

A unified, self-organizing model of garden path phenomena, center-embedding phenomena, and interference effects

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Two phenomena in sentence processing, the difficulty associated with garden path sentences and the difficulty associated with center embeddings, have generally been ascribed to different features of the parsing mechanism. For example, garden path phenomena are claimed to stem from biases (possibly structural, lexical, discourse, etc.) that cause the parser to favor a parse that eventually turns out to be wrong (e.g., Frazier & Rayner, 1982; MacDonald et al., 1994). Center embedding difficulty has been ascribed to the strain of simultaneously holding in memory the states of multiple partially completed constituents (Gibson, 1998). The current proposal follows Vosse & Kempen (2000)'s observation that that both phenomena arise naturally in a system in which perception of words spawns the activation of phrase-tree fragments which interact in a self-organizing fashion to form larger tree structures. This kind of model treats garden path phenomena as a kind of interference effect: in such cases, one fragment gets the jump on another early in a sentence, but later arriving information allows the initially squashed choice to make a comeback bid, the battle for dominance delaying stabilization. Likewise, because the system allows all words in a sentence to interact with one another, a sequence of similar noun phrases (e.g., "the dog the cat the rat...") followed by a sequence of verbs that can combine with any of them ("...chased bit died") leads to considerable interference and often failure of the parse. Moreover, several recent research projects have found evidence for the novel claim of the self-organizing perspective that all words can interact with each other: Van Dyke et al. (2005) found that that the semantic compatibility of a noun in an embedded clause with the verb phrase in the matrix clause affects eye movements (1); Tabor et al. (2004) found that the parser experiences interference from locally coherent structures even if they are incompatible with the already existing primary parse (2).

We present an interactive activation model with each of the properties outlined above. It consists of a hierarchical syntactic lattice whose nodes take on activation values corresponding to elements in a phrase structure tree. The lattice is coupled with a linking matrix, which specifies how elements of the perceptual input (words) are linked to pieces of the syntactic lattice. The syntactic lattice and the linking matrix are coupled dynamical systems (described by continuous differential equations). They evolve in time toward stable states which do a locally optimal job of integrating the constraints imposed by the input and the grammar.

Whereas Vosse & Kempen's model only predicted likelihood of parse success, the current model also predicts reading times. It incorporates linguistically motivated phrase structure elements and thus produces interpretable parses of complex linguistic constructions which are hard to evaluate in other connectionist systems. Moreover, the continuous initial activation states are tuned to priors based on frequency of words and constructions, capturing empirically attested frequency effects. We suggest that the unification achieved by this treatment stems from allowing structure to emerge via self-organization.

Examples

- (1) The worker was surprised that the resident who said that the *neighbor/warehouse* was dangerous *had complained about the investigation*.
- (2) The woman addressed *the man served the beer* by the waiter in coattails.

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On the proper place of frequency information within a model of garden-path recovery

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We will present a model of garden-path recovery making two major claims: First, reanalysis is a diagnostic repair process as proposed by Fodor and Inoue (1994, 1998). Second, garden-path recovery is sensitive to frequency properties of lexical items but not to other types of frequency information. In contrast to the original diagnosis model, we hypothesize that lexical frequency always comes into play when a lexical property has to be changed during reanalysis, even when prompted by a transparent syntactic symptom.

Different types of syntactic ambiguities in German are our main empirical domain. Evidence for diagnosis comes from experiments that varied the symptom (e.g., case versus agreement) signaling the need for reanalysis. Symptom frequency has been shown to have no effect. Evidence for lexically-based frequency effects comes from investigations of number-ambiguous NPs, for which garden-path strength correlates with corpus frequencies.

After reviewing this evidence we will specify the details of our model. In a nutshell, we propose that diagnosis uses purely structural information, mainly argument-structure and linking information. When lexical properties have to be changed during reanalysis, the lexicon must be reconsulted, and frequency effects arise.

To test the model, we ran an experiment using a speeded-grammaticality judgments procedure in which locally ambiguous OS-sentences were compared to unambiguous control sentences (cf. Materials Description, below). The object was either a definite NP which was both number- and case-ambiguous ("den Studenten": "the-ACC student" or "the-DAT students") or a proper name like "Peter" which is case-ambiguous between nominative, accusative, and dative.

