Current issues in sentence comprehension: Lecture 01

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What this course is about

- This course is mainly about sentence comprehension.
- We will focus mainly on some of the recent work on retrieval and predictive processing, with a bigger focus on prediction.
- I will do most of the presenting, but class participation is highly encouraged.

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Today's plan

- I will give a short introduction to the field of sentence comprehension (lecture notes provided).
- Then I will introduce some of my lab's recent work.
- This will prepare us for the upcoming readings.

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If you are taking this course for credit

1. Grading will be based on a short report (2-3 pages at most) on one or more of the papers discussed in the course. The report can be in Japanese, German, French, English, or Hindi.
2. Extra credit will be given for original ideas/proposals in the summary, and for class participation.
3. If you come up with a new experiment design that attempts to resolve an open question, then you are very likely to get a high score.

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Research interests in my group

1. Computational models of sentence comprehension processes
2. Expectation effects in sentence processing
3. Models of good enough parsing and underspecification
4. Silent prosody
5. Individual differences in parsing
6. Experimental methods (e.g., coregistration)
7. Statistical methods (particularly Bayesian data analysis)

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The ACT-R model of sentence comprehension

Key references

1. Lewis and Vasishth 2005 [9]
2. Lewis, Vasishth, and Van Dyke 2006 [10]
3. Vasishth, Bruessow, Lewis, and Drenhaus, 2008 [18]
4. Engelmann et al 2012 [2]
5. Jäger et al (2015) [6]
6. Engelmann et al (submitted) [1]

Engelmann and I are also writing a book (Cambridge Uni Press), and will teach a one-week course at ESSLLI 2016 in Bolzano on the ACT-R model.

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Example 1 of interference/decay effects

Chinese Relative Clauses

Retrieval accounts (e.g., Gibson 2000, Lewis and Vasishth 2005) predict **slower** processing at the head noun in subject relatives compared to object relatives.

(1) a. Single-embedded SR

[GAP_i yaoqing fuhao de] guanyuan$_i$
invite tycoon DE official
xinhuaibugui
have bad intentions

'The official who invited the tycoon has bad intentions.'

b. Single-embedded OR

[fuhao yaoqing GAP_i de] guanyuan$_i$
tycoon invite DE official
xinhuaibugui
have bad intentions

'The official who the tycoon invited has bad intentions.'

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The evidence is remarkably unclear

source	coef.	SE	n	method
Gibson Wu 2012	-123.20	46.84	36	SPR
Vasishth et al 2013 expt 3	-109.40	54.80	40	SPR
Lin et al 2011 expt 1	-100.00	30.00	48	SPR
Lin et al 2011 expt 2	-30.00	32.05	40	SPR
Qiao et al 2012 expt 2	-28.00	23.80	24	LMaze
Qiao et al 2012 expt 1	-16.00	44.26	32	GMaze
Wu et al 2011	50.00	40.00	48	SPR
Hsiao and Gibson 2003	50.00	25.00	35	SPR
Wu et al 2009	50.00	23.00	40	SPR
Jaeger et al 2013 expt 1	55.62	65.14	49	SPR
Chen et al 2008	75.00	35.50	39	SPR
Jaeger et al 2013 expt 2	81.92	36.25	49	ET
Vasishth et al 2013 expt 2	82.60	41.20	61	SPR
Vasishth et al 2013 expt 1	148.50	50.90	60	SPR

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The evidence is remarkably unclear

This lack of clarity in the Chinese data has partly to do with local ambiguities in Chinese RCs.
I will return to this when discussing expectation accounts.

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Example 2 of interference/decay effects: Processing polarity

This effect is solid (widely replicated)!

