short NP object:

Local Particle: Joe threw **out** the documents.

Non-local Particle: Joe threw the documents **out**.

Long NP object:

Local Particle: Joe threw **out** the very important documents that he brought home.

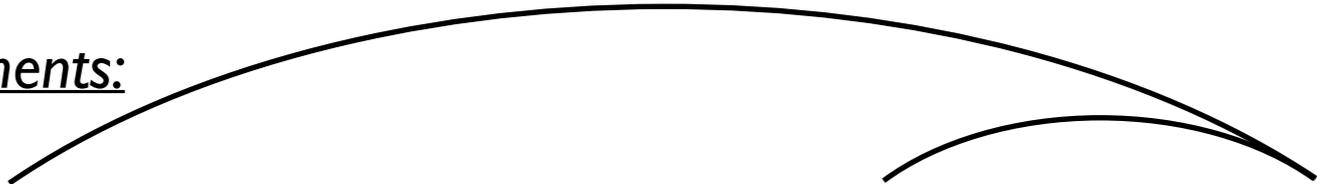
Non-local Particle: Joe threw the very important documents that he brought home **out**.

# Information processing: Working memory

**Working memory:** Local connections are easier to make than long-distance ones (Gibson, 1998, 2000; Grodner & Gibson, 2005; Warren & Gibson, 2002; Lewis & Vashishth, 2005; Hawkins, 1994)

Ambiguous attachments:

The bartender **told** the detective that the suspect **left** the country **yesterday**.



**yesterday** is preferred as modifying **left** rather than **told**

(Frazier & Rayner, 1982; Gibson et al., 1996; Altmann et al., 1998; Pearlmutter & Gibson, 2001)

Unambiguous connections:

The **reporter wrote** an article.

The **reporter** from the newspaper **wrote** an article.



The **reporter** who was from the newspaper **wrote** an article.



# Retrieval / Integration-based theories

Integration: connecting the current word into the structure built thus far: Local integrations are easier than longer-distance integrations

- The Dependency Locality Theory (DLT) (Gibson, 1998; 2000): intervening **discourse referents** cause retrieval difficulty (also in production)
- Activation-based memory theory: similarity-based interference (Lewis & Vasishth, 2005; Vasishth & Lewis, 2006; Lewis, Vasishth & Van Dyke, 2006): **intervening similar elements** cause retrieval difficulty
- Production: Hawkins (1994; 2004): **word**-based distance metric.

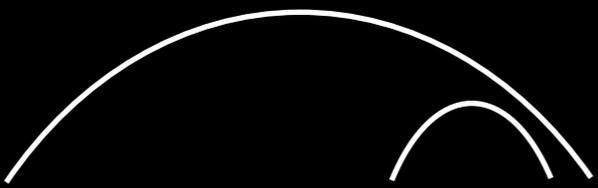
# Dependency Length Minimization

*Futrell, Mahowald & Gibson, 2015, PNAS*

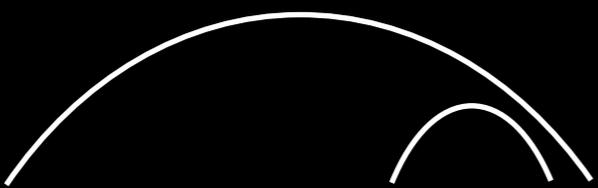
- Corpora from 37 languages parsed into dependencies, from NLP sources: the HamleDT and UDT; cf. WALS (Dryer 2013)
- Family / Region  
*Indo-European (IE)/West-Germanic; IE/North-Germanic; IE/Romance; IE/Greek; IE/West Slavic; IE/South Slavic; IE/East Slavic; IE/Iranian; IE/Indic; Finno-Ugric/Finnic; Finno-Ugric/Ugric; Turkic; West Semitic; Dravidian; Austronesian; East Asian Isolate (2); Other Isolate (1)*
- **Result:** All languages minimize dependency distances (c.f. Hawkins, 1994; Gibson, 1998)



