INTERFERENCE EFFECTS FROM GRAMMATICALLY UNAVAILABLE CONSTITUENTS DURING SENTENCE PROCESSING

[Julie A. Van Dyke, Haskins Laboratories, 2007]

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Projektseminar : Konnektionistische Sprachverarbeitung

Overview

- Motivation
- Introduction
- The experiments
- Discussion
- Conclusions

Motivation

The banker that praised the barber climbed the mountain. (SRC)

The banker that the barber praised climbed the mountain. (ORC)

Motivation

Gordon & colleagues (2001, 2004):

The banker that praised the barber climbed the mountain. (SRC)

The banker that the barber praised climbed the mountain. (ORC)

The banker that praised Joe climber the mountain. (SRC)

The banker that Joe praised climbed the mountain. (ORC)

The banker that praised you climber the mountain. (SRC)

The banker that you praised climbed the mountain. (ORC)

Introduction

- The hypothesis
  - *retrieval* as the source of interference
  - supported by the memory literarure
  - gramatical relations are created via cue-based retrieval of necessary constituents

Introduction

- formalized by following equation:

$$P(I_i \mid Q_1, \ldots, Q_m) = \frac{\prod_{j=1}^{m} S(Q_j, I_i)^{w_j}}{\sum_{k=1}^{N} \prod_{j=1}^{m} S(Q_j, I_k)^{w_j}}$$

- the probability of retrieving a particular item:
  - is increased by the probe-to-item strength
  - is decreases by the sum of the probe-to-items strengths for all items stored in the memory

Introduction

- Bespiel: Van Dyke and McElree (2006)
  - memorized words: table, sink, truck

It was the boat that the guy who lived by the sea sailed in two sunny days.

It was the boat that the guy who lived by the sea fixed in two sunny days.

Introduction

- two kind of interferences:
  - syntactic interference

    The worker was surprised that the resident who was living near the dangerous warehouse was complaning about the investigation. (LoSyn)

    The worker was surprised that the resident who was said that the warehouse was dangerous was complaning about the investigation. (HiSyn)

Introduction

- two kind of interferences:
  - syntactic interference

    The worker was surprised that the resident who was living near the dangerous warehouse was complaning about the investigation. (LoSyn)

    The worker was surprised that the resident who was said that the warehouse was dangerous was complaning about the investigation. (HiSyn)

Introduction

- two kind of interferences:
  - syntactic interference

    The worker was surprised that the resident who was living near the dangerous warehouse was complaning about the investigation. (LoSyn)

    The worker was surprised that the resident who was said that the warehouse was dangerous was complaning about the investigation. (HiSyn)

Introduction

- semantic interference

The worker was surprised that the resident who said that the warehouse was dangerous was complaning about the investigation. (LoSem)

The worker was surprised that the resident who said that the neighbor was dangerous was complaning about the investigation. (HiSem)

Introduction

- semantic interference

The worker was surprised that the resident who said that the warehouse was dangerous was complaning about the investigation. (LoSem)

The worker was surprised that the resident who said that the neighbor was dangerous was complaning about the investigation. (HiSem)

Introduction

- semantic interference

The worker was surprised that the resident who said that the warehouse was dangerous was complaning about the investigation. (LoSem)

The worker was surprised that the resident who said that the neighbor was dangerous was complaning about the investigation. (HiSem)

The Experiments

- syntactic interferences were observed earlier and the experiments are intended to replicate these findings
- semantic interferences shoud make no difference in LoSyn situations, but shoud increase reading times in HiSyn situations

The Experiments

- 3 Experiments
- semantic and syntactic interference were crossed in a 2x2 Design

Sentence region	Example stimulus
Introduction	The worker was surprised that the resident
Intervening region	
LoSyn/LoSem	who was living near the dangerous warehouse
LoSyn/HiSem	who was living near the dangerous neighbor
HiSyn/LoSem	who said that the warehouse was dangerous
HiSyn/HiSem	who said that the neighbor was dangerous
Critical region	was complaining
Spillover region	about the
Last word	investigation

Experiment 1

- „Got It ?“ Task
- 35 students, all native speakers of English
- Piloting
  - 160 item sets x 3 = 480 sentences
  - result:150 corected item sets

Sentences for Semantic Interference Pilot

Condition	Sentence
Target	The worker was surprised that the resident was complaining about the investigation.
Implausible distractor	The worker was surprised that the warehouse was complaining about the investigation.
Plausible distractor	The worker was surprised that the neighbor was complaining about the investigation.