(2) a. Accessible NPI licensor
Kein Pirat, [der einen Braten gegessen hatte,] war **jemals** sparsam

b. Inaccessible NPI licensor
*Ein Pirat, [der **keinen Braten** gegessen hatte,] war **jemals** sparsam

c. No NPI licensor
*Ein Pirat, [der einen Braten gegessen hatte,] war **jemals** sparsam

Condition	Data	Model
(2a) Accessible licensor	85	96
(2b) Inaccessible licensor	**70**	**61**
(2c) No licensor	83	86

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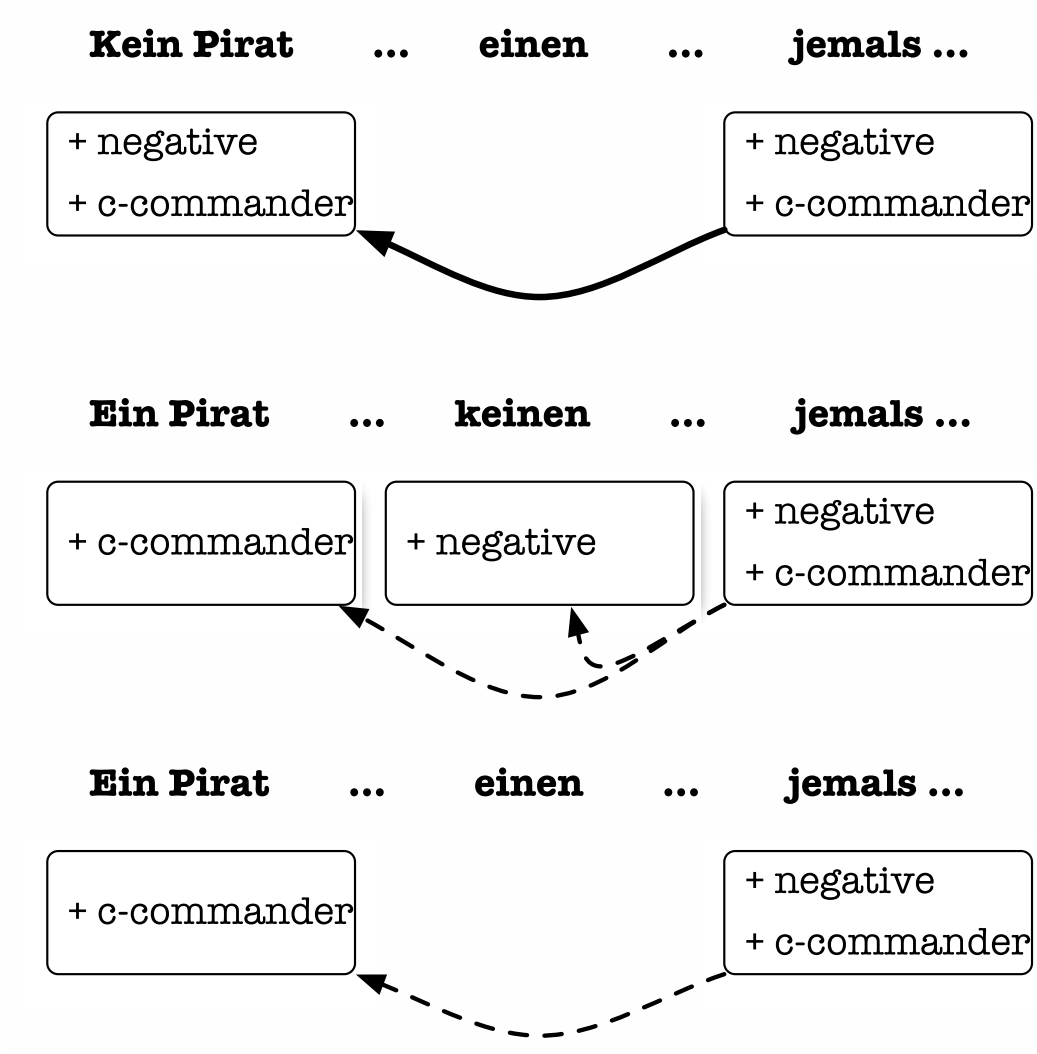
Assumptions for NPIs



An interesting puzzle: absence of interference in antecedent-reflexive configurations

- Colin Phillips' group has uncovered some very interesting cases involving antecedent-reflexive configurations where they find either no interference, or a much reduced effect.
- The key finding from their work is that the parser uses the principles of the binding theory to find the antecedent; the parser largely does not suffer from interference from distractor nouns that are not candidate antecedents.

