

Edward Gibson (2000)

Dependency Locality Theory

Anna Finzel Anne Beyer Melanie Tosik

October 28, 2013

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

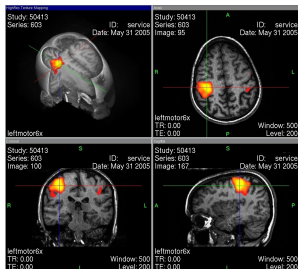
- Ambiguity Resolution

Criticism

Discussion

Bibliography

Why study psycholinguistics and language processing?



DANS, KÖN OCH JAGPROJEKT

På jakt efter ungdomars kroppsspråk och den "synkretiska dansen", en sammansmältning av olika kulturers dans, har jag i mitt fältarbete under hösten rört mig på olika arenor inom skolans värld. Nordiska, afrikanska, syd- och östeuropeiska ungdomar ger sina röster höra genom sång, musik, skrik, skrat och gestaltar känslor och uttryck med hjälp av kroppsspråk och dans.

Den individuella estetiken framträder i kläder, frisyrier och symboliska tecken som förstärker ungdomarnas "jagprojekt" där också den egna stilen i kroppsrörelserna spelar en betydande roll i identitetsprövningen. Upphållsrummet fungerar som offentlig arena där ungdomarna spelar upp sina performance-liknande kroppsspråk.

Figure : ©Wikimedia Commons

Difficulty

(1a) The canine carnivore whose habitat which local afforestations comprise is threatened by imported fungi spurns vegetal fodder.

Difficulty

(1a) The canine carnivore whose habitat which local afforestations comprise is threatened by imported fungi spurns vegetal fodder.

- infrequent lexical items

Difficulty

(1a) The canine **carnivore** whose **habitat** which local **afforestations** comprise is threatened by imported **fungi** spurns vegetal **fodder**.

- infrequent lexical items
- new discourse referents

Difficulty

(1a) The canine carnivore whose habitat which local afforestations **comprise is threatened** by imported fungi **spurns** vegetal fodder.

- infrequent lexical items
- new discourse referents
- assignment of structures

Difficulty

(1a) The canine carnivore whose habitat which local afforestations comprise is threatened by imported fungi spurns vegetal fodder.

- infrequent lexical items
- new discourse referents
- assignment of structures
- distance

Difficulty

- (1a) The canine carnivore whose habitat which local afforestations comprise is threatened by imported fungi spurns vegetal fodder.
- (1b) Foxes only eat meat. They live in forests, where dangerous new mushrooms grow.

Dependency Locality Theory

- requires information sources
- is constrained by computational resources
 1. structural integration (BUILDING)
 2. memory (MAINTAINING)
- \Rightarrow depend on **locality**

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

No complexity

(2a) [A]

(2b) [The reporter disliked the editor].

(2c) [NP V NP]

Slight complexity

(3a) $[B_1 [A] B_2]$

(3b) [The reporter [who the senator attacked] disliked the editor].

(3c) $[NP [RC] V NP]$

High complexity

(4a) $[C_1 [B_1 [A] B_2] C_2]$

(4b) [The reporter [who the senator [who John met] attacked]
disliked the editor].

(4c) $[NP [who NP [RC] V] V NP]$

Lexical frequency or plausibility?

NO!

(5a) [A [B] [C]]

(5b) [John met the senator [who attacked the reporter] [who disliked the editor]].

(5c) [NP V NP [RC] [RC]]

Lexical frequency or plausibility?

NO!

(4b) [The reporter [who the senator [who John met] attacked] disliked the editor].

(5b) [John met the senator [who attacked the reporter] [who disliked the editor]].

Processing difficulty \rightarrow quantity of resources required

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Incomplete Dependency Hypothesis

Hypothesis: Difficulty depends on **number** of incomplete syntactic dependencies.

(2b) [The reporter disliked the editor].

Incomplete Dependency Hypothesis

Hypothesis: Difficulty depends on **number** of incomplete syntactic dependencies.

(2b) [The reporter ! disliked the editor].

