# CUNY 2004

## The Seventeenth Annual CUNY Conference on

## Human Sentence Processing

March 25 – 27, 2004

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# Special Session

This year's CUNY conference features a special session on the *Relation between Sentence Comprehension and Sentence Production*, which is generously funded by the National Science Foundation.

There are long traditions of research in both sentence comprehension and sentence production, and it has always been recognized that there must be at least *some* connection between the two areas, even if the connection is just that speaking and understanding are based upon the same lexicon and the same grammar. However, for a long time, the two fields investigated largely different phenomena, using largely different methodologies. This, together with some additional considerations, led to the conclusion that sentence comprehension and sentence production are largely independent cognitive systems.

Both sentence comprehension and sentence production are areas that have long-standing research traditions, going back at least to the 1960s, and have assembled a large body of results. Although the received opinion for many years was that comprehension and production are very different processes carried out by different cognitive systems, there are currently many reasons to reevaluate the received opinion. The past 5 years in particular have seen a substantial growth in results that allow for closer comparison of the two areas. The main themes of the special session will be: (i) What, if anything, do sentence comprehension and production have in common, beyond the fact that they operate over similar representations (e.g. same lexicon)? (ii) Do sentence comprehension and production operate on the same time-scale, and with the same degree of incrementality? (iii) How can the various parallels between comprehension and production that are emerging from lab-based studies be reconciled with widespread findings of comprehension/production asymmetries in both language disorders and language development? (iv) In methodological terms, how closely is it possible to match tasks across both comprehension and production?

The special session will include 5 invited talks, and 5 submitted talks, plus a number of poster presentations.

# Jerrold J. Katz Young Scholar Award

In memory of our friend and distinguished colleague, the Jerrold J. Katz Young Scholar Award is awarded for the paper or poster presented at the CUNY Conference on Human Sentence Processing best exemplifying the qualities of intellectual rigor, creativity, and independence of thought which characterized Dr. Katz's life and work. Any author listed as the first author on a presentation, who is pre-doctoral or up to three years post-PhD, and who is not yet tenured, is eligible for consideration. The amount of the award is $500.

The recipient of the Jerrold J. Katz Young Scholar Award in 2002 was John Hale (Johns Hopkins University), for his paper entitled, "The information conveyed by words in sentences," presented at the 15th Annual CUNY Conference on Human Sentence Processing, New York, NY.

# Information Session about NSF and NIH Funding

During the Lunch and Poster Session III on Saturday March 27th, Dr. Joan Maling and Dr. Weijia Ni will be available to discuss funding opportunities at NSF and NIH with anybody who is interested. Joan Maling is currently Director of the Linguistics Program at NSF. Weijia Ni is currently Scientific Review Administrator for Language and Communication at NIH.

# Contents

# Thursday March 25<sup>th</sup>

# Poster Session I

# Friday March 26<sup>th</sup>

# Poster Session II

# Saturday March 27<sup>th</sup>

*‡ Special Session*

# Poster Session III

# CUNY CONFERENCE

# Thursday, March 25

# Paper Presentations

# Continuous update of the message during language production in unrestricted conversation: Evidence from eye movements.

**Sarah Brown-Schmidt[1], Michael K. Tanenhaus[1]**

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Understanding how production constrains comprehension, and vice versa, will likely require investigations of interactive conversation, where participants are both speakers and addressees. As a first step, we designed an interactive task in which two naïve participants were seated in front of displays containing an identical set of 14 pictures, separated into two domains that looked like 'islands'. At the beginning of each trial, a picture on one participant's screen was highlighted, cueing that participant to tell her partner to click on that object. Some target objects appeared with a cohort competitor on the same screen (e.g., peach/peas) and some targets appeared with a scalar contrast item, e.g., a large and a small peach. We report data from twenty pairs; all mentioned effects are reliable at $p<.05$.

Speakers frequently used pre-nominal scalar adjectives, e.g., "the large peach" when target objects appeared with a contrast member on the same island; when no contrast was present, scalars were rarely used (72% vs. 8%). When the target and the contrast appeared on the same island, yet the speaker failed to use a pre-nominal scalar, disfluencies increased 20% over cases with a pre-nominal scalar. We found the opposite pattern when a scalar contrast was not present; here, extraneous modification was associated with disfluency. Listeners' interpretation of their partner's referring expressions reflected these modification patterns. When speakers mentioned which island the target was on, e.g. "On the top, the large peach", addressees interpreted these expressions with respect to the referential domain indicated by the locative construction and the scalar contrast member, e.g. rarely looking at a size-matched cohort competitor, 'the big peas' when the top island included the big peas, the big peach and the small peach (but the small peas was on the bottom island).

Most strikingly, the speaker's eye movements to the contrast member predicted the form of the referring expression when a contrast was present. When size was never mentioned, speakers rarely looked at the contrast member (e.g. the small peach), a markedly different pattern than for NPs with modification, where speakers typically did look at it. For trials with looks to the contrast member, the timing of the speaker's first look to the contrast member predicted the form of the NP. When using pre-nominal modification, speakers first looked to the contrast object approximately 1900ms before the NP onset. For post-nominal repairs, e.g., "The peach…oh…BIG one" speakers first looked at the contrast 1600ms later, just before uttering the NP. Thus, new visual information, encountered during production led to a repair-- a process that requires continuous communication between message formulation and utterance generation, perhaps via monitoring. More generally, our results illustrate how the interplay between eye movements and production can provide insights about the planning process during production.

# Paying Attention to Attention: Perceptual Priming Effects on Word Order

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In investigating language production processes, factors driving sentential word order receive much attention. A role for perceptual prominence seems clear in ordering simple conjoined noun phrases (e.g. *A bear and a dog*) [4], and conceptual factors, like animacy, influence argument order (e.g. assignment of grammatical subject) [2], but the role of perceptual prominence in constituent order is unclear. Some find no relationship between initially-fixated stimuli and subject-role assignment [1], while others find evidence supporting a role for attention (perceptual prominence) in constituent order [3,5]. These latter manipulations, however, have all been overt attention-getting devices, and often have rigid task demands allowing for minimal generalization.

The current study seeks to address these issues and investigate the role visual attention plays in descriptions of scenes. Speakers' attention was captured via a brief (60-75 ms) black target stimulus against a white background immediately prior to scene presentation, covertly drawing initial fixation to the scene participant in the corresponding location. The covert cue was effective at directing initial fixation (eye movements were tracked). No participant reported noticing the manipulation in the post-experimental interview.

Two scenes types were used, designed to elicit either Conjoined Noun Phrases (CNPs), (e.g. A dog and a cat sleep), or Perspective Verbs (e.g. give/receive). Norming demonstrated a Preferred (e.g. giver) and Dispreferred (e.g. receiver) sentential subject for each Perspective scene, and strong effects of Left-Right position for CNPs. Subjects were instructed *only* to describe the scenes. Data were collected in a 2X2 factorial design, crossing Left-Right position with location of attention-capturing prime.

Order of mention of scene characters was coded (see table). Collapsing across sentence types, significant effects of Left-Right Position and Priming were observed; leftmost and attention-captured entities were more likely to be first-mentioned ($p$'s<0.05). Further analyses showed that Left-Right position was significant only for CNPs ($p$'s<0.05), not for subject selection in Perspective verbs. Both sentence types, however, showed significant, stable effects of Priming, with primed characters more likely to appear first in CNPs ($p$'s<0.05) and to be the subject of a Perspective verb ($p$'s<0.05).

Results suggest that perceptual prominence (covert attention-capture here) can influence subject choice, at least when sentence structure is largely preserved ("The man gives /The woman receives the gift"). Different syntactic structures will be investigated, including Symmetrical predicates (e.g. hug, meet) which allow for variation between independent and shared subject roles, and Transitives (e.g. shoot, hit), which require passivization to adjust first-mentioned participant. Overall, our data offer support for a production model with some degree of incrementality in sentence production and word order. It remains to be seen whether major structural revisions can be driven by covert attention capture.

**Percent Character A* First-Mentioned**

*Coinjoined NPs*

|  | Character A Primed | Character B Primed | Average |
|---|---|---|---|
| **Character A on Left** | 82% | 64% | **73%** |
| **Character B on Left** | 52% | 41% | **46%** |
| Average | **67%** | **53%** |  |

*Perspective Verbs*

|  | Character A Primed | Character B Primed | Average |
|---|---|---|---|
| **Character A on Left** | 84% | 74% | **78%** |
| **Character B on Left** | 77% | 61% | **70%** |
| Average | **81%** | **66%** |  |

* Character A = preferred subject for Perspectives, arbitrarily assigned for CNPs.

# Incrementality, prediction, and attention in a scaleable network model of linguistic competence and performance.

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An ever-increasing body of experimental evidence from psycholinguistic studies indicates that people not only interpret sentences incrementally, dynamically revising their interpretations as they encounter new information, but also that preferred interpretations generate expectations about what is to follow. It has also been established that the human processor has the ability to integrate diverse sources of information, including prosody, syntax and semantics, frequency, discourse, and even from visual scenes containing objects and events.

When taken collectively, these hallmarks of linguistic performance - incremental, dynamical, probabilistic, integrative, and predictive - have led many researchers to explore subsymbolic models of sentence comprehension. Because subsymbolic systems automatically develop distributed representations according to soft constraints, they have been successfully applied to cognitive phenomena for which more data exists than theory. Yet such systems have proven to be very difficult to scale up to realistic levels of linguistic coverage and complexity. Furthermore, the very nature of distributed representations makes it difficult to ascertain whether such models are achieving adequate linguistic competence, let alone the precise form that competence takes.

In this paper we present a network architecture for incremental sentence comprehension that is both more transparent and scaleable, yet also broadly exhibits incremental ambiguity resolution behaviour that is still cognitively plausible. The model is based on a simple recurrent network, but generates explicit semantic representations of input sentences. The network was trained on hand-annotated Minimal Recursion Semantics (MRS) dependency graphs of some 5000 sentences from the recently-released LinGO Redwoods HPSG Treebank (Oepen, Flickinger, Toutanova, & Manning, 2002), and was able to accurately learn to incrementally develop and revise such deep semantic representations. Examination of the network revealed that it also could maintain several alternative interpretations simultaneously, pruning away those which were untenable. When tested on the original VerbMobil sentences from which the Redwoods Treebank corpus was transcribed, the model demonstrated robustness to many of the speech errors, repairs, and dysfluencies of those original sentences. Finally, when trained and tested on a variant of the McClelland and Kawamoto data on the prepositional phrase attachment ambiguity, the model was able to account for the data as well as previous subsymbolic models which had been crafted to model that data only.

We further report recent findings on extending the architecture to modelling language comprehension in context. For example, the revised model permits semantic representations of visual scenes to be input concurrently with the incremental processing of words from a related utterance. Our simulations indicate that the model is able to exploit scene information in a manner suggested by recent visual world studies (Kamide, Scheepers, & Altmann, 2003; Knoeferle, Crocker, Scheepers, & Pickering, 2003) to anticipate and resolve an ambiguous sentence-initial noun phrase in favor of the role played by the corresponding character in the scene. A further extension consolidates several experimental results into a single network that directly maps highly-active semantic representations (typically recently encountered or anticipated material) to visually depicted entities and events. Preliminary results suggest this mapping may permit more precise modeling of attention in visual scenes in response to linguistic stimuli, as reflected by visual world experiments. Such a model should help to tease apart the influence of short-term contextual effects of the immediate visual environment from the long-term empirical role of language experience reflected by the models training.

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# Syntactic and Semantic Predictors of Tense in Hindi: An ERP Investigation

**Andrew Nevins[1], Colin Phillips[2], & David Poeppel[2]**

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Previous ERP studies have shown that different types of linguistic anomaly give rise to differing electrophysiological response profiles, reflecting the syntactic, semantic, or phonological source of the anomaly (cf. Hagoort & Brown, 1999; Friederici, 2001). In this study we take advantage of the split-ergative case-marking system of Hindi to set up two types of tense-marking violations. The violations themselves are identical, but they arise from predictions that are generated either by a syntactic cue or by a semantic cue (cf. Allen, Badecker, & Osterhout, 2003). We show that the same violation elicits clearly contrasting responses, depending on the source of the prediction. This indicates that the parser tracks not only the content but also the causes of its linguistic predictions.

Hindi is one of many languages that follow a tense/aspect-based split-ergative case system. Present and future tense clauses follow a nominative-accusative case system, but past perfective clauses follow an ergative-absolutive case system. Hindi clauses are also canonically verb-final. Therefore, case marking can provide a cue to the tense of an upcoming verb. For example, ergative case is only allowed on the agent in past perfective transitive clauses (ergative case is restricted to transitive subjects). Hence, an ergative-marked subject provides a reliable syntactic cue that the upcoming verb is past tense. Alternatively, it is possible to predict an upcoming past tense verb using only semantic information, by presenting an adverbial such as 'last week' in an intransitive clause. Subjects of intransitive clauses are marked with nominative case, which provides no cue to the tense of the verb. Using these two types of predictors of past tense, we compared ERP responses to sentences with congruous (past) and incongruous (future) tense-marking, as illustrated in (1-4).

(1)  Haalanki **pichle shaam** vo   rahgiir patthar ke-upar **giraa**,       lekin use     choT   nahiin aayii
    Although **last   night** that traveler stone   upon   **fell-past**, but   to-him injuries didn't happen
  "Although last night that traveler *fell* upon a stone, he wasn't injured"
 (**Adverb, Congruous Tense**)

(2) *Haalanki **pichle shaam** vo   rahgiir patthar ke-upar **giregaa**, lekin use     choT   nahiin aayii
    Although **last   night** that traveler stone   upon   **fell-fut**,  but   to-him injuries didn't happen
  "Although last night that traveler *will fall* upon a stone, he wasn't injured"
 (**Adverb, Incongruous Tense**)

(3)  Haalanki **us   bunkar-ne** ek baRaa sveTar jaldi   **bunaa**,       lekin graahak-ne   sabhii-ki kimaat ek-hi dii
    Although **that weaver-erg** one big     sweater quickly **wove-past**, but   customer-erg all-of      prices same gave-past
  "Although that weaver *wove* one big sweater quickly, the customer paid the same for all of them"
 (**Ergative Subject, Congruous Tense**)

(4) *Haalanki **us   bunkar-ne** ek baRaa sveTar jaldi   **bunegaa**, lekin graahak-ne   sabhii-ki kimaat ek-hi dii
    Although **that weaver-erg** one big     sweater quickly **wove-fut**, but   customer-erg all-of      prices same gave-past
  "Although that weaver *will weave* one big sweater quickly, the customer paid the same for all of them"
 (**Ergative Subject, Incongruous Tense**)

All critical verbs appeared at the end of a preposed adverbial clause, in order to ensure that ERP responses were not contaminated by end-of-sentence wrap-up effects. The distance between the verb and the tense-cue was held constant across conditions. Native speakers of Hindi (n=10) read 30 examples of each of the 4 conditions (drawn from 120 sets of items, Latin Square design), interspersed with 330 fillers. Sentences were presented visually in Devanagari script in an RSVP paradigm (650ms SOA) while continuous EEG was recorded at 30 scalp electrodes. Subjects responded to an acceptability judgment after each sentence. Results showed a clear contrast between the two types of tense violation. Syntactically-cued tense violations elicited a P600 response, with a standard occipital/parietal scalp topography, $F(1,9)=5.52$, $p<.05$. In contrast, semantically-cued tense violations elicited a centrally distributed N400 response.

Given that ergative case and the adverbial are equally good predictors of past tense morphology, and given that the tense violations were identical across conditions, the differential ERP responses indicate that the parser tracks not only predictions but also the causes of those predictions. A parsing model that merely tracks the statistical reliability of the cues to tense, or a system that tracks the content but not the cause of linguistic violations, would have difficulty in explaining our findings. We propose instead that the cues for incremental representation are stored in a modular architecture.

# Parsing and Grammar – Evidence from Infinitival Complementation

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This presentation will adress the topic of complexity in human parsing and the means provided by the grammar to reduce complexity. Our domain of inquiry will be infinitival clauses as they are found in verb-final languages like Dutch or German. Such clauses can either precede their selecting control verb or follow it, as shown in (1) (intraposition) and (2) (extraposition).

(1) Ich weiß,  dass Max ein Buch zu lesen versucht hat.
    I    know that M.  a    book to read  tried     has

(2) Ich weiß,  dass Max versucht hat, ein Buch zu lesen.
    I    know that M.  tried      has a  book to read

While extraposition is a well-known mean to avoid center-embedding, the grammar offers a second option to reduce the processing load caused by infinitival clauses: The syntactic process of clause-union allows to merge the infinitival clause with its matrix clause, thereby transforming a biclausal structure (3) into a monoclausal one (4).

(3) [S_fin NP1 [S_inf NP2 V_inf ] V_fin]

(4) [S_fin NP1 NP2 [V V_inf V_fin]]

After clause-union, a sentence with an infinitival complement has a the same structure as a sentence with only non-clausal arguments. Clause-union has two crucial properties from a processing perspective. First, it is not visible on the surface (for sentence (1), the grammar provides both analysis (3) and (4)). Second, only a subset of control verbs allow clause-union, as shown by several syntactic tests.

While the phenomenon of clause union has attracted intensive attention within grammatical theory, psycholinguistic work is rare (e.g., Bach, Brown & Marslen-Wilson, 1986; Joshi, 1989). We have conducted several experiments investigating clause-union in German. First, we measured the clause-union property of control verbs by letting subjects rate verbs in various clause-union tests taken from the syntactic literature. Then we conducted two selfpaced-reading and two speeded-grammaticality judgments experiments. The main results are:

- Overall, intraposition is more difficult than extraposition
- Intraposition but not extraposition correlates with the clause-union property of verbs: The general disadvantage of intraposition (center-embedding) is strongly reduced with verbs allowing clause-union.
- Readers compute a monoclausal structure even for verbs disallowing clause-union, as shown by the absence of semantic effects connected to biclausal structures in a self-paced reading study.

We argue that this pattern of results is compatible with theories of phrase-structure parsing assuming that phrases are computed incrementally even when their head is in final position but not with head-driven models. Due to principles like Minimal Structure Building and Right Association, the parser will always compute the monoclausal structure during first-pass parsing. This structure is evaluated as soon as the verb arrives which might result in a mismatch if the verb does not allow clause-union. However, this lexical mismatch does not result in an automatic structural revision. For verbs allowing clause union, we therefore get a reduction of complexity with intraposed infinitival clauses because clause-union eliminates the biclausal structure (that is, the complexity-causing center-embedding) without interfering with the verb's selection properties. For verbs disallowing clause-union, the monoclausal structure is also kept, resulting in a conflict with verb properties and the absence of semantic effects connected to the biclausal structure. In sum, our account explains the strong correlations between comprehension measures and clause-union properties of verbs. We will show how our account can be implemented in a theory of phrase-structure composition along the lines of Phillips (2003).

# "But It's *Already* On a Towel!":
## Reconsidering the One-Referent Visual Context

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A great deal of recent work in psycholinguistics makes use of the so-called visual world paradigm. Participants move objects in response to spoken commands, and the critical manipulations concern the relation between the visual world and the linguistic features of the utterance. In a seminal study (Tanenhaus et al., 1995), it was reported that if there are two objects of the same type, an ambiguous PP is immediately interpreted as a modifier because the information is necessary to pick out the proper referent. In contrast, in one-referent conditions (Figure 1), participants are garden-pathed given a sentence such as (1). Comprehenders misinterpret the PP as a goal because the PP is not pragmatically necessary.

Closer examination of the one-referent condition calls this conclusion into question, leading to concerns about the appropriateness of the visual world paradigm for studying parsing. First, adults tend to make errors in the one-referent condition (Trueswell et al., 1999). More importantly, the pragmatics of the visual world make it seem unlikely that participants would often interpret the PP as a goal, because the object is already in a location of the specified type. To examine this issue systematically, production and comprehension experiments were conducted.

In the production experiment, ten participants interacted with a confederate, asking her to move objects around in accordance with a diagram the participants had in front of them. In one condition, the participant had to tell the confederate to put an object such as an apple already sitting on a towel onto another towel. In the other condition, the object on a towel was to be moved to a different goal – a box, for example. In the latter condition, 78% of the time participants simply said "Put the apple in the box". But in the former condition, on no trial did any participant say "Put the apple on the towel". Instead, some mention of the existence of two towels was always made. Thus, the input comprehenders receive should not lead them even momentarily to misinterpret the ambiguous PP as a goal in the one-referent condition.

The second experiment tested this prediction. Participants received either short (2) or long (3) instructions, which they executed while wearing a head mounted eyetracker. The results showed that participants made twice as many fixations to the goal when they heard (2a) compared to (2b). This result suggests that comprehenders did not interpret the PP as a location as strongly when given (2b) as when given (2a). Also, participants made incorrect moves 22% of the time when given (3a). Three quarters of the incorrect moves were made within the first six trials. This pattern indicates that participants were confused by the combination of the instruction and display in the one-referent condition. These results imply that performance in the one-referent condition does not reflect garden-pathing, which also calls into question the interpretation of the findings from visual world paradigm studies used to test interactions among information sources during comprehension.

(1) Put the apple on the towel in the box.
(2)  a. Put the apple in the box. (different goal)
    b. Put the apple on the towel. (same goal)
(3)  a. Put the apple on the towel in the box. (different goal)
    b. Put the apple on the towel on the other towel. (same goal)



| target | same |
|---|---|
| object | goal |
| distractor | different |
| object | goal |
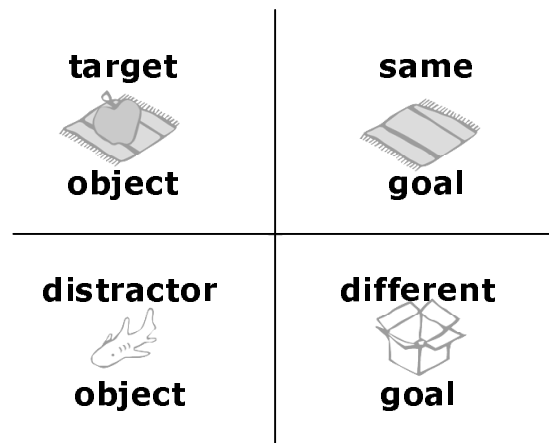
**Figure 1**

# Presupposition and referential prediction in real-time sentence comprehension

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Previous visual world studies have shown that predicate-based information rapidly constrains the candidates available for subsequent reference. For example, upon hearing a verb or preposition (e.g., "The boy will *eat* the…" / "Put the cube *inside* the…"), consideration is immediately narrowed to scene objects whose properties are compatible with the evoked event (e.g., edible things / containers, Altmann & Kamide, 1999; Chambers et al., 2002). This outcome has been suggested to reflect an expectation-based processing system that continuously integrates linguistic and nonlinguistic information to define the interpretive domain for subsequent input.

One characteristic of these studies is that the relevant properties of referential candidates (e.g., edibility, containerhood) could always be assessed through visual inspection. This raises the question of whether rapid anticipatory effects depend on the ability to identify perceptually-based "affordances" of objects-- a process that is often argued to be an automatic and possibly precognitive component of visual perception (e.g., Gibson, 1977). This question is important for two reasons. First, it bears on the generality of the reported effects, e.g., whether the effects still occur when the linguistically-relevant properties of candidates are imperceptible, and/or whether perceptible properties are particularly salient in visual world experiments. Second, recent "embodied" approaches to language understanding propose that linguistic and conceptual symbols are grounded in perception (e.g., Barsalou, 1999) and that establishing the meaning of a sentence involves deriving affordances from these perceptual symbols (e.g., Glenberg & Robertson, 1999). The goal of the current study was to evaluate whether and how non-perceptual information associated with referents is used in the course of real time referential interpretation.

In three experiments, we monitored listeners' eye movements as they followed instructions such as "Put the triangle in area two. [...] Now return the triangle to area...". Experiment 1 showed that the verb *return* immediately restricted attention to an object that was moved during an earlier trial. In contrast, no anticipatory effect was observed when the nonpresuppositional verb *move* was used. This suggests that the presupposition of previous displacement evoked by *return* was immediately integrated with information in memory concerning the "history" of candidate referents. Experiment 2 provided further evidence that predicate-based constraints are evaluated against non-perceptual properties of candidates. Using a referential communication task, we found that *return* restricts the listener's attention to only those objects whose previous displacement is known to both the speaker and the listener. Experiment 3 investigated how referential candidacy is further contoured by pragmatic factors, namely the perceived goal underlying the original action of displacement. Critical instructions were of the type "Attach the triangle to the [top/side] of the square... Now return the triangle to...". When the moved object formed part of a new recognizable object (e.g., a "house", given the "top" instruction), listeners were slower to fixate this object upon hearing *return* than when the first action did not produce an identifiable new object (e.g., with the "side" instruction). This was the case regardless of whether a purpose clause explicitly named the new object (e.g., "Attach the triangle to the top of the square *to make a house*").

Taken together, the results clarify the kinds of information that are relevant in the real-time construction of referential domains: First, lexical presuppositions appear to restrict domains in the same way as "core" lexical constraints, e.g., selectional restrictions. Second, these domains reflect an evaluation of the conceptual "properties" of referential candidates (including their relationship to the goals of ongoing behavior), and not simply perceptually-based affordances. We suggest that this second outcome reveals limitations in the explanatory value of affordances in embodied approaches to language.

# Anticipatory Eye Movements Reflect Semantic Event Structure, not Subcategorization Frequency

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Spoken language eye movement research, introduced by Tanenhaus et al. (1995), is fulfilling its promise by clarifying how lexical, semantic, and world knowledge are integrated during sentence comprehension. Tanenhaus et al. demonstrated that real world context influenced the interpretation of a syntactically (and semantically) ambiguous sentence. Anticipatory eye movements in passive listening tasks (e.g., Altmann & Kamide, 1999) are of particular interest for understanding how verb-based knowledge is used. However, insights from this research are probably limited to semantic, as opposed to syntactic, representations. For example, Altmann and Kamide reported anticipatory looks to a cake upon hearing "The boy ate the…" compared to "The boy moved the...". Do those looks reflect an expectation that food will be mentioned because the verb is transitive? Or do the anticipatory looks reflect understanding the verb's meaning? For most verbs, syntactic and semantic arguments are identical, but regardless of whether "eat" is used transitively or intransitively, its semantic event structure is unchanged. There is no direct object (DO) in the surface form of "The boy ate at 9:00.", but the sentence means that he ate <u>something</u>.

Experiment 1 compared transitive-biased and intransitive-biased verbs for which the semantic event structure required a theme. The intransitive control offered neither a syntactic nor a semantic slot for a theme. In Example (1), the verb conditions are separated by slashes. In sentence completions, a NP complement occurred 86%, 45%, and 5% of the time for each verb type, respectively. The probability of an anticipatory look to a potential DO was not predicted by subcategorization bias. Rather, intransitively biased and transitively biased verbs showed an equally high proportion of looks to a potential DO compared to the intransitive control. The critical time window included the verb and the subsequent word. Participants listened passively and answered comprehension questions.

This result may appear to conflict with Snedeker and Trueswell's (2003) finding that verb bias influenced looks to a target instrument (e.g., feather) following an ambiguous DO modifier\instrument ("with the feather"). They compared verbs like "tickle" that were very frequently used with instruments in sentence completions, with verbs like "feel" that were less frequently used with instruments and verbs like "choose" that were most often used with DO modifiers. Their paradigm differed from ours in that participants carried out the specified action, and crucially, the critical window followed the onset of "feather" rather than the onset of the verb. Therefore, one cannot conclude that the verbs implicitly introduced an instrument into the discourse model, weighted by co-occurrence frequency. Rather, the verb bias effect may reflect real world knowledge constraints on ambiguity resolution.

Experiments 2 (originally presented at CUNY-2002) and 3 explored how context/plausibility influenced anticipatory looks to potential arguments (recipients) and adjuncts (instruments, locations) during passive listening. Example sentences are in (2) – (4), with plausible and implausible targets separated by a slash. An effect of plausibility was found for arguments only, and only when both a plausible and implausible argument were pictured. That is, upon hearing "The newspaper was difficult to read but the mother suggested it anyway…" participants were just as likely to make an anticipatory look to a toddler as a teenager, if only one potential recipient was pictured. In contrast, when both a toddler and teenager were pictured, the teenager received more anticipatory looks.

These results, taken together with prior research, suggest the following generalizations and implications. Hearing a verb directs visual attention to its lexically-specified arguments. This argument status effect reflects semantic event structure rather than syntactic subcategorization. Therefore, semantic interpretations must be developed rapidly, perhaps in an anticipatory manner, guided by the verb's event structure (or in verb-final languages, the event-structure suggested by phrases early in the sentence). Plausibility effects, reflecting the use of real world knowledge, are observed only when choosing among multiple objects that satisfy the event structure constraints.

## Examples

(1)  The bully had had a bad morning, so he attacked/fought/quarreled during the lunch period at school.
(2)  Dative/Recipient. *The newspaper was difficult to read, but the mother suggested it anyway to her <u>teenager/toddler</u> last week.*
(3)  Action/instrument. *The donkey would not move, so the farmer beat it vigorously with a stick/hat every day.*
(4)  Intransitive/Location. *The girl slept for a while on the <u>bed/bus</u> this afternoon.*

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# Relative Clause Prediction in Japanese
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The head-final property of Japanese presents many potential hazards for incremental parsing, among which the head-final relative clause (RC) structures are perhaps the most notorious. There is normally no indication of the RC structure until the end of the RC, and this gives rise to widely discussed cases of processing difficulty (e.g. Inoue, 1991; Mazuka & Itoh, 1995). In this paper we present three experiments that show that Japanese speakers are able to use cues from numeral classifiers to anticipate an upcoming RC structure and hence avoid the processing difficulty normally associated with RCs. Furthermore, these same cues are sufficient to block the formation of long-distance dependencies that would violate island constraints on scrambling.

The presence of an RC in Japanese normally cannot be detected until the parser reaches the head of the RC, or in unambiguously embedded structures the complementizer-less verb (1). Our studies explore the consequences of the fact that genitive numeral classifiers associated with the head of the RC may precede the RC. There are cases where the numeral classifier is semantically incompatible with the subject of the RC, as in (2), where the numeral classifier (satu) and its potential local host NP (sensee) are mismatched. This mismatch may provide a cue to the presence of an RC structure.

Experiment 1 (sentence fragment completion, n=121) showed that locally matching vs. mismatching numeral classifiers successfully regulate expectations for RCs. In classifier-mismatch conditions (3a) 86.5% of completions involved RCs, whereas in classifier-match conditions (3b) there were almost no RC completions (0.02%). Experiment 2 (self-paced reading) showed that information from mismatching numeral classifiers can be used online to avoid classic garden path effects associated with RCs. Reading times at the embedded verb, which disambiguates in favor of the RC structure, showed a significant facilitation in the classifier-mismatch condition (4a) relative to the classifier-match condition (4b), $F1(1, 40)=4.4$, $p<.05$, $F2(1, 23)=4.2$, $p<.05$.

We next investigated whether information from mismatching numeral classifiers not only predicts an upcoming RC structure, but also triggers syntactic constraints involving RCs. Previous studies on Japanese parsing show that speakers favor a long-distance scrambling analysis of fronted dative NPs (Aoshima et al., 2003). This preference is potentially in conflict with the constraint on scrambling out of RCs (Saito, 1985). Experiment 3 (self-paced reading) replicated Aoshima et al.'s finding of a pre-verbal Filled Gap Effect in conditions with matching numeral classifiers (6), but showed that this effect disappeared in conditions where mismatching classifiers indicate an upcoming RC structure. The Filled Gap Effect (Crain & Fodor, 1985; Stowe, 1986) was observed in a slowdown immediately after the embedded dative NP in the scrambled-match condition (6a) relative to the unscrambled-match condition (6b), $F1(1, 86)=4.6$, $p<.05$, $F2(1, 23)=5.02$, $p<.05$. This effect is expected if the fronted dative NP undergoes long-distance scrambling that places it inside the embedded clause. No such contrast is found in the classifier-mismatch conditions (5a, 5b), $Fs<1$, indicating that long-distance scrambling is blocked when classifiers cue an upcoming RC. Thus, island constraints on movement apply immediately in Japanese, as found in English (e.g. Stowe, 1986; McElree & Griffith, 1998), despite the extreme rarity of these constructions in Japanese.

## Examples

(1) [Taroo-ga      gap yonda] hon… Taroo-Nom read book…
    'The book that Taroo read…'
(2) [san-satu-no [sensee-ga yonda] hon]…
     three-Classifier(book)-Gen teacher-Nom read book
    'three books that the teacher read'
    (san-satu means roughly three copies.)
(3) a. Dono NP-ni NP-top san-satu-no Adj sensee-ga …
      which NP-Dat three-classifier(book)-Gen teacher-Nom
   b. Dono NP-ni NP-top san-nin-no Adj sensee-ga …
     which NP-Dat three-classifier(human)-Gen teacher-Nom
(4)a. NP-top / san-satu-no / Adj / sensee-ga / Adj / NP-Dat / Adv / V / hon-o / NP-Dat / V. three-Cl(book)-Gen
               teacher-Nom book-Acc
(4)b. NP-wa / san-nin-no / Adj / sensee-ga / Adj / NP-Dat / Adv / V/ hon-o / NP-Dat / V. three-Cl(human)-Gen
               teacher-Nom book-Acc
(5) Classifier Mismatch Conditions
    a. Wh-Dat / NP-Top / three-Cl(book)-Gen / Adj / teacher-Nom / Adj / NP-Dat / Adv / V / book-Acc / V-Q?
    b. NP-Top / wh-Dat / three-Cl(book)-Gen / Adj / teacher-Nom / Adj / NP-Dat / Adv / V / book-Acc / V-Q?
(6) Classifier Match Conditions
    a. Wh-Dat / NP-Top/ three-Cl(human)-Gen / Adj / teacher-Nom / Adj / NP-Dat / Adv / V / book-Acc / V-Q?
    b. NP-top / wh-Dat / three-Cl(human)-Gen / Adj / teacher-Nom / Adj / NP-Dat / Adv / V / book-Acc / V-Q?

# 2-year-olds use verb information in rapid inferential learning of novel nouns

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Adults can use verb information to limit the domain to which reference will subsequently be made by a post-verbal grammatical object in online sentence interpretation (1). In a picture-book task children too used semantic context to infer the appropriate referent of a novel noun thematically related to a familiar verb (2). Because children in such offline tasks typically check out the options and indicate their choice after several seconds, it is not clear how rapidly these inferences occur. Can young language learners use linguistic knowledge online as the sentence unfolds to identify the referent of a novel object word paired with a semantically constrained familiar verb?

We observed 36 26-month-olds in an online looking-while-listening procedure (3). On 8 Teaching Trials children were shown two pictures of exotic objects: a Japanese pastry paired with a plastic appliance, or a 3-wheeled Indian rickshaw paired with a multicolored scrubber, all unfamiliar and carefully matched for visual salience. On 4 trials they saw the pastry/appliance pictures and heard You can eat the manju; on 4 they saw the rickshaw/scrubber pictures and heard You can drive the tempo. On 8 Test Trials children saw both target objects together and heard either Where's the manju? or Where's the tempo? Video records of eye movements on were coded frame-by-frame by coders unaware of trial type and target location. Accuracy on Test Trials was well above chance: children mapped manju onto the pastry and tempo onto the vehicle. A week later children were asked to identify the referents of manju and tempo in a book containing 4 pictures/page. Correct recognition of both target words showed longterm retention of the mappings between novel words and unfamiliar objects learned inferentially.

The most surprising finding was how quickly 26-month-olds made this connection. The very first time they heard You can eat the manju or You can drive the tempo in the presence of two unfamiliar objects, children began orienting to the correct target picture as they heard the verb. Thus by the time the novel object name was spoken at the end of the sentence, almost 80% of the children were already looking at the appropriate referent. Although none of the four unfamiliar objects was ever directly identified as a manju or a tempo, 26-month-olds used verb knowledge to infer correctly which novel picture should be associated with each novel word. Moreover, verb knowledge motivated children's search within a fraction of a second on their first encounter with the unfamiliar words.

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# Age-Related Effects on Learning to Parse: Evidence from Korean-English Bilinguals

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Recent work on bilingual processing of relative clause (RC) attachment preferences (e.g., *Someone shot the servant of the actress who was on the balcony*) has revealed clear cross-linguistic variation as well as differences in parsing in bilinguals and monolinguals (e.g., Cuetos & Mitchell, 1988; Dussias, 2003; Fernandez, 1999; Papadoupoulo & Clahsen, 2003). Such differences may reflect generalized cross-linguistic differences in parsing strategies (Mack, 1992), and if so, they challenge the validity of universal parsing approaches, while being more compatible with experience-based parsing models that accommodate variation in learned parsing routines.

In particular, bilingual processing studies have revealed the effect of learner variables on RC attachment preferences, although not all are in agreement about which variables are most strongly associated with such preferences. One variable of special interest is the age at which a bilingual has been exposed to his/her L2, but there is little data on the relationship of this variable to RC attachment. In addition, any conclusion concerning bilingual processing based solely on speakers of Western languages seems incomplete, calling for investigations based on users of non-Western languages.

This study thus compared first and second language processing in monolingual and bilingual speakers of Korean and English in the resolution of RC attachment ambiguities, as shown in the Korean example below:

(1) Palkhoni-ey  iss-nun   yepaywu-uy     kay-lul   nwukwunka   chong-ulo     sswassta
    balcony-loc  is-rel.   actress-gen.   dog-acc.  Somebody    gun-with      shot (past)
    (= Somebody shot (the) dog of (the) actress that was on (the) balcony.)

Three questions were asked: (1) Are there parsing differences between Korean and English monolinguals? (2) Do bilingual speakers of Korean and English parse similarly to monolingual speakers of these languages? and, (3) Does age of L2 exposure (AOA) have an effect on parsing? (with AOA operationalized here as age of arrival in the country of the target language)

Participants in the study were 21 Korean monolinguals, 18 English monolinguals, and 41 Korean-English bilinguals ranging from advanced to native-like English proficiency, categorized into three different groups based upon age of arrival in the United States (i.e., early ≤ age 7 < late < age 12, adult< age 20). Two off-line non-timed questionnaires on RC attachment ambiguity, similar to the one used in Fernandez (1999), were used. Results indicated that English and Korean monolinguals prefer different attachment sites. Regardless of AOA, the bilinguals showed preferences similar to those of Korean monolinguals when processing Korean (L1). However, in processing English (L2), only the early bilinguals performed similarly to English monolinguals. The late and adult bilinguals used L1 parsing strategies when processing their L2. This suggests that, despite lengthy L2 exposure and/or advanced L2 proficiency, bilinguals who were exposed to their L2 after a certain age continue to use L1 parsing strategies, at least with respect to RC attachment.

These findings can be explained by experience-based parsing models which permit customization of the parser for different languages that in turn, in conjunction with age-based maturational effects, may result in different parsing routines.

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# CUNY CONFERENCE

# Thursday, March 25

# Poster Session I

# Integrating the Spatial Semantics of Verbs and Prepositions

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Tenny (1995) distinguishes between motion verbs, which specify motion along a path (e.g. *dart*, *wander*), and stative verbs, which do not (e.g. *squawk*, *sleep*). Prepositional counterparts to these two types of verbs are the PATH functions (e.g. *across*, *to*), which specify motion along a path, and PLACE functions (e.g. *inside*, *at*), which locate an object's static position in relation to another's (Jackendoff, 1983). Thus, motion verbs typically take PATH functions whereas stative verbs typically take PLACE functions. We investigated how the spatial semantics of these types of verbs and prepositions are integrated during online sentence processing. Crucially, we examined cases in which a motion verb is juxtaposed with a PLACE function. We reasoned that there are two mechanisms by which this conflict can be reconciled. (i) Verb priority: the verb determines whether the phrase is describing an action taking place along a path or at a location. Thus, the interpretation of the preposition is enriched to accommodate the path bias of the motion verb (e.g., *to protect her nest, the bird darted at the hunter just now*). (ii) Preposition priority: The path of the verb is omitted and the interpretation of the preposition is not enriched (e.g., *because he woke up early, the child wandered at the school last Tuesday*). The main difference between these two is that for (i), the interpretation of the preposition is coerced into a PATH reading, whereas for (ii), the path of the verb is simply omitted, as it is optional. One prediction of this account is that reading times for (i) relative to a baseline should be increased as a result of the enriched interpretation (e.g., Traxler et al., 2002), whereas reading times for (ii) should not be higher than baseline because the verb's path is optional. This prediction was confirmed using a single-word self-paced reading task, using stimuli like the verb priority items in (1) and preposition priority items in (2).

**Examples**

(1)     *Verb Priority*
          a. Motion verb, PATH preposition: To protect her nest, the bird darted to the hunter just now.
          b. Motion verb, PLACE preposition: To protect her nest, the bird darted at the hunter just now.
          c. Stative verb, PATH preposition: To protect her nest, the bird squawked to the hunter just now.
          d. Stative verb, PLACE preposition: To protect her nest, the bird squawked at the hunter just now.

(2)     *Preposition Priority*
          a. Motion verb, PATH preposition: Because he woke up early, the child wandered to the school last Tuesday.
          b. Motion verb, PLACE preposition: Because he woke up early, the child wandered at the school last Tuesday.
          c. Stative verb, PATH preposition: Because he woke up early, the child slept to the school last Tuesday.
          d. Stative verb, PLACE preposition: Because he woke up early, the child slept at the school last Tuesday.

For the verb priority items, both of the inconsistent items (1b & 1c) have significantly longer RTs than the consistent ones (1a & 1d), whereas for the preposition priority ones, only (2c) is slower, with (2b) on par with the consistent items. Moreover, this effect is evident beginning with the word after the preposition, supporting a highly incremental view of the integration of spatial semantics. The results will be discussed in relation to recent psycholinguistic accounts of enriched composition (McElree et al., 2001; Pinango et al., 1999; Traxler et al. 2002).

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# Context and the real-time comprehension of scope ambiguity

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This study investigates the on-line comprehension of doubly-quantified sentences such as (1a). These sentences are ambiguous between a surface-scope (1b) and a less frequent, dispreferred inverse-scope interpretation (1c), which arises from a more complex linguistic representation (May 1977, Heim & Kratzer 1998). Referential theories of sentence processing (Crain & Steedman 1985, Altmann & Steedman 1988) predict that the processing cost of assigning the dispreferred interpretation should be mitigated by a supportive discourse context. However, structure-driven theories (Frazier 1987, Frazier & Fodor 1978) predict a cost for the more complex structure regardless of discourse context. Results from two self-paced reading experiments demonstrate a processing cost associated with the dispreferred inverse-scope interpretation not only when it is supported by the context, but even when it is required by the grammar.

Both experiments presented quantified sentences embedded in paragraphs that supported either the surface- or inverse-scope interpretation. (The inverse-scope supporting contexts introduced multiple discourse referents before the quantified sentence.) Two off-line questionnaire studies indicated that the inverse-scope interpretation was assigned to only 19% of ambiguous target sentences presented in isolation, but to 53% of sentences in inverse-scope supporting contexts. In Experiment 1 the target sentence appeared in four conditions: ambiguous in the surface-scope supporting context, ambiguous in the inverse-scope supporting context, unambiguous surface-scope (2) in the surface-scope supporting context, or unambiguous inverse-scope (3) in the inverse-scope supporting context. In Experiment 2, which did not include the unambiguous conditions, the ambiguous target sentence (either surface- or inverse-scope supported) was followed by a sentence with a singular (4a) or plural (4b) definite NP subject, which disambiguated the quantified sentence to the surface-scope or inverse-scope interpretation, respectively. Paragraphs were presented on a computer, one clause at a time, in a self-paced reading task. After each paragraph, the participant answered a question that indicated which interpretation she had assigned to the quantified sentence. The proportion of surface- and inverse-scope responses to the on-line comprehension question was nearly identical to the off-line questionnaire.

In Experiment 1, residual reading times for the quantified sentence were significantly longer in both the inverse-scope conditions than in the surface-scope conditions (main effect of context: $F1(1,23)=16.7, p<0.001$; $F2(1,23)=14.6, p<0.001$; no effect of ambiguity: $F1(1,23)=1.4$, n.s.; $F2(1,23)=1.6$, n.s.). In Experiment 2, although the quantified sentence was read more slowly in the inverse-scope conditions, this difference was not significant ($F1(1,31)<1$, n.s., $F2(1,23)<1$, n.s.). However, the subsequent disambiguating sentence was read more slowly in inverse-scope supporting conditions than surface-scope ($F1(1,27)=3.98, p=0.06$; $F2(1,23)=3$, n.s.), and significantly more slowly with a plural subject than with a singular subject ($F1(1,27)=10, p<0.01$; $F2(1,23)=5.25, p<0.05$).

The results indicate processing difficulty associated with assigning inverse scope not only where it is the dispreferred interpretation, but also in supportive contexts, and even in conditions where inverse-scope is the only possible interpretation, namely, in sentences with *different* or a plural subject. Since neither a favourable discourse context nor the absence of competing analyses is sufficient to mitigate the processing cost of the inverse-scope interpretation, we conclude that the greater structural complexity of the inverse-scope representation is responsible for this cost, as a structure-driven model predicts.

**Examples**

(1)      a.      An experienced climber scaled every cliff.
            b.      *One climber scaled all the cliffs.*
            c.      *Several climbers each scaled a different cliff.*
(2)                The experienced climber scaled every cliff.
(3)                A different climber scaled every cliff.
(4)      a.      The climber was very skilled.
The climbers were very skilled.

**Residual Reading Times (msec)**

| Experiment 1 | quantified sentence | Experiment 2 | quantified sentence | | disambiguating sentence |
|---|---|---|---|---|---|
| unambig. surface | -62 | ambig. surface | 298 | singular subject | 63 |
| ambig. surface | 97 | ambig. surface | 297 | plural subject | 247 |
| unambig. inverse | 326 | ambig. inverse | 328 | singular subject | 176 |
| ambig. inverse | 351 | ambig. inverse | 337 | plural subject | 377 |

# Quantifier-variable binding across sentence borders
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I present data from an online acceptability judgment task that investigates the role of discourse relations on the acceptability of quantifier-variable binding across sentence borders. These data support the claim that quantifier-variable binding is possible between two sentences that bear a causal discourse relation, while it is unacceptable between sentences that do not bear this relation.

Background. It has traditionally been assumed that the scope of universal quantifiers such as each and every is sentence-bound, that is, they may not bind pronouns in subsequent sentences, as seen in example (1).

However, there are cases that show that this prediction seems to be too strong, as illustrated in (2). The contrast between (2a) and (2b) indicates that the availability of the binding relation depends on the structure of the discourse. In an eye tracking study reported in Carminati et al. (2002), no significant slowdown in reading times was found for conjoined sentences for which a binding relation was available. A sentence pair of their study can be seen in (3).

Current Study. The aim of the study presented here is two-fold. First, it shows that quantifier-variable binding across a sentence border is also available in German. Second, I want to argue that grammatical instances of the phenomenon must satisfy specific discourse requirements. In particular, I'm investigating whether a causal discourse relation allows for a quantifier to bind a pronoun in a following sentence.

The materials used in this study were two-sentence discourses that differed with respect to two conditions: causality and antecedent type. With respect to causality there were two levels: either the sentence-pairs were standing in a causal relation or in a non-causal relation. With respect to antecedent type there were also two levels: the nominal phrase in the first clause, which served as an antecedent for the pronoun in the second clause, was either quantificational (every N) or referential (the/my N or name). This led to the four discourse types illustrated in (4).

Discourses like (4a:c) and (4a:d) had a quantificational antecedent (every patient of ours) in the first sentence, while discourses like (4b:c) and (4b:d) had a referential antecedent (my friend Christian). There was a causal connection between the sentences in discourses like (4a:c) and (4b:c), but not between (4a:d) or (4b:d).

24 native speakers of German saw 16 items of each type in a frame-by-frame fashion. Following each discourse, participants were asked to give acceptability judgments on a scale from 1 (acceptable) to 5 (unacceptable).

In a 2x2 ANOVA, significant evidence for main effects of both factors, antecedent type (subject: $F(1,94)=18.54$, $p<.001$; item: $F(1,62)=26.75$, $p<.001$) and causality (subject: $F(1,94)=17.43$, $p<.001$; item: $F(1,62)=26.2$, $p<.001$), were found. However, while there was a highly significant effect of causality on the quantificational sentences (t-test $p<.001$), only a numeric effect of causality could be seen for the referential items (t-test $p=.12$). This difference is reflected in a significant interaction (subject: $F(1,94)=8.53$, $p<.005$; item $F(1,62)=12.95$, $p<0.001$).

These results support the hypothesis that causality plays a role for inter-sentential quantifier-variable binding. The absence of a causal discourse relation does not affect the referential cases in the same way, which I will take as evidence that the effect is not due to a general incompatibility of the two sentences in the non-causal case.

## Examples

(1)   [Every dog]$_i$ came in. $^\#$[It]$_i$ lay down under the table.                                    (Heim 1982:13)

(2)   a. [Every rice-grower]$_i$ owns a wooden cart. [He]$_i$ uses it when [he]$_i$ harvests the crop.          (Sells 1985)
      b. [Every rice-grower]$_i$ owns a wooden cart. $^\#$[He]$_i$ used it yesterday to harvest the crop.

(3)   a. [Every Midwestern farmer]$_i$ planted corn and then [he]$_i$ worried endlessly about the weather.
      b. [Every Midwestern farmer]$_i$ admitted that [he]$_i$ worried endlessly about the weather.   (Carminati et al. 2002)

(4)   a. Jeder unserer Patienten,/ der sich im     letzten Jahr ein Bein brach,/ hatte Ärger mit der Krankenversicherung
         Every ours   patients   who self in+the last    year a  leg  broke  had  trouble with the health insurance
         'Every patient of ours who broke a leg during the last year experienced trouble with his health insurance.'
      b. Mein Freund Christian,/... (continued like 4a)
         My friend Christian,/ ...

      c. Er  musste  sich deswegen /mit   viel  Papierkram / herumschlagen.
         He needed  self  therefore  with much paper stuff    beat around
         'For that reason, he needed to bother with a lot of paper work.'

      d. Er  hatte aber / auch schon  vorher / viel  Pech      mit Versicherungen.
         He had    but   also already before  much bad luck with  insurances
         'But he had already had a lot of trouble with insurances before that.'

| | mean judgments |
|---|---|
| (4a:c) | 2.08 |
| (4a:d) | 1.84 |
| (4b:c) | 3.43 |
| (4b:d) | 2.07 |
| | [table 1] |

# The Real-time Application of Structural Constraints on Binding in Japanese

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This study presents new evidence for on-line, pre-verbal application of structural constraints on variable binding and movement in Japanese. Under the assumption that structural constraints can apply pre-verbally only if sufficient structure is present to instantiate those constraints, these findings provide evidence that speakers of head-final languages construct articulated structural representations before reaching the verb of a sentence (cf. Bader, 1994).

A previous study by Aoshima et al. (2003) argued that Japanese speakers actively search for antecedents of the personal pronouns *kare/kanojo* 'he/she' only in grammatically sanctioned positions. The antecedents in that study were all referential NPs. However, a stronger test involves the use of a Japanese pronoun that can be bound by a quantificational NP, since bound variable anaphora is more strictly subject to a c-command requirement (Reinhart, 1983). The pronoun *soko*, which refers to an organization such as a company, allows both referential and quantificational antecedents, and yields a bound variable interpretation if it is c-commanded by a quantificational NP (QNP) such as *dono-NP-mo* 'every NP' (Ueyama, 1998; Hoji et al., 2000).

Because of the possibility of scrambling, *soko* inside a sentence-initial dative object NP may take a following subject QNP as its antecedent (1a). Meanwhile, *soko* inside a sentence-initial nominative subject NP cannot take a following dative object QNP as its antecedent, due to the failure of c-command (1b). Experiment 1 (acceptability judgment, n=48) confirmed this contrast, showing higher ratings for scrambled conditions (2) than non-scrambled conditions (3), $F_1(1,47)=12.0$, $p<.01$; $F_2(1,11)=14.1$, $p<.01$.

Experiment 2 (self-paced reading, n=32) investigated whether the structural contrast between (2) and (3) is immediately active in on-line processing. The design of the study independently manipulated the presence (4) vs. absence (5) of scrambling, and the congruity of the QNP in second NP position in the sentence as a possible antecedent of *soko*, i.e. institution vs. person (*dono bucyoo-mo* 'every manager'). An immediate reading-time effect of the congruity of the QNP in second NP position was observed in the scrambled conditions, $F_1(1,31)=4.3$, $p<.05$; $F_2(1,23)=3.1$, $p=.09$, but not in the non-scrambled conditions, $Fs < 1$. This contrast suggests that structural constraints on variable binding are immediately active.

In contrast to studies that have examined binding relations involving referential NPs, this study found that reading times were slower when the QNP was a congruous antecedent for *soko* than when it was an incongruous antecedent. We suggest that this effect reflects the fact that in the absence of discourse cues, pronouns are preferentially interpreted as referential rather than as bound variables (Shapiro & Hestvik, 1995; Frazier & Clifton, 2000). Thus, encountering a congruous QNP in a grammatically accessible position required participants to reanalyze the pronoun as a bound variable. No such reanalysis was required when the same QNP appeared in an inaccessible position.

Taken together, these results suggest that the parser incrementally assembles structure and computes structural relations among NPs in advance of the verb in head-final languages. We interpret these findings as support for incremental full-attachment models (e.g. Inoue & Fodor, 1995; Mazuka & Itoh, 1995).

**Examples**
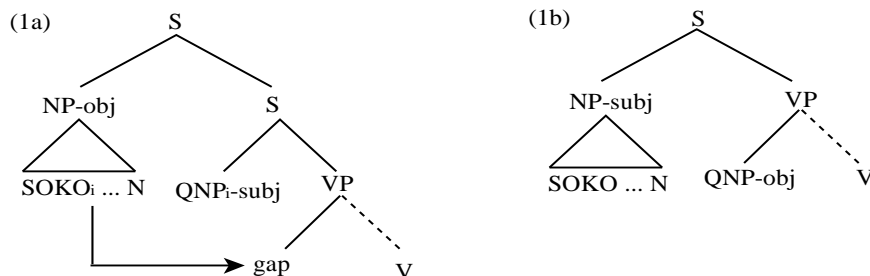


(2) [soko$_i$-no itiban yuusyuuna syain]-ni     [dono hokengaisya]$_i$-mo syookyuu-o   yakusokusita rasii.
   *soko-gen most  excellent  employee-dat  every insurance company-mo raise-acc   promised  seem*
   'It seems that every insurance company$_i$ promised a raise to its$_i$ most excellent employee.'
(3) *[soko$_i$-no itiban yuusyuuna syain]-ga    [dono hokengaisya]$_i$-ni-mo syookyuu-o   yookyuusita rasii.
   *soko-gen most excellent  employee-nom every insurance company-dat-mo raise-acc requested   seem*
   'It seems that its$_i$ most excellent employee requested a raise from every insurance company$_i$.'
(4)   a. Adv / [SOKO-gen NP]-dat / Adv / QNP$_{MATCH}$ / Adv / NP-acc / V-that / QNP$_{MISMATCH}$-top / V.
      b. Adv / [SOKO-gen NP]-dat / Adv / QNP$_{MISMATCH}$ / Adv / NP-acc / V-that / QNP$_{MATCH}$-top / V.
(5)   a. Adv / [SOKO-gen NP]-nom / Adv / QNP$_{MATCH}$-dat / Adv / NP-acc / V-that / QNP$_{MISMATCH}$-top/ V.
      b. Adv / [SOKO-gen NP]-nom / Adv / QNP$_{MISMATCH}$-dat / Adv / NP-acc / V-that / QNP$_{MATCH}$-top/ V.

# Parsing Preferences are Determined by Local, not Global Determinants

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We will present a combined experimental and corpus study adressing the questions of (i) what information sources guide the HSPM's first-pass decisions and (ii) what are the units to which parsing principles apply (fineness of grain). Grammatical-function ambiguities will be our domain of inquiry.

So far, psycholinguistic work on grammatical-function ambiguities has concentrated on subject-object ambiguities and has found a rather general first-pass preference for sentences with the subject preceding the object. However, with regard to the factors underlying first-pass preferences, subject-object ambiguities are problematic because of the confounding of local and global preferences given either a structural or a frequency-based sentence processor. For example, SO-sentences occur more often than OS-sentences but subjects also occur more often than objects. Similar considerations hold for structure-based theories.

To avoid these problems, we have investigated sentences with two ambiguous objects. In (1) and (2), the two objects "Maria" and "Peter" can be locally analysed as either dative-object in front of accusative object or accusative-object in front of dative object. Disambiguation is achieved by the unambiguous-case marking on the clause-final NP. The two objects can be both in non-topicalized position (1) or one of them can be topicalized (2).

(1) a.   Ich habe Maria nicht nur  Peter vorgestellt, sondern auch seinen     Bruder.
         I   have Mary not   only Peter introduced, but       also  his-ACC brother
         "I introduced not only Peter to Maria but also his brother"
    b.   Ich habe Maria nicht nur Peter vorgestellt, sondern auch seinem     Bruder.
         I   have Mary not   only Peter introduced, but       also  his-DAT brother
         "I introduced Maria not only to Peter but also to his brother"
(2) a.   Maria habe ich nicht nur  Peter vorgestellt, sondern auch seinen     Bruder.
         Mary  have I   not   only Peter introduced, but       also  his-ACC brother
    b.   Maria habe ich nicht nur Peter vorgestellt, sondern auch seinem     Bruder.
         Mary  have I   not   only Peter     introduced, but also his-DAT   brother

A local structural theory predicts the first object to be analysed as an accusative object because accusative is less marked than dative case in German (cf. Bayer et al., 2001). A global structural theory would predict no preference because globally seen, both analyses contain exactly the same arguments, and with two animate NPs as in (1) and (2) the grammar does not impose any particular ordering among them.

The predictions for frequency based models come from a corpus study we have conducted using the Tiger Corpus of the University of Stuttgart (containing ca. 58000 clauses). An overall analysis not taking animacy information into account showed: (i) Accusative objects outnumber dative object by far. (ii) When both objects are in non-topicalized position, the order DAT > ACC is much more frequent then ACC > DAT. (iii) When one object is topicalized, DAT > ACC is slightly more frequent than ACC > DAT.

Sentences with two lexical animate NPs (as in (1) and (2)) are exceedingly rare, amounting to only a handful of examples in the corpus. To remedy this situation we are now analyzing a larger untagged corpus.

The different predictions were tested in three experiments using the method of speeded-grammaticality judgments. Sentences as in (1) and (2) as well as unambiguous control sentences were investigated. The experimental results show a strong garden-path effect when sentences are disambiguated toward DAT > ACC. The strength of the resulting garden-path effect was roughly equivalent whether one object was topicalized or not.

These results are only compatible with local parsing principles. We have to assume that the first object is assigned accusative case either because of structural simplicity or because accusative is more frequent than dative case, and that the second object is assigned dative case as the last case that has not yet been assigned.

# When is a Path Not a Path? Eye Movements and Parsing in the Visual World

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One recent argument for the immediate use of non-linguistic information by the parser involves the visual world paradigm (Tanenhaus, et al., 1995; Trueswell, et al., 1999; Spivey, et al. 2002), which assumes a tight link between linguistic and visual processing. In these sorts of experiments, participants interact with a display containing a target, a distractor, an incorrect goal, and a correct goal while listening to and carrying out instructions such as (1) and (2).

Two different display types are typically used (Figure 1). In the one referent display, the distractor object is not referred to in the utterance. In the two referent display, the distractor is identical to the target. The incorrect goal (e.g. the towel) is always the object referred to by the noun in the first PP, and is identical to the object on which the target is placed.

The typical finding in these experiments is that subjects look more often to the incorrect goal in the one referent display condition, suggesting that they are garden pathed. This pattern is found in response to temporarily ambiguous instructions such as (1); no such looks are generally reported for syntactically disambiguated utterances such as (2). The explanation for the garden path effect is that participants do not need the PP "on the towel" to identify the target. Therefore, the parser immediately assumes that "on the towel" must be a goal. This "mistake" is not made in the two referent display condition, because "on the towel" is necessary to correctly identify the target.

These studies assume that the majority of eye movements to the incorrect goal in this task are due to garden pathing during the processing of ambiguous instructions. However, subjects also exhibit behaviors during this task that suggest that eye movements are not exclusively under the control of the linguistic system. In some cases, participants fixate objects that are visually salient but have not been mentioned (yet or at all). In other cases, they fixate a single point throughout a trial, often during periods of high concentration (Cooper, 1974). Such decoupling of visual and syntactic processing could lead to eye movement performance which appears to reflect garden-pathing but in fact does not.

We report three experiments examining these possibilities. While main effects of sentence type (ambiguous vs. unambiguous) and display (one referent vs. two referent) were found, the previously reported interaction between the two variables was not; that is, subjects behaved as if they were garden pathed even in the syntactically disambiguated conditions. Moreover, manipulations of the ambiguity of the display elicited patterns of eye movements that were inconsistent with predictions based solely on the assumption that linguistic processing is the main factor driving eye movements. The results of these experiments suggest that the direction-following task used in these visual world experiments may elicit eye movements that are caused by processes other than garden pathing. In previous experiments, these eye movements have not been distinguished from those made because of syntactic misanalyses. Some candidate processes include simple word recognition, and also processes related to executing hand movements and interpreting visual scenes.