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Can syntactic constraints override working memory constraints?

Sturt 2003

(7a) *Accessible-match/inaccessible-match*
Jonathan was pretty worried at the City Hospital. He remembered that the surgeon had pricked himself with a used syringe needle. There should be an investigation soon.

(7b) *Accessible-match/inaccessible-mismatch*
Jennifer was pretty worried at the City Hospital. She remembered that the surgeon had pricked himself with a used syringe needle. There should be an investigation soon.

(7c) *Accessible-mismatch/inaccessible-match*
Jonathan was pretty worried at the City Hospital. He remembered that the surgeon had pricked herself with a used syringe needle. There should be an investigation soon.

(7d) *Accessible-mismatch/inaccessible-mismatch*
Jennifer was pretty worried at the City Hospital. She remembered that the surgeon had pricked herself with a used syringe needle. There should be an investigation soon.

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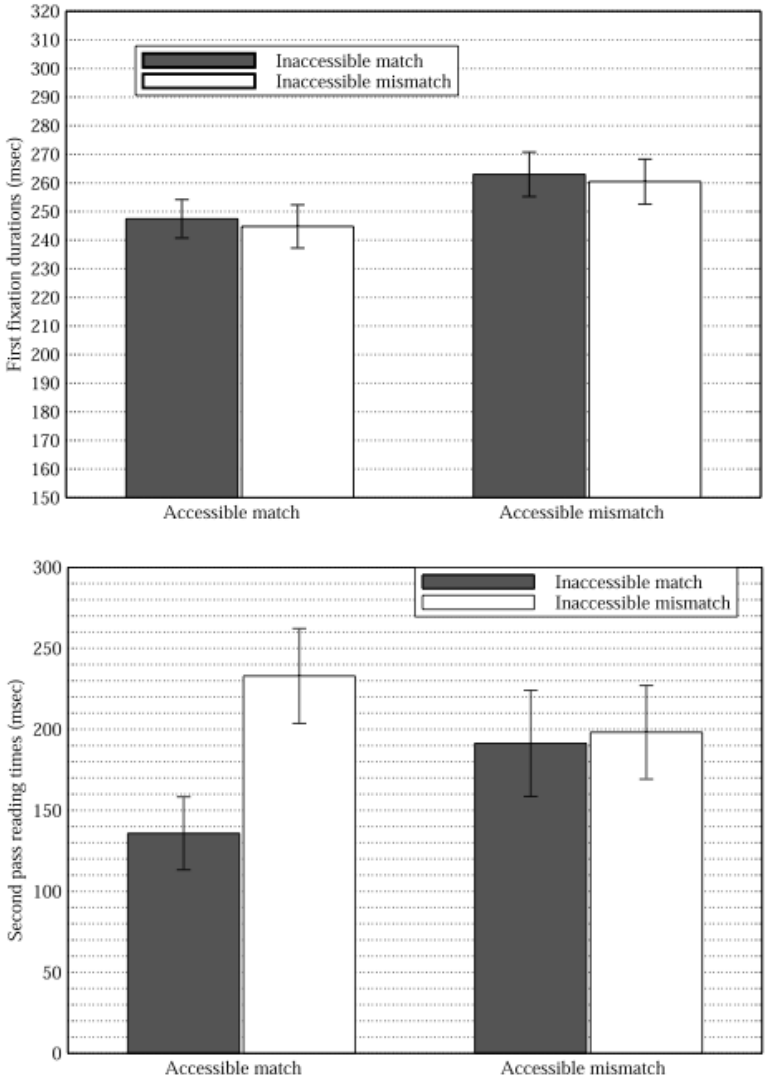
Can syntactic constraints override working memory constraints?

