

Sentence Processing II

LIGN 170, Lecture 7

Verbal working memory

- When processing language, it is necessary to keep what you have just read / heard in mind
- Verbal working memory
- There is variation in working memory ability among individuals

Verbal working memory

- Just & Carpenter (1992) Model of working memory
- Total capacity of the working memory system is determined by the amount of activation available for functions
- Two kinds of functions:
 - Storage (adding to memory)
 - Computation (manipulating something in memory)

Connection to language

- People judge certain sentences as unacceptable, even when the sentences actually follow the rules of the language
- Example:
 - The woman the man the host knew brought left.
 - But, sometimes these effects are mitigated:
 - The woman someone I knew brought left.

Filler-gap dependencies

- Wh-questions
 - Did the woman think a car hit a tree?
 - What_i did the woman think _____i hit a tree?
 - What_i did the woman think a car hit _____i?

Filler-gap dependencies

- Relative Clauses:
 - Subject
 - I met **the actor_i** that _i accused the woman.
 - Object
 - I met **the actor_i** that the woman accused _i.
- The **filler** needs to be kept in working memory until it can be assigned to the **gap**

Psychological Reality

- ERP data indicates an increase in working memory burden between filler and gap
- Increase in negativity between filler and gap
- Largest over front of head
- fMRI data suggests locus in areas associated with working memory
- Largest burden for object-fillers compared to subject

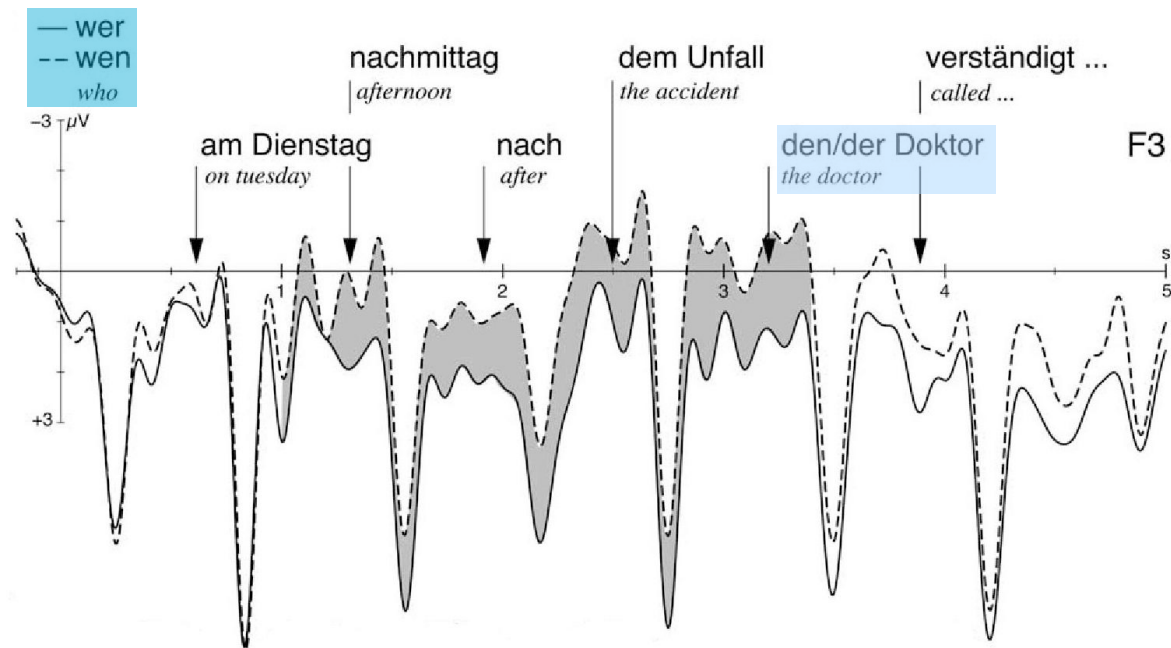
Fiebach, Schlesewsky, Freiderici, 2002

- German
- Thomas wondered who[nom / acc] on Tuesday afternoon after the accident ____ the[acc / nom] doctor called has?
- who[nom] called the doctor[acc]?
- who[acc] the doctor[nom] called?

Thomas fragt sich,

Subject: **wer** am Dienstag nachmittag nach dem Unfall **den** Doktor verständigt hat.
*who_[nom] on Tuesday afternoon after the accident **the**_[acc] doctor called has?*

Object: **wen** am Dienstag nachmittag nach dem Unfall der Doktor **den/der** verständigt hat.
*who_[acc] on Tuesday afternoon after the accident the_[nom] doctor **den/der** called has?*



- Object dependencies appear to be more difficult than subject
- Even when subject filler is displaced from gap, object filler produces larger LAN effect

Two questions

1. At what point in the sentence can you make this association?

2. How much processing load can a person handle?

Measuring memory capacity

- Individual differences in working memory
 - Reading span test
 - Subjects must retain words in working memory while doing an additional language task

Instructions

- Read each sentence out loud when it is presented
- When you see a blank page, state the last word of the sentences you just read
- Five blocks:
 - 2 sentences, 3 sentences, 4 sentences, etc.