Corpus counts show: (i) dative OS-sentences are about 10 times more frequent than accusative OS-sentences; (ii) the 48 experimental ambiguous nouns have a strong bias toward plural (ca. 80%). Forty-eight students participated in the experiment. The main results were:

- (i) Sentences with definite NP objects caused garden-path effects of ca. 10% in comparison to unambiguous control sentences, with no significant difference between accusative and dative sentences. For both types of locally ambiguous sentences, percentages of correct judgments correlated significantly with the frequency of corpus usage as singular or plural noun (accusative: $r = .29$, $p < .05$; dative: $r = -.48$, $p < .01$; corpus frequency measured in percentage singular use).
- (ii) Sentences with proper name objects caused much stronger garden-path effects (ca. 34% for both accusative and dative), as expected given that these sentences allow an SO-structure up to the disambiguating verb.
- (iii) The factor case was significant, with accusative sentences being judged slightly worse (ca. 7%) than dative sentences, but did not interact with the two other factors.

These results allow two main conclusions. First, there was a clear effect of lexical frequency on garden-path recovery, as witnessed by the correlations reported above. Second, ambiguous accusative sentences did not cause stronger garden-path effects than ambiguous dative sentences, despite being strongly disfavored by both structural and lexical frequency. As we will show in detail, this second finding follows from our assumption that diagnosis itself operates on purely symbolic structures and is therefore not affected by frequency.

Materials Description

- (1) dass [NP]-DAT/ACC der Direktor geholfen-DAT / unterstützt-ACC hat
 that the director helped supported has
 "that the director helped / supported NP"

NP	(a) Definite Ambiguous	[den Studenten] "the student(s)"
	(b) Definite Unambiguous	[den einen / die beiden Studenten] the one-ACC / the two-DAT student(s)
	(c) Proper Name Ambiguous	[Peter]
	(d) Proper Name Unambiguous	[meinen / meinem Freund Peter] my-ACC / my-DAT friend Peter

Thematic role revision in Japanese: An auditory ERP investigation of passive and causative constructions

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Many theories assume that revising thematic roles is costly. This is supported by evidence from multiple languages, using different measures (Bornkessel, et. al., 2003; Clifton, et. al., 2003). However, in a strict head-final language like Japanese, where massive local ambiguities are present and structural revisions often take place towards the sentence final position, it is unclear whether such revisions necessarily increase processing load (e.g., Mazuka & Ito, 1996). This study investigated the cost of thematic role revision and subsequent processes in Japanese, using passive and causative sentences.

An auditory experiment compared ERPs time-locked to the onset of a critical morpheme (underlined in examples below) in passives (b), passive-controls (c) and causatives (d) to those elicited by an active control condition (a). Assuming an incremental assignment of thematic roles via case information (nominative = (proto-)agent, dative = (proto-)recipient, accusative = (proto-)patient), both passives and causatives should require a thematic revision.

In comparison to the active condition, the passive and causative conditions elicited a central negativity (150–350ms). An absence of similar negativity in the unambiguous passive-control suggests that this negative deflection indicates a cost for thematic role reassignment rather than a difference between active and passive/causative structures per se. The electrophysiological correlate for thematic reanalysis observed here thus differs markedly from previous findings of an early parietal positivity for thematic revisions in German (Bornkessel, et. al., 2003). A possible explanation for this difference lies in the nature of the disambiguating information: whereas the German findings were obtained in a comparison of (lexically) differing verb classes, the reanalysis effects in the present study were induced by passive and causative morphemes. The negativity observed here might therefore reflect a reassignment of thematic roles via rule-based rather than idiosyncratic lexical information.

In addition to the negativity described above, causatives elicited a P600 effect with an anterior distribution. As anterior P600s have been shown to correlate with an increase in syntactic complexity (Friederici et al., 2002), the observed effect may result from the processing of the bi-clausal structure associated with this type of causative construction. The absence of a comparable effect in passives suggests that, in contrast to a number of suggestions in the theoretical linguistic literature (see Hoshi, 1999, for an overview), passives should be analyzed as mono-clausal rather than bi-clausal.

The present study thus revealed that there is a cost to thematic role revision in Japanese passives and causatives. Thematic reanalysis was also clearly separable from processing costs (anterior P600) engendered by a complex (bi-clausal) syntactic structure. These findings therefore highlight the importance of maximizing incremental interpretation even in the face of strict head-finality. Possible explanations for the difference in results between the present study and those conducted in German will be discussed along with further implications of the study for Japanese sentence processing.

Example sentences (critical positions underlined)

(a) Active voice

Pro	[Ana-ga	Piitaa-ni	mitibata-no	isikoro-o	nage- <u>ta</u> -to	iwareteiru
Pro	[Ana-nom	Peter-dat	roadside-gen	pebble-acc	throw-past]-that	is said

'It is said that Ana threw Peter pebble(s) on (the) roadside.'