Experiment 1

- 48 item sets were randomly chose (from the 150)
- 4 lists were constructed (each list contained one of the 4 conditions for each item)
- 144 filler items were used (e.g. *The informed citizen elected the candidate who spoke in Arkansas and Pennsylvania*) half of them were ungramatical (e.g. *The friendly manager encouraged the employees earn sizeable bonuses)* to mantain vigilance
- each experimental sentence was separated by 3 filler items

Experiment 1

- Procedure: noncumulative, self-paced, moving-window format, one word at a time
- Question: Did you get it? yes/no
- Measures:
  - accuracy for the „Got it?“ answer
  - reading times
- Analysis:
  - reading times only for yes answers
  - reading times trimmed within 2.5 x standatd deviation (affected 2.5% of the data)

Experiment 1

- Results

Interference type	Accuracy	Reading time (ms)		
		Critical region	Spillover region	Last word
LoSyn/LoSem	.91 (.02)	858 (24)	566 (16)	723 (43)
LoSyn/HiSem	.83 (.03)	912 (34)	571 (16)	697 (41)
HiSyn/LoSem	.81 (.03)	871 (30)	551 (18)	667 (37)
HiSyn/HiSem	.78 (.03)	875 (30)	568 (15)	822 (81)

Experiment 1

Interference	Git it?	Critical region	Spillover region	Last word
syntactic	YES	-	-	-
semantic	YES	YES	-	YES
interaction	-	-	-	YES

Sentence region	Example stimulus
Introduction	The worker was surprised that the resident
Intervening region	
LoSyn/LoSem	who was living near the dangerous warehouse
LoSyn/HiSem	who was living near the dangerous neighbor
HiSyn/LoSem	who said that the warehouse was dangerous
HiSyn/HiSem	who said that the neighbor was dangerous
Critical region	was complaining
Spillover region	about the
Last word	investigation

Experiment 2

- 1st aim: extends experiment 1 to test how well participants understood the sentences
- 2nd aim: seek online evidence for syntactic interference
- 36 participants, all native speakers of English
- 36 items x 4 conditions
- 3 filler items after each experiment sentence

Experiment 2

- sentences were presented one at a time on single line
- after every experimental sentence and after half of the filler items a comprehention question followed (cloze format with two-alternative force-choice)

  e.g. _____ was complaining abut the investigation.

- eye-tracking method to retrieve additional data

Experiment 2

- Results
  - accuracy for the comprehention question
  - 4 eye-tracking measures:
    - first pass
    - regression path
    - total reading time
    - proportions of regressions back

Interference type	Accuracy
LoSyn/LoSem	.90 (.02)
LoSyn/HiSem	.82 (.03)
HiSyn/LoSem	.86 (.03)
HiSyn/HiSem	.73 (.04)

Experiment 2

Measure and interference type	Critical region	Spillover region	Final word
First pass			
LoSyn/LoSem	376 (16)	320 (12)	286 (19)
LoSyn/HiSem	382 (19)	364 (21)	274 (19)
HiSyn/LoSem	413 (21)	325 (16)	259 (20)
HiSyn/HiSem	418 (19)	296 (15)	271 (22)
Regression path			
LoSyn/LoSem	454 (26)	970 (98)	1,695 (213)
LoSyn/HiSem	495 (30)	1,205 (100)	1,806 (183)
HiSyn/LoSem	594 (41)	1,365 (140)	1,925 (192)
HiSyn/HiSem	663 (44)	1,295 (140)	2,131 (244)
Total time			
LoSyn/LoSem	630 (35)	502 (30)	362 (36)
LoSyn/HiSem	653 (35)	540 (29)	373 (35)
HiSyn/LoSem	738 (42)	491 (25)	349 (34)
HiSyn/HiSem	761 (38)	493 (24)	360 (40)
Proportion of regressions			
LoSyn/LoSem	.12 (.02)	.54 (.05)	.81 (.05)
LoSyn/HiSem	.14 (.02)	.50 (.05)	.87 (.04)
HiSyn/LoSem	.18 (.02)	.60 (.05)	.92 (.03)
HiSyn/HiSem	.22 (.03)	.53 (.04)	.86 (.05)

Experiment 2

		Syntactic	Semantic	Interaction
Critical region	First pass	YES	-	-
	Regression path	YES	-	-
	Total time	YES	-	-
	Proportion of regressions	YES	-	-
Spillover region	First pass	YES	YES	-
	Regression path	YES	-	-
	Total time	-	-	-
	Proportion of regressions	-	-	-
Final word	First pass	-	-	-
	Regression path	YES	YES	YES
	Total time	-	-	-
	Proportion of regressions	YES	-	-

