

The Emperor's Psycholinguistics¹

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Accepted July 1, 1997

We discuss and debunk five common assumptions about the interrelation of semantics, syntax, and frequency during sentence processing. In the course of this, we explore the implications of the view that syntax is assigned as the last stage of comprehension rather than the first: Statistically based perceptual strategies propose an initial semantic representation, which then constrains the assignment of syntactic representations. This view accounts for a variety of facts, as well as suggesting some surprising new ones.

¹ The reference section at the end of this paper includes the major works that represent various positions on the five issues we discuss. For this general paper, we do not ascribe particular positions to other individuals, because doing so accurately would add greatly to the length of the discussion: We are sure that we would still not satisfy the individuals that we had represented their positions fully. But we can succinctly represent our own contributions with some accuracy. The proposal concerning "syntax last" is part of a book in preparation by T. G. B. and D. J. T. M. S. developed the analyses of Spanish and suggestions about telicity; T. G. B. and M. S. carried out the priming research in Spanish and also formulated the predictions about the interaction of beliefs and telicity. John Kim assisted in an early study of unaccusative trace priming in English. Brian McElree was a collaborator on the original study of NP-trace priming in English; Kathy Straub, Ken Shenkman, and Caroline Carrithers participated in studying the contrast between NP-trace priming in lexical versus syntactic passive sentences. Andy Barss drew our attention to Example (25b), and has offered many helpful comments on other sentences discussed in this paper. We have also benefited from discussions on various germane topics with Ken Forster, LouAnn Gerken, Eloise Jelinek, Joel Lachter, Itziar Laka, Janet Nicol, Mark Seidenberg, and Mike Tanenhaus. Finally, various sources have supported the research reviewed in this paper: the National Science Foundation, Air Force Research Foundation, ONR, Montclair State University, The University of Arizona.

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The enduring questions about language processing involve the relation between syntax, semantics, and frequency information. Five assumptions on this issue have driven different lines of psycholinguistic research during the last decade. We plead guilty to having held many of these logistically convenient positions at one time or another, but it is time that we stop and reflect. Given the nature of this special journal issue, we do not document Who holds What position today: You know who you are. And so does everyone else.

The five assumptions are:

1. If sentence syntax processing is modular, unaffected by other kinds of knowledge, then semantic and contextual information cannot behaviorally affect it.
2. Syntactic processing proceeds without sensitivity to probabilistic information.
3. Sentence comprehension could be based entirely on distributed cues, without access to a sentence-level syntax.
4. If syntax assignment is necessary for comprehension, it is logically and factually prior to the assignment of semantic information.
5. Syntactic structural properties of sentences cannot be affected by conceptual beliefs.

Every one of these assumptions is a doubtful opinion at most.

MAKING MOUNTAINS OUT OF MODULES

In the 1960s, most structural psycholinguists followed the implications of Chomsky's Example Sentence (1): Syntactic processing proceeds independently of semantic information.

(1) Colorless green ideas sleep furiously

Forster and Fodor crystallized the concept of independent processing into the general idea that syntactic processing is modular—it proceeds autonomously, quickly, without reference to other sources of information. Modularity comes in various forms. The basic idea is that syntactic processing forms major compositional units of meaning, say propositions, and then the meaning of those propositions can interact with other meanings and context.

This set the scene for a decade of intense efforts to show that the modularity hypothesis is wrong: The focus is on demonstrating that semantic information does, in fact, inform ongoing syntactic processing. For example, there has been much argument about whether the misleading and incoherent

reading of reduced relatives (2a) is affected by the semantic relations between the initial nounphrase and the subordinate clause verb [with even more confusion caused by (2b) and less by (2c)]: Some people have reported faster reading times for the critical phrases in sentences like (2c) and slower times in (2b)

- (2)a. The horse raced past the barn collapsed
- b. The runner raced past the barn fell ('runner' is a better agent for 'raced', and a poorer patient than 'horse')
- c. The rock raced past the barn fell ('rock' is a worse agent for 'raced' and a better patient than 'horse').

The problem is that apparent on-line positive evidence for the impact of such semantic information on syntactic processing does not undermine the claim that the syntactic processing is modular. The reason is simply that a processor can process ahead of the currently available input. For example, when a subject has read the initial sequence of (2c) as in (3), the syntactic processor could construct several options for complete propositions, as in (4):

- (3) The rock/runner raced. . . .
- (4)a. s(The rock/runner raced)s
- b. s(The rock/runner raced NP)s
- c. s(The rock/runner s(raced . . .)s)s

The notion of semantic propositions projected from semantically impoverished lexical items in syntactic frames is common enough, as in:

- (5) Something was done to him

Just as there is a semantic proposition associated with (5), each one of those complete-but-lexically unfilled clausal structures in (4) has an associated semantics, e.g.,

- (6)a. The rock/runner raced
- b. The rock/runner raced something/somebody
- c. The rock/runner (something raced it)

Each of those semantic notions has an associated pragmatic probability, which differs in likelihood. Thus, the effect of different pragmatic probabilities can appear to occur online, before a proposition is complete, but that could be due to the system's ability to project possible completions as it processes.