(b) Passive

(c) Passive-control (with *niyotte*)

Pro	[Ana-ga	Piitaa-ni / -niyotte	mitibata-no	isikoro-o	nage- <u>rare</u> -ta]-to	iwareteiru
Pro	[Ana-nom	Peter-dat / -by	roadside-gen	pebble-acc	throw-passive-past]-that	is said

'It is said that Ana was thrown pebble(s) on (the) roadside by Peter.'

(d) Causative

Pro	[Ana-ga	Piitaa-ni	mitibata-no	isikoro-o	nage- <u>sase</u> -ta]-to	iwareteiru
Pro	Ana-nom	Peter-dat	roadside-gen	pebble-acc	throw-cause-past-that	is said

'It is said that Ana made Peter throw pebble(s) on (the) roadside.'

Intonation for mind readers: The case of second occurrence focus

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In a 1972 paper called 'Accent is predictable (if you're a mind reader),' Dwight Bolinger argued forcefully that accent placement in English is not predictable from syntactic structure. But prosody is not entirely done on a whim either. My talk starts with a very brief state-of-the-art report on how accents indicate *focus*, which in turn is interpreted in terms of properties of the discourse (such as Givenness). In any given discourse, the choices of what a speaker may focus in a given sentence are limited, and consequently their accent placement is, to some extent, predictable.

But not all foci are accented, as so-called *second occurrence focus* (2OF) shows. For example, the word *vegetables* is the semantic focus of *only* in both (1a) and (1b), but it is accented only in (1a); intuitively this is because it is repeated in (1b) (whence the name):

- (1) a. Everyone already knew that Mary only eats [VEGetables]_F.
 b. Even [PAUL]_F knew that Mary only eats [vegetables]_{2OF}.

How then do we know a 2OF, when we hear one — mind reading, after all? Comfortingly, a number of recent studies show that 2OFi, though unaccented, are prosodically marked, mostly by lengthening. This means that focus and accent are not directly linked. But can we predict just when accents are used? I offer an account in which focus is realized as relative prominence (stress) in metrical structure (following Truckenbrodt (1995)), which is then associated with accents. Blending together elements of the focus theories in Rooth (1992) and Schwarzschild (1999), the proposal does predict when foci will be accented, and when they will be merely stressed. It also illustrates the outlines of a theory of focus that brings together results from syntactic/semantic research in information structure with those from intonational and prosodic phonology.

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Prosody and logical scope in English

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It is well established that prosody interacts with surface syntax, in the grammar and in language processing (Selkirk 1984, Lehiste 1973, Kjelgaard & Speer 1999), but the relation between prosody and logical scope is more controversial (Jackendoff 1972, Büring 1997, Baltazani 2002, McMahon-Leddon et al. 2004, Hirotani 2004). The language production method presented here encouraged speakers to try to use prosody to disambiguate scopally ambiguous sentences. Our results suggest that prosody reflects scope reading preferences, which are in turn driven by logical entailments and surface order.

Subjects saw 192 sentences such as "Every circle hits a square," which contained two of four different operators ("every," "a," "a few," and "not"). Pictures representing both potential scope readings accompanied each sentence, and one picture was designated as the target. Subjects were instructed to read aloud each sentence verbatim, but to communicate the target picture rather than the non-target. Each sentence was presented twice (non-consecutively), alternating targets, to provide a fully-crossed design. Several acoustic parameters were analyzed, including operator duration and sentence-final pitch contour.

We performed ANOVAs with the factors Scope (wide vs. narrow) and Context Operator (the other operator in the sentence), for each acoustic measure, and for each operator. Interestingly, operator duration (and not final pitch contour) was a good predictor of quantifier scope, but final pitch contour (and not operator duration) was a good predictor of the scope of negation. This suggests that there are different prosodic strategies for different operator types.

For the measure of operator duration, Context Operator interacted significantly with Scope for each quantifier (all p 's < .05). This demonstrates that quantifier scope creates prosodic differences, and that the magnitude and direction of these differences depend on the identity of both quantifiers in the sentence. Planned contrast analyses revealed a complex yet coherent picture. In short, subjects lengthened operators when they were trying to convey the meaning with the strongest entailment properties.

The pattern of final pitch contour also interacted with the entailment properties of the readings, though in an apparently opposing way, further suggesting that these two different prosodic effects have different sources. In short, the pattern confirms the theory of Büring (1997), such that final pitch rises (signifying Büring's "topic accent") are only compatible with readings whose entailment properties are weak in a particular way. This contrasts with the pattern seen with lengthening.

We hypothesized that entailment relations between the quantifiers underlie preferences in scope interpretation, and that prosody is used to reflect these preferences. In a follow-up experiment, we asked subjects to rate how well each sentence fit the target picture, in order to get a measure of scope preferences. Results show significant interactions (all p 's < .001) that closely match the prosodic patterns reported above, confirming our hypothesis.