Sturt 2003



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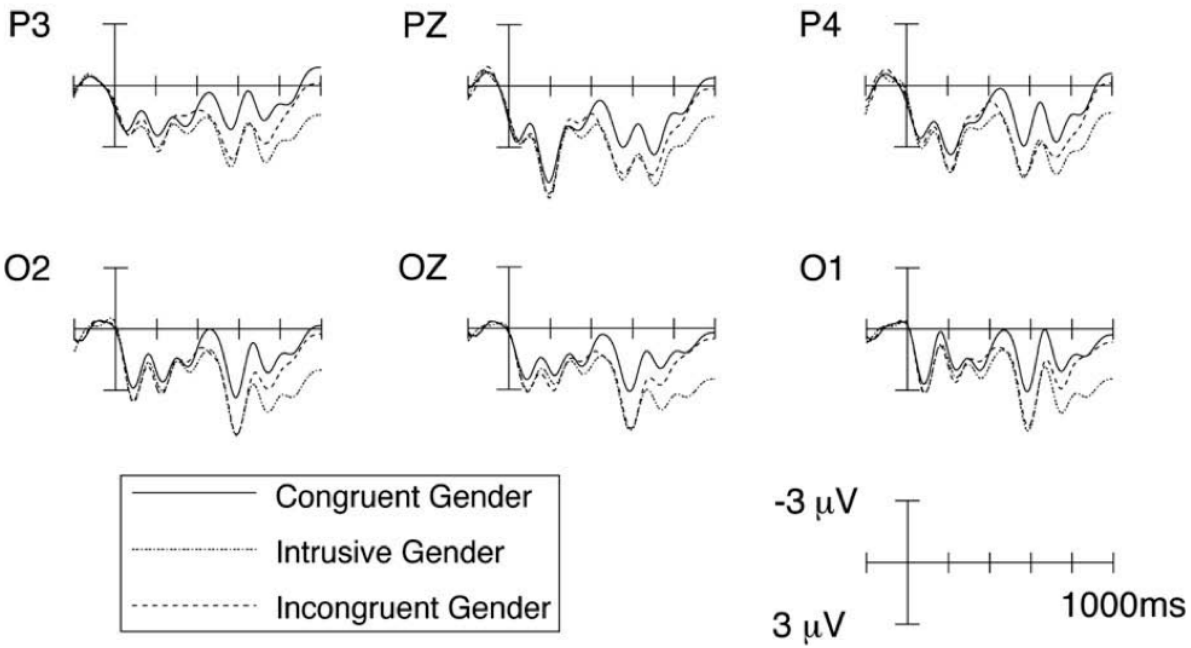
Can syntactic constraints override working memory constraints?

Xiang et al 2009

Congruent	The tough *soldier* that Fred treated in the military hospital introduced *himself* to all the nurses
Intrusive	The tough *soldier* that *Katie* treated in the military hospital introduced *herself* to all the nurses
Incongruent	The tough *soldier* that Fred treated in the military hospital introduced *herself* to all the nurses



Can syntactic constraints override working memory constraints?

Dillon et al 2013

Table 1
Summary of agreement conditions in Experiment 1. Critical and spillover regions included in the analysis are underlined.

Agreement conditions for Experiment 1
Grammatical, no intrusion
1. The new executive/ who oversaw/ the middle manager/ apparently/ was dishonest/ about the company's profits
Grammatical, intrusion
2. The new executive/ who oversaw/ the middle managers/ apparently/ was dishonest/ about the company's profits
Ungrammatical, no intrusion
3. The new executive/ who oversaw/ the middle manager/ apparently/ were dishonest/ about the company's profits
Ungrammatical, intrusion
4. The new executive/ who oversaw/ the middle managers/ apparently/ were dishonest/ about the company's profits

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Can syntactic constraints override working memory constraints?

Dillon et al 2013

Table 2
Summary of reflexive conditions in Experiment 1. Critical and spillover regions included in the analysis are underlined.