Thus, our current behavioral methods in psycholinguistics cannot easily distinguish between a nonmodular syntax processor, and a modular one with the capacity for such syntactic projections.

SYNTACTIC PROCESSING PROCEEDS WITHOUT SENSITIVITY TO FREQUENCY INFORMATION

The fact that people can understand the price of copra has been rising for decades in Delhi is evidence that syntactic processing does not depend on pragmatic support. That is, you understood "the price . . . Delhi," even though in the context of this paper it is more bizarre than the rest of the sentences. Such facts have suggested that syntactic processing is not sensitive to frequency information at a pragmatic level. Some researchers have canonized this idea, and taken it as further evidence that syntactic processing is modular.

Yet other examples show that syntax can be quite sensitive to the frequency of syntactic structures themselves. The difficulty of sentence (2a) occurs because the first and second sequences are potential independent declarative sentences with simple structures (7).

- (7)a. The horse raced past the barn.
- b. The barn fell.

The result is that it is almost impossible to overcome the misleading analyses to arrive at the correct one: Rereading or rehearing the sentence often confuses the perceiver even more. And, while semantic manipulations like those in (2c) may affect reading time, they do not completely remove the general perceptual complexity of the construction, compared with (8).

- (8) The rock thrown past the barn disappeared

The salience of the simple declarative sentences might be coded by a set of perceptual schemata, which play an early role in sentence comprehension, e.g., (9a) and (9b). Example (9a) captures the fact that a surprisingly good segmentation into major phrases can be derived simply by starting a new phrase at every function word, with the head defined by that function word and the entire phrase labelled as that type. That is, a determiner defines a noun phrase (NP) with a head noun, a preposition defines prepositional phrases (PP) with a head noun; an auxiliary defines a verb phrase (VP) with head verb, etc. For example, this strategy applies to the first sentence of this paragraph, to yield the segmentation and labeling in (9b). This is a fairly good initial segmentation into labeled phrases, and, with a few modifications, even more impressive results are achievable with the simple strategy.

The output of a perceptual scheme like (9a) can then feed into higher-order strategies which postulate likely thematic relations between phrases; e.g., (10a) through (10c)

- (9)a. Function word . . . $Xf = [f \dots X] f$

- b. (The salience) np
 - (of (the simple declarative sentences) np) pp
 - (might (be coded) vp) vp
 - (by a set) np) pp
 - (of perceptual schemata) pp
 - (which play) wh
 - (an early role) np
 - (in comprehension) pp
- (10)a. (NP BE *X*) = agent/experiencer of *X* (where *X* is a verb or adjective or other predicate phrase)
- b. NP VP (NP) = agent, action, (patient)
- c. NP (BE) V + past participle (by NP) = patient, verb (agent)

But, why should the salience of the sequences in (2) overwhelm the specific passive morphology in (10c), when the latter is in fact the correct interpretation? Suppose that the initial stage of syntactic processing utilizes “perceptual strategies,” schemata that are built up out of perceptual experience. On this view, the salience of the NP V (NP) sequences with the assignment in (10b) is based on the fact that, in English, agent-first sequences are much more frequent than agent-last sequences. Furthermore, sequences with initial NPs and BE are much more likely to be either a progressive form [and subject to (10b)], or a predicate, subject to (10a). Thus, (10c) is a statistically less supported strategy than (10a) and (10b), and can be overwhelmed by them in cases like (2).

For purposes of this discussion, it does not matter if such strategies are accumulated as overarching perceptual templates, or if they are coded within lexical representations: In both cases, the salience emerges out of the frequency of the canonical structure. However, there are nonstatistical theories of the perceptual salience of canonical structural sequences. For example, autonomous structure building theories of sentence comprehension utilize particular tree-building strategies, which may make canonical sentences less computationally complex than other forms. A frequently studied tree-building strategy is “minimal attachment,” a member of the family of principles that minimize node-to-terminal node ratio and maximize flat structures. On this view, an autonomous syntax builder always first chooses syntactically acceptable structures that do not involve adding nonterminal nodes. Our reading of the literature is that the language phenomena supporting the independent operation of minimal attachment have been successfully discounted, with one exception: reduced relative constructions like (2a)

So, we have a single construction with two explanations for its overwhelming complexity. We believe that the statistical explanation is superior for several reasons. First, minimal attachment does not explain the over-

whelming unacceptability of sentences like (2a); indeed, the general rule in structure-building is that if the preferred structure does not work out, then the parser goes to less preferred ones. Why does that not work in a case like (2a)? Why does the parser keep blocking? One possibility is that the salience of the NVN sequence as a complete proposition triggers a recoding of it into semantic terms, making the correct re-analysis more difficult. But in that case, why does the sentence become much easier if the *second* NV sequence is semantically blocked, as in (11)?