**Examples:**

(1) Put the frog on the towel in the box.
(2) Put the frog that's on the towel in the box.
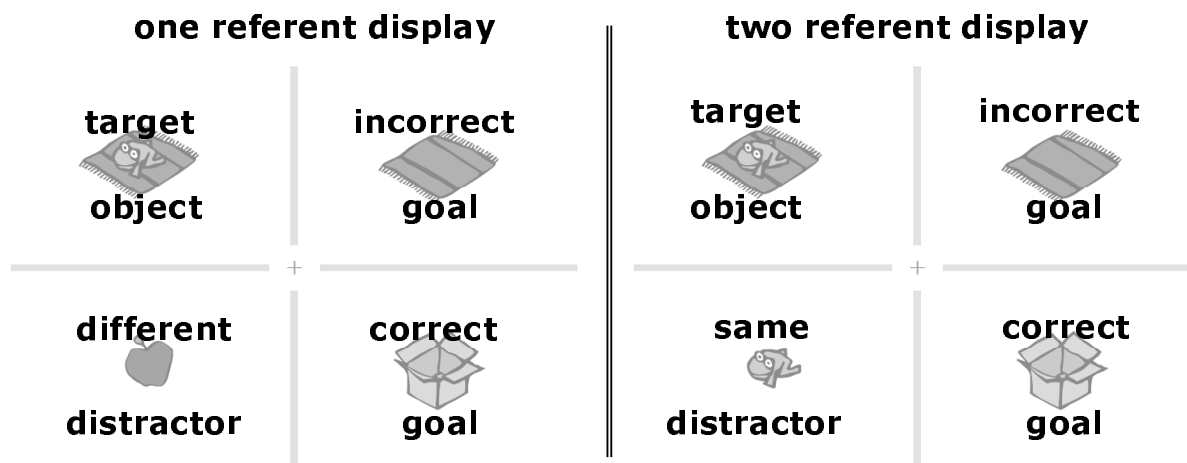


*Figure 2*

# Argument and adjunct static locations are processed differently

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It is widely accepted that readers use participant information encoded in the lexical representations of verbs during sentence comprehension. However, the representations of this participant information are less well understood. Koenig, et al. have proposed that arguments are those participants that are semantically obligatory for only small classes of verbs and serve to individuate verb meanings. Thus, participants that are not semantically obligatory or, are semantically obligatory, but do not individuate the meaning of one verb from another are semantic adjuncts.

Conklin, et al. tested this specificity hypothesis by examining self-paced reading times and make-sense judgments for WH filler-gap sentences whose verbs require a source location (*eject*) or an event location (*beat*), as in (1a-b). Sources express the location from which an event originates. Because they are required of only a small set of verbs they are arguments. Event locations locate an event and all its participants. They are obligatory for all events, and thus do not individuate verb meaning and are adjuncts. While both the argument and adjunct fillers are grammatical, Conklin et al. expected that readers would have processing difficulty at the post-verbal region only for adjunct NPs because they provide neither semantic nor syntactic cues about the role of the wh-filler. Filler type interacted with verb type. Specifically, NP-filler sentences (1a) whose verbs did not specify a source (*beat*) were read slower relative to their PP-filler controls (1b) than were NP-filler sentences whose verbs *did* specify a source (*eject*). PP-filler sentence RTs did not differ with respect to verb type because the preposition in the filler provided a strong syntactic cue to gap location. However, for NP-filler sentences, semantic argument information from source verbs aided processing. While these results support the specificity hypothesis, there are two potential confounds. Sources and event locations were marked by different prepositions. Moreover, sources require motion while event locations are static. Thus, source information may have been more salient than event location information.

Using identical methods, logic, and predictions, we addressed these confounds and tested the specificity hypothesis using verbs that require either a participant location (*hoard* or *bury*) or an event location (*eat*). The prepositional phrases *in the bush* and *in the hole* in (2a-b) are examples of participant locations, which are semantically required of few verbs. Crucially, these PPs help distinguish the meaning of *hoard* from *bury* because their direct objects are required to be in locations with different properties. That is, you cannot bury something in a bush, since there are selectional restrictions on the properties of a participant location for a burying event. Contrastively, *in the park* in (2a-b) introduces an event location that does not help distinguish *hoard* from *bury*. The events of hoarding or burying can both take place in the park or in any other location that fills this role. Again verb type and filler type interacted. We found that the RTs to NP-filler sentences (3a) whose verbs require participant locations (*hoard*) were faster relative to their PP-controls (3b) than were RTs of NP-filler sentences whose verbs did not semantically specify a participant location (*eat*). These differences emerged at the post-verbal region.

These results provide further support for the specificity hypothesis that posits that a verb's arguments must express a participant role that is semantically obligatory of only a small set of verbs. In other words, participant roles that help individuate the meaning of one verb from others are lexically encoded as arguments. Furthermore, these results show that readers use such participant information rapidly during for on-line sentence processing. Our participant location and event location PPs had the same preposition and were semantically similar because both described static containment relationships. Thus we can rule out the two confounds that were present in Conklin, et al.'s study. Additionally, these results cannot be reduced to differences in co-occurrence frequencies of participant types with participant location and event location verbs since a corpus study showed that they did not correlate with RTs.

## Examples

(1)     a.      Which stadium | was the noisy spectator | ejected/beaten | from/in by the security guard | on Sunday?

        b.      From/In which stadium | was the noisy spectator | ejected/beaten | by the security guard | on Sunday?

(2)     a.      The chipmunk hoarded the acorns in the bush in the park.

        b.      The chipmunk buried the acorns in the hole in the park.

(3)     a.      Which bush | were the squirrel's acorns | hoarded/eaten | in by the chipmunk | last fall?

        b.      In which bush | were the squirrel's acorns | hoarded/eaten | by the chipmunk | last fall?

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# Whenever the psycholinguist checks, prosodic phrasing and verb bias interact

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Kjelgaard and Speer (1999) showed that prosodic phrasing interacts with syntactic processing at the earliest possible moment. Their cross-modal naming results demonstrated that intonation phrases and intermediate phrases could eliminate garden paths at the point of syntactic disambiguation in closure ambiguities like those in Table 1. However, the effects might have hinged on their choice of verbs. The finding that phrasing immediately influenced which syntactic structure was built—when the verbs as a group occurred equally frequently with the structural alternatives—is similar to the results of Garnsey, Pearlmutter, Myers, and Lotocky (1997). They found that plausibility immediately influenced the resolution of a written temporary syntactic ambiguity, but only when the verbs were equi-biased.

I present two cross-modal naming experiments that begin to define the relationship between prosodic phrasing and verb bias. Each experiment consisted of a 2 (prosodic boundary: late or early) X 3 (verb bias: intransitive, equi, or transitive) X 2 (visual target: it's or is) design. Experiment 1 fragments ended in intonation boundaries (H%). Experiment 2 fragments ended in intermediate boundaries (H-).

**Table 1. Summary of Conditions and Example Stimuli**

| Verb Bias | Prosodic Boundary | Auditory Fragment with Prosodic Contour | | | | | Syntactic Closure of Visual Target | |
|---|---|---|---|---|---|---|---|---|
| | Late | EXP 1: | | H* | | H* L-H% | | |
| | Early | EXP 1: | | H* | L-H% | H* | | |
| | | | | | | | | |
| | Late | EXP 2: | | H* | | H* H- | | |
| | Early | EXP 2: | | H* | H- | H* | | |
| | | | | | | | Late | Early |
| Intransitive | | Whenever the lady moves the door | | | | | it's | is |
| Equi | | Whenever the lady checks the room | | | | | it's | is |
| Transitive | | Whenever the lady loads the car | | | | | it's | is |

In Experiment 1, IT'S was named more quickly than IS in late boundary conditions and more slowly than IS in early boundary conditions. The results replicate Kjelgaard and Speer (1999) and provide new evidence that the location of an intonation boundary determines the initial structure of these ambiguities regardless of verb bias.

In Experiment 2, IT'S was named more quickly than IS in all but the early boundary intransitive-bias condition. In that condition, IS was named as quickly as IT'S. These results contrast with Kjelgaard and Speer (1999) and suggest that in the current materials only the combination of an early intermediate boundary and an intransitive-bias verb produces an initial intransitive structure.

The results of these experiments do support Schafer's (1997) claim that intonation phrases and intermediate phrases affect processing differently. Yet while the Experiment 1 results are consistent with her Interpretive Domain and Prosodic Visibility Hypotheses as she applied them to a syntax-first model, the Experiment 2 results are not.

The results of both experiments, as well as the overall pattern of correlations between verb bias and naming times, support a constraint-based approach (e.g., Boland, 1997; Trueswell, Tanenhaus & Kello, 1993) with modification. In this modified approach, multiple syntactic structures are generated and weighted by frequency. Following Schafer (1997), intonation phrases mark interpretive domains that trigger wrap-up of semantic/pragmatic processing; intermediate phrases reduce visibility between a node and potential attachment sites. However, in addition to Schafer's hypotheses, boundary location has a separate effect on the weights of competing syntactic structures.

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# Parallel Positions

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Parallelism (similarities in internal structure) between conjoined elements facilitates their processing (Frazier, Munn, & Clifton 2000; Frazier et al. 1984; Mauner, Tanenhaus, & Carlson 1995). Parallelism can also influence the interpretation of ambiguous ellipsis sentences, such as *Ben defended a murderer in court, not Jack* (Carlson 2001, 2002, 2003): the similarity between *Ben* and *Jack* increases responses interpreting the remnant *Jack* as a subject (not an object) of *defended*. But how does this preference for parallel elements in parallel positions work? Here, we explore two aspects of this question: the kinds of internal positions where parallel elements can appear, and the kinds of external structures which give rise to parallelism.

First, what kinds of internal positions can parallelism affect? Carlson (2002) studied only structures ambiguous between subject and object interpretations, leaving open the possibility that parallelism can only distinguish between syntactic positions with different thematic roles. Experiment 1 (written questionnaire) thus tested whether lexical parallelism, or similarity in the syntactic form of NPs, could distinguish between two subject positions (1a-c). Condition (a), with *Mary* and the matrix subject (*John*) both proper names, did receive significantly more matrix interpretations (i.e., *Mary also said...*) than either the neutral (b) or embedded-biased (c) conditions ((1), p's<.05). The featural similarity between *Mary* and *John* in (a) favored an interpretation where these two arguments were subjects of the same verb, not just subjects of any verb, showing that parallelism is evaluated over a detailed syntactic or semantic representation.

Secondly, what syntactic structures lead to parallelism? Most work on parallelism is consistent with a theory in which certain connectives, like *and*, lead to expectations of similarity in their conjuncts (Kehler 2001). To test this hypothesis, Experiment 2 (auditory questionnaire) studied Antecedent-Contained Deletion (e.g., *John wanted his wife to invest in every stock his broker did*). In ACD, the remnant (*his broker*) is embedded inside a relative clause within two VPs, and no connectives signal that similarity of this remnant to another argument will be helpful. Still, it is an ellipsis structure, and ellipsis structures demand a certain amount of syntactic parallelism in order to be possible at all. Indeed, prosodic parallelism created by placing pitch accents on the matrix subject and the remnant, or on the embedded subject and the remnant (seen in (2)), had a significant effect on interpretation (p's<.01); the effect of lexical parallelism was marginal. Therefore ACD structures are ones in which parallelism operates, despite their obvious dissimilarity to conjoined structures. This suggests that parallelism is a more general property than it first appeared, one which can be important for non-conjoined ellipsis structures as well as conjoined structures with or without ellipsis. In general, we suspect that discourse situations of comparison or contrast give rise to such expectations of similarity.

## Examples

| Experiment 1 | % Matrix |
|---|---|
| (1)  a. John said the doctor went to Europe and Mary did too. | 60 |
|       b. John said Fred went to Europe and Mary did too. | 47 |
|       c. The doctor said Fred went to Europe and Mary did too. | 43 |

| Experiment 2 | % Matrix |
|---|---|
| (2)  a. John's WIFE wanted him to invest in every stock his BROKER did. | 35 |
|       b. John's wife wanted HIM to invest in every stock his BROKER did. | 24 |
|       c. JOHN  wanted his wife to invest in every stock his BROKER did. | 27 |
|       d. John wanted his WIFE to invest in every stock his BROKER did. | 19 |

# The mood of sentence complements: Assessing the influence of verb-specific information on parsing in Spanish

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This paper presents two self-paced reading experiments that examined the influence of verb-specific information on sentence processing in Spanish. We studied a particular type of information —the mood constraints a matrix verb imposes on a subordinate verb— that, to our best knowledge, had not been studied to date. Spanish affords us a way, that is not possible in English, to examine the role this information plays in the early stages of parsing. Since subcategorization for a subjunctive (or indicative) sentence complement (SC) is generally assumed to be a lexical property of verbs, the role of lexical information on parsing could be studied in a novel way by examining the (rapid or late) detection of mood anomalies. Such anomalies were created by using (1) verbs that subcategorize for a subjunctive SC and (2) verbs that subcategorize for an indicative SC, and by manipulating (3) the mood (subjunctive/indicative) of the subordinate verb. Thus, ungrammatical sentences were created by presenting a subordinate verb that did not satisfy the mood constraints imposed by the matrix verb.

In experiment 1 subjects read sentences such as those in (1):

**Examples**

(1)a.  La peluquera le ha aconsejado a la clienta$_i$ que (*pro$_i$*) llegue (subjunctive) antes de las diez
   [The hairdresser has advised the customer$_i$ that (*pro$_i$*) should arrive before ten o'clock]
 b.  *La peluquera le ha aconsejado a la clienta$_i$ que (*pro$_i$*) llegará (indicative) antes de las diez
 c.  La peluquera$_i$ le ha prometido a la clienta que (*pro$_i$*) llegará (indicative) antes de las diez
   [The hairdresser$_i$ has promised the customer that (*pro$_i$*) will arrive before ten o'clock]
 1.  *La peluquera$_i$ le ha prometido a la clienta que (*pro$_i$*) llegue (subjunctive) antes de las diez

Whereas verbs such as "aconsejar" (to advise) in (1a) and (1b) obligatorily require the subjunctive mood in the SC, verbs such as "prometer" (to promise) in (1c) and (1d) obligatorily require the indicative mood in that complement. In (1a) and (1c) the subordinate verb is in the mood required by the matrix verb. In (1b) and (1d) the subordinate verb is not in the mood required by the matrix verb, thus making the SC alternative ungrammatical. The mood anomalies can only be detected if verb-specific information has been accessed.

Experiment 1 aimed (1) to examine whether subjects are sensitive to such mood manipulations, and —in case they are sensitive— (2) to examine at which sentence region the anomaly is detected. The ANOVA showed increased reading times at the subordinate verb region in the ungrammatical conditions as compared to the grammatical ones. These results indicate that verb-specific information is already available to the parser at this region.

To further study the availability of this source of information, we run a second experiment that aimed to examine whether such information is made available as soon as the parser recognizes the main verb. For this purpose we used sentences such as those in (1) but with a major change: the order of the clauses was inverted, that is, the SC preceded the main clause. The results clearly showed that subjects detected the anomaly as soon as the matrix verb was encountered in the input string.

The combined results showed that a particular type of verb-specific information (regarding mood constraints on the subordinate verb) is activated as soon as the matrix verb is recognized and has a very rapid influence on sentence processing. This finding is in accordance with one of the claims of lexicalist parsing models, which assume lexical information plays a central role in the early stages of parsing.

# Comprehension of wh- movement structures in aphasia:
# Evidence from eyetracking

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Individuals with agrammatic Broca's aphasia show impaired comprehension of sentences with movement (Caramazza & Zurif 1976, among others). Sussman & Sedivy (2003), using an eyetracking paradigm, found that normal listeners show visual evidence of gap-filling during comprehension of sentences with wh- movement. At the position of a possible gap or trace in a wh- question, listeners looked to a picture corresponding to the wh- element. This study uses the same methodology to examine gap-filling for wh- movement structures in agrammatic aphasia. Results show that both normal and agrammatic participants' eye movements reflected their off-line comprehension of wh- movement structures. Further, for agrammatic participants, both comprehension and eye-movement patterns were more normal-like for simple wh- questions than for more complex object cleft structures. This result suggests that not all movement structures are equally impaired in aphasia, contrary to many grammar-based theories of agrammatic comprehension (e.g, Grodzinsky 1990).

Three individuals with mild to moderate agrammatic Broca's aphasia (ages: 58-78; WAB AQ: 58-78; 8-12 years post-stroke) and three non-agrammatic age matched individuals (one anomic aphasic patient and two non-brain-damaged controls, ages: 56-76) listened to brief stories like (1) followed by a beep and either an object wh- question (1a), an object-cleft sentence (1b), or a yes/no question (1c). They were instructed to respond aloud to the final sentence, either answering the question or judging the sentence true or false. Participants heard 30 experimental stories and 20 fillers while their eye movements were recorded. Visual displays accompanying the stories contained a picture of the critical sentence's subject (the boy in (1)), object (the girl), location (the school), and an inanimate distractor not mentioned in the story (a door).

Mean accuracy in responses to wh- questions was high for all participants: 100% correct for controls and 87% correct for agrammatics (above chance for all 3, $p$s<.05, Sign test). In addition, all six participants looked to the object more often or longer than the subject during the gap region of the wh- question (from onset of verb to onset of locative PP, underlined in (1)). All participants also showed more anticipatory looks to the object during the verb for wh- questions than for yes/no questions, in line with Sussman & Sedivy's findings for normal listeners. However, the agrammatics differed in their comprehension of object clefts: One agrammatic participant showed high accuracy (90%, cf. 87% accuracy for controls) but the other two agrammatics performed at chance (both 50% correct). Further, the controls and the agrammatic participant with high response accuracy looked to the object more often than the subject during the gap region for the clefts, but the two agrammatics performing at chance showed no evidence of gap-filling for clefts.

Together, these results demonstrate a tight link between on-line performance in eyetracking tasks and off-line sentence comprehension, even in disordered populations. Further, they show that not all wh- movement structures are equally impaired among agrammatics. This dissociation is surprising under many purely grammatical accounts of agrammatic comprehension, such as the original version of the Trace Deletion Hypothesis (Grodzinsky 1990) or the Double-Dependency Hypothesis (Mauner, Fromkin & Cornell 1993). Under such accounts, the relative complexity of a sentence containing a wh- movement dependency should not affect how difficult it is for agrammatic comprehenders. Rather, the result is in line with a recent account in which sentence complexity in addition to grammatical form plays a crucial role in recovery and generalization in aphasia (Thompson, et al, 2003). This account argues that the comprehension and production of a given sentence type by agrammatics (as well as its recovery) is predicted by the sentence's complexity. Among sentences involving wh- movement, the more complex a sentence, the harder it will be for agrammatic patients to produce and comprehend. More complex object clefts are therefore harder to comprehend, and more difficult for aphasics to recover during treatment.

## Examples

(1) This story is about a girl and a boy.
One day, they were playing at school.
The girl was pretty, so the boy kissed the girl.
They were both embarrassed after the kiss.

a.      Who did the boy <u>kiss that day at</u> school?
b.      It was the girl that the boy <u>kissed that day at</u> school.
c.      Did the boy kiss the girl at school that day?

# "Head position" in Ambiguity Resolution: On- and Off-line Effects
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This paper presents the findings of three experiments, all employing both on-line and off-line measures, which investigate the effect of Head position in the resolution of NP/0 ambiguity in wash-type (1a,b) and NP/SC ambiguity in believe-type (2a,b) structures.

(1a)   while the  waitress washed the *gleaming and shiny* <u>glasses</u> <u>fell</u> onto the floor

(1b)   while the waitress washed the <u>glasses</u> *which were gleaming and shiny* <u>fell</u> onto the floor

(2a)  the teenage girl believed the *loud and sudden* <u>comments</u> <u>were</u> only made because ...

(2b)  the teenage girl believed the <u>comments</u> *which were loud and sudden* <u>were</u> only made because ...

Fodor & Inoue (1998) propose a model of reanalysis where, for wash-type structures only, difficulty of recovery is proportional to the linear distance between the head of the ambiguous NP and the disambiguating region, making (1b) harder than (1a).  This Head position effect, however, is predicted not to occur for NP/SC, believe-type ambiguities.  Constraint-based approaches which assume that the same parsing process applies to all ambiguities must predict that Head position affects both wash and believe type structures similarly, contrary to Fodor & Inoue's model. In this case, the Head effect is here assumed to stem from support given to a just-completed linear pattern by the addition of the inserts (italicised), when that pattern corresponds to a representational schema resulting from the abstraction of distributional regularities in the input during acquisition.

Until recently, empirical data addressing Head position came mainly from off-line tasks where effects have been looked for, and found, for wash structures only (eg. Christianson et al, 2001). On-line empirical research has been inconclusive: Ferreira et al's (1993) eye-tracking study looks at wash ambiguities only, and finds no effect; Sturt et al (1999) compare both structural types, and find no on-line evidence of a head effect for either type; recently, Van Dyke & Lewis (2003) look for and find a (marginal) on-line effect for believe structures.

The three experiments presented here contribute to the debate by  providing on-line and off-line data for both types of ambiguity.  All employ a timed word-by-word self-paced reading paradigm and use stimuli such as (1a,b) and (2a,b) above which control for informational content and which compare the effect of Head position on the resulting garden path.  In addition, Expts 1 and 2 (a simpler, more powerful replication) also collect off-line comprehension data using a follow-up question to investigate the resulting semantic representation, after Christianson et al, whereas Expt 3, a web-based experiment, gathers  grammaticality judgments instead. In addition, subjects in experiments 1 and 2 underwent a Reading Span assessment. Findings are given below:

| | | | Expt 1 | Expt 2 | Expt 3 |
|---|---|---|---|---|---|
| **Online** | **Reading times** | Wash | -none- | Head effect ** | -none- |
| | | Believe | Head effect ** | Head effect * | Head effect * |
| **Offline** | **Comp. Qns** | Wash | Head effect * | Head effect * | |
| | | Believe | -none- | -none- | |
| | **Gram. Judg.** | Wash | ***p<.001   **p<.01   *p<.05  (F1 analyses) | | Head effect *** |
| | | Believe | | | Head effect *** |

On- and off-line effects of Head position were found for both types of ambiguity. The fact that similar effects were found for both structures supports the assumption that the same parsing process is being used throughout, even when task type changes. *Believe* items exhibited robust on-line effects of Head position, replicated three times, and off-line effects in the grammaticality judgment tasks, which run counter to predictions from the Fodor & Inoue model.  The fact that no off-line effects of Head were found in the resulting thematic representations of the *believe* items is perhaps a result of the overall comparative ease of reanalysis of these structures (a secondary finding). Reading Span modulates the Head position effects in *wash* ambiguities, with High span subjects exhibiting greater Head position-induced garden paths. If a parallel constraint-based model is adopted, with incoming information constraining the "flow" of activation from one analysis to another, any single analysis may be subject to a maximal activation.  Then, if High span readers are better able to maintain multiple analyses in parallel (eg. MacDonald et al, 1992), they may be less subject to ceiling effects, rendering the effect of the Head constraint more discernible. This would also explain the finding of an on-line effect for *wash* structures in Expt 2, as the mean Reading Span of the subjects was particularly high. A constraint-based approach can also potentially account for the difference in the overall garden paths induced by these structures by considering the *absence* of the comma and the *absence* of "that" as constraints, and taking into account their relative strengths.  Since such an approach is directly supported in its predictions for the Head effect, and a parallel version potentially provides explanations of the additional, rather complex, findings, I argue that a parallel constraint-based approach offers the best fit for this data.

# Processing Relative Clauses in Russian

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There are at least two general classes of theories of the processing of relative clauses (RCs) which are viable with all known RC processing behavior: resource-based theories (e.g., Gibson, 2000; Lewis, 1996) and surface word-order based theories (e.g., Bever 1970; MacDonald & Christiansen, 2002). This paper attempts to evaluate these theories using Russian as the target language. Like English, Russian is an SVO language. Unlike English, however, Russian allows scrambling of the verb and its arguments, so that all combinations of S, V and O are possible. We report the results of a self-paced moving-window word-by-word reading experiment, in which two factors were manipulated: (1) the type of extraction (subject- vs. object-extracted), and (2) the word order within the RC (non-scrambled vs. scrambled), resulting in four conditions: (a) non-scrambled/subject-extracted (SVO word-order in the RC), (b) non-scrambled/object-extracted (OSV word-order), (c) scrambled/subject-extracted (SOV word-order), and (d) scrambled/object-extracted (OVS word-order). See the example stimuli below.

The surface word-order theory predicts that non-scrambled/subject-extracted RCs should be easiest to process, because the word order in the RC (SVO) matches the default surface word-order in Russian. Depending on how the surface word-order theory is formalized, it may be consistent with a variety of possible predictions about the complexity of the other three conditions. For example, according to one version of a surface word-order theory, the complexity of a surface word order increases with the number of displacements (moved elements) from the default word order in a clause. According to this version of the theory, the OSV and SOV word orders should be the next most complex (one displacement each), with the OVS word order being the most difficult, because it requires two displacements from the SVO word order. Consider now the predictions of one resource-based theory, the dependency locality theory (DLT, Gibson, 2000). According to the DLT, local connections between dependent elements are easier to process than longer distance ones. Therefore, this theory predicts that the SVO and the OVS word orders (non-scrambled/subject-extracted and scrambled/object-extracted) should be easier to process than the OSV and the SOV word orders (non-scrambled/object-extracted and scrambled/subject-extracted).

The reading-time results are presented in Figure 1. The RTs during the critical region (the RC and the Verb) revealed a significant crossover interaction between scrambling and extraction-type, as predicted by the DLT, but not by the surface word-order based theories. Critically, the OVS word order (scrambled/object-extracted) was faster than the OSV or the SOV word orders. However, at the RC region, the non-scrambled/subject-extracted version was the fastest of the four conditions, in support of the word-order based theories. These and other theories will be evaluated in depth in the presentation.
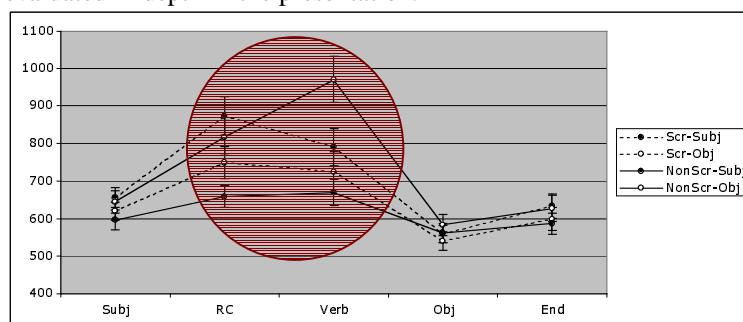


Figure 1: Reading times per region in the four conditions. The critical region is circled.
["Scr-Subj" = scrambled/ subject-extracted, "Scr-Obj" = scrambled/ object-extracted,
"NonScr-Subj" = non-scrambled/ subject-extracted, "NonScr-Obj" = non-scrambled/ object-extracted.]

## Examples

| | | |
|---|---|---|
| NonScr-Subj | Diktator <u>kotoryj   nenavidel dissidenta</u>   proiznes rech na sobranii | |
| [SVO] | dictator  who-Nom hated        dissident-Acc gave speech at meeting | |
| | 'The dictator who hated the dissident gave a speech at the meeting' | |
| NonScr-Obj | Diktator <u>kotorogo dissident       nenavidel</u> proiznes rech na sobranii | |
| [OSV] | dictator  who-Acc dissident-Nom hated        gave speech at meeting | |
| | 'The dictator who the dissident hated gave a speech at the meeting' | |
| Scr-Subj | Diktator <u>kotoryj     dissidenta      nenavidel</u> proiznes rech na sobranii | |
| [SOV] | dictator  who-Nom dissident-Acc  hated        gave speech at meeting | |
| | 'The dictator who hated the dissident gave a speech at the meeting' | |
| Scr-Obj | Diktator <u>kotorogo nenavidel dissident</u>       proiznes rech na sobranii | |
| [OVS] | dictator  who-Acc hated        dissident-Nom gave speech at meeting | |
| | 'The dictator who the dissident hated gave a speech at the meeting' | |

# Verbal Working Memory in Sentence Comprehension
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A major question in psycholinguistic research concerns the nature of the verbal working memory (WM) resources used in language processing. Some researchers (Caplan & Waters, 1999; cf. Just & Carpenter, 1992) have hypothesized that the verbal WM pool can be divided into two sub-pools: (1) verbal WM for natural language comprehension and production; and (2) verbal WM for non-linguistic verbally-mediated cognitive tasks. This paper attempts to empirically evaluate this hypothesis. One way to address this question is via dual-task paradigms in which participants perform two tasks simultaneously: (1) on-line sentence processing, and (2) a non-linguistic verbally-mediated task. The underlying assumption is that we should observe a super-additive interaction when the complexity of both tasks is high only if the two tasks rely on overlapping pools of resources. Previous dual-task experiments found either no interaction or only a suggestion of one (e.g. King & Just, 1991; Just & Carpenter, 1992; Caplan & Waters, 1999; Gordon et al., 2002). In all of the previous experiments, however, the secondary task involved storage of words or digits across the sentence-processing task. Crucially, the storage component of on-line sentence comprehension is unlike the storage involved in keeping track of a list of unconnected items. Consequently, it is possible that the lack of on-line interactions between syntactic complexity and memory load in earlier studies could be a result of the distinct nature of the storage processes involved. Moreover, there have been no previous attempts to explore the potential interaction between integration processes in sentence comprehension and secondary verbally-mediated tasks, which involve similar but non-linguistic on-line integration processes. In the current paper, we propose a novel paradigm to address this issue.

In Experiment 1, participants simultaneously performed a self-paced reading task and a self-paced arithmetic addition task in a 2x2 design crossing syntactic complexity (low, high) and arithmetic complexity (low, high). The on-line addition task is similar to on-line sentence comprehension in that an incoming element – a number – must be integrated into the representation constructed thus far: the working sum. Since there was no difference in linguistic complexity between the easy and hard arithmetic conditions, a super-additive interaction between the two tasks when the complexity of both tasks is high would indicate that the verbal WM resources that are involved in performing the arithmetic task overlap with those that are involved in syntactic integration processes. In contrast, if language processing relies on an independent verbal WM resource pool, there should be no such interaction. In addition to two main effects, we observed a significant interaction between syntactic and arithmetic complexity during the critical region of the linguistic materials (Fig. 1): participants processed the complex/complex condition more slowly than would be expected if the two tasks relied on independent resource pools. To address a potential confound of shared attentional resources in dual-task paradigms, Experiment 2 was conducted, where participants simultaneously performed a self-paced reading task and a self-paced spatial-rotation task in a similar 2x2 design crossing syntactic complexity with the complexity of the spatial task. Critically though, the spatial-rotation task does not rely on verbal WM resources, and should not therefore interact with the sentence-processing task if the cause for the observed interaction in Experiment 1 is an overlap in the use of verbal WM resources. As in Experiment 1, there were two main effects of complexity in the critical region. However, in contrast to Experiment 1, these effects were strictly additive, with no trace of interaction (Fig. 2). The results of the two experiments therefore support a WM framework where on-line linguistic processing and on-line arithmetic processing rely on overlapping pools of verbal WM resources.
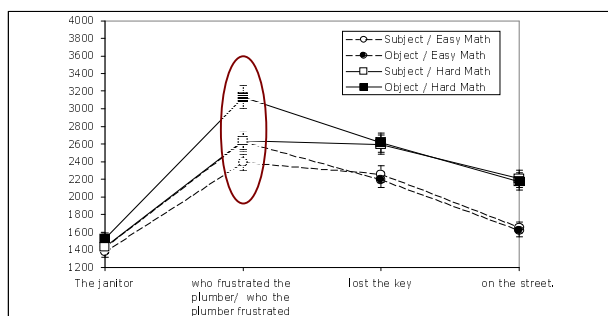


Figure 1: Reading times per region in the four conditions of Experiment 1. The critical region is circled.
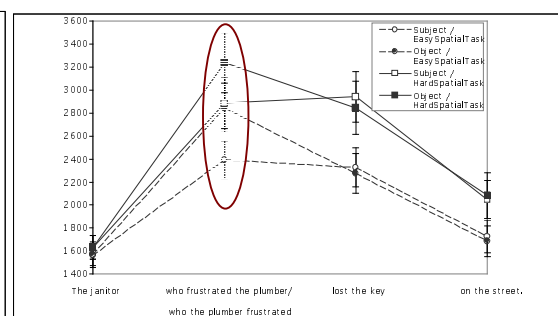
Figure 2: Reading times per region in the four conditions of Experiment 2. The critical region is circled.

# Processing Polysemy: Making Sense of Sense

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Three eye movement studies addressed questions about processing polysemous words during reading for comprehension, without any superimposed judgment task. They were motivated by the hypothesis that the processor may remain uncommitted to a particular sense of a polysemous word in the absence of biasing evidence. Experiment 1 employed sentences like (1) where a polysemous word like "book" was later disambiguated (by "tattered" or "enjoyable"). Disambiguation to the subordinate sense took no longer than to the dominant sense. Further, disambiguation to the subordinate sense ("tattered") took no longer to read when there was no prior disambiguation "book cover" than when determination of the appropriate sense was present. These results are expected if readers need not commit to a particular sense of a word in the absence of biasing context. When additional information is processed, readers can then home-in on a particular sense of the polysemous word.

Experiment 2 addressed the question of whether readers must commit to a particular sense at the end of a sentence, even without biasing information. If so, then across sentence boundaries readers should show disruption at the disambiguation when it favors the subordinate sense of the polysemous word and there is no preceding bias to the subordinate sense. Results from 40 subjects in an Eyelink eyetracking experiment disconfirm that prediction for items like those used in Experiment 1. Sentence 1 either left the interpretation of "book" undetermined or biased the interpretation towards the dominant (content) or subordinate (physical object) sense. Sentence 2 disambiguated "book" to either sense. No reading time differences were found on the disambiguating region of sentence 2 when sentence 1 was either unbiased or biased towards the appropriate sense. In addition, no inflated re-reading times were detected on the unbiased polysemous word in sentence 1 when it was later disambiguated towards the subordinate sense. Thus, across sentence boundaries too, there is no indication that late disambiguation to a subordinate sense creates a disruption for a polysemous word like "book."

Various indications suggest that not all polysemous words are processed alike. We suspect that a wide variety of distinct types of polysemy exist. One clearly different type of polysemy than the "book"-type involves the derivation of new word senses using lexical rules, e.g., fruit –> tree (Copestake & Briscoe, 1995). Experiment 3 examined both the underived and derived senses of fruits using sentences like (2). Eye movements in these sentences patterned entirely differently than in Experiments 1 or 2, with longer reading times on the disambiguation for the subordinate/derived sense of the word and more rereading of the polysemous word ("olive") when the derived sense was instantiated. In other work (in progress) we also find small but reliable effects of derived lexical senses of words, e.g, the count noun counterpart of mass nouns, derived (we assume) by a lexical rule of portioning. Thus, one basic division in word processing is between homophony (ambiguity) and polysemy. Another is between different types of polysemous items, each with a distinct processing complexity profile.

## Examples

(1) Mary thought that the book (cover) looked tattered/enjoyable and on further inspection it turned out that she was right.

(2) The peasant noted that the olive (tree) was very tall/ripe, which was due to the exceptional weather.

## Reference

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# The Source of Syntactic Illusions

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Many studies have investigated sentences that are grammatical but difficult to parse, due to ambiguity or complexity, but very few have investigated sentences that are ungrammatical but are perceived as acceptable (cf. Gibson & Thomas, 1996), which we refer to as 'Syntactic Illusions'. This paper investigates the source of the syntactic illusion in (1), noted by Montalbetti (1984), which is perhaps the best-known syntactic illusion, but has not been systematically investigated. (1) is impossible due to the absence of a compatible sortal in the comparative clause that can be compared to the sortal people in the main clause. Results from our questionnaire studies show that although the illusion is real, it does not reflect lack of semantic competence, and arises specifically when the resolution of a comparative construction is masked by the resolution of VP-ellipsis.

(1)        More people have been to Russia than I have.                                    [syntactic illusion]

Experiment 1 (acceptability rating, n=25, Latin Square design) confirmed that the illusion is genuine in normal informants. Sentences in the syntactic illusion condition (1) were rated just as highly as grammatical phrasal comparatives (2), and higher than ungrammatical examples in which the VP-ellipsis in (1) has not applied (3). Importantly, in sentences that are just like (1) but lack extraposition (4), ratings were just as low as in the ungrammatical condition (3). This shows that speakers do have sensitivity to the lack of a compatible sortal for the comparative, and thus indicates that the illusion in (1) is specifically associated with extraposition contexts, and not with general 'semantic blindness'.

(2)        More people have been to Russia than just me.                                    [phrasal comparative]
(3)        More people have been to Russia than I have been to Russia.          [no ellipsis]
(4)        More people than I have have been to Russia.                                    [no extraposition]

Experiment 2 (n=12) demonstrated a reverse illusion in sentences involving comparative deletion (CD: 5-6), providing evidence that the illusion in (1) is also specifically related to the presence of VP-ellipsis, and does not reflect deletion processes in general. The well-formed CD in (5) was rated highly. Ironically, this semantically coherent comparative was judged significantly less acceptable than the illusion in (1) when the comparative clause was extraposed (6).

(5)        Taller people than I am have been to Russia.                                    [comparative deletion]
(6)        Taller people have been to Russia than I am.                                    [comp. del. + extrapos.]

Based on the finding that the syntactic illusion with comparatives is specifically associated with the combination of VP-ellipsis and extraposition, we propose that the illusion arises from the fact that acceptable VP-ellipsis resolution masks the failure of comparative deletion in sentences like (1). English allows comparative deletion involving either syntactically parallel (7) or non-parallel deletion sites (8). Importantly, English also allows occurrences of comparative deletion (9) to be embedded inside occurrences of VP-ellipsis (10).

(7)        More Germans have been to Russia than $<_{CD}$ Germans> have been to China.      [parallel CD]
(8)        More Germans have been to Russia than I have met $<_{CD}$ Germans>.                [non-parallel CD]
(9)        John looks taller than Bill looks $<_{CD}$ tall>.                                    [CD only]
(10)      John looks taller than Bill does $<_{VPE}$ look $<_{CD}$ tall>>                      [CD inside VP-ellipsis]

We suggest that a deletion site is preferentially resolved in parsing using a local antecedent, accounting for the higher acceptance of comparative deletion (5 > 4) in non-extraposed contexts, and the higher acceptance of VP-ellipsis (1 > 6) in extraposed contexts. Furthermore, successful resolution of the VP-ellipsis in (1), paired with the knowledge that English allows VP-ellipsis sites to contain a comparative deletion site, gives rise to the illusion of acceptability in (1).

We compare the detailed contrasts in acceptability predicted by our account with the broader array of syntactic illusions predicted by the account sketched by Townsend & Bever (2001), who propose that (1) is acceptable as a result of (somehow) merging the two acceptable templates in (11-12).

(11)      More people have been to Russia than I (could believe).
(12)      …people have been to Russia [more (often)] than I have.

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# Processing Crossed Dependencies in English

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It has long been noted that certain structures with crossed dependencies in English are complex to process or even ungrammatical (Rochmont & Culicover, 1990; Givón, 1993). For example, it is difficult to interpret (1) such that the PP "on the hill" modifies "saw", and the PP "with the telescope" modifies "the girl", because this interpretation results in crossed dependencies. In this paper we investigate whether the difficulty of arriving at a crossed-dependency structure in examples like (1) is due to processing difficulty resulting from (A) a linguistic-structure constraint or (B) a resource limitation:

A: Linguistic structure constraint: The linguistic structure underlying crossed dependencies / extraposition is difficult to process because it violates grammatical expectations.

B: Resource limitation: Dependencies connecting words to intermediate attachment sites in the current structure are difficult to obtain because they tax memory resources.

The resource hypothesis is motivated by the observation that attachment to the middle site of a three-NP-site ambiguity is more difficult to obtain than attachment to the first or last site, as in (2) (Gibson et al., 1996).

This paper will present results from two self-paced moving-window word-by-word reading experiments that tested the two hypotheses with respect to processing relative clauses (RCs). Both experiments were 2x2 designs, crossing the RC attachment-site (local vs. intermediate NP) and the attachment-site of the preceding PP (NP vs. VP). (See (3) for an example item from Experiment 2.) Crucially, attaching the PP "of the movie" to the preceding NP "the star" results in a structure in which the RC crosses no dependencies in attaching to either the local NP site ("movie") or the intermediate NP site ("star"). In contrast, attaching the PP "about the movie" to the verb "interviewed" results in a structure in which the RC crosses the PP-verb dependency for the intermediate attachment to "star". As a result, the resource hypothesis predicts a main effect of RC attachment site, such that the intermediate attachment should be slower than the local attachment. In contrast, the structural constraint hypothesis predicts an interaction between the two factors, such that crossed dependent attachment (3a) should be slowest of the four.

In experiment 1, number agreement disambiguated the RC attachment, whereas two cues provided disambiguation in experiment 2: the animacy of the relative pronoun and the plausibility of the NP-RC relationship. There were no RT differences in either experiment prior to the disambiguation region. RTs showed strong support for the structural constraint in the disambiguating region: an interaction driven solely by slow RTs for the crossed dependency condition. The results therefore provide evidence for the existence of a structural constraint in English dependency-structure syntax such that crossed dependencies/extraposed structures are more complex than non-crossed-dependency structures. The presentation will also present data from additional experiments investigating what factors make crossed dependencies easier/harder to process, such as the coherence relation between the extraposed element and its head (Kehler, 2002) and the type of verb in the main clause (Givon, 1993).

**Examples**:
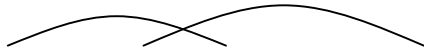
(1) The boy [VP saw [ NP the girl ] [PP on the hill ] [PP with the telescope] .

(2) [NP1 The lamps near [NP2 the painting of [NP3 the houses ]]] [RC that was damaged in the flood ] …

(3) a. VP, non-local: The reporter interviewed the star about the movie who was married to the famous model.
    b. VP, local: The reporter interviewed the star about the movie which was filmed in the jungles of Vietnam.
    c. NP, non-local: The reporter interviewed the star of the movie who was married to the famous model.
    d. NP, local: The reporter interviewed the star of the movie which was filmed in the jungles of Vietnam.

# Can speakers order a sentence's arguments while saying it?

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The present experiment is part of a series to learn when speakers may make decisions regarding argument order and sentence structure. Some theories hold that speakers make early commitments to the structure of their sentences, with many major decisions made before sentence onset (Bock, 1987; Ferreira, 2000). For example, selection of a verb commits a speaker to an elementary tree structure that orders its arguments in Ferreira's TAG model. Other theories posit that people can and do create sentence structures more incrementally (e.g., Chang, Dell, Bock, & Griffin, 2000; Kempen & Hoenkamp, 1987).

Eye movements provide valuable information regarding when people plan their words (Griffin & Bock, 2003). Speakers gaze at referents as they prepare words to refer to them (Griffin, 2001; Meyer et al., 1998). Events of giving such as a student offering an apple to a teacher provide describers with a choice between two sentence structures (see 1-2 below). The prepositional dative places the theme immediately after the verb whereas the ditransitive places the goal in that position. Across multiple tasks, indecision is associated with eye movement shifts between visible choices (e.g., Russo & Rosen, 1975). We hypothesized that shifts in gaze between the theme and goal would be more frequent when speakers were uncertain of which argument to mention after the verb (or which structure to use). Moreover, the point in time when the increase in shifts occurred would indicate whether speakers decided structure and order prior to or during the articulation of sentences.

A first experiment (Griffin & Garton, 2003) indicated that speakers shifted their gaze between the theme and goal significantly more often when they generated an answer like (1) to (3) compared to (4), where the argument order (and wording) was provided in the question. Although gaze durations tend to decrease as word preparation becomes easier, it is unlikely that repetition priming from the words in the question would decrease gaze shifts (i.e., the number of times a gaze on the theme or goal was followed by a gaze on the other argument). The difference in shifts was only significant for the time between the onset of the subject noun and the onset of the main verb (e.g., "boy is"), when speakers typically begin preparing post-verbal nouns (Griffin & Bock, 2000). The difference was significant both for raw shifts and shifts per second, which controls for differences in speech duration. This result supports the idea that speakers may decide the order of their arguments at the last second and thus, structure sentences while uttering them.

In the present experiment, we recorded the speech and eye movements of 24 participants as they described pictures that were preceded by word pairs that were associatively related (5) or unrelated (6) to the theme. This manipulation eliminates the lexical priming component of the first experiment. Associated words tend to have little or no effect on speed of object naming (Lupker, 1979), although they should make the themes more available conceptually, leading them to be mentioned earlier than goals (Bock, 1987). Prepositional datives were the favored structure for pictures in earlier experiments. Theme-related words should strengthen the bias to produce prepositional datives, reducing uncertainty about which argument to express immediately after the verb, and thereby reducing the number of theme-goal gaze shifts relative to the unrelated condition. Based on the Chang et al model and earlier results, we predicted that fewer shifts would take place after speech onset (between the onsets of the subject noun and main verb) when speakers were primed with related word pairs. Preliminary analyses confirm that we replicated Bock's effect and speakers produced 8% more prepositional datives after theme-related words. Eye movement analyses are underway to determine whether this priming effect influenced gazes prior to or during speech. Results that again suggest that arguments were ordered during speech would seriously challenge models of sentence production in which speakers must make early commitments to specific argument orders and syntactic structures.

## Examples

(1) Prepositional dative: A boy is handing an apple to a teacher (SOURCE THEME GOAL)
(2) Ditransitive: A boy is handing a teacher an apple (SOURCE GOAL THEME)
(3) Intransitive: Is a boy sitting on a couch?
(4) Prepositional dative: Is a boy handing an apple to a teacher?
(5) Theme-related words: RED CIDER
(6) Unrelated words: THIRST COLD

# Effects of visual and verbal Feedback on Alignment

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It's been shown that restrictions on feedback in communicative tasks have an important impact on how speakers ground their communicative acts and the effectiveness of it. Generally speaking, the more interlocutors are allowed to interact, the quicker they solve communicative tasks, and, on a linguistic level, the quicker they agree on referring expressions for objects under discussion.

Whereas the effects of verbal feedback have so far been mainly investigated with respect to linguistic measures (e.g. number of words per referring expression), the effects of non-verbal feedback were thought of as mainly influencing a more emotional component of communication. However, recent research has shown that visual feedback (in terms of a shared work space) also has an effect on the smoothness and effectiveness of the communication (less pauses, less overlap, e.g., [1]).

In our study we investigated the effects of visual and verbal feedback on alignment, e.g., on the number of words in a referring expression in a communicative task.

Two subjects were each seated in front of a monitor, separated by a dividing wall. Their task was to bring a set of tangrams into their predefined target positions on a grid. The participants took turns in giving instructions on which tangram was to be moved into which position.

In a between subjects design, we varied the type of feedback participants could give. In the full-feedback condition subjects were allowed to talk freely, additionally the monitors were connected, so that participants could see which item was moved by their partner. In the verbal feedback condition, subjects were allowed to talk freely, but their monitors were unconnected. In the visual feedback condition no verbal feedback was allowed, but the monitors were connected. In the no-feedback condition, addressees were neither allowed to talk nor were the monitors connected.

For full feedback we expected alignment to be most effective, and for verbal feedback fewer words were expected per referring expression than for visual feedback. This assumption conforms with an alignment model in which entrainment is achieved through "channels" connecting respective (linguistic) levels in interlocutors [2].

We analysed several measures for alignment, e.g. the number of words used for a referring expression, number of disfluencies, and success of the descriptions. The combination of both feedback modalities was the most effective condition across all measures, followed by the verbal feedback condition. With visual feedback only, however, alignment turned out not to be consistently worse than the verbal only condition. Without feedback, subjects used more words initially and over time approached the average number of words of the visual feedback condition.

The results suggest that visual feedback is less effective than verbal feedback in a communicative task as the one described above. Nonetheless, visual feedback obviously not only has effects on more emotional components of communications but can also have similar effects on linguistic measures like, e.g., the number of words used in a referring expression, as verbal feedback.

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# The role of function words in lexical access and syntactic processing

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This paper examines two hypotheses concerning the role of function words in lexical access and syntactic processing. *Function word stripping* claims that the phonological, statistical, and acoustic properties of function words allow listeners to quickly segment them, so that any word immediately following a function word will be rapidly identified. *Function word predictiveness* holds that the rapid identification of function words enables listeners to make predictions about the grammatical categories of upcoming words, speeding up access only to words that are strongly predicted to follow. We show that function word predictiveness more accurately reflects the role of function words in syntactic processing.

Christophe et al. (1997) found what they called a function word stripping effect on lexical access. In their phoneme-monitoring task, French-speaking subjects found target phonemes faster at the boundary between a function word and content word than between two content words. In this experiment, constituents of target noun phrases always occurred in the order Det N Adj, so the content word following the function word was always the syntactic head of the NP and hence was predicted by the Det. Since English reverses the position of adjective and noun, English NPs allow us to test whether speeded reaction times to target items located on the N were due to their adjacency to a determiner or to their grammatical category. If speeded RTs in the French experiment were due to function word stripping, then we expected faster RTs to targets located on adjectives in English than to those located on nouns. But if speeded RTs in French were due to function word predictiveness, then we expected slower RTs to targets located in adjectives in English than to those in nouns.

In addition to testing for a grammatical category effect, we examined the role of the prosodic environment of the target. We predicted that the presence of nearby prosodic boundaries would vary the strength of the cue to function word identification. Thus, target NPs were located either sentence-initially (at an intonational phrase boundary) or sentence-medially (inside an intonational phrase), with stress patterns and length controlled for up to the point of target onset. The determiners used were balanced between *a*, *the*, *his*, and *her*, and all nouns and adjectives contained in target NPs were monosyllabic and controlled for frequency. Target phonemes appeared only once in a sentence.

**Examples**

Noun condition / sentence initial condition:
[The tough neck] of the turtle protected him from the family dog.
Noun condition / sentence medial condition:
Harvey wore [a brave smile] to fifth grade P.E. every morning.
Adjective condition / sentence initial condition:
[The gray fort] loomed over the coastline as the pirates approached.
Adjective condition / sentence medial condition:
Mother gave him [a neat tool] from the Sears catalog for Christmas

47 English-speaking subjects were visually presented with a target phoneme they were to listen for in the following auditorily presented sentence. Results showed a main effect of the sentential position of the NP (initial or medial) ($F(180)=13.4$, $p <.001$) and an interaction of position with the grammatical category of the word containing the target phoneme (adjective or noun) ($F=(180)$, $p<.001$). Crucially, in sentence-initial position, average RTs to adjective targets were significantly slower than those to noun targets ($t(90)=2.215$, $p< .03$).

These results support the function word predictiveness hypothesis and not the function word stripping hypothesis because access to the first content word following the function word was slowed rather than speeded up sentence-initially. In addition, because there were no differences in RTs to nouns vs. adjectives sentence-medially, we conclude that function word identification is more accurate at prosodic phrase boundaries than within phrases.

# Prosodic disambiguation of participle constructions in English

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We explore the effects of prosodic structure on ambiguous participle constructions in English as in (1), where '-ing' form can either describe the action of the main subject, *Aaron*, (high attachment) or that of the immediately preceding noun phrase, *a poor guy* (low attachment). We extend work by Price, Ostendorf, Shattuck-Hufnagel & Fong (1991) who showed prosodic disambiguation for this type of sentences in English.

**Examples**

(1)  Aaron followed a poor guy drinking his soda.
   a. [Aaron followed]$_{IP}$ [a poor guy drinking his soda]. (earlyIP)
   'A poor guy was drinking his soda.' (low attachment)
   b. [Aaron followed a poor guy] $_{IP}$ [drinking his soda]. (lateIP)
   'Aaron was drinking his soda.' (high attachment)

A written comprehension study was conducted to obtain baseline preferences in reading. Participants read ambiguous sentences from a computer monitor and completed two tasks, answering comprehension questions such as "Who was drinking soda?" with '1 definitely *Aaron*', '2 possibly *Aaron*', '3 either *Aaron* or *the poor guy*', '4 possibly *the poor guy*', or '5 definitely *the poor guy*,' and rating the acceptability of each interpretation on a 5-point scale, (1='acceptable' and 5='not acceptable'). The mean response for the comprehension question was 3.23, indicating the ambiguity of these constructions and a bias toward the low attached reading. Similarly, results in the acceptability rating task showed that both readings of the sentence were fairly 'acceptable'. We also found that readers considered the low-attached reading (mean 1.98) to be more acceptable than the high-attached reading (mean 2.38).

We investigated the effect of prosody using spoken versions of the same materials. We predicted that an Intonational Phrase (IP, hereafter) boundary before the ambiguous '-ing' form (lateIP) would induce more high attached readings, while an IP boundary in a previous location in the sentence (earlyIP) would result in more low-attached readings. After listening to one prosodic rendition of each sentence, participants answered the same comprehension questions as in the written study, using the same five options and rated each interpretation using the same 5-point scale. The mean comprehension response for EarlyIP sentences (3.74) showed that they were most often interpreted as low attached. The mean for LateIP sentences was significantly lower, 2.82 (t=9.28, p<0.01), showing that they were less likely to be interpreted as low-attached (see Figure 1). Acceptability ratings also showed that, while all pronunciations were relatively acceptable, in the earlyIP condition, the high attachment interpretation was significantly less acceptable (2.82) than that for low attachment (1.59) (t=13.2, p<0.01). The opposite was found in the lateIP condition, where the high attachment reading (1.97) was significantly more acceptable than that for low attachment (2.27) (t=-3.34, p<0.01). Also noticeable was the fact that low-attached sentences pronounced with earlyIPs were more acceptable than high-attached sentences with lateIPs (1.59 vs. 1.97), which suggested that the syntactic bias for low attachment (from the reading study) interacted with prosodic phrasing during comprehension. Another possibility is that the late IP pronunciation is consistent with both a high-attached reading of the sentence and a non-restrictive reading of low-attached interpretation of the participle phrase.
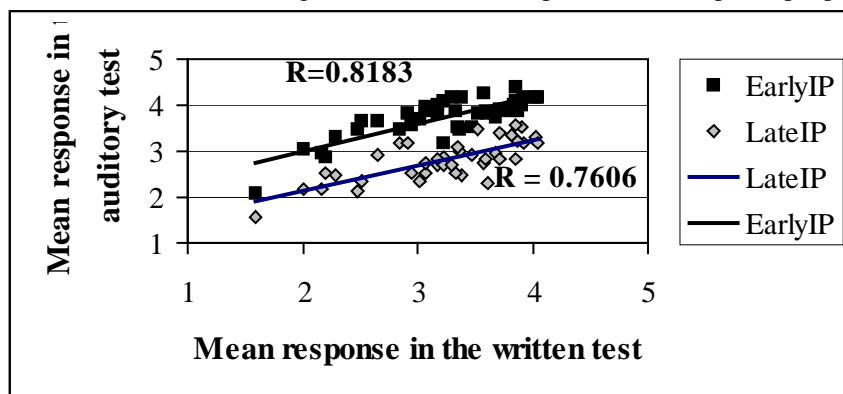


Figure 1. Written and auditory responses for comprehension questions. 1 indicates a high-attached reading and 5, a low-attached reading.

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# Different Time Courses of Integrative Semantic Processing for Plural and Singular Nouns: Implications for Theories of Sentence Processing

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The research investigated the time course of integrative semantic processing during sentence processing. The results of two on-line reading experiments demonstrated that the semantic integration of a noun with a preceding adjective occurred more rapidly when the noun was plural than when the noun was singular. Reading time was measured on sentences containing an NP composed of an adjective and a noun whose combined meaning was plausible or anomalous (Experiment 1) or was typical or atypical (Experiment 2). Sample sentences from Experiment 1 are shown in 1. Sample sentences from Experiment 2 are shown in 2. In both experiments, reading time was measured using a self-paced moving window. Slashes indicate presentation boundaries. The results showed that the effects of semantic plausibility and typicality were observed immediately during the processing of plural nouns, but were observed at a delay for singular nouns, occurring on sentence regions following the singular nouns. The results suggest that the time course of integrative semantic processing may be linked with comprehenders' analysis of the incoming noun as the head of the noun phrase versus the first noun in a noun compound. Plural nouns are more rarely compounded than singular nouns (Haskell, MacDonald, & Seidenberg, 2003; c.f., Gordon, 1985; Kiparsky, 1982) and may be more rapidly identifiable as the head of the noun phrase. Implications for theories of sentence processing will be discussed.

**Examples**

1　　Plural Noun – Anomalous
　　a.　Fred /read /that /the careful /castles /had been /studied /for /centuries /by historians./
　　Plural Noun - Plausible
　　b.　Fred /read /that /the ancient /castles /had been /studied /for /centuries /by historians./
　　Singular – Anomalous
　　c.　Fred /read /that /the careful /castle /had been /studied /for /centuries /by historians./
　　Singular - Plausible
　　d.　Fred /read /that /the ancient /castle /had been /studied /for /centuries /by historians./

2　　Plural Noun – Atypical
　　a.　Hank /said /that /the sugary /olives /were /likely /the source /of the /bacteria./
　　Plural Noun - Typical
　　b.　Hank /said /that /the salty /olives /were /likely /the source /of the /bacteria./
　　Singular Noun - Atypical
　　c.　Hank /said /that /the sugary /olive /was /likely /the source /of the /bacteria./
　　Singular Noun - Typical
　　d.　Hank /said /that /the salty /olive /was /likely /the source /of the /bacteria./

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# Locality, Frequency, and Obligatoriness in Argument Attachment Ambiguities

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One current issue in sentence processing is the time course in which various types of information influence the parser. The goal of this self-paced reading time study was to investigate whether the attachment of the ambiguous preposition in the examples below is initially influenced by structural principles alone, or whether various non-structural factors also play a role. The prepositional phrase (PP) complement in (1) and (2) may attach to one of two verbs, where the first verb (*put*) obligatorily requires a locative and the second verb (*coax, hurl*) optionally allows one. Additionally, the co-occurrence frequency of the embedded verb for an optional PP complement was manipulated, such that the verb typically appeared with a PP complement (e.g. *coax, hurl*), typically did not appear with a PP complement (e.g. *leave, move*), or had a neutral bias for a PP complement (e.g. *throw, drop*).

Residual reading times were investigated at two points of interest in each sentence: the first PP and the disambiguation region (the pronoun in the 1-PP condition, and the second preposition in the 2-PP condition). Comparisons were made within condition, and sentences (a) and (b) served as both test sentences and control sentences at different points in the sentence. For example, (1b) served as the control for (1a) at the initial preposition: (1b) is ambiguous and whichever attachment is made is unproblematic at this point. On the other hand, the preposition "onto" in (1a) is only compatible with the main verb. Reading times were expected to be slower at this point if "onto" was initially attached to the embedded verb "stained". Similarly, (1a) served as the control for (1b) at the pronoun. It was assumed that "onto" in (1a) was correctly assigned to "put" by this point in the sentence, thus no reading difficulty was expected to occur at "he". In (1b), however, the preposition "into" may or may not have been attached to "put". If "into" had been assigned to the embedded verb, the pronoun would cause reanalysis to occur and reading times were expected to be slower at this point in (1b) than in (1a).

Three experiments tested the predictions made for the sentences in (1) and (2) by the Garden Path Theory (GPT; Frazier 1979), the Dependence Locality Theory (DLT; Gibson 1998, 2000), and the Late Assignment of Syntax Theory (LAST; Townsend & Bever 2000). The GPT and the DLT predicted reading difficulties in (1). Specifically, the GPT predicted a garden path effect at the preposition "onto" in (1a), and both theories predicted a garden path effect at the pronoun "he" in (1b). The LAST predicted a garden path effect at the initial preposition, "at", in (2a), and another garden path effect at the second preposition, "into", in (2b). None of these theories predicted that the attachment of the initial preposition in these structures might be influenced by the bias of the embedded verb for a PP complement.

The sentences in (1) elicited reading difficulties regardless of the bias of the embedded verb. These results suggest that the preposition was initially attached to the embedded verb, and that this attachment was made on the basis of structural information alone. However, (2a) elicited a garden path effect when the embedded verb was biased against a PP complement. When the embedded verb typically appears with a PP complement or has a neutral bias for a PP complement, it appears that the initial preposition is initially attached to the embedded verb (which is the correct parse). However, when the embedded verb was biased against a PP complement, it appeared as if the initial preposition was initially attached to the main verb, suggesting that verb bias may also initially inform the parse.

None of the three theories considered was able to account for the entire set of results. The GPT correctly predicted that (1a) would be read more slowly than (1b) at the preposition "onto", and that (1b) would be read more slowly than (1a) at the pronoun "he". The DLT correctly predicted that (1b) would be read more slowly than (1a) at the pronoun, but failed to predict that a preposition would be associated with an incompatible verb in (1a). The GPT and the DLT each failed to predict that there would be reading differences between the sentences in (2) when the embedded verb was biased against a PP complement. Finally, the LAST failed to account for the findings from all three experiments. A variable-choice model that permits verb-specific information to influence attachment may account for the results.

## Examples

(1) 1 PP: Ambiguity resolved immediately (a) or later in sentence (b), at bolded word; underlined word ambiguous
  (a)  Gavin put the jacket that Jodi stained **onto** the coat rack before he took off his hat.
  (b)  Cole put the rabbit that Abby coaxed <u>into</u> its carrier before **he** took it home.

(2) 2 PPs: Ambiguity resolved immediately (a) or later in sentence (b), at bolded word; underlined word ambiguous
  (a) Gavin put the jacket that Jodi hurled **at** the closet onto the coat rack.
  (b) Cole put the rabbit that Abby coaxed <u>into</u> the living room **into** its carrier.