Reflexive conditions for Experiment 1
Grammatical, no intrusion
1. The new executive/ who oversaw/ the middle manager/ apparently doubted/ himself on/ most major decisions
Grammatical, intrusion
2. The new executive/ who oversaw/ the middle managers/ apparently doubted/ himself on/ most major decisions
Ungrammatical, no intrusion
3. The new executive/ who oversaw/ the middle manager/ apparently doubted/ themselves on/ most major decisions
Ungrammatical, intrusion
4. The new executive/ who oversaw/ the middle managers/ apparently doubted/ themselves on/ most major decisions

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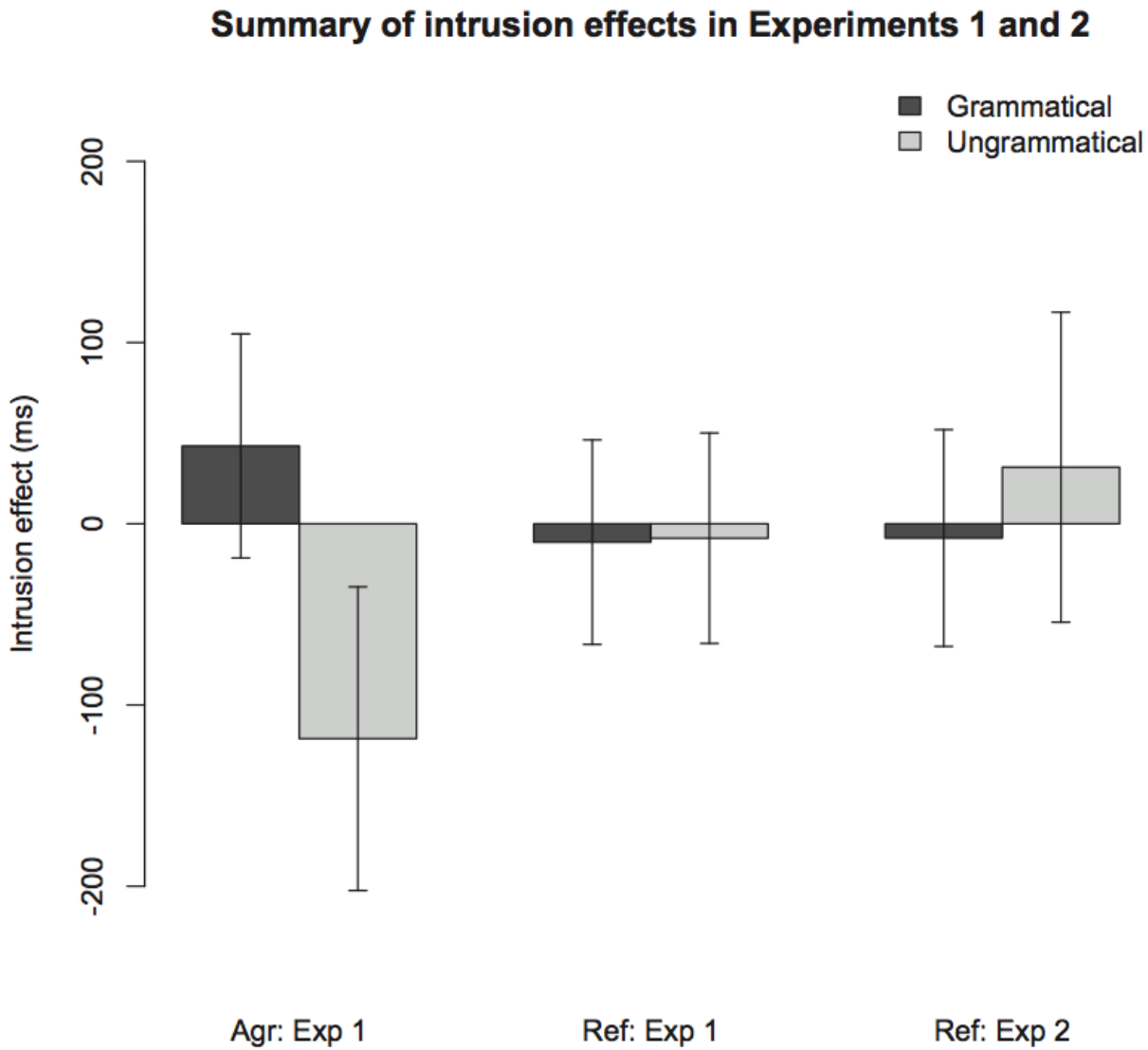
Can syntactic constraints override working memory constraints?