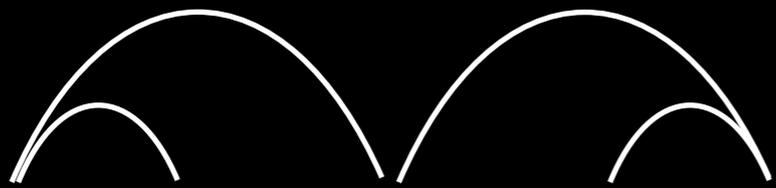
the girl kicks the ball



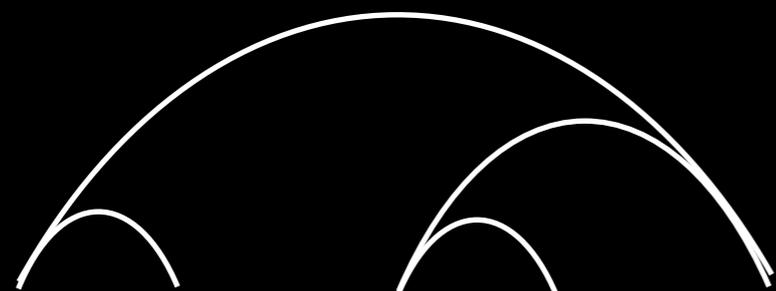
the girl the ball kicks



the ball the girl kicks



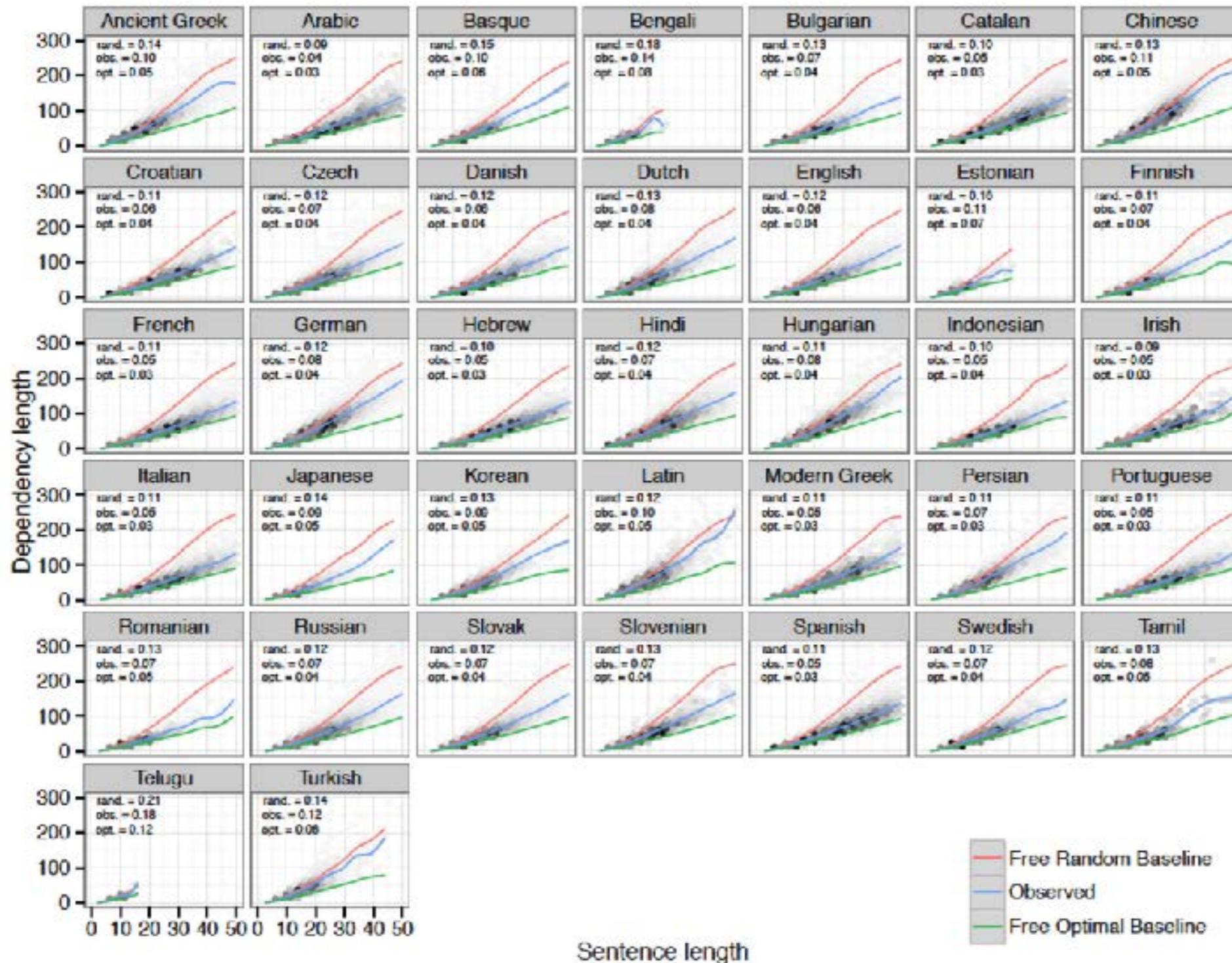
girl the kicks the ball



ball the girl the kicks

# Dependency Length Minimization

*Futrell, Mahowald & Gibson, 2015, PNAS*



Courtesy of National Academy of Sciences, U. S. A. Used with permission. Source: Futrell, Richard, Kyle Mahowald, and Edward Gibson. "Large-scale evidence of dependency length minimization in 37 languages." *Proceedings of the National Academy of Sciences* 112, no. 33 (2015): 10336-10341. Copyright © 2015 National Academy of Sciences, U.S.A.

# Potential project

Result to replicate: Subject-extractions in Relative clauses (RCs) are easier to process than object-extractions:

Subj-RC: The reporter who attacked the senator admitted the error.

Obj-RC: The reporter who the senator attacked admitted the error.

RTs faster at “attacked” in SRC than in ORC

Two explanations: ORCs are rare, and longer-distance

Extension: evaluation other kinds of extraction in English:

Dative extractions: infrequent, long-distance

The boy who the girl gave the book to admitted the error.

The boy to whom the girl gave the book admitted the error.

Genitive extractions: infrequent, short-distance

The girl whose friend invited the kids to the party was kind.

9.59J/24.905J Lab in Psycholinguistics  
Spring 2017

For information about citing these materials or our Terms of Use, visit: <https://ocw.mit.edu/terms>.