SCORING: A subject's score on the test is the highest set size at which they remembered all of the words correctly from at least 3 of the 5 sets of that size.

If they remembered all of the words correctly from only 2 of the 5 sets, they get an additional .5 added to their score. For example, if a subject remembers both words from all of the 2-sentence sets but then only remembers all 3 words for 2 of the 3-sentence sets, their score would be 2.5.

READING SPAN TEST SCORE SHEET

Name: _____

Date: _____

Exptr: _____

Score: _____

Sets of 2

__advance
__candidate

__star
__ground

__status
__resting

__campfire
__anger

__while
__God

Sets of 3

__town
__visit
__album

__door
__lake
__temper

__doubts
__week
__enthusiasts

__case
__read
__elders

__paper
__him
__children

Sets of 4

__applauded
__blindly
__later
__much

__future
__church
__cheating
__patient

__community
__lunch
__design
__cold

__me
__sorry
__documented
__panes

__control
__made
__followed
__production

Sets of 5

__trip
__was
__asleep
__us
__year

__society
__wood
__style
__building
__feet

__stare
__maddening
__mind
__student
__face

__so
__distance
__errors
__dust
__pictures

__be
__smell
__semester
__law
__life

Sets of 6

__going
__objective
__answered
__ever
__all
__bitter

__gum
__superhuman
__circular
__vision
__land
__voices

__look
__dish
__abruptly
__pinch
__securely
__sensitivity

- Test is administered in addition to other tasks
- Score is used to group subjects
- Compare low-span (2.5) to high-span (4+) readers in additional task
- Median split: Compare top half to bottom half

Reading span and relative clauses

- Center-embedded subject relative clause
- The **reporter** [that ___ attacked the senator] admitted the error.
- Two concepts:
 - The reporter attacked the senator
 - The reporter admitted the error
- Relatively easy to process

Reading span and relative clauses

- Center-embedded subject relative clause
- The **reporter** [that ___ attacked the senator] admitted the error.
- Why?
 - Have only one thematic role dependency at one time
 - Reporter is agent in both clauses
 - Small working memory burden

Reading span and relative clauses

- Center-embedded object relative clause
- The **reporter** [that the senator attacked ____] admitted the error
- Two concepts:
 - The **reporter** admitted the error
 - The senator attacked the **reporter**
- Relatively hard to process: 15% errors in paraphrasing