Dillon et al 2013



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Conclusions so far

1. The ACT-R model performs reasonably well for explaining interference effects
2. The model fails to account for some critical data points; I will discuss this in connection with the first reading, Engelmann et al[1]
3. We have a fairly well-developed theory of how eye-movement control and parsing interact (Engelmann PhD dissertation). We plan to use this model to derive predictions for
   - 3.1 how eye movements are influenced by parsing processes
   - 3.2 the effect of underspecification and good enough parsing on eye movements
4. It's still not clear to me whether the parser is exempt from interference effects; most of the evidence for this has been based on low-powered null results. We need more detailed modeling and high powered studies (replications urgently needed!).

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Expectation-based processing

Key references

The main reference here is Levy 2008 [8].
Our work in this area tries to understand the relationship between expectation and dependency distance.

1. Vasishth and Drenhaus 2011 [19]
2. Husain et al 2014 [3]
3. Husain et al 2015 [4]
4. Jäger et al 2015 [5]
5. Safavi et al (submitted) [16]

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Expectation-based processing

Switch to Lena Jäger slides
All the details are in reference: [5]

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Conclusions so far

1. Suprisal effects might precede retrieval temporally (Vasishth and Drenhaus 2011 [19])
2. Strong expectations (for exact verb) can override locality effects (Husain et al 2014 [3])
3. But we also see strong evidence for locality in Hindi in a naturalistic eyetracking corpus (Husain et al 2015 [4])
4. And in Persian, we see amazingly strong locality effects, contra the Levy account (Safavi et al (submitted) [16])
5. However, in Chinese, when we remove all local ambiguities between SR/ORs, we see strong expectation effects and no effect of locality (Jäger et al 2015 [5])

In other words, we have a very diverse picture: whether expectation dominates or locality effects dominate depends on language and on construction.

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Computational models of good-enough processing and underspecification

Key references

A very important paper is Swets et al 2002 [17]. But also see the papers by Ferreira and Christianson's group on GE processing.

1. Malsburg and Vasishth 2013 [20]
2. Logačev and Vasishth 2015 [11]
3. Logačev and Vasishth (submitted) [12]
4. Nicenboim et al (submitted) [15]
5. Nicenboim et al (2015) [14]

Computational models of good-enough processing and underspecification

Malsburg et al 2013 investigated adjunct attachment ambiguities and found (among other things) that

1. readers sometimes underspecify to attachment to conserve memory
2. "high-capacity readers commit to an attachment decision more often than low-capacity participants, leading to more errors and a greater need to reanalyse in garden-path sentences"

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Computational models of good-enough processing and underspecification

Logačev et al (2015, submitted) investigated the Swets et al ambiguity attachment data, and showed that

1. subjects could be induced to read ambiguous structures more slowly than unambiguous ones, by encouraging them to build/consider both parses
2. Swets et al's underspecification idea for ambiguous sentences has at least two realizations computationally:
   - 2.1 partial specification
   - 2.2 no specification

   Logacev et al (submitted) show using computational modeling that the simpler no specification account might be the better realization.

But these are early days.

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Conclusions so far

1. Underspecification accounts such as Swets et al's seem very plausible, but the evidence both from data and modeling is a bit weak
2. We are seeing good evidence for task-dependent effects in parsing
3. The unrestricted race model account that Swets et attack can explain the Swets et al data, but needs a lot more cross-linguistic support
4. Working memory capacity might play a role in determining whether the parser backs off to a good-enough parsing approach. This needs much more study
5. Computational modeling provides support for a simpler underspecification account than that proposed by Swets et al

Metrical stress impacts parsing decisions

Key references

1. Kentner 2012 [7]
2. McCurdy, Kentner, Vasishth 2012 [13]

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Kentner 2012, Cognition

nicht mehr

Two readings of nicht mehr:

1. Temporal adverbial reading (preferred): nicht mehr
2. Comparative reading: nicht mehr

Two types of stress patterns on verbs:

1. Medial stress: ermitteln: determine
2. Initial stress: nachweisen: prove

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Kentner 2012, Cognition

nicht mehr

Temporal reading:

(3) Der Polizist sagte, dass man nicht mehr
The policeman said that one not more
ermitteln kann, **wer** der Täter war
determine can who the culprit was
'The policeman said that one couldn't determine **anymore** who the culprit was.'