# The use of relational vs. typical participant information in sentence processing

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The rapid use of lexically encoded participant information in interpreting sentences is now well established. What is more controversial is the nature and form of the participant information that is used. The *typicality hypothesis* articulated, e.g., in McRae et al. (1997) holds that this information consists of a list of typical properties of fillers of participant roles (e.g., *mean* for the agent of *frighten*) and of typical participants in events denoted by verbs (e.g., *waitress* for the agent of *serve*). In contrast, the *relational hypothesis* articulated in Mauner, et al. (1995), and others, holds that this information *also* includes more abstract, relational, information about the role *both* typical and atypical participants play in the denoted events (e.g., causality, volition, see Dowty, 1991). Koenig et al. (2003) provide evidence supporting the latter view. They first argue that some verbs require and lexically encode an instrument participant role (*scratch*) while others only allow and do not lexically encode an instrument (*vandalize*). They then show that, even when WH-fillers were judged equally plausible, the post-verbal regions of sentences that contain a verb that encodes an instrument role (*scratch* in (1)), are read faster than that those that contain a verb that does not encode an instrument role (*vandalize* in (1)), as the relational hypothesis would predict.

But, another interpretation of Koenig et al.'s results that is compatible with the typicality hypothesis is that their fillers (e.g., *key*) primed the situations evoked by the instrument verbs (e.g., *scratch*) more than the situations evoked by the non-instrument verbs (e.g., *vandalize*), along the lines of McRae et al. (2001). To exclude this possibility, we conducted two distinct region-by-region self-paced reading experiments with a secondary incremental make-sense judgment in which fillers were either abstract names for instruments (e.g., *implement, tool, device, utensil,* (2)) or the inanimate WH-pronoun *what* (3) (regions indicated with (|)).We found that the italicized post-verbal regions in (2) and (3) were read faster in the lexically encoded obligatory instrument verb condition (*scratch*) than in the non-encoded optional instrument verb condition (*vandalize*).

Note that WH-fillers in these experiments contributed either no semantic content or no content aside from naming the role played by the questioned object. Therefore, they cannot differ in typicality across instrument and noninstrument verb conditions in the sense of McRae et al. Only the relational hypothesis predicts the obtained reading time differences. Thus, the results of these two experiments confirm Koenig et al. (2003) and suggests that not all lexical semantic information relevant to on-line processing can be reduced to typicality of participants.

**Examples**

(1)    Which key | did the teenagers | scratch/vandalize | the girl's new car with | last night?
(2)    Which implement | did the teenagers | scratch/vandalize | *the girl's new car with* | *last night*?
(3)    What | was the girl's new car | scratched/vandalized | with | *in the parking lot* | *last night*?

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# The on-line establishment of hyperonymic anaphorical relations

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One of the most fundamental questions in language comprehension concerns how the comprehension process is influenced by the context in which an utterance is encountered. Contextual information is particularly important in the resolution of anaphorical relations, i.e. in establishing and maintaining reference throughout the discourse. Typically, the resolution of anaphoric expressions during on-line comprehension is examined using personal pronouns (e.g. Osterhout & Mobley, 1995; van Gompel & Majid, 2004). However, there are also other means of establishing (felicitous) anaphoric relations, for example by the use of hyperonyms (e.g. 1).

(1a) *Peter fragt sich, wer den Karpfen gestohlen hat.*
   Peter asks himself who the carp stolen has
   'Peter is wondering who stole the carp.'

(1b) *Dann erfuhr er, dass der Junge den Fisch/Karpfen gestohlen hat.*
   then heard he that the boy the fish/carp stolen has
   'Then he heard that it was the boy who had stolen the fish/carp.'

In a study using event-related potentials (ERPs), we contrasted the processing of anaphoric referential expressions (*carp* in 1b) with that of anaphoric hyperonyms (*fish* in 1b). While in a neutral context ('Peter is wondering what happened.'), the two variants of (1b) do not differ from one another at the position of *fish/carp*, there are clear differences between the two in the anaphoric context provided by (1a). Thus, the repetition of the referential expression (*carp*) gives rise to a reduction of the N400 component between 300 and 500 ms post critical word onset (in comparison to a neutral context), while the same effect is delayed by approximately 70 ms in the case of the anaphoric hyperonym (*fish*).

On the one hand, these results indicate that the integration of a nominal constituent is eased by the availability of an anaphoric relationship, as reflected in the reduced N400. Moreover, and perhaps more importantly, the ERP effects give a precise indication of the time course involved in the processing of a hyperonym-hyponym relationship at the sentence level. It thus appears that the activation of the concept 'carp' – and thereby the ease of integration of the corresponding noun phrase in the target sentence – is delayed by approximately 70 ms because this is the time required by the comprehension system to identify the new nominal element 'fish' and establish its hyperonymic relationship with the antecedent concept 'carp'. These results therefore suggest that semantic relations such as hyperonymy are immediately used in the establishment of anaphorical relationships, thereby easing the integration of arguments at the sentence level. Nonetheless, these processes are constrained by the structure of the mental lexicon and the semantic relationships encoded therein.

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# Differential processing of sentential information: Effects on Recovery from the Garden Path

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In this series of eye-tracking experiments, garden-path sentences containing a subordinate-clause ambiguity were used to examine the interaction of early and late reading comprehension processes in circumstances where the initial garden-pathed reading might influence the final interpretation of the sentence. Participants read sentences that were either clearly disambiguated on both syntactic and semantic grounds, or that had two possible interpretations, one requiring a plausible inference.

In Experiment 1 we compared single-meaning sentences such as (1):

(1) While Sally rode her pony rested in its stall.

in which the disambiguation is complete, with sentences such as (2):

(2) While Sally rode her pony broke into a canter.

that has dual-interpretations.

Although "her pony" is clearly the subject of the main verb "broke", the reader may plausibly infer that Sally is riding her pony. A comprehension question such as (3):

(3) T or F: Sally rode her pony.

checked the reader's interpretation of the ambiguous NP. Following dual-meaning sentences readers answered "True" about 65% of the time, compared to 25% for single-meaning sentences.

Reading times were longer for single than for dual-interpretation sentences. Differences appeared in rereading and were also found to interact with comprehension as measured by response to the comprehension question.

Since the initial grouping of words is responsible for the garden-path effect, we considered it important to see how far this influenced final understanding (Christianson, Hollingworth, Halliwell, and Ferreira, 2001). In a second experiment the clause order was reversed to establish the extent to which the inference would be made when there was no initial ambiguity. Responses showed that the effect of inferential information was just as strong: participants answered "True" slightly more frequently following the reverse clause sentences, although the difference was not significant, indicating that the initial garden-path reading had no noticeable effect on final interpretation. As with the garden-path sentences, the reverse-clause sentences were reread more in the single-meaning condition.

A third experiment manipulated the presence of commas to separate the clauses and eliminate the garden-path. This was intended to confirm the degree of garden-pathing and to provide a further check of the degree of inference made when the initial misanalysis was avoided. Responses were similar to Experiment 2: effects were again found on rereading times for both sentence types with an interaction between rereading and response.

Finally, in Experiment 4, a preliminary sentence provided context for the alternate meanings of the dual-interpretation sentences (Pickering and Traxler, 1998). The single-meaning sentences were included for comparison. The context sentence was effective in influencing responses, and also had an effect on reading times, significantly on rereading of the context sentence. Dual-meaning sentences for which the context supported the inference were read more quickly than the single-meaning sentences; those sentences for which the inference was disconfirmed took longer. The results show that an initial misanalysis had no significant effect on final understanding. However, it appears that when the reader's initial interpretation is compatible with his or her final interpretation reanalysis is abbreviated.

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# Prefrontal Cortex and the Role of  Selectional Processes in Language Comprehension: Frogs, Napkins, and Broca's Area

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Lesions to Broca's area typically result in a collection of linguistic impairments, including deficits in production and the comprehension of particular syntactic structures. Consequently, numerous theories have claimed that this region of left prefrontal cortex (PFC) is home to syntactic processing, and perhaps subserves grammatical representations. However, recent neuroimaging findings demonstrate the involvement of Broca's area in selecting among competing sources of information [1]. Thus, Broca's area might mediate the selection/resolution of multiple linguistic analyses during comprehension: damage should selectively impair ambiguity resolution and garden-path recovery.

We tested this hypothesis by assessing sentence processing abilities in three patients with damage to left PFC. Two had lesions sparing Broca's area (P1, P2) and one had a lesion including Broca's area (P3). P1 and P2 exhibited relatively preserved and fluent speech. By contrast, P3 had effortful, disfluent speech, characteristic of agrammatic aphasia.

Patients were given spoken instructions to move objects on a table while direction of gaze was recorded. Critical instructions contained a temporary syntactic ambiguity like (1a) where "on the napkin" could be the Goal of "Put" or a modifier of "frog". Alternatively, the phrase was unambiguous (1b).

> 1.        a. Put the frog on the napkin into the box.
>           b. Put the frog that's on the napkin into the box.

Like previous studies of normal children and adults [2], referential scenes contained a Target Animal (frog on napkin), an Incorrect Goal (napkin), a Correct Goal (box), and a Competitor Animal (horse or frog in bowl, corresponding to 1-Referent or 2-Referent scenes). If Broca's area is responsible for selection, then damage should result in comprehension patterns similar to those previously observed for five-year-olds [2]. This is because frontal systems develop late, with general selectional impairments often observed through the teenage years. Thus, patients with Broca's area damage should show—like young children—an inability to select syntactically subordinate interpretations.

Indeed, striking differences were observed between P3 and the other frontal patients: only P3 generated error patterns similar to five-year-olds. Specifically, P3's errors were localized to Ambiguous trials: 63% (5/8) versus 0% (0/4) for Unambiguous. All but one error involved the Incorrect Goal, and were of the sort previously observed for children: three 'hopping' (frog to empty napkin then box), one 'falling short' (frog to empty napkin), and one 'other' (Competitor frog to empty box). P3's errors were more likely in 2-Referent contexts (4/4) than 1-Referent contexts (1/4), a pattern also similar to children's. Moreover, all of P3's errors involved selecting the Competitor Animal (frog in bowl), suggesting that "on the napkin" was routinely interpreted as the Goal of "Put"— and never as a modifier of "frog"—regardless of visual context. By contrast, frontal patients with Broca's area spared were like normals: P2 made no errors, and P1 made one on an Unambiguous trial. P3's eye movements were also similar to five-year-olds': all but one Ambiguous trial had look(s) to the Incorrect Goal upon hearing "napkin". Eye movements to the Incorrect Goal for P1 and P2 were observed, but at a considerably lower rate than for P3.

These findings support the hypothesis that Broca's area subserves selection among competing syntactic analyses. When faced with temporary ambiguity, P3 showed great difficulty overriding strong lexico-syntactic tendencies. The dominant syntactic analysis—the first prepositional phrase being an argument of "Put"—was initially selected, and subordinate parses were rarely, if ever, recovered. P3 had little difficulty with unambiguous forms, despite similar length and complexity, suggesting preserved syntactic knowledge, but damaged selectional abilities. Results will be discussed in relation to the role of Broca's area in competitive selection and a neurologically plausible, lexically-based parsing system. We will also discuss data collected from normal adults who participated in the 'Put' task, a reading garden-path study (using the DO/S ambiguity), and a set of measures of working memory. The results revealed individual differences in the ability to recover from garden-paths generally: garden-paths in reading correlated with garden-paths in the visual-world task. Taken together, these findings suggest an important role for a linguistic selection mechanism in parsing, possibly localized to prefrontal cortex.

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# Japanese Exclamatives and the Strength of Locality Conditions in Sentence Generation

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Previous studies on Japanese sentence processing have demonstrated a locality bias in the comprehension of questions: after encountering a *wh*-phrase, readers expect to encounter a licensing question particle at the first grammatically available verb position (Miyamoto & Takahashi, 2003). This study investigates the interaction of this locality bias with grammatical constraints, using the Japanese exclamative expression *nante*, which may itself appear in embedded clauses, but only allows a main clause licenser. Results of our sentence completion task indicate that speakers will go to great lengths to provide a local licenser for the exclamative, but are able to do so without sacrificing grammatical accuracy.

When the Japanese expression nante appears as a part of a larger noun phrase it strongly signals an exclamative phrase. Like wh-expressions in Japanese, nante must be licensed by verbal particles (in this case either da or ka). Unlike other wh-expressions, however, the licensor of nante can only appear in a main clause. From the perspective of on-line processing, this grammatical requirement creates a potential conflict with the independently established bias for wh-expressions to find a local licensor (Miyamoto & Takahashi, 2003). We investigated how speakers resolve this conflict using a sentence fragment completion task (n=42), that compared how speakers complete fragments containing exclamative or interrogative expressions, such as dono, 'which'. In two conditions (1-2) these expressions appeared in-situ in an embedded clause.

Completions of the wh-in-situ conditions showed a very strong bias to produce a local licensing question particle inside the embedded clause (92.9%), consistent with previous findings (Aoshima et al., 2003). Surprisingly, the exclamative condition also showed a strong local licensing bias (79.0%). The embedded clauses were frequently completed as quotations that inherit all the properties of main clauses, thereby allowing local licensing of nante with no violation of any grammatical requirements. Quotations were generated in 65.7% of exclamative conditions, but in only 2.1% of wh-conditions, F1(1,41)=99.7, p<.0001; F2(1,29)=321.3, p<.0001.

Second, we compared exclamative (3) and interrogative (4) expressions that had undergone scrambling to sentence initial position. Previous studies have shown that scrambled interrogative expressions are frequently analyzed as if they are scrambled from an embedded clause (Aoshima et al., 2003). However, this option should not be available for an exclamative with a local licensor, since it is impossible to scramble an NP out of a direct quotation (Uchibori, 2001).

Consistent with our prediction, completions in the exclamative conditions showed very few evidence of embedded clause placement of either the exclamative or its licensor (10.0%). The scrambled interrogative condition showed evidence of greater numbers of embedded clause interpretations (39.5%), as evidenced by embedded question particles or embedded verbs that select a dative argument. The contrast between exclamative and interrogative scrambled conditions was significant F1(1,41)=49.1, p<.0001; F2(1,29)=58.0, p<.0001.

Taken together, the results from this study show that the local licensing bias observed in the comprehension of wh-expressions extends to a sentence generation task, and that the bias is so strong as to require creative strategies, such as the generation of quotations, in order to reconcile locality with grammatical requirements.

## Examples

```
(1)  NP  -wa    [NP  -ga     [nante  Adj   N]  -ni   …    [exclam.-condition, in-situ]
         -top        -nom                         -dat
(2)  NP  -wa    [NP  -ga     [dono   Adj   N]  -ni   …    [interr.-condition, in-situ]
         -top        -nom                         -dat
(3)  [Nante  Adj   N  -ni]  NP  -wa    [NP  -ga  …        [exclam.-condition, scrambled]
                     -dat        -top        -nom
(4)  [Dono   Adj   N  -ni]  NP  -wa    [NP  -ga  …        [interr.-condition, scrambled]
                     -dat        -top        -nom
```

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# Long-Distance Dependencies involving Clitic Pronouns in Spanish
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This study uses experimental evidence from Spanish to investigate how topic-clitic dependencies whose tail consists of a preverbal clitic pronoun are interpreted. Just as the presence of a wh-phrase in English reliably requires an upcoming gap, in Spanish the presence of a topicalized phrase reliably requires the occurrence of a clitic pronoun in sentences like (1)(e.g., Rivero, 1980, Contreras, 1991). This paper presents results from two questionnaire studies and two on-line studies that confirm the clitic requirement, and show that the presence of a topicalized phrase facilitates the processing of the first following clitic.

Experiment 1 (acceptability rating, n=39) showed that Spanish speakers strongly prefer that dependencies involving topicalized NPs be completed by an overt pronoun rather than by a gap. Experiment 2 (sentence completion, n=15) confirmed that this generalization extends to active sentence generation. Experiments 3 and 4 investigated whether this leads to active prediction of pronouns in on-line processing, parallel to active gap creation in languages like English (e.g., Stowe, 1986).

Experiment 3 (self-paced reading, n=55) compared reading times in two conditions, both of which contained a topicalized NP and a clitic pronoun in an embedded clause. In one condition (2a) the embedded clitic was the first clitic after the topicalized NP, and thus completed the topic-clitic dependency. In the second condition (2b) there was an additional clitic pronoun in a higher clause, allowing earlier completion of the topic-clitic dependency. Results showed that the embedded clause clitic pronoun was read more quickly in (2a), despite the fact that the referent of the pronoun was more recently activated in (2b), ($F_1(1,54)=3.62,p<.06$; $F_2(1,23)=4.27$, $p<.05$). This 'anti-locality effect' for the processing of the pronoun is expected if processing of the topicalized NP initiates active prediction of an upcoming pronoun. Additionally, since the dependency-completion effect appeared in a pre-verbal position, it lends support to claims that verbs are not needed for the completion of long-distance dependencies (Gibson & Hickok, 1993), contrary to direct association approaches (Pickering & Barry, 1991).

In order to establish whether the facilitation effect is specifically due to the topic NP, rather than to a more general anti-locality effect, Experiment 4 is currently comparing topic-clitic constructions with other Spanish constructions in which topicalization is absent but the linear order of NPs is identical. The new conditions take advantage of the fact that Spanish allows post-verbal subjects, by placing an NP just like the topicalized NP in final position of the context sentence (3). Thus, the linear distance between the pronouns and their antecedents are matched across topicalization (3ab) and non-topicalization conditions (3cd). If the facilitation of the embedded clitic pronoun is due to topicalization, then the effect should be absent in the non-topicalization conditions. Alternatively, if processing of the second pronoun in a sentence gives rise to a general anti-locality effect, then the facilitation effect should be observed at the second pronoun, independent of the presence of topicalization.

**Examples**

(1) **A esos músicos**, el director de la orquesta **los** necesita.
   *To these musicians, the director of the orchestra them-acc(masc) needs.*
(2) *Context sentence:*
   Yendo a la escuela, mi hermana mayor y yo vimos a mis amigas Ana e Irene.
   *Going to school, my sister and I saw my friends Ana and Irene*
(2a/b) **A estas chicas**, mi hermana mayor más tarde **(a) Ø / (b) les** dijo que
   *To these girls, my sister  old   later on {Ø them-dat} said that*
      ya   lo    cree que **las**    conoce desde hace tiempo.
      *indeed it-acc(masc) thinks that them-acc(fem) knows  for a long time.*
(3) *Context sentence:*
   Cuando abrieron las puertas del teatro en el que se celebraba el casting,entró precipitadamente **un grupo de chicas**.
   *When the doors of the theatre where the casting was given opened, a group of girls entered precipitately.*
(3a/b) **A estas chicas**, el organizador del casting **(a) Ø / (b) les** explicó
   *To these girls, the organizer of the casting {Ø/them-dat} explained*
   con todo tipo  de detalles que  el manager **las**   iría llamando por apellido.
    *with all sort of details that the manager them-acc(fem) will call by name.*
(3c/d) El organizador del casting **(c) Ø / (d) les** explicó con todo tipo de detalles
   *The organizer of the casting {Ø them-dat}explained with all sort of details*
   que el manager **las**      iría llamando por apellido.
   *that the manager them-acc(fem) will call    by name.*

# The time course of recovery for grammatical category information during lexical processing for syntactic construction

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We will discuss results from several related investigations of lexical access in language production that focus on syntactic classes and their interaction with the generation of sentence structures. Earlier work by Pechmann and Zerbst (2002) reported grammatical category effects in naming performance in a picture-word interference task. Grammatical category information was not activated when subjects produced bare noun descriptions of simple objects. But, a robust effect appeared when the response procedures required speakers to produce target words embedded in syntactic frames. Follow-up experiments explored this effect using parallel tests conducted in German and in English (Pechmann, Garrett, & Zerbst, in press). We demonstrated first that compilation of a simple NP would yield grammatical class effects in picture word interference experiments, and further, that these effects appear in the same time frame as that generally observed for semantic processing. A significant feature of the comparison across languages is that the effects emerge in German and English with very similar activation profiles. On these grounds we can rule out the possibility that the syntactic effects first reported by Pechmann and Zerbst actually depended on syntactic gender activation rather than major categorial constraints. Grammatical gender constraints are lacking in the English language version of the experiments. More generally, these major grammatical category effects are distinguishable from any lexical semantic values of distractors used (as indicated by the lack of interference in the bare noun version of the tests). This affirms the need to distinguish any general semantic correlates of grammatical category from processes triggered by the integration of lexical content in phrasal environments.

Two further observations concern the time course of processing. The results showed activation of syntactic information in the same time frame as that normally observed for semantic distractors. Additional work by Pechmann & Zerbst (in press) directly compares semantic, syntactic, and phonological distractors and confirms an early emergence of syntactic constraints. The three distractor types were tested in two coordinated experiments at several successive time frames. In both experiments, syntactic activation preceded semantic activation. Semantic and syntactic activation were subsequently contemporaneous and continued to be significant at probe points for which significant phonological activation appeared. This was followed by the fading out of syntactic and semantic activation prior to full phonological activation. The appearance of syntactic interference at a point prior to semantic interference may reflect either a task specific maintenance of the syntactic frame used across successive stimulus presentations, or it may reflect very early conceptually driven grammatical encoding steps. The pattern overall suggests a significant degree of concurrence in the elaboration of the three processing types. Research in progress extends these findings to other grammatical category contrasts (e.g., verb distractors).

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# The conceptual-syntactic interface during real-time language comprehension

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Traditionally, semantic and conceptual representations have not been distinguished for the purposes of comprehension. Research on the syntax-semantics interface, however, suggests the existence of a level, SEM, with an organization that is distinguishable from conceptual representation. Here, we investigate whether the language processor access this level during comprehension.

Consider the following triad: 'cows', 'cattle', 'beef'. The referents of 'cattle' and 'cows' belong to the same conceptual category as they are both not substances but entities consisting of objects. They differ syntactically however in that only 'cows' can pluralize (*cattles). We propose that these two sets of features come together in one independent level of representation SEM which mediates conceptual and syntactic representations. The correlation between those classifications is achieved on the SEM level by two features, [? struc] and [? ind]: semantic representations are [+struc] if they have an internal structure that determines what counts as one minimal instance of the concept; they are [+ind] if they contain an individuation function that provides direct access to individual elements.

These features distinguish 'cattle' from both 'cows' and 'beef' on the SEM level: the semantic representation of 'cattle' differs from that of 'cows' because it does not contain an individuation function ('cattle' is [-ind], whereas 'cows' is [+ind]), and it differs from that of 'beef' in having an internal structure ('cattle' is [+struc], whereas 'beef' is [-struc]). These SEM features identify three nominal classes: [+struc, -ind] nouns or collectives (eg. 'cattle' or 'furniture'), [+struc, +ind] nouns or plurals (eg. 'cows'), and [-struc, -ind] or mass nouns (eg. 'beef').

We hypothesize that if this level of representation is accessed for the purposes of comprehension, priming effects based on these properties should be observed. This predicts that collectives such as 'furniture' should have a facilitating effect for other collectives such as 'cattle' (coll-coll), as compared to plurals like 'cows' (coll-plu) or mass nouns such as 'beef' (coll-mass). This is so based on the commonality of SEM features for the coll-coll pair, in contrast to the coll-plu pair which only shares [+struc], and the coll-mass pair which only shares [+ind].

This hypothesis was originally successfully tested in English, and has now been tested in three other languages: German, Persian and Spanish. These languages were chosen because they vary in interesting ways in the manner they represent collectivity (e.g., Persian only shows plurality through collectivity). Yet, they are all predicted to exhibit the same effect, thus reflecting a feature of the architecture of the comprehension system rather than a language-specific idiosyncracy.

Our predictions were tested using a lexical decision task (unimodal paradigm). They are all borne out by the results: Means for German: coll-coll=710.85ms < coll-plu=733.17ms, $p=0.0048$; coll-mass=734.88, $p=0.008$); for Spanish:coll-coll=700.23ms < coll-plu=736.01ms, $p=.032$; coll-mass=743.63ms, $p=.009$; and for Persian:coll-coll =718.52ms, mass-coll=731.09ms, $p=0.05$; mass-mass= 753.45ms < coll-mass=794.39 ms, $p= 0.0007$).

We place these findings in a model of the architecture of the language system in terms of its abstract representation and dynamic implementation.

## Examples

1) a. collective(prime)-collective(target) pair:      cattle [+struc,-ind]  - furniture[+struc,-ind]
   b. collective (prime)-plural (target) pair:        cattle [+struc,+ind] - chairs [+struc,+ind]
2) a. collective(prime)-collective (target) pair:     cattle[+struc,-ind]   - furniture[+struc,-ind]
   b. collective (prime)-mass (target) pair:          cattle [+struc,-ind]  - water [-struc,-ind ]

# Processing secondary predicates: does locality matter?

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**Arguments, adjuncts, and the role of locality.**

English post-verbal adjectives can be interpreted either as depictives, i.e. as defining a state in which either the subject or the object is during the event described by the verb (1), or as resultatives, where the adjective specifies a resultant state of the event described by the verb (2).

1. *Depictive:* The boy$_i$ carried the flag$_j$ wet$_{(i/j)}$.

2. *Resultative:* The boy painted the wall blue.

While depictives are always optional and are properly treated as adjuncts, resultatives are usually analyzed as causative constructions where the main verb takes as its argument a small clause like complement headed by the resultative phrase (e.g. Dowty 1979, Carrier & Randall 1993). Since post-verbal adjectives can be interpreted either as adjuncts or as arguments (depictives vs. resultatives) or as attaching locally or non-locally (subject vs. object depictives), they provide a potentially fruitful domain for investigating both argument/adjunct asymmetries as well as the role of structural parsing principles in adjunct interpretation. Specifically, it has been proposed that if a phrase cannot be analyzed as an argument or a theta-assigner, it is interpreted via construal (rather than attachment), which is not sensitive to locality (Frazier and Clifton, 1996). Consistent with this, Frazier and Clifton found no differences between unambiguous subject and object depictives in whole sentence reading times. Frazier and Clifton also report that resultative interpretations are intuitively preferred, although this prediction is not explicitly tested.

In the present study we used a moving window self-paced reading paradigm to test whether resultatives are indeed processed faster than depictives (due to the argument status of resultatives) and whether depictive interpretation shows evidence of locality insensitivity. Unlike Frazier and Clifton, we tested both ambiguous and unambiguous depictives.

**Materials.**

(i)  *Unambiguous object depictive vs. resultative.*
The artist returned/knocked the picture frames crooked despite the warnings.
(ii)  *Unambiguous subject depictive vs. resultative.*
The teenage boy painted his walls bored/turquoise while his parents were out of town.
(iii)  *Unambiguous subject vs. object depictive.*
The taxi-driver gave away his old car saddened/dented after many years.
(iv)  *Ambiguous subject vs. object depictive.*
The postman delivered the mail dirty and shredded/irritated after the rainstorm.

**Results.**

Resultatives were processed faster than both object depictives and subject depictives. Unambiguous subject and object depictives were processed equally fast, but in ambiguous contexts subject depictives elicited longer reading times than object depictives in the spill-over region of the disambiguating adjective.

**Conclusion.**

First, consistent with the construal hypothesis, resultatives were processed faster than depictives. However, this result can also be explained purely on the basis of frequency: our corpus analysis of secondary predicate constructions in the Penn Treebank corpus indicates that resultatives are an order of magnitude more frequent than depictives. Second, contrary to the predictions of the construal hypothesis, we found evidence for a local attachment preference for ambiguous depictives. This result cannot be explained on the basis of frequency: subject depictives are more frequent than object depictives (Penn Treebank corpus).

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# Antecedent Priming at Gap Positions in Children's Sentence Processing

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Previous studies have argued that empty categories (or syntactic 'gaps') form part of the adult sentence processing mechanism by showing that at gap sites, a moved constituent is mentally reactivated.

This study examines whether children reactivate a moved constituent at its gap position. We further ask how children's more limited working memory span affects the way they process filler-gap dependencies. Object-relative clauses such as (1) were tested in a cross-modal picture priming paradigm (McKee, Nicol, & McDaniel 1993):

(1)    John saw the peacock to which the small penguin gave the nice birthday present [e] in the garden last week.

44 5 to 7 year-old children and 54 adult controls listened to 20 experimental sentences such as (1) (and 60 filler sentences) during which one of two picture probes (selected and matched using the Snodgrass & Vanderwart, 1980, norms) were presented as visual targets: an identical target, i.e. a picture of the antecedent (a peacock for (1)), or an unrelated target, i.e. a picture of an unrelated item matched for length and frequency to the identical targets. On the appearance of the target picture, the participants were required to decide as quickly and accurately as possible whether the object shown was alive or not alive. The targets were presented at one of two positions, either at the gap site (i.e. immediately after 'present' in (1)) or at a control position 500msec earlier. Pre-tests were administered to ensure that the children were able to correctly judge the pictures used as experimental targets, and that they were able to understand the type of sentences and the vocabulary items used in the main experiment. Furthermore, all participants underwent a standardized working memory test (children: Gaulin & Campbell 1994; adults: Daneman & Carpenter 1992).

The results revealed a statistically significant interaction between the participants' working memory span and antecedent reactivation: High Span children (n=19) and High Span adults (n=22) responded significantly faster to identical targets at the gap position than at the control position (children: 1158 vs. 1245ms; adults: 678 vs. 694ms), and vice versa for unrelated targets. For the Low Span participants, there was no such interaction.

The antecedent reactivation effect in the High Span participants indicates that in both children and adults, dislocated arguments access their antecedents at gap positions. The absence of antecedent reactivation in the Low Span participants, we argue, is due to the extra time these participants require to retrieve the filler from working memory.

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# Misinterpretation and Heuristics in Bilingual Processing

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Trueswell, Sekerina, Hill, & Logrip (1999) reported an important difference in how English adults and children process garden-path sentences like

(1)     *Put the frog on the napkin in the box*. (1-REF context: 1 frog vs. 2-REF context: 2 frogs)

Adults successfully used the Referential Principle (Crain and Steedman, 1985) in the visual context with two frogs and recovered from the temporary garden-path interpretation (e.g., picking up the frog and moving it to the napkin). Errors in actions were not expected for the adults at all. Indeed, they exhibited very few (3% the AMB conditions), as well as did not look at the empty napkin in the 2-REF AMB condition. In contrast, children ignored the Referential Principle and produced 60% errors in the AMB conditions irrespective of the type of context.

In an eye-tracking experiment, we examined how fluent bilingual Russian-English adults process the same construction (n=24). The Type of Context (1-REF vs. 2-REF) was crossed with the Syntactic Ambiguity (2) resulting in 16 experimental items:

(2)     a. *Put the frog on the napkin in the box.*          AMB
        b. *Put the frog on the napkin and in the box.*     UNAMB

It was predicted that the bilingual participants' performance in English would closely resemble that of the English monolingual adults: 1) more errors in the AMB conditions, and 2) similar eye movement patterns.

The analysis of the actions did not confirm the predictions:

Table 1. Percentages of errors in bilingual adults' actions

|             | 1-REF     | 2-REF |
|-------------|-----------|-------|
| Ambiguous   | 18.8%     | 17.0% |
| Unambiguous | **36.7%** | 16.3% |

First, the bilingual adults produced substantially more errors in general (22%) than the monolingual speakers in the Trueswell *et al.*'s study (3%), irrespective of syntactic ambiguity, and made more errors in 1-REF conditions ($F1(3,20)=7.84$, $p=.011$). Second, the participants ignored the instruction to perform a "hopping" action in 1-REF, UNAMB condition -- when the frog was already on the napkin -- and instead put it directly into the box. This resulted in a significant interaction between Type of Context and Syntactic Ambiguity ($F1(3,20)=6.84$, $p=.0165$) driven by the errors in 1-REF, UNAMB condition.

Why do the bilinguals misinterpret these sentences? It is clear that the overall high error rate for the bilinguals isn't due to lack of the Referential Principle; otherwise we would have found the expected ambiguity effect. We propose an explanation along the lines of a shallow processing system that under certain circumstances yields "good enough" representations (Ferreira, 2003). Instead of applying elaborate algorithms to calculate interaction of syntactic disambiguation cues (presence of *and*) and referential visual context, the bilinguals rely on a fast heuristic – *put* requires a Destination. As a result, their actions look more like actions of monolingual English children than adults. The very high error rate in the 1-REF, UNAMB condition is explained by application of an implausibility heuristic in a configuration with one frog on the napkin and another empty napkin that appears infelicitous when combined with the instruction (2b). Forthcoming eye movements analysis will provide a more detailed investigation of heuristics in bilingual sentence processing.

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# Semantic Integration and Hierarchical Feature-Passing in Sentence Production

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Hierarchical feature-passing has been proposed as the underlying mechanism by which agreement is implemented in sentence production (Bock et al., 2002; Franck et al., 2002; Vigliocco & Nicol, 1994, 1998). For example, using subject NPs containing a head noun and two local nouns (e.g., *the helicopter for the flight over the canyon*) in a subject-verb agreement error elicitation task, Franck et al. found a higher agreement error rate when N2 was plural (*flights*) compared to when N3 was plural (*canyons*). Error rates thus depended on the syntactic distance from the plural local NP to the highest subject NP node, with shorter distances yielding increased error rates.

Solomon and Pearlmutter (in press) argued that another factor influencing agreement error rates is semantic integration, the degree to which two elements are linked at the message level during production. For example, tightly integrated subject NPs like *the pizza with the yummy toppings* (*pizza* and *toppings* are closely linked) elicited more agreement errors than less integrated subjects like *the pizza with the tasty beverages*, relative to singular controls. In such cases, hierarchical distance between the local NP and the subject NP node does not vary, so the effect of integration is distinct from hierarchical effects.

To determine whether hierarchical feature-passing is needed in addition to semantic integration, the current study first measured integration between relevant noun pairs in Franck et al.'s stimuli. 240 participants rated the stimuli on a 1-7 scale (1=weakly integrated), revealing that N1 and N2 were more integrated than N1 and N3 (M=4.5 and 3.0, respectively). Thus integration and hierarchical distance were confounded, and Franck et al.'s result might have been due to integration differences rather than hierarchical feature-passing.

Whether feature-passing affects error rates when integration is controlled was examined next, using 24 stimuli like *the mango by the pineapple near the blender*, in which N2 and N3 number were varied, and N1 was always singular. Rated integration between the relevant noun pairs was matched (M=3.8 for both N1-N2 and N1-N3, 140 participants), and separate norming (60 participants) showed that the final PP in the stimuli (*near the blender(s)*) modified N2 (*pineapple(s)*) rather than N1; the attachment rate to NP2 was 70%. 43 participants then produced completions for these stimuli using the subject-verb agreement error elicitation procedure. The error rate when all nouns were singular was 1%; it was 3% when only N3 was plural, 18% when only N2 was plural, and 23% when both nouns were plural. This yielded an effect of N2 number and no effect of N3 number. Critically, the size of the number effect (relative to the pure singular (condition) was much larger when only N2 was plural than when only N3 was.

These results show that hierarchical distance does influence agreement error rates when integration is controlled, and, combined with Solomon and Pearlmutter's results, show that both semantic integration and hierarchical distance are relevant factors in producing subject-verb agreement.

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# The time-course of the processing of coordinate constructions

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Although over 50\% of sentences included in text corpora (across languages) contain coordinate structures, little is known about how they are processed. The time course of processing coordination structures can shed light on the general behaviour of the language processor.

The issue investigated in this paper concerns the specification of the granularity of the widely assumed incremental processing approach. An eye-tracking experiment was designed to distinguish between a *weakly incremental* and a *strongly incremental* account of the processing of coordination. Consider the case of VP coordination in (1a):

**(1a)**      The pilot [VP1 embarrassed John] and [VP2 put himself in a very awkward situation].

The two accounts make different predictions about the time-course with which VP2 is connected to the current partial phrase marker (CPPM). According to the strongly incremental account (e.g. Lombardo & Sturt, 2002, Schneider, 1999), the structure corresponding to a verb phrase coordination schema VP-->VP1and VP2 is immediately inserted into the CPPM using an adjoining operation, making VP2 immediately available as a predicted node connected to the CPPM.

In contrast, the weakly incremental account predicts delayed attachment. For example, Steedman (2001) argues for a combination of a bottom-up parsing algorithm with flexible-constituency Combinatory Categorial Grammar. This combination allows fully incremental interpretation in many cases, but VP coordination still requires delayed attachment. Although two conjuncts can be attached together as soon as processing of VP2 begins, it is impossible to combine the conjoined VP with higher structure until both conjuncts are complete, because of the bottom-up algorithm  (see Schneider (1999) for discussion of this and related approaches).

1a-d shows the experimental design:

**1    a Reflexive/match (see above)**
        **b Reflexive/mismatch**
The pilot embarrassed Mary and put herself in a very awkward situation.
         **c Pronoun/match**
The pilot embarrassed John and put him in a very awkward situation.
         **d Pronoun/mismatch**
The pilot embarrassed Mary and put her in a very awkward situation.

A reflexive or a pronoun could occur as an argument of the second verb, at a point where the second conjunct was still incomplete (as assessed by a continuation pre-test).  The reflexive/pronoun could either agree or disagree with the matrix subject in stereotypical gender (see Sturt, 2003). A gender-mismatch cost at the reflexive in first-pass measures would be consistent with the strongly incremental approach, as it would demonstrate the availability of structural relations (e.g. c-command) well before the end of VP2. The pronoun conditions controlled against an explanation of any early gender-congruency effects in terms of a structurally-blind strategy of matching the anaphor with the first-mentioned character; any such superficial strategy should result in gender-congruency effects for the Pronouns (which would otherwise be ruled out by Principle B). The design ensured that all conditions included grammatical antecedents for pronouns/reflexives.

As predicted by the strongly incremental account, the results showed a gender-congruency effect at the anaphor region for the reflexives, but not for the pronouns, in all standard first-pass measures .

This implies that VP2 is incorporated into the CPPM very quickly---models of coordination processing should allow for this attachment to occur at least as soon as the conjunction and second verb have been processed.

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# Indefinite definites during online reference assignment

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In this abstract, we present work arguing for two distinct classes of definite noun phrase in English: "traditional" definites, denoting a single, unique entity and "Indefinite Definites, which fail to fix a unique referent in the context. Additionally our work bears on two central questions in online reference resolution: 1) the influence of task demands on the process of reference resolution and 2) the influence of specific lexical biases in determining the definiteness of a noun phrase.

The definite article in English has long been analyzed as referencing uniquely identifiable entities within the discourse context. Spivey, Tanenhaus, Eberhard and Sedivy (2002) demonstrated the operation of this assumption of uniqueness in online processing in an eye-tracking study. When the context contained multiple referents for the target noun, but one of these referents was made "unique" by being placed at a distance from the other candidates (which were clustered together), participants restricted their eye-movements to the separated item immediately upon hearing "the [noun]."

This work will focus on a class of lexically governed definite noun phrases in English that appear not to entail assumptions of uniqueness. For these nouns (Indefinite Definites or ID's), the use of the article "the" does not serve to pick out a single, distinct entity in the discourse, and may be felicitously uttered in context containing any number of equally salient tokens.

We used eye-tracking during spoken language containing ID and non-ID versions of the same sentence to test whether listeners' immediate on-line reference resolution reflected the difference between the two noun classes. Participants heard sentences such as "Lydia will read the newspaper" vs. "Lydia will read the book" while they viewed displays containing an actor (Lydia), two newspapers/books sitting together, one newspaper/book sitting by itself, as well as paired and singleton tokens of a distractor. Participants were then required to click on the item they felt the actor would use to perform the action described.

In cases where the participant heard a sentence containing an ID, they were more likely to chose a member of the group target than the singleton target (66% vs. 34%). For non-ID trials, this tendency was reversed (42% vs. 58%). A t-test revealed a significant difference between response patterns for the two noun types (t(7)=3.0, p<.01). Eye-movements during the noun also revealed a greater number of looks to group targets during ID trials. Both of these results are in keeping with the intuition that ID's are more likely to refer to "non-specific" referents. Looks to the singleton target, however, did not vary as a function of noun type. Furthermore, there were greater numbers of looks to the group target than to the singleton target for both ID's and non-ID's. This result contrasts with that found for non-ID's (regular definite NP's) in Spivey et. al (2002).

In summary, the results of this experiment establish Indefinite Definites as a distinct class of noun phrases. This distinction is evident during on line processing, as reflected by the greater number of eye-movements to group targets during the target noun in the spoken materials in ID trials. Though regular definites reliably behaved differently than ID's, they did not conform to the expectations generated by the Spivey et. al. study. Possible explanations for this discrepancy include differences in the types of tasks used in the two experiments, as well as the different types of visual displays these entailed.

# Ungrammaticality as Failed Self-Organization

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The interpretation of grammaticality judgment data is notoriously tricky. Pragmatic and processing factors, which most current theories treat as independent of grammatical well-formedness, are nevertheless capable of influencing judgments [1]. We tested standard symbolic parsing theories against a self-organizing approach to ungrammaticality in two experiments.

In the self-organizing model, perception of each word activates a fragment of a syntactic tree which seeks to combine with the fragments activated by other perceived words to form a parse, guided by both syntactic and pragmatic biases. Noise in the activation values can cause the model to stabilize in different configurations under the same linguistic input. Negative grammaticality judgments occur when the model fails to stabilize on a single parse.

This model makes several distinguishing predictions: (A) merely locally coherent syntactic sequences in the input (e.g., "the player tossed the Frisbee" in the reduced version of (1a)) can lead to the formation of local tree structures which compete with the global structure, making parse failure more likely; (B) Chains of abstract nodes without lexical support are prone to fail to link in the presence of noise (e.g., when the parser builds "player [[[thrown the Frisbee VP] IP] CP]" in (1b) the CP and IP nodes suffer from this weakness); (C) Pragmatic context that heightens appropriate role characteristics of an argument facilitates appropriate lexical stabilization of the role-assigner, thus discouraging parse failure (e.g., the difficult Recipient-fronting of sentence (2) is predicted to be judged grammatical more often when the player who received the Frisbee has been previously identified).

Experiment 1 collected Yes-No grammaticality judgments after subjects read each sentence in non-cumulative, word-by-word self-paced reading. Reduction increased negative judgments in both (1a) and (1b), but increased them more in (1a), confirming prediction (A). Significant increase of negative judgments under reduction in (1b) confirmed prediction (B).

In Experiment 2, the sentences in (2) were presented all at once on a computer screen, and grammaticality judgments were made on a scale from 1-7. The sentences were presented with and without a role-biasing preceding context. A main effect of reduction reconfirmed prediction (B). A main effect of context confirmed prediction (C).

If, as is standardly assumed, a global grammar guides the parsing process, then the locally coherent structure in (1a) should never be built. If building more nodes is more difficult than building fewer, then the reduced versions of (1b) and (2) should slow the processor down, but it is not clear why parsing should fail. It is true that negative judgments could stem from naïve participants' inability to distinguish syntactic anomaly from processing strain and pragmatic anomaly, but an account which provides a common explanation seems preferable.

Self-organization unifies the results by claiming that well-formedness is not a condition that gets checked but the result of successful coordination among a large number of potentially conflicting forces. Ungrammaticality judgments reflect failure of convergence, regardless of the source domains of the conflicting information.

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## Examples

(1a) The coach chided the player (who was) tossed the Frisbee by the opposing team.
(1b) The coach chided the player (who was) thrown the Frisbee by the opposing team.

(2) The player (who was) thrown the Frisbee barely managed to catch it.

# Processing relative clauses with and without psych-perception verbs.

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Sentences with object-relative clauses (e.g., 1a) are generally more difficult to process than sentences with subject-relative clauses (e.g., 1b).

(1a) The lawyer that the banker irritated filed a hefty lawsuit.
(1b) The lawyer that irritated the banker filed a hefty lawsuit.

Explanations for this difference have appealed variously to working memory load (Wanner & Maratsos, 1978), parallel vs. contrasting syntactic functions of the sentential subject (Keenan, 1978), perspective shifting (MacWhinney & Pleh, 1988), similarity-based memory interference (Gordon et al., 2000), multiple simultaneous constraint satisfaction (Gennsri and MacDonald; 2004), and difficulty making and revising verb-argument binding decisions (Traxler et al., 2002).

In eye-movement monitoring studies, participants have consistently showed interaction effects when animacy of the critical nouns is manipulated, as in (2a-2d; Traxler et. al, 2002; submitted):

(2a)  The musician that the accident frightened phoned the police.
(2b)  The musician that witnessed the accident phoned the police.
(2c)  The accident that the musician witnessed caused a big traffic jam.
(2d)  The accident that frightened the musician caused a big traffic jam.

The interactions occur because no object-relative penalty occurs in sentences with inanimate sentential subjects (e.g., 2c), but a large object-relative penalty occurs in sentences with animate sentential subjects (e.g., 2a). Findings such as these are difficult to reconcile with the memory-load explanation of the object relative penalty, but the generality of the findings may be questioned because of the high proportion of psych-perception verbs in the previous studies.

Thus, in the current eye-movement monitoring experiment, experiencer-theme verbs (e.g., *frighten*, *witness*) were replaced by more concrete verbs (e.g., 3a-3d)

(3a)  The fireman that/ the fire burned/ didn't cause/ much damage.
(3b)  The fireman that/ fought the fire/ didn't cause/ much damage.
(3c)  The fire that/ the fireman fought/ didn't cause/ much damage.
(3d)  The fire that/ burned the fireman/ didn't cause/ much damage.

"/" marks indicate where the sentences were segmented for analysis. The first scoring region is the "relative clause" region; the second is the main verb. The relevant nouns and verbs were equated for length and frequency, as were the plausibility of the relative clause and main clause interpretations. First-pass regressions data from the relative clause region showed a main effect of clause type; object-relatives had more regressions than subject-relatives. The main verb region also produced a main effect of relative clause type in the first-pass data. Interactions of sentential subject and clause type occurred in the relative clause region on first pass (significant by F1 but not F2), regression-path duration, and total time. Similar interactions occurred in the main verb region on all of the dependent measures except first pass time. This experiment shows that experiencer-theme verbs are not necessary to produce animacy by clause-type interactions in sentences with subject- and object-relative clauses. Hence, the overall pattern of results is most consistent with the argument binding hypothesis.

# The Production of Sentences That We Fill Their Gaps

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Resumptive pronouns are produced by English speakers in a variety of contexts, despite the standard view that they are ungrammatical in English. One robust generalization is that resumptive pronouns are more likely to be produced in structural positions that preclude extraction. Several researchers have suggested that resumptive pronouns are therefore a 'last resort', in that they serve to save a sentence that would otherwise violate a 'hard' grammatical constraint. The question we address here is whether resumptive pronouns are a 'last resort' of the competence grammar (McKee and McDaniel, 2001; Cresswell, 2002), or of the production system (Kroch, 1981). Results reported here support the latter possibility.

We focused on resumptive pronouns in one particular context, illustrated in (1), in which the head of a relative clause is associated with the possessor of the direct object. In an elicited production study, 44 adult participants were shown 24 picture contrasts designed to elicit a variety of relative clauses. Six critical trials provided contexts where responses like (1) were possible. Multiple alternative responses expressing exactly the same information were available for each of these trials (2–4), and 'truncated' responses (5) were also entirely appropriate in the trial contexts. The grammatical alternative that is most similar in both structure and content to (1) is (2), however, the decision to use this comparatively rare structure has to be made early on during production (by the third word), or else it is no longer a possibility.

(1) The man who the spider is falling on **his** head
(2) The man whose head the spider is falling on
(3) The man with the spider falling on his head
(4) The man who has a spider falling on his head
(5) The man who the spider is falling on.

The remaining trials targeted responses with simple relativized subjects or objects (e.g. *The grasshopper that the man is catching*). The same 44 subjects completed a graded acceptability judgment test which included sentences like (1), (2), and (5), as well as sentences with resumptive pronouns in extractable positions and unrelated grammatical and ungrammatical fillers.

## Results

Resumptive pronouns were only produced during the 6 trials targeting answers like those in (1–5), so the results focus on these 6 trials. Note that many sentence beginnings in (1) are incompatible with the production of a resumptive pronoun later in the response (2–4), and thus initial speaker commitments may inadvertently sidestep a resumptive opportunity. Half of the subjects never had a resumptive opportunity (most responses began like (3) and (4). However, among the remaining 22 subjects, resumptive pronouns were robustly produced whenever the opportunity arose (whenever sentences began like 1 or 5). 43 resumptive pronouns were produced out of 64 total opportunities (65%), and these were spread out among 18/22 subjects (85%). These results sharply contrast with the judgment results. Most adults rated sentences like (1) as unacceptable, despite the fact that many of them had recently produced such sentences. The mean rating for these sentences on a 5-point scale was 2.2, compared to 4.4 for a variety of grammatical sentences. Furthermore, sentences like (1) were judged to be as bad as sentences with resumptive pronouns in extractable positions (e.g. *I called the teacher who my daughter was afraid of **her***).

Our results suggest that resumptive pronouns like those in (1) are a last resort of the production system rather than the grammar. We produce sentences like (1) despite our own judgments of their unacceptability. These results are compatible with incremental models of sentence production in which speakers begin to speak before the entire utterance is planned. Initial choices for expressing a message sometimes preclude the possibility of finishing an utterance in a grammatically correct way.

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# CUNY CONFERENCE

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# Paper Presentations

# Interpreting Split Constituents in Russian: Pragmatic and Prosodic Effects

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An eyetracking study investigated how Russian listeners use prosodic, syntactic and referential evidence to interpret contrastive modifiers. Russian-speaking adults (n=24) heard instructions to move objects on a board. Critical instructions contained a split constituent (1) common in Colloquial Russian when contrasting pairs of objects.

(1)        KRASN-uju        polozhite        ZVEZdochk-u        v Poziciju 3.
           Red-FEM          put              star-FEM           in Position 3

Corresponding scenes contained two objects of the same critical color: a *red star* (Target) and a *red bird* (Competitor). Names for these objects had the same grammatical gender, such that "Red-FEM…" could refer to either object. Location of Contrastive Stress (Early, on Adjective, vs. Late, on Noun) was crossed with Type of Visual Scene (Two Pair vs. One Pair) in a 2x2 factorial design. In Two Pair scenes, both the Target and Competitor had a contrastive object present (e.g., a *yellow star* and a *blue bird*). In One Pair scenes, only the Target had a contrastive object (e.g., a *yellow star*).

If Russian listeners interpret split constituents in a pragmatically appropriate fashion, they ought to know which object (Target vs. Competitor) is referred to in One Pair scenes, at "Red-FEM…" even though two red objects are present. Listeners should prefer the Target because only it can be contrasted with another object of the same type (*a yellow star*). Two Pair scenes should result in no early preference, since both red objects have a contrastive member. Stress on the adjective (Early Prosody) should magnify this effect: the Early, One-Pair condition should show the strongest Target preference.

Plots of the proportion of fixations over time showed a sharp rise in looks to both the Target and Competitor during the Adjective. But, as predicted, One Pair Scenes demonstrated an early Target preference, especially when prosody supported the contrast (Early Prosody). Specifically, during the second half of the Adjective, One Pair scenes showed a significant advantage for the Target over the Competitor (F1=7.84, p<.05; F2=5.46, p<.05). This advantage interacted with Prosody (F1=5.74, p<.05) with the Target advantage occurring for Early Prosody (F1=15.34, p<.001; F2=6.50, p<.05) but not Late Prosody (Fs<2). In contrast, Two Pair scenes showed very little Target advantage (Fs<1), and no Prosody interaction (Fs<1). During the first half of the Verb, One Pair scenes continued to have a Target advantage (F1=5.37, p<.05; F2=5.61, p<.05) but which no longer interacted with Prosody (Fs<1). Two Pair scenes still showed no significant Target advantage (Fs<2): listeners needed the noun to disambiguate in this condition.

Our findings indicate that contrastive constructions are incrementally interpreted even without having perceived the head noun, and that this process is sensitive to pragmatic factors. A split scrambled adjective ("Red put…") preferentially refers to a red object that has a contrastive member present. This finding is in line with the interpretation of scalar adjectives in English (Sedivy et al., 1999) but further shows that these processes occur predictively even without a head, and can apply to nonscalar adjectives (color adjectives). We will discuss possible reasons why earlier findings in English have not observed pragmatic effects on with color adjectives.

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# Prominence Differences in Definite NP Anaphor Resolution:
# Grammatical Subject and Semantic Distance Effects

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Previous work involving anaphoric category noun phrases (NPs) has found that reference back to an antecedent that is a typical exemplar of the category is faster than reference back to an antecedent that is less typical, both for antecedents in grammatical subject position (Garrod & Sanford, 1977) as well as less prominent positions (Rayner, Kambe & Duffy, 2000). However, Almor (1999) found that antecedents that were made highly prominent via clefting (see table below) caused a reversal of the standard typicality pattern, with atypical antecedents causing faster anaphor reading times, while less prominent antecedents still produced standard typicality effects. These results suggested that subject position may not have been sufficiently prominent to trigger inverse typicality effects in previous work, despite its well-known psychological and linguistic status as a prominent syntactic position.

We tested the prominence of subject position with respect to semantic distance with two experiments that varied semantic distance and antecedent syntactic position. Previous difficulty in clearly replicating Almor's original typicality results caused us to chose an alternate manipulation of semantic distance that we believe is predicted by Almor (1999) to produce effects analogous to inverse typicality: the relationship of the antecedent and anaphor within a semantic hierarchy. In this manipulation, antecedents for a category NP anaphor ("reptile") could be either one level ("snake") or two levels ("cobra") away within a semantic hierarchy, corresponding to typical and atypical antecedents, respectively. Self-paced reading times were recorded at the anaphor ("The reptile") in both experiments.

Experiment 1 tested the effects of antecedent prominence using clefts. The results show the predicted inverse distance effect for anaphors to clefted antecedents, with semantically more distant antecedents causing faster reading times. This pattern was reversed for non-clefted antecedents. This pattern is exactly analogous to the effects found by Almor, and establishes that an inverse effect can be found using such this alternate semantic distance manipulation and that our materials could find such an effect with clefted antecedents.

The key test is thus whether the materials elicit an inverse distance effect when the antecedent is in subject position, which was tested in Experiment 2. The results show that this is the case, replicating the pattern of results from Experiment 1. These results suggest that subject position is sufficiently prominent to trigger inverse semantic distance effects and raises the question of why such effects have not been found in previous studies in which antecedents were in subject position.

**Table: Reading times (in msec) at "The reptile"**

| | **Experiment 1** | **snake** | **cobra** |
|---|---|---|---|
| Clefted: | What the mongoose stood up to was the [snake/cobra]. | | |
| | The reptile // hissed and got ready to strike. | 574 | 542 |
| Non-clefted: | It was the mongoose that stood up to the [snake/cobra]. | | |
| | The reptile // hissed and got ready to strike. | 561 | 584 |
| | **Experiment 2** | | |
| Subject: | The [snake/cobra] frightened the hunter. | | |
| | The reptile // looked ready to strike at once if threatened. | 623 | 597 |
| Object: | The hunter was frightened by the [snake/cobra] for a moment. | | |
| | The reptile // looked ready to strike at once if threatened. | 576 | 619 |

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# A Model of Disfluency Processing Based on Tree-Adjoining Grammar

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Researchers in sentence comprehension are increasingly focusing on spoken language. This interest in utterances rather than written sentences means that the field must expand its theories to explain how disfluencies are processed. The challenge is particularly intriguing when errors such as repeats and corrections are considered, because these disfluencies introduce lexical content which the parser cannot know in advance should not be included as part of the phrase marker under construction. The considerable frequency of such disfluencies in natural speech suggest that just as the parser requires operations to perform garden path reanalysis, it must also have mechanisms for revising structure when it finds itself in a reparandum-plus-repair context.

An ongoing research program on the comprehension of utterances with disfluencies has led to a number of important insights (Bailey & Ferreira, 2003; Ferreira, Lau, & Bailey, 2004). First, disfluencies affect first-pass parsing because they affect temporal processing dynamics and influence the availability of various structural alternatives. This point has been demonstrated in studies showing that sentences like (1) are processed identically to those like (2), indicating that disfluencies produce the so-called Head Position Effect (Ferreira & Henderson, 1991). Second, disfluencies affect either first-pass parsing or garden-path reanalysis (these two possibilities have not yet been empirically distinguished) because disfluencies correlate with certain types of syntactic constituents, and that co-occurrence information can be used by the parser to resolve structural ambiguities. This point was shown in an experiment demonstrating that a disfluency in a position as in (3a) led listeners to fixate more quickly on the object corresponding to a complex NP than did a disfluency in the position shown in (3b). Finally, and most critically for this presentation, information from a reparandum lingers and influences the final interpretation of an utterance. Sentence (4a) was judged acceptable less often than (4b), and conversely, (4c) was judged grammatical more often than (4d). These results not only demonstrate that disfluencies influence interpretations, they also provide further evidence for the importance of verb argument structure information during parsing.

Based on this empirical work, we have developed a model of disfluency processing which assumes that the parser consults a Tree Adjoining Grammar to build phrase structure incrementally. On this approach, filled and unfilled pauses affect the timing of Substitution operations, which then determine how long a given structural analysis is entertained. Repeats and corrections are handled by a mechanism we term "Overlay", which operates when the parser cannot perform Substitution or Adjoining. In this situation, the parser looks for a root node identity; if one is found, the appropriate, correct tree fragment is overlaid on the reparandum tree(s). This L-TAG model of disfluency processing highlights the need for the parser to sometimes coordinate the mechanisms that perform garden-path reanalysis with those that do disfluency repair. The model also suggests an intriguing relationship between disfluencies and coordination structures. The research program as a whole demonstrates that it is possible to study disfluencies systematically and to learn how the parser handles filler material and linguistic items produced in error.

## Examples

(1)   a.   Sandra bumped into the busboy and the uh uh waiter told her to be careful
       b.   Sandra bumped into the busboy and the waiter uh uh told her to be careful
(2)   a.   Sandra bumped into the busboy and the short and pudgy waiter told her to be careful
       b.   Sandra bumped into the busboy and the waiter who was pudgy told her to be careful
(3)   a.   Put the uh uh frog on the towel in the box
       b.   Put the frog on the uh uh towel in the box
(4)   a.   I want you to put uh drop the frog
       b.   I want you to drop the frog
       c.   I want you to drop uh put the frog
       d.   I want you to put the frog

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# Generating associations of cause and consequence
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We investigate the message-level planning of cause and consequence in language production, by examining the nature of participants' continuations to discourse fragments in four experiments. Previous studies have found conflicting results about whether people tend to produce causes or consequences. We show instead how causality decisions are determined by features of the discourse. Our experiments indicate that the choice of continuation, and the relationship between the continuation and prior text are influenced by (a) text length (b) agent typicality and (c) previous causal context.

First, we show that more causal continuations are generated when the text is short vs. long. We do this with two methods that, crucially, do not confound the comparison with the unwanted presence of additional content in the long condition (Experiment 1 and 2). We show also how event typicality influences causal expectations, since more causes were generated after atypical (vs. typical) events (Experiment 3). Finally, we manipulated previous causality content. Participants were presented with discourses fragments containing either cause-consequence (e.g., *Beryl admired John so she applauded him*) or consequence-cause. (*Beryl applauded John because she admired him*). This provided several types of finding. Firstly, we found that readers not only prefer to continue a discourse from the previous consequence (vs. cause, van den Broek et al., 2000), but that this preference is moderated by a recency effect. Hence, there are twice as many continuations from a previous consequence, when that consequence is in the most recent clause (compared to the clause earlier). Secondly, we found that the causal content of the continuation is influenced by the type of event from which the continuation follows. Hence, participants are more likely to provide the cause of an event, if its consequence has already been described. By the same token, more consequences are generated if the cause is already known. We argue that people seek to satisfy gaps they perceive in the causal structure of the discourse model, and may use additional cues from discourse length and agent-semantics to influence their decisions.

# Relating Production and comprehension of relative clauses
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The source of comprehension difficulty for object relative clauses (ORCs) has sparked extensive debate. Here, we explore a production-based account, that comprehension difficulty stems from comprehenders' sensitivity to verbs' distributional properties and ultimately, to producers' choices: Speakers avoid or favor ORCs in different situations, and comprehenders have difficulty primarily on those structures that speakers avoid.

To pursue this approach, we examined the influence of verb biases in producing and comprehending ORCs. We compared theme-experiencer verbs (e.g., *annoy, please*) to ordinary agent-theme verbs. Theme-experiencer verbs exhibit non-canonical patterns of role assignments: unlike ordinary verbs, they often express their experiencer-"affected" role in subject position, resulting in production of a passive construction (F. Ferreira, 1994).

Experiment 1 investigated structure choice in relative clause (RC) productions. Participants saw three RC component phrases at varying locations on a screen and produced a sentence including them. Conditions (1-2) contained theme-experiencer and agent-theme verbs respectively (adapting materials from Traxler et al.'s (2002) comprehension studies, which co-varied noun animacy and verb type).

(1)      [director that] [movie] [pleased]
(2)      [movie that] [director] [watched]

Productions contained passive RCs (i.e., speakers avoided ORCs) more for theme-experiencer than for agent-theme verbs, replicating patterns in main clauses (Ferreira, 1994). We found the same passivization patterns in a large written corpus, suggesting that verb properties modulate producers' structure choices in RCs.

Experiment 2 tested whether comprehenders were sensitive to these verb properties, comparing reading times for ORCs and passive relatives as a function of verb type, as in (3-4):

(3)      a. The director that the movie pleased had received ... (Active/theme-experiencer)
         b. The director that was pleased by the movie had received ...  (Passive/theme-experiencer)
(4)      a. The movie that the director watched had received...          (Active/agent-theme)
         b. The movie that was watched by the director had received... (Passive/agent-theme)

Self-paced reading times at *had* revealed that ORCs with theme-experiencer verbs were harder than with agent-theme verbs (3a > 4a), with passive structures being easier overall. We regressed corpus and Experiment 1 production data on Experiment 2 ORC reading times and found reliable correlations: the more a verb is passivized in an RC, the harder the active ORC is for comprehenders. This suggests that the availability of alternative frequent syntactic structures and argument configurations (passive RCs) interfere with proper role-assignments in comprehension.

Experiment 3 extended these results by independently manipulating ORC subject animacy and verb type, as in (5), with stimulus properties carefully matched.