This paper reveals an apparently complex interface between prosody and scope, but it argues that expectations driven by entailment properties provide a coherent basis for this perceived complexity. These findings are important contributions to our understanding of both the processing of scope and the function of prosody in production.

Explaining the preference for narrow-scope negation in *not-because* sentences

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Frazier and Clifton (1996) report a preference for narrow scope negation (BEC>NOT) in ambiguous negated 'because' sentences, i.e., easier processing of sentences like (1a) than (1b). In their analysis the *because*-clause is syntactically higher than negation in BEC>NOT sentences. Under Construal Theory, this does not constitute a Late Closure violation; the non-primary *because*-clause is not attached but associated, subject to various influences including Immediate Interpretation and Minimal Revisions. Together, these preserve the meaning initially assigned (*Jane didn't purchase*), yielding BEC>NOT. Alternative explanations of the BEC>NOT preference invoke the unusual prosodic contour and/or pragmatic presuppositions of the NOT>BEC reading. (For discussion, see Hemforth and Konieczny 2004; Koizumi 2005.)

Our experiment employed a new design, and provided data favoring the prosody/pragmatics approach. Constructions biased to BEC>NOT or NOT>BEC, see (1), were presented as main clauses or were embedded in *if*-clauses, as illustrated in (2). The *if*-clause context minimizes marked properties of the NOT>BEC reading. A NOT>BEC utterance typically lacks the prosodic phrase boundary before *because* that is characteristic of BEC>NOT, and often ends with a continuation rise (Hirschberg and Avesani, 2000). In the *if*-clause context, any internal boundary is reduced by the dominant syntactic break preceding the main clause, and a high final boundary tone is natural. Also, the main clause that must follow an *if*-clause meets the intuitive need for continuation after a bare NOT>BEC statement. (Intuitively, stating a non-reason raises the question of what the actual reason was.) Explanations appealing to prosodic and/or pragmatic factors therefore predict that the main-clause preference for BEC>NOT should reduce or even reverse in the *if*-clause context. But in the absence of these construction-specific ameliorating effects, an *if*-clause is not expected to facilitate processing of non-preferred readings. To check this, our design included PP-attachment ambiguities, see (4), in both main-clause and *if*-clause contexts.

The target constructions were presented visually, as the first of three successive frames, displayed response-contingently; see (2)-(3) for illustration. Frame 2 displayed a follow-up question appearing as a second sentence or a second clause, following main-clauses and *if*-clauses respectively. Frame 3 offered two answer alternatives; the task was to select the more appropriate answer. Only participants with question-answering accuracy above 80% overall (N=64 native English speakers) were included in the data analyses.

Frame 1 reading times for *not-because* sentences showed the predicted Scope × Context interaction, $F_1(1,60)=16.76$, $p<.001$, $F_2(1,20)=9.03$, $p<.01$. Versions biased to NOT>BEC were read more slowly than those biased to BEC>NOT in the main-clause context, $p's<.01$, but not in the *if*-clause context, $p's>.25$. By contrast, the PP-construction showed the expected attachment-site effect, $p's<.001$, but no Site × Context interaction, $F_1(1,60)=1.30$, $p>.25$, $F_2(1,20)=0.60$, $p>.25$. These findings for *not-because* cannot be explained by persistence of an initial on-line interpretation, but are explicable on the assumption of marked prosody/pragmatics for the NOT>BEC reading: When these are neutralized, the usual preference for BEC>NOT is no longer evident. While little support for a pragmatics account was reported by Hemforth and Konieczny (2004), a precise comparison of the relative contributions of prosody versus pragmatics will necessitate further experimentation.

Examples

- (1) Jane didn't purchase the white blouse because ...
 a. BEC>NOT bias ... it had a stain. (She decided not to purchase it.)
 b. NOT>BEC bias ... it suited her. (She purchased it, but for a different reason.)
- (2) a. Main-Clause, NOT>BEC Jane didn't purchase the white blouse because it suited her.
 b. If-Clause, NOT>BEC If Jane didn't purchase the white blouse because it suited her,
- (3) a. Frame 2, Follow-up Question [Do/do] you know why she bought it?
 b. Frame 3, Answer Alternatives She liked the sleeves. She likes dark colors
- (4) (If) Jason examined the beetles [with his microscope/with green stripes] after the trek ended

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Missed cues: Speaker-hearer mismatch and variability

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Evidence abounds in the literature that speakers use various prosodic cues to inform listeners of the syntax. The present study questions the natural assumption that the types of cues speakers use are similar in nature to those that listeners mainly utilize. We present the results from production-perception studies using Japanese complex NPs with branching ambiguity revealing that naïve speakers' intentions often don't convey well to listeners. This is explained by our further findings: (i) Not only the magnitude but also the types of cues that speakers use varies depending on their awareness of the ambiguity examined; (ii) the types of cues listeners utilize and those that speakers manipulate do not completely match.