Experiment 3

- experiment 2 showed a slowdown in the critical region for both syntactic and semantic interferences
- this could be caused by the two adiacent verbs
- experiment 3 tries to test this hypothesis by introducing a adverbial phrase between the two verbs
- if the interference is an artifact of reading two adjacent verbs, it should not be present in the critical region

Experiment 3

- 40 students, all native speakers of English
- the items from experiment

  2 were adapted:

  - pre-critical region
  - longer spillover
  - longer final region

Sentence region	Example item
Introduction	The pilot remembered that the lady
Intervening region	
LoSyn/LoSem	who was sitting in the smelly seat
LoSyn/HiSem	who was sitting near the smelly man
HiSyn/LoSem	who said that the seat was smelly
HiSyn/HiSem	who said that the man was smelly
Pre–critical region	yesterday afternoon
Critical region	moaned
Spillover region	about a refund
Final region	for the ticket

- same procedures as in experiment 2

Experiment 3

- Results
  - accuracy for the comprehention question
  - 4 eye-tracking measures:
    - first pass
    - regression path
    - total reading time
    - proportions of regressions back

Interference type	Accuracy
LoSyn/LoSem	.85 (.03)
LoSyn/HiSem	.77 (.03)
HiSyn/LoSem	.77 (.03)
HiSyn/HiSem	.66 (.03)

Experiment 3

Measure and interference type	Pre–critical region	Critical region	Spillover region	Final region
First pass				
LoSyn/LoSem	449 (15)	274 (9)	448 (24)	464 (26)
LoSyn/HiSem	455 (16)	282 (8)	437 (19)	480 (23)
HiSyn/LoSem	462 (18)	294 (11)	442 (21)	483 (29)
HiSyn/HiSem	447 (17)	280 (11)	424 (23)	463 (24)
Regression path				
LoSyn/LoSem	472 (17)	314 (14)	607 (33)	1,875 (200)
LoSyn/HiSem	493 (22)	315 (13)	553 (28)	2,147 (223)
HiSyn/LoSem	490 (21)	354 (18)	625 (30)	2,068 (232)
HiSyn/HiSem	551 (36)	344 (23)	615 (41)	2,474 (317)
Total time				
LoSyn/LoSem	586 (29)	414 (25)	711 (43)	649 (46)
LoSyn/HiSem	640 (41)	421 (25)	707 (47)	705 (43)
HiSyn/LoSem	622 (31)	451 (28)	731 (51)	675 (44)
HiSyn/HiSem	710 (47)	467 (38)	766 (59)	663 (46)
Proportion of regressions				
LoSyn/LoSem	.03 (.01)	.08 (.02)	.17 (.03)	.50 (.04)
LoSyn/HiSem	.04 (.01)	.08 (.02)	.11 (.02)	.54 (.04)
HiSyn/LoSem	.03 (.01)	.10 (.02)	.17 (.02)	.50 (.05)
HiSyn/HiSem	.08 (.02)	.13 (.03)	.16 (.02)	.52 (.05)