Comparative reading:

(4) Der Polizist sagte, dass man nicht mehr
The policeman said that one not more
ermitteln kann, **als** die Tatzeit
determine can than the time of crime
'The policeman said that one couldn't determine anything more than the time of the crime.'

Kentner 2012, Cognition

stress clash induced by nicht mehr

Nicht mehr with medial stress verb:

(5) a. Der Polizist sagte, dass man nicht mehr
The policeman said that one not more
ermitteln kann, **wer** der Täter war
determine can who the culprit was

'The policeman said that one couldn't determine **anymore** who the culprit was.'

b. Der Polizist sagte, dass man nicht mehr
The policeman said that one not more
ermitteln kann, als die Tatzeit
determine can than the time of crime

'The policeman said that one couldn't determine anything more than the time of crime.'

Kentner 2012, Cognition

stress clash induced by nicht mehr

Nicht mehr with initial stress verb:

(6) a. Der Polizist sagte, dass man nicht mehr
The policeman said that one not more
nachweisen kann, **wer** der Täter war
prove can who the culprit was

'The policeman said that one couldn't determine any more who the culprit was.'

b. **Stress clash**:

Der Polizist sagte, dass man nicht mehr
The policeman said that one not more
nachweisen kann, **als** die Tatzeit
determine can than the time of crime

'The policeman said that one couldn't prove anything more than the time of crime.'

Prediction: disambiguation × stress interaction; stress clash should lead to temporal reading, which leads to a garden-path in (b).

Kentner 2012, Cognition

stress clash induced by nicht mehr

Raw reading measures (means) broken down by condition and region of interest.

Measure	Condition	Region of interest			
		0	1	2	3
SKIP	TEMP-INI	0.15	0.45	0.24	0.2
	TEMP-MED	0.09	0.41	0.23	0.19
	COMP-INI	0.10	0.47	0.24	0.17
	COMP-MED	0.08	0.49	0.33	0.21
RRT (std.err.) in ms	TEMP-INI	84 (10)	68 (11)	97 (12)	38 (7)
	TEMP-MED	88 (10)	71 (10)	87 (11)	65 (13)
	COMP-INI	101 (13)	81 (13)	132 (13)	113 (16)
	COMP-MED	86 (13)	57 (10)	100 (14)	79 (16)

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Conclusions so far

1. The metrical structure imposed by silent prosody can influence the syntactic parsing system (Kentner).
2. There is no evidence that discourse context can override the effect of silent prosody in the *nicht mehr* construction (McCurdy et al). Maybe there is a strong and early influence of silent prosody on syntactic parse decisions; this needs further study.

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Individual differences impact parsing strategies

Key references

This work is largely led by Bruno Nicenboim, but Titus von der Malsburg was the one who got us started on this issue:

1. Malsburg and Vasishth 2013 [20]
2. Nicenboim et al (submitted) [15]
3. Nicenboim et al (2015) [14]

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Conclusions so far

1. Low capacities might be failing to complete retrieval more often, leading to faster reading times in non-local dependencies.
2. High capacities show longer reading times with long-distance dependencies compared to low capacities, because they may be completing dependencies more often.
3. These results are tentative and need replication.

We will focus mainly on expectation-based processing

1. Head-final languages like Japanese are going to be a very important source of information for expectation-based accounts.
2. The interaction of expectations and silent prosody, the role of individual differences, and the effects of task demands is a wide open area of investigation in research on expectation.
3. My hope is to use this course to open up new research directions and to generate new discoveries from work on Japanese.

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