(11) The horse raced past the barn panted.

The statistical strategy answer is simply that when the NVN pattern leads to a locally coherent semantic structure, it is overwhelmingly attractive. And the demonstrated fact that semantic factors as in (2c) can mitigate the power of the incorrect reading further shows that the strict independent structure building approach may be wrong.

Finally, we can look at how strategies may interact to find further evidence for them. Consider (12a) in which the passive morphology is more explicitly represented than in (2a), thus triggering the passive strategy (10c) more strongly, making the sentence easier to understand.

(12)a. The horse raced by the jockey fell

This is reasonable since the word *by* explicitly marks the agent of the reduced relative. But suppose the passive morphology is superficially, but not really enhanced, as in (12b).

(12)b. The horse raced by the barn fell

Suppose that further research confirms our intuition that (12b) is in fact easier than (2a). Why would it be so? *The barn* cannot be a good agent for racing a horse, so that interpretation is blocked. But on the statistical strategies model, the fuller presentation of the apparent passive morphology activates the passive strategy more strongly. While the particular agent (*barn*) is wrong, the system is left with an activated passive construction template, which can then apply correctly to the sentence. We see no way that structure building theories can accommodate such facts (if true).

A serious objection to a statistical strategies model has been that the strategies are probabilistic and fail in certain instances; accordingly, the sentence comprehension system must refer to the syntax at some points. Hence, there must be a last-resort structure building parser anyway: We should study that parser as an example of cognitive architecture, whatever variation in behavior is introduced by variation in construction frequencies. For a time, this objection seemed relevant: It was certainly hard to test a full perceptual strategies model, because there was no readily available computational sys-

tem that could simulate the simultaneous application of overlapping statistically grounded strategies. Connectionist models today offer such a computational framework, and we already see various attempts to build parsers out of statistically confirmed information. This may cast some existence doubt on the claim that parsing requires an autonomous syntactic structure builder.

And it may in fact be the case that, when the system runs out of strategies, sentences indeed become impossible to grasp. Consider (13), which is unacceptable to our informants.

(13) The shopkeepers were unsatisfied by midnight

There is no obvious grammatical reason why (13) is unacceptable, as shown by the acceptability of several kinds of parallel constructions in (14a) through (14e).

- (14)a. The shopkeepers were still unsatisfied by midnight
- b. The shopkeepers were unhappy by midnight
- c. The shopkeepers were unsatisfied at midnight
- d. The shopkeepers were dissatisfied by midnight
- e. The shopkeepers were unsatisfied by the price

It may be that (13) runs afoul of a conflict between a salient perceptual strategy based on the apparent passive morphology (10c), and the fact that *unsatisfied* is a lexical passive (i.e., an adjective that only looks like a syntactic passive). The apparent local applicability of (10c) requires that *unsatisfied* be derived from an agentive verb, which it cannot be. At the same time, the temporally delimiting quality of the final phrase requires that there have been a change of state, i.e., ordinarily expressed as a verb if one is available; and one apparently is. But then, it isn't really a verb. . . . Thus, on the strategies view (10c) elicits competing initial representations without a resolution.

Of course, it remains to be seen if a statistical strategies approach to parsing will account for all the facts, when enhanced within a connectionist framework. We may find that a structural parser is still needed for certain oddball cases. However, that is far from demonstrating that autonomous structure building principles do the job, or that such strategies as the canonical sentence sequence do not apply at all. Human behavior is at least partially driven by frequency in every domain we have studied: It would be very strange if this were not also the case in language processing.

THE ROLE OF SYNTAX IN DEFINING LANGUAGE OBJECTS: THE BLIND MEN AND THE ELEPHANT

The role of statistical strategies or autonomous structure building parsers is to provide candidate parses that must be checked against possible

syntactic structures: Those models still assume that syntactic knowledge plays a part in language processing. Some researchers suggest that the power of statistical parsers within connectionist frameworks may be so great that syntactic knowledge does not play a causal role in sentence comprehension. They argue that after enough experience with language, the “pattern completion” property of distributed connectionist mapping systems will fill in information relevant to finding a semantic analysis, even when it is not explicit in the surface form of a sentence.