The left- vs. right-branching ambiguity (LB / RB) in Japanese complex NPs exemplified in (1) has been argued to be prosodically distinguishable by durational and F0 cues, predominantly by a raised F0 peak on Word 2 (*CD-Gen*) in the RB structure (metrical boost; Kubozono. 1988), contrasting with a downstepping pattern obtained in the LB structure.

In a production study employing a game-like task, accompanying visual contexts were manipulated into the following conditions: Unambiguous (there was only one possible target object corresponding to either RB or LB in each scene), and Ambiguous (objects corresponding to both analyses were present in each scene). Phonetic analyses of the collected utterances from naïve speakers (N=8) revealed that when the speakers were not alerted to the ambiguity (unambiguous condition), the difference between the LB and RB intended utterances was modest and appeared mainly in the F0 cues, on the peak height differences on Word 1 and Word 2. In contrast, when the speakers were made aware of the ambiguity (ambiguous condition), the prosodic manipulation was made mainly on final lengthening of Word 1 and Word 3 and the pause following Word 2.

The collected utterances were then fed to a forced-choice perception study (N=12). Listeners' performance in detecting the intended interpretation was statistically no better than chance except for LB-intended utterances, even when the speakers were made aware of the ambiguity. A multiple regression analysis indicated that the cues contributing to RB / LB distinctions in listeners are mainly the word final lengths of Word 1 and Word 2, suggesting that most types of cues manipulated by speakers did not play important roles in listeners' comprehension. The listeners' relatively good performance on LB-intended utterances from the ambiguous conditions is attributed to a relatively strong match between the speakers' cues and listeners' cues.

In fact, the status of the F0 cues in both speakers and listeners also relies on a lower lexico-phonological factor: lexical accent. We will further show that the presence/absence of lexical accent on Word1 affects the availability and usefulness of F0 cues by its (in)ability to trigger downstep on Word2: F0 cues are most effective when downstep is expected. In other cases, distinctions by using durational cues (pause and final lengthening) are required to compensate for the ineffectiveness of F0 cues.

Example

(1) Word 1 (Adj) Word 2 (N1-Gen) Word 3 (N2-Acc) Word 4 (Verb)

ao'i	siidi'i-no	ke'esu-o	sa'sitekudasai
blue	CD-Gen	case-Acc	point to

Point to the case of the blue CD. (LB interpretation)

Point to the blue case of the CD. (RB interpretation)

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Case and prosody interact with argument structure expectations

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Predictive sentence processing is assumed to hinge on the subcategorization frame of the verb (Jurafsky, 1996). But in verb-final structures, subcategorization information is available late. The crucial question here is whether there are alternative sources of information that help to predict upcoming structure. Case effects on argument structure expectations have been attested for a variety of verb-final languages, e.g., Japanese (Kamide, Altmann, & Haywood, 2003). In addition, data from English indicate that prosody qualifies as a potential predictor of sentences' length (Grosjean & Hirt, 1996). Consequently, we decided to investigate the interaction of case and prosody with argument structure expectations in German verb-final sentences.

A completion study revealed that subjects preferably produced two-argument structures when they were given fragments consisting of a nominative and an accusative whereas they preferably produced three-argument structures when they were given fragments consisting of a nominative and a dative (animate referents only, cf. (1)).

In a phonetic production experiment, we tested whether speakers differentiate between argument structures by means of prosody. Native speakers of German produced nominative-first sentences which differed in the number of arguments (two- vs. three-argument sentences) and in the case of the second argument (accusative vs. dative; cf. (2a-2d)). Analyses of the intonation contours revealed no effect of case. However, F₀-values on the second argument were significantly higher for three-argument sentences than for two-argument sentences from the onset of the noun on.

In a gating experiment, we tested whether hearers use case and prosodic cues to predict argument structure. Sentences consisted of two or three arguments, and the second argument was either marked for accusative or for dative. Two-place verbs and definite determiners both began with a labio-dental plosive such that an interference of coarticulatory information could be excluded. The sentences were recorded from a trained speaker. Each trial started with the visual presentation of two sentences in one case condition that were lexically identical up to the offset of the second noun (e.g., either (2a) and (2b) or (2c) and (2d)). Then, six consecutive gates (3) were presented acoustically. After each gate, subjects had to decide whether the fragment originated from the two- or the three-argument sentence.

