

BACKGROUND AND MOTIVATION

Research Questions

- **General:** What is the *functional architecture* of the working memory system that underlies language processing?
- **Specific:** Do syntactic storage and syntactic integration costs rely on the same pool of working memory resources?

Evidence for syntactic storage

Chen, Gibson and Wolf (2005)

Zero predicted verbs: The detective **suspected** and that thief **knew** that the guard **protected** the jewels and so he reported immediately to the museum curator.

One predicted verb (late): The detective **suspected** that the **knowledge** that the guard **protected** the jewels **came** from an insider.

One predicted verb (early): The **suspicion** that the thief **knew** that the guard **protected** the jewels **worried** the museum curator.

Two predicted verbs: The **suspicion** that the **knowledge** that the guard **protected** the jewels **came** from an insider **worried** the museum curator.

Result: The difficulty of processing the critical region increases with an increasing number of pending expectations. See also Chomsky & Miller (1963), Wanner & Maratsos (1978), Lewis (1996), Gibson (1998, 2000).

Evidence for syntactic integration

Grodner & Gibson (2005)

The **nurse supervised** the administrator while...

The **nurse** from the clinic **supervised** the administrator while...

The **nurse** who was from the clinic **supervised** the administrator while...

Result: The difficulty of processing an incoming word (*supervised* in the example above) which needs to be connected to a word earlier in the sentence increases with an increasing distance (measured in terms of number of words / discourse referents / similar elements) between the to-be-retrieved word and the incoming word. See also Gibson (1998, 2000), Gordon et al. (2001), Warren & Gibson (2002), Vasishth & Lewis (in press), (c.f. Konieczny, 2000).

The relationship between syntactic storage and syntactic integration

Fiebach, Schlesewsky and Friederici (2002) (see also Felsler, Clahsen and Munte, 2003)

Syntactic storage effects: a **sustained left-anterior negativity** lasting from the time when a syntactic expectation is postulated until the time when it is resolved (the amplitude is modulated by the distance between the site where an expectation is postulated and the site where it is resolved; strength and distribution are modulated by individual working memory capacity) (see also Kluender & Kutas, 1993; King & Kutas, 1995)

Syntactic integration effects: a **late positivity** (peaking between 400ms and 700ms) at the integration site (the amplitude is modulated by the distance back to the attachment site) (see also Kaan et al., 2000; Phillips et al., 2003)

EXPERIMENT

Design & Materials

- Design - 2 x 2
Integration Cost: low / high
Storage Cost: low / high

| | | | | | | | | |
|------------------|--|------------------------------|-----------------------|-----------------------|------------------------------|----------|-------------------------------------|-----------------------|
| LowInt-LowStor | After the appraiser notified the dealer, | from a small town in Greece, | the thief knew | that the painting, | which the millionaire | intended | could sell for millions of dollars, | |
| LowInt-HighStor | After the appraiser notified the dealer, | from a small town in Greece, | the thief's knowledge | that the painting, | which the millionaire | intended | could sell for millions of dollars, | proved to be useless. |
| HighInt-LowStor | After the appraiser notified the dealer, | the thief knew | that the painting, | which the millionaire | from a small town in Greece, | intended | could sell for millions of dollars, | proved to be useless. |
| HighInt-HighStor | After the appraiser notified the dealer, | the thief's knowledge | that the painting, | which the millionaire | from a small town in Greece, | intended | could sell for millions of dollars, | proved to be useless. |

Predictions

If syntactic storage and syntactic integration costs rely on the **same pool** of working memory resources, then we should observe a super-additive interaction in the region where both types of costs are high.

If syntactic storage and syntactic integration processes rely on **different pools** of working memory resources, then the effects of the two types of costs should be additive in the region where both types of costs are high.

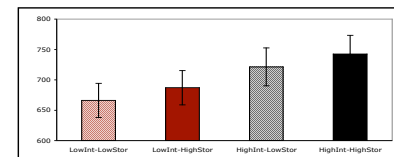
RESULTS AND CONCLUSIONS

Reading Times

Data collection:
• 45 subjects
• 40 items

Procedure:
• Self-paced region-by-region reading
• Center-screen presentation

Raw reading times at the critical region

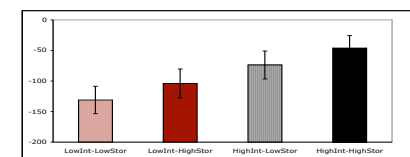


Main effect of Integration cost:
F1(1,44)=18.7; MSE=137713; p<.001
F2(1,39)=13.3; MSE=113379; p<.001

Main effect of Storage cost:
F1(1,44)=6.83; MSE=19842; p<.02
F2(1,39)=5.89; MSE=22981; p<.02

Interaction:
Fs < .1, ps > .9

Residual reading times at the critical region

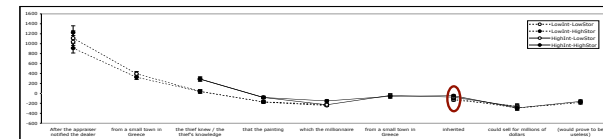


Main effect of Integration cost:
F1(1,44)=17.8; MSE=149284; p<.001
F2(1,39)=19.9; MSE=133422; p<.001

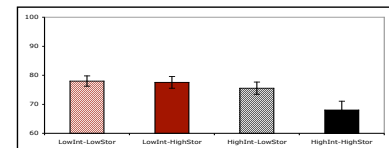
Main effect of Storage cost:
F1(1,44)=9.21; MSE=33535; p<.005
F2(1,39)=7.98; MSE=32354; p<.01

Interaction:
Fs < .1, ps > .9

Residual reading times across the whole sentence



Comprehension Accuracy



Main effect of Integration cost:
F1(1,44)=12.4; MSE=1620; p<.002
F2(1,39)=4.402; MSE=1424; p<.05

Main effect of Storage cost:
F1(1,44)=2.98; MSE=720; p=.091
F2(1,39)=5.47; MSE=694; p<.05

Interaction:
F1(1,44)=2.46; MSE=569; p=.124
F2(1,39)=5.59; MSE=574; p<.05

Summary & Conclusions

In **on-line** language processing, at the critical region, we observe two main effects - (1) a syntactic storage cost effect, and (2) a syntactic integration cost effect - but no interaction.

In **off-line** language processing (comprehension performance), we observe an interaction (marginal in the participants analysis) such that the condition where both types of costs are high is more difficult than the other three conditions.

1. In **on-line** language processing, the two types of working memory costs - syntactic storage costs and syntactic integration costs - appear to rely on **independent pools of working memory resources**.
2. One possible account of the interaction in **off-line** (post-interpretive; Caplan & Waters, 1999) language processing (as measured by comprehension accuracies) is that the cost of **accessing** the sentence representation (the propositional content) rises non-linearly, possibly reaching a threshold, as a function of the amount of WM resources spent in constructing the representation in on-line processing.