(5)      a. The candidate that the opponent nicknamed has ... (agent-theme/animate subject)
         b. The candidate that the opponent infuriated has ...  (theme-exp./animate subject)
         c. The candidate that the debate infuriated has ...      (theme-exp./inanimate subject)

Self-paced reading times showed effects of both animacy and verb factors (5a < 5b < 5c). RTs again correlated with active/passive production choices and argument configurations in written corpora. Producers strongly favor passive RCs over active ORCs like (5c); we suggest that this asymmetry leads comprehenders to activate alternative more likely role assignments while parsing items like (5c).

These results link production and comprehension in RCs: Both animacy and verb properties modulate production choices and comprehension difficulty by activating alternative competing structures and thematic roles. In production, alternative conceptually salient roles are accessed first, resulting in passives, while in comprehension, typical alternative roles and syntactic structures interfere during parsing of rarely-produced structures. Overall, these results suggest that unlike claims by syntax and memory-based accounts (Gordon et al. 2001, Traxler et al. 2002), production preferences play an important role in understanding ORC comprehension difficulties.

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# Grammars with Parsing Dynamics: a New Perspective on Alignment

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This paper has two goals. Using a grammar formalism in which syntax is no more than parsing-driven growth of semantic representation (Dynamic Syntax: DS, Kempson et al 2001), we sketch a model of production in which generation is defined in terms of parse routines. We then show how this tight coupling of parsing/generation directly reflects dialogue alignment patterns (P&G Pickering and Garrod forthcoming), including the phenomenon of shared utterances, problematic for systems in which parsing and production involve different mechanisms.

DS is a constraint-based system in which syntax is defined as word-by-word incremental monotonic growth of semantic representations (logical forms in tree format). Tree growth is goal-directed, with general and lexical actions induced by the words in sequence updating partial trees, introducing and meeting (sub-)goals. Syntactic movement is altogether replaced by structural underspecification of tree-relations which get fixed during the construction process. Anaphoric expressions are also treated as introducing a form of underspecification, which is resolved relative to an evolving context modelled as a set of (partial) trees and recently activated lexical actions.

Production uses the same parsing system to produce a suitable string given a fixed goal tree (Purver and Otsuka 2003). The lexicon is searched for words (and their associated lexical actions) which are used to incrementally build a string and associated partial trees, just as in parsing, subject to the additional constraint that these trees subsume the goal tree. The production process is therefore also word-by-word incremental (cf. Ferreira 1996), and is defined entirely in terms of the parsing process, with tree representations and their update actions being shared between the two. Context is also shared, allowing production to use anaphora and recently activated words. (1)-(3) will be used as illustration.

The major task of this production model is full lexicon search, so methods of side-stepping this are to be expected, and the dialogue alignment patterns discussed by P&G follow in consequence. Use of structures and actions previously provided in context bypasses the search -- hence high incidence of anaphora, ellipsis and lexical repetition/alignment. As syntax is defined in DS as progressive growth of semantic structure, apparent syntax-specific alignment (e.g. repeating double-object vs. equivalent dative constructions; Branigan et al. 2000) also follows, as it reduces to lexical alignment (words with double-object and full-dative variants provide distinct forms of tree update, defined as discrete lexical specifications). Self-monitoring is built into the model, as the production process builds all the same information as would the process of parsing the same string. Finally, a simple analysis of shared utterances ((4)-(5)) follows directly from the modelling of production and parsing as sharing all routines and representations: the switch from parsing to production requires only the provision of a goal tree. A prototype computational implementation of this model will be presented.

We conclude that DS meets the P&G challenge of providing a linguistic theory that directly reflects dialogue alignment, with production and parsing essentially inter-related.

## Examples

|       |                                                        |
|-------|--------------------------------------------------------|
| (1)   | John greeted Mary.                                     |
| (2)   | John greeted Mary. She smiled.                         |
| (3)   | Mary, John greeted.                                    |
| (4)   | A: What did Alex buy ... / B: Eliot? A teddy.          |
| (5)   | A: If you try and do enchiladas or erm / B: Tacos? (BNC)|

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# How artists with keys help nuns with umbrellas: The role of prior comprehension on disambiguation

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Do people draw upon two distinct sets of representations and processes when they produce language and understand language?. Such a state of affairs would of course be highly unparsimonious. Yet most research in language comprehension and language production has taken place in isolation from each other, based on quite different assumptions about the architecture of the human language processor. For example, the lemma occupies a central position in theories of lexical production, but has no clear analogue in theories of lexical comprehension. More recently, some researchers have put forward theories that bring together production and comprehension within a single system (e.g., Kempen, 2000). Such theories require empirical support. In this paper, we present evidence that some syntactic processes/representations are shared between production and comprehension.

If shared processes/representations exist, then prior use of them in comprehension could affect their subsequent use, giving rise to priming effects. Branigan, Pickering, and Cleland (2000) found evidence that prior comprehension of syntactic structure can affect subsequent production of that structure. They asked naïve participants to alternately describe pictures and find pictures that matched a (Confederate) partner's description. Participants tended to reuse whichever structure they had just heard for their own descriptions. Branigan et al. interpreted their findings in terms of the residual activation of syntactic rules that are employed in both production and comprehension.

But these results are unidirectional. If syntactic rules are shared in this way, we would also predict the reverse pattern, with priming from production to comprehension. In Experiments 1 and 2, we demonstrate that comprehension of particular structures can be primed within a picture selection task: Participants had to decide which of two pictures matched a description. We crossed the structure of the Prime and Target descriptions (High- vs. Low-Attached, as in [1] & [2]). Participants were significantly faster to select the appropriate picture when they had previously comprehended a description with the same structure than the alternative structure (Experiment 1), and selected a picture that could be described using the primed structure significantly more often than one that could be described using the alternative structure (Experiment 2). Hence, syntactic structure can be primed in comprehension.

In the critical experiment, Experiment 3, we show that choice of structure in comprehension is influenced by prior production of that structure. Participants produced either a High- or -Low-Attached description for a picture. They subsequently read a description that was ambiguous between a High- and -Low-Attached structure, and chose between two pictures, one appropriate for each analysis. After producing a High-Attached prime, they were more likely to choose High-Attached targets; after producing Low-Attached primes, however, they were more likely to choose Low-Attached targets.

Our results provide strong evidence that syntactic priming occurs for comprehension. More importantly, however, they provide evidence that production and comprehension employ shared processes/representations at the syntactic level at least. This strengthens the theoretical arguments for a parsimonious architecture in which many elements are shared.

**Examples**

    [1]      The artist prodding the monk [with the key].
    [2]      The artist prodding [the monk with the key].

# Are words all there is?
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Recent research on language comprehension and production points to the possibility of substantial sharing of syntactic resources in normal language use. Similar disruptions to agreement occur in reading (Pearlmutter, Garnsey, & Bock, 1999) and speaking (Bock & Miller, 1991). Structural priming has been shown to extend from comprehension to production (Branigan, Pickering, & Cleland, 2000; Potter & Lombardi, 1998) without substantial reductions in magnitude relative to the within-modality effects of priming (Bock, 2002).New evidence has established the occurrence of priming within comprehension (Scheepers & Crocker, in press). All of these developments increase the credibility of a modality neutral performance grammar (Kempen, 1997) in which the structural mechanisms of language production operate in parsing, too, and under similar constraints. Drawing on two different types of experimental evidence, I explore the prospects for explaining this convergence in terms of shared lexical processes.

In parsing, there is a debate about the extent to which the lexicon participates in, guides, or pre-empts structural analysis (MacDonald, Pearlmutter, Seidenberg, 1994). A closely related question has been raised with respect to structural priming in production. Beginning with Pickering and Branigan (1998), Pickering and colleagues have established that the repetition of verbs substantially increases the magnitude of priming, and have proposed an interpretation of the results within a lexicalist framework. Although other priming results are harder to reconcile with the preservation of activity in a lexical network, the viability of a lexical account of structural priming can be seen as reducing or eliminating the need for abstract structural mechanisms in either production or comprehension. To test the lexical dependence of structural priming in a different context, Konopka and Bock (2004) compared priming from idiomatic and nonidiomatic phrasal verbs. Idiomatic phrasal verbs are lexical or constructional by definition (Jackendoff, 2002), whereas nonidiomatic phrasal verbs participate in a productive structural alternation. To the degree that structural priming is lexically dependent, priming from idiomatic and nonidiomatic phrasal verbs to other phrasal verbs should differ. Consistent with Pickering and Branigan's data, the repetition of phrasal verbs enhanced priming, replicating the relevant lexical effect. The new findings to be reported have to do with whether idiom status likewise affected structural priming.

A second line of evidence for lexical dependence comes from patterns of eye fixations during language comprehension and production. In production, the timing of eye movements to the elements of events is tightly linked to the timing of lexical selection and encoding (Griffin, 2001; Meyer, Sleiderink, & Levelt, 1998), which points to strongly incremental, word-by-word formulation of speech. To begin to make a case that structural formulation also modulates the timing of eye movements, I review results from studies of time-telling (Bock, Irwin, Davidson, & Levelt, 2003). The findings suggest an early process of disintegration in language production that mirrors end-of-clause integration processes in language comprehension.

The conclusion is that words, even structurally sophisticated words, are unlikely to be enough to explain how we produce language. But the illustrative and farther-reaching point is that in drawing such conclusions, it is becoming feasible to draw on experimental evidence from language production to complement or contrast with the evidence from language comprehension.

# Comprehension and production in dialogue
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Traditionally, language production and comprehension have generally been thought of as largely separate systems, and researchers in one field have paid little attention to results in the other field. However, production and comprehension might parsimoniously draw much of the same information (e.g., same lexical entries or grammatical rules), in which case it would be inappropriate to study them separately. Such "parity of representation" appears very likely when we consider that people do not normally perform isolated acts of production or comprehension. In dialogue, interlocutors are constantly switching between the two tasks (e.g., speakers' behavior is greatly affected by feedback), and such parity would be highly beneficial, for example when interlocutors complete each others' utterances.

The main part of my talk outlines the interactive-alignment model of dialogue (Pickering & Garrod, in press; cf. Garrod & Pickering, 2004), which assumes that dialogue is successful to the extent that interlocutors end up with similar (aligned) situation models, and that this alignment is largely brought about by an automatic process in which they align at different levels of linguistic representation at the same time. This model assumes parity at all levels, so that lexical, syntactic, semantic, and phonological representations are shared between production and comprehension. After arguing that it should be possible to study the cognitive mechanisms underlying dialogue, I review experimental evidence suggesting that people align at different linguistic levels, with a particular focus on syntactic priming effects in dialogue. For example, I show that people tend to repeat each other's choice of verb alternation (e.g., prepositional vs. double object construction; Branigan et al., 2000) and noun modification (e.g., adjective vs. relative clause; Cleland & Pickering, 2003). Intriguingly, such repetition occurs between languages (Hartsuiker et al., in press), and may even be unaffected by language change under some circumstances. More briefly, I show that alignment occurs at other linguistic levels.

The interactive-alignment model predicts that alignment at one level leads to more alignment at other levels, and that this "percolates up" to the situation model. For example, syntactic priming evidence demonstrates that priming is greatly enhanced by lexical repetition (e.g., of the verb). The process of alignment therefore takes place largely without recourse to conscious decision making (e.g., to use the same expression). I therefore propose that the alignment leads to the accumulation of what we term an "implicit common ground" of shared information. I then consider how self-monitoring can be regarded as alignment within the speaker, and predict that monitoring occurs at all levels of representation. Finally, I propose that alignment can lead to an account of "routinization", whereby interlocutors construct expressions whose form and interpretation are more-or-less fixed for the interaction (and which are of course shared between production and comprehension).

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# Understanding parsing by Understanding Production
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Research into the processes underlying language comprehension is typically conducted independently from research investigating processes of language production. This independence rests on an underlying assumption that the tasks of production and comprehension are too different to be profitably investigated conjointly. This talk offers an alternative view, that key insights into parsing and other comprehension processes can be gained through an understanding of production processes. I will describe the Production-Distribution-Comprehension (PDC) account, which holds that parsing preferences previously ascribed to parsing principles or other features of the language comprehension architecture instead have a production origin.

The PDC account begins with incrementality and other properties of the production system: In order to maintain fluency in language production, speakers make certain lexical and syntactic choices, for example putting more accessible material early in an utterance, thereby giving them more time to plan more difficult material. Across many utterances and speakers, these production-driven choices lead to particular distributional patterns of word order and sentence structure. These distributional patterns in turn provide data for the comprehension system concerning the frequency of words and phrases in the language. Within constraint-based accounts of parsing and comprehension, distributional patterns underlie the constraints that drive the comprehension processes. A key challenge for the PDC is to make explicit the links from production demands to production choices to distributional patterns to parsing biases, and thus the research strategy must encompass both production and comprehension data. I will illustrate this account with corpus, production and comprehension studies for relative clauses and other syntactic constructions. I will argue that the PDC account offers insights into comprehension processes that are not afforded by comprehension-specific views. For example, the PDC suggests an answer to the origin of the constraints that are so central to constraint-based accounts of parsing: that they can be ultimately traced to the architecture of the production system.

# Human Grammatical Coding:
# Shared structure formation resources for grammatical encoding and decoding

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Language production and language comprehension both involve the on-line formation of conceptual and syntactic structures. These processes may be called grammatical encoding (structure formation during production) and grammatical decoding (parsing and interpreting). (In this paper, we disregard morphological, referential and lexical retrieval processes.) It is standardly assumed that the cognitive system of human language users contains separate processing components for these tasks—components with very different operating characteristics (although both rely on a single grammar and lexicon). This assumption is typically justified by the widely divergent task demands the two components have to face. For instance, dealing with ambiguity is a major concern for grammatical decoding but not for grammatical encoding; and linear order is given in the case of grammatical decoding but has to be computed on-line during grammatical encoding. Let us call this the heterogeneous dual-processor model.

However, psycholinguistic research has uncovered substantial similarities between grammatical encoding and decoding:

- Similar control structures: E.g., both processes can be characterized as lexically guided, incremental, near-deterministic, and constraint-based.
- Similar empirical profiles: E.g., syntactic priming affects the two processes in similar ways, and so does grammatical (in)congruence.

In order to account for these and other commonalities, it has been proposed that the two heterogeneous processors share their working memory. This proposal is unsatisfactory, though, because it does not address the control structure similarities. Instead, two alternative theoretical options look more promising:

- The *homogeneous dual-processor model:* The grammatical encoding and decoding tasks are carried out by two exemplars of the same type of grammatical processor; and
- The *single-processor model:* Grammatical encoding and decoding are two "modi operandi" of one and the same processing component.

How to tell these alternatives apart experimentally, in particular the single-processor model from the dual-processor models? The former model predicts that processing capacity recruited for encoding purposes cannot be assigned to decoding, and vice-versa. On the latter models, encoding and decoding activities draw on independent (non-shared) processing resources. Now suppose we can design a task that requires the participants to encode and decode simultaneously, without implicating divided attention (e.g., without having to monitor two input channels or to deal with two meanings at the same time). As grammatical structure formation is standardly considered to be an automatic process that does not require conscious attention, the dual-processor models predict that structure formation can take place in the encoding and decoding components in parallel without the need to share processing capacity. (Theories of self-monitoring during speaking usually work from this assumption, e.g., the perceptual loop theory.) The single-processor model predicts that the larger the processing capacity assigned to one of the two tasks, the smaller the amount left for the other.

In the mixed encoding/decoding paradigm that we have explored, participants perform a kind of "slow-motion shadowing" task. In each trial, they read a sentence that is presented word-by-word or in fragments spanning a few words. In one variant of the task, some of the sentences contain syntactic errors. The participants are instructed to read aloud the input fragments in grammatically correct form. This requires that, for each input fragment, they decide whether the fragment can be pronounced overtly "as is", or has to undergo a syntactic modification in order to restore well-formedness. In another variant, the input sentences are well-formed but the output sentences should embody a (morpho)syntactic modification of the input. In all variants, voice reaction times are measured to each input fragment. Notice that, during any trial, there is only one input sentence whose decoding gives rise to one meaning only, and that the encoding task yields an output sentence that is a syntactic paraphrase of the input.

The pairs of an input and an output sentence are constructed in such a way that the initial sequence of input fragments leads the participants to expect different downstream fragments than the initial sequence of output fragments does. The RTs to these downstream fragments can reveal whether the actual expectations are based on the grammatical structure assembled for the perceived input fragments or on the modified structure that underlies the output sentence (or on a mixture of both).

Provisional RT patterns obtained thus far clearly indicate that, in this dual-task paradigm, the participants' expectations followed the output structures they encoded themselves, not on the initial structure of the decoded input. In a control condition (self-paced reading aloud without paraphrasing instructions), the RT pattern agreed with input-based expectations.

These data suggest, contra the dual-processor models, that grammatical encoding and decoding tasks draw on the same processing resources. In conjunction with the above task similarities, they support the idea of a single "human grammatical coder."

When presenting the paper, we hope to discuss how this idea squares with other known facts concerning grammatical encoding and decoding, in particular their interplay in self-monitoring.

# What Ambiguity, Optionality, And Incrementality Reveal About Sentence Production And Comprehension

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The "PC problem" refers to the fact that sentence production and comprehension are basically different (possibly opposite) processes that must share something -- minimally, representations of the language itself. I illustrate this problem by examining the relevance to each process of three factors: ambiguity, optionality, and incrementality. Ambiguity happens when a linguistic expression can mean more than one thing. It is of obvious relevance to language comprehension, and has been heavily investigated in sentence-comprehension research. Similar kinds of ambiguity have been investigated less in language production, and what research has been done suggests that ambiguity has little or no effect on how speakers produce structures online. Optionality happens when a meaning can be expressed in more than one way. Optionality is of obvious relevance to language production, and has been heavily investigated in sentence-production research. At the same time, optionality has been virtually ignored in sentence-comprehension research (except inasmuch as a similar-meaning expression can be used as a control for an ambiguous expression), probably because it is not relevant to the comprehension process. I suggest that this complementary pattern of research emphasis and relevance illustrates the similarity and differences between comprehension and production: Comprehension and production are similar in that each has the high-level processing goal of determining the right output given a particular input, which raises the challenge of ambiguity for comprehension and optionality for production. They're different in that at the level of processing implementation, comprehension and production must be 'built' to deal with these different problems -- ambiguity in the case of comprehension, optionality in the case of production. Next, I turn to incrementality, which is a property of processing systems rather than linguistic expressions. Incrementality refers to the fact that we process elements of expressions as soon as possible, so that in production, we produce as soon as minimally producible material is formulated, and in comprehension, we interpret as soon as minimally interpretable material is perceived. Current evidence suggests that both comprehension and production are heavily incremental, and in production, so much so that incrementality determines how (and how easily) we produce particular structures. I suggest that the shared incrementality of comprehension and production again reflects a common high-level processing goal of each processing system. In this case, it's a temporal imperative, in that both comprehension and production are 'anxious,' and so try to yield output as soon as possible. But again, this shared high-level goal is played out by different specific processes, each sculpted to deal with its own distinct challenges. Together, these analyses suggest that comprehension and production share high-level processing goals, but differ in terms of processing implementation. Finally, for comprehension and production to end up using the same language, the two also must share a representational vocabulary. I will close by briefly reviewing some frameworks that accommodate all of these similarities and differences, and touch on how evidence of tight interactions between comprehension and production can be cast in such frameworks.

# CUNY CONFERENCE

# Friday, March 26

# Poster Session II

# Transitives, intransitives and passives: How is transitivity represented?

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Sentence processing research (e.g., Clifton et al., 1984; Stowe et al., 1991) has shown that transitivity frequencies can influence the ease with which people process syntactic ambiguities (although it is less clear when these frequencies are used). This suggests that language users somehow mentally represent the activation of transitive and intransitive structures. However, very little is known about how this activation is stored. We conducted two experiments to fill this gap.

Experiment 1 addressed two questions. First, is the activation of transitivity information in active and passive transitives represented together or separately? Second, does each individual verb have a separate activation for transitive structures (lexically specific representation) or is the activation of transitive structures represented for the class of verbs as a whole (category-general representation)?

We used the syntactic priming methodology. Participants either read an active transitive prime sentence (1a/c) or a passive transitive prime (1b/d). We controlled for the number of noun phrases in the conditions. Subsequently, participants completed a target fragment (2), in which the verb of the prime was either repeated or not.

**Examples**

1a. It is surprising that the contractor has phoned the engineer. (active, verb repeated)
1b. It is surprising to the contractor that the engineer was phoned. (passive, verb repeated)
1c. It is surprising that the contractor has sued the engineer. (active, verb not repeated)
1d. It is surprising to the contractor that the engineer was sued. (passive, verb not repeated)

2. When the actress phoned.......

We scored the percentage of (active) transitive completions.

The results showed a main effect of voice: Participants produced more transitives following actives than following passives. We conclude from this that transitivity activation for actives and passives is represented separately. Furthermore, there was no verb repetition effect, nor an interaction with voice: Participants produced as many transitives when the verb was repeated as when it was not. The fact that the priming effect was independent of verb repetition suggests that the activation of the transitive structure is represented at the category-general level.

In Experiment 2, we investigated whether passives are represented similarly to intransitives. Passives without *by*-phrase have a surface structure that is somewhat similar to that of intransitives. Hence, if people represent the activation of surface structure (word order) rather than thematic information (number and type of arguments), passives may prime intransitives. Experiment 2 contrasted passives (1b/d) and intransitives (1a/c).

**Examples**

1a. It is surprising to the engineer that the contractor has phoned. (intransitive, verb repeated)
1b. It is surprising to the contractor that the engineer was phoned. (passive, verb repeated)
1c. It is surprising to the engineer that the contractor has sued. (intransitive, verb not repeated)
1d. It is surprising to the contractor that the engineer was sued. (passive, verb not repeated)

2. When the actress phoned.......

We observed an interaction between voice and verb repetition. There was no verb repetition effect following passives. In contrast, following intransitives, participants produced more intransitives when the verb was repeated than when it was not. Thus, the representation of intransitives is lexically specific. Finally, there was no difference between the passive and intransitive non-repeated conditions, suggesting that passives did not prime transitives at all.

Experiment 1 and 2 suggest that the activation of active transitives is represented at the category-general level, whereas the activation of intransitives is represented at the lexically specific level. We argue that representing the activation of active transitives for individual verbs would not be cost-effective, because the active transitive structure occurs very frequently. In contrast, intransitives are less frequent. Finally, we conclude that passive transitives do not share a representation with active transitives. They also do not share the same representation as intransitives, because Experiment 2 showed a verb repetition effect for intransitives but not for passives.

# Semantic category effects in sentence production

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Several linguistic accounts (e.g., Levin, 1993; Pinker, 1989) suggest that verb semantics predict the range of possible argument structures for a verb, and that verbs can be categorized into semantically coherent categories which share meaning components relevant to argument structure. Analyses of the frequency distributions of alternate argument structures for SC-taking verbs (e.g., *suggested*, *claimed*) and for dative and benefactive verbs (e.g., *gave*, *saved*) demonstrated that verb semantic category (e.g., manner of speaking, verbs of future having) can also account for the relative frequencies of the syntactic alternatives for a given verb (sentential complement versus direct object for SC-taking verbs and double object versus prepositional object for dative verbs) (Argaman, 2003; Argaman and Pearlmutter, 2002). Given this relationship between verb category and argument structure preferences, the psychological reality of verb categories was examined in sentence production, in a syntactic priming experiment.

Previous research has shown that the syntactic structure of a target utterance is influenced by the syntactic structure of a preceding utterance (e.g., Bock, 1986). Furthermore, Pickering and Branigan (1998) showed that when the verb in the prime sentence is identical to the verb in the target sentence the magnitude of the priming effect increases. In the current investigation, the magnitude of priming was examined under three match conditions: the prime verbs and target verb were either identical, from the same semantic category, or from different semantic categories. Participants read a set of five prime sentences, four with one alternative structure and one with the other alternative structure, creating a bias for one alternative or the other. Participants then had to produce out loud a completion of a sentence initial fragment, comprised of a proper name and a target verb in the past tense (e.g., *Sarah advised*). 18 experimental items used SC-taking target verbs, and 12 used dative or benefactive target verbs. These were randomly intermixed with 30 filler trials.

The pattern of results demonstrated the largest priming effect in the same verb match condition (13%), smallest priming effect for the different category condition (3%), and intermediate priming effect for the same category condition (6%). These results suggest a model of the lexicon in which verb category is represented and accessed during production.

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# Prosodic Principles guide parsing preferences while reading – an ERP investigation of relative clause attachment

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Numerous recent studies have revealed that relative clause length influences attachment preferences in sentences of the type NP1-*of*-NP2-RC. Length effects might override a language's neutral attachment preference and have been observed for many languages, e.g. Croatian, French, Spanish and Japanese. These findings can be explained by an approach which states that prosodic phrasing influences syntactic processing even during silent reading (e.g. Fodor, 2002).

While length effects have been studied rather extensively, only a few studies examine the impact of lexical elements on phrasing (e.g. Lovric, 2003 for Croatian). The present EEG study was designed in order to obtain a more precise on-line record of processing of comparable ambiguous structures in German. Visual processing of the target sentences was examined.

Sentences were disambiguated via number agreement of the finite verb with one of the two NPs (high attachment by agreement with NP1 vs. low with NP2). The second factor of interest was choice of preposition (*null* (the Genitives in (1)) vs. thematic preposition *bei* (B) vs. non-thematic preposition *von* (C)). A set of 46 sentences per condition was tested. While former studies (e.g. Hemforth, 2000) established a general high attachment preference for German genitives, a low attachment preference for the items comparable to those in B has also been reported. The *von*-DPs were of special interest as they express the same semantic relation as the genitives, but differ in their syntactic status and might therefore introduce a distinct prosodic pattern.

Interestingly, participants did not exhibit clear attachment preferences for the genitives – no significant differences for (1) forced high vs. forced low could be observed. In contrast, we found a preference for low attachment with both the (2) and (3) items, indicated by a fronto-centrally distributed positivity between 300 and 1000 ms after the onset of the critical verb, which was found for sentences that were biased towards high attachment compared to their low attachment counterparts. Though being more frontally distributed, the effect resembles the P345 component (for a discussion see Schlesewsky and colleagues, 2003) which has been claimed to occur when re-analysis of a dispreferred structure does not involve the addition of structural nodes (Friederici & Mecklinger, 1996).

Based on the idea that *von* is non-thematic, the difference observed can be best explained by a prosodic preference for the sentences containing a preposition (thematic or non-thematic) to lower attachment preferences by grouping NP2 and the RC in one prosodic unit.

The results are consistent with a recently conducted offline-questionnaire, which shows that there are significantly less high-attachment answers with sentences containing overt prepositions than with genitives ($p < .001$).

## Examples

(1)      Holger kannte die **Kolleginnen** $\varnothing$ der <u>Juristin</u> die lange im Büro **waren** / <u>war</u>.
Holger knew the colleagues$_{pl}$ of-the judge$_{sg\,(GEN)}$ who long in-the office were$_{pl}$ / was$_{sg}$.
'Holger knew the collegues of the judge who had been /has been in the office for a long time'
(2)      Holger kannte die **Kolleginnen** *bei* der <u>Juristin</u> die lange im Büro **waren** / <u>war</u>.
Holger knew the colleagues$_{pl}$ near the judge$_{sg(DAT)}$ who long in-the office were$_{pl}$ / was$_{sg}$.
(3)      Holger kannte die **Kolleginnen** *von* der <u>Juristin</u> die lange im Büro **waren** / <u>war</u>.
Holger knew the colleagues$_{pl}$ of the judge$_{sg(DAT)}$ who long in-the office were$_{pl}$ / was$_{sg}$.

# Modelling Attachment Decisions with a Probabilistic Parser

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Probabilistic parsing models have been used successfully to model attachment decisions in sentence processing (e.g., Jurafsky 1996, Crocker and Brants 2000, Sturt et al. 2003). However, most models focus on a small selection of phenomena and do not account for the ease with which humans understand the vast majority of sentences. Also, all existing models deal exclusively with English data.

We describe an incremental, two-stage probabilistic model of human parsing for German. The model is broad coverage, i.e., it assigns sentence structure to previously unseen newspaper text with high accuracy. It also makes incremental predictions for the attachment decisions for PP-attachment ambiguities. We investigate whether a purely probabilistic model is able to account for the attachment preferences in German verb final sentences, which have not been modelled before.

In cases of PP attachment ambiguity, the PP can be attached to a preceding NP or the verb. The word order in German verb second sentences is similar to English (Ex. (1)). German verb final sentences provide a challenge for the study of PP-attachment, as the PP is processed before the sentence head is seen (Ex. (2)).

**Examples**

| (1) | Iris | stoerte | die Rentnerin | mit der Rockmusik. | |
| | Iris | annoyed | the pensioner | with the rock music. | |
| (2) | (… dass) Iris | die Rentnerin | mit der Rockmusik | stoerte. |
| | (… that) Iris | the pensioner | with the rock music | annoyed. |

Reading studies (e.g., Konieczny et al. 1997, whose materials we use) have shown that in verb second sentences, the PP is preferentially attached according to the subcategorisation bias of the verb (as in English). In verb final sentences, where subcategorisation information cannot be accessed immediately, the PP is preferentially attached to the (seen) NP site. In Konieczny et al.'s (1997) materials, attachment is disambiguated by the semantic implausibility of one alternative. Significant effects were observed on the PP.

Our parsing model consists of two modules. One is a syntactic module based on a standard probabilistic parser (trained on NEGRA, a syntactically annotated corpus of German). This module guarantees broad coverage of language data. After the PP has been processed, the parser ranks the attachment alternatives according to their probability. The second stage is a shallow semantic module. It makes the final attachment decision by ranking the alternatives according to frequency measures which are standardly used in computational linguistics to disambiguate PP-attachment (Volk 2001). Conflicts between the decisions made by the two modules (i.e., different ranks for the alternatives) are interpreted as conflicts between verb preference and semantic disambiguation and hence predict increased reading times. The model's predictions were evaluated against average reading times from Konieczny et al.'s (1997) eye-tracking study.

The model correctly accounts for attachment preferences in verb second sentences. This replicates modelling results for English (Jurafsky 1996, Crocker and Brants 2000, Sturt et al. 2003). However, the model fails to correctly account for the attachment preferences in verb final sentences.

To resolve the attachment, the syntactic module relies on verb subcategorisation information and on a global attachment preference if the verb is absent. The experimental data from Konieczny et. al (1997) show a global preference for NP attachment, while in our corpus, verb attachment is more frequent. Therefore, the syntactic module consistently makes a wrong prediction for verb final sentences, which compromises the model's performance. However, our model would have been successful had the global preference in the corpus data been for NP attachment. This indicates that the new phenomenon of PP attachment in verb final sentences can in principle be covered by the probabilistic framework. Our results highlight how sensitive probabilistic models are to idiosyncrasies in the training data. Note that in general, balanced corpora consisting of data from different sources are more reliable than newspaper-only corpora like NEGRA.

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# Pitch Accent's Interaction with Other Cues of Salience in Pronoun Referent Resolution

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Four experiments examine the effects of pitch accent on a potential referent of a pronoun during sentence comprehension. Materials for all studies were three-sentence discourses with a main character and two potential referents. The referents were presented in the second sentence of the discourse, and a single pronoun appeared in the third. The first potential referent was the Agent of an action while the second was the Patient. The following is an example of material sets for Experiment 1:

"Karen knew some of her friends were going to this year's Halloween party. When she arrived, she scanned the room and saw a <u>sheriff</u> serving a <u>pirate</u> near the punch bowl. Right away, Karen recognized <u>him</u> and went over to say 'hi'."

Discourses were recorded such that a pitch accent appeared either on the first potential referent or the second – a fact validated via acoustic analysis of the prosodic contour of the materials. The accented NP always had a higher pitch. In contrast to many studies on pitch accent and pronouns, the accent in these experiments was not contrastive stress but rather focus stress.

Participants listened to 32 discourses (8 with pitch accent on the first potential referent, 8 with pitch accent on the second, and 16 fillers) and answered a multiple-choice question about each item. The results showed that pitch accent increased the likelihood that participants would choose the accented entity as the pronoun's referent. (See Table 1.)

In the second experiment, the same discourses were used, but with a passive construction. (e.g. Experiment 2: "… a sheriff being served by a pirate …"). The results of this experiment showed no effect of pitch accent. One possible explanation is that the Patient was explicitly marked as salient by appearing in subject position. In passive constructions, when the prosodic cue appeared somewhere else, it did not sway interpretations because the Patient was still the most salient entity.

It was hypothesized that a similar pattern of results might occur for Goal and Source theta roles. Goals tend to be preferred over Sources as the pronoun's referent (Stevenson et al., 1994). Thus, if the Goal appeared in subject position, it would be explicitly marked as salient, and pitch accent would have no effect. However, prosody would influence interpretations when the Goal did not appear as the subject of the embedded clause. Experiments 3 and 4 examined this issue. In Experiment 3, the effect of prosody was observed with Source-Goal verbs (e.g. "… a sheriff serving a drink to a pirate …"). As predicted, the effect was not observed with Goal-Source verbs in Experiment 4 (" a sheriff accepting a drink from a pirate…"). (See Table 1).

Taken together, the findings suggest a principled interaction of pitch accent on potential referents with other referential cues in pronoun referent resolution. Most notably, pitch accent affects interpretations when the most salient thematic role appears as the object, but it has no effect when the order of the thematic roles suggests that the subject is the most salient entity. Thus, pitch accent loses its potency when the salience of one of the candidates is bolstered by the arrangement of theta roles.

**Table 1**

*Mean proportion of the time the first potential referent was selected.*

| | Pitch on first | Pitch on second | p value | Interaction |
|---|---|---|---|---|
| Experiment 1 (Agent-Patient) | .82 | .66 | < .001 | .01 |
| Experiment 2 (Patient-Agent) | .78 | .76 | .50 | |
| Experiment 3 (Source-Goal) | .91 | .79 | .007 | .03 |
| Experiment 4 (Goal-Source) | .80 | .82 | .65 | |

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# On the primacy of word category information: Direct time course evidence

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Event-related potential (ERP) measures have provided convincing evidence for models of language comprehension assuming an initial stage of (post-phonological) processing drawing exclusively upon word category information (Friederici, 2002). However, these findings have also been subject to a great deal of debate (Hagoort, 2003), partly because of the lack of converging support from other experimental methods. Yet independent experimental evidence for the primacy of word category information is difficult to come by, because the examination of this type of manipulation requires a method with a very high degree of temporal resolution

An experimental technique that allows for a direct examination of the time course of processing is the speed-accuracy trade-off (SAT) method (e.g. McElree & Griffith, 1995). The present study employed a variant of the SAT methodology (McElree, 1993) to compare the time course of ungrammaticality detection for word category (1a) and agreement violations (1b). The corresponding grammatical control conditions are shown in (1c).

Participants read the sentences in (1) embedded among a variety of filler conditions and concurrently judged their acceptability by means of button presses every 350 ms. From these responses, full time course functions of the accuracy of processing were computed.

The results show that the word category violation rises to terminal (asymptotic) accuracy more quickly than the agreement violation, as was confirmed by fitting the data to an exponential approach to a limit ($d'(t) = \lambda[1-e^{-\beta(t-\delta)}]$ for $t > \delta$, 0 otherwise). This equation provides three crucial parameters: asymptotic accuracy ($\lambda$), rate of rise ($\beta$) and intercept, i.e. departure from chance performance ($\delta$). The $\beta$ and $\delta$ parameters collectively characterise the dynamics of the function, i.e. the speed of processing. Indeed, the data were best fit by a model assuming an earlier intercept for the word category condition, thereby yielding an estimated dynamics difference ($1/\beta+\delta$) of 360 ms between the two violation types, which cannot be explained in terms of length differences (estimated dynamics difference due to length: 110 ms). These findings mirror ERP data on identical manipulations (Mauth et al., 2002), in which the word category violation elicited an early left-anterior negativity, while the agreement violation engendered a temporally delayed left-anterior negativity. The present data thus provide strong converging support for an initial stage of (post-phonological) comprehension, in which only word category information is drawn upon. They thereby support "word category first" models of sentence comprehension (Frazier, 1978; Friederici, 2002).

**Examples**

(1)      a. *Das ist die Sauce, die du Verfeinerung.
          this is the sauce that you as refinement
      b. *Das ist die Sauce, die der Koch verfeinerst.
          this is the sauce that the chef refine$_{2SG}$
      c. Das ist die Sauce, die der Koch / du verfeinert/verfeinerst.
          this is the sauce that the chef / you refines$_{3SG}$/refine2$_{SG}$

# Beliefs about mental states in lexical and syntactic alignment:
# Evidence from Human-Computer dialogs

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There is increasing interest in the cognitive aspects of interactions between humans and computers. Such research is theoretically interesting because it elucidates whether beliefs about an interlocutor's "mind" affect communicative behavior. People do not generally believe that computers have human minds, but often behave as if attributing human characteristics to them (Reeves & Nass, 1996). It is uncontroversial that beliefs about an interlocutor can affect some aspects of behavior (e.g., choice of topic), but little is known about how far such influences extend, in particular, whether they can influence relatively 'automatic' aspects of language processing, or are limited to 'higher order' aspects of processing (as e.g., Clark's 1992 model might predict). This paper presents three experiments that investigate whether beliefs about an interlocutor can permeate lexical and syntactic processing in dialog.

In all three experiments, naïve participants played a dialog game in which they believed that they were interacting with either a person or a computer. In fact, their "interlocutor" was always a computer program that produced pre-scripted utterances. The experimental task was presented as a picture-matching and -describing game, involving interacting with an unseen interlocutor by typing. On a matching (prime) turn, the participant read a picture description "from their interlocutor", and decided if it matched a picture displayed on-screen. On a describing (target) turn, they typed a description of a picture displayed on-screen "for their interlocutor".

In Experiment 1, we presented pictures of single objects. We manipulated whether the "interlocutor" produced a preferred term (e.g., chair) or dispreferred term (e.g., seat) for an object, and examined which term the participant used to describe the same object subsequently. There was a strong tendency to lexically align with the "interlocutor", but this interacted with beliefs about the identity of the interlocutor: Participants used the same term more often with a "computer interlocutor" than with a "human interlocutor". (See Table 1.)

In Experiments 2 and 3, we presented pictures of ditransitive actions. We manipulated the syntactic structure of the prime description (Prepositional Object [PO] vs. Double Object [DO], as in [i-ii]), and examined the syntax of the subsequent target description. In Experiment 2, the prime and target picture involved the same verb; in Experiment 3, the verbs differed. Participants tended to syntactically align with the "interlocutor". In Experiment 2, alignment was greater for a "computer interlocutor" than a "human interlocutor". However, there was no such difference in Experiment 3. (See Table 2 and Table 3, respectively.)

Taken together, our results suggest that both lexical and syntactic processing in dialog are affected by beliefs about an interlocutor. However, the fact that greater alignment was found for "computer interlocutors" in only Experiments 1 and 2 suggests that there may be a strategic component since people may be more aware of lexical repetition (Experiment 1) and of syntactic repetition with the same verb (Experiment 2). But Experiment 3 provides evidence that alignment also has a non-strategic component, in keeping with accounts stressing that alignment is a basic organizing principle of dialog (Pickering & Garrod, in press).

i.        The pirate handing the cake to the sailor. PO
ii.       The pirate handing the sailor the cake. DO

Table 1: Percentage of (lexical) alignment in Experiment 1
"computer interlocutor"      65.9
"human interlocutor"         12.7

Table 2: Percentage of (syntactic) alignment in Experiment 2 (same verb in prime and target)
"computer interlocutor"      85.3
"human interlocutor"         55.0

Table 3: Percentage of (syntactic) alignment in Experiment 3 (different verb in prime and target)
"computer interlocutor"      26.9
"human interlocutor"         32.1

# Accounting for Individual Differences in Processing Anomalies of Form and Content

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The Referential Theory of Crain & Steedman (1985) offers a way to conceptualize how syntactic and pragmatic sources of information are used on line by individuals with different processing capacities (Ni, Crain & Shankweiler, 1996). Sentence anomaly can serve as a "litmus test" to tease apart syntactic and pragmatic operations that are ordinarily intertwined in on-line language comprehension. In two previous studies of college students, we have found distinct patterns of eye-movements in reading sentences containing either a syntactically or pragmatically anomalous verb, or no anomaly (Ni, Fodor, Crain & Shankweiler, 1998; Braze, Shankweiler, Ni & Palumbo, 2002). Syntactic anomaly evoked an immediate peak in regressive eye movements (at the verb), while regressions due to pragmatic anomaly peaked at sentence end. Additionally, Braze et al. (2002) showed that participants tend to re-fixate sentence regions appropriate to each anomaly type; the parser uses "intelligent" repair strategies when on-line parsing mechanisms fail (Frazier & Rayner, 1982; Fodor & Inoue 1994).

Our present study uses the same methodology and comparable sentence materials (examples below) to compare two age-matched groups which differ in working memory capacity as assessed by a "listening span" test of verbal working memory (Daneman & Carpenter, 1980). The high capacity group is similar to participants in our previous studies, while the other group is markedly lower (the groups also differed on a number of other dimensions, including reading skill). This study asks whether these groups are differently sensitive to syntactic and pragmatic sources of information in the linguistic signal. Test sentences were designed to be within easy reach of the less-skilled readers.

The Referential Theory predicts that use of pragmatic cues in parsing will tax working memory more than use of syntactic cues because, while syntactic operations are automatic and informationally encapsulated, pragmatic ones are effortful and rely on open-ended world knowledge. Individuals with sufficient memory capacity may exploit both types of information in parsing, but even here the theory predicts the temporal priority of syntactic over pragmatic processes due to the unidirectional information flow and weak interactivity of the model (top down information can be used to prune syntactic representations from the workspace, but not to motivate them). Thus, the Referential Theory predicts that individuals with higher working memory capacities will be better able to exploit pragmatic cues in the linguistic signal than will those with lesser memory capacities. However, use of syntactic information is predicted to be less subject to individual variation.

Our data shows a clear effect of syntactic anomaly with no group differences. Consistent with our previous findings, both groups show an increase in regressive eye movements at the syntactically anomalous verb (examples b and d). However, only the high working memory group show an increase in regressive eye-movements in the presence of Pragmatic anomalies (examples c and d). Further, even the high memory group shows a lag in sensitivity to pragmatic anomaly relative to syntactic anomaly. Regressive eye-movements due to pragmatic anomaly do not occur until several words after the anomalous verb. Moreover, only high memory participants make appropriate regressions, as in Braze et al. (2002); low memory participants seem unable to exploit informational cues to guide their regressive eye-movements.

## Examples

a. The daisies were slowly wilting in the hot weather this afternoon.		NO ANOMALY
b. The daisies had slowly wilting in the hot weather this afternoon.		SYNTACTIC ANOMALY
c. The puddles were slowly wilting in the hot weather this afternoon.		PRAGMATIC ANOMALY
d. The puddles had slowly wilting in the hot weather this afternoon.		DOUBLE ANOMALY

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# The Time Course of Associative and Discourse Context Effects:
## An Eye-Tracking Study

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In this eye-tracking experiment, associative priming and discourse congruity were manipulated independently to examine the extent to which discourse level representations can affect associative priming, and to compare the time course of discourse and associative priming effects. Previous work examining individual sentences suggests that lexical relatedness alone may not influence eye movements during reading. For example, Morris (1994) found that first-pass gaze durations could be influenced by sentence-level representations, but not simple relatedness priming. Traxler et al. (2000) also found sentential congruity effects coming on-line before processing benefits of intra-lexical priming emerged. However, both of these studies used words that were schematically related (e.g., lumberjack - axe), so it is unclear if word pairs with a perhaps more basic associative relationship (e.g., lost - found) would elicit facilitation. The effect of discourse congruity on eye movements during reading is yet to be determined, although effects of sentential congruity have been shown as various stages of processing. Some studies have uncovered early effects of semantic congruity (Morris, 1994; Traxler et al. Experiment 3, 2000), while others only show effects on total reading time (Traxler et al. Experiments 1 and 2, 2000).

To examine associative and discourse context effects, thirty-five sets of four-sentence stories were created such that the last word of the third sentence varied in overall discourse congruence and lexical association with a preceding word. Lexical association was determined by existing norms and story congruity was rated in pre-tests. It is important to note that within a stimulus set the third sentence is identical up until the critical word. Therefore all of the sentences are congruous when read in isolation, it is only the previous context that makes the critical word congruous or incongruous at the discourse level.

First fixation duration, first pass gaze duration, and right-bounded reading times were examined to assess the time course of associative and discourse priming effects. Both, first fixation and gaze duration measures showed a main effect of associative priming ($F_1(1,35) = 4.50$, $p = 0.041$; $F_2(1,34) = 4.52$, $p = 0.041$ and $F_1(1,35) = 7.81$, $p = 0.008$; $F_2(1,34) = 5.77$, $p = 0.022$, respectively). Discourse congruence did not affect either of these measures (first fixation: $F_1(1,35) = 1.20$, $p = 0.281$; $F_2(1,34) = 1.42$, $p = 0.241$; gaze duration: $F_1(1,35) = 2.80$, $p = 0.103$; $F_2(1,34) = 2.66$, $p = 0.112$). Right-bounded reading times showed an effect of associative priming ($F_1 (1,35) = 7.06$, $p = 0.012$; $F_2(1,34) = 7.29$, $p = 0.011$) and discourse congruence ($F_1 (1,35) = 14.93$, $p < 0.001$; $F_2(1,34) = 11.23$, $p = 0.002$), but no interaction between these conditions. In contrast with some of the previous literature, these results are consistent with the idea that lexical context such as word association can influence lexical processing before message-level context can have an effect. In subsequent processing, discourse context can influence meaning integration in sentences, but it does not influence the activation of lexical items.

**Example (critical words are in bold, associative primes are italicized):**

Congruent - Associated / Unassociated
Margot's checkbook slipped out of her purse when she was out to lunch.
She didn't realize it was gone until she received it in the mail, and saw it was missing checks.
Margot could not believe the checkbook had been *lost* and **found/used**.
She was mad at herself for being so careless.
Incongruent - Associated/ Unassociated
Margot was cold as she sat at the edge of the ferry.
She tugged her sweater out of her overstuffed backpack and with it came her checkbook, which flew overboard.
Margot could not believe the checkbook had been *lost* and **found/used**.
She was mad at herself for being so careless.

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# Syntactic vs. Prosodic Focus Effects in Parsing

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The focus of a sentence represents the most important information in that sentence. However, it remains unclear how a speaker can ensure that a perceiver understands the intended focus structure of an utterance. In English, focus may be indicated in various ways, including pitch accents, focus particles (*only*), and clefting (Rooth 1992). Perceivers' interpretations of ambiguous ellipsis sentences can also be affected by the position of pitch accents (Carlson 2002ab, Frazier & Clifton 1998) or *only* (Liversedge et al. 2002, 2003, Stolterfoht et al. 2003); the way a perceiver interprets an ellipsis sentence reveals the focus structure assigned to its antecedent clause. Focus-sensitive ellipsis sentences thus provide a testing ground for how focus markers are used by perceivers to determine focus structure. Four studies examined the effects of *only* and clefting, both alone and in conjunction with pitch accents, on the interpretation of ellipsis sentences. The results indicate that both syntactic and prosodic focus markers influence but do not completely determine perceivers' positioning of focus. Further, they show that syntactic focus marking does not override prosodic information in focus perception, contra some analyses of different types of focus marking (Kiss 1998), but that they have separate and additive effects.

Two self-paced reading experiments (Experiments 1-2) demonstrated that *only* and clefting could each affect the interpretation of replacive sentences (Sag 1980, Merchant 2001) which are ambiguous between subject and object readings (see (1), where the senator could not be joined by the judge, or could not join the diplomat).

(1)     a. (Only) the judge joined the diplomat for coffee, not the senator...
        b. The judge joined (only) the diplomat for coffee, not the senator...

Experiment 1 (self-paced reading) used sentences like (1), with and without *only*. On-line, perceivers read the remnant (*the senator*) faster when *only* was present to suggest focus on one of the arguments. Following questions showed a baseline of 36% subject responses in the absence of *only*, and this number was increased by subject *only* and decreased by object *only* (Table 1). Experiment 2 (self-paced reading) used sentences like (2).

(2)     a. It was Shirley who t counseled Naomi during the flight, not Donna...          (subject cleft)
        b. It was Shirley who Naomi counseled t during the flight, not Donna...          (object cleft)

At first, perceivers were slower in processing object clefts ((2b), consistent with Gordon et al. 2001); but ultimately, object clefts favored the object interpretation and subject clefts favored the subject analysis (Table 2). These two experiments showed that both *only* and clefting were important in suggesting a focus structure and thus resolving the ambiguous ellipsis structure.

Two auditory questionnaires then crossed subject vs. object accent with subject vs. object position of *only* (Experiment 3) or clefting (Experiment 4). This was accomplished by having two prosodic renditions of each sentence: one with the first-clause subject accented (*judge* in (1)), and one with the first-clause object accented. Each experiment found significant main effects of accent position and syntactic focus position (Tables 1-2; p's<.001, no interactions), with effects being roughly additive. None of the sentences were truly disambiguated by the focus indicators, and sentences with indicators in multiple positions were very ambiguous (37-56% subject responses).

These experiments show that syntactic and prosodic focus markers influence but do not fully determine the position of focus and subsequent ellipsis resolution for perceivers. Sentences remained ambiguous unless two types of focus marking indicated a particular focus structure, suggesting that speakers can not easily convey an intended focus structure. Further, the results indicate that syntactic focus indicators did not generally override pitch accents, which is unexpected on some analyses of focus (Kiss 1998). Finally, since all results were due to differences in the unambiguous first clause, rather than in the ambiguous remnant (which was identical across conditions), these experiments demonstrate the need for a global sentence representation which retains detailed prosodic and semantic information over clause boundaries.

Table 1: % subject interpretations for *only* items

|              |                   | Subject only | Object only |
|--------------|-------------------|--------------|-------------|
| Experiment 1 | Self-Paced Reading | 63%          | 23%         |
| Experiment 3 | Subject Accent    | 81%          | 43%         |
|              | Object Accent     | 40%          | 5%          |

Table 2: % subject interpretations for clefted items

|              |                   | Subject cleft | Object cleft |
|--------------|-------------------|---------------|--------------|
| Experiment 2 | Self-Paced Reading | 83%           | 26%          |
| Experiment 4 | Subject Accent    | 87%           | 37%          |
|              | Object Accent     | 56%           | 18%          |

# Linear and hierarchical hypotheses reconciled: grammatical formulation and ongoing parsing in the production of subject-verb agreement errors

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The processing of subject-verb number agreement is investigated in contexts that facilitate mismatch-interference production errors. Recent psycholinguistic studies have shown that number mismatch between the subject head NP and an intervening NP is likely to cause agreement errors in production (Bock & Cutting, 1992; Vigliocco & Nicol, 1998; Franck, Vigliocco & Nicol, 2002) and to increase reading time in comprehension (Nicol, Forster & Veres, 1997; Pearlmutter, 2000). The structural position of the intervening NP and number markedness appear to be factors affecting the processing of agreement. The intervening NP that is the nearest to the topmost subject-NP projection is more likely to cause a mismatch-interference effect particularly if it has a plural number feature. This pattern of results has been considered to provide support to a hierarchical hypothesis as opposed to a linear distance hypothesis for agreement processing. The former predicts greater interference from the highest intervening NP during grammatical encoding since its number feature would mistakenly percolate to the topmost NP. A linear hypothesis would predict interference from the NP immediately preceding the verb. It would, nevertheless, also predict that the longer the distance between the head noun of the subject NP and the verb the more likely the interference of an intervenient NP would be. This length effect would be due to the loss of the features of the head noun from memory. There are therefore two independent predictions from the linear hypothesis. In this paper, these predictions are dissociated in order for the factor favoring the production of agreement errors to be distinguished from the one most likely to characterize the potentially intervening NP.

Two elicited production experiments are reported. In both experiments, a cross-modal task was used with auditory presentation of preambles corresponding to an NP and visual presentation of an infinitive verb. The task consisted in producing a sentence with the preamble as the subject NP of that verb. The participants were educated native speakers of Brazilian Portuguese. In the first experiment, two variables were manipulated: the linear distance between the head of the subject NP and the verb, and the hierarchical distance between the intervening NP and the head of the subject NP. The results show a significant effect of linear distance with more errors in the long distance condition, and a non-significant effect of hierarchical distance, though the means were in the direction predicted by the hierarchical hypothesis. In the second experiment, the predictions concerning the intervening NPs were contrasted in the most favorable condition for agreement errors to occur. In this study, pseudo-verbs were used in order to avoid a possible semantic bias to a particular intervening NP. It was verified that the highest intervening NP with a plural feature induces more production errors than both its singular counterpart and a lower intervening plural or singular NP immediately preceding the verb. These results are compatible with the hierarchical hypothesis. In order to reconcile them with the linear effect obtained in Experiment 1, a model of agreement processing in production is proposed, according to which syntactic agreement proceeds automatically and agreement attraction errors are not predicted to occur during grammatical formulation. This model takes into account the fact that the subject NP can be parsed once it is uttered, that is, before the uttering of the agreeing verb. The representation of the subject NP provided by the parser would be vulnerable to decay and interfere in the encoding of the verb, conducted on the basis of the information provided by the grammatical formulator. This model can, therefore, provide a cause for agreement errors in terms of memory decay at the same time as it can explain the fact that hierarchical position is a factor determining which NP is likely to interfere in the processing of agreement. Markedness would make the number feature of the head of the subject NP less vulnerable to decay. Unlike the percolation model, this "hybrid model" ascribes agreement attraction errors to a post-syntactic processing stage. This model can also account for self-repairs immediately after agreement errors.

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# Implicit Causality as an Inherent Feature of Verbs and Verb Classes

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Since the early 1970's, psycholinguists have investigated a feature of certain verbs termed "implicit causality": Verbs differ in whether they associate the cause of an event or state to their agent or patient (e.g., Garvey & Caramazza, 1974). With verbs such as "blame" or "admire" people predominantly attribute the cause to the patient (Example 1: most people will indicate that Mary is the cause). These verbs are referred to as N2 verbs. N1 verbs such as "phone" or "amaze", on the other hand, impute causality mainly to the agent (Example 2: most people will indicate John as the cause). This bias also affects on-line comprehension: An explicitly mentioned cause is harder to understand if it is incongruent with the implicit cause than if it is congruent with the implicit cause (see Example 3, taken from Stewart, Pickering, & Sanford, 2000).

The present study examined the source of the implicit causality bias and the time course of its emergence during processing. We began by focusing on the strength of the implicit causality bias of the verb itself. We also sought to determine the relationship between this bias and verb argument structure. Therefore we looked at four verb types: agent-patient (AP) verbs (e.g., phone, interrogate), agent-evocator (AE) verbs (e.g., punish, compliment), stimulus-experiencer (SE) verbs (e.g., amaze, inspire), and experiencer-stimulus (ES) verbs (e.g., admire, respect). Rudolph and Fösterling (1997) showed that this taxonomy can account for up to 90% of the variance in causal attributions.

In the first experiment, 140 verbs taken from the psycholinguistic literature were tested in a completion task. Participants read "John blamed Bill because …" and provided a continuation. This experiment revealed that the bias was especially strong with SE (80% N1), ES (81% N2) and AE verbs (76% N2). The AP verb bias was significantly weaker (58% N1).

The second experiment was similar except that the conjunction "because" was omitted, so participants provided continuations for fragments like "John blamed Bill…". This allowed us to isolate the implicit causality of the verb from the contribution of the connective "because". As expected, participants provided fewer causal completions. Interestingly, this was especially true for AP verbs (only 41%). The other verb types elicited significantly more causes: 59% to 75%, even though neither the instructions nor materials mentioned causes. Moreover, within these causal continuations the N1 or N2 bias was identical to the one in Experiment 1. Finally, verb type had a major effect: e.g., following ES verbs many continuations started with "because" or "for", whereas following SE verbs people used "with" or "when" more often to convey the cause. These findings suggest that implicit causality is an inherent feature of certain verbs, and that it emerges even without causal connectives. Moreover, it appears that causality is related to verb argument information.

The third experiment used eye movement monitoring to investigate at what point in the sentence the implicit causality has its effect (see Example 4). The focusing account (e.g., McDonald & MacWhinney, 1995) predicts that the implicit causality of the verb will have an immediate effect on reading a following unambiguous pronoun (a pronoun that is incongruent with the implicit causality should be read slower than one that is congruent). The integration account (e.g., Garnham, Traxler, Oakhill, & Gernsbacher, 1996) predicts an effect only at the point where the implicit and explicit cause are being integrated (so after reading the explicit cause in the second clause of the sentence). During first-pass reading no effects of congruency were found on or shortly after the pronoun. The results did show that incongruent sentences induced more regressions at the end of the sentence, leading to more rereading of the explicit cause (independent of the ambiguity of the pronoun). This pattern of eye movements strongly suggests that the implicit causality bias influences on-line reading at a later, semantic integration stage where the implicit cause is integrated with the explicit cause and that it does not have an immediate "focusing" effect.

## Examples

(1)     John admired Mary.
(2)     John amazed Mary.

(3a)    Daniel apologized to Arnold because Daniel had been behaving selfishly.        (congruent)
(3b)    Daniel apologized to Arnold because Arnold didn't deserve the criticism.        (incongruent)

(4a)    Jim apologized to Roy because he had not corrected the mistake.    (ambiguous pronoun, congruent cause)
(4b)    Jim apologized to Roy because he had not deserved the comment.  (ambiguous pronoun, incongruent cause)
(4c)    Jim apologized to Amy because he had not corrected the mistake. (unambiguous pronoun, congruent cause)
(4d)    Amy apologized to Jim because he had not deserved the comment. (unambiguous pronoun, incongruent cause)

# Phonological Typicality Affects Sentence Processing

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Some words have a phonological form that is more typical of its lexical category than others, and this may provide useful cues for language acquisition. We suggest that the phonological typicality of a word, relative to its lexical category, may also influence both lexical access and sentence processing in adulthood.

Focusing on nouns and verbs, we measured phonological typicality by transforming words into a slot-based phonological representation with three slots for onset, two slots for nucleus, and three slots for the coda (e.g.,

/k . . e . l p ./, /h . . e . l p ./ and /s t r i i  t . ./). Each phoneme was represented in terms of 11 phonemic features. We then computed the Euclidean distance between the resulting phonological representations and all other nouns and verbs. We found that nouns tend to be closer to other nouns ($t(3156) = 11.06$, $p < .001$) and verbs closer to other verbs ($t(3156) = 2.97$, $p < .005$) in terms of their phonology .

Subsequently, we conducted a lexical decision experiment to determine whether phonological typicality affects lexical processing. Stimuli were controlled for frequency, length, phonological neighborhood, and familiarity. The results showed that ("nouny") nouns which had a phonological form highly typical of nouns were responded to more quickly than low-typicality nouns, and the same effect was found for ("verby") verbs (Typicality x verb/noun, $F(1, 46) = 19.706$, $p < .001$). Although this suggests that phonological typicality, relative to lexical category, influences lexical access, the question remains whether phonological typicality may also affect the processing of sentences.

We investigated the influence of phonological typicality on sentence processing in the context of syntactic ambiguities arising from the lexical category ambiguity associated with noun/verb homonyms. A set of sentences was created in which the phonological typicality of the homonyms was manipulated in such a way that 10 words were phonologically typical nouns and 10 were phonologically typical verbs. Half of the sentences for both nouns and verbs were resolved with a noun interpretation of the ambiguity and the other half with the verb interpretation. Consider the following example:

1. (a) Chris and Ben were glad that *the bird perches were easy to* install.
                          7     8     9     10    11   12


   (b) Chris and Ben were glad that *the bird perches easily in the* cage.
                          7     8     9      10   11   12


The noun/verb ambiguous homonym, 'perches', is a phonologically typical noun. Accordingly, it was predicted that participants would consider the noun resolution (1a) over the verb interpretation (1b) given the high noun-typicality of 'perches'. In other words, they should be slower ("garden-pathed") when encountering a verb resolution compared to encountering a noun resolution. A 2 (typical V vs. typical N) X 2 (N resolved vs. V-resolved) X 6 (word in critical region) repeated measures ANOVA was conducted. Plausibility, frequency of usage, and degree of typicality were all controlled for in such a way that no significant differences existed between nouny and verby homonyms. A significant three-way interaction ($F_1 (5, 90) = 4.62$, $p = .001$, partial-$\eta^2 = .204$, $F_2 (5, 90) = 2.78$, $p = .022$, partial-$\eta^2 = .134$) revealed that phonological typicality did influence the manner in which participants preferred to resolve the sentences.

Specifically, for the phonologically typical verbs, RTs rose from position 9 (ambiguous) to position 10 (disambiguation) for the noun resolved sentences. Interestingly, RTs fell from position 9 to position 10 for the verb resolved sentences. As such, it appears that phonological typicality not only causes participants to garden-path in the infelicitous condition, but also exerts a facilitative effect in the felicitous condition. The same general pattern of results occurred for the phonologically typical nouns; however, it was less marked.

Previous research has indicated that the phonological typicality of a word, respective of its lexical category, is likely to assist young children in lexical category assignment during language acquisition (Kelly, 1992). In contrast, investigations into the role that phonology may play in on-line language comprehension tasks have so far been largely lacking. The results from the present study, however, suggest that nouns differ from verbs in terms of phonological typicality, and that these differences affect not only lexical access, but also on-line sentence processing in adults.