Chi-squares and analyses of variance were computed. On Gates 2 and 3, decisions were above chance in the two-argument conditions only (2a and 2c). On Gate 3, a main effect of case was found. On Gate 4, the pattern changed with decisions now being above chance in the two-argument accusative as well as in the three-argument dative condition (2a and 2d). Finally, on Gates 5 and 6, they were above chance in all conditions except the three-argument accusative condition (2b). On Gates 4 to 6, there were no main effects but a significant interaction of number of arguments and case.

To summarize, completion data and phonetic data show that case and prosody qualify as predictors of argument structure. Moreover, data from a gating experiment reveal that prosodic information has only a modulating effect on case-dependent argument structure preferences.

Examples

- (1) Der Doktor wird den/dem Krankenpfleger ...
the_[NOM] doctor will the_[ACC/DAT] nurse ...
- (2) a. Der Doktor wird den Krankenpfleger duzen.
the_[NOM] doctor will the_[ACC] nurse address informally
'The doctor will address the nurse informally.'
- b. Der Doktor wird den Krankenpfleger dem Rollstuhlfahrer zeigen.
the_[NOM] doctor will the_[ACC] nurse the_[DAT] wheel-chair-user point out to
'The doctor will point out the nurse to the wheel-chair-user.'
- c. Der Doktor wird dem Krankenpfleger danken.
the_[NOM] doctor will the_[DAT] nurse thank
'The doctor will thank the nurse.'
- d. Der Doktor wird dem Krankenpfleger den Rollstuhlfahrer zeigen.
the_[NOM] doctor will the_[DAT] nurse the_[ACC] wheel-chair-user point out to
'The doctor will point out the wheel-chair-user to the nurse.'
- (3) Der Doktor wird | den | Kran | ken | pfe | ger ...
gate1 | Gate 2 | Gate 3 | Gate 4 | Gate 5 | Gate 6
the doctor will | the nurse ...

Effects of constituent length on boundary informativeness

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In production, the prosodic phrasing of an utterance depends on syntactic structure and constituent length, among other factors (Watson & Gibson, 2004; Ferreira 1993). In comprehension, prosodic boundaries that coincide with potential syntactic boundaries facilitate processing (Speer et al. 1996) and affect interpretation (e.g., Carlson et al. 2001). But do listeners discount prosodic boundaries which could be due to length? Two auditory questionnaires on different structures found that prosodic boundaries had smaller effects with long constituents, suggesting that listeners consider the reasons why speakers produce prosodic boundaries as well as the boundaries themselves.

Experiment 1a explored the interpretation of ambiguously-conjoined nouns as in (1). Conditions (a-b) had short first names, while (c-d) contained long full names. Prosodically, conditions (a, c) had Intonational Phrase (IPh) boundaries after the first and third names, while (b,d) had IPhs after the second and third names. Participants heard these sentences and then chose between paraphrases with parentheses indicating phrasing and a statement of the number of people participating (1 or 2 for the (a,c) grouping but 2 for the (b,d) grouping). A significant main effect of IPh position was found, replicating Lehiste (1973), with the early break suggesting the grouping in (1a). A significant interaction showed that the boundaries had a larger effect with the shorter names. Experiment 1b replicated these effects using sentences in which the longer NPs were definite descriptions (e.g., *the plantation owner or the tenant farmer and the new caretaker*) instead of names. The length effect was the same whether length involved more syllables or increased lexical content as well.

Experiment 2 studied ambiguously-attached adverbials as in (2). The adverbial phrases could attach into the nearest VP (*telephoned*) or the matrix VP (*learned*), and a prosodic boundary before the adverbial has been shown to increase matrix attachments (Carlson et al. 2001). Here, the sentences either contained no IPh boundaries (a, c) or an IPh before the adverbial (b, d). Conditions (c–d) contained longer adverbial phrases than (a–b). There was a significant main effect of boundary presence but also an interaction, with the boundaries only affecting the short sentences.

In two distinct structures, lengthening constituents reduced the effects of prosodic boundaries on syntactic attachment. These results suggest that listeners not only use prosodic boundaries in parsing, but they gauge the informativeness of those boundaries based on other sentence properties. Here, they considered a competing motivation for the boundaries, namely length, while in other studies, listeners have responded to the presence of other prosodic boundaries (Clifton et al., 2002).