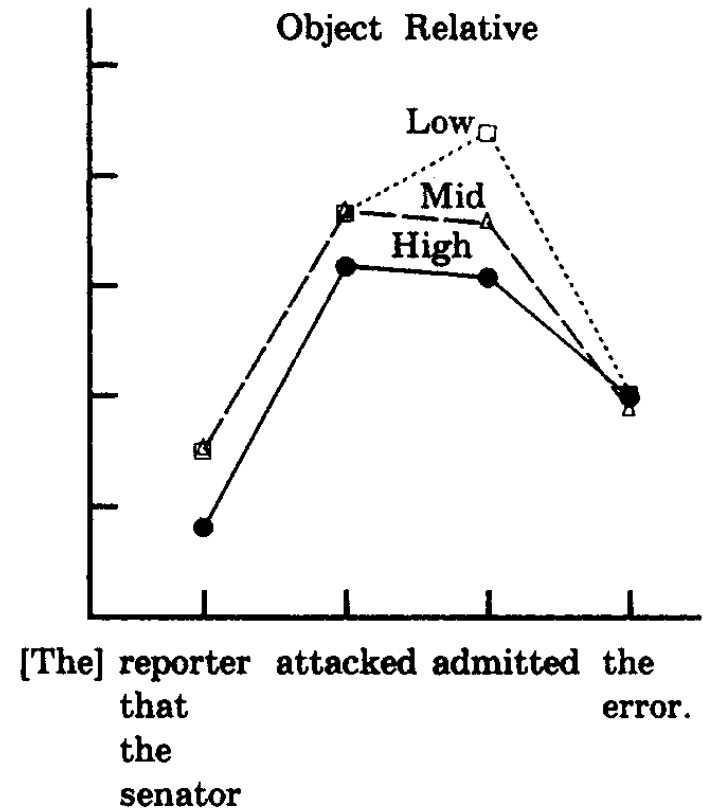
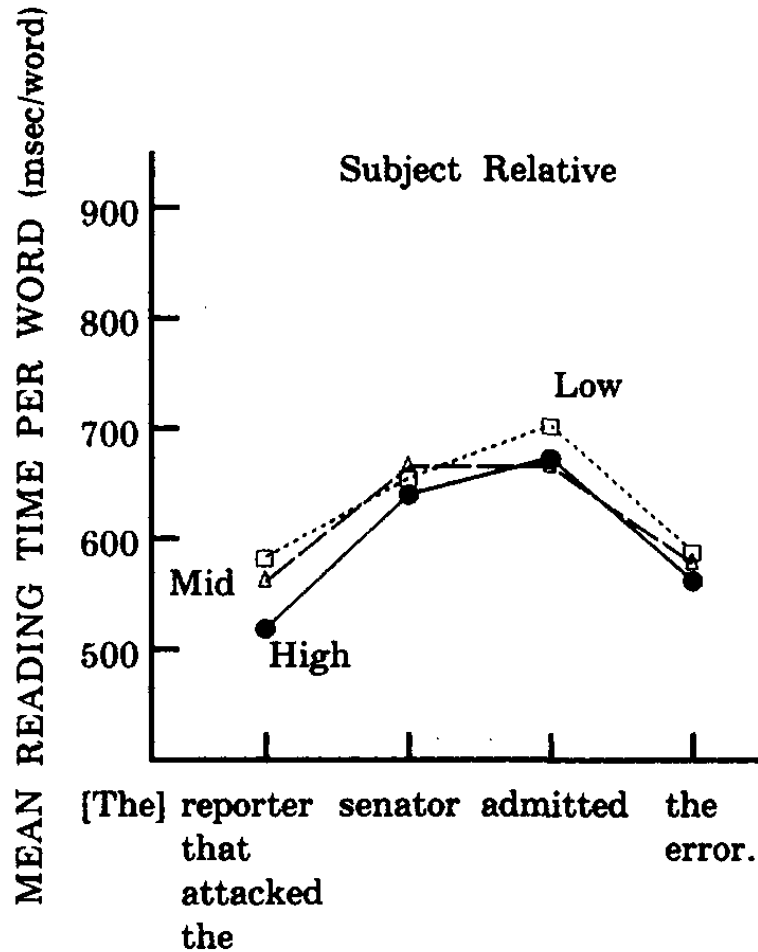
Why difficult?

- The **reporter** [that the senator attacked ____] admitted the error
- Embedding interrupts the main clause – drawing on working memory
- Difficult to know embedded thematic role of reporter and senator
- Difficult to associate two different thematic roles to single constituent

King and Just (1991)

- If object relatives cause extra burden, how does individual working memory ability interact?
 - Subject reading span - High, medium, low
 - Relative clause - Subject, object
- Method:
 - Self-paced reading with comprehension questions

Results



Results

- Low-Span readers (2.5 and lower):
 - Longer RT than high-span at *admitted* in Objects relative condition
 - Comprehension poorer for Object Relatives than subject relatives - despite longer reading times!
 - Half of the subjects even comprehending at chance

Other findings

- Low-span readers depend more on pragmatic context than on syntactic structure for difficult sentences
- When sentences are not “reversible”, low-span readers do much better overall
- The robber that the fireman rescued stole the jewelry.

Two questions

1. At what point in the sentence can you make this association?

2. How much processing load can a person handle?

Two questions

1. At what point in the sentence can you make this association?

2. How much processing load can a person handle?

Depends on the person

Longer dependencies cause greater burden

Object-dependencies have larger burden than subject-dependencies

Two questions

1. At what point in the sentence can you make this association?

2. How much processing load can a person handle?

- Important to know because it has implications for the ease of processing of dependencies
 - Sooner: easier
 - Later: harder

Two strategies

- Try to end dependency as soon as possible ("hot potato" strategy)
- Use information from the verb to help

1. Play hot potato

- Try to dump the filler at every reasonable opportunity
- Filled-gap effect

What did the man build _____



1. Play hot potato

- Try to dump the filler at every reasonable opportunity
- Filled-gap effect

What did the man build a doghouse with ____?



Increase in reading time

2. Take advantage of verbs

- Use information from the verb to aid in determining what the role of the filler is, rather than waiting for the gap site

Boland et al. (1989)

- Embedded anomaly technique
 - Two types of wh-fillers are used
 - Plausible objects of the verb
 - Implausible objects of the verb

The sheriff wasn't sure *which* $\left\{ \begin{smallmatrix} \text{horse} \\ \text{rock} \end{smallmatrix} \right\}$ the cowboy
raced ____ down the hill

Logic: Sentence will become implausible when a gap is posited & filled with implausible object

The sheriff wasn't sure *which* $\left\{ \begin{smallmatrix} \text{horse} \\ \text{rock} \end{smallmatrix} \right\}$ the cowboy
raced ____ down the hill

- Several possible tasks:
 - Ask the subject which sentences make sense and which do not
 - See how long a subject takes to make a decision that a sentence makes sense
 - Ask subject to say at which word sentence stops making sense
 - Look at reading times for each word in the sentence

Experiment #1

Verbs with one post-verbal argument (transitive)

Which $\left\{ \begin{smallmatrix} \text{star} \\ \text{stone} \end{smallmatrix} \right\}$ did the assistant **watch** __ all through the night?