# Exploring the prosody of the RC attachment construction in English and Spanish

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We re-examine and supplement—with expanded duration analyses and new pitch contour analyses—the preliminary report of Fernández et al. (2003) on patterns of phrasing in English and Spanish sentences containing the relative clause (RC) attachment construction, see (1). That study, prompted by the findings of Hemforth et al. (submitted), examined utterances elicited using written stimuli, as in (2). Prosodic analyses bear on an account of behavioral findings under two assumptions (Fodor, 1998): that implicit prosody projected during silent reading factors into attachment decisions, and that projected prosody resembles explicit prosody. Our goal (as in Fernández et al.) is to determine what aspects of attachment preference do and do not have prosodic correlates.

Hemforth et al.'s study of attachment preference, contrasting the construction's usual post-verbal object placement with pre-verbal subject placement, replicates the cross-linguistically invariant effect of RC length (higher attachment for longer RCs), and reveals two notable new features. Uniformly across languages, pre-verbal placement weakens the effect of RC length on attachment. Additionally, for Spanish but not English, mean rates of N1-attachment shift across sentence types: Spanish attaches higher than English post-verbally, but lower pre-verbally.

Fernández et al. establish that phrasing patterns correlate with Hemforth et al.'s findings for RC length, but not for attachment shift. In N2 durations, where final-lengthening plus optional pausing accompany the N2][RC phrase-break which arguably promotes N1-attachment, they report a length-by-placement interaction. For both languages, N2 durations are reliably greater before long RC, but this effect is reduced for N2 durations in sentences with N1-*of/de*-N2-RC placed pre-verbally. This interaction plausibly originates in the global prosody of pre-verbal placement sentences: an obligatory phrasing break between the super-heavy subject and its matrix verb reduces the likelihood of a break internal to N1-*of/de*-N2-RC.

However, N2 durations altogether lack the language-by-placement interaction required if Spanish attachment shift (and English non-shift) were similarly correlated with modulation of the likelihood of N2][RC phrasing breaks. To definitively rule an account in these terms of attachment shift, our expanded analyses of N2 duration incorporate comparisons of target-sentence N2 with corresponding measures drawn from the preamble sentences of the elicitation protocol. The latter provide estimates of N2's intrinsic duration, and these baselines are critical since phonetic content inevitably varies in a cross-linguistic study, e.g., *bridegroom* versus *novio*. Analyses here confirm the finding of a null language-by-placement interaction.

Acknowledging that sentence prosody recognizes not only the siting of phrasing breaks but also their intonational category, we consider also the possibility that pre-verbal and post-verbal placement can trigger N2][RC breaks of different kinds. Our pitch contour data suggest that in Spanish this may be so. The rising contour assigned by Spanish to N2 in post-verbal materials is reserved for the close of RC in pre-verbal materials, where N2 carries instead a falling contour. Since in English N2's contour uniformly falls, N2][RC phrasing tunes indeed correlate with the behavioral pattern. Still to be determined is what translation different pitch contour patterns have in formal prosodic analyses, and how in turn these might factor into a prosodic account of attachment preference.

**Examples**

(1) a. The guest impressed the brother of the bridegroom who (often unknowingly) snores.
    b. The brother of the bridegroom who (often unknowingly) snores impressed the guest.

(1′) a. El invitado impresionó al hermano del novio que (a menudo inconscientemente) roncaba.
     b. El hermano del novio que (a menudo inconscientemente) roncaba impresionó al invitado.

(2) a. The guest impressed the brother of the bridegroom.
       (The brother of the bridegroom impressed the guest.)
    b. Which bridegroom? The bridegroom who (often unknowingly) snores.

(2′) a. El invitado impresionó al hermano del novio.
        (El hermano del novio impresionó al invitado.)
     b. ¿Qué novio? El novio que (a menudo inconscientemente) roncaba.

# Effects of Transitional Probability and Predictability on Eye Movements

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A number of eye movement experiments have shown that words that are highly predictable from the context are read faster, and skipped more often, than words that are less predictable (e.g., Rayner & Well, 1996). Recently, McDonald and Shillcock (2003a, 2003b) found evidence for a different type of predictability, namely transitional probability (TP). TP, or word-to-word contingency statistics, is the probability that a given word N+1 follows a word N. For example, the probability of "tribute" following "pay" is higher than the probability of "dollars" following "pay". McDonald and Shillcock (2003a) showed that, with a neutral preceding context, first fixation and gaze durations on the second word were slightly though reliably shorter for high-probability words compared to low-probability ones. Importantly, they claim that this is a low-level effect independent from (high-level) predictability effects. If so, then an increase in predictability should not overcome the TP effect.

An eye-tracking experiment with 40 participants was carried out with the aim of replicating M&S's results and investigating whether TP effects can still be found in more restraining contexts. Items like the following were constructed (C=contextually restraining context, N=neutral context, H/L=High/Low-probability. First fixation and gaze durations on the target word -tribute/dollars- can be found between brackets):

C-H   By means of this official ceremony, we pay tribute to the veterans abroad. (285, 320)
C-L   Instead of giving foreign currency, we pay dollars to the veterans abroad. (293, 334)
N-H   It is not more than reasonable that we pay tribute to the veterans abroad. (294, 327)
N-L   It is not more than reasonable that we pay dollars to the veterans abroad. (300, 341)

We replicated M&S's results and showed that reading times on the high-probability words were faster than on the low-probability words, both on gaze and total reading times (and marginally so on first fixation). We also found an immediate effect of context, with reading times on the target word faster when preceded by a constraining context. No interaction was observed, indicating that the TP was comparable in neutral and constraining contexts. However, just as in M&S's experiment, there was a slight mismatch in Cloze values for the neutral context conditions (CH=22%, CL=6%, NH=7%, NL=0.6%). When comparing the CL and NH conditions, which have comparable Cloze values, no TP effects were found for any of the measures. We conclude that the TP effect might not be independent from predictability. A follow-up experiment is being carried out with more constraining contexts.

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# A derivational approach to Reanalysis

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My aim is to show that the history of the derivation explains in an elegant way why some local ambiguities can lead to a garden-path while others doesn't cause any processing difficulties.

I adopt Phillips (96) left-to-right derivational approach to phrase structure. As an illustration, look at the derivation of (1).

(1)　　　The man eats sausages.

| (i) | (ii) | (iii) | (iv) |
|-----|------|-------|------|
| [the] | [the man] | [[the man] eats] | [[the man] [eats [sausages]] |

There are two relevant differences with respect to a standard derivation. First**, the sentence is generated in a strictly linear way** (the derivation begins with the leftmost term and ends with the rightmost one). The second difference is that in the course of the derivation, **the insertion of an item can destroy the structure previously built**. This crucially entails that the structure of constituents is not permanent: note that *the man eats* is a constituent at step (iii) but not at step (iv).

Phillips claims that this new way of generating sentences accounts for syntactic and parsing problems. His approach makes the following prediction for syntax :

(2)　　　"*Once a constituent has been destroyed, it is no longer available to any syntactic process*" (Phillips 2003).

(2) accounts for well-known syntactic problems (e.g. explains why constituency tests yield contradictory results). I propose to generalize the prediction in (2) to parsing as in (3).

(3)　　　Once a constituent has been destroyed, it is no longer available to either syntactic or parsing processes.

I argue that (3) underlies the contrast between garden-path sentences and reanalysable ones. The reanalysis is a costly process when it must resort to unavailable constituents, that is, constituents detroyed during the initial (and preferred) parse. In other words, if, in the course of the derivation, you have to **rebuild a constituent destroyed in a preceding step**, the output of the derivation will be a garden-path sentence. As an illustration of the proposal, consider the derivations of (4) and (5).

(4)　　　? While Mary was mending the sock fell off her lap.

(5)　　　Steve had known Max hated sharks**.**

| | |
|---|---|
| a)[was mending] | a) [had known] |
| b)[was [mending the sock]] | b) [had [known Max] |
| c) [was mending] [the sock fell off her lap]] | c) [had [known [Max hated sharks]]] |

Notice that reanalysis of the sock in 4 (c) entails backtracking: the constituent [was mending] which has been created at step 4 (a) and destroyed at step 4 (b), is re-built at step 4 (c). On the contrary, no backtracking is necessary in (5). That is, step 5 (c) doesn't involve a constituent no longer available: the substitution of the DP Max by the CP Max hated sharks affects the VP known but does not require re-building a constituent destroyed.

To conclude, this derivational approach to reanalysis provides a strong argument for a derivational approach to parsing problems in general. Ambiguity resolution problems can then be explained by looking at the history of the derivation. To this end, I  proposed, in Gautier (2003), the structural principle in (8).

(8)　　　Destroy: choose the derivation that destroys the most last constituent built.

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# Who's Gorping the Duck? Word Order Guides Early Sentence Comprehension

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What role does syntactic knowledge play in guiding early sentence comprehension? In this study we examined whether 26-month-olds use word order to understand transitive sentences. Prior research has shown that even 17-month-olds interpret word order sensibly in transitive sentences with familiar verbs, as in "Cookie Monster is tickling Big Bird" (Hirsh-Pasek & Golinkoff, 1996). By 26 months, children interpret word order appropriately even in sentences with novel verbs, as in "The duck is blicking the bunny around" (Fisher, Eisengart, & Gertner, in prep.). These prior results are ambiguous, however, in two ways. First, success in these studies could be due to knowledge of the specific construction used, rather than to a more abstract knowledge of the word order of English. That is, children might know that the noun preceding "tickle" names the tickler, or that an active agent comes first in the caused-motion construction signaled by "around." Second, success in these tasks could be achieved by focusing on the first noun of the sentence, without requiring knowledge of the direct object's likely semantic role. Our studies address these two issues.

In Experiment 1, we asked whether children understand the significance of word order in transitive sentences that are presented without lexical cues identifying a specific construction. 26-month-olds watched a pair of novel events presented on side-by-side video monitors. In one event, a duck performed a causal action on a bunny (a duck wheeled a bunny back and forth in a cart); in the other, the bunny performed a different causal action on the duck (the bunny rotated the duck in a swivel chair). This event pair was accompanied by a soundtrack repeating a sentence with a novel verb, with either the duck as subject ("The duck is gorping the bunny"), or the bunny as subject ("The bunny is gorping the duck"). The children looked longer at the event in which the subject of the sentence they heard was the agent of an action. Thus 26-month-olds interpret word order in transitive sentences, in the absence of lexical information supplied by a known verb or path expression.

In Experiment 2, we examined whether children can not only associate the preverbal noun with the agent of an action, but also associate the postverbal noun with the patient role. Another group of 26-month-olds saw the same events as in Experiment 1, but heard sentences in which the subject was a pronoun ("He is gorping the bunny", or "He is gorping the duck"). If the children understand English word order, then upon hearing the sentence "He is gorping the duck", for example, they should look longer at the event in which the duck is the patient rather than at the event in which the duck is the agent. This is exactly what the children did: they looked longer at the event in which the direct object of their test sentence was the patient of the causal action.

Taken together, these results demonstrate that 26-month-olds have a robust understanding of word order in transitive sentences, even in sentences containing an unfamiliar verb. These findings, and ongoing experiments varying sentence structures, help reveal how children with a limited vocabulary use the very beginnings of syntactic knowledge to guide early sentence interpretation.

# The Bayesian Basis for Linguistic Expectations in Language Processing

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This paper presents results from a self-paced word-by-word reading experiment in Russian that provide evidence for a Bayesian account of sentence processing preferences. Russian has a rich morphological agreement system. In target structures (1), the first word is a participle-form of an obligatorily-transitive verb (e.g. "respect") which agrees with the noun it modifies in morphological case, gender, and number. For a grammatical sentence, two nouns are required after the sentence-initial participle: (a) a noun satisfying *the subcategorization requirement* of the participle (abstract-case=accusative in (1a) and (1b), abstract-case=dative in (1c) and (1d)) must immediately follow, and (b) a noun that the participle-phrase modifies satisfying *the agreement requirement* of the participle (morphological-case=accusative, gender=feminine, number=singular in (1a)-(1d)) must follow thereafter. Crucially, the two nouns must occur in the order described.

We varied two aspects of agreement on the first noun: morphological case (+/-MorphCaseAgr) and gender (+/-GenderAgr). To the best of our knowledge, all current models of sentence processing predict no difference among the four resulting conditions, because the first noun satisfies the subcategorization requirement (i.e., abstract-case) in all conditions, and its agreement properties should not affect processing in any way. We propose a novel hypothesis, which is based on Bayesian expectations: it may be preferable to satisfy more specific expectations over less specific ones. Bayesian principles explaining the non-accidentalness of events apply in many cognitive domains, including vision, learning and reasoning (e.g., Hoffman, 1998, Tenenbaum, 2000). It is therefore natural to apply these ideas to language processing. Applying the Bayesian idea, we note that the agreement requirement of the participle is more narrow (requiring the satisfaction of three agreement criteria – morphological case, gender and number) than the subcategorization requirement (requiring the satisfaction of only one criterion – abstract case). A Bayesian model predicts that a noun consistent with both the agreement and the subcategorization constraints will be initially preferentially interpreted as satisfying the agreement constraint, despite the resulting ungrammaticality. This model therefore predicts facilitation of processing of the first NP when it satisfies more requirements of the participle. This effect should then reverse on the following NP when it is discovered that the first NP is not the head noun for the participle and reanalysis is required.

The results (2) fit the predictions of the Bayesian proposal. In particular, there were two main effects at the first noun, with +MorphCaseAgr-conditions processed faster than -MorphCaseAgr-conditions, and +GenderAgr-conditions processed faster than -GenderAgr-conditions. Furthermore, there were two main effects on the second noun, in the reverse direction, as predicted by the Bayesian account. In conclusion, we have provided evidence that, as suggested by e.g., Tabor et al. (2003), the sentence comprehension mechanism is not necessarily sensitive to global grammaticality. However, the evidence supports a novel view of how the syntactic constraints interact: Bayesian constraints (like those proposed by Jurafsky, 1996, Narayanan & Jurafsky, 2001), without a global constraint on grammaticality.

(1)a     *+MorphCaseAgr/+GenderAgr*
         Uvazhavshuju         skripachku (acc/fem)  pianistku  rasserdil dirizher…
         Respecting violinist (acc/fem)     pianist                angered conductor…
         'The conductor angered the pianist who respected the violinist…'

   b     *.+MorphCaseAgr/-GenderAgr*
         Uvazhavshuju         skripacha (acc/masc)  pianistku  rasserdil dirizher…
         Respecting violinist (acc/masc)     pianist                angered conductor…

   c     *.-MorphCaseAgr/+GenderAgr*
         Pozvonivshuju        skripachke (dative/fem)        pianistku  rasserdil dirizher…
         Calling              violinist (dative/fem)  pianist                 angered conductor…

   d     *.-MorphCaseAgr/-GenderAgr*
         Pozvonivshuju        skripachu (dative/masc)        pianistku  rasserdil dirizher…
         Calling              violinist (dative/masc) pianist               angered conductor…

(2)
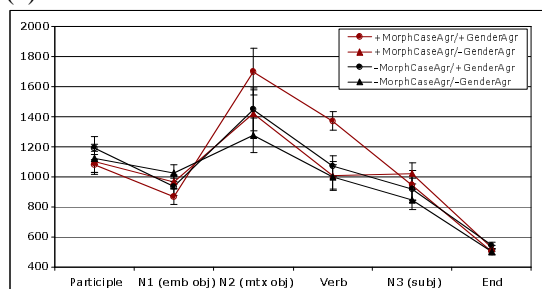


Mean reading times per word across the four conditions of the experiment.

# Marking discourse contexts: Intitial planning versus local production effects in the production of adjectives

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The production patterns of adjectives have been linked to their discourse function and processing load in production. Sedivy (2003) demonstrated that scalar adjectives are produced in the presence of two alike objects, but are rarely produced in the absence of such a contrast, whereas color adjectives are produced in contrastive and non-contrastive environments. Gregory et al. (2003) demonstrated that scalar adjectives, which are more semantically complex than color modifiers, increase processing load during articulation as measured by disfluency rates in production, whereas the need to mark a contrast did not affect articulation. However, that study focused on the moments immediately preceding the utterance of a referential expression and did not take into account utterance planning. There is evidence that discourse constraints affect initial utterance design, not the fast on-line processes of articulation (Bard et al. 2002). This study focuses on whether marking a contrast has affects in utterance planning and during articulation.

We analyzed productions from 13 speakers. Objects were displayed on a grid on a computer screen and speakers had to give instructions to a confederate on moving the objects to the appropriate configuration. Speakers' utterances were broken into 5 regions: Onset (the time between viewing the display and the beginning of the utterance); preamble ("can you please"); verb ("move"); determiner ("the"); adjective ("big"); noun ("cup").

We found speakers took significantly longer (~100 ms) to initiate speaking in the presence of a contrast. These results suggest that marking a contrast affects utterance design. We also found that the determiner region was significantly longer in the contrast condition versus the no-contrast. The increase in length was due to an increase in disfluencies: there were twice as many disfluencies, which indicate planning problems, in the contrast condition versus the no-contrast condition. While at initially this fact suggests that marking a discourse contrast increases planning difficulty during articulation, it was reported in earlier studies that adjectives are generally not produced in the no-contrast condition for scalar adjectives. Thus, the increase in planning difficulty in the determiner region might be a result of adjective planning rather than marking a contrast.

To test whether the increase in planning difficulty in the determiner region was due to producing an adjective, we focused on adjectives versus no adjectives. There were 33% disfluencies in the determiner region of utterances containing adjectives, compared to only 12% in those not containing adjectives. We replicate earlier findings that demonstrate an increased processing load with the use of scalar adjectives compared to other adjective types. We found that the verb plus determiner region was longer before scalars than colors. This difference reflects the planning difficulties of scalars adjectives: there were 41% disfluencies prior to scalar adjectives compared to 24% with colors.

In sum, we demonstrate that marking a contrast affects utterance planning, but does not have clear affects during articulation. We also confirm that the use of scalar adjectives increases processing load. We aim to analyze the eye-tracking results of this study to further investigate the processes that underlie discourse level effects from local planning effects.

# Number Attraction Effects - Evidence from German Relative Clauses

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So-called attraction errors have provided important insights into the processing of syntactic features during both production and comprehension. Such agreement errors occur in constellations where a singular subject is followed by plural noun. We will call the latter 'distractor' because it seems to be responsible for the agreement error.

The first question we will address concerns the mental representation of grammatical number. There are several morphological differences between German and English. First, in German the finite verb is unambiguously marked for number; secondly some determiners and several masculine nouns are ambiguous wrt. number, even their combination (determiner + noun) can be ambiguous (e.g. *der Lehrer* 'the teacher' is nominative-singular or genitive-plural). Given this morphological marking we might expect attraction effects for singular distractors in German as well.

The second question concerns the mechanisms underlying number-attraction errors. It is often assumed that the number feature of the distractor percolates to the head noun. Alternatively, however, the number feature of the verb could be erroneously checked against the "wrong" head (the distractor).

Here, we will present evidence from comprehension studies, using the method of speeded grammaticality judgments. Sentences were presented visually in a word by word fashion with each word appearing at the same position on a computer monitor (mid-screen). Immediately after the last word of a sentence, participants had to judge the grammaticality of the sentence as quickly and as accurately as possible.

In Experiment 1 the distractor occurred inside a relative clause (cf. 1a). The subject of this relative clause was always a first-person pronoun, the verb was unambiguously marked for the first person singular. The relative clause was attached to the head noun, the subject of its matrix clause. The main verb occured in clause-final position.

The number of the head noun and the distractor was either singular or plural, furthermore ungrammatical sentences were constructed by changing the number feature of the last verb, resulting in eight conditions. The condition 'singular-plural, grammatical' is shown in (1b).

(1)     a.     Structure: [CP          [DP **head**     [RC          distractor     ... V ]]     ... **V**]
        b.          dass der Steuerberater, dessen Assistentinn-en ich gestern informiert habe, den Fehler nicht bemerkt                                                                                                    hat.
             that the tax-adviser.sg/pl, whose assistent-pl     I yesterday informed have, the error    not   noticed has.
             'that the the tax-adviser whose assistents I have informed yesterday did not notice the error.'

Results of experiment 1 are shown in Table 1. An attraction effect occurred for both singular and plural head nouns. For grammatical sentences, the data do not show any clear asymmetry. We will show how these findings fit general assumptions about the mental representation of grammatical number.

Table 1   Percentage of correct judgments for experiment 1 (standard error in parentheses)

| Status/Number | singular - singular | singular - plural | plural - plural | plural - singular |
|---|---|---|---|---|
| grammatical | 93 (1.7) | 81 (2.6) | 88 (2.1) | 76 (2.6) |
| ungrammatical | 95 (1.3) | 80 (2.4) | 79 (3.1) | 75 (3.1) |

Previous research has only considered configurations where the distractor followed the head noun. In experiment 2, we investigate the reverse constellation: the distractor is contained in the main clause and the head noun is the subject of a relative clause attached to the distractor (cf. (2a) and (2b) for the condition 'singular-plural'). Thus, the distractor does not intervene between the verb and the head noun but rather precedes the head noun.

(2)     a.     Structure: [CP ...     [DP     distractor     [RC          **head**     ...     **V**     ]]]
        b.          Das Rennen machte der Kandidat,     dessen Sponsor-en dem Verein mehr Geld angeboten haben.
             The race          made   the candidat.sg whose sponsor-pl the   club   more money offered      have.pl
             'The candidate whose sponsors have offered more money to the club won.'

Table 2   Percentage of correct judgments for experiment 2 (standard error in parentheses)

| Status/Number | singular - singular | plural - singular | plural - plural | singular - plural |
|---|---|---|---|---|
| grammatical | 86 (3.2) | 69 (4.2) | 85 (3.0) | 79 (3.2) |
| ungrammatical | 86 (3.6) | 67 (3.4) | 89 (3.1) | 82 (3.5) |

Again, an attraction effect occured for both singular and plural distractors, but significantly larger for plural distractors. This means that even a preceding distractor can cause attraction errors. We will argue that this favors a checking account of attraction errors since in a percolation account we would not expect downwward feature percolation across a clausal boundary into the relative clause. Under a checking account, we can assume that the number feature of the verb is erroneously checked against the relative pronoun which is coindexed with the distractor. Pied-piped phrases like *dessen Sponsor* might be especially prone to confuse the parsing mechanism because superficially, the relative pronoun occupies the same position as articles which are often crucial for number marking in German.

# The accessability of referents in RC-attachment

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Across languages it has been shown consistently, that in three-site ambiguities such as (1) attachment to N2 is strongly dispreferred whereas the acceptability of N3 and N1 depends on the particular construction as well as on the language investigated.

**(1) the sister of the doctor of the teacher who was in France**

In the literature on RC-attachment, explanations for this phenomenon sometimes rely on the assumption that the three potential attachment sites differ in accessibility, salience or activation (e.g. Lewis, 2000, Hemforth, Konieczny, & Scheepers, 2000a,b; see Gibson, Pearlmutter, Canseco-Gonzalez, & Hickock, 1996 for an alternative approach ). But differences in the salience or activation of the three sites have never been directly shown empirically.

In a series of repetition priming experiments we probed for the three potential referents of the relative pronoun at different positions in the relative clause. However, in all experiments we only found recency effects (N3 > N2 > N1) not matching the attachment preferences. From this we may conclude that salience of the antecedents does not play a role in RC-attachment. But it may also be that the priming task does not tap into the right kind of processes.

Therefore we recently applied a different task. Subjects were presented with unambiguous sentences like (2) on the computer screen. Number marking on the three NPs and the verb in the RC disambiguated the attachment. They then had to read them aloud. After that the sentence disappeared from the screen and subjects had to recall it immediately. Reading aloud as well as recalling were tape recorded and transcribed.

**(2) The sisters of the doctor of the teacher who live in France**

The results from the error patterns in this task are highly revealing. Not only did subjects "adjust" N2-attachments to N1 or N3 attachments reliably more often than vice versa. In 7.7 % of all cases at least one of the three noun phrases was omitted. So we counted how often one of the NPs was not recalled. This was reliably more often the case for N2 than for N1 or N3, closely mirroring the attachment preferences. Reconstruction of NP2 in the sentences to be recalled appears to be harder than reconstruction of NP1 and NP3. This should be the case if the trace of NP2 is less active than that of NP1 or NP3.

# Information status and pitch accent distribution in spontaneous English dialogues

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Revealing the relations between pitch accent types and the informational status of words requires a both a refined discourse analysis and phonological transcription, ideally of spontaneous speech. While the use of accentuation to mark 'newness' has been studied extensively, the assignment and distribution of different pitch accent types has been investigated only with carefully scripted productions.

We created a cooperative unscripted dialogue task to elicit spontaneous repetition of target words in discourse. Participants gave instructions for decorating four Christmas trees, producing 24 target adjective-noun pairs conveying new/given and contrastive information about ornaments. On each trial, a photograph of an ornament and its intended location on the tree was shown on a monitor in the recording booth. The participant, a 'director,' told a 'decorator' sitting outside the booth which ornament to pick and where to place it. Eight color-term adjectives and eight object nouns were combined to make a set of simple NP tags for the ornaments of each tree. Within a tree, the target adjectives and nouns appeared three times each. Giveness and/or contrastiveness of the item names was induced by either consecutive mention of color adjective or object noun (e.g. blue in the sequence *blue ball – blue house*) or distant mention, i.e. the word was repeated after several intervening trials. Each target adjective or noun appeared in a consecutive trio once within the four trees, so that each tree had 2 color and 2 object trios (e.g. adjective trio: *green candy - green ball - green bell*; object trio: *orange house – brown house – gray house*).

Productions from subset of four speakers who used similar discourse segmentation strategies were transcribed using an adapted version of Grosz and Sidner's (1986) intention-based discourse analysis. Each target word was tagged for its newness or givenness and also for contrastiveness at both the discourse (D) level and the discourse segment (DS) level. Utterances containing target words were ToBI-transcribed (Beckman & Ayers, 1994). The analyses show that contrastiveness was a good predictor of accent type (L+H*). Although the words marked as *new* at the DS level were not necessarily accented more frequently than the words marked as *new* at D-level, the *given* words at the DS-level were apparently deaccented more frequently than the *given* words at the D-level. Thus, the discourse segment level of structure may play a more important role in constraining the *deaccentuation* of given words than in licensing accentuation on new words. Local word position (adjective or noun) interacted with both contrastiveness and discourse segmentation in the assignment of accent.

# Quantifiers in Discourse: An ERP study

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Quantifiers, such as *three*, *some*, and *every* have a restrictor, i.e., a domain that is quantified over. The restrictor set of a bare (noun-less) quantifier is often ambiguous. For instance, 'four' in (1) can either refer to a subset of the eight ships just mentioned ('of the'-reading), four other ships ('other'- reading), or four different entities (e.g. *four people*, non-anaphoric reading).

(1)      Eight ships were docked in the harbor. <u>Four</u>…

Data from previous studies using behavioral techniques (Kaan & Wijnen 2001) suggest that an 'of the' reading is preferred. In the present study we investigated when this preference occurs during processing, and how a violation of this preference is reflected in ERPs. To this aim, we used items of the form illustrated in (2), in which the bare quantifier in the second sentence either is compatible with the preferred 'of the' reading (2a, Q1>Q2), or is not (2b, Q1<Q2).

(2)      a. Eight ships were docked in the harbor. <u>Four</u> had sailed out that morning.

         b. Two ships were docked in the harbor. <u>Four</u> had sailed out that morning.

Twenty participants silently read 36 items in each of the conditions (2a) and (2b) while their EEGs were recorded. Relative to the (2a) condition, ERPs to the underlined quantifier in the Q1<Q2 condition (2b) showed a reduced P200 component, followed by an N400 between 300 and 600ms. This effect cannot be due to plausibility difference between the conditions, since the ERPs for plausible versus less plausible items (as rated by an off-line questionnaire) did not show any difference. Furthermore, the ERP effects cannot be due to the numeric distance or other properties of the number words used: A number comparison task using the same participants, pairs of number words and presentation parameters did not show any difference between the Q1<Q2 and Q1>Q2 conditions.

These results suggest that the sentence processor immediately looks for the restrictor of a bare quantifier. If the preferred 'of the' reading is not possible, a new discourse referent needs to be set up. Further research will be carried out to determine to what extent the N400 elicited here reflects the violation of the expectancy for an 'of the' continuation, or the effort involved in setting up a new discourse referent in response to this violation. Finally, the fact that the same number words elicit different ERP components depending on the task (reading vs. number comparison) suggests that the mechanisms dealing with number information are specific to particular task domains.

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# MEG responses in the comprehension of Japanese sentences

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Recent studies indicate that the N400 response to semantically anomalous sentences observed in electroencephalography (EEG) is detectable at sentence-end in magnetoencephalography (MEG). We report an MEG study using Japanese sentences, which replicates N400-like responses in MEG (sentence (1a)). The critical region is the embedded verb, therefore sentence-end confounds such as wrap-up effects are avoided. Furthermore, we detected a P600-like response in (1d), providing supporting evidence for the claim that wh-phrases in Japanese, as is the case for fronted wh-phrases in English, generate the expectation for a specific type of constituent at the earliest possible point in the sentence (Miyamoto & Takahashi, 2002).

The magnetic activity was measured in a magnetically shielded room with a 160-channel whole-head magnetometer (Kanazawa Institute of Technology, Japan). Data were sampled at 500Hz, with acquisition between 0.03 and 100Hz. Data from five subjects analysed thus far yielded the following patterns. (All analyses were conducted at the fourth region including the embedded verb and its complementizer. See the region in *italics* in (1).)

First, we replicated the MEG brain response to semantic anomalous words (Halgren et al., 2002; Helenius et al., 1998). For four subjects, an N400-like effect was detected peaking around 370 ms after the onset of the embedded verb in (1a), which is not compatible with the initial segment of the sentence (`Mary drank a book at the café') in comparison to the control (1b) (`Mary drank water at the café'). For the fifth subject, a similar response was found around 420 ms. Equivalent current dipoles (ECD) around the peak, which were calculated and superimposed for each subjects' MRIs, were located in or near the left superior temporal cortex.

Second, larger activity (as measured by the root mean square, RMS, over 49 channels from the left temporal area) was detected peaking around 620 ms after the onset of the embedded verb in (1d) in comparison to (1c) ($F1(1,4)=10.39$, $P<0.05$) and (1b) ($F1(1,4)=7.26$, $P<0.06$). This supports behavioural results indicating that readers have diffculty at that point when processing (1d) because the wh-phrase `what' creates the expectation for a question particle (e.g., *ka*) and this expectation is contradicted by the declarative complementizer *to* `that' (leading to a *typing mismatch effect*; Miyamoto and Takahashi, 2002). In (1b), there is no wh-phrase, therefore there is no expectation for a question particle; in (1c), the requirement for *ka* is satisfied at the embedded complementizer position. This result is compatible with earlier EEG findings according to which the P600 is not just an ungrammaticality marker, but rather an indicator of difficulty in attaching an incoming constituent to the grammatical representation of the sentence fragment read so far (Kaan et al., 2000).

**Examples**

(1) a. Masao-ga     hon-o      kissaten-de *nonda-to* Jiro-ga    omotta-no?     (semantically anomalous)
    Masao-Nom book-Acc café-at      drank-that Jiro-Nom thought-Q
    `Did Jiro think that Masao drank a book at the café?'
    b. Masao-ga    mizu-o     kissaten-de *nonda-to* Jiro-ga    omotta-no?
    Masao-Nom water-Acc café-at      drank-that Jiro-Nom thought-Q
    `Did Jiro think that Masao drank water at the café?'
    c. Masao-ga    nani-o     kissaten-de *nonda-ka* Jiro-ga    kiita.
    Masao-Nom what-Acc café-at      drank-QP Jiro-Nom asked
    `Jiro asked what Masao drank at the café.'
    d. Masao-ga    nani-o     kissaten-de *nonda-to* Jiro-ga    omotta-no?     (typing mismatch effect)
    Masao-Nom what-Acc café-at      drank-that Jiro-Nom thought-Q
    `What Jiro think Masao drank at the café?'

# When Stored Knowledge Competes with Scene Information in Sentence Comprehension

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The present research aims to determine the relative importance of depicted event information versus stored linguistic and world knowledge during on-line spoken sentence comprehension. Experimental evidence from sentence comprehension testifies to the rapid influence of both types of information. People's prior linguistic and world knowledge has immediate effects on the comprehension of unambiguous sentences (Kamide et al., 2003). On the other hand, non-stereotypical agent-action-patient event structures that have to be extracted from depicted scenes also influence rapid construction of mental role-representations in disambiguation of initially ambiguous German and English sentences (Knoeferle et al., 2003). Even within relatively interactive frameworks, such as Jackendoff (2002), there are reasons to expect a priority of stored (selectional, stereotypical & world) knowledge in online thematic role-assignment. In contrast to a Jackendoffian framework, the importance of the visual environment in shaping our cognitive architecture is emphasized by research in the tradition of Clark (1992) (e.g., Tanenhaus et al., 1995).

To investigate priority of stored versus scene knowledge, the present study monitored eye-movements in scenes while people were listening to related OVS (PATIENT-VERB-AGENT) sentences. An image showed two agent-action-patient events, e.g., wizard-spying-on-pilot, and detective-giving-food-to-pilot. Crucially, one agent on each image was a plausible competitor for the depicted event action performed by the other agent (e.g., the detective was a plausible competitor for the depicted wizard-spying event). By manipulating the verb people heard, we created four conditions, crossing the factors "competitor/no-competitor" with "depicted"/"plausible". For the competitor conditions (1) the verb "bespitzeln" ('spy-on') allowed two entities as likely agents: the wizard, being depicted as performing a spying-action (1a), and the detective, a plausible competitor for a spying-action (1b). For the no-competitor conditions (2), the verb permitted either a depicted or a plausible agent only: "verköstigen" ('give-food-to') determined the detective (2a) as depicted agent; "verzaubern" ('jinx') identified the wizard as plausible agent. (2b) Materials were constructed so as to avoid potential biases of specific plausible or depicted relations. Participants were instructed to listen to the sentences, inspect the images, and to try and understand sentences and scenes. There was no other task. We expected effects in the eye-movements shortly after people had heard the verb. Following Jackendoff (2002), we would expect more anticipatory looks to the plausible agent (detective) over the depicted agent (wizard) for the competitor conditions (1). Conversely, an approach suggesting greater reliance on information extracted from the immediate scene, would predict the opposite pattern of looks.

For the competitor conditions (1), we found more looks to the depicted agent (the wizard) (ps < 0.001). For sentences (2) (no competitor), we observed clear disambiguation using either depicted information or plausibility (ps < 0.01): For (2-a), significantly more fixations went to the likely depicted agent (detective-giving-food) than to the wizard, and vice versa for (2-b). A three-way interaction (Part/Items x Competitor(yes/no) x Target Agent (depicted/plausible) confirmed that the difference between the competitor conditions (1), and conditions (2) was significant (ps < 0.05). Our results show within a single study that people use both stored knowledge and information that has to be extracted from depicted scenes effectively. In the face of competition, however, they suggest greater priority of depicted information.

## Examples

| | | | | | |
|---|---|---|---|---|---|
| (1a) | Den Piloten | bespitzelt | gleich | der Zauberer. | |
| | 'The pilot (PAT.) | spies-on | soon | the wizard.' | (depicted AGENT) |
| (1b) | Den Piloten | bespitzelt | gleich | der Detektiv. | |
| | 'The pilot (PAT.) | spies-on | soon | the detective.' | (plausible AGENT) |
| (2a) | Den Piloten | verköstigt | gleich | der Detektiv. | |
| | 'The pilot (PAT.) | gives-food-to | soon | the detective' | (depicted AGENT) |
| (2b) | Den Piloten | verzaubert | gleich | der Zauberer. | |
| | 'The pilot (PAT.) | jinxes | soon | the wizard.' | (plausible AGENT) |

# The Role of Verbs in Korean-English Translation

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How much message-level information do speakers prefer to have before starting to utter a sentence? The present study tested the importance of actions and verbs when translating from written sentences to spoken ones. We used English and Korean because of their structural differences. Korean is a verb final language, where the preceding noun phrases are relatively flexible in their order. English has a dominant and somewhat rigid subject-verb-object structure. Among other variations in stimulus sentences, we varied the number of content words and phrases occurring before versus after verbs in written English sentences. Translators' eye movements were recorded to indicate how much of each sentence they read before speaking and where they looked while speaking. Written sentences are static and available for translators to review before and during translation. Based on previous research (see Rayner, 1998), we assume that translators had to fixate on or near words to recognize them. We also assume that translators had to recognize words before they could translate them. The more translators read before speaking, the more message-level information we infer that they had available for production processes.

In Ferreira's (2000) TAG model of sentence production, a verb must be selected before a noun can be assigned as a subject. Although the model does not directly address translation, it holds that verbs always have priority in generating sentence structure. The subject of a sentence should not be produced before a verb has been translated. So, translation onsets should increase with the number of words preceding verbs in English source sentences. When translating from verb-final Korean to English, translators should wait until they have read an entire clause before they begin their translation (or they might skip ahead to the verb).

The results did not support the predictions of the TAG model (or several other plausible a priori hypotheses). Translation onsets did not significantly differ for English source sentences where the verb occurred early (e.g., 1) versus late in the sentence (2). However, the probability of translators fixating a verb before speaking was significantly higher when it occurred early in a sentence. In contrast, the probability of fixating on a second noun before speaking was significantly lower in the sentences where it followed the verb. On average, translators read two and half content words, regardless of grammatical class, before they began speaking. This suggests that verb selection is not mandatory for sentence construction to begin.

Further analysis of the time course for eye movements on the written words relative to their translations indicate that speakers fixate on a written word about one second before they produce its translation regardless of source language. Translators' eye movements to words during translation are very similar to speakers' gazes to objects during picture description tasks (Griffin & Bock, 2000). However, it is easier to relate eye movements to preparing non-nouns in the translation task than in picture description. Therefore, monitoring eye movements during written sentence translation may provide another useful tool for addressing some questions in sentence production.

**Examples**

(1)　　The children studied in the kitchen.
(2)　　The man on the sofa was sleeping.

# Prosody and Attachment in Brazilian Portuguese

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The Implicit Prosody Hypothesis – IPH (Fodor, 1998, 2002) predicts that prosody is mentally projected by readers onto written word strings and can affect syntactic ambiguity resolution. The present study provides independent evidence of   Brazilian Portuguese (BP) prosodic patterns in oral production and shows that these patterns can predict attachment preferences in the parsing of sentences in silent reading. We investigate whether constituent length affects the overt prosody and the interpretation in silent reading  of two  structures in BP  – relative clauses (RC), which may attach to a high or a low noun, as in (1);  and prepositional phrases (PP), which can either attach high  to the verb or low to the NP, as in (2). In the oral production studies, attachment  was forced high or low by  number agreement in the RC sentences and by  previous context in the PP sentences. In each study,  42 short (up to 5 syllables, only one stress) and 42 long (10-12 syllables) RC/PPs with forced low and high attachments were read aloud by 7 speakers and subjected to acoustic analyses. Results indicated a significant longer duration of the stressed syllable of the noun immediately preceding the long RC/PPs than preceding the short RC/PPs, signaling a greater probability of a prosodic break between that noun and the long RC/PPs than for their short counterparts. This is compatible with other evidence that the distribution of prosodic breaks is influenced by length as well as by syntactic structure (Selkirk, 2000).

In order to assess whether pre-RC/PP breaks favor high attachment in silent reading (cf. Lovric, 2003 for RCs in Croatian),  four speeded compatibility judgment experiments were  implemented.  In experiments 1 and 2,  24 subjects read ambiguous short or long RC/PP  complete sentences and  judged  whether a follow-up sentence corresponding to high or low attachment, as in (a) and  (b),  was an adequate statement about the previous sentence. Experiments 3 and 4 used the same technique, except that sentences were presented to another 24 subjects in 4 noncumulative segments, as shown by slash marks in (1) and (2). For the long RCs, which are most comparable to those tested by Myamoto (1999), an overall high attachment preference (76%)  was observed, in conformity with Maia & Maia (2001) and Myamoto & Finger (2002), though contrasting with  Myamoto (1999). As predicted by the IPH, there were significant interactions between RC/PP length and acceptance rates for high and low attachment. Segmentation also had a significant effect. For long RCs and PPs, it shifted acceptance toward low attachment. For short RCs and PPs, it shifted acceptance toward high attachment (for PPs, nonsignificant trend only), reducing the effect of attachee length. In contrast with Gilboy & Sopena (1996), who proposed that "in small segmentation there is no cue for prosodic boundaries", our data suggests that small segmentation provides an <u>excess</u> of cues for prosodic boundaries: results are exactly as predicted if readers treat every segment boundary as signaling a prosodic boundary. Thus,  the IPH offers an elegant explanation of the findings.

### Examples

1. Um homem reconheceu /o cúmplice /do ladrão /que fugiu (depois do assalto ao banco).
 "A man recognized/ the accomplice/ of the thief/ who ran away (after the bank robbery)"
(a) O cúmplice fugiu.                   (b) O ladrão fugiu.
   "The accomplice ran away."           "The thief ran away."
2. O funcionário /localizou /o passageiro /com o celular (de capa dura).
 "The clerk/ located /the passenger /with the (hard cover) cell phone"
(a) O funcionário tinha um celular   (b) O passageiro tinha um celular.
   "The clerk had a cell phone."         "The passenger had a cell phone."

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# Filler-gap dependencies vs. lexical-thematic associations
# in typical and atypical language development

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A considerable controversy surrounds whether sentences involving movement are processed through filler-gap dependencies (Swinney, et al., 1988) or through lexical associations between the moved constituent and its subcategoriser (Pickering & Barry, 1991). This paper contributes to this debate in two ways: First we investigate on-line processing of wh-questions in typically developing (TD) children (aged 5-18 years) to provide a developmental perspective, about which we know little. Second, we study G(rammatically)-SLI children, who are characterised by a domain-specific deficit affecting grammatical but not lexical processes in order to shed light on how they process wh-questions in real time.

G-SLI children are characterised by a relatively pure grammatical impairment across a broad range of morphosyntactic phenomena in comprehension, expression and judgement of sentences. The Representational Deficit for Dependent Relations (RDDR) hypothesis provides an account for the syntactic deficit in G-SLI children according to which the operation "Move" is optional in G-SLI grammar (van der Lely, 1998). Initial tests of this hypothesis in the production and judgement of wh-questions revealed tense and gap-filling errors (van der Lely & Battell, 2003; van der Lely, Jones & Marinis, 2003). This indicated that G-SLI children might sometimes merge the wh-word at Spec,CP, rather than compute a movement operation, and predicts that G-SLI children will show reduced or no reactivation of the filler at the gap when they process wh-questions in real time. Instead, they may show a priming effect at the subcategorising verb, as lexical-thematic processes may not be affected. We tested this proposal, by investigating the processing of wh-questions in sentences, as in (1), using a cross-modal picture-priming paradigm (McKee, et al., 1993).

(1)     *Balloo gives a long carrot to the rabbit.*
        *Who did Balloo give [1] the long [2] carrot to [3] at the farm?*

17 G-SLI subjects (10;2-17;2), 14 age-matched-controls (CA) and three groups of 38 language-ability-controls (LA1:5;9-7, LA2:7;2-8;2, LA3:8;3-9;6) listened to stories consisting of 60 experimental and 200 filler sentences, during which they saw a picture of the antecedent (in example (1) *a rabbit*) or an unrelated picture matched for length and frequency in one of three positions: at the offset of the subcategorising verb [1], at the gap [3] or at a control position [2]. Children had to make an animacy decision by pressing one of two buttons and afterwards they had to answer to the question, giving us a measure of the children's comprehension.

In the animacy task, G-SLI children were as accurate as their age-matched controls. They performed significantly better than the LA1 group matched for grammar and the LA2 group matched for vocabulary, and the difference between G-SLI and LA3 was approaching significance. This shows that despite their grammatical impairment, G-SLI children's performance in a task involving semantic (animacy) properties is in the normal range. All groups scored 84% or higher in the comprehension task, but G-SLI children were significantly worse than CAs and LA3s, but did not differ significantly from the LA1 and LA2 controls. Thus, their comprehension is similar to that of younger children matched for their grammar or vocabulary. As far as antecedent reactivation is concerned, G-SLI children showed a qualitatively different pattern from all groups of TD children. All groups of TD children showed some degree of priming of the antecedent at the position of the trace. LA1 and LA2 children not only showed some degree of priming at the trace, but also at the verb, indicating that they process questions through both syntactical and lexical-thematic dependencies. In contrast, children with G-SLI showed reactivation of the antecedent at the position of the verb, but not at the trace. This indicates that instead of establishing a syntactic dependency between the filler and the gap, they process wh-questions through a lexical-thematic dependency between the verb and its arguments. This concurs with previous findings from off-line experiments in the production and judging of wh-questions and supports the RDDR hypothesis, according to which children with G-SLI at times merge the wh-word directly at the specifier of the CP.

# Children's use of prosody in the comprehension of syntactically ambiguous sentences.

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How children use prosodic cues in the comprehension of syntactically ambiguous sentences has been the focus of much research in recent years. Snedeker & Trueswell (2001) and Choi & Mazuka (2003) both reported that young children appear to have difficulty utilizing prosodic cues in comprehending syntactically ambiguous sentences (see Snedeker & Yuan, 2003, for a different finding).

This paper reports the results of a study of four- to six-year old children's use of prosody in the comprehension of syntactically ambiguous sentences in Japanese. Using a picture selection task, we presented two types of syntactically ambiguous sentences which can be disambiguated by prosody.

The first type are complex sentences with embedded relative clauses (CS) as shown in (1). When the prosodic phrase boundary is placed after the first NP (/1/ in the example below), the first and the second verb are interpreted as coordinate VPs modifying the accusative-marked, object NP. We call this the ***distant interpretation*** since the first VP (putting on boots) is associated with a non-adjacent NP. In contrast, when there is a prosodic boundary after the first verb, (/2/ in the example below) the first NP is interpreted as the subject of the first verb only. We will call this the ***local interpretation***, since the first VP is associated locally with the preceding NP. The second type are noun phrases with multiple pronominal modifiers (NP) as shown in (2). When the prosodic boundary is placed after the first phrase (yellow) (/1/), it is interpreted to modify the last phrase (yellow flower) (***distant interpretation***). Alternatively, when there is a prosodic boundary after the second phrase (/2/), the first PP is interpreted as modifying the second phrase (yellow box) (***local interpretation***).

When there are no prosodic cues, Japanese adults prefer the distant interpretation for the CS construction, while they prefer the local interpretation for the NP modifier construction. When these sentences were presented auditorily either with local or distant prosody, Japanese adults were able to choose pictures that are appropriate for the prosody in an off-line norming task. The prosodic boundaries in both of the constructions were IP boundaries. The acoustic properties of the boundaries for the two constructions were made to be as similar as possible.

The results of the picture selection task, however, showed different results. Both Japanese children and adults were able to use prosodic cues to disambiguate the local and distant interpretations of the CS sentences. The use of prosody to interpret NP modifiers by Japanese children and adults, however, was quite different from that of CS condition. Both adults and children consistently interpreted the first phrase to locally modify the second phrase (as 'yellow box') irrespective of the prosody. The results suggest that children as young as four *do* have the ability to use prosody to resolve syntactic ambiguity. However, it is not the case that they always rely on prosodic cues to choose an interpretation when presented with an ambiguous construction. The fact that children and adults failed to utilize the prosodic cues in the same construction lend support for a hypothesis that assumes that the underlying mechanism for sentence comprehension for children are the same as adults.

**Example sentences**

(1)  **Onnanoko-wa /1/ <u>nagagutsu-o haite</u> /2/ suwatteiru otokonoko-o miteimasu.**
     Girl-TOP     boots-ACC wearing      sitting down boy-ACC    looking at
       a. Distant interpretation (boundary /1/)
        "The girl is looking at a boy who has put on boots and is sitting down."
       b. Local interpretation (boundary /2/)
        "The girl puts on boots, and is looking at a boy who is sitting down."

(2)  **<u>Kiiro-no</u> /1/ hako-no /2/ yoko-no hana.**
     Yellow     box      next to flower.
       a. Distant interpretation (boundary /1/) "The yellow flower next to the box."
       **b.** Local interpretation (boundary /2/) "The flower next to the yellow box."

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# The Effects of Pragmatic Context, Syntactic Context, and Working Memory Capacity on the Resolution of Lexical Ambiguity

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It has been suggested that the resolution of lexical ambiguity is time dependent, occurring within 200 ms after initial processing (Seidenberg, Tanenhaus, Leiman, & Bienkowski, 1982). Other findings indicate that high-span readers are able to maintain multiple meanings of an ambiguous word over time when disambiguating information is not initially available (Miyake, Just, & Carpenter, 1994). Furthermore, within the context of a Wh-question that is devoid of biasing information (e.g., *"Which bank did the woman see?"*), Meyer and Peterson (2000) found that ambiguity resolution occurred following the processing of the verb, suggesting that ambiguity resolution occurs following the syntactic/thematic integration of the ambiguous word. However, Meyer and Peterson utilized the cross-modal priming methodology (Swinney, 1979), which does not allow for continuous sampling of meaning activation. The current study attempted to provide a continuous measure of meaning activation by utilizing eye tracking and the passive-listening visual world paradigm (Cooper, 1974). In addition, the effects of working memory capacity and biasing pragmatic contxt were also examined.

In Experiment 1, during critical trials, participants listened to Wh- question stimuli containing an ambiguous word (e.g., *"Which diamond did the man like?"*). Each question was followed by a disambiguating reply sentence (e.g., *"The one with the rubies."* or *"The one with the bleachers."*). While listening to the speech stimuli, participants viewed an array that contained one dominant-related image (e.g., a ring), one subordinate-related image (e.g., a baseball), and two unrelated images. Thirty-six percent of the trials were critical, and the remaining trials were fillers (ambiguous words were not systematically presented, and all of the images were unrelated). Three predictions were made: 1) The pattern of fixations would indicate initial activation of both meanings, which would be maintained until after the verb occurred. 2) Following the verb, the ambiguous word would be integrated with the syntactic context and the dominant meaning would be selected (dominant-related targets would be fixated at a greater rate than subordinate-related targets). 3) If the disambiguating reply were consistent with the subordinate meaning, then the initial interpretation would be revised (subordinate-related targets would now be fixated at a greater rate than dominant-related targets).

The results of Experiment 1 are presented in Figure 1. During the question, fixation probabilities for related pictures remained equivalent to the baseline probability of fixating unrelated pictures, failing to support prediction 1. The probability of fixating dominant-related pictures became greater than baseline at approximately 3000 ms, coinciding with the offset of the verb, and thus supporting prediction 2. The fixation probability for subordinate-related pictures became greater than baseline at approximately 3500 ms, but remained lower than the probability of fixating dominant-related pictures. The probability of fixating dominant-related pictures remained high if this interpretation was supported by the reply (offset at 4700 ms). If the subordinate interpretation was supported, then the probability of fixating subordinate-related pictures increased, becoming greater than the probability of fixating dominant-related pictures at about 6100 ms (supporting prediction 3).

Given the lengthy lag between the offset of the subordinate-biasing context and preferential fixation of subordinate-related images, in Experiment 2 we explored the possibility that earlier biasing pragmatic information could lead to earlier selection of the subordinate meaning (using stimuli such as *"Which diamond was very valuable? The one with the rubies."* or *"Which diamond was very overgrown? The one with the bleachers."*). As predicted, contextually-consistent subordinate-related pictures were preferentially fixated earlier than in Experiment 1. When analyzed separately for high- and low-span participants, results were consistent with the hypothesis that high-span readers are more likely to use inhibition and/or selection processes to initially select the dominant meaning and to eventually select the contextually-consistent meaning (Gunter, Wagner, & Friederici, 2003).

Experiment 3 examined the impact of competition among related targets. The stimuli from Experiment 1 were used, with the following exception: one related target picture was presented along with three unrelated images. The pattern of results was similar to Experiment 1. However, the results also indicate that both consistent and inconsistent related targets are typically fixated at a greater rate when a related competitor is not present.
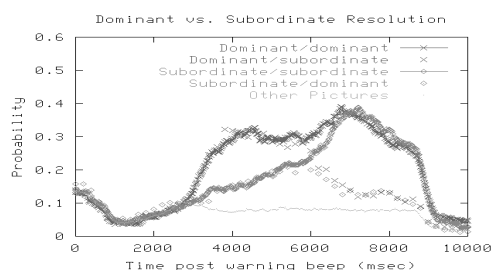


**Figure 1.** Probability of fixating a related image, by pragmatic context.

# Structural vs. Semantic Focusing: Distributional Evidence from Referential Forms in Adverbial Clauses

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Approaches to anaphoric interpretation differ in the way they model anaphoric interpretation. Across fields, however, a consensus has been reached that anaphoric interpretation may be affected by a number of factors. In this paper, we focus on two such factors: structural (Grosz et al, 1995) and semantic focusing (Stevenson et al, 2000). Structural focusing predicts that in example (1), the pronoun is co-specified with the subject of the preceding clause. Semantic focusing predicts that the pronoun in (2) is co-specified with the entity expressing the patient role because verb focusing makes more salient the entity associated with the endpoint of the event. Both accounts run into problems, as send in examples (2), (3), and also (4) taken from Suri et al (1999).

We formulate the hypothesis that syntactic structure is one of the factors affecting the strength of structural versus semantic focusing effects. Specifically, we claim that the syntactic locality defined by the main clause and its dependent (tensed) subordinate clauses defines the territory for semantic focusing. Once this locality is crossed, semantic focusing loses its force to structural focusing. Here we report two experiments (in English and Modern Greek), in which we compare and contrast the interpretation of a pronoun in an adverbial clause with the interpretation of a pronoun in a main clause. For the English case a sentence completion task was designed examining two conditions shown below. In the first condition, a main clause containing two same gender referents and an action verb was followed by a period and another main clause containing a sentence adverb and an ambiguous pronoun. In the second condition, a main clause was followed by a subordinate conjunction and an ambiguous pronoun. A total of five subordinate conjunctions and five adverbials were used, picked from a variety of semantic classes (when, although, because, so that, while and then, however, as a result, moreover, period). A similar experiment was conducted in Greek.

Figure 1



**Examples**

 (1) John$_i$ invited Bill$_j$ for dinner. He$_i$ …
 (2) John$_i$ criticized  Bill$_j$ because he$_j$
 (3) John$_i$ criticized Bill$_j$. Then, he$_i$…
 (4) a. Dodge-i was robbed by an ex-convict-j.
     b. The ex-convict-j tied him-i up
     c. because he-i wasn't cooperating.
     d. Then, he-j took the money and ran.

**Condition A**: The boxer kicked the referee. As a result, he…
**Condition B:** The boxer kicked the referee because he…

For reasons of space, we show here only the results of the English experiment. Figure 1 shows that in the main-main condition the pronoun tends to be interpreted as the subject of the preceding main clause whereas no such tendency is shown in Condition B (main effect of type of clause, $F(1, 19) = 79.33$, $p<0.00$). Closer inspection of the results per connective (not shown here) reveal  interesting focusing effects due to the meaning of the connectives, especially the subordinate conjunctions. We got similar results for Greek, which we take as preliminary indication that syntactic structure might be used for manipulating focusing domains across languages. The results of these experiments raise interesting questions about the factors determining the strength of various focusing mechanisms as well as the specific role of subordination in focusing and reference processing cross-linguistically. We are currently testing this pattern in discourses in which  the subordinate conjunction is implicit.
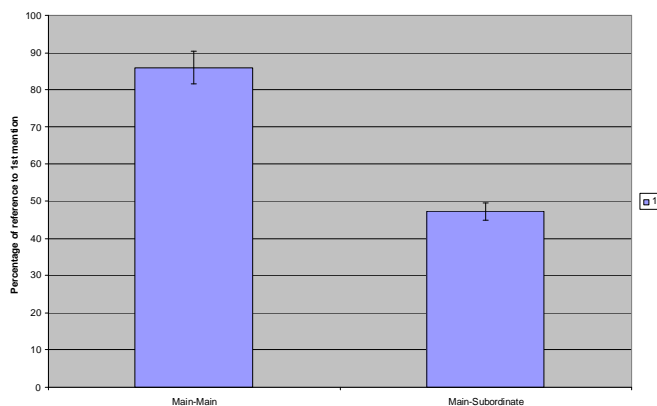
# Verb Event Structure Effects in On-line Sentence Comprehension

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In this paper, we present experimental evidence that event structure information, specifically inherent verb telicity, is used immediately in the comprehension of structurally ambiguous sentences. An eventive verb is inherently telic if its meaning requires the notion of an endpoint; otherwise, the verb is atelic. On-line reaction times (RTs) and errors showed that in sentences like (1a) through (1d), less comprehension difficulty occurs when the embedded verb is telic (*tripped* or *noticed*) than when it is atelic (*applauded* or *escorted*).

(1) a. *The actress applauded by the writer left in a hurry.* (optionally transitive, atelic)
    b. *The actress tripped by the writer left in a hurry.* (optionally transitive, telic)
    c. *The actress escorted by the writer left in a hurry.* (obligatorily transitive, atelic)
    d. *The actress noticed by the writer left in a hurry.* (obligatorily transitive, telic)

This result was obtained in three different experimental paradigms: the word maze (Freedman & Forster, 1985), speaker change monitoring (Townsend & Bever, 1991), and self-paced reading. The experiments fully crossed two independent variables, telicity/atelicity and obligatory versus optional transitivity, in order to tease apart the effects of these two types of verb information.

Figure 1 shows the maze experiment results. In the word maze, the participant is presented with the first word of a sentence followed by a pair of words, only one of which can grammatically continue the sentence. The participant is asked to choose which of the two words forms a grammatical continuation. Following a correct choice, the participant is presented with further series of word pairs, and the task is to choose a grammatical continuation word at each step. The RTs reflect the time required to integrate each word into the sentence as it is parsed. The dependent variable in the current experiment was the reduced relative effect (RRE), calculated as the RT at each position for the ambiguous sentence, such as those in (1), minus the RT for the corresponding unambiguous version, which includes *that was* before the embedded verb.

The results in Figure 1 show that telicity significantly decreased the RRE on the earliest disambiguation region, the preposition *by*. On this region, obligatory transitivity has the opposite effect. Obligatory transitivity leads to a decrease in the RRE later in the sentence, as found by MacDonald (1994) and others. The results show that telicity and obligatory transitivity both immediately affect the severity of the garden path independently of each other.

Additionally, we report the results of a computerized study that provides evidence that naïve native speaker judgments of verb phrases in sentence frames provide an objective means of categorizing verb phrases as telic or atelic. Examples of the frames include *It took an hour to_*, *_in an hour*, and *_for an hour*. The participants were 24 English-speaking students in an undergraduate introductory linguistics course.

The research strongly suggests that verb event structure information is used at least as early as purely syntactic information in processing. Sentence processing models that can incorporate verb event structure information are supported.
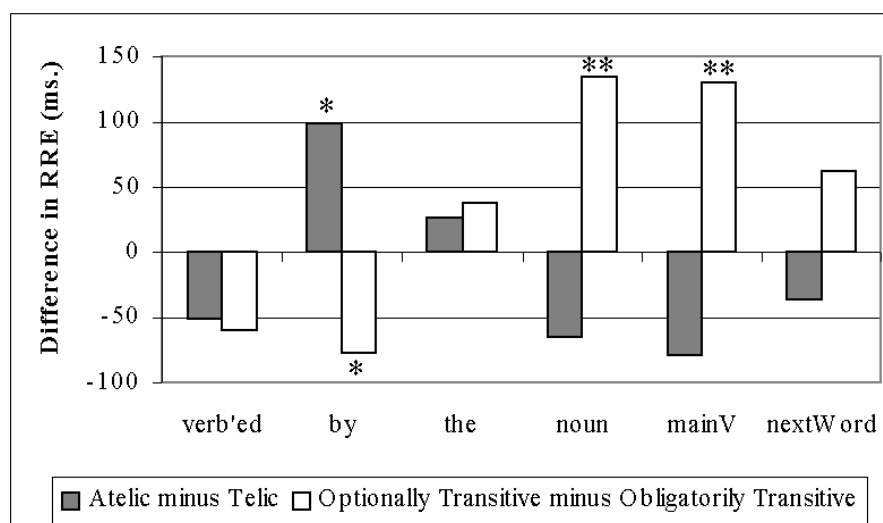


**Figure 1**

# From event cognition to language production

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Models of language production assume that language-specific demands on the formulation of messages have become automatic in adult speakers and shape the preparation of encodable messages even before the activation of specific lexical items (Levelt, 1989). Similarly, in language acquisition, the mobilization of linguistic resources in preparation for speech is assumed to be affected by knowledge of what is normally encoded in the local language (Choi & Bowerman, 1991). In both cases, however, decisions about what to encode linguistically and what to leave unexpressed are crucially mediated by non-linguistic (pragmatic) factors. How such considerations operate given the expressive resources made available by typologically distinct languages has not been systematically addressed so far.

Here we compare experimentally verbal descriptions of motion produced by adult and 8-year-old speakers of English and Greek. These languages differ in terms of how types of motion information (e.g. manner, direction) are conflated within the clause (Talmy, 1985). In English, both kinds of information are typically encoded: manner appears in the verb and direction in PPs. In Greek, manner information has low prominence: the verb usually encodes the direction of motion, while manner information may be omitted altogether:

(1)      The man ran down the stairs.                                    *English*
(2)      O andras  katevike        tis skales (trexontas).             *Greek*
         'the man  descended        the stairs (running)'

Our goal was to determine how these language-specific restrictions on lexicalization/clause structure interface with a (probably universal) pragmatic constraint on event encoding, the omission of inferable information (a factor known to affect event descriptions; Brown & Dell, 1987; Lockridge & Brennan, 2002). In some of our scenes, manner of motion was inferable, even if not explicitly mentioned, through properties of the subject and/or predicate (e.g. a man was WALKING down the stairs); in others, it was not (e.g. a man was RUNNING down the stairs). We expected the inferable/opaque distinction to have an effect for production only in those languages which do not typically encode manner of motion (e.g. Greek) but to be inert in languages that routinely encode it (e.g. English). Our results confirmed this prediction. Greek speakers were overall more likely to exclude manner of motion information from their descriptions than English speakers (40.6% vs. 21.4%, $p<.0001$). Nevertheless, both Greek children and adults were more likely to include manner in scenes with non-inferable vs. transparent manner ($p<.0001$); no such adjustment occurred in the speech of English speakers, where manner was already preferentially encoded.