Examples

- | | | |
|--------|--|------------|
| (1) a. | (Pat) or (Jay and Lee) convinced the bank president to extend the mortgage. | 82% Early |
| b. | (Pat or Jay) and (Lee) ... | 20% |
| c. | (Patricia Jones) or (Jacqueline Frazier and Letitia Connolly) ... | 73% |
| d. | (Patricia Jones or Jacqueline Frazier) and (Letitia Connolly) ... | 30% |
| (2) a. | (Susie learned that Bill telephoned last night.) | 24% Matrix |
| b. | (Susie learned that Bill telephoned) (last night.) | 40% |
| c. | (Susie learned that Bill telephoned last night after the general meeting.) | 28% |
| d. | (Susie learned that Bill telephoned) (last night after the general meeting.) | 28% |

Accent type and givenness in German scene descriptions: Evidence from multi-modal priming

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In spoken discourse research, one major area of interest concerns the role of givenness of a particular referent in discourse. Generally speaking, given referents are supposed to occur early in a sentence and tend to carry an L* accent, if accented at all (G-ToBI notation: cf. Grice et al., 2005). New information, on the other hand, is generally assumed to be marked by an H* accent (Pierrehumbert & Hirschberg, 1990). In a perception experiment addressing the effects of different degrees of givenness, participants were presented with one of three prime conditions and subsequently had to rate a synthesized scene description in the context of the prime (Baumann & Hadelich, 2003). The preference of deaccentuation over an accent (H+L* or H*) as a marker of a referent following an auditorily primed referent was interpreted as evidence for a higher degree of activation of the auditorily primed entities. When no prime was presented, both accent types were preferred over deaccentuation. Even though this result confirmed the assumptions stated earlier, the question remains whether actual speakers would produce accent types comparable to those in the synthesized primes.

We address the question of whether the intonational marking of discourse referents in the production of German declarative sentences varies according to their degree of (cognitive) activation. We distinguish three activation states corresponding to given, accessible, and new information (cf. Chafe, 1994).

In our experiment, participants had to describe action scenes in one sentence. We manipulated the modality of the prime presented before the action picture. These primes introduced the patient of the following scene either as a picture (e.g., picture of a monkey, visual-prime condition) or in a short description (auditory-prime condition, see Example 1). A no-prime condition served as a baseline. The dependent measures were word order and accent type of the given referents in the target descriptions. We predicted the strongest priming effects for auditorily presented stimuli and expected effects on both levels measured, i.e., more patient-first constructions and/or deaccentuations of the target referents. The visual primes were expected to influence the structure of the description without causing deaccentuation (cf. Baumann & Hadelich, 2003). In the no-prime condition, we expected participants to produce unbiased baseline structures and newness accents on the target NPs.

The analyses revealed a significant effect of prime type on sentence structure: We found significantly more patient-first sentences after auditory priming. In the visual-prime condition, we found fewer patient-first sentences, and in the no-prime condition, virtually no patient-first descriptions were produced. Additionally, we observed a significant effect of prime type on accent type of the first NP, with significantly more deaccentuations in the auditory-prime condition.

We interpret this as support of the notion of givenness in terms of activation degrees, with different presentational modes activating entities to different degrees. Furthermore, we suggest that, as the visual-prime condition did not differ from the no-prime condition with respect to accent type of the first NP, topicalization of a given entity might be a more preferable marker of (partial) givenness than deaccentuation.

Example (Auditory Prime)

- (1) "Auf dem Teppich sitzt ein Affe."
Lit. "On the carpet is sitting a monkey."

Re-active filling

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Considerable evidence indicates that forming a filler-gap dependency proceeds actively, in advance of direct evidence that licenses it. We know less about how persistently the parser pursues this strategy, which is potentially risky if the cost of retrieving fillers grows as new material is integrated. Here we find that active filling effects disappear when verbs are linearly very distant from the filler, *unless* that filler participates in another dependency preceding the verb.

In two experiments we manipulated filler plausibility [1, 2] to probe for active filling effects at verbs embedded in relative clauses. We used *spray-load* verbs [3], since these ditransitives can host gaps not immediately adjacent to the verb, while their tight selectional restrictions allow for immediate detection of an implausible filler, in principle. To create distance between the verb and the position that provides bottom-up evidence for the gap, we relativized the verb's second object. Thus implausibility detection effects that are slightly delayed may nevertheless be attributed to 'active' dependency formation. An off-line rating study (N=14) confirmed that the implausible fillers were considerably worse than plausible ones in both argument positions (Bonferroni-corrected t-tests, both p 's < .001).

Experiment 1. We probed for active effects at verbs either four (SHORT) or nine words (LONG) distant from the relativizer (Example 1). Material was interpolated by attaching a PP to the RC subject. Self-paced reading results (N=24; moving-window) reveal a strong plausibility effect one word beyond the critical verb in the SHORT condition ($F_1(1,23)=12.4, p < .01$; $F_2(1,23)=6.98, p < .02$). In the LONG condition, however, no effect is observed at the verb or the first argument (F 's < 1.5; n.s.); only after the gap position has been processed is slow-down evident ($F_1(1,23)=9.21, p < .01$; $F_2(1,23)=6.64, p < .02$).