Incomplete Dependency Hypothesis

Hypothesis: Difficulty depends on **number** of incomplete syntactic dependencies.

(3b) [The reporter [who the senator attacked] disliked the editor].

Incomplete Dependency Hypothesis

Hypothesis: Difficulty depends on **number** of incomplete syntactic dependencies.

(3b) [The reporter ! [who ! the senator ! attacked] disliked the editor].

Incomplete Dependency Hypothesis

Hypothesis: Difficulty depends on **number** of incomplete syntactic dependencies.

(4b) [The reporter [who the senator [who John met] attacked] disliked the editor].

Incomplete Dependency Hypothesis

Hypothesis: Difficulty depends on **number** of incomplete syntactic dependencies.

(4b) [The reporter ! [who ! the senator ! [who ! John ! met] attacked] disliked the editor].

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Why DLT then?

- (4b) [The reporter [who the senator [who John met] attacked] disliked the editor].
- (6) [The reporter [who the senator [who I met] attacked] disliked the editor].
- Incomplete Dependency Hypothesis does not explain faster processing of pronouns (Warren & Gibson 1999)
 - Syntactic Prediction Locality Theory (Gibson 1998) as antecedent of DLT
 - DLT gives more accurate accounts
 - encompasses two aspects
 1. needed resources of (a) integration and (b) storage
 2. distance
 - \Rightarrow resources consume **costs**

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

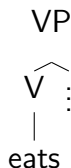
Discussion

Bibliography

How do we process new input words?

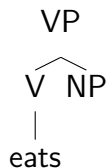
eats

How do we process new input words?



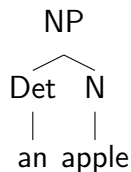
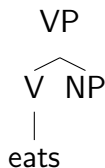
- construct syntactic structure

How do we process new input words?



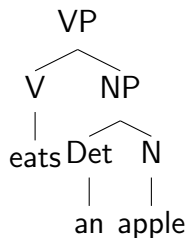
- syntactic prediction (cf. Storage Cost)

How do we process new input words?



- integrate into structure built so far

How do we process new input words?



- interpretation

How do we process new input words?

1. construct maximal projection
2. structural integration
3. interpretation
 - 3.1 integration in discourse model
 - 3.2 evaluating plausibility
4. reanalysis

How do we process new input words?

1. construct maximal projection
2. **structural integration**
3. interpretation
 - 3.1 **integration in discourse model**
 - 3.2 evaluating plausibility
4. reanalysis

Discourse Integration

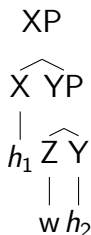
discourse referent

Entity that has a spatiotemporal location in the discourse model

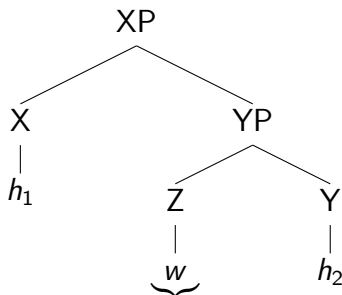
Simplification: only heads of NPs and VPs that introduce new discourse referents consume substantial resources

Structural Integration

Relating the head of a newly constructed maximal projection to a head in the current syntactic structure



Structural Integration Cost



depends on the
number of words
(i.e. structural integrations)
in the interim

Energy Unit (EU)

Simplified measurement for expressing resource requirements as a combination of

- discourse processing cost
- structural integration cost

DLT Integration Cost

DLT simplified discourse processing cost

1 EU if w is head of a new discourse referent

0 EUs otherwise

DLT simplified integration cost

1 EU for each new discourse referent between h_1 and h_2

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

General Nesting Complexity Effects

- (1) The reporter [who the senator attacked] disliked the editor.
- (2) The reporter [who the senator [who John met] attacked] disliked the editor.

General Nesting Complexity Effects

- (3) The reporter [who the senator attacked] disliked the editor.
- (4) The reporter [who the senator [who John met] attacked] disliked the editor.