In another experiment, a new group of Greek speakers was asked to describe our scenes to hearers who lacked visual access to them. Despite lack of visual co-presence, mention of manner information did not increase overall ($p=.68$), but the inferability/opaqueness asymmetry persisted. Taken together, these findings suggest that general pragmatic requirements (e.g. the omission of inferable information) interface in different ways with lexical-structural properties of individual languages during the formulation of codable messages. They also suggest that children are sensitive to such interface constraints on event encoding.

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# The effect of visual properties on the organization of an artificial lexicon

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Controversial neuroimaging evidence suggests that perceptual or motor characteristics of semantic categories, in addition to phonological relatedness, may affect the organization of lexical representations[1]. Some difficulty in examining the semantic organization of the lexicon arises from the massive entanglement of semantic, lexical, and perceptual dimensions in natural language stimuli[2]. An artificial lexicon permits greater control over many of these characteristics, including frequency, phonological neighborhood, and perceptual experience. Previous studies with artificial lexicons using the visual world paradigm find standard lexical access patterns (e.g. cohort, frequency effects, etc)[3]. We extended this approach to examine how correlated perceptual features (motion vs. surface appearance, spatial properties) influence lexical organization.

Subjects learned a 16-word artificial lexicon. Eight lexical items referred to novel shapes and eight to modifiers of those objects (four motions and four colors/textures). Subjects heard a two-word phrase while viewing a scene containing 4 objects and 4 modifier icons. Their task was to move a mouse to click on the appropriate modifier icon and apply its perceptual property with a click to the appropriate object. Feedback provided during training resulted in accurate modifier and object selection (> 85% correct). Icons with motion and non-motion properties were grouped in separate screen regions (see figure). The eight modifier words were trisyllabic and shared their initial two syllables with another word, creating four cohort pairs. Two cohorts fell within a modifier category (W1- motion A, W2 – motion B) and two were between-category (W1- motion X, W2 – color Y). One member of each cohort pair was a target 5x more often than the other member, although both were equally likely to appear as distracters for other targets. A target's cohort was never onscreen during training. The eight object words were bisyllabic, equibiased, and highly dissimilar to all other words. After training, a final testing phase featured all icons and objects presented as targets with equal frequency, target modifier cohorts present on 50% of trials, and no feedback. In addition to mouse click responses, eyegaze was monitored with a head-mounted eye tracker.

Post-experiment debriefing revealed subjects were unaware of the categorical grouping of the modifier icons. However, subjects implicitly learned the spatial properties inherent in the display organization. When a target's cohort was a member of the same category, gaze was more rapidly restricted to the region of the display containing the correct modifier icon than when the cohort belonged to the opposite category. High frequency targets elicited more rapid gaze shifts than low frequency targets. Both effects were evident even when the cohort was not in the display, indicating that both phonological and spatial perceptual features of newly learned lexical representations influence lexical access. Because perceptual characteristics of categories are an integral and accessible part of the lexical representation, lexical activation effects may be seen in cortical areas that mediate processing of specific perceptual properties, (e.g., MT/MST for motion), an hypothesis we are exploring in neuroimaging studies.

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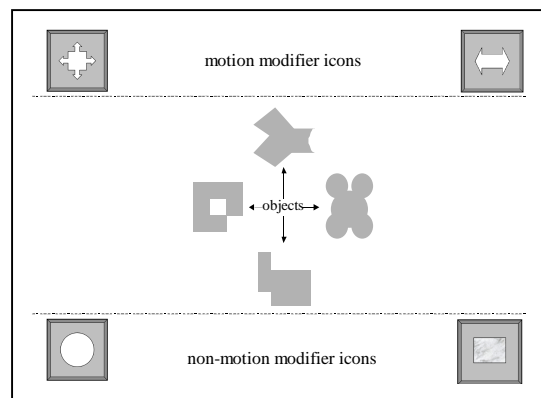
# Syntactic and Semantic Prominence in Pronoun Resolution

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Subjects are preferred antecedents for pronominal reference (Mathews and Chodorow, 1988). Many models of discourse coherence (e.g., Centering Theory: Grosz et al., 1995) account for this by assuming a hierarchy of syntactic prominence for antecedents as in (1). The upper part of this hierarchy has been validated in numerous studies (e.g., Hudson-D'Zmura and Tanenhaus, 1997). However, for many verbs in English, syntactic role is conflated with semantic role: That is, syntactic SUBJECTS are often semantic AGENTS, and so on. So it could be that what appears to be the result of the prominence of syntactic SUBJECTS is actually the result of the prominence of semantic AGENTS with respect to a hierarchy of semantic roles as in (2). This paper presents the results of two sentence-completion experiments which compare the influence of syntactic prominence and semantic prominence on the salience of antecedents for subsequent pronominal reference.

Entities realized in syntactic positions higher on the syntactic hierarchy in (1) are more syntactically prominent: they appear higher in the syntactic tree and appear to be more salient as antecedents (Mathews and Chodorow, 1988; Hudson-D'Zmura and Tanenhaus, 1997). Entities realized with higher roles on the semantic hierarchy in (2) are more semantically prominent: they inherit more proto-AGENT entailments (Dowty, 1991) and are typically mapped onto higher syntactic positions. Based on these assumptions, two studies examined whether either syntactic prominence or semantic prominence or possibly some combination of the two factors better explains participants' pronoun resolution preferences.

The first experiment compares *tough*-constructions to non-*tough*-constructions as in (3)-(4). In (3), syntactic and semantic prominence converge and the utterance should therefore have a single salient entity, namely *John*. However, in (4), syntactic and semantic prominence diverge onto separate entities: as a surface SUBJECT, *Matt* is the syntactically most prominent entity, but it is less semantically prominent than the embedded AGENT, *John*. Hence, this condition allows observation of the relative influence of syntactic and semantic prominence. In a forced-choice sentence-completion task, for (3), participants (n=32) preferred a continuation beginning with a pronoun that was coreferent with the SUBJECT over a continuation beginning with a pronoun that was coreferent with the OBJECT 75% of the time (significant by both subjects and items). However, for (4), participants showed no preference for either continuation (49% to 51%, n.s. by both subjects and items) suggesting that both syntactic and semantic prominence play a role in determining discourse salience.

The second experiment was designed to examine the lower part of the syntactic and semantic hierarchies by using constructions which allow alternation of their internal arguments—*spray/load* verbs as in (5)-(6). As in Experiment 1, there is a convergence and divergence of syntactic and semantic prominence for these arguments. In (5), the semantic THEME, *paint* is both syntactically and semantically prominent but in (6), *wall* is syntactically more prominent while *paint* is semantically more prominent. Results of the sentence-completion task were similar to Experiment 1: After (5), participants (n=24) preferred a continuation in which a sentence-initial pronoun *it* was coreferent with *paint* 70% of the time (significant by both subjects and items). However, after (6), neither continuation was preferred (48% to 51%, n.s. by both subjects and items).

The experimental evidence suggests that both syntactic and semantic prominence contribute to the discourse salience of entities: neither factor alone determined participants' preferences in the split conditions (when syntactic and semantic prominence diverge). Furthermore, the results of the Experiment 2 validate the lower part of the syntactic hierarchy (which has long been assumed but never explicitly verified experimentally). I will also discuss parallel on-line results consistent with the above results and describe how semantic prominence might be fleshed out and integrated into a model of discourse salience.

## Examples

(1)  SUBJECT > OBJECT > OBLIQUE

    (2)      AGENT > THEME > OTHERS

    (3)      $John_j$ could hardly beat $Matt_i$. $He_{i/j}$ …

    (4)      $Matt_i$ was tough for $John_j$ to beat $\emptyset_i$. $He_{i/j}$ …

    (5)      John sprayed some $paint_i$ on a $wall_j$. $It_{i/j}$ …

(6) John sprayed a $wall_j$ with some $paint_i$. $It_{i/j}$ …

# An activation-based model of agreement errors in production and comprehension

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We will present an activation-based model of verb-production that captures a wide variety of known evidence on agreement errors. The model is build atop ACT-R 5.0's architecture, which provides us with mechanisms for *i.* declarative chunk activation and decay, *ii.* cost-dependent rule selection, and *iii.* task-specific modelling. Whether a plural or a singular verb is produced depends on the accessibility of Subject's plural marking. The activation of plural-marking chunks decays, so that it might not be found when its retrieval is attempted at the verb, resulting in a general singular error (Hemforth and Konieczny, 2003). This effect is then modulated by task and construction specific variations. The model will come in variants for different experimental paradigms, which are nevertheless based on the same core for verb-production.

The first model variant presented here performs the completion task for written production as used in Hemforth and Konieczny (2003) and is hence a combined sentence processing and production model. In the experiments, participants had to add number marked auxiliaries in order to complete the sentences. The model first reads two NPs, embedded in a variety of constructions, and then produces the auxiliary. Modifier attraction errors in subject-modifier constructions, as found in (1), (cf. Bock & Miller, 1991; Vigliocco & Nicol, 1998) are due to encoding errors during plural marking ("feature percolation"), where the plural feature of the modifier-NP sometimes gets wrongly assigned to the Subject-NP. This effect is due to the necessity of reactivating the Subject-NP for modifier attachment and is therefore restricted to modifier-NPs.

The model is embedded in comprehension model that performs incremental interpretation and verb-anticipation (Konieczny and Döring, 2003). For that reason, after reading a verb-argument, all previous arguments are reactivated to find the best matching interpretation for the given set of arguments. Consequently, in S-O-V constructions (2), the plural feature of the subject-NP might be reactivated, and more likely so when the object-NP is marked for plural as well, by virtue of spreading activation from the current goal (i.e. by virtue of being within the focus of attention). The singular error for plural subjects is hence predicted to be reduced for plural objects, which is in fact what Hemforth and Konieczny (2003) found. Under time pressure though, the object plural-marking may be left under-specified for its root so that Object-attraction errors may occur at the verb (Hartsuiker et al., 2001). In all constructions, cognitive load results in less attention, i.e. source activation, being devoted to relevant chunks, increasing the likelihood of errors in general (Fayol, Largy & Lemaire, 1994).

We are planning to extend the model to other types of tasks (as pure production tasks) to be able to account for task-specific differences. We will argue that many of the cross-linguistic evidence on agreement errors in production is due to an interaction of the task demands of the specific paradigm used (basically whether or not intermediate recall and time pressure were involved, cf. Fayol , Largy & Lemaire, 1994) and properties of the (language specific) constructions (basically their lengths).

**Examples**

*Subject-modifier-verb*

(1)　　Die　　Farbe/Farben　　auf　　(der　　Leinwand/den　　Leinwänden)　　_____　　trocken.
　　　　The color/colors on the canvas/canvasses _____ dry.

*Subject-object-verb*

(2)　　Ich　　habe　　gehört,　　dass　　(der　　Mann/die　　Männer)　　die　　Frau/Frauen　　besucht　　_____.
　　I have heard that the man/men the woman/women visited _____.

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# Morpho-syntactic information contributes to short-term memory for sentences

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In several studies it has been shown that short-term recall of a sentence proceeds as a regeneration of its meaning (via propositional and lexico-semantic representations) by means of regular speech production (e.g., Potter & Lombardi, 1990). This regeneration process is aided by phonological information, if available (e.g., Martin, Shelton, & Yaffee, 1994; Rummer & Engelkamp, 2001). In contrast, it has not been demonstrated so far whether morpho-syntactic information contributes as well. Though there is some evidence aganst a direct contribution of syntax (Lombardi & Potter, 1992), these studies do not rule out an influence of syntactic information in general (e.g., Rummer, Engelkamp, & Konieczny, 2003). In particular, this holds for morpho-syntactic properties of the to-be-recalled words. One such morpho-syntactic property is grammatical gender of nouns. Several studies have demonstrated an influence of grammatical gender on speech processes (see Schriefers & Jescheniak, 1999, for an overview). In German, grammatical gender allows for distinguishing between lexico-semantic and lexico-syntactic features, as there is no clear correspondence between the conceptual and the grammatical gender of a noun.

To investigate the possible contribution of morpho-syntactic information to short-term sentence recall, an experiment based on Potter and Lombardi's (1990) intrusion paradigm was conducted. In this type of experiment subjects are presented with an unrelated list of five words which contains either a *lure* noun or a *control* noun. The lure noun is semantically related to a *target* noun within the subsequently presented and to-be-recalled sentence and, in addition, fits the sentence context better than the target noun. Sentences and word lists are presented via *rapid serial visual presentation* (RSVP). Presenting the lure noun in the word list leads to intrusions of this noun when the sentence has to be recalled.

In the present experiment, we additionally varied gender congruency between lure and target word, that is, for each target noun one lure noun identical and one differing in grammatical gender were chosen. Congruent and incongruent lure words were matched with respect to cloze probability, frequency, word length, and semantic relatedness to the target noun. Each trial included either a congruent lure, an incongruent lure or a control word. A higher degree of gender-congruent lure intrusions as compared to intrusions of gender-incongruent lure words would support the assumption that morpho-syntactic information contributes to short-term sentence recall as well. The German example illustrates the experimental procedure and the lure-target relations (English translation in brackets).

Our results are in line with the hypothesized influence of morpho-syntactic information on short-term recall of sentences. To investigate whether this gender influence is due to the abstract lexical property "gender" or to an influence of the determiner, further experiments have to be conducted.

## Example

| | |
|---|---|
| Word list with gender-*congruent* lure: | Maus <u>Restaurant</u> [*neut.*]/Hoheit Tür Baustelle Anfang (mouse <u>restaurant</u> [*neut.*]/highness door site beginning) |
| Word list with gender-*incongruent* lure: | Maus <u>Kneipe</u> [*fem.*]/Hoheit Tür Baustelle Anfang (mouse <u>pub</u> [*fem.*]/highness door site beginning) |
| Sentence presentation: | Die Kollegen hatten ihn mehrfach aufgefordert, sie abends in das [*neut.*] <u>Café</u> am Stadtrand zu begleiten. (The colleagues had often asked him to accompany them to the [*neut.*] <u>café</u> on the outskirts in the evening.) |

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# The Non-linear Interaction of Constraints in Pronoun Resolution

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Arnold (1998) suggested that anaphora resolution be viewed as a type of ambiguity resolution, much like lexical and syntactic ambiguity resolution. She proposed a model for anaphora resolution based on the probabilistic constraints approach to language representation and processing (MacDonald, Pearlmutter, and Seidenberg, 1994; Trueswell and Tanenhaus, 1994). A crucial prediction derived from this proposal is that interactions among constraints are non-linear: information that may not constrain interpretations when considered in isolation becomes very constraining when considered in conjunction with other information. This prediction was tested in two experiments which investigated the interaction between syntactic parallelism, implicit causality, and global discourse focusing for the resolution of weak object pronouns (clitics) in Greek. The experiments were conducted in Greek because, due to the particular facts about the linear position of weak object pronouns (unlike English, where object pronouns canonically follow the verb, in Greek weak object pronouns precede it), it was possible to investigate the effects of the three factors independently from other confounding factors, such as verb-semantics in the clause/sentence containing the pronoun.

In both experiments participants provided oral continuations to fragments consisting of a subject NP followed by a clitic case-marked accusative (direct object) or genitive (indirect object)—(2). The clitic could be interpreted as co-referential with one of two NPs used in the previous sentence as arguments of implicit causality verbs, such as 'annoy' (subject-biasing verb) and 'hate' (object-biasing verb)—(1). Accusative clitics had a syntactically parallel potential antecedent, while genitive clitics did not. In Experiment 1, the fragment and the sentence containing the implicit causality verb were preceded by a neutral context sentence, while in Experiment 2, where global discourse focusing was manipulated, the context biased towards one of the potential antecedents for the clitic.

Experiment 1 demonstrated that when implicit verb causality and syntactic parallelism biases did not converge, implicit verb causality had no effect on antecedent preferences and syntactic parallelism had a weak effect. However, when both implicit verb causality and parallelism pointed to the same antecedent, selection of that antecedent became almost obligatory.

In Experiment 2 discourse focusing was shown to override individual effects of parallelism and implicit causality. When, however, both the causal bias of the verb and syntactic parallelism supported the same assignment, global discourse focusing effects were neutralised.

These two experiments, in demonstrating the non-linear nature of interactions between constraints, support the potential of constraint-based approaches to provide a unified account of processing architecture from the lexical to the discourse level.

## Examples

(1)     O               Gianis             eknevrize/misuse to              Giorgo.
        The-masc-nom    Gianis-nom         annoyed/hated    the-masc-acc    Giorgo-acc.
        *John annoyed/hated George.*
        I               Maria             ton…/                          tu…
        The-fem-nom     Maria-nom         clitic-masc-acc…/              clitic-masc-gen…
        *Mary clitic-masc-acc…/clitic-masc-gen...*

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# An eye-tracking study of stressed pronoun resolution
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Venditti, Stone, Nanda, and Tepper (2002) investigated stressed and unstressed subject pronoun interpretation in an eye-tracking experiment, claiming that their results contradict the predictions of Smyth's (1994) pronoun resolution model. That model incorporates both a feature match condition (pronouns and antecedents should match in grammatical role, among other things) and a constituent parallelism requirement (the exact structure of both clauses must be identical; see Chambers & Smyth, 1998). In our paper we first argue that Venditti et al. (2002) have misunderstood the Smyth model and show that their results are compatible with it. We then present two eye-tracking experiments that provide further support for the Smyth model.

In Venditti et al. (2002) participants looked at still pictures of animals in various situations while listening to sentences containing a subject pronoun. Sentences like (1) met the grammatical role parallelism requirement but not the constituent parallelism requirement: the first clause was SVO followed by an instrument PP, and the second clause was SVO with a subject pronoun and no instrument. For this type of sentence, participants looked mainly at the subject antecedent for unstressed pronouns, and at the object antecedent for stressed pronouns. Venditti et al. (2002) claim that Smyth's account cannot explain the stress effect observed in these conditions. However, Smyth (1994) would predict that a subject pronoun in a structurally non-parallel sentence is resolved before the adjunct, or lack there of, is encountered downstream, and is thus resolved in the same manner as a subject pronoun in a structurally parallel sentence. Only the resolution of non-subject pronouns (not discussed by Venditti et al., 2002), as in (2), is affected by structural non-parallelism, since these pronouns occur in sentence final position, and the lack of adjunct becomes obvious when the end of the sentence is reached, as indicated by punctuation or prosody.

In our Experiment 1 participants watched an animation in which one shape bumped another, and then heard a sentence like (3). The task was to look as quickly as possible at the antecedent. The shape that was looked at determined how the animation continued. For example, in (3), if participants looked at the square, the square would bump the circle. In structurally parallel sentences with unstressed pronouns, participants looked at the grammatically parallel antecedent, whether subject or object, and with stressed pronouns, the reference switched in both cases. For structurally non-parallel sentences (i.e. those with an adjunct in only one clause), responses to subject pronouns were identical to the parallel condition, replicating Venditti et al. (2002). Importantly, object pronouns, whether stressed or unstressed, were not reliably resolved in the same way as in the parallel condition, in line with Smyth's predictions. However, one possible criticism of this experiment is that the response measure (looks to antecedent) did not accurately reflect on-line pronoun resolution.

Experiment 2 (in progress) eliminated this possible confound. The animation was time-locked to auditory presentation, and eye-movement data were recorded. The task no longer required a volitional eye-movement response as in Experiment 1; instead, at the end of the animation, participants indicated whether what they saw matched their interpretation of the sentence they had heard. We predict that both stressed and unstressed object pronouns will be more ambiguous in structurally non-parallel sentences than in parallel ones, as seen in eye-movements (on-line), as well as reaction times and matching judgments (off-line).

## Examples

(1)    The lion hit the alligator with a long wooden rake, then he hit the duck.
(2)    The lion hit the alligator with a long wooden rake, and then the duck hit him.
(3)    The square bumped the triangle and then it bumped the circle.

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# Allocation of Memory Resources during the Incremental and Computational Processing of Complex Sentence — A Case Study of the Processing of Chinese Sentences with Relative Clause

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The current study investigates the nature of the allocation of memory resources in computing the syntactic and semantic information over the timecourse of the incremental processing of sentence comprehension by examining the relative ease of the processing of object-extracted and subject-extracted RCs in Chinese. Psycholinguistics studies have demonstrated that object-extracted RCs (OR) are harder to comprehend than subject-extracted RCs (SR) in languages with post-nominal head-initial RCs such as English (Gibson, 1998; Gordon, Hendrick, & Johnson, 2001). In contrast, Chinese has prenominal head-final RC that its linguistic index of RC ("DE" as "that" in English) appears only later within the RC structure, and thus the interpretation of the RC can be easily ambiguated with the interpretation of the matrix clause as shown below.

**English**

1a. SR: [[The lawyer(i) that [e(i) attacked the politician]] stole the ballots].
1b. OR: [[The lawyer(i) that [the politician attacked e(i)]] stole the ballots].

**Chinese (shown only with the English translation for each Chinese word; "DE": RC marker):**

2a. SR: [[[e(i) Attack(ed) the politician] DE the lawyer(i)] stole the ballots.]
2b. OR: [[[The politician attack(ed) e(i)] DE the lawyer(i)] stole the ballots.]

The crucial contrast is that while in English the processing of matrix and embedded materials is temporally distinguished; in Chinese the processing of embedded materials of RC is confounded with the interpretation of matrix clause. To illustrate, in the Chinese OR (2b.), *the politician  attack(ed)* (NV) is naturally interpreted as the matrix subject and verb before encountering the relativizer, DE. This is especially true when the RC is under high structural constraints (when modifying the matrix object) where the initial linguistic materials preceding the embedded RC commit a matrix-clause parsing as shown below.

**Object-modifying**

Chinese-SR:  Nm  Vm  [(e) Vr Nr  DE  Nm]rc
Chinese-OR:  Nm  Vm  [Nr Vr (e) DE  Nm]rc

Therefore, such filler-gap difference in Chinese RC induces the interaction of integration cost and structural-building cost during the incremental processing of sentence comprehension that can be exploited to delineate the nature of source allocation in memory during the real-time interpretation of syntactic and semantic information over the course of sentence comprehension

A series of self-paced reading-time experiment was conducted within which we used different types of RC (subject-/object-extracted) when the RC was under differing degrees of structural constraints (the RCs modified both subject and object of the matrix clause) and when the RC's processing induced different degrees of cost (definite NP/indexical pronoun). The results indicate that:  First, the object-subject processing differences appeared only in the later part of the sentence and it is modulated mainly by the incremental nature of sentence processing that it is greater when the RC is more deeply embedded within the sentential structure (when modifying matrix object).  Second, having an indexical pronoun as the embedded NP of RC reduced comprehension difficulty and eliminated the RC-Type processing differences.  This indicates that crucially, the additional processing resources released by having an indexical pronoun in RC can be allocated immediately to the processing of subsequent linguistic materials, and thus confers processing advantage in managing garden-path effect over having a descriptive NP in RC.  The implication of the results is discussed in light of the evaluation of the relative merit and generality of contrasting theories in terms of object-subject processing differences (Gibson, 1998; King & Just, 1991; Lewis, 1996; MacWhinney & Pleh, 1988). They also shed lights on our understanding of how the incremental and computational properties of sentence processor dynamically allocates the processing resources in integrating different kind of information into the mental model.

# CUNY CONFERENCE

# Saturday, March 27

# Paper Presentations

# Use Of Grammatical Constraints In The Processing Of Backwards Anaphora

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Much recent work on the processing of syntactic dependencies suggests that the parser actively attempts to complete a dependency as soon as possible, often setting processes of structure building and interpretation in motion even before encountering the lexical information that signals the completion (e.g. the 'filled-gap' effect, Crain & Fodor, 1985). One question that such research has raised is whether these active strategies apply across-the-board or whether they are sensitive to general syntactic constraints. Several studies of wh-dependencies suggest that active gap creation is sensitive to island constraints (Stowe, 1986; Traxler & Pickering, 1996; McElree & Griffith, 1998). In this study we extend evidence for active processing to a different kind of dependency, backwards anaphora, and show that these processes exhibit a similar sensitivity to syntactic constraints.

Van Gompel & Liversedge (2003) provide evidence that the parser uses an active strategy to process backwards anaphora with sentences like (1):

(1)        When he was fed up, the boy/girl visited home very often.

They show a 'gender mismatch effect', such that the subject of the main clause is read more slowly when its gender prevents interpretation as the antecedent of the pronoun, suggesting that the parser expects the anaphoric dependency to be completed in the subject position. Our study extends this paradigm to investigate whether this expectation is also present in positions from which coreference would be ungrammatical. Principle C of the Binding Theory (Chomsky, 1981) states that a pronoun cannot c-command its antecedent. This constraint captures the impossibility of coreference in sentences like (2). If the active-coreference process is sensitive to Principle C, such sentences should not elicit the gender mismatch effect.

(2)        *He$_i$ was fed up when the boy$_i$ visited home.

58 subjects performed a self-paced reading task that independently manipulated the grammatical accessibility of the second subject NP (accessible, 3ab; inaccessible, 3cd) and the gender congruity of the second subject NP (gender match, 3ac; gender mismatch, 3bd). All experimental sentences also contained a third subject NP, in order to ensure that all pronouns could ultimately be associated with a sentence-internal antecedent. There was a significant interaction of gender mismatch and grammatical accessibility $F_1(1,57)=3.87$, $p < .05$ due to a slowdown effect at the mismatching name in the grammatically accessible conditions (3ab) that was not present in the grammatically inaccessible conditions (3cd), $F < 1$.

(3a)        Because last semester while **she** was taking classes full-time <u>Kathryn</u> was working two jobs to pay the bills, Russell never got to see her.

(3b)        Because last semester while **she** was taking classes full-time <u>Russell</u> was working two jobs to pay the bills, Erica promised to work part-time in the future.

(3c)        Because last semester **she** was taking classes full-time while <u>Kathryn</u> was working two jobs to pay the bills, Erica felt guilty.

(3d)        Because last semester **she** was taking classes full-time while <u>Russell</u> was working two jobs to pay the bills, Erica felt guilty.

In order to exclude the possibility that the gender mismatch effect at the second subject NP might simply reflect the need to establish a new discourse referent, a fifth condition was included, which had a name as the first subject, rather than a pronoun (3e). No slowdown was observed at the second NP in this condition, relative to the accessible gender match condition (3a), Fs < 1.

(3e)        Because last semester while Erica was taking classes full-time Russell was working two jobs to pay the bills, she promised to work part-time in the future.

Based on these results we conclude that the 'active search' strategy evidenced by the gender mismatch effect in (3a-b) is also sensitive to the syntactic constraints on binding/coreference described by Principle C (cf. Hirst & Brill, 1980).

In contrast to the relatively straightforward findings presented here, studies examining the other binding principles (Principles A and B) in cases of forwards anaphora have reported mixed evidence concerning the extent to which processing is sensitive to the syntactic constraints (e.g., Nicol & Swinney, 1989; Gordon & Hendrick, 1997; Badecker & Straub, 2002; Runner et al., 2002; Sturt, 2003). We suggest that, due to the fundamental differences in the time course of processing forwards vs. backwards anaphora, the two cases may need to be considered separately.

# Knowing what a novel word is not:
# Efficient processing of prenominal adjectives by young children

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Incremental speech processing leads to problems of indeterminacy as the listener must choose between alternative possible structures and meanings from moment to moment. On hearing *Susie fixed her back porch,* at the word *back* a listener might prematurely conclude that Susie had hired a chiropractor rather than a carpenter. Although adults can most often use lexical information to determine that a word is a prenominal adjective and not a noun, the indeterminacy problem is more prevalent for children because they constantly encounter words entirely unfamiliar to them. What happens when infants hear a novel prenominal adjective following the determiner *the*? Since in most cases the word following *the* will turn out to be a noun, the novel adjective could be mistaken for a potential object name, and such misinterpretation could disrupt efficient processing of the familiar target word following the prenominal adjective  When encountering a novel adjective, do 24-month-olds mistake it for a noun and then have to revise their interpretation?  Can prosodic information in the speech stream help children and adults resolve this kind of ambiguity on-line?  In two studies we investigated children's on-line responses to target nouns preceded by familiar and novel adjectives, while in a third study we looked at a parallel case for adult processing.

Expt.1 asked whether 24-month-olds (n=64) were disrupted in identification of target nouns preceded by adjectives. Children were tested in a looking-while-listening procedure in which they saw pairs of pictures while hearing sentences naming one of the pictures. Their eye movements were video-recorded and analyzed frame-by-frame to determine speed and accuracy of participants' looking responses as sentences unfolded.  There were three conditions within subjects:  No-adjective (*Where's the bunny?*), Familiar-adjective (*Where's the nice bunny?*), and Unfamiliar-adjective (*Where's the lace bunny?*). Between subjects we manipulated whether adjectives were accented or deaccented.  Although prenominal adjectives were potentially confusable with nouns, we found that children were equally efficient in identifying target nouns whether or not they  were preceded by an adjective, as long as the adjective was deaccented.  However, accurate responding to target nouns declined when prenominal adjectives were accented, especially when they were unfamiliar.

For baseline comparison and to address alternate explanations, Expt.2 explored the full cost of interpreting a prenominal word as a noun to processing efficiency.  24-month-olds (n=27) heard stimuli as in Expt.1, except that prenominal adjectives were replaced with familiar nouns (*Where's the duck apple?*). The prenominal nouns were matched to the adjectives used in Expt.1 in acoustic features, and none of them was pictured. In this case children's responding was significantly disrupted indicating that misinterpretation of even a short prenominal word can be problematic for efficient on-line comprehension.

Expt.3 tested adults' (n=24) ability to use only prosodic information to disambiguate homophones acting as either prenominal adjectives or final nouns (*The boy had a cold,* vs. *The boy had a cold nose*).  For this study we employed a gating procedure in which the target homophones were gated at perceptual markers within the word.  At each gate adults predicted how the sentence would continue or end, and thus whether the homophone was functioning as an adjective or a noun.  Adults demonstrated impressive accuracy in using prosody to identify ambiguous homophones as either nouns or adjectives as early as the onset of the vowel, and sometimes even earlier.

Together these three studies support the hypothesis that young language learners like adults can efficiently "listen through" deaccented prenominal adjectives to avoid misinterpretation with the use of prosodic cues.  When prosody indicates that a prenominal word is not the final word of an utterance and that another focused word is potentially still upcoming in the speech stream, even very young listeners demonstrate no disruption in the efficiency of their comprehension.  However, as prosodic and lexical cues in combination bias a listener increasingly towards a noun interpretation, misinterpreting a prenominal word as a noun can be disruptive to processing subsequent words in the speech stream.

# Suprasegmental Cues to Meaning in Child-Directed Speech

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Several studies have shown that preschool-aged children, unlike adults, systematically reject the inverse scope interpretation of scopally ambiguous sentences like (1) in favor of the surface scope interpretation (Musolino, Crain and Thornton 2000, Lidz and Musolino 2002).

(1) Every bunny didn't jump over the fence.
    (i) None of the bunnies jumped over the fence. ($\forall > \neg$ ; surface scope)
    (ii) Some of the bunnies jumped over the fence, some didn't. ($\neg > \forall$ ; inverse scope)

Given that researchers since Jackendoff (1972) mention a distinct suprasegmental or prosodic/intonational pattern for each scopal interpretation, one possible explanation for this result is that children have not yet learned how to interpret the suprasegmental cues to scope used by adults. (See Thornton and Wexler, 1999, for a review of studies suggesting that use of similar cues begins at age 5 or 6). The current study of child-directed speech undermines this line of reasoning. We found that parents did not provide any cues to scope (as judged by adult listeners) when reading to children. They did, in contrast, provide strong prosodic cues in a baseline condition of pronoun disambiguation. These results thus contribute to a growing literature on the role of particular features of child-directed speech in language acquisition.

We conducted two studies examining the use of suprasegmental cues in ambiguous sentences. In the first, parents were recorded reading stories to their children. Each story included two ambiguous sentences disambiguated by context: one scopally ambiguous sentence, and one with ambiguous pronoun reference, as in (2):

(2) Eddie rammed Mark into a haystack, and then <u>he</u> rammed <u>him</u> right out of the yard

While the default interpretation of (2) assigns Eddie as the referent of "he" and Mark as the referent of "him," speakers can reverse preferred the referent ordering by placing a pitch accent on "he" and/or "him" (Akmajian and Jackendoff 1970, Smyth 1994, Kameyama 1999). We predicted that if there is a suprasegmental correlate of scope, then parents should also make a systematic distinction between interpretations in the scope condition. As expected, for the pronoun sentences, 64% of parents produced a pitch accent on "he" and/or "him" when intending the reverse order, while 0% produced a pitch accent when intending the default order. However, for the scope condition, no discernable pattern was observed.

In the second study, participants listened to ambiguous sentences excised from the recorded stories, and chose which of two possible meanings the speaker intended. For the pronoun sentences, there was a significant effect of intended interpretation (t = 12.43, P < .0001): participants judged sentences produced in the default context to have the default interpretation 89% of the time, but judged sentences produced in the reverse ordering context to have the default interpretation only 44% of the time. Furthermore, sentences actually produced with at least one accented pronoun were correctly judged to have the reversed reading 81% of the time. In contrast, there was no effect of intended interpretation for scopally ambiguous sentences: participants judged them as having inverse scope 59% of the time, independent of the context of utterance.

These experiments demonstrate that while parents use suprasegmental cues to disambiguate sentences with ambiguous pronoun reference in child-directed speech, they do not disambiguate scopally ambiguous sentences. Thus, children's failure to compute inverse scope must not be due to their inattention to suprasegmental cues to meaning.

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# The On-Line Processing of Contrastive Stress in Pronoun Referent Resolution

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Two on-line experiments addressed the question of *when* prosodic cues are processed during pronoun referent resolution. Three-sentence auditory discourses were used such as the following (relevant critical words are bolded):

"Excited by their costumes for the Halloween play, some of the third graders started rough-housing back stage. An **alien** pinched an **acrobat** just behind the curtain and a ghost pinched **her** near the backdrop. Soon the whole audience heard the giggling back stage."

For each of the 48 experimental discourses, two versions of the second sentence were recorded: one with a canonical pitch accent contour, and another with contrastive stress over the pronoun. Acoustic analysis of the materials validated that the accented pronouns were higher in pitch than the unaccented ones.

An off-line experiment validated the effect of contrastive stress over the pronoun. When no accent appeared on the pronoun, participants chose the second potential referent with parallel grammatical function 85% of the time – a finding reported in previous studies, e.g., Chambers & Smyth (1998). With contrastive stress, participants selected the first NP 80% of the time.

For the on-line experiments, Cross-Modal Lexical Priming was used to assess the activation of the two potential referents. In this paradigm, participants listen to discourses over headphones and at the same time make lexical decisions about letter strings that appear on a computer screen at critical points (here, at the pronoun). Facilitation in reaction time, or priming, for words that are semantic associates of a character in the story in comparison to a control word matched for number of letters, frequency and a priori reaction time is an indication that the story character was activated at the moment the probe appeared on the screen. In the example above, the semantic associate of alien was *space*, and the control word was *union*. The Cross Model Lexical Priming technique was used to examine (re)activation of potential antecedent referents (story characters) at the pronoun under different stress conditions. This within-subjects design involved three factors: Prosody (unstressed x stressed), Probe position (800 ms before the pronoun x the offset of the pronoun) and Probe type (related x control). The position before the pronoun served as a baseline to ensure that significant effects were not the result of residual priming. Experiment 1 used probes associated with the first potential referent (alien) and Experiment 2 used probes associated with the second (acrobat). Forty-eight subjects participated in each experiment.

As shown in Table 1, the on-line results mirrored those of the off-line interpretations. Significant priming was observed at the pronoun for the first NP when contrastive stress appeared on the pronoun. However, there was no significant priming for the second NP at the pronoun with contrastive stress. In contrast, when there was no contrastive stress, there was a significant priming effect at the pronoun only for the second NP. Together, the results indicate that when contrastive stress appears on the pronoun, the prosodic information is used immediately to influence the listener's interpretation of the pronoun's referent.

**Table 1.**

*Difference of reaction times (ms) to related versus control probes for Experiments 1 and 2.*

|  | Related - Control Reaction Times (ms) | |
|---|:---:|:---:|
| First NP | Before Pronoun | At Pronoun |
| Stressed Pronoun | 15 | 37* |
| Unstressed Pronoun | 4 | 20 |
|  |  |  |
| Second NP |  |  |
| Stressed Pronoun | 38* | 6 |
| Unstressed Pronoun | 6 | 33* |

\* p < .05 in a paired comparison.

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# Prosodic Boundaries in the Comprehension and Production of Wh-questions in Tokyo Japanese

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Deguchi & Kitagawa (2002) and Ishihara (2002) both proposed a grammatical 1-to-1 relation between the domain of pitch compression and the scope of the wh-phrase in scopally ambiguous Japanese wh-questions, as in (1) ('Obligatory Pairing Hypothesis' (OPH)). Hirotani (2003) proposed, instead, a processing account where prosodic boundaries influence listeners' interpretation of the wh-phrase. Specifically she argued that the processor prefers the wh-operator and its binder to be in the same prosodic unit ('Scope Prosody Correspondence' (SPC)). However, her experiment did not explicitly manipulate pitch compression. The current paper presents listening and production studies of Japanese wh-questions.

Study 1 investigated the effect of prosodic boundaries (Major Phrase (MaP)) and pitch compression on the interpretation of wh-questions, as in (1). When a MaP appeared after the embedded Q-marker (Emb-Q) like (1a, b), a strong bias for the embedded scope interpretation was obtained for the wh-phrase. However, without such a boundary (1c, d), both embedded and matrix interpretations were available. Moreover, an effect of pitch compression was found only when there was no MaP after the Emb-Q (1c, d), suggesting that pitch compression is used only in the absence of a prosodic boundary. These results favor SPC over OPH.

(1)      [$_{CP}$[$_{IP}$John-wa      [$_{CP}$Mary-ga      **nani**-o      katta-**ka**]      kikimasita]-**ka**]?
         John-TOP      Mary-NOM   what-ACCbought-Q      asked-Q

'Did John ask what Mary bought?' (Embedded scope) or 'What did John ask whether Mary bought?' (Matrix scope)
[Parentheses=MaP; underline=pitch compression; %=percentage of embedded scope interpretation responses]

| | | | | | |
|---|---|---|---|---|---|
| a. | (John-wa | Mary-ga) | (**nani**-o | katta-**ka**) | (kikimasita-**ka**)?      86% |
| b. | (John-wa | Mary-ga) | (**nani**-o | <u>katta-**ka**</u>) | (kikimasita-**ka**)?      85% |
| c. | (John-wa | Mary-ga) | (**nani**-o | katta-**ka** | kikimasita-**ka**)?      63% |
| d. | (John-wa | Mary-ga) | (**nani**-o | <u>katta-**ka**</u> | <u>kikimasita-**ka**</u>)?      54% |

Study 2 examined the ease of comprehending unambiguous indirect wh-questions, as in (2). It indicated that SPC is relevant whenever scope-relative items are processed, regardless of scope ambiguity. Listeners judged the prosodic phrasings which grouped the wh-phrase and the Emb-Q together (2a, b) easier than other prosodic phrasings (2c, d). Control sentences without wh-phrases, which were length and verb-matched to the indirect wh-question conditions, showed no significant differences.

(2)      [$_{IP}$John-wa      [$_{CP}$Mary-ga      **nani**/neko-o      katta-**ka**]      kikimasita]
         John-TOP      Mary-NOM   what/cat-ACC      bought-Q      asked
         'John asked what Mary bought / John asked whether Mary bought a cat'

Ratings  1: Easiest, 7: Most difficult
    Wh / Control

| | | | | | | |
|---|---|---|---|---|---|---|
| a. | (John-wa | Mary-ga) | (**nani**/neko-o | katta-**ka**) | (kikimasita) | 3.96 / 4.47 |
| b. | (John-wa | Mary-ga) | (**nani**/neko-o | katta-**ka** | kikimasita) | 3.91 / 4.41 |
| c. | (John-wa | Mary-ga) | (**nani**/neko-o) | (katta-**ka**) | (kikimasita) | 4.20 / 4.31 |
| d. | (John-wa | Mary-ga) | (**nani**/neko-o) | (katta-**ka** | kikimasita) | 4.23 / 4.43 |

Study 3 investigated the prosodic phrasings Tokyo speakers produce for unambiguous wh-questions with different scope assignments (3a, b). The sentence types were manipulated in blocks. In the block where speakers could compare (3a) and (3b), a MaP was systematically inserted after the Emb-Q in (3a) but not in (3b). However, in the block which contained only one type of questions in (3a, b), a MaP after the Emb-Q was optional for both (3a, b). The latter result is not consistent with OPH or the proposal that a MaP after the Emb-Q is a default prosody (Kitagawa & Fodor 2002). However, the result can be explained by a conflict between two grammatical length constraints (BinMin & BinMax (Selkirk 2000)).

(3)      a. [$_{CP}$[$_{IP}$John-wa      [$_{CP}$Mary-ga      **nani**-o      katta-**ka**]      kiita]-**nokai**]?(Embedded scope)
            John-TOP      Mary-NOM   what-ACC      bought-Q      asked-Q[-**wh**]
         b. [$_{CP}$[$_{IP}$John-wa      [$_{CP}$Mary-ga      **nani**-o      katta-**ka**]      kiita]-**ndai**]?(Matrix scope)
            John-TOP      Mary-NOM   what-ACCbought-Q      asked-Q[+**wh**]

The present studies show that the prosodic phrasing speakers produce for wh-questions is not the same as the prosodic phrasing listeners prefer: In production, a MaP boundary may be placed after the Emb-Q in either an embedded or matrix question; in comprehension a boundary after the Emb-Q biases listeners towards an embedded question analysis. This mismatch can be explained by assuming that speakers use syntax-phonology interface constraints (Selkirk 2000; Sugahara 2003) while listeners use a processing constraint like SPC in addition to the grammatical constraints.

# Prosodic phrasing in DO/SC and Closure sentences

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Two temporary ambiguities (1-2) arise because an NP following a verb can be analyzed either as the verb's object or as the subject of a following clause. While both trained and untrained speakers reliably use prosody to disambiguate DO/NO sentences (Speer et al. 1996, Schafer et al. 2001), there is little evidence that speakers prosodically disambiguate DO/SC sentences (Stirling & Wales 1996, Watt & Murray 1996, Anderson 2002). Anderson's (2002) study of DO/SC sentences proposed that they are more difficult to disambiguate than DO/NO sentences because their syntactic structure does not map neatly onto prosodic structure. Specifically, the two analyses of DO/SC sentences differ only in whether a clause begins after the verb, while DO/NO sentences differ also in whether a clause ends after the verb, and English prosodic boundaries tend to coincide with the ends of syntactic constituents (Selkirk 2000). The present new production study supports Anderson's account, showing that speakers who produce clear disambiguating prosodic boundaries in DO/NO sentences do not prosodically disambiguate DO/SC sentences.

Sixteen speakers each recorded 20 DO/NO sentences and 16 DO/SC sentences. An additional within-items factor was the subject NP's length in DO/SC sentences (3). Speakers read each sentence silently, answered a written comprehension question about it, then read the sentence aloud.

Speakers nearly always prosodically disambiguated the DO/NO sentences: In 99% of DO sentences (1a) they produced the largest prosodic boundary after the object-NP, while 96% of NO sentences (1b) had the largest prosodic boundary after the verb. That is, prosodic boundaries occurred at the ends of syntactic clauses. The same speakers were less consistent in producing DO/SC sentences. In 83% of these DO sentences (2a), they produced the largest prosodic boundary after the object-NP, but they used this same prosodic pattern in 23% of SC sentences (2b), and produced 56% of SC sentences with no prosodic boundary after either the verb or the following NP. While Anderson's (2002) perception study showed that the only prosodic contour that allows listeners to correctly identify SC sentences has a major prosodic boundary following the verb, our speakers produced this prosody in only 18% of SC tokens; significantly more often than in DO sentences (p<0.01) but significantly less often than they produced no boundaries in the ambiguous region (p<0.01). Further, the manipulation of subject length affected SC productions, with a long subject making the helpful post-verbal boundary even less likely (p<0.05). Speakers were therefore responsive to syntactic and length differences in DO/SC sentences, but they rarely produced the one prosody that would be most helpful to listeners.

Our results indicate that talkers frequently indicate the end of a syntactic clause with a prosodic boundary but do not use prosody to mark a clause's beginning, in line with Selkirk (2000). This result is crucial to the difference between the easily disambiguated DO/NO (closure) sentences and the more difficult DO/SC sentences. Clearly, the syntax plays a major role in constraining the prosodic phrasing of a sentence.

**Examples**

(1) Direct Object/No Object (DO/NO) or Late/Early Closure Sentences
a.      [While the skipper sailed the schooner] [the dinghy began to leak.]    (DO)
b.      [While the skipper sailed] [the schooner began to leak.]    (NO)
(2) Direct Object/Sentence Complement (DO/SC) Sentences
a.      [Tom noticed his roommate during the lecture.]    (DO)
b.      [Tom noticed [his roommate was looking tired.]]    (SC)
(3) Subject Length Manipulation
      {Tom/Thomas Morgencrantz} noticed…

# Processing pitch accents: Interpreting H* and L+H*

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We investigated whether differences in the acoustic properties of sentence level accents can affect how a listener interprets referents with respect to their discourse model. Specifically, we examined the interpretation of "presentational" (H*) and "contrastive" (L+H*) accents, which have been proposed by Pierrehumbert & Hirschberg (1990) and others (see Ladd, 1996 for a review) to have different acoustic and semantic properties. There has been a great deal of debate as to whether these accents are interpreted differently by listeners, and empirical studies investigating this question have produced mixed results (Ladd, 1983; Bartels & Kingston, 1994; Krhamer & Swerts, 2001).

We investigated this question in two experiments using the visual world paradigm. In Experiment 1, the goal was to determine whether L+H* is associated with elements in a contrast set and whether H* is associated with elements that are new to the discourse. Participants were presented with a 5x5 grid on a computer. The grid contained eight objects: two cohorts whose initial segments were identical (e.g. a camel and a candle), an item that was a member of a category containing one of the cohorts (e.g. a dog that, like the camel, is an animal), an unrelated item (windmill), and four geometrical shapes. Participants were first instructed to click on a group of objects (1a). Then they were instructed to move one of the four objects to a different location (1b). We manipulated two factors: 1) the discourse status of the moved object and 2) the accent that occurred on it.

The context sentence in (1a) created a discourse context such that one of the cohorts (camel) was indirectly mentioned, making it given and creating a situation where it could potentially be contrasted with the other animal. In the same context, the other cohort (candle) was new and not in focus. Thus, more looks to the candle are predicted in the H* condition than the LH* condition and more looks to the camel are predicted in the LH* condition than the H* condition. Participant eye gazes were consistent with these predictions.

In Experiment 2, we demonstrate that when the category contrast set that was established in Experiment 1 is absent, listener preferences change. The same auditory stimuli that were used in Experiment 1 were used in Experiment 2, but the objects in the visual display differed so that the cohort referred to in (1a) (i.e. camel) was the only member of the category. In this context, L+H* did not bias listeners towards looking at the given cohort (camel), but instead, biased listeners towards looking at the new cohort (candle), suggesting that listeners took the entire display of objects as members of the relevant contrast set since another contrast set was not explicitly provided.

The results from these studies suggest that H* and L+H* are interpreted differently by listeners and that this interpretation occurs rapidly on-line.

**Examples:**

(1)      a. Click on the animals.
           b. Now, move the CAMEL/CANDLE above the triangle.
                    H*/ L+H*

# Grammatical repetition and garden-path effects
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A common intuition suggests that people have less difficulty processing sentences like (1) if they have recently processed similar sentences, but little hard evidence supports this intuition.

(1)  The defendant examined by the lawyer turned out to be unreliable.

In fact, there is little general evidence for any effects of grammatical repetition on comprehension. Early studies suggested that presentation of many sentences of a particular grammatical form affected processing of sentences with the same form (Mehler & Carey, 1967; Carey, Bever, & Mehler, 1970; but see Dooling, 1974). Some studies show facilitation of a second conjunct if it is grammatically or semantically similar to the first (Frazier, Munn, & Clifton, 2000; Frazier, Taft, Roeper, Clifton, & Ehrlich, 1984). Levelt and Kelter (1982) found that people preferred answers that were grammatically congruent with their questions. Snyder (2000) found that repeated exposure to some but not all types of "marginal" sentences increased their acceptability. Cuetos, Mitchell, and Corley (1996) found that children preferred one interpretation of an ambiguous relative clause following extensive exposure. Trueswell and Kim (1998) found that comprehending an ambiguous sentence was affected by the preferred analysis of a subliminally presented verb. None of these involve normal comprehension of pairs of sentences related in grammatical form.

Thus, we conducted two eye-movement monitoring experiments in which participants read prime-target sentence pairs that maintained or changed grammatical form. Sentences like (1a) and (1b) would be followed by either (2a) or (2b)

(1a)  The defendant/ examined/ by the lawyer/ turned out to be unreliable.  (Reduced)
(1b)  The defendant/ examined/ the bloody glove/ during the recess.  (Main Verb)
(2a)  The doctor/ examined/ by the specialist/ had a large mole.  (Reduced)
(2b)  The doctor/ examined/ the patient/ who had a large mole.  (Main Verb)

"/" marks indicate where the sentences were segmented for analysis. The first region is the "verb" region, the second region is the "NP/PP" region. Sentences were rotated across lists to counterbalance for length and frequency, and so that every target sentence also served as a prime sentence. In Experiment 2, the initial verb/past participle changed between the prime and target sentence; but otherwise the design was the same. Experiment 1 showed that potentially ambiguous reduced-relative sentences were processed more easily if they were immediately preceded by another sentence of the same form using the same ambiguous verb (see Table 1). Experiment 2 showed no comparable effects when the sentence form was repeated but the verb was not (See Table 2). The early effects of grammatical repetition suggest that people initially consider both analyses, in contrast to many traditional theories of parsing. Verb-specificity effects suggest that grammatical information is largely localized to individual verbs during comprehension.

# On Structure and Frequency: Case in PP and VP

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How can frequency information be integrated into structure-based models of the human parser? We will adress this question with regard to the processing of case. Prior psycholinguistic research on case ambiguities has only considered case assigned by verbs (subject-object and object-object ambiguities). In this presentation, we will consider the processing of case in both verbal and prepositional contexts in German. We have conducted several experiments using the method of speeded grammaticality judgments comparing prepositional to verbal case as well as prepositional case in different constructions. Examples of verbal and prepositional case ambiguities are given in (1) and (2).

(1) a.       Ich habe Maria/ein paar Studenten geholfen-DAT.
           I   have M.    a   pair  students  helped.
           "I helped Maria/a couple of students"

    b.       Ich habe Maria/ein paar Studenten unterstützt-ACC.
           I   have M.     a   pair students    supported
           "I supported Maria/a couple of students."

(2) a.       Ich habe an-DAT Maria/ein paar Studenten herumkritisiert.
           I   have to       M.    a   pair  students   criticised.
           "I criticised Maria/a couple of students"

    b.       Ich habe an-ACC Maria/ein paar Studenten gedacht.
           I   have to       M.    a   pair students    thought
           "I thought of Maria/a couple of students."

For processing purposes, there are two major linguistic differences between verbal and prepositional case: (i) When assigned by verbs, dative case is marked; when assigned by prepositions, there is no markedness difference between dative and accusative case. (ii) Prepositions can be ambiguous with respect to their case, verbs cannot.

We selected six case-ambiguous prepositions and determined in a corpus analysis how frequently each preposition occurs with which case. In three experimental studies, sentences like (1) and (2) were investigated together with unambiguous control sentences. The following differences between prepositional and verbal case appeared:

(i) There was a strong accusative preference for verbs (replicating earlier results by Hopf et al. 1998), but no clear-cut preference with prepositions.

(ii) For verbal but not for prepositional case, the strength of the resulting garden-path effect was strongly dependent on the lexical make-up of the case-ambiguous NP ('Maria' vs. 'ein paar Studenten' in (1) and (2)).

For the prepositional sentences, we computed the correlations between our experimental results and the prepositions' case preferences as determined in the prior corpus analysis. There were no significant correlations between corpus counts and garden-path strength (unambiguous minus ambiguous sentences), but substantial correlations between corpus counts and case odds (accusative minus dative sentences), for both unambiguous and ambiguous sentences. Note that this is unexpected under standard frequency-based parsing models (Jurafski, 1996; McDonald, 1994).

In a further study, sentences like (2) were compared to sentences like (3) where the crucial PP was topicalized.

(3) a.       An-DAT ein paar Studenten habe ich herumkritisiert.
           to         a   pair  students  have I   criticised.
           "I criticised a couple of students"

    b.       An-ACC ein paar Studenten habe ich gedacht.
           to         a   pair  students  have I   thought
           "I thought of a couple of students."

Besides confirming the results of the prior studies, this study showed a substantial processing disadvantage for both ambiguous and unambiguous topicalized accusative PPs but not for dative PPs. Furthermore, the strength of this disadvantage (topicalized minus non-topicalized sentences) correlated with the case preferences found in the corpus counts.

We will argue that this pattern of results can only be explained by a model integrating both structural and frequency-based factors. We will present a detailed model of this kind showing (i) how the processing differences between verbal and prepositional case follow from their different markedness properties within the grammar, and (ii) how the particular frequency effects with prepositions (corpus counts do not correlate with garden-path strength but correlate with case odds and topicalization disadvantage) follow if we assume that the memory representations set up during parsing are liable to decay and reinstantiation in proportion to corpus frequencies.

# RC Attachment in Dutch: On-Line Reading Preferences Correspond to Corpus Frequencies When Lexical Variables Are Taken into Account

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An intriguing question in psycholinguistics is whether sentence comprehension and sentence production are driven by independent cognitive processes. Two attachment ambiguity studies are often cited as evidence against the position that sentence comprehension corresponds to sentence production (and against experience-based models of sentence processing in particular). First, Gibson and Schütze (1999) studied the ambiguous NP conjunction to three possible host sites illustrated in (1). They found that high conjunctions were easier to read than middle conjunctions even though previous corpus counts had indicated that middle conjunctions are more frequent than high conjunctions. Second, Mitchell and Brysbaert (1998) analyzed a Dutch corpus for sentences like (2), and observed that low-attaching relative clauses were twice as frequent as high-attaching relative clauses, despite the finding that in Dutch reading studies high attachment is preferred (e.g., Desmet, De Baecke, & Brysbaert, 2002).

In relation to the first study, Desmet & Gibson (2003) argued that the contradiction was due to a lexical variable in the items, namely the use of the pronoun "one" in the conjoined NPs instead of full NPs. When this variable was taken into account the on-line reading preference was in line with the corpus findings. In the present study we investigated whether another lexical variable could also explain the contradiction in the RC attachment ambiguity presented by Mitchell and Brysbaert (1998).

First, we collected a Dutch corpus consisting of six different types of text register. This corpus study revealed that the animacy and concreteness of the NP1 could possibly explain the contradiction between corpus frequencies and reading time experiments. Sentences with a concrete inanimate NP1, an abstract animate NP1 or an abstract inanimate NP1 – which made up the larger part of the corpus - revealed an NP2 attachment bias. However, all previous Dutch reading studies predominantly used another type of sentences (sentences with an animate concrete NP1). Interestingly, these sentences where highly infrequent and revealed an NP1 attachment bias in the corpus.

Next, we performed an eye-tracking experiment to investigate whether this interaction could also be observed in on-line reading times. We constructed sentences that – as in the corpus - had a concrete animate NP1, a concrete inanimate NP1, an abstract animate NP1, or an abstract inanimate NP1 and of which the RC attached to NP1 or to NP2 (see 3). The results of this experiment confirmed that at the disambiguating region the type of NP1 interacted significantly with the attachment preference in the direction predicted by the corpus.

We conclude that lexical factors need to be taken into account to solve the contradiction between sentence production and sentence comprehension for the constructions in (1) and (2). We discuss the implications for both lexicalist and structuralist experience-based accounts of sentence processing (e.g., Jurafsky, 1996; Mitchell, Cuetos, Corley, & Brysbaert, 1995; Sturt, Costa, Lombardo, & Frasconi, 2003; Tabor, Juliano, Tanenhaus, 1997) and for alternative discourse-based explanations (e.g., Bock, 1986; Hemforth, Konieczny, & Scheepers, 2000; McRae, Ferretti, & Amyote, 1997).

## Examples

(1)     The salesman ignored a customer with a baby with a dirty face and ...
        a. a wet diaper (low conjunction)
        b. one with a wet diaper (middle conjunction)
        c. one with a baby with a wet diaper (high conjunction)

(2)     Someone shot the servant of the actress who …
        a. was on the balcony with her arm in a cast (low attachment)
        b. was on the balcony with his arm in a cast (middle attachment)

(3a)    The people respect the decisions of the president that (guarantee/guarantees) there will be no war.
(3b)    The people respect the documents of the president that (guarantee/guarantees) there will be no war.
(3c)    The people respect the organizations of the president that (guarantee/guarantees) there will be no war.
(3d)    The people respect the advisors of the president that (guarantee/guarantees) there will be no war.

# Construction frequency and sentence comprehension
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This paper presents results from two self-paced moving-window experiments that provide evidence that the human sentence processing mechanism is sensitive to construction frequencies independent of other factors. Experiment 1 compared the sentential-subject construction to a control condition in which the same clause is the complement of noun in subject position, as in (1). Earlier research has demonstrated that ambiguity with a demonstrative interpretation of the word "that" in sentence-initial position results in difficulty in processing the initial component of the sentential-subject construction (Tabor,Juliano&Tanenhaus,1997). In order to minimize this ambiguity effect, we presented the materials region-by-region, such that the first region in (1a) consisted of the word "that" followed by the embedded definite NP "the lawyer". The results of the experiment were as follows: (a) the sentential-subject condition was significantly slower than the NP-subject condition in the initial region "that the lawyer"; (b) there were no differences between the conditions in the following two regions ("was misleading", "the jurors") (Fs<1); (c) the sentential-subject condition was again significantly slower during the main verb of the sentence "angered"; (d) there were no differences in the remaining region (Fs<1).

These results have important ramifications for theories of sentence comprehension. The crucial observation is that there is difficulty in processing a low-frequency construction (the sentential-subject construction) during its onset and, critically, **during its offset** (at the main verb of the sentence). These results cannot be explained by lexical-frequency differences, because the words are identical through the offset of the construction. Furthermore, spillover explanations are unlikely, because there are no RT differences in the immediately preceding region. Other proposed factors from the literature such as discourse context, plausibility (Tanenhaus&Trueswell,1995; Gibson&Pearlmutter,1998), entropy-reduction (Hale,2003) or resource theories (eg., Gibson,2000) also do not explain these findings. For example, Gibson's resource theory makes no predictions about the contrast because integration and storage constraints are matched. We therefore hypothesize that human sentence processing mechanism is sensitive to construction frequency (Mitchell etal,1995; Jurafsky,1996; Tabor_etal,1997; Tabor&Hutchins,2003; Tabor_etal,2003) as in Goldberg(1995). The relevant low-frequency construction in (1) consists of a clause headed by the complementizer "that" in subject position.

In Experiment 2, we investigated the genitive-extracted relative-clause construction, as in (2). (2a) is a subject-extracted version of this construction, whereas (2b) is object-extracted. We compared these conditions to ones without the genitive pronominal "whose" in the extraction, but which contained the same NPs in the same thematic relations (including an embedded genitive-NP). The critical result of this experiment was a main effect of genitive-extraction being slower than non-genitive-extraction (along with a main effect of subject-extraction being faster than object-extractions – replicating much previous work – and no interaction). Crucially, both effects occur at the offset of the construction, at the main verb of the sentence. As with Experiment 1, these effects cannot be explained by current models.

We will discuss these results in the context of two theoretical ideas that are core to many models – probabilistic grammar and locality – and we will present computational models of the results which extend current theories.

**Examples:**

Experiment 1 materials (region-by-region presentation; regions are separated by "|"; critical regions in bold; 24 items, 32 participants)
(1) a. Sentential subject
   **That the lawyer** | was misleading | the jurors | **angered** | the judge.
   b. NP subject, clausal complement of a noun
   The evidence | **that the lawyer** | was misleading | the jurors | **angered** | the judge.

Experiment 2 materials (word-by-word presentation; critical region in bold; 24 items, 48 participants)
(2) a. subject-extracted, genitive
   The hairdresser, whose daughter insulted the beautician's sister, **got in** an accident.
   b. object-extracted, genitive
   The beautician, whose sister the hairdresser's daughter insulted, **got in** an accident.
   c. subject-extracted, non-genitive
   The hairdresser's daughter, who insulted the beautician's sister, **got in** an accident.
   d. object-extracted, non-genitive
   The beautician's sister, who the hairdresser's daughter insulted, **got in** an accident.