No alternate possibility at verb for implausible “stone”:
watch the stone

Experiment #1

Verbs with one post-verbal argument (transitive)

Which $\left\{ \begin{smallmatrix} \text{stone} \\ \text{star} \end{smallmatrix} \right\}$ did the assistant **watch** — all through the night?

No alternate possibility at verb for implausible “stone”:
watch the stone

RESULTS: For the implausible condition at verb
Longer reading times
More “stop making sense” responses

Experiment #1

Verbs with two post-verbal arguments (ditransitive)

Which { baby
poem } did the babysitter read __ in a funny voice?

Alternate possibility for “baby”:
read *the poem to* ____ ...

RESULTS: For the implausible condition at “in”
Longer reading times
More “stop making sense” responses

Experiment #1

Verbs with sentence (infinitival) complements

Which {^{movie}_{girl}} did the woman **remind** __ to watch the show?

Alternate possibility for “movie”:
remind the girl to ...

RESULTS: For the implausible condition at “to”
Longer reading times
More “stop making sense” responses

- So, comprehenders appear to be filling gaps before the gap is actually encountered (when possible)
- When alternative structure is available, comprehenders are more flexible - associating the filler with the gap when necessary

Experiment #2

- Prediction that when a filler cannot be assigned to direct object (DO) position, it will be assigned to indirect object (IO) position

Bob wondered
which {bachelor} Ann granted *a maternity leave* to _____ this
 {secretary} afternoon. DO IO

“bachelor” should cause problems at some point during
“maternity leave” - as comprehenders associate it with IO
gap

Experiment #2

Bob wondered
which { bachelor } Ann granted *a maternity leave* to this
 { secretary } afternoon. DO IO

RESULTS: For the implausible condition
Longer reading times at *leave*
More “stop making sense” responses

- Take-home message from Boland et al. (1989)
- Thematic role information from a verb can be used to immediately influence filler-gap assignment
 - In advance of gap position!
- Helps comprehenders accurately posit the grammatical role of the gap
 - Allows faster resolution of filler burden

Two strategies

- Try to end dependency as soon as possible (“hot potato” strategy)
- Filled-gap effects
- Use information from the verb to help
 - Plausibility effects before gap site

Summary: Filler-gaps

1. At what point in the sentence can you make this association?

At the gap

Earlier if information allows (e.g. verb)

2. How much processing load can a person handle?

Depends on the person

Something (nearly) completely different

Non-literal language

Raining cats and dogs



- Idioms
 - It rained cats and dogs at the picnic.
 - The old geezer finally kicked the bucket.
- Non-compositional meaning:
 - The meaning of the idiomatic phrase does not equal the meaning of the composite parts

Raining cats and dogs



- Compare to frequent, non-idiomatic phrases
- I like my coffee with cream and suger.
- Put the salt and pepper on the table.

- The form of idioms is very rigid
 - It rained cats and puppies.
 - The old geezer finally kicked the pail.
- Compared to non-idiomatic phrases
 - I like my coffee with cream and cinnamon.
 - Put the salt and butter on the table.

Other examples of idioms

- John bought the farm
- John's always beating a dead horse
- John's keeping tabs on Mary
- John let the cat out of the bag.
- John spilled the beans.

Idioms

- Some argue that idioms are stored whole in the lexicon
- Example: “Kick the bucket” entry
- So, how do we process idioms?
- Try literal meaning, fail, search for idiomatic entry?
- But many idioms are processed as fast as literal phrases!

Complications

- Not all idioms are equally non-compositional
 - Gibbs & Nayak (1989)
 - decomposable - “miss the boat”
 - nondecomposable - “kick the bucket”
 - Decomposable idioms
 - Are more flexible syntactically and lexically
 - Processed more quickly than literal phrases and nondecomposable idioms

Processing idioms

- People successfully do compositional analysis for some idioms
- Works for decomposable ones where there is a clear relationship between the compositional meaning and the idiomatic one
- Could be calculating compositional meaning while also accessing figurative meaning in parallel

Metaphors

- My brother is a bottomless pit.
 - (eats a lot)
- I thought she would melt/break down when he left.
 - (be completely unhappy, cry)
- It's an oven in here!
 - (very hot, suffocating)

- One view (e.g. Lakoff & Johnson, 1980)
 - *Our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature*
- Language is significantly metaphorical, even language that seems literal
- So, metaphors are processed like the rest of language