DLT Integration Cost

DLT simplified discourse processing cost

1 EU if w is head of a new discourse referent

0 EUs otherwise

DLT simplified integration cost

1 EU for each new discourse referent between h_1 and h_2

Other Nesting Complexity Effects

Lack of difficulty when processing nested structures with pronoun subject:

- (5) The reporter [who the senator [who John met] attacked] disliked the editor.
- (6) The reporter [who the senator [who I met] attacked] disliked the editor.

Other Nesting Complexity Effects

Contrast between embedding RC within CC and CC within RC:

- (7) The fact that [_{CC} the employee [_{RC} who the manager hired] stole office supplies] worried the executive.
- (8) The executive [_{RC} who the fact that [_{CC} the employee stole office supplies] worried] hired the manager.

Other Nesting Complexity Effects

Increased complexity when adding another new discourse referent at a nested location:

- (9) The possibility that the administrator who the nurse supervised lost the medical reports didn't bother the intern from the maternity ward.
- (10) The possibility that the administrator who the nurse **from the maternity ward** supervised lost the medical reports didn't bother the intern.

DLT Integration Cost

OVERSIMPLIFICATION!

- structural integration cost not linear
- no processing cost for old discourse referents/ other words
- no storage cost (yet)

Still able to account for nesting complexity effects other theories could not explain

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Subject-extracted vs. object-extracted RCs

(11) *Subject extraction*

The reporter who sent the photographer to the editor
hoped for a good story.

(12) *Object extraction*

The reporter who the photographer sent to the editor
hoped for a good story.

Subject-extracted vs. object-extracted RCs

(13) *Subject extraction*

The reporter who sent the photographer to the editor
hoped for a good story.

(14) *Object extraction*

The reporter who the photographer sent to the editor
hoped for a good story.

→ more complex

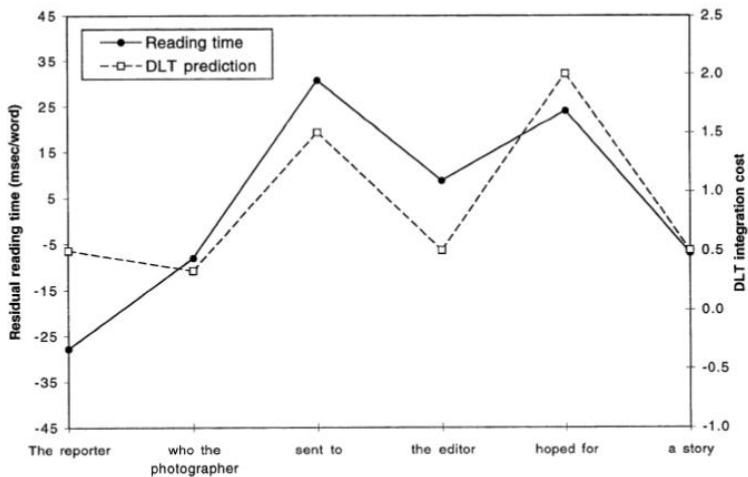


Figure 5.3

A comparison between residual reading times and locality-based integration costs in an object-extracted RC structure.

©Gibson 2000: 111

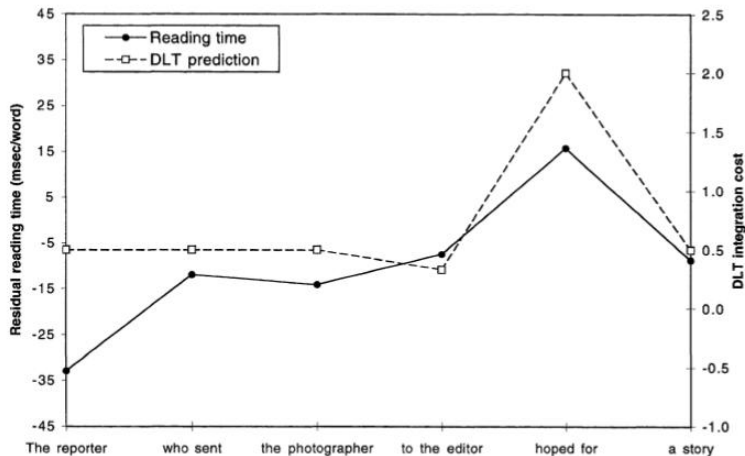


Figure 5.4

A comparison between residual reading times and locality-based integration costs in a subject-extracted RC structure.