# CUNY CONFERENCE

# Saturday, March 27

# Poster Session III

# Rapid Syntactic Diagnosis: Separating Effects of Grammaticality and Expectancy

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A number of ERP findings suggest that some syntactic violations may be detected within ~150-200ms after a critical word, as shown in the *(early) left anterior negativity* (ELAN) elicited by contrasts like (1-2). Such findings raise the puzzle of how it is possible to diagnose the well-formedness of an incoming word so quickly. Some accounts of the speed of these responses focus on the category-level *ungrammaticality* of examples like (2) (Neville et al., 1991; Friederici, 2001). Another recent account focuses on *expectancy* (Urban et al., 2003), due to the fact that the ELAN is typically observed in contexts where one category is locally predicted by the preceding word (e.g., the possessor *Max's* predicts an upcoming noun), but a different category is encountered. Urban et al. (2003) motivate this account by arguing that early negativities are reduced when expectancy is modulated but grammaticality is held constant. Here we present results from an ERP study of English that independently varies grammaticality and expectancy, and shows that the account of Urban et al. (2003) is too broad, and propose a more fine-grained account of how rapid diagnosis is performed.

(1)        The woman admired Max's drawing <u>of</u> the flowers.
(2)        *The woman admired Max's <u>of</u> drawing the flowers.

The examples in (3-4) are similar to (1-2) in the respect that they present a syntactic violation marked by the word *of*. An adverbial phrase excludes the possibility of an NP-internal attachment for the final PP. However, (3-4) are different from (1-2) in the respect that the final PP in (4) does not violate any prediction, since all arguments of the verb have already been encountered. If the early anterior negativity is specifically associated with violations marked by high frequency function morphemes, such as English *of* or the German participle prefix *ge-*, then it should also be elicited by violations like (4). However, if the early negativity is associated with predictive mechanisms, then it should not be elicited in (4).

(3)        The witness accused the unknowing suspect falsely <u>of</u> the vandalism.
(4)        *The witness identified the unknowing suspect falsely <u>of</u> the lineup.

If the early anterior negativity reflects mismatch with a predicted category, independent of grammaticality, then it should also be elicited when an incoming word mismatches the predicted noun, but is nevertheless grammatical, as at the adverb *very* in (5), relative to the control in (6).

(5)        The teacher praised Max's <u>very</u> enthusiastic sister.
(6)        The teacher praised Max <u>very</u> enthusiastically.

Our ERP study recorded brain responses while participants read sentences like (1-6) in an RSVP paradigm (500ms SOA; n=24; 30 electrodes; 32 items per condition; Latin Square design; 128 targets interspersed with 288 filler items). Results at the word *of* in (2 vs. 1) replicated the finding of an early anterior negativity, followed by a later posterior positivity (P600). In contrast, no early negativity was elicited at the word *of* in (4 vs. 3) or at the word *very* in (5 vs. 6). The violation in (4) elicited a P600 response. The grammatical-but-unexpected continuation in (5) elicited an N400 response. These findings suggest that an account of the ELAN should make reference to the combination of grammaticality and predictive mechanisms. The ELAN cannot simply reflect a mismatch to a predicted category, as suggested by Urban et al. (2003). We suggest that ELAN is elicited specifically when a word appears in a context where no local licenser is available (e.g., when the preposition *of* does not follow a noun).

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# Depth of Wh-Embedding: Experimental Evidence for the Convergence of On-line Processing and the Economy of Representation

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We will adress the question as to how feature-checking by the HSPM works when the checkable feature is itself embedded in another phrase, as in sentences like "A picture of whom do you think t is on the table" or "Whose picture do you think t is on the table". Here, "whose" in the specifier of DP is less deeply embedded than "whom" in complement position. In contrast to Chomsky (1995) who claims that depth of embedding of features does not cause additional processing load, we will propose the Deep-Checking Principle: A minimal number of nodes between Checking Feature and Checked Feature is optimal.

If the Deep-Checking Principle is psychologically real, then it should be reflected in on-line parsing. Several speeded-grammaticality judgments were obtained for embedded and non-embedded wh-phrases in both matrix and subordinate clauses in German. We found that both depth of embedding of wh-features as well the position of the wh-word (left-edge vs. non-left edge) affected processing load. Whereas the former finding follows from the Deep-Checking Principle, the latter finding follows from the assumption that features are checked without delay.

We conclude that psycholinguistic evidence indicates that Deep-checking, and Feature-checking in general, should be represented by an economy metric both in the grammar and in realtime processing. Furthermore, we will argue that the formulation of feature-checking as an operation of the grammar cannot be successful if it is not informed by how feature-checking proceeds in real-time.

# Syntactic templates and linking mechanisms:
# A new approach to grammatical function asymmetries

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Grammatical function asymmetries in sentence comprehension are typically viewed as arising from a reconstruction to the canonical order. From this perspective, the well-known increases in processing cost for object-initial sentences are engendered by the fact that the object cannot be interpreted in the position in which it is encountered. These assumptions hold even for grammatical theories without movement, e.g. HPSG, in which interpretation of a fronted object also presupposes an association with a base position. They are also implicit in processing models such as that of Gibson (1998), in which the inverted order results in enhanced prediction and integration cost.

We present an alternative interpretation of these asymmetries based on the assumptions of Role and Reference Grammar (Van Valin & LaPolla, 1997). In this theory, syntactic structures are represented as templates and argument interpretation is accomplished by a system of linking rules that associate an argument with a generalised semantic role (GSR; Actor/Undergoer). The interpretation of an argument is therefore logically independent of its syntactic position, although both may coincide (cf. English). Languages differ in terms of their template inventories (i.e. with regard to permissible phrase structures) and their linking systems. Whereas English, for example, relies primarily on linear order for argument linking, case-marking languages such as German allow for a direct linking between morphological case and GSRs. Psycholinguistic evidence supports this distinction between different language types (Schlesewsky & Bornkessel, *in press*).

Decoupling phrase structure (templates) and interpretation (linking) accounts for a number of findings in the comprehension literature. It derives, for example, the hitherto elusive differences between English and German in the activation of Broca's area during the processing of object-initial sentences. Increased activation in this region obtains in English object relatives (e.g. Caplan et al., 2001). In German, however, it is only measurable in clause-medial argument order variations (Röder et al., 2002) but not in wh-questions or relative clauses (Fiebach et al., 2001). From a reconstruction-based perspective, these findings defy explanation because the successful interpretation of all of these permutation types crucially hinges on some sort of reconstruction. In terms of linking properties that are independent of phrase structure, by contrast, the cross-linguistic differences are naturally accounted for. English consistently links on the basis of linear order. Therefore, all object-initial structures require an "inverse linking" and thus engender additional processing (linking) costs. In German, by contrast, linking is accomplished via morphological case marking and construction-specific properties. While the clause-medial region in unmarked German sentences directly reflects the argument hierarchy in the semantic representation of the verb, the clause-initial region can host any single constituent (argument or adjunct). On-line linking processes are sensitive to this distinction and inverse linking is, therefore, only costly in clause-medial contexts.

We will show that, beyond these recent findings, our approach can also account for the classical psycholinguistic results in the domain of grammatical function asymmetries (e.g. Frazier & Flores d'Arcais, 1989; Gibson, 1998; cf. also Hopf et al., 1998).

# Discourse Processing and Prosodic Boundaries

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There are likely to be differences between processing at the sentence level and at the discourse level. Frazier & Clifton (under rev.) propose that salience is determined differently in discourse, with elements of the main assertion (typically constituents high in the tree) becoming more important than recent constituents. In support of this, F&C found more matrix interpretations for VP Ellipsis sentences presented as two written sentences (1b) instead of one (1a). But where does sentence processing leave off and discourse processing begin in auditory processing? A simple hypothesis would be that the L-L% prosodic boundary, which is typically (though not exclusively) associated with the ends of utterances (Beckman & Elam 1997), would encourage discourse processing in auditory studies compared to other prosodic boundaries. Two auditory questionnaires showed that this hypothesis is too simple, that pitch accents actually had more effect on processing, and that additional cues to sentence-finality were necessary to indicate discourse status.

Experiment 1 presented VP Ellipsis sentences in the four prosodic conditions in (2). One manipulation was the placement of pitch accents on the remnant NP (*Joe*) and either the matrix subject (*Lucy*) or the embedded subject (*Kathy*) of the first clause. VP Ellipsis is known to be affected by the parallelism or similarity of elements in the different clauses (Mauner, Tanenhaus, & Carlson 1995; Frazier et al. 1984). We predicted that similarity between pairs of NPs in being accented (or focused) would encourage interpretations placing them in corresponding positions (Carlson 2001, 2002), so the *Lucy-Joe* accent pattern would encourage matrix interpretations (with Joe also mentioning something). The other factor was the type of prosodic boundary: L-H%, the 'continuation rise' associated with continuing discourse and phrases dependent on subsequent utterances for interpretation; vs. L-L%, which is used utterance-finally and when a phrase can stand alone (Pierrehumbert & Hirschberg 1990). The L-L% contour was predicted to encourage matrix interpretations. (Note that sentences can begin with *and*, though it's not favored in formal written English.) In fact, while accent position significantly affected interpretation, with the matrix subject accent producing more matrix responses (p's<.05), there was no discernible effect of the boundary difference. (An additional experiment using IPh vs. ip boundaries found that also ineffective.)

In Experiment 2, we bolstered the prosodic boundary difference by also deleting the conjunction in the L-L% conditions (3). There were significant effects of accent position (p's<.002) and boundary/*and* (p's<.02) but no interaction. The accent position effect was robust and consistent with the parallelism effects in much recent ellipsis work. The conditions with L-L% boundaries and no conjunction were able to increase matrix interpretations, showing that with sufficient evidence, the greater salience of high constituents found by F&C in written processing also holds for auditory processing. But different boundary tones on their own were not sufficient evidence for perceivers to switch to discourse processing, contra the simple hypothesis presented above. The interpretation of L-L% boundaries must be flexible, interacting with other kinds of lexical and syntactic information, and demands further research.

## Examples

(1) a. Lucy mentioned that Kathy got sick and Joe did too.
    b. Lucy mentioned that Kathy got sick. Joe did too.

| Experiment 1 | %Matrix |
|---|---|
| (2) a. LUCY mentioned that Kathy got sick (L-H%) and JOE did too. | 55% |
| b. Lucy mentioned that KATHY got sick (L-H%) and JOE did too. | 42% |
| c. LUCY mentioned that Kathy got sick (L-L%) and JOE did too. | 53% |
| d. Lucy mentioned that KATHY got sick (L-L%) and JOE did too. | 42% |

| Experiment 2 | %Matrix |
|---|---|
| (3) a. LUCY mentioned that Kathy got sick (L-H%) and JOE did too. | 61% |
| b. Lucy mentioned that KATHY got sick (L-H%) and JOE did too. | 36% |
| c. LUCY mentioned that Kathy got sick (L-L%). JOE did too. | 70% |
| d. Lucy mentioned that KATHY got sick (L-L%). JOE did too. | 54% |

# Early Effects of Topicality, Late Effects of Parallelism

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Parallelism – syntactic, prosodic, or lexical similarity among sentence constituents – has been shown to affect comprehension of both ambiguous and unambiguous sentences (Carlson 2002ab; Frazier et al. 1984). Carlson & Dickey (2003) argued that parallelism can even affect on-line parsing in temporarily ambiguous comparative ellipsis sentences like (1). In a self-paced reading study, they found that readers experienced a garden path when the objectparallel remnant *the nurse* (1a) was followed by an auxiliary *did*, disambiguating toward the subject interpretation of the remnant. No such garden path was found for the subject-parallel *Annabelle* (1b). However, definites like *the nurse* are also lower on the givenness hierarchy (Ariel 1990) than proper names. The lack of a garden path for *Annabelle* may be because readers expected the more topical proper name to be the subject of the elided clause (cf. Hoeks, Vonk & Schriefers 2002).

This alternative hypothesis was tested in a self-paced reading task. Thirty-two participants read sixteen comparative ellipsis sentences like (2), with the relative givenness of the NPs reversed. If parallelism was responsible for the garden path Carlson & Dickey found, then (2b) – where the remnant is parallel to the preceding object – should show a garden path at the following segment. If relative givenness or topicality was responsible, then readers should expect a subject continuation following the proper name and show a garden path in (2a).

Results favor the topicality/givenness explanation. At the than-NP segment, there was a main effect of NP type across the four conditions, with proper names (2b,d) read more slowly than definites (2a,c) (F1=6.91, p=.013; F2=6.76, p=.02). This pattern is identical to that found by Carlson & Dickey. However, a crossover interaction of segment and NP type was observed between the than-NP segment and the following segment in the first two conditions (F1=10.15, p=.003; F2=9.58,p=.007): reading times increased at *did last term* for the definite condition (2a) but not for the object-parallel proper name condition (2b).

Interestingly, parallelism still strongly affected participants' ultimate interpretation of the sentences. Responses to sentence-final comprehension questions as in (3) showed main effects of both parallelism and disambiguation (p's<.001): sentences with subject parallelism received reliably more subject interpretations than the object-parallel conditions (and subject disambiguation also raised subject interpretations compared to the ambiguous conditions). The early preference for a subject continuation following topical (but object-parallel) proper names was thus overridden by parallelism in participants' final interpretations. As in earlier studies (Carlson & Dickey 2003, e.g.), the presence of an auxiliary did not fully disambiguate the sentences to the subject interpretation, even though the auxiliary was sufficient to create a garden path during reading.

These results suggest that parallelism does not affect on-line parsing preferences. Instead, they provide additional evidence that the relative topicality of NPs or their rank in hierarchies of givenness can affect parsing decisions (Warren & Gibson 2002; Hoeks et al. 2002). However, parallelism clearly influences later-forming "gist" representations of a sentence's meaning, overriding or even reversing on-line effects of syntactic form on comprehension. It appears that parallelism facilitates the formation of long-term judgments of sentence meaning or well-formedness, but does not shape on-line comprehension processes.

## Examples

(1)       a. Tasha | called the doctor | more often | than the nurse | did yesterday …
          b. Tasha | called the doctor | more often | than Annabelle | did yesterday …
          c. Tasha | called the doctor | more often | than the nurse | last Thursday …
          d. Tasha | called the doctor | more often | than Annabelle | last Thursday …

(2)       a. The professor | annoyed Duncan | more frequently | than the TA | did last term |
          b. The professor | annoyed Duncan | more frequently | than Arnold | did last term |
          c. The professor | annoyed Duncan | more frequently | than the TA | last semester |
          d. The professor | annoyed Duncan | more frequently | than Arnold | last semester |
          … with complaints about the students.

(3)       What do you know about the TA?
          a. The TA was annoyed by the professor.
          b. The TA annoyed Duncan.

# Reliability of prosodic cues to children in sentence processing

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The present study attempted to tease apart the extent to which young children utilize prosody in sentence processing. Pre-school aged Korean-speaking children showed an ability to use prosody in resolving a lexical-segmentation ambiguity. By contrast, children appeared not utilizing prosody as much to resolve a syntactic ambiguity (Choi & Mazuka, 2003, Snedeker et al., 2003). The current study investigated whether this pattern is unique to sentences with syntactic ambiguities, by testing children with different types of ambiguities: semantic and phrasal syntactic ambiguity.

Sentence (1) contains (lexical) semantic ambiguity because the meaning is resolved by determining the lexical meaning of the wh-word. When the first word *oti* is phrased separately from the following word as in (1a), it's an indefinite pronoun, meaning 'somewhere,' whereas it's wh-word 'where' when phrased together with the following word as in (1b) (Jun & Oh, 1996). This ambiguity, when presented with neutral context, can only be resolved using available prosodic information. The two interpretations share the same syntactic structure in Korean due to wh-in-situ. By comparison, phrase (2) below contains a syntactic ambiguity (Schafer & Jun, 2002). It can be interpreted as either (2a) or (2b) according to variable prosodic phrasing. With the (2a) type of prosodic grouping, the phrase is NP1 modification, referring to a yellow fish. Prosodic grouping as in (2b) indicates that the adjective, 'yellow', modifies NP2 or noun complex, referring to the eyes of fish that are yellow, but not the fish itself. This type of ambiguity requires not only an ability to detect and use prosodic grouping information but also syntactic decision to arrive at the intended meaning.

A total of 95 children aged 3 to 6 participated in Experiment 1 (semantic ambiguity condition), where they were told a series of stories and asked a question with either yes/no prosody or wh-prosody at the end of each story. The measurement was their responses (yes/no or NP) to questions. Children were not different from adults in distinguishing the type of questions based on the prosody: 3-4-year-olds (78.8% accurate), 5-6-year-olds (81%), and adults (76.6%). This indicated that children used the prosody reliably to resolve this type of sentential ambiguity. In Experiment 2 (phrasal syntactic ambiguity), the same age range of children (n = 160) were asked to find the matching picture while listening to either type of the phrases below (2a or 2b). 3-4-year-olds were 49.4% accurate and 5-6-year-olds were 51.9% accurate (adults--78.5%), showing a great difficulty in using the prosody to differentiate the meaning of the phrases. These results suggest that children may not solely rely on prosody as a reliable source when it comes to resolving syntactic ambiguity, particularly in the absence of other types of disambiguating cues.

## Examples

**(1)** **oti**                          **gayo ?**
     Where (or somewhere)       go

(1a)  $[oti]_{ph1}$ $[gayo]_{ph2}$         "Are you going somewhere?" → yes/no question

(1b) $[oti\ gayo]_{ph1}$                "Where are you going?"       → wh-question

**(2)** **noran    mulkoki  noon**
     yellow    fish       eye(s)
     Adj.     NP1       NP2

(2a) [yellow fish's] eyes

(2b) yellow [fish's eyes]

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# Differences in native and non-native sentence production

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The syntax of adult second language (L2) speech can differ from that of natives even at very high levels of proficiency. This divergence has been attributed to deficits either in representations of the L2 syntax, or in the processing of these representations (e.g., Prévost & White, 2000; Hawkins & Chan, 1997). Even when non-native syntax appears to be native-like, it is unclear whether the underlying representations and processing strategies are the same as in native speakers.

We report two experiments which used syntactic priming to investigate language production in native speakers and two groups of non-native speakers (intermediate and advanced learners) of Spanish. Syntactic priming is the tendency for people to repeat a syntactic structure they have heard in an immediately preceding, but otherwise unrelated sentence (see Pickering & Branigan, 1999 for a review). Patterns of priming are informative about the nature of underlying syntactic representations (Branigan et al., 1995), implying that the speaker possesses an abstract representation for the persisting structure and that use of this structure is facilitated through previous processing. Recent research on syntactic priming (e.g., Ferreira, 2003) has shown an inverse preference effect – more priming is seen for less known structures than better known structures. Because L2 learners have less experience with syntactic structures in the target language than a native speaker of that language, the procedures for processing these structures will be weaker and we would predict more priming in non-natives than natives.

In Experiment 1 a naïve participant and a native Spanish confederate played a picture-description game in Spanish; there were 12 participants in each subject group. The experimental cards depicted transitive actions. We manipulated the structure of the confederate's prime description (e.g., Active (1) vs. Passive (2)). The identity of the verb in the prime and target was also varied (Same vs. Different Verb) – repeating the verb has been shown to increase priming effects in natives and we wanted to see how this manipulation would affect non-natives. Our dependent variable was the syntactic structure that participants produced for a subsequent target picture.

The results showed an overall priming effect, which interacted with Verb: Participants produced more passive structures after hearing a passive structure than after an active structure, and this tendency was stronger when the verb was repeated (ps < .001). Although there was reliable priming for all groups, it was significantly stronger for non-native speakers (Priming effect: Intermediate learners 45%; Advanced learners 54%) than for native speakers (10%). The difference in magnitude of priming was significant between native speakers and each group of non-native speakers (p < .01); the two non-native speaker groups did not differ from each other.

These results can be explained by non-native speakers having less experience with processing syntactic structures in the second language. The processing of these structures is therefore more influenced by the immediate context, making them more accessible following priming than in native speakers. However, an alternative explanation for the non-natives showing a larger priming effect could be due to the nature of the task. The dialogue situation could create a social pressure to conform to the speech of the interlocutor, which non-natives may feel more strongly than natives. In order to remove this social pressure a second experiment was run which was identical to Experiment 1, except that participants interacted with a computer, rather than a confederate. There were 16 participants in each of the three subject groups. The pattern of results was identical: an overall priming effect that was reliable for each group considered individually, but significantly greater for non-native than native speakers.

Together, these findings imply that these L2 speakers have abstract representations for syntactic structures, shared between comprehension and production. However, the processing of these structures differed from native speakers. Priming is predicted to be stronger in non-native speakers because the processes involved in L2 production are weaker, and the resting baseline of activation for these structures lower. They may therefore be particularly susceptible to a boost from previous activation (cf. Hartsuiker & Kolk, 1998, for a similar argument regarding aphasics). An additional factor to consider is that, although grammatical, the passive is an uncommon structure in spoken Spanish. Priming is stronger for less preferred structures but if a particular structure is highly dispreferred by a native speaker in a particular context, syntactic priming is not strong enough to overrule a strong dispreference (e.g., Pickering, Branigan & McClean, 2002, found no priming for heavy noun phrase shift constructions in English). The L2 speakers in this study are presumed not to have developed native-like knowledge about the appropriateness of the passive in Spanish, and so remain susceptible to priming.

Future studies are needed to identify the exact causes of the increased priming effect in these non-native speakers. We plan to investigate priming of other structures which are more preferred by native speakers of the L2, and also structures which exist only in the L2 and not in the learner's native language.

**Examples**

(1) El tren persigue el camion          *The train chases the lorry*
(2) El camión es perseguido por el tren     *The lorry is chased by the train*

# Syntactic focus and first-mention status affect pronoun coreference

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Pronouns are a widespread, low-load means of keeping track of a discourse focus, serving to link and integrate appropriate incoming information with its representation. In a discourse, syntactically focused entities are more salient than others [2], and experiments with noun-phrase anaphora have shown a processing advantage when the antecedent was syntactically focused [1]. Two self-paced reading experiments examined the processing of pronouns, addressing how syntactic focusing and position of the antecedent affected the prominence of a discourse representation in working memory.

Drawing on the memory literature, a recent, just-processed item is accessed more quickly than entities in less recent positions, suggesting that the most recent item is in a specialized state of focal attention [4]. I investigated whether syntactic focusing was consistent with the same type of memory state that a just-processed representation enjoys, and also whether an antecedent being first-mentioned [3] influenced syntactic focusing effects. If the same focal state underlies both a syntactically focused antecedent and a just-recent one, then the respective processing times at a coreferring pronoun area should be similar, while the case of a nonfocused and nonrecent antecedent should be more difficult. This was tested by contrasting sentences with a pronoun referring to an antecedent that was (1) focused and recent, (2) focused but nonrecent, (3) nonfocused yet recent, and (4) nonfocused and nonrecent. The focused antecedent in the first sentence appears below in bold, with the target and spillover areas underlined in the second. Slashes delineate the presentation regions.

(1)   What/the/eldest princess/wore/was/the/**diamond necklace**./It/glinted/in the ballroom/of the palace.
(2)   It was/the/**eldest princess**/who/wore/the/diamond necklace./She/curtseyed/in the ballroom/of the palace.
(3)   It was/the/**eldest princess**/who/wore/the/diamond necklace./It/glinted/in the ballroom/of the palace.
(4)   What/the/eldest princess/wore/was/the/**diamond necklace**./She/curtseyed/in the ballroom/of the palace.

Reading times on the pronoun revealed no significant differences, while the spillover verb showed a main effect of focus. Focused conditions were read more quickly than nonfocused ones (433 vs. 454 ms). Comparisons revealed that this effect was mainly due to the two nonrecent conditions differing significantly, as the focused-nonrecent condition had a faster reading time than the nonfocused-nonrecent one (2 vs. 4: 430 vs. 457 ms). The two recent conditions did not differ, and furthermore, the focused-nonrecent condition did not differ from either recent one. This is consistent with focus increasing the activation or prominence of a mental representation, similar to that of recency's influence on prominence.

The second experiment investigated whether syntactic focusing alone contributed to prominence, or if the combination of syntactic focus and the antecedent being the first-mentioned item was key. Using the same design, the subject antecedent was moved from first-mentioned position by embedding it within a matrix clause, as shown below for the nonfocused-nonrecent condition.

(5)   The nobles/recognized that/what/the/eldest princess/wore/was/the/**diamond necklace**./She/curtseyed/in the ballroom/of the palace.

Reading times on the pronoun revealed no significant differences, but once again, the spillover verb showed a main effect of focus, with focused conditions being read more quickly than nonfocused ones (492 vs. 518 ms). Comparisons showed that this effect was mostly due to the two recent conditions differing (1 vs. 3: 496 vs. 531), that is, when the antecedent was the third NP of the first sentence. These results suggest that with a first-mentioned subject introduced in the matrix clause, recency no longer plays a role for prominence within the embedded sentence. Yet, centrally, focus is again sufficient to render an antecedent representation more prominent.

In both experiments, focusing an antecedent facilitated pronoun coreference, producing shorter reading times for focused than nonfocused conditions. This provides evidence consistent with a syntactically focused representation being cognitively prominent. However, the two experiments showed mixed results for the role of a just-mentioned entity being functionally in cognitive focal attention, perhaps due to the first-mentioned matrix subject overshadowing the embedded antecedents.

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# Dependency and Length as Processing Constraints on Word Order in Particle Constructions

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Why do languages opt for the word orders that they do? Japanese places its verbs and other phrasal heads at the ends of its constructions, while English generally places heads to the left. Although English uses relatively fixed word order, there are some structures that allow a choice. For example, one can say '*I went with my friend to the store*' or equally felicitously '*I went to the store with my friend.*'

Recent research has begun to investigate what factors influence word order preferences. Hawkins has proposed that performance constraints drive languages to choose word orders that minimize processing demands (Hawkins, 1994, 2001). Experimental studies testing Hawkins' predictions have shown that the length of the direct object noun phrase (*the ball* vs. *the big blue and white ball*) affects word order preferences in dative constructions, with participants strongly preferring '*Mary threw me the big blue and white ball*' to '*Mary threw the big blue and white ball to me*' (Stallings, MacDonald, & O'Seaghdha, 1998). Additional corpus studies have shown that the complexity and newness of the noun phrase influences ordering preferences (Arnold, Wasow, Losongco, & Ginstrom, 2000).

In this study we examine ordering preferences in verb particle constructions in a comprehension task. Verb particle constructions include a verb (e.g., *throw*) and a particle (e.g., *out*, *up*, *on*) that can either be produced adjacently as in '*he threw out the garbage*' or separately (with an intervening object noun phrase) as in '*he threw the garbage out.*' Verb particle constructions also vary in the degree to which the verb depends on its particle for its meaning. For example, *chew out* depends on '*out*' for its meaning*, while *finish up* does not get much of its meaning from '*up*' (see Gries, 1999, for a linguistic description of possible dependency relationships). We tested the effects of adjacency, dependency, and length on word order preference in verb particle constructions. To determine dependency, 200 undergraduates rated the similarity of 209 verb particle-verb pairs (e.g., *look up-look*). We chose 75 pairs that varied in dependency as stimuli for a masked priming experiment. Sixty native English speakers participated in the masked priming lexical decision experiment, where low dependency items (*finish up-finish*) produced greater priming than high dependency pairs (*chew out-chew*). We then tested sentences varying in dependency of the verb particle, adjacency, and length of the intervening noun phrase (short *his watch* versus long *his old and broken watch*) on reading times in a self-paced reading task. Results indicate that it is more difficult to process shifted sentences with long intervening noun phrases (*The man will give his old and broken watch away.*) and this is especially true when the verb and particle are highly dependent (*The company will rule the idea for new renovations out*). Thus, word order preferences in particle constructions are affected by processing constraints such as adjacency, dependency, and NP length. These findings support Hawkins' (1994, 2001) notion that word order is determined by performance factors.

# The on-line processing of relative clauses in Brazilian Portuguese and English

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It is well known that sentences with multiple center-embedded clauses are far more difficult to process than sentences with multiple right-branching complement clauses (Miller & Chomsky, 1963, and many others). However, a number of studies of English have found that this generalization does not extend to cases of single embedded clauses, where right-branching structures have been found to be more difficult than center-embedded clauses (Hakes et al., 1976; Holmes, 1973). Some recent accounts of this effect predict that it is either cross-linguistically general (Gibson et al., in press) or specific to English, due to the apparent absence of the effect in off-line studies of Brazilian Portuguese (Gouvea, 2003). This study presents results from parallel on-line studies of English and Brazilian Portuguese that lend support to the language-general account.

In order to distinguish between general versus language-specific accounts, we conducted a fully parallel self-paced reading study of relative clause processing in English and Brazilian Portuguese. Target sentences in both languages contained center-embedded (1) and right-branching (2) subject and object relative clauses.

(1a)    The student that hugged the colleague with the long hair insulted the teacher after the exam at the public school. [center-embedded, subject RC]

(1b)    The student that the colleague with the long hair hugged insulted the teacher after the exam at the public school. [center-embedded, object RC]

(2a)    The teacher insulted the student that hugged the colleague with the long hair after the exam at the public school. [right-branching, subject RC]

(2b)    The teacher insulted the student that the colleague with the long hair hugged after the exam at the public school. [right-branching, object RC]

The BP results (n=30) showed that right-branching relatives presented longer reading times than center-embedded relatives, $F1(1,29)=3.9$, $p=.05$, $F2(1,23)=7.6$, $p<.05$. The English results (n=25) showed a non-significant tendency in the same direction. Clearly, neither language shows evidence for increased difficulty in the center-embedded conditions, for subject and object relative clauses alike.

Gouvea (2003) argued that the increased difficulty of right-branching single embeddings is due to the ambiguity created in English right-branching relatives by the availability of extraposition structures like (5). In support of this account, Gouvea shows that extraposition is unavailable in Brazilian Portuguese, and presents results from an off-line study (RSVP grammaticality judgment task) that shows that center-embedded relatives induce more errors in Brazilian Portuguese, whereas right-branching relatives induce more errors in English.

(5)    Any girl$_i$ could break the table easily that$_i$ takes karate lessons.

In order to verify the role of extraposition in explaining the patterns of difficulty, all participants in the on-line studies completed an acceptability rating questionnaire. This study replicated Gouvea's finding that extraposition is far more acceptable in English than in Brazilian Portuguese. This excludes the possibility that our findings about the difficulty of relative clause processing might have differed from Gouvea's due to differences in the acceptability of extraposition in our Brazilian subjects.

In sum, these results lend support to accounts that link the difficulty of single-embedded right-branching relatives to an inherent syntactic or discourse property of these structures (Gibson et al., in press), as opposed to ambiguity-based accounts.

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# The Costs of Maintaining Syntactic Predictions in Ambiguity Resolution

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The nature and importance of syntactic complexity in structural ambiguity resolution is a controversial issue. A number of investigators have suggested that structural preferences might emerge solely from lexical properties (MacDonald, Pearlmutter, & Seidenberg 2004; Spivey & Tanenhaus 1998; Trueswell & Tanenhaus 1994). Contra this position, Grodner, Gibson, & Tunstall (2002; GGT) argued that the number of syntactic heads required to grammatically complete each partial analysis affects which alternative is favored. In a reading study, GGT embedded reduced relative clauses (RRs) which were temporarily compatible with a main clause analysis (MV) in a sentential complement (SC) (1a) or a relative clause (RC) (2a). Within an SC, there is no difference between the heads needed to complete the MV or RR when the ambiguity is introduced at the verb (one for each). Thus, non-structural biases dominate parsing preferences. However, within an RC, a discrepancy emerges. The MV requires one head while the RR requires three. Correspondingly, GGT found a reliably larger ambiguity effect within an RC than an SC.

Although GGT's results are suggestive, it is possible that their effects were driven by the complexity of the RC environment. The RR in (1b) results in a doubly nested structure and a verb prediction must be maintained over the ambiguous region. This may impose an extrinsic memory load which attenuates the influence of semantic plausibility. Analogously, individuals with larger memory spans are more sensitive to semantic and other non-structural contraints (MacDonald, Just, & Carpenter 1992). Consistent with this, Eastwick & Phillips (2000) found that individuals were less sensitive to thematic plausibility when the RR was embedded in a context where the relative storage costs of the MV and RR did not differ, but a subject-verb dependency crossed the ambiguous region. While interesting, this result does not speak directly to GGT's hypothesis.

To test the GGT hypothesis directly, we conducted a self-paced moving-window word-by-word experiment comparing the resolution of temporarily ambiguous MV/RR sentences in sentential complements (2a) and indirect questions (2b). All items were plausibility biased toward the RR. The conditions were identical except that the indirect questions were initiated by a wh-pronoun and the sentential complements by the overt complementizer "that." In (2a), the MV and RR analyses each require a single syntactic head (an object for the MV, and a verb for the RR). Thus GGT's hypothesis predicts little or no syntactic bias and plausibility constraints should reduce difficulty with the RR. By contrast, in (2b), the MV requires no additional heads, while the RR requires a verb and an embedded gap position. Thus there is a structural bias toward the implausible MV interpretation. To assess difficulty with the RR resolution, reading times over the disambiguating by-phrase were compared to unambiguous control sentences. These analyses revealed that temporarily ambiguous RRs were significantly harder to process in an indirect question than in a sentential complement. This corroborates the view that the parser favors the analysis involving the fewest outstanding predicted heads even when non-structural factors militate in the other direction.

## Examples

(1)     a. GGT MV/RR within sentence complement:
       The witness said that the evidence (that was) examined by the lawyer was unreliable.
       b. GGT MV/RR within relative clause:
       The witness who the evidence (that was) examined by the lawyer implicated turned out to be unreliable.
(2)     a. MV/RR within sentence complement:
       The witness determined that the evidence (that was) examined by the lawyer implicated his next-door neighbor.
       b. MV/RR within embedded question:
       The witness determined who the evidence (that was) examined by the lawyer implicated in the crime.

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# Using a Speaker's Eyegaze During Comprehension:
# A Cue Both Rapid and Flexible

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Eyegaze is a powerful potential disambiguating cue in referential communication. Our 3 experiments explored the time course and the flexibility with which this cue can be used in spoken dialogue. We balanced naturalness and control in the following way: pairs of naïve directors and matchers sat across a table separated by a low barrier so they could see each other's faces but not each other's displays. Matchers' eye movements were recorded with a head-mounted eyetracker, and directors' were captured via the scene camera. Each display held identical copies of the same objects (e.g., red/green/ blue circles/ triangles/squares, with five or six dots) located *either* (1) in a mirrored arrangement so that a what was to the director's right was to the matcher's left (Congruent displays), or (2) in an arrangement that was not spatially correspondent (Non-congruent). Display types were blocked, with Congruent displays for half the experiment and Non-congruent displays for the other half (counterbalanced for order). Directors followed non-verbal schematic cards in order to instruct matchers which target objects to move and where to place them. On critical trials, in addition to a target object (e.g., blue triangle with five dots), there was a competitor (e.g., blue triangle with six dots) either next to it (Near) or at least two spaces away (Far), to be compared to trials with no same-color competitor.

In Experiment 1, directors' non-congruent displays had objects arranged in a circle rather than left-to-right like matchers' displays, and both partners were made aware of when their displays were spatially correspondent and when they were not. Directors and matchers coordinated their eyegaze so that when directors referred to objects, matchers made their initial looks in the vicinity of the objects they presumed the directors were fixating (Hanna & Brennan, 2003). Matchers were faster to identify Far competitors than Near competitors.

Experiment 2 was like Experiment 1, except that the non-congruent displays consisted of reversed versions of the congruent displays, so that what was to the director's right was to the matcher's left. Unlike in Experiment 1, partners were not informed about the relationships between their displays. Directors and matchers coordinated their eyegaze and used it as a disambiguating cue, but only when they experienced congruent displays first; when they experienced reversed displays first, they tended to ignore partners' eye gaze throughout the experiment, even when displays were spatially congruent.

In Experiment 3, we repeated Experiment 2's design, but informed subjects as to when their displays matched and when they were reversed. In addition, to reduce looking back and forth between target and competitor, we modified the objects so that they could be distinguished more easily (e.g., a blue circle with the letters "AE" vs. a blue circle with "LM"). When they were aware of the mapping between their displays, matchers were able to rapidly use directors' eyegaze as a disambiguating cue for both mirrored and reversed displays. Eyegaze turns out to be a flexible cue that can be used both rapidly and strategically during language comprehension.

# Agreement Processing in a complex number system

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Attraction effects, where speakers erroneously make a verb agree with an intervening ('local') noun rather than with the subject head noun, are well established with plural local nouns; sentences like "The readiness of our conventional forces are at an all-time low" are well-attested (Bock & Miller, 1991). Similar effects have recently been observed with singular local nouns (Haskell & Bock, 2003).

It has been proposed that agreement processes are based on the distinction between 'one' and 'more than one', where 'one' represents the default and 'more than one' represents the marked option (Eberhard, 1997). Research has so far concentrated on agreement in languages that can only make a two-way distinction between singular and plural. Does a binary markedness distinction also hold for languages that have a more complex number system? We report a study that exploited the 3-way number distinction between singular, dual and plural in Slovene to address this issue.

Under Eberhard's (1997) model, the singular form is unmarked. Singular heads should therefore be susceptible to attraction errors, but singular local nouns should not elicit attraction errors. Conversely, under her model the dual and plural should both be marked forms, hence both dual and plural local nouns should elicit attraction errors, but dual and plural head nouns should not be susceptible to attraction errors when a singular local noun intervenes.

Her model as it stands could not account for any differences between attraction error rates following dual versus plural head or local nouns. Such differences could be accounted for if the model were modified to incorporate a third level of markedness. According to Corbett (2000), we would expect the markedness to be ordered: singular < plural < dual. This fits with the frequency of the number values and also with the amount of homophony which each has with other forms.

135 native Slovenian speakers performed a sentence completion task. They were presented with a preamble (a complex NP containing a head noun and a postmodifying relative clause) and an intransitive verb independently rated as more plausible with the local than with the head noun. Their task was to repeat and complete the preamble using the verb. The number values (singular vs. dual vs. plural) of the head and local noun were orthogonally combined, yielding 9 different conditions, as in the dual head-singular local noun example below:

Strica,      ki      ju      je      obiska-l-Ø      hrupen-Ø necak-Ø

uncle-md  REL  ACC-3d AUX.3s visit-PST-ms noisy-ms  nephew-ms

*Two uncles whom a noisy nephew was visiting*

Percent singular, dual and plural agreement errors in each condition (match conditions in bold)

| Response | Condition | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **ss** | sd | sp | ds | **dd** | dp | ps | pd | **pp** |
| sing | | | | 18.5 | 11.0 | 7.4 | 9.3 | 2.8 | 2.0 |
| dual | 0.7 | 9.7 | 1.6 | | | | 3.8 | 21.0 | 5.3 |
| plural | 0.6 | 1.5 | 5.0 | 2.5 | 4.3 | 11.6 | | | |

Table note. Condition 'sp' means singular head noun and plural local noun; 'ds' means dual head noun singular local noun, and so on.

In common with previous studies, preambles containing only singular nouns very rarely resulted in a sentence with non-singular agreement. Plural heads were more likely to result in dual agreement than singular heads; dual heads were more likely to result in plural agreement than singular heads; dual heads were more likely to result in singular agreement than plural heads. Furthermore, dual agreement was more likely in the singular-plural condition than in the singular-singular condition, but plural agreement was more likely in the dual-dual condition than in the dual-singular condition, suggesting that the presence of the singular local noun diminishes random drift towards higher number values.

Although the singular is least susceptible to errors in the match (ss) condition, it acts more like a marked form in local position, eliciting errors. The dual and plural are neither the same, nor is the dual unambiguously more marked than the plural. Thus we can conclude that failures of agreement in Slovene neither follow the predictions that can be derived from Eberhard's theory nor the predictions that follow from Corbett's linguistic description. Interestingly, there is a tendency for agreement to fail in a way that results in a decrease in number, and that number decreases by one step (e.g., from plural to dual, or from dual to singular).

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# Age-related Effects in Communication and Audience Design

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Part of being a cooperative speaker involves tailoring utterances to suit the communicative needs of your audience. Although a number of studies have explored the circumstances under which young adults engage in such audience design (Fussell, & Krauss, 1989; Horton & Gerrig, 2002; Horton & Keysar, 1996), there has been relatively little research examining whether older adults differ in how much they take their partner into account during conversation. To the extent that audience design relies upon the successful encoding and retrieval of partner-specific information, older adults, who are more likely to exhibit deficits in basic memory processes such as source monitoring (Brown, Jones, & Davis, 1995; Spencer & Raz, 1995), may be less able to adjust their speech to particular addressees. To address this possibility, we carried out a study that would allow us not only to assess possible age-related effects in audience design, but also to examine whether pairs of younger and older adults differ in how they interact while establishing common ground, which necessarily forms the basis for subsequent partner-related adjustments.

This study contained two phases. In the first phase, pairs of younger or older participants jointly carried out a referential communication task involving matching sets of picture cards. Over the course of six rounds, the pairs were given the opportunity to develop common ground for how to talk about each of the pictures. Then, the second phase of the study examined whether each of the participants would use this common ground to adjust their descriptions of the pictures depending on whether they were talking to the same partner or to somebody completely new. In this phase, both participants independently described a series of target pictures presented on a computer screen, and prior to each trial they were visually cued for whether their description would be heard by the partner with whom they had worked previously or by an unfamiliar partner. These cues consisted of digital pictures of the partners' faces. The pictures used to cue the familiar partner were taken at the start of the experimental session and subsequently incorporated into the presentation of the experimental stimuli. To cue the unfamiliar partner, we used one of two previously created pictures that showed an individual from the same age cohort as the participant pairs. Although the descriptions were not actually transmitted to live partners, we went to some lengths to convince the participants that the unfamiliar partner was a genuine, naïve participant and that the communication task was real.

One set of analyses examines the processes by which how younger and older pairs work together to accomplish the card-matching task. In line with previous research using similar paradigms (Arbuckle, Nohara-LeClair, & Pushkar, 2000; Hupet, Chantraine, & Nef, 1993), older adults appear to require more words and more turns to make each match, which may reflect qualitative differences in how older adults approach this kind of task. More directly related to audience design, however, is whether the participants' descriptions during the second, computer-based task would be affected by the status of the partner. Specifically, we are interested in how the content and timing of the speakers' descriptions differ according to the intended recipient. Preliminary analyses reveal that younger adults are more likely to produce shorter descriptions and fewer hedges in their descriptions for the familiar partner, which suggests that they are designing their utterances differently for the two audiences. Older adults, however, do not appear make the same distinction between familiar versus unfamiliar addressees—their descriptions tend to be longer and more elaborated regardless of the conversational partner. Such age-related differences in audience design have consequences not only for cognitive aging, but also for basic models of communication and language use. In particular, these results support the hypothesis that conversational common ground relies upon domain-general memory processes.

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# Chinese Counterfactual Conditionals

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Conditionals, which involve the operation of inferences in logical reasoning, serve as an ideal probe for investigating the interface between language and cognition. Claims that the lack of grammatical subjunctives in Chinese lead to impaired abilities in counterfactual reasoning (Bloom, 1981) have received a good deal of attention, particularly in the popular science literature on cognition (e.g. Pinker, 1994). Although some studies have demonstrated that Chinese speakers are, in fact, able to competently carry out counterfactual reasoning (Au, 1983; 1984 & Liu, 1985), the possibility remains that Chinese speakers show a residual difficulty in the on-line processing of counterfactuals. This study reports a reaction-time study that shows counterfactuals are effectively processed on-line in Chinese-speaking individuals. Furthermore, it shows that this is possible using less heavily contextually biased materials than in the previous off-line studies. Important questions remain: in the absence of grammatical cues, (1) how are counterfactual discourses in Chinese processed online, and (2) from a developmental perspective, how does counterfactual reasoning develop.

In order to address these questions, we employed Carpenter and Just's constituent comparison model (1975), which required subjects to judge whether the meaning (including presuppositions) of a target sentence is consistent with that of a test sentence and to respond Yes or No as quickly as possible. Although the meaning of conditionals in Chinese may be context dependent (Li & Thompson, 1992), the sentences used in this study, unlike those in Au & Liu, were rendered unambiguously counterfactual by the presence of an aspect marker *le* and negation *meiyou*. For example, the counterfactual target sentence below has as its default (i.e. decontextualized) reading only a counterfactual interpretation. In this example, clause A of the target sentence "If I hadn't been late" presupposes a positive statement that "I was late". Therefore, when a test sentence like "I was late" is encountered, subjects' responses are expected to be Yes. On the other hand, when a test sentence like "I was not late" is shown on the screen, a No response is expected.

Target sentence (counterfactual example):
A[ Ruguo wo meiyou chidao], B[chizi jiu bu hui    kaizou     le ].
  If  I   not   late,   car then not would drive away ASPcompleted
"If I hadn't been late, the car would not have driven away"
Test sentences:
Wo chidao le.        "I was late" (Yes for clause A)
 I  late ASPcompleted
Wo meiyou chidao.     "I was not late" (No for clause A)
 I  not   late
Chezi kaizou  le.     "The car drove away" (Yes for clause B)
 car drove away ASPcompleted
Chezi meiyou  kaizou.   "The car did not drive away" (No for clause B)
 car  not    drive away

A target sentence is presented first and then followed by a test sentence. The time difference between two onsets is 5 second. Reaction times and error rates were measured across three developmental age-groups in college students (n=20 & mean age is 22), high school students (n=16 & mean age is 15), and elementary students (n=15 & mean age is 12). There are two possible processing strategies to be arbitrated among. One is under the influence of the *Congruent Principle*, which prefers a match in word order between the target sentence and the test sentence. Under this scenario, the No trials would have faster reaction times than the Yes trials because a negation marker and the same predicate are included in both sentences. The second processing mechanism is free from congruency influences: subjects activate the true meanings of counterfactuals. In this model, the Yes trials would have lower latencies than the No trials. The observed results demonstrate that Yes trials in fact have lower latencies than No trials, suggesting that Chinese-speaking subjects have no problem in shifting to the counterfactual mode of reasoning as readily as their English-speaking counterparts (Carpenter, 1973). An age-group effect is also observed; speed and accuracy of processing counterfactuals improved with age. Error rates of No and Yes trials on counterfactuals for elementary students are 24.5% and 14.3%, respectively; for high school students are 21.5% and 18.3%; for college students are 10.9% and 12.8%. We conclude that counterfactual reasoning in Chinese is effectively processed online without context loading. Moreover, the ability to process counterfactuals continues to develop throughout late childhood and into adulthood.

# Effects of Phrase Order on Sentence Processing in Chinese Double-object Structures

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Much recent research on sentence processing has focused on lexical and discourse factors, raising questions about whether there remains any significant role for structural factors. However, some evidence suggests structural factors do play an independent role (e.g., Grodner, Gibson, & Tunstall, 2002). One construction where one might expect effects of structural factors is the ditransitive construction, exemplified by "Lingyun gave the paper to Elaine." Hawkins (1994, in press) has proposed that typologically different languages prefer different word orders depending on processing efficiency tied to structure (syntactic weight) factors, in addition to lexical and semantic factors. For example, the order of NP and PP in a given sentence should depend on the relative weight of each, with head-initial languages like English preferring short-before-long but head-final languages like Japanese preferring long-before-short (in both comprehension and production) because these sentence configurations allow earlier cues to the phrase structure of a sentence in these languages. Corpus and production data from head-initial and head-final languages have generally supported Hawkins' approach (e.g., Stallings, MacDonald, & O'Seaghdha, 1998; Yamashita & Chang, 2001). However, such languages confound two different factors: the basic order of phrases, and the position of heads within those phrases. Inconsistent head ordering languages like Chinese provide a critical test case. In Chinese VPs and PPs (including some IOs) are generally head-initial but NPs (including DOs) are head-final. If the position of the phrasal heads is most important, DO-before-IO order should be preferred, because this results in the greatest degree of "Domain Minimization" for phrase structure processing (Hawkins, in press). Under some conditions there should also be a preference for a short-before-long order of the DO and IO.

The current study examined word-order preferences during sentence comprehension in Chinese using an on-line self-paced reading task. Twenty-four native Chinese speakers read double-object sentences with a long DO and short IO or a short DO and long IO, and with the DO preceding or following the IO (e.g., 1, 2). Results reveal a clear and consistent preference for a short-before-long order, regardless of the relative order of DO and IO ($F(1,23)=30$, $p<0.001$). Surprisingly, effects of DO/IO order were weak and inconsistent ($F<1$; $F(1,23)=2.7$, $p=0.12$ for the interaction). Additional analyses suggest that, although Chinese NPs are head final, comprehenders are sometimes able to identify the phrase well before the head. This leads to novel predictions for both comprehension and production. Ongoing work is testing some of these predictions.

Postverbal reading times (ms)

|  | DO-before-IO | IO-before-DO |
|---|---|---|
| short-before-long | 3196 | 3134 |
| long-before-short | 3256 | 3300 |

**Examples**

(1)a. baba hui ji [gei xiao erzi] [ji zhang tamen quanjia  zuotian ganggang zhao de zhaopian].
　Father will send  to little son several CL   they  whole-family yesterday just    take DE photo
 b. baba hui ji [ji zhang tamen quanjia  zuotian ganggang zhao de zhaopian] [gei xiao erzi].
　Father will send several CL   they  whole-family yesterday just   take DE photo  to little son
　"Father will send to his little son several family photos that they just took yesterday."
(2) a. Zhangsan yao song [gei ta pengyou] [dajia dou renwei tebie haohe de zhongguo shangdeng chaye].
　Zhangsan will give to he friend  people all  think very delicious DE  Chinese high-quality tea
 b. Zhangsan yao song [dajia dou renwei tebie haohe de zhongguo shangdeng chaye] [gei ta pengyou].
　Zhangsan will give people all  think very  delicious DE Chinese high-quality tea   to he friend
　"Zhangsan will give to his friend high-quality Chinese tea that people all find very delicious."

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# Reference resolution in Dutch:
# What pronouns and demonstratives can tell us

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According to many researchers, the form of referring expressions is connected to the accessibility/topicality of their referents: The most reduced referring expressions (e.g. pronouns) refer to highly accessible referents, whereas more marked expressions (e.g. demonstratives) refer to less accessible referents (e.g. [1], [4]). In languages with full and reduced pronouns, full forms are said to refer to less accessible referents (e.g. [3]).

We investigate these claims in an eye-tracking study of Dutch, which has full and reduced pronouns and demonstratives. The pronouns *hij* (he) and *zij* (she) are used for masculine and feminine human referents, respectively. Interestingly, there is an asymmetry between the masculine and feminine paradigms: there exists a reduced form of *zij* (she) in standard Dutch – *ze* – but the reduced masculine form *ie* occurs only in colloquial Dutch. Moreover, *ie* is a clitic and cannot occur sentence-initially [5]. In addition to pronouns, the demonstrative *die* 'that' is also used for both masculine and feminine referents.

Accessibility-hierarchy approaches predict that the most reduced forms within a gender (masculine=*hij*, feminine=*ze*) are used for the most salient referents, and less reduced forms (masculine/feminine=*die*, feminine=*zij*) for less salient referents. This, combined with the finding that subjects are more salient than objects (e.g. [2]), predicts that *hij* is more likely to refer to a preceding subject than *die*, and that *ze* is more likely to refer to a preceding subject than *zij* (which is more likely to refer to a preceding subject than *die*).

To test this, we measured participants' (N=16) eye-movements as they viewed pictures while listening to stories. Their task was to correct any mistakes in the stories. Each target item contained a sentence with two masculine or two feminine human referents, followed by the critical sentence beginning with *ze/zij/hij/die* (ex. 1). These referential forms were spoken with neutral intonation, i.e. they were not stressed. Target pictures contained two feminine or two masculine referents, resulting in four conditions: (1) masculine-masculine.*Hij*, (2) masculine-masculine.*Die*, (3) feminine-feminine.*Ze*, (4) feminine-feminine.*Zij*. The critical sentence was incorrect for both referents, because we wanted participants to provide – through their corrections – another measure of their interpretations.

Eye-movements showed a pattern incompatible with an accessibility-hierarchy explanation. In the masculine conditions, *hij* is significantly more likely to refer to the subject than *die* ($p < 0.05$), as predicted. However, in the feminine conditions, *ze* and *zij* do not fit the predictions. Both are interpreted as referring to the subject. *Hij*, *ze* and *zij* show increased looks to the subject, whereas *die* does not, resulting in a significant gender-pronoun interaction starting approximately 400-800ms after the pronoun.

These results, combined with sentence-completion data we collected, suggest that in Dutch, the full form vs. reduced form (*ze/zij*) choice is not triggered by referent salience, but that the pronoun vs. demonstrative (*hij/die)* choice is. Corpus data indicate that the use of the full form *zij* may in fact be prompted by contrast (see also [6] on the role of contrast in the use of Estonian full pronominal forms). Overall, these results show that different anaphoric forms within one language can be sensitive to different factors, and their referential properties cannot be captured by a unified notion of salience.

(1) ...The student poked the teacher with a pencil. *Hij/Die/Ze/Zij* was wearing a green sweater…

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# Effects of prosodic boundaries on ambiguous syntactic clause boundaries in Japanese

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Kang and Speer (2004) demonstrated that the prosodic boundary information was crucially used by listeners in resolving syntactic clausal ambiguity in Korean. In contrast to English, Korean has neither lexical stress nor phrasally assigned pitch accents. In addition, Korean syntax differs from English in that it includes *pro*-drop, verb-final structure and the presence of complementizers after an embedded clause, the combination of which contributes to ubiquitous syntactic clausal ambiguity. Given this, Kang and Speer argued that prosodic boundaries could provide some of the most salient and reliable information about the structure of spoken sentences and potentially assume a fundamental role in spoken language processing in Korean.

Although Japanese shares many syntactic properties with Korean, its prosodic structure is distinctly different, including lexically assigned pitch accents. Given syntactic similarity but intonational difference, we tested to see if Japanese sentence comprehension relies on prosodic boundary information as listeners understand similar ambiguities. Japanese materials were ambiguous sentences with the same syntactic structure as those used in Kang and Speer's Korean study. For example, the two-word sentence-initial fragment in (1) is ambiguous such that the initial nominative-marked NP may be the subject of either the immediately following verb, or the sentence-final main verb. Depending on the types of head nouns modified by relative clauses, this fragment can be continued as in (2), or as in (3). At the completion of the sentences, (2) is not ambiguous anymore (temporary ambiguity) while (3) still shows ambiguity (global ambiguity). The critical difference for these two examples is that for (2), the initial noun cannot be the subject of the following embedded verb whereas for (3) the initial noun may or may not be the subject of the embedded verb. In addition, for the type of sentence (3), *pro* needs to be posited for the subject of the main verb (3a) or of the embedded verb (3b) and the referents of this *pro* should be recovered from the context.

### Examples

(1) Taro-ga       nigeta          …..
    Taro-nom    run away       …..

(2) Taro-ga       nigeta       shijin-o       oikaketa
    Taro-NOM   run away    poet-ACC     chased
    `Taro chased the poet who ran away.'

(3) Taro-ga       nigeta       mura-o       osotta
    Taro-NOM   run away    village-ACC  attacked
    a. `(Someone) attacked the village where Taro ran away.'
    b. `Taro attacked the village where (someone) ran away.'

For these two types of sentences, an auditory perception study was conducted with 40 Tokyo Japanese speakers. For each sentence type, participants heard two different intonations, one with an Intonational Phrase (IP, henceforth) boundary right after the initial NP and the other with no IP at the same location. Immediately after each sentence, participants indicated whether they understood it. Since the critical distinction was which NP was the subject of the embedded verb, participants also answered a comprehension question such as "Who ran away?". There were three response choices; e.g. '*Taro*'(NP1), 'poet' for sentence type (2) /'definitely someone other than *Taro*' for sentence type (3) (NP2), and finally 'two are equally possible.' Results for sentence type (2) showed significantly more NP2 choices for the IP condition where syntactic and prosodic boundaries coincided (90.8%), than for the noIP condition (82.4%). Therefore, the absence of an IP boundary after the initial NP induced more erroneous responses. By contrast, for sentence type (3), the presence or lack of an IP boundary was used to resolve the syntactic ambiguity. There were significantly more choices of the initial NP, '*Taro*' (60.2%) when there was no IP boundary, as compared to (33.7%) when there was an IP boundary at the same location. Hence, the absence of an IP boundary following the initial NP biased listeners toward the interpretation where the initial NP was the subject of the following embedded verb. The reverse pattern was found for NP 2 choices. There were significantly more NP2 choices (40.4%) when there was an IP boundary after the initial NP than when there was no IP boundary (15.4%). The very fact that listeners could posit *pro* for the embedded verb is remarkable especially in the absence of any preceding context. Once again, as in Korean, the results demonstrated the fundamental importance of prosodic phrasal structure to the assignment of syntactic constituency during sentence comprehension, particularly in the case of a head-final, *pro*-drop language.

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# The influence of depicted event scenes on written comprehension of locally ambiguous sentences

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Linguistic context has been found to influence comprehension of written sentences (Crain & Steedman, 1985; Altmann & Steedman, 1988). Similarly, visual contexts (visual referential context, depicted agent-action-patient events) have been shown to influence the auditory comprehension of locally ambiguous sentences (Tanenhaus et al., 1995, Knoeferle et al., 2003). One interpretation for the findings by Tanenhaus et al. (1995), and Knoeferle et al. (2003) is that the visual scene facilitates the comprehension of typically disfavored sentence structures, similar to the way in which a linguistic context may reduce comprehension difficulty in reading.

In the present experiment, we investigate whether the attentional eye-movement patterns observed in the visual world experiments by Knoeferle et al. (2003) reflect indeed processes of incremental thematic role-assignment. The method chosen was cross-modal comprehension where written sentences were preceded by *visual* contexts. The aim was to clarify how cross-modal comprehension proceeds at the visual-linguistic interface online, and to confirm our interpretation of what eye-movements in visual scenes reveal about comprehension processes: Are they truly indicative of language comprehension processes? In order to investigate this issue, we monitored eye-movements while people were reading initially ambiguous English main verb (MV)/reduced relative (RR) sentences after they had inspected a visual scene. The scene that preceded the sentence either showed the events described by the respective sentence, or did not display the events. There were hence four conditions, crossing the factors "Visual Context Type"(depicted event/no depicted event) with "Sentence structure" (MV/RR) (see Examples (1a), (1b), (2a), and (2b)). The Depicted Event images (1) always showed two events, one described by the MV sentence (ballerina-splashing-cellist), the other corresponding to the RR clause (fencer-sketching-ballerina). When the scene showed such events, thematic role-relations between the event participants were available from the scene prior to reading the sentence. If the depicted event scenes do indeed reduce comprehension difficulty for the RR clauses as compared to MV structures in the Depicted-Event conditions (1) versus the No-Depicted-Event conditions (2), then this should manifest itself in reduced reading times on the second noun phrase/by-phrase of the RR clauses in (1b) versus (2b).

An analysis of data from 32 participants confirmed that this prediction was borne out. We found a significant interaction of "Visual Context Type" and "Sentence Structure" in Regression Path Duration on the NP2/by-phrase region. Planned comparisons revealed that the difficulty associated with RR structures was smaller in the "Depicted Event" condition than in the "No Depicted Event" condition.

In addition, we found a significant interaction of "Visual Context Type" and "Sentence Structure" on the post-verbal region (*apparently*) with the opposite pattern. Reading times for this region were longer for RR clauses in (1b) than in (2b). We interpret this finding as indicative of an earlier structural revision for RR clauses in (1). This finding further confirms that the visual context reduced the processing difficulty associated with RR clauses on the prepositional phrase.

The results support the hypothesis that depicted agent-action patient events, and visual environments in general, influence both spoken and written sentence comprehension. In particular, they provide clear support for an interpretation of findings by Knoferle et al. (2003) in terms of thematic role-assignment processes. Furthermore, they indicate that results from studies which monitor anticipatory eye-movements in visual scenes do indeed reflect processes that are not unrelated to those revealed by reading-time studies.

## Examples

|  | Visual Context Type | Sentence Structure | |
|---|---|---|---|
| (1a) | Depicted Event | MV | The ballerina splashed apparently the cellist in the white shirt. |
| (1b) | Depicted Event | RR | The ballerina sketched apparently by the fencer splashed the cellist. |
| (2a) | No Depicted Event | MV | The ballerina splashed apparently the cellist in the white shirt. |
| (2b) | No Depicted Event | RR | The ballerina sketched apparently by the fencer splashed the cellist. |

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# The Modulation of Lexical Repetition Effects by Discourse Context:
## An ERP Study of Coreference

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Coreference occurs when two linguistic expressions refer to the same thing. Coreference can be established with a variety of linguistic forms, including pronouns, repeated names and repeated expressions. The use of repeated expressions to establish coreference allows an investigation of the relationship between basic processes of word recognition and higher-level language processes that involve the integration of information into a discourse model. Swaab, Camblin, & Gordon (in press) used event-related potentials (ERPs) to examine whether repeated expressions that are coreferential within a discourse context show the kind of repetition priming that is shown in lists of words. Unlike the result typical for word lists, in which repetition priming is increased when two words are presented more closely (i.e., a lag effect), Swaab, Camblin, & Gordon (in press) demonstrated a reverse-lag effect for repeated coreferential names within a discourse; that is, the lag effect was reversed when the linguistic manipulation that brought two words closer together made the antecedent phrase linguistically more prominent. The current experiment uses non-coreferential (length- and gender-matched) new names to provide an explicit baseline for measuring coreferential processes during reading. ERPs were recorded as participants read sentences (presented with RSVP) like those shown in Examples 1-4, in which the subject of the sentence comprised a singular or conjunctive noun phrase, and in which the critical expression (to which the EEG was measured; italicized in the example) was either a repetition of the first-mentioned character in NP1 or a new name. For repeated names (but not for new names), the amplitude of the N400 was reduced in the conjunctive NP condition (Ex. 2) relative to the singular NP condition (Ex. 1) where the initial name was highly focused. This reversed-lag effect shows that integration of a repeated expression is easier when the initial name is not in focus. When the initial name was highly focused, relative to the new names (Ex. 3) no clear reduction of the N400 was found to the repeated name (Ex. 1), which also is a reflection of the difficulty of memory integration of the repeated name with a highly focused antecedent. In contrast, when the initial name was not highly focused, we did find a reduced N400 to the repeated names (Ex. 2) relative to the new names (Ex. 4), indicating that, in the absence of clear linguistic focus, repeated names are more easily integrated than new names. These results suggest that processes of coreference, which take advantage of information available in discourse organization, can sometimes override the recognition and memorial mechanisms for processing individual words.