Experiment 2. Stimuli from Experiment 1 were modified so that the RCs dominated coordinate VPs (Example 2), and therefore two gaps, as required by the Coordinate Structure Constraint [4]. The second verb's ordinal position matched the critical verb's position in Experiment 1's LONG condition; this LONG condition also constituted a length-matched control. Only the second verb differed in plausibility with respect to the filler. A slowdown due to filler implausibility occurs one word beyond the critical verb ($F_1(1,30)=7.18; p < .02$; $F_2(1,23)=5.95; p < .03$), indicating dependency formation has taken place before direct evidence for the second gap. The control replicated the Experiment 1 LONG condition.

These results support an architecture in which filler representation decays (e.g., [5]), but they also show how it can be strengthened — by second-gap prediction, or reactivation by the first dependency [cf. 6] — so active effects surface later. Previous work [7] showed that filler retrieval *time* is dependency-length-invariant, so it is unlikely that the plausibility effect's displacement reflects greater access time. We consider competing accounts of why either retrieval and integration of semantic features at the verb may be less reliable under a decay regime. Finally, we note that the processor's predictive capacity must be keenly sensitive to grammatical principles (at least, the Coordinate Structure Constraint); otherwise we lack an explanation for active dependency formation at the second verb.

Examples

- (1) The { **adhesive coating / computer program** } that ...
 - SHORT the talented engineer methodically sprayed the special test surfaces with in his ...
 - LONG the talented engineer from the high-tech aerospace firm methodically sprayed the special test surfaces with in his new laboratory could make his company a lot of money.
- (2) The { **adhesive coating / computer program** } that ...
 - (a) TWO-GAP the talented engineer designed for his boss and methodically sprayed ...
 - (b) ONE-GAP the talented engineer from the high-tech aerospace firm methodically sprayed the special test surfaces with in his new laboratory ...

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An fMRI study of parasitic gaps: Uncovering the subprocesses of filler-gap dependencies

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In computing filler-gap dependencies, the parser must at a minimum (a) store the filler ("Which parcel" in (1)) in Working Memory (WM), and (b) identify/fill its gap ("■" in (1)). We teased gap identification processes apart from storage processes and localized them in neural tissue through an fMRI investigation. We did so by using two sets of minimal pairs: First, by turning to parasitic gap constructions (Engdahl, 1983; Nissenbaum, 2000) we generated minimal pairs, such as (2)–(3), which helped us focus on gap identification since storage demands are satisfied earlier than the parasitic gap (by the first ■ in (2)). Second, a contrast between subject-(4) and object-(5) gaps helped us vary filler-gap storage demands.

There is evidence from both aphasia (Grodzinsky, 2000) and imaging (Caplan et al., 1999) that Broca's area is necessary for comprehending filler-gaps. Additionally, there is fMRI evidence that this region recruits WM resources during their comprehension (Cooke et al., 2001) and that this WM is specific to filler-gaps rather than general to syntactic dependencies. The dual contrast in (2)–(5) provides an opportunity to see whether gap identification relies on either the same part of Broca's area as do storage requirements or a distinct region within/outside Broca's area.

In a rapid event-related design we presented the four conditions in (2)–(5): (a) *wh*-object question; (b) *wh*-subject question, (c) parasitic gap, (d) pronoun dependency. Thirteen right-handed, native English speakers participated in the experiment. One-hundred and twenty (30 per condition) sentences were presented auditorily in each of two runs that were counter-balanced across subjects. Comprehension questions requiring a True/False response appeared on one-quarter of the trials.

In a deconvolution analysis, the contrast [(2)–(3)] produced bilateral activation of the Orbital Gyrus, BA47, at $p < .01$ (FDR corrected). The contrast [(5)–(4)] produced activation in posterior Left Inferior Frontal Gyrus, BA44, at $p < .01$ (FDR corrected).

Collectively, the results demonstrate the importance of the left inferior frontal cortex in filler-gap comprehension. Within this region, Broca's area (BA44) was activated by storage processes, replicating previous results. In comparison, gap identification activated a more anterior and inferior aspect of the left inferior frontal lobe that is outside the standard definition of Broca's area (BA44 and BA45). This novel finding identifies gap identification as a neurally distinct process from that of filler storage.

Examples

- (1) Which parcel did the boy deliver ■?
- (2) Which parcel did the boy deliver ■ after dropping ■?
- (3) Which parcel did the boy deliver ■ after dropping it?
- (4) Which boy ■ delivered a parcel after fishing?
- (5) Which parcel did the boy deliver ■ after fishing?

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