©Gibson 2000: 112

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

The DLT Storage Cost Component

DLT storage cost

1 memory unit (MU) is associated with each syntactic head required to complete the current input as a grammatical sentence.

Input word

The reporter who the senator attacked disliked the editor

Storage cost 2 1 3 4 3 1 1 1 0

Interrelation between Storage and Integration Cost

Set of assumptions:

- Integrations and storage access the same pool of resources
- There is a fixed capacity of resources in the resource pool
- Each predicted syntactic head takes up a fixed quantity of resources

→ the more resources that are required in storage, the slower integrations occur

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Applying the DLT to Ambiguity Resolution

Ambiguity resolution hypothesis

In choosing among ambiguous structures, two of the factors that the processor uses to evaluate its choices are DLT storage and structural integration cost.

- (15) The bartender told the detective that the suspect left the country yesterday. ✓
- (16) The evidence examined by the lawyer turned out to be unreliable. ?
→ temporary local ambiguity

What's happening here?

- (17) The evidence examined by the lawyer turned out to be unreliable.

→ temporary ambiguity at *examined* between main verb (MV) and past-participle reduced relative (RR) interpretation

- MV and RR equally frequent (Brown corpus)
- Plausibility favours RR
(evidence is likely to be examined, but not vice versa)
- No structural integration cost difference
(both attachments are local)
- Potentially small memory cost difference favouring MV

What's happening here?

(18) The evidence examined by the lawyer turned out to be unreliable.

→ temporary ambiguity at *examined* between main verb (MV) and past-participle reduced relative (RR) interpretation

- DLT memory costs are balanced or favouring MV
- Weighing all factors together, RR is preferred (plausibility)

→ Resource use?

Resource Use Hypothesis

Is ambiguity resolution really only determined by lexical frequencies and plausibility, with no effect of resource use? (“constraint-based” processing theories)

→ Comparing the resolution of an ambiguity with a small resource complexity difference with the resolution of ambiguities with larger resource complexity differences:

(19) The witness who the evidence examined by the lawyer implicated seemed to be very nervous.

→ DLT strongly favours MV structure

→ Plausibility factors highly favouring RR

Test set

- (20) *Large storage cost difference, ambiguous*
The witness who the evidence examined by the lawyer implicated seemed to be very nervous.
- (21) *Large storage cost difference, unambiguous*
The witness who the evidence that was examined by the lawyer implicated seemed to be very nervous.
- (22) *Small storage cost difference, ambiguous*
The witness thought that the evidence examined by the lawyer implicated his next-door neighbour.
- (23) *Small storage cost difference, unambiguous*
The witness thought that the evidence that was examined by the lawyer implicated his next-door neighbour.

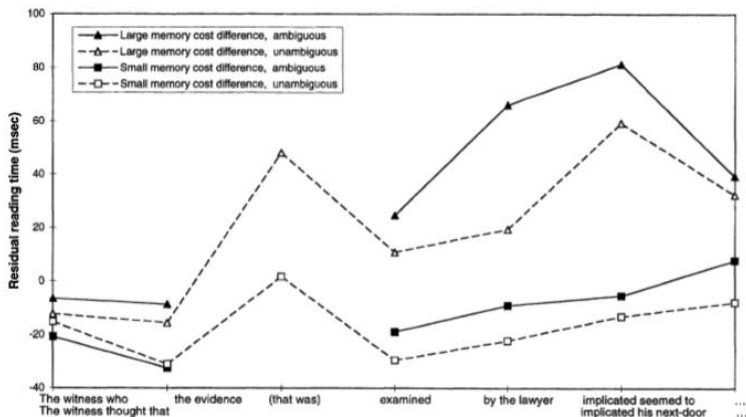


Figure 5.5

Residual reading times for sixty subjects taking part in a self-paced, word-by-word, moving-window reading experiment involving four conditions that crossed DLT storage complexity difference (high storage complexity difference, low storage complexity difference) with ambiguity (ambiguous, unambiguous).