**Examples**

(1)     At the office Dennis moved the desk because *Dennis* needed room for the filing cabinet.
(2)     At the office Dennis and Amanda moved the desk because *Dennis* needed room for the filing cabinet.
(3)     At the office Dennis moved the desk because *Lester* needed room for the filing cabinet.
(4)     At the office Dennis and Amanda moved the desk because *Lester* needed room for the filing cabinet.

# Noun Phrase Type and Referential Processing in Korean:
## An Eye-tracking Study

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A great deal of research has shown that sentence complexity effects are moderated by the types of noun phrases (NPs) in a sentence. However, it is still a matter of debate what characteristics of NPs cause reduction in processing difficulty. For instance, in a complexity rating study, Warren and Gibson (2001) found that complexity of object-extracted relative clauses (RCs) (*e.g., The reporter that you/the doctor met spoke very quickly.*) was most reduced by having indexical pronouns (e.g., *you* or *I*) in the subject position within the RC.

Warren and Gibson propose that indexical pronouns impose less of a load on working memory than other types of referring expressions because they refer to entities that are immediately available and most accessible in the comprehender's environment. However, the similarity-based interference account (Bever, 1974; Gordon, Hendrick & Johnson., 2001) views indexical-pronoun effects in a different way. In a series of self-paced reading experiments, Gordon et al. found greatly decreased difficulty in object-extracted RCs when the sentential subject and the subject in the RC came from different referential types (e.g., when one was a name and the other was a common noun). This suggests that interference can occur when the critical NPs are of the same type.

The present study reports results from two eye-movement experiments investigating how and when the accessibility and similarity of the critical NPs affect the processing of complex sentences in Korean, a verb-final language with canonical SOV order. In Korean, it is possible to stack a large number of sentence initial NPs without causing severe processing difficulty. Further, Korean orthography allows the visually presented word size to be held constant across types of NPs which greatly facilitates comparisons across conditions when using eye-tracking methodology.

The first experiment tested center-embedded complement clause structures to determine how the accessibility and similarity of two adjacent subject NPs contribute to processing difficulty. We varied whether the matrix subject NP and the embedded subject NP were pronouns or descriptions as shown:

**Examples**

(1) ***Kutul-i***        ***wuli-ka***            silhum-ul                    haysstako            malhayssta.
   *They-NOM*         *we-NOM*             experiment-ACC            ran                    said
   'They said that we ran experiments.'
(2) ***Uysa-ka***        ***haksayng-i***        silhum-ul                    haysstako            malhayssta.
   *Doctor-NOM*       *student-NOM*        experiment-ACC            ran                    said
   'The doctor said that the student ran experiments.'
(3) ***Kutul-i***        ***haksayng-i***        silhum-ul                    haysstako            malhayssta.
   *They-NOM*         *student-NOM*        experiment-ACC            ran                    said
   'They said that the student ran experiments.'
(4) ***Uysa-ka***        ***wuli-ka***            silhum-ul                    haysstako            malhayssta.
   *Doctor-NOM*       *we-NOM*             experiment-ACC            ran                    said
   'The doctor said that we ran experiments.'

Both first-pass reading and rereading time data produced a significant effect of the type of the matrix subject NP, with the description condition taking longer to read than the pronoun condition in first NP and second NP regions. Effect of the similarity of two adjacent subject NPs were not detectable in first-pass times but were significant in rereading times (longer rereading time for same type of NPs). In the second experiment pronouns were replaced with names. While no effects approached significance in the first-pass reading, there was a significant interaction between the type of the matrix and embedded subject NP in rereading. These interactions showed that reading time for matrix subject NP was elevated when the following, embedded subject NP was of a matched as compared to non-matched type.

These results provide evidence that the referential form of individual NPs and the similarity of two adjacent NPs both contribute to processing difficulty and that similarity-based interference occurs late in text integration and comprehension process.

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# On the Role of Pauses and Intonation in the Interpretation Of Sentence-Medial Parenthetical Adverbs in English

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Commas and prosodic boundaries have been shown to affect the resolution of closure ambiguities and garden path sentences (Clifton 1993, Hill 1996, Speer et al. 1996). Potentially ambiguous adverbs in English such as *naturally* in (1) have been presented (e.g., Jackendoff 1972) as another example where commas and auditory breaks are crucial to meaning, here distinguishing between **S**entential (1.a) and **M**anner readings (1.b) of the adverbs. Previous work, however, gives no empirical evidence of the role of such cues in this type of ambiguity, relying instead on intuitive data.

(1)       Mr. Nathaniel River's grandfather (,) <u>naturally</u> (,) recited the old poems,
          a.  since of course he figured everyone wanted to hear him reciting.
          b.  you could tell from his delivery that he had been a skilled reciter.

Experiment 1 of the current study investigated whether talkers (5 participants) actually produce silent pauses as a means of disambiguation (a pause was deemed to be present if the silent portion was never shorter than a minimum duration taken to be equal to the average duration of an intervocalic stop produced by the speaker increased by four standard deviations). Surprisingly, parenthetical adverbs appearing in text with commas were not reliably uttered with pauses and seldom formed autonomous Intonational Phrases (contra, for example, Nespor & Vogel (1986)'s claim that they do so automatically). More consistently, talkers produced a pitch contour difference between the two readings: a falling (H* L-L%) contour (= **S**entential intonation) for the adverbs with commas but a rising (L*+H) contour (= **M**anner intonation) for the adverbs without commas.

A perception study (Experiment 2: 40 participants) further supports that it is the F0 difference, not pause insertion, that most effectively steers the listener in the intended directions. In the experiment, listeners were asked to identify the best continuations to sentences like (1) in four different prosodic conditions (see Table 1 below). The results show that the F0 patterns were sufficient to indicate prosodic boundaries, with or without silence, demonstrating that pauses are redundant cues. Additionally, while previous work had divided adverbs into simple **S**entential or **M**anner-biased classes, the adverbs actually span a wide range of reading preference levels. Thus for some adverbs, their reading preference overrode the effect of intonation.

The results above taken together suggest that (i) the power of commas and pauses as a disambiguating means varies depending on the types of ambiguity involved, and more sophisticated prosodic contours may be more important; and (ii) that factors other than prosodic cues, (specifically inherent lexical biases factor, as in the verb biases reported in e.g., Garnsey et al. (1997)), must be considered in the discussion of the resolution of the potentially ambiguous adverbs in English.

**Table 1**: Four Auditory Stimuli Types

| SP | SNP | MP | MNP |
|---|---|---|---|
| **S**entential intonation + 250ms. pauses before and after the adverbs | **S**entential intonation without pauses | **M**anner intonation + 250 ms. pauses before the adverbs | **M**anner intonation without pauses |

# Constraints on Variables in Neural Net Syntax
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Previous work has shown that Simple Recurrent Networks (SRNs) can extract information from a corpus of sentences sufficient to represent grammatical dependencies such as subject-verb agreement (Elman 1993; Rohde and Plaut, 1999). Impressive as these results may be, there are at least two open questions about the form of the knowledge that these networks acquire which remain open: (1) How structurally specific are the generalizations that SRNs learn about grammatical dependencies? To what degree can SRNs abstract over different structures to form a unified generalization about a grammatical dependency? (2) How lexically specific is the knowledge SRNs learn? Are grammatical dependencies learned as general relations between constituents (or word classes) or as relations between specific words?

Human linguistic abilities are at their core based on variable-containing generalizations—i.e., they are not tied to specific lexical items or specific syntactic structures (Marcus, 2001). Knowing whether SRNs can form such generalizations is therefore of considerable interest in evaluating their suitability as a model of human language acquisition. To address these issues, we investigated the ability of SRNs to learn to assign reference to anaphoric elements like *himself* in sentences like *John saw himself*, following the work of Joanisse and Seidenberg (2003). Our training regimen was as follows:

**Stage 1**: We trained an SRN to perform word prediction on a corpus of transitive sentences with subject-verb agreement, recursively embedded relative clauses, and reflexive pronouns. When the network error stopped decreasing, the hidden units of this network were frozen.

**Stage 2**: A second SRN was added, using the hidden units of the first network as input. This second network was trained to map words to their referents.

Motivation for this two-stage design derives from the idea that the first SRN induces a representation of sentence structure in its hidden units. If this representation embodies the actual syntactic structure, then it should suffice as input for learning the structurally defined antecedents of reflexives.

The quantitative performance of this network on word prediction was comparable to previously reported results: mean divergence error per word was 0.021 outsample, 0.018 insample. On the referent assignment task, the quantitative results were quite good: 97% correct outsample, 98.2% insample. Such numerical results do not speak to the matter of generalization, though. Upon detailed testing, we found that the network broke down on examples like *John who saw Bill likes himself*, assigning *Bill* as the antecedent of *himself*. Examination of the range of failures revealed that the presence of the (non-constituent) linear sequence *Bill likes himself* was the basis for these errors. This suggests that the network has not learned a general structural principle (use a locally c-commanding subject) to carry out reference resolution, as the presence of linear sequences is irrelevant to such a principle.

To further investigate the network, we examined the structure of the representational space it induced by comparing hidden unit representations for specific sentence contexts. For example, in the sentences *John who saw Bill likes himself* and *John likes himself,* the contexts immediately preceding the word *himself* are equivalent in that, according to the grammar employed, the contents of relative clauses have no predictive relationship to what follows them. Hidden unit representations for such equivalent contexts were compared in a set of 63 sentences in which the subject, main verb, and sentence type (the presence and structure of a relative clause) were systematically varied. One might expect this set of points in hidden unit space to cluster together according to subject, since the subject is the only predictive feature at that point in the sentence. But hierarchical cluster analysis and multidimensional scaling revealed that the representations of contexts corresponding to different sentence types were more separated than those representing different subjects. This finding further demonstrates that the network has learned to handle the same syntactic relation differently in different syntactic contexts.

Finally, we exploited the fact that the Stage 2 network uses a pre-acquired representation of sentence structure to test the lexical specificity of the network's constraint on reflexive binding. In the training data for stage 2, we withheld sentence-interpretation pairs in which one of the names served as the antecedent for a reflexive (which were not withheld in stage 1 training). When the fully trained network was tested on sentences in which this name was the reflexive's antecedent, it systematically failed to provide a viable interpretation. This result suggests strongly that the network's generalizations are lexically specific, posing a cognitively plausible instance of Marcus's (2001) *a rose is a rose* problem.

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# Word-order and prosody in the attachment of relative clauses in Japanese

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An extensive literature has investigated the interpretation of relative clauses (RCs) as in (1) (from Cuetos & Mitchell, 1988). However, most discussions have been restricted to postnominal RCs. In Japanese, the attachment of prenominal RCs has been controversial because of segmentation problems in self-paced reading experiments (Kamide &Mitchell, 1997; Kamide et al., 1998). We report a series of experiments that (1) confirm the local preference in KM's items and (2) indicate that word-order but not implicit prosody has a critical role in RC attachment in Japanese.

Experiment 1 eliminated segmentation problems in the non-cumulative moving-window self-paced reading presentation by showing the two head nouns in one region (region 2 in (2)), therefore making the nonlocal noun available as early as possible. Results confirmed the preference for local attachment as (2b) was read faster than (2a) in region 2 ($F1(1,19) = 28.73$, $P < 0.01$; $F2(1,23) = 13.2$, $P < 0.01$). In regions 3 and 4, nonlocal attachment was faster in the participants' analysis. In region 3, we replicated RC-length effects found by Kamide and colleagues, which are compatible with the proposal that implicit prosody affects comprehension during silent reading (Fodor, 2002). Plausibility as measured by two norming studies does not account for reading times in any of the regions except region 4.

Experiment 2 tested the importance of implicit prosody (Fodor, 2002). According to working memory results, phonological effects (e.g., phonological similarity and word length effects) are eliminated in the memorization of word lists when participants repeat non-sense syllables aloud (inner-speech suppression, ISS) by preventing rehearsal in the phonological loop (Baddeley, 1990, for a summary). If implicit prosody is effected in the phonological loop, it should be eliminated with ISS. This was the case as some length effects observed in the silent conditions were eliminated in the ISS conditions. Nevertheless, we replicated the reading time patterns of Experiment 1: initial local preference which reverts to non-local preference at the end. There was no interaction between task and attachment in any of the regions. Thus, prosody is unlikely to be the critical factor determining attachment given that reading patterns remain the same even when prosody is suppressed.

In (2ab), the complex object NP (headed by `fingerprint') is scrambled to the front of the clause. Experiment 3 compared canonical (3b) to scrambled (3a) word-orders. With scrambling, local attachment was faster ($F1(1,31) = 4.77$, $P < 0.05$, $F2(1,23) = 3.77$, $P = 0.065$) replicating Experiments 1 and 2, whereas nonlocal attachment was numerically faster with canonical order ($F1(1,31) < 1$; $F2(1,23) = 1.15$, $P = 0.29$). The interaction (attachment x word-order; $Ps < 0.05$) supports the claim that word-order is a critical factor in RC attachment, which we relate to the importance of the matrix predicate for the salience of the non-local noun  (Frazier, 1990; Gibson et al, 1996).

## Examples

(1) the daughter of the colonel [RC who suffered the accident ]

(2) (from Kamide & Mitchell, 1997; numbers indicate the regions in the non-cumulative self-paced presentation)

a. Non-local attachment

```
1 (RC)                    2 (head nouns)
Hoosekibako-no sumi-ni  nokotteita          hannin-no   shimon-o
jewelry-box-gen corner-loc remained         criminal-gen  fingerprint-acc

3 (matrix subject)   4 (matrix predicate)
keisatsu-ga          nantoka  mitsukedashita.
police-nom           somehow  discovered
```
`The police somehow found the fingerprint of the criminal that remained in the corner of the jewelry box.'

b. Local attachment

```
1 (RC)                    2 (head nouns)          3 (matrix subj)   4 (matrix predicate)
50dai dansei-to suiteisareru   hannin-no shimon-o      keisatsu-ga       nantoka mitsukedashita.
50's male-as supposed   criminal-gen fingerprint-acc police-nom       somehow discovered
```
`The police somehow found the fingerprint of the criminal who is supposed to be a man in his 50's.'

(3)      a. Scrambled conditions:   RC  head-nouns  matrix-subject  matrix-predicate.
b. Canonical conditions:    matrix-subject  RC  head-nouns  matrix-predicate.

# On the Use of Structural and Lexical Information in Second Language Processing

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Felser, Roberts, Marinis & Gross (2003) examined second language (L2) learners' resolution of relative clause attachment ambiguity and argued that L2 processing differs from first language (L1) processing in that L2 learners can use lexical information, but not structural information. The present study investigates whether Felser et al.'s claim can be generalized to L2 processing of other constructions. We show that the use of structural information is in fact attested in processing of subject and object relative clauses.

Traxler, Morris & Seely (2002) examined English native speakers' eye-movement in processing subject relative (SR) and object relative (OR) clauses, in which animacy of the first and second noun is manipulated (1). They found significantly longer gaze at the relative clause region in (1b) than in other three conditions. The results indicate two things: (i) the parser uses structural information that the English canonical word order is SVO, and hence a reanalysis is forced when the parser encounters the non-canonical word order as in OR (1b) and (1d), but (ii) this reanalysis is facilitated when the sentential subject is inanimate (1d), since an inanimate noun is a poor Agent and unlikely to be the subject.

These constructions allow us to examine whether structural or lexical information (or both) is used in L2 sentence processing. The following predictions are made:

**Prediction 1:**

If L2 learners use only structural information, they will process SR (1a) & (1c) more easily than OR (1b) & (1d).

**Prediction 2:**

If L2 learners use only lexical information, they will process relative clauses in which the verb has an animate external argument (1a) & (1d) more easily than (1b) & (1c), since animate nouns are good Agent and likely to be the subject.

**Prediction 3:**

If both types of information are used, SR (1a) & (1c) will be processed easily, and reanalysis induced in OR (1d) will be facilitated since the sentential subject is a poor agent. Thus, (1b) will be perceived as more complex than other three conditions.

Forty-four advanced Japanese-speaking learners of English took a sentence complexity rating questionnaire, in which they read English sentences and rated their complexity on a five-point scale. In this task, the rating is assumed to reflect the maximum intuitive complexity incurred during sentence processing (cf. Warren & Gibson, 2002).

The results show that Prediction 3 is borne out: (1b) was rated as significantly more complex ($p<.001$) than other three conditions which did not differ significantly, replicating the L1 eye-tracking data in Traxler et al. (2002). Our findings indicate that **both structural and lexical information are used in L2 processing**: (i) SR was processed easier than OR by structural information, and (ii) OR caused reanalysis but it was facilitated in (1d) by lexical information. The results suggest that L2 processing is similar to L1 processing, in contrast to Felser et al. 's claim.

**Examples**

(1)      a.      *Animate-Inanimate SR*
                 The musician that witnessed the accident angered the policeman a lot.
                 b.      *Animate-Inanimate OR*
                 The musician that the accident terrified angered the policeman a lot.
         c.      *Inanimate-Animate SR*
                 The accident that terrified the musician angered the policeman a lot.
         d.      *Inanimate-Animate OR*
                 The accident that the musician witnessed angered the policeman a lot.

# Individual differences in online syntactic
# processing in monolingual adults as reflected by ERPs

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Recent studies (Weber-Fox et al., 2003; Yamada et al., 2001) have indicated that event-related potentials (ERPs) are sensitive to specific aspects of linguistic proficiency within the population of normal monolingual English speakers. Previous studies concerning individual differences in adult native speakers have primarily focused on differences in working memory (Friederici et al, 1998, Just and Carpenter, 1992).

The present study seeks to determine whether individual differences in linguistic proficiency are reflected in brain organization for language within a population of normal native speakers of English. The ERP paradigm used was designed to highlight individual differences: participants with a wide range of educational backgrounds were recruited from the community; sentences were semantically and syntactically simple so as to reduce working memory demands; and the sentences were presented in the auditory modality so as to eliminate possible literacy confounds. Participants were given three subtests of the Test of Adolescent and Adult Language (TOAL-3) and the composite standardized scores were used to form two groups (N = 12). Low proficiency participants averaged below the $25^{th}$ percentile on each subtest, while High proficiency participants averaged above the $75^{th}$ percentile. Stimuli in the ERP paradigm consisted of naturally spoken English and "Jabberwocky" sentences, the latter formed by replacing open class words with pronounceable pseudowords. ERPs were recorded to insertion phrase structure violations and averaged to the critical word in each sentence (underlined):

**Examples**

| | |
|---|---|
| English: | Betsy can eat the apple at <u>this</u> park. |
| | *Betsy can eat the apple at that <u>this</u> park. |
| Jabberwocky: | Bapfa can eeg the agger at <u>this</u> pilt. |
| | *Bapfa can eeg the agger at that <u>this</u> pilt. |
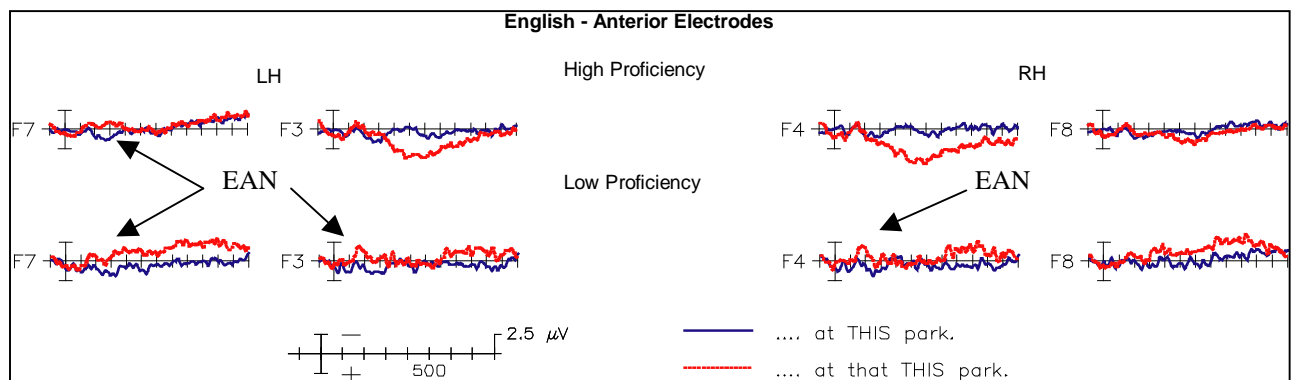


Syntactic violations in both English and Jabberwocky conditions elicited an early anterior negativity (EAN) followed by a late centro-parietal positivity (P600). In the Jabberwocky condition, the EAN was bilaterally distributed for both groups. In the English condition, the EAN in the High proficiency group was focalized over left lateral anterior sites, while the effect elicited in the Low proficiency group was more widely distributed across left lateral and medial and right medial anterior sites. Previous research has suggested that computational demands related to syntactic difficulty may be reflected in more widespread neural activity reflecting the recruitment of additional resources (Just et al., 1996). The present results suggest that while both groups may recruit additional resources in processing syntactic violations with reduced semantic information, Low proficiency speakers may recruit additional resources in processing simple spoken sentences in their native language compared with High proficiency speakers.

In the High group, the P600 in Jabberwocky was reduced compared to English, lending support to the hypothesis that the P600 indexes in part an attempt at semantic reanalysis in the face of a syntactic error. The P600 effect for English was larger and more widespread in the High group than the Low group, suggesting a difference in the extent to which the two groups attempt a reanalysis when faced with a syntactic error in their native language.

The results suggest that both later, more controlled processes and syntactic processes thought to be early and automatic (Friederici, 2002) might be sensitive to individual differences in linguistic proficiency within a population of normal monolingual speakers.

# Distinguish the indistinguishable: Frequency-based analyses of N400 effects

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The language processing system is often confronted with conflict engendering events that require resolution. The enhanced processing costs thus arising have long been used to gain insight into comprehension mechanisms. A promising methodological approach to this area of research became available with the advent of event-related potentials (ERPs), which provide not only precise temporal resolution, but also various dimensions for the classification of processing conflicts (e.g. polarity, topography). A seminal finding in this regard was that lexical-semantic processing difficulties consistently elicit a centro-parietal negativity peaking at 400 ms post critical word onset (N400). However, more recent findings have cast doubt on the association between the N400 and a homogeneous set of neural processes. Studies examining mental arithmetic and face processing have shown that the N400 is not confined to language. Furthermore, it has been elicited by linguistic manipulations independent of the lexical-semantic domain. We present a way of disentangling the relation between linguistic domains and ERP effects via the analysis of EEG frequency characteristics. Previous work indicates that activity in different frequency bands may correlate with distinct linguistic subdomains (Roehm et al., 2001). Here, we show that two sentence-level N400 effects that are of distinct linguistic origin but indistinguishable in terms of latency and topography are dissociable via frequency characteristics. To this end, we reanalyse the data of an ERP study in which two N400s were observed (Frisch & Schlesewsky, 2001). The first (Fig.1, C) formed part of a biphasic N400-P600 pattern in (ill-formed) German sentences with two subjects (1), whereas the second (Fig.1, B) obtained in grammatical sentences with an inanimate subject (2).

Three measures were applied: evoked power (EPow), whole power (WPow), and phase locking index (PLI). EPow measures the proportion of evoked EEG activity in a specific frequency band relative to critical stimulus onset. WPow measures the total power in a frequency band. The PLI measures the degree of inter-trial variation inphase between the responses to critical stimuli and thereby quantifies phase-locking of oscillatory activity irrespective of its amplitude. This method allows for a dissociation of the two N400 effects engendered by a case violation and an animacy violation, respectively, which are indistinguishable in terms of classical ERP measures. Whereas linguistic problem detection is associated with theta band activity (~3.5-7.5 Hz), conflict resolution correlates with activity in the delta band (1-3 Hz). The data further differentiate between the neuronal processing mechanisms involved in different types of conflict resolution on the basis of frequency characteristics (power vs. phase locking). Irresolvable processing conflicts lead to an abandonment of processing as reflected in an immediate reorganisation of the comprehension system, thereby giving rise to a higher degree of phase locking. Effortful conflict resolution, by contrast, engenders a higher degree of whole power by way of the additional processing cost. The measures applied here therefore not only provide a differentiation of ERP components in terms of different frequency bands, but also shed light on the underlying nature of the processing mechanisms drawn upon in conflict resolution.

## Examples

(1) Peter / fragt sich, / welcher Arzt / der Jäger / gelobt / hat.
   *Peter asks himself, [which doctor]$_{SUBJ}$ [the hunter]$_{SUBJ}$ praised has*
(2) Peter / fragt sich, / welchen Arzt / der Zweig / gestreift hat.
   *Peter asks himself, [which doctor]$_{OBJ}$ [the twig]$_{SUBJ}$ brushed has*
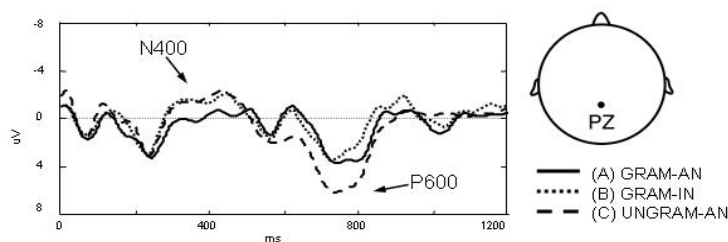


Figure 1.

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# Children's Comprehension of Japanese Topicalization and the Role of Referential Context

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Japanese canonical active sentences have an SOV word order. Young children (age 3-6) have difficulties in comprehending non-canonical scrambled OSV sentences, misconstruing them as if they were SOV (Hayashibe 1975, K.Sano 1977). However, Otsu (1994) demonstrated that Japanese 3-and-4-year-olds can comprehend scrambled OSV sentences without problems when the scrambled phrase is introduced in previous discourse and it is accompanied by a definite marker sono 'that'. In this paper, I inquire into what is required for children's comprehension of Japanese object topicalization sentences, which have non-canonical OSV word order, but also carry a topic particle wa attached to the object phrase.

There have been no previous studies that have examined Japanese children's acquisition OSV topicalization. By examining this construction, we can reevaluate Otsu's findings. One might think that the topicalization marker wa would aid in children's comprehension of OSV sentences. But it is not sufficient that the initial phrase be marked as a topic. My results show a similar result to Otsu's: children need a context to comprehend OSV sentences.

In this experiment, I tested Japanese children's comprehension of active SOV (the control), scrambled OSV, and topicalized OSV sentences in two environments: without discourse context or sono and with discourse context and sono. Following the earlier studies mentioned above, the experiment consisted of an act-out task, in which each child was presented stimulus sentences (with 4 types of verbs) and asked to act-out what the sentences meant by manipulating toy props. The subjects were divided into two groups: Group A were given stimulus sentences in isolation, and age-matched group B were given with discourse context and sono.

Results are provided in Table 1. Children in group A performed poorly with topicalization, indicating that an initial topic phrase is not sufficient for children's good comprehension of non-canonical word order. In contrast, children in the group B, for whom the discourse context and sono were provided, performed very well with topicalization. These results demonstrate that children need a discourse context and a definite marker sono on the initial phrase to comprehend non-canonical word order. The topicalization marker wa is not sufficient itself.

Our results give support to Meroni & Crain's (2003) claim that children's performance in syntactic processing can be improved when there is support of referential context. Also, our results show that young children do not lack grammatical knowledge of scrambling and topicalization, confirming the Continuity Assumption of grammatical competence (Pinker 1984, Crain&Wexler 2000).

**Table 1: Correct Response Rate of the Act-out Task**

| Group A | | | |
|---|---|---|---|
| *Age* | *Active* | *Scrambling* | *Topicalization* |
| 6 (N=9,mean 6;3) | 94.3%(33/35 ) | 75.0%(27/36) | 61.1%(22/36) |
| 5 (N=7,mean 5;5) | 96.4%(27/28) | 74.1%(20/27) | 57.2%(16/28) |
| 4 (N=7,mean 4;6) | 78.6%(22/28) | 50.0%(14/28) | 28.6%(8/28) |
| 3 (N=2,mean 3;9) | 100%(8/8) | 62.5%(5/8) | 37.5%(3/8) |
| Group B | | | |
| *Age* | *Active* | *Scrambling* | *Topicalization* |
| 6 (N=9,mean 6;3) | 97.2%(35/36) | 100%(36/36) | 100%(36/36) |
| 5 (N=7,mean 5;6) | 100%(28/28) | 92.9%(26/28) | 100%(28/28) |
| 4 (N=7,mean 4;5) | 89.3%(25/28) | 85.7%(24/28) | 82.1%(23/28) |
| 3 (N=2,mean 3;10) | 87.5%(7/8) | 75%(6/8) | 75%(6/8) |

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# The Cost of Enriched Composition: Eye-Movement Evidence from German

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Reading research in English has shown that the processing of logical metonymy as in "The student began the book" is costly compared with, e.g., "The student read the book" (McElree et al., 2001; Traxler, Pickering, & McElree, 2002). An explanation for this is that the interpretation of "began the book" requires type shifting of the object noun ("book") into an event representation (e.g. "began reading the book"), a mechanism also known as enriched composition (cf. Pustejovsky, 1995).

The present experiments were designed to answer two important questions: **(A)** Are the results explainable in terms of subcategorization preferences? (Corpus counts suggest that many verbs of the *begin* type prefer VP over NP complements). **(B)** Does a manipulation of the subject-NP contribute to the cost of enriched composition? (Sentence completion results suggest such an influence; cf. Lapata, Keller, & Scheepers, 2003).

Our main experiment was an eye-tracking study in German, comprising six conditions (see literal translations below): (1) contains a metonymic verb, (2) and (3) non-metonymic *control* verbs, and the (a) vs. (b) versions refer to the subject-NP manipulation. Note that, in German, a potential complement verb of "began" (1) would have to occur in clause-final position (e.g. "The student began the book with great pleasure *to read*"); early processing difficulty around "the book" in (1) would therefore be difficult to explain in terms of a subcategorization-preference violation (contrasting with English, where a complement verb would have to follow the matrix verb "began").

The materials were pre-tested by means of plausibility ratings and sentence completion studies assessing the predictability of the object noun ("book"). Reading times in the critical regions (verb, object-NP) were analysed in two steps. First, we conducted multiple regression analyses with reading time per region as criterion and number of characters, plausibility, and object-predictability as predictors. Second, comparisons between conditions were performed on *residual times* (raw reading times minus predicted times from the multiple regressions).

The residual time analyses revealed a reliable increase in processing load for the metonymic verb conditions (1) as compared to the control conditions, (2) and (3), which was particularly prominent in residual regression-path duration on the object-NP and residual total time on the verb (i.e., clearly before the clause-boundary, where no effects were found: $Fs < 1$). This can be taken as a replication of previous results from English.

Interestingly, there were no significant effects of the subject-NP manipulation - not even in (2) or (3). An analysis of raw reading time (where the expected subject-NP effects in (2) and (3) *did* show up) suggested that this was due to the fact that residual times were adjusted for plausibility differences across conditions (plausibility was found to be a significant predictor of raw reading time in multiple regression; calculating residual times obviously eliminated the effects of the subject-NP across conditions).

Hence, with respect to question **(B)**, we conclude that influences of the subject-NP on reading time do not go beyond plausibility. With respect to question **(A)**, we found that previous results from English are unlikely to be due to a subcategorization-preference violation upon encountering "the book" in (1) – the present German findings cannot be explained in this way. At first glance, it appears that our German data could be construed as some sort of temporary *ambiguity* or *prediction* effect (locally, "the book" may be the object of "began" or of a predicted complement verb of "began"); however, the absence of even just a marginal effect at the clause boundary suggests that no complement verb was predicted in the first place. This also explains why our German readers performed a ('potentially unnecessary') type shifting operation upon encountering "the book" in (1): apparently, there is a subcategorization-preference independent tendency to initially interpret "the book" as direct object of "began" (in line with findings from Pickering, Traxler, & Crocker, 2000). Taken together, we conclude that converging results from German and English provide strong support for the cost of enriched composition.

## Examples

(1)      The {a. student, b. author} began the book with great pleasure,..
(2)      The {a. student, b. author} read the book with great pleasure,..
(3)      The {a. student, b. author} wrote the book with great pleasure,..

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# Saying what's on your mind: Working Memory effects on syntactic production.

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When speakers produce sentences, they tend to use syntactic structures that allow them to mention easy-to-remember things earlier and difficult-to-remember things later. One way to explain such accessibility effects is as a working memory (WM) effect: In order to reduce load on WM, speakers ought to produce items that are more active in WM sooner and produce items that are less active in WM later. If so, individual differences in speakers' WM spans should affect accessibility effects. Specifically, speakers with smaller WM should be less able to maintain a constituent in WM especially when WM is otherwise taxed, and thus those speakers should not produce highly accessible things earlier, compared to speakers with larger or untaxed WMs.

In Experiment 1, speakers saw and remembered a list of two words (e.g., manager excuse). They then saw a single word (e.g., excuse) and indicated if it was on the initial list. On critical trials, the single word was one of the first two, thereby making it more accessible. Speakers then saw a sentence onset, and produced a sentence with that onset that then included both words from the list at the start of the trial. WM-load was manipulated by having speakers produce sentences with short subjects (in the onset fragment; The employee told…) or long subjects (The employee who spent last night partying told…). We used a median split on speaking-span-task performance (Daneman & Green, 1986) to classify speakers into low- and high-span groups.

The accessibility manipulation was effective, as only 16% of the forgotten post-verbal NPs were the accessible word, whereas 84% of the forgotten words were not. Speakers with low-WM-spans were influenced by accessibility only when under a low load (with short subject NPs), whereas speakers with high-WM-spans were influenced by accessibility only when under high load. This shows that accessibility effects emerge only when the relevant items can be maintained in WM, and when there is enough of a WM load to make an accessibility-based strategy advantageous.

Experiment 2 assessed these issues in a more naturalistic paradigm. Speakers described dative-eliciting pictures (e.g., a pirate giving a nurse an apple) in response to heard questions about the subject of a picture, which was described with a short NP (What's going on with the pirate?) or a long NP (What's going on with the pirate with the peg-leg?). Speakers then read one of the post-verbal NPs (apple or nurse), thereby making that NP more accessible, and then described the relevant picture to the questioner. High-span speakers produced syntactic structures with accessible NPs earlier, both in answers with short and with long subjects. Low-span speakers showed this accessibility effect only for sentences with short subjects and not for sentences with long subjects, where the high load presumably overwhelmed WM. Furthermore, the condition where speakers did not use accessibility effects was also the most disfluent condition, suggesting that accessibility effects are, in fact, related to the difficulty of sentence production.

Together these experiments show that availability manipulations affect sentence production when WM is likely to be involved, and that the way in which availability manipulations affect production depends on WM capacity.

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# Structural Focus and Prosodic Focus in Hungarian
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One special property of language is our ability to highlight certain elements of what we say, making them more salient than other elements. This is called "focus." In a language like English, one of the major ways to indicate focus is prosodic accenting. However, is there any role for prosody in languages which have a special syntactic position for focused items (e.g. Hungarian)? To investigate this question, the present study examined Hungarian sentences with elements placed in topic and focus positions, varying the information status of these two elements.

Neutral word order for Hungarian is SVO. Sentences observing this structure are completely unmarked in the discourse; they can be used to begin a narrative or a new topic (Horváth 1986), they contain no presupposed information, and the focus position remains empty. By contrast, in focus sentences in Hungarian, a post-verbal element is preposed to the syntactic focus position immediately to the left of the verb. The topic, if present, falls in sentence-initial position preceding the focus element.

In this experiment, ten target sentences containing both a topic and a focus were each embedded in three different contexts, which varied with respect to the information status of the elements in topic and focus position. The passages were produced by a native speaker of Hungarian and the target sentences were then excised from each scenario. Nine other native Hungarian speakers listened to the excised target sentences and were asked to match each sentence with one of the three contexts.

Acoustic analyses of the speaker's productions revealed three different intonation patterns for the three different contexts: (a) when the topic was new and the focus old, there were downstepped H*+L accents on both topic and focus, with primary stress on the focus; (b) when the topic was old and the focus new, there was a L*+H accent on the topic, H*+L on the focus with primary stress on the topic; (c) when both were contrastive, the same accent pattern as (b) but with a prosodic boundary between the topic and the focus and a fully deaccented verb.

In the perception task, the three prosodies were perceived as significantly different from each other both by subjects and by items ($F1(3,9)=16.415$, $p<.001$; $F2(3,10)=4.991$, $p<.05$). Additionally, the renditions were matched to their contexts more accurately than chance by subjects and by items (A: $t1(9)=1223.17$, $p<0.005$; $t2(10)=7.02$, $p<0.005$; B: $t1(9)=545.05$, $p<0.005$; $t2(10)=8.29$, $p<0.005$; Context C: $t1(9) = -761.4$, $p<0.001$; $t2(10)=4.86$, $p<.001$). Context A received the highest percentage of correct responses, followed by context C and finally by context B. The information structure that was easiest for subjects to identify was when the topic was new and the focus was old.

The results of this study show that even in a language with focus and topic positions, prosody is used to indicate different information structures. That is, speakers use different accent patterns in different contexts, and perceivers can use the prosody to recover the information status of topic and focus elements. Interestingly, the prosody seems to interact with the syntactic positions, since there was not an invariant contour used for both new topics and new foci, for example.

# The Role of Verbal and Spatial Working Memory in Relative Clause Attachment Preferences

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An influential finding in psycholinguistic research is that the resolution of the relative clause (RC) attachment ambiguity (as in 1) varies across languages. English, for instance, reveals an NP2 preference in that speakers tend to interpret the RC in (1) as being about "the actress" (Cuetos & Mitchell, 1988). Dutch speakers, on the other hand, show an NP1 preference and tend to interpret the RC as being about "the sister" (Brysbaert & Mitchell, 1996). The present study was designed to show that individual differences in working memory (WM) capacity can account for a significant amount of variance in the RC attachment preference. In addition, we explored whether the predictive power of reading span in sentence comprehension is explained by domain-specific skill or by a domain-general factor. In particular, we evaluated whether reading span predicted English attachment preferences independently of a non-verbal measure of WM capacity.

We used an individual differences design that measured verbal WM using a variant of the reading span task, spatial WM using the spatial span task, and RC ambiguity attachment preferences using an off-line questionnaire with 20 experimental items. As is standard in individual differences research, our sample was relatively large (N = 150), and we presented the stimuli in a fixed order to all participants to avoid participant x order interactions.

The two measures of WM correlated significantly with each other as well as with attachment preferences (Table 1). The positive correlation between spatial span and reading span is consistent with accounts of WM hypothesizing a domain-general WM factor. On the other hand, while reading span did predict attachment preferences after controlling for spatial span, there was no relationship between spatial span and attachment preferences after controlling for reading span. Therefore, reading span may correlate with attachment preferences not because it reflects a domain-general factor, but because both involve some of the same specific processes (MacDonald & Christiansen, 2002). In short, although there was evidence in this study for a domain-general WM factor, this factor alone did not account for the correlation between reading span and attachment preferences.

Although a weak overall NP2 preference (53%) was found, the results suggested that participants high in reading span (high-spans) drove this tendency. Table 2 indicates that high-span participants displayed an NP2 preference, low-span participants an NP1 preference, and mid-spans no preference. According to Mendelsohn and Pearlmutter (1999), who found similar results for object RCs, it is possible that low-span participants only retain the head NP of the subject, whereas high-span participants have enough WM capacity to keep track of both the head and the modifier. Preliminary analyses of data collected in Dutch have revealed that greater WM capacity leads to an increased preference for NP2 attachments, just as in English. The fact that the individual differences result can be generalized to a language that normally shows an NP1 preference suggests that an appeal to working memory may not be apt as an explanation for the cross-linguistic variation in attachment preferences. Nevertheless, the results highlight the importance of appropriate sampling in studies of attachment preferences, and they provide evidence that parsing strategies may be affected by working memory constraints.

**Example**

(1) The sister of the actress who shot herself on the balcony was under investigation.

**Table 1. Correlations**
(**$p < .01$, *$p < .05$)

|               | Spatial Span | Attachment Preferences |
|---------------|--------------|------------------------|
| Reading Span  | .416**       | -.338**                |
| Spatial Span  | --           | -.193*                 |

**Table 2. Percent NP2 Attachments as a Function of Performance on the Reading Span Task**
(data presented categorically for simplification—statistical analyses were performed on continuous data)

|                   | High Span | Middle Span | Low Span |
|-------------------|-----------|-------------|----------|
| % NP2 attachments | 67        | 51          | 41       |

# Long tails of reading time distributions modeled by a self-organizing parser

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Symbolic models of sentence processing usually make an additive process assumption. For example, garden path sentences are thought to take longer to read because, in addition to the normal parsing process, there is a reanalysis process.

Real reaction time data exhibit variation. The simplest augmentation of the additive model assumes gaussian noise is added independently to each process. This predicts normally distributed reaction times with garden pathing associated with increase in both mean/mode and variance.

It is well-known, however, that reaction time distributions are typically skewed, with a quick onset and a long tail. The hard conditions of a task increase the skewing without necessarily adjusting the mode [1]. Some prior approaches have argued that the skewing stems from the presence of different kinds of underlying processes: the convolution of a normal and a exponential distribution (an exgaussian distribution) has fit the data well in some studies (eg., [2]). [3] note that dynamical, self-organizing models that posit interactions among processes at multiple time scales predict that the log of reaction time should be approximately normal (i.e., the distributions are approximately lognormal) and they show close fits to data from word-identification studies.

We collected self-paced reading data on control sentences (1a) and garden path sentences (1b) from both a self-organizing model and human subjects.

In the model, perception of each word activates a fragment of a syntactic tree which seeks to combine with the fragments activated by other perceived words to form a parse. Gaussian noise in the activations results in skewed reaction time distributions with the garden path case (1b) producing a positive shift in both mean and variance.

We examined human reaction time distributions across participants and items at the four word region starting at the disambiguating verb ("frayed"). We compared the best-fitting (maximum likelihood) self-organizing model to the best normal, exgaussian, and lognormal fits, finding that the self-organizing model was closer to the data than the normal model. The lognormal and the exgaussian fit better than the other two models (and were comparable to each other). We conclude that the self-organizing model is closer to the mark than the additive process model and thus looks promising as way of explicitly understanding the source of the structure of reaction time distributions in sentence processing. Including interactions at more levels of linguistic structure (e.g., orthographic/phonological, semantic, pragmatic) may improve its performance.

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## Examples

(1a) When the boys climbed the rock the rope frayed badly and broke apart.
(1b) When the boys climbed the rope frayed badly and broke apart.

# (Lack) of context effects during lexical ambiguity resolution

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We present an eye-movement reading study to investigate two questions. Firstly, is there competition during lexical ambiguity resolution? Previous studies have shown that balanced ambiguous words preceded by neutral contexts (e.g., "pupil" in [1]) are harder to read than unambiguous words (e.g., Rayner & Duffy, 1986; Duffy et al., 1988).

(1) Peter mentioned the pupil, so we heard.

This is consistent with the claim that competition between meanings causes processing difficulty. However, the frequency of the unambiguous words was matched with the summed frequency of the two meanings of the ambiguous word. Hence, the frequency of each meaning was only half that of the control word, which may have caused the reading time differences.

We therefore compared balanced ambiguous words in neutral contexts (1) both with words matched for the summed frequency of the meanings as well as with words matched for the frequency of a single meaning. Ambiguous words were read slower than both summed frequency and single meaning controls. The difference between ambiguous words and single meaning controls indicates that the meanings of ambiguous words compete.

Secondly, is competition modulated by preceding contexts? In contrast to other studies on balanced words, we investigated negative contexts such as that in (2), which make one of the meanings implausible.

(2) Peter supported the pupil, so we heard.

According to context-sensitive models (e.g., Kellas & Vu, 1999; Martin et al., 1999; Tabossi, 1988), a biasing context has an immediate effect on ambiguity resolution. Therefore, competition in (2) should be reduced. In contrast, according to models that claim that use of context is delayed (e.g., Swinney, 1979; Tanenhaus et al., 1979), competition in (1) and (2) should initially be similar. In fact, if context is initially ignored during the selection of a single meaning, ambiguous words in a biasing context (2) may be harder than ambiguous words in a neutral context (1). The processor may initially select the implausible meaning in (2), but this results in difficulty when the reader discovers that the selected meaning is implausible.

Reading times for the ambiguous word did not differ in (1) and (2), indicating that competition occurred regardless of the preceding context. Furthermore, readers made more first-pass regressions from the ambiguous word in (2). This suggests that readers ignored context during the selection of a single meaning and that difficulty occurred because they discovered that the selected meaning was implausible. In order to make sense of the sentence, readers made a regression.

Our results support competition models which claim that the effect of (negative) contexts is delayed (e.g., Swinney, 1979). They are also consistent with the reordered access model if one assumes that context can only increase the activation of a meaning, but that a negative context cannot decrease it (e.g., Duffy et al., 1988). However, the results provide evidence against non-competitive models (e.g., Hogabaum & Perfetti, 1975) and context-sensitive models (e.g., Martin et al., 1999; Tabossi, 1988).

# Constraint defeasibility and concurrent constraint satisfaction in human sentence processing

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Hakes (1972) was the first to show that increasing head-dependent distance in English can facilitate processing, and later studies found similar results for German (Konieczny 2000) and Hindi (Vasishth 2003) in a variety of head-final constructions. Based on the German studies, Konieczny (2000) suggests that processing is easier just in case the predictibility of an upcoming verb is greater.

By contrast, Discourse Locality Theory (Gibson 2000) predicts an increase in processing difficulty with increasing distance, but only if the intervening elements introduce new discourse referents.

These two views appear to be irreconcilable given the data, but we argue that two distinct constraints apply during processing, verb predictibility (we define this as increased activation of a predicted verb type) and referent-building cost, and that either constraint can dominate, resulting in a processing speedup, or both can apply and cancel out each other's effects, resulting in no difference in processing difficulty.

A self-paced reading study was carried out in which the final noun phrase (NP) was either followed immediately by a verb selecting for it (1a), or this verb and its dependent NP were interrupted by an adverb (1b), a genitive NP (1c), or a prepositional phrase (1d). In (1b)-(1d) the verb immediately followed the interrupting phrase.

(1) a. Der Junge, der [den Lehrer, der den Direktor traf], beleidigte, flog von der Schule
   The young-man, who the teacher, who the director met, insulted, fled from the school
   'The young man fled from the school who the teacher insulted who the director met.'
   b. ...der den Direktor NEULICH traf,...
   c. ...der den Direktor DES GYMNASIUMS traf,...
   d. ...der den Direktor BEIM ABSCHLUSSFEST traf,...

The results showed a significant slowdown at the verb "traf" only when the genitive NP preceded it (1c vs. 1a); in the other cases (1b,1d) there was no difference in reading time at "traf" (compared to 1a). By contrast, an eyetracking study conducted previously and using the same materials (Vasishth, Cramer, Scheepers, and Wagner, 2003) showed a significant speedup at the verb only when the adverb was intervening (1b vs 1a).

The divergent results in the two experiments are not incompatible if, between the two methodologies eyetracking versus noncumulative self-paced reading, only the latter taps into memory-intensive effects such as referent-building and referent-maintaining costs. This would explain why the genitive NP resulted in a slowdown at the verb in self-paced reading but not in eyetracking.

Taken together, and in conjunction with earlier results from Hindi and German, these two experiments suggest that (i) when an intervening element predicts a verb but introduces no discourse referent (adverb), verb processing is facilitated, (ii) when an intervening element introduces a discourse referent but does not predict a verb (genitive NP), there is increased difficulty at the verb, and (iii) when an intervening item predicts a verb AND introduces a referent (PP), the two constraints cancel each other out. We argue that this explanation entails an architecture where constraints apply concurrently and where processing load is determined by the net effect of all constraints applying at given point during parsing: opposing constraints that apply in a given context can neutralize each other's effects.

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# Linguistic Focus and Discourse Representation: Evidence from Rereading

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The role of linguistic focus in reading is currently unclear. Results in the eye-movement literature have been inconsistent across studies. For example, Birch and Rayner (1997) found that readers slowed down when reading a focused region of a sentence, while Morris and Folk (1998) found the opposite result (with both sets of results showing effects in relatively late eye-movement measures like total time). However, most of the reported experiments used different sentence frames for different focus conditions, which could potentially have affected the eye-movement measures.

We report findings from an eye-movement experiment using a re-reading paradigm (Raney & Rayner,1995). Participants read a text twice, with the possibility of one word changing between the first and second text displays. We were particularly interested in fixation behavior in the second display, which we expected to vary as a function of focus, in conditions where the word changed.

In the current experiment, participants had a secondary task of detecting the word changes, which were always to a semantically similar word. In (2), the word *rucksack* changes to *backpack*. Following the context in (1a), we consider this word to be in a focused position because of the embedded question (*which woman...*), which implicitly sets up a set of alternatives in the discourse representation. This results in focus being assigned to the NP *the woman carrying the rucksack/backpack* in (2). The word *rucksack/backpack* is crucial in answering the previous embedded question. The non-focus context sentence (1b) did not have this property.

In two other conditions (focus/no-change, non-focus/no-change) the word *backpack* appeared in both first and second displays. Note that the content of the critical second sentence is identical across conditions in the second display.

## Examples

(1)a    **First sentence: Focus:** We all wondered which woman was the new employee.
  b    **First sentence: Non-focus:** We all wondered where the new employee was going.

(2)    **2nd and 3rd sentences (both focus conditions, with change)**
    The woman carrying the rucksack/backpack looked a bit lost.
    In such a big building it's so easy to lose your way.

In the second text presentation focus interacted with change: readers made a higher total number of fixations on a changed critical word than an unchanged one, but only when the word was in focus; there was no effect of change for unfocused words. Similar effects were found in first-pass reading time and skipping rate. Analysis of the *first* text display investigated whether this focus effect could be explained by low-level perceptual factors, i.e. whether *rucksack* was simply fixated more often or for longer on first reading, leading to deeper initial encoding. However, this was not the case. Reading times and number of fixations were not affected at all by focus in the first display.

These results support a model where focus enhances the level of detail with which lexical information is maintained in the discourse representation (see also Sturt et al, in press). They are not compatible with models which emphasize the effect of focus on initial perceptual processes during reading.

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# Effects of the locality of syntactic dependencies on eye-movements in reading

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Much recent work argues that working memory bottlenecks are an important source of on-line sentential complexity effects (Gibson 1998; Gordon, Hendrick and Johnson 2001; VanDyke and Lewis 2003). However, the supporting evidence is almost exclusively from self-paced reading experiments. The limited window methodology typically used in such experiments does not permit parafoveal preview or allow readers to reinspect earlier parts of a sentence, a common response to difficulty when reading. This serializes the input in a way that may impose an unnatural burden on the processes which maintain and manipulate partial linguistic representations, resulting in an overestimation of the influence of memory limitations on sentential complexity.

The present experiment investigates whether memory bottlenecks account for syntactic complexity effects on eye-movements. We adapted stimuli like (1) from Grodner, Watson, & Gibson's (2000)(GWG) experiment testing the integration cost metric of Gibson's (1998) Dependency Locality Theory (DLT). GWG found that the difficulty in processing a word, indexed by self-paced reading times, is strongly affected by the length of the material intervening between the word and the position upon which it is dependent in the partially interpreted structure. Dependency lengths were varied by manipulating whether the sentence's subject headed an object-extracted relative clause (RC) (1d,e,f below) or not (1a,b,c), and whether the most-embedded subject was unmodified (1a,d), modified by a prepositional phrase (1b,e) or by an RC (1c,f). The greatest variation in dependency length occurs at the matrix and embedded verbs.

(1)　　a. (The nurse) (scolded ) (the aide) while ...
　　　　b. (The nurse) (from the clinic) (scolded) (the aide) while ...
　　　　c. (The nurse) (who was) (from the clinic) (scolded) (the aide) while ...
　　　　d. (The aide who) (the nurse) (scolded) (helped) (the medic) while ...
　　　　e. (The aide who) (the nurse) (from the clinic) (scolded) (helped) (the medic) while ...
　　　　f. (The aide who) (the nurse) (who was) (from the clinic) (scolded) (helped) (the medic) while ...

While complexity due to dependency length is captured by the DLT's integration cost metric, the DLT also predicts complexity due to storing predictions for required syntactic categories. This storage cost metric did not predict self-paced reading times in GWG. However, storage costs may be evident in more natural reading, when readers can reread structures that they had difficulty keeping in memory.

In the current experiment, second pass and total reading time reflected the influence of both integration and storage costs. Dependency length accounted for over 50% of the variance in regression path duration, second pass, and total reading times at the verbs, replicating the pattern found by GWG. Storage costs accounted for over 35% of the variance in second pass and total reading times over all regions of the sentence. Regression patterns showed an interesting dissociation. The percentage of first pass regressions out of a region was correlated with storage costs ($r^2$=.18, F=6.2, p<.05). Integration costs were not related to this measure. The opposite was true for regressions into a region. The percentage of regressions into the verb regions was correlated with integration cost ($r^2$=.73, F=19.0, p<.01), but storage cost did not predict the percentage of regressions into any regions. This suggests that upon the introduction of a new dependency, readers reinspected previous regions, possibly to better consolidate the dependency structure of the current partial parse in memory before moving on in the text. In contrast, readers were more likely to reinspect the conclusions of longer dependencies. This may reflect a broad tendency to look back at points in the text where there was difficulty integrating a word into a mental representation. This eye-tracking evidence corroborates and extends previous results, demonstrating that memory effects in complexity are not dependent on a limited window display.

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# Adjectival Modifiers and Reference Resolution:
# When Prosodic Focus Matters

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Previous eye-movement studies have shown that listeners establish referents in sentences as soon as adjectival modifiers uniquely identify them (e.g., [1]). Furthermore, Sedivy and colleagues [2] found a preference to interpret modified nouns contrastively. They observed earlier saccades to a second referent when it formed a contrastive set with a first referent than when it did not. Surprisingly, Sedivy and colleagues did not find an effect of prosodic focus over and above the use of adjectival modifiers. This could be because the first referent had lacked the relevant prosodic marking. The present study therefore tested the use of prosodic focus for the resolution of reference ambiguity again, crucially changing the prosodic marking of the first referent (narrow rather than broad focus).

Experimental displays contained a first referent (red book), a contrastive second referent (green book), a non-contrastive second referent (green shirt), and an unrelated distractor object. First, 32 native German listeners were told in German to "click on the RED book". Narrow prosodic focus on the color adjective, as indicated by capital letters, is appropriate given that the display contains a contrasting object (green book). Second, listeners were either told to click on the other member of the contrastive set (green book) or on the non-contrastive object (green shirt). Prosodic focus in the second instruction was either on the adjective (narrow focus in 1(a) and (b)) or on the noun (broad focus in 1(c) and (d)):

**Examples**

    (1)        Click on the RED book.

    (a)        Now click on the GREEN book.
    (b)        Now click on the GREEN shirt.
    (c)        Now click on the green BOOK.
    (d)        Now click on the green SHIRT.

It was predicted that narrow focus in the second instruction strongly marks the upcoming referent as belonging to the contrastive set (green book), whereas broad focus should not bias the interpretation. Indeed, in both 1(a) and (b) only fixation probabilities for the contrastive object (green book) increased immediately after adjective onset, prior to noun onset. In 1(b), the increase in fixation probabilities for the non-contrastive object (green shirt) was delayed until after noun onset. Narrow focus apparently raised the significance of objects that belong to the contrast set. Contrary to Sedivy et al., we only found a contrastive interpretation for color adjectives when narrow focus was given in the second instruction. In the broad focus conditions (1(c) and (d)), immediately after adjective onset both the contrastive and the non-contrastive object were fixated. The increase in fixation probabilities for the non-contrastive object in 1(d) was not delayed. The results suggest an interplay between the preference for contrast sets and the use of prosodic focus. Whereas broad focus on the first referent in Sedivy et al.'s study could not modulate the interpretation of subsequent prosodic focus, narrow focus in our study could. In sum, listeners not only interpret color adjectives incrementally, taking the visual context into account, but use prosodic focus immediately to resolve reference ambiguities.

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# Interaction between Subject Type and Ungrammaticality in Doubly Center-Embedded Relative Clauses

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It is well known that a doubly center-embedded relative clause (RC/RC), such as (1), is very difficult to process. Associated phenomena are: (2a) An ungrammatical RC/RC in which the second verb has been dropped, is judged to be as, or more, acceptable than the grammatical version (V2-drop effect) [1,2]; (2b) When the innermost subject is a first- or second-person pronoun, an RC/RC seems less complex (N3-type effect) [3]. We have investigated whether there is an interaction between these factors.

In a self-paced reading experiment, we crossed the N3-type with grammaticality. N3 was a name (1), a first-person pronoun (2b), or a third-person pronoun with a referent (3). Each N3-type appeared in grammatical and V2-drop sentences. In the region following the final verb, reading times increased for grammatical sentences (compared to V2-drop sentences) only under the name condition, indicating that V2-drop was felicitous only under that condition. These results suggest that the prediction of V2 (incurred by N2, the outer RC's subject) was maintained in the pronoun conditions, but not in the name condition.

The leading account of complexity, the Dependency Locality Theory (DLT) [4], has difficulty in accounting for these effects. Under the DLT, the highest integration cost is incurred at V2. However, this cost is incurred upon encountering V2, and cannot explain dropping V2's prediction prior to V2's occurrence. Furthermore, the proposed mechanism of the N3-type effect (that integration cost is greater across a new discourse referent than a previous discourse referent) was not supported in an experimental test of that assumption [5]. Thus the DLT cannot adequately explain the V2-drop and N3-type effects, or their interaction.

In contrast, we propose a model in which structural factors to explain these phenomena [6]. Subjects of incomplete clauses are stored in serially in syntactic Working Memory (WM) on successive temporal "slots" of an underlying oscillatory cycle [7]. At the conclusion of the inner RC, the representation of N3 should be deleted from WM (i.e., inhibited). Therefore, WM is searched for the corresponding syntactic structure. For example, when N3 is a name, a search for a full-NP subject of an RC is carried out. In general, WM read-out is initiated only at the start of a cycle, to preserve ordering information. Because WM items are accessed consecutively, N2 is encountered before N3. In the name condition, N2 matches the search criteria, since N2 is also a full-NP, RC subject. Therefore, the search is terminated and inhibition is prematurely initiated at N2, thereby deleting both N2 and N3 from WM. As a result, only the matrix subject remains, and V2-drop becomes felicitous. In the pronoun conditions, N3's syntactic type differs from N2, so N2 does not match the search criteria. Therefore, deletion of the inner RC proceeds correctly (leaving N2 in WM), and V2-drop is not felicitous.

## Examples

(1) The vase that the man that Sue dated bought fell off the shelf.
(2) * a. The vase that the man that Sue dated fell off the shelf.
  b. The vase that the man that I dated bought fell off the shelf.
(3) According to Sue, the vase that the man that she dated bought fell off the shelf.

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# Bilingual Sentence Processing: Relative Clause Attachment in Basque and Spanish

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I. Monolingual studies have shown that relative clause attachment ambiguity, illustrated by the sample English sentence in (1), is resolved in different ways by speakers of different languages. In English, there is a weak tendency for the relative clause to be taken as modifying the syntactically lower noun phrase, the actress, but in Spanish, a significant preference for the relative clause to modify the higher noun phrase, the lover, has been found (e.g., Cuetos & Mitchell 1988, Carreiras & Clifton, 1993, Carreiras & Clifton, 1999). Readers in other languages showed either a high attachment advantage in Dutch (Brysbaert & Mitchell, 1996), French (Zagar, Pynte & Rativeau, 1997) German (Hemforth, Konieczny & Scheepers, 1994), as well as a low attachment advantage in Italian (De Vincenzi & Job, 1993; De Vincenzi & Job, 1995)

II. Here we present a study on relative clause attachment preferences for Basque, where we have found a strong low attachment advantage. Basque is a head final language, and therefore, it has pre-nominal relative clauses (see example in (2)).

In order to investigate attachment preferences for this type of sentences in Basque and Spanish a questionnaire study was carried out with Basque-Spanish bilinguals. Relative clause ambiguous sentences were presented in Basque and Spanish to 4 groups of subjects: (a) bilinguals from birth received each language from each parent. (b) Basque dominants received only Basque up to the age of 4 years (both parents spoke Basque with them), (c) Spanish dominants were exposed only to Spanish up to the age of 4 and (d) Spanish monolinguals, who where born in the Basque Country but has not contact with Basque.

III. For the group of Basque dominants (b) our data showed a significant Low Attachment preference both in Basque (78,68%) and Spanish (59,69%). The same pattern was obtained for the group of birth bilinguals (a) (Basque: (78,75%; Spanish: 65,83%). Data for Spanish dominants showed no uniform attachment preference. Data will be discussed in terms of current models of relative clause attachment (Frazier´s (1987) Garden Path Theory, Cuetos and Mitchell´s (1988) Tunning Hypothesis, Frazier and Clifton´s (1996) Construal, MacDonald, Pearlmutter and Seidenberg´s (1994) Constraint-Satisfaction model, Gibson (1998) SPLT and Fodor (1998)) focusing specially on bilinguals' syntactic processing.

## Examples

(1)  Someone shot the lover of the actress [that was on the balcony]
(2)  Norbait-ek        [balkoi-an    zegoen]     aktore-a-ren   maitale-a tirokatu zuen
        someone-Erg    balcony-Loc was-Comp actor-D-Gen  lover-D   shoot   did

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# Authors Index