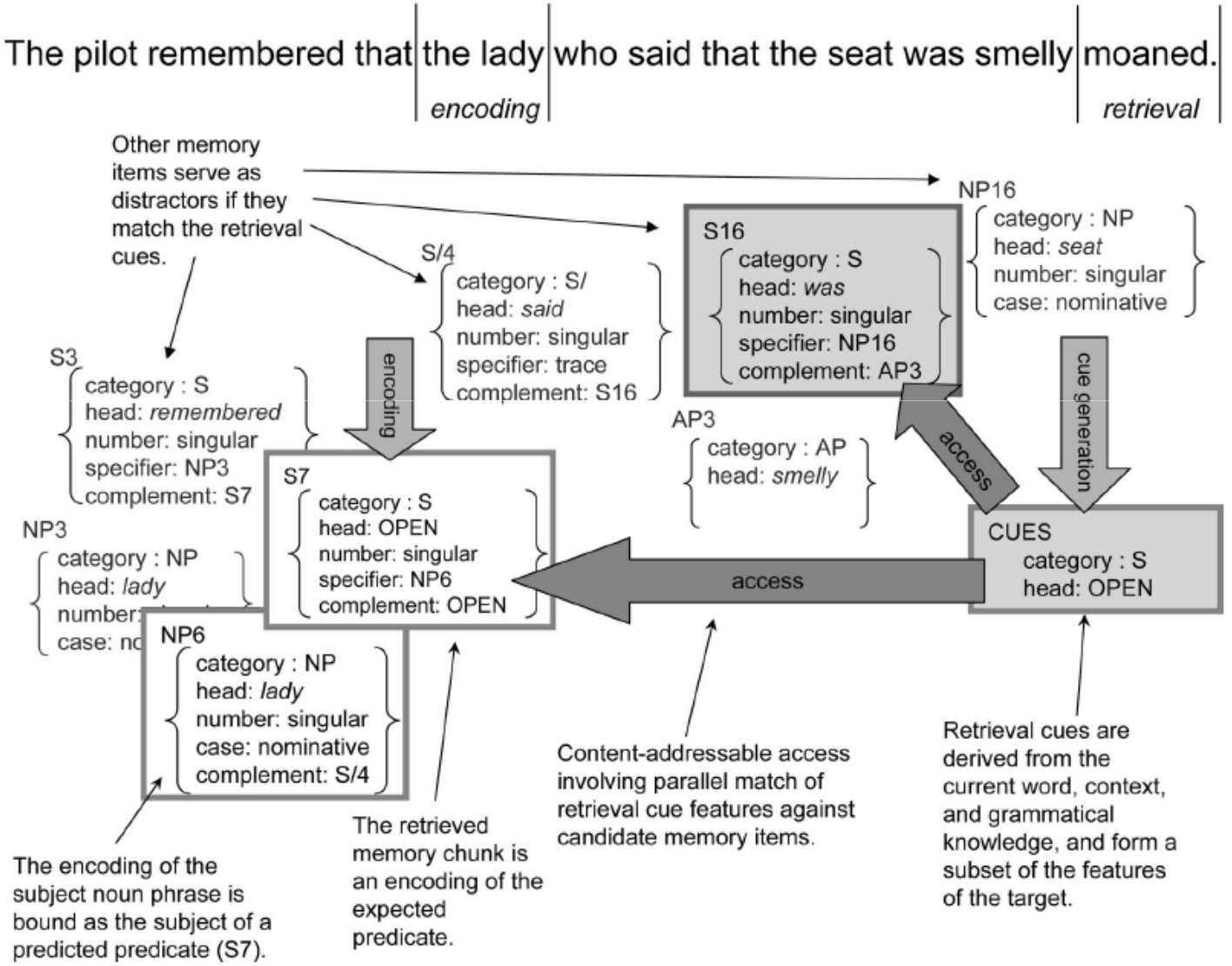
Experiment 3

		Syntactic	Semantic	Interaction
Pre-critical region	First pass	-	-	-
	Regression path	YES	YES	YES
	Total time	YES	YES	YES
	Proportion of regressions	-	YES	-
Critical region	First pass	YES	-	-
	Regression path	YES	-	-
	Total time	YES	-	-
	Proportion of regressions	-	-	-
Spillover region	First pass	-	-	-
	Regression path	-	-	-
	Total time	-	-	-
	Proportion of regressions	-	-	-
Final word	First pass	-	-	-
	Regression path	-	YES	YES
	Total time	-	-	-
	Proportion of regressions	-	-	-

Discussion

- explicit link between memory processes and language comprehention
- syntactic interference observed in the critical region
- semantic interference observed in later regions (the study do not provide an explanation)
- syntactic/semantic interferences present a challange for grammar-driven parsers
- cue-based parsers can offer solutions

Discussion


The pilot remembered that | the lady | who said that the seat was smelly | moaned.
encoding
retrieval
Other memory items serve as distractors if they match the retrieval cues.
NP16
category : NP
head: seat
number: singular
case: nominative
S16
category : S
head: was
number: singular
specifier: NP16
complement: AP3
S/4
category : S/
head: said
number: singular
specifier: trace
complement: S16
S3
category : S
head: remembered
number: singular
specifier: NP3
complement: S7
encoding
AP3
category : AP
head: smelly
access
cue generation
S7
category : S
head: OPEN
number: singular
specifier: NP6
complement: OPEN
NP3
category : NP
head: lady
CUES
category : S
head: OPEN
access
NP6
category : NP
head: lady
number: singular
case: nominative
complement: S/4
The encoding of the subject noun phrase is bound as the subject of a predicted predicate (S7).
The retrieved memory chunk is an encoding of the expected predicate.
Content-addressable access involving parallel match of retrieval cue features against candidate memory items.
Retrieval cues are derived from the current word, context, and grammatical knowledge, and form a subset of the features of the target.

Conclusions

- readers an listners „do not violate their knowledge of grammar in arriving at an interpretation of a sentence“ (Fraizet & Clifton, 1996)
- Van Dyke argued that interference effect leave readers no choice but to do so

Thank you !