Figure : ©Gibson 2000: 118

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Criticism

1. no proper “exchange rate” for the “currency”
2. no explanation of priming effects
3. no critical attitude towards spillover effect

Criticism

“To reduce noise, the words are grouped in two- and three-word regions, and the average residual reading times are provided for each region. Because there is a reading-time spillover in self-paced reading, such that slow reading times are often reflected one or two words after a point of high complexity, locations of high predicted DLT integration cost were grouped with the following word.” (Gibson 2000: 111)

Criticism

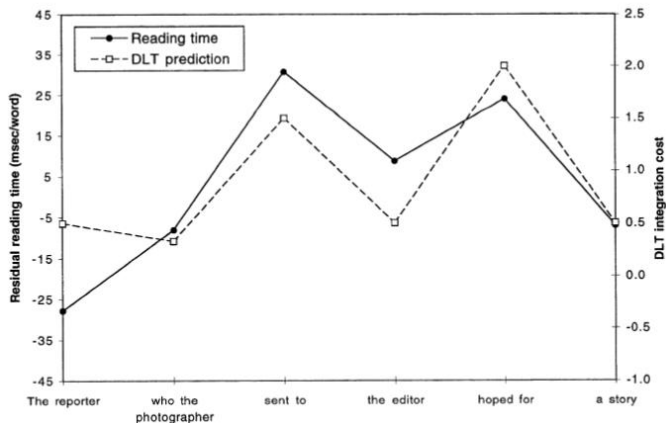


Figure 5.3

A comparison between residual reading times and locality-based integration costs in an object-extracted RC structure.

Figure : ©Gibson 2000: 111

Any questions?

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs

- Ambiguity Resolution

Criticism

Discussion

Bibliography

Discussion

Konieczny 2000:

(7a) Er hat den Abgeordneten begleitet, und ...

(7b) Er hat den Abgeordneten ans Rednerpult begleitet, und

...

(7c) Er hat den Abgeordneten an das grosse Rednerpult begleitet, und ...

- \Rightarrow speed-up while getting closer to the verb
- similar results in Hindi (Vasishth 2002; Vasishth & Lewis 2006)
- contradiction to DLT

Discussion

- How do you explain the findings in German and Hindi?
- What about the facts
 1. that German relative clauses are verb-final,
 2. that German is very case-sensitive and
 3. that in Hindi, relative pronouns remain in their original position and do not have to be moved to the beginning of the relative clause?
- Can we conclude anything from this?

Outline

Introduction

Nesting Complexity

Incomplete Dependency Hypothesis

Why DLT then?

The Dependency Locality Theory

- Integration Costs

 - Nesting Complexity Effects

- Comprehension Times

- Storage Costs







- Ambiguity Resolution

Criticism

Discussion

Bibliography

Bibliography

-  Gibson, E. (1998). Linguistic complexity: Locality of syntactic dependencies. *Cognition*, 68, 1–76.
-  Gibson, E. (2000). The dependency locality theory: A distance-based theory of linguistic complexity. In Miyashita, Y., Marantz, A., & O'Neil, W. (eds.), *Image, language, brain*, Cambridge, MA: MIT Press, 95–126.
-  Konieczny, L. (2000). Locality and parsing complexity. *Journal of Psycholinguistic Research*, 29(6), 627–645.
-  Vasishth, S. (2002). Working memory in sentence comprehension: Processing Hindi center embeddings. PhD thesis, Ohio State University.
-  Vasishth, S. and Lewis, R. L. (2006). Argument-head distance and processing complexity: Explaining both locality and anti-locality effects. *Language*, 82(4), 767–794.
-  Warren, T. and Gibson, E. (1999). The effects of discourse status on intuitive complexity: Implications for quantifying distance in a locality-based theory of linguistic complexity. Poster presented at the Twelfth CUNY Sentence Processing Conference, CUNY, New York.