Here is the problem with this. Spreading activation systems must be trained on actual objects. This works well in cases of object recognition where there are real objects, independent of the system: The system can be trained on a wide range of cases, and will arrive at activation configurations that reflect that range. But in the case of language, there is a circularity in this approach: There are no real objects, independent of the linguistic knowledge about sentences. The role of syntax is to define those objects, namely, the well-formed sentences of the language. Thus, a connectionist parser must be exposed to syntactic knowledge at some point in its history. This does not invalidate the idea that the adult parsing system is totally free of syntactic access: But it is a pyrrhic victory if it requires that a full syntax, along with an already effective parser, be available to train the immature parsing system.

SYNTAX FIRST? SYNTAX LAST!

Let us suppose that computing the syntax is indeed a causal factor in sentence comprehension. It is commonly assumed that the syntax is computed first: Hence the aphorism “Syntax proposes, semantics disposes.” The syntactic processor provides correct candidate representations and the semantic/pragmatic processes integrate the information with prior knowledge and expectations. An important argument in favor of this order of processing events is that semantic analysis requires syntactic structure of some kind, to isolate predicates and segregate their arguments.

So this could be how things work. But it has two unappealing features. First, comprehension is fast, really fast: Whatever your syntactic theory, syntax is complex, really complex. If it boggles the mind that a complete and correct syntax is assigned prior to comprehension, why does it not boggle the comprehension system? Second, there are clear cases of within-sentence influence of the compositional meaning of phrases on the syntactic analysis itself. Consider the contrasts in (15) and (16).

- (15)a. The stubborn shopkeepers were ruined for years by the flood

- b. The stubborn shopkeepers looked ruined for years by the flood
- c. The stubborn shopkeepers were ruined [NP-trace] at midnight by the flood
- d. *The stubborn shopkeepers looked ruined [NP-trace] at midnight by the flood
- (16)a. The stubborn shopkeepers were attacked [NP-trace] for years by the king
- b. *The stubborn shopkeepers looked attacked for years by the king

The meaning of the sequence at the end of the sentence provides a lot of information relevant to the kind of construction that goes with the past participle. Example (15a) can specify a state, as indicated by the acceptability of (15b). But (15c) specifies a particular event at a particular time: thus, it is a true syntactic passive, with movement of the surface subject, and a trace left behind in object position, parallel to the structure in (16a). This is shown by the unacceptability of (15d), parallel to that of (16b) [note that (15d) is ungrammatical on the relevant reading, in which *at midnight* modifies *ruined*]. Assigning the correct and different syntactic structures to (15a) and (15c), without the semantic context, presents a conundrum for a pure parser. This predicts that morphologically passive sentences with potential lexical passives would present much more computational demand than passive form sentences with pure syntactic passives. No one has tested this to our knowledge, but it seems counterintuitive. (We describe in the next section some possible models of how conceptual structure can influence syntactic structure during processing.)

The reader might object to the premise that NP-trace is even assigned as part of the comprehension of sentences like (16a). Some syntactic theories do not differentiate lexical and syntactic passive constructions within the syntactic derivation (e.g., Head Phrase Structure Grammar, various versions of unification theory). And, if one pursues a theory on which syntax is not causally related to processing at all, then there is certainly no reason to expect a trace to be assigned during comprehension to so-called syntactic passives.

For such reasons, various laboratories have been investigating experimental evidence for the presence of NP-trace when sentences are understood. For example, people recognize that a word drawn from the moved noun phrase (e.g., *stubborn*) was in the sentence more quickly when there is a trace [Examples (17a) through (17c)] for that phrase than in corresponding constructions without a trace [Examples (18a) through (18c)].

- (17)a. The stubborn shopkeepers seemed [NP-trace] to be happy
- b. The stubborn shopkeepers were likely [NP-trace] to be happy

- c. The stubborn shopkeepers were attacked [NP-trace] by the king
- (18)a. The stubborn shopkeepers wanted [PRO] to be happy
- b. The stubborn shopkeepers were eager [PRO]to be happy
- c. The stubborn shopkeepers were ruined by the king

The relative salience of the critical word in sentences with trace is directly explained by the fact that the trace accesses a representation of its antecedent: Thus, the subject phrase is represented twice in the sentence structure, which makes it more salient. Interestingly, the subject of a complement, PRO, does not prime its antecedent, even though it refers to it. (This relative failure of PRO to prime its antecedent has been found by several laboratories.) Strict interpretation of theories with trace and PRO predicts this difference: Trace accesses a copy (or starts with the original) of the antecedent; PRO is merely co-indexed with its antecedent. The difference in priming is a striking confirmation, at least of the construct validity of this purely syntactic distinction.

Alas, most of the research on the salience of NP-trace involves the printed word, and further investigation is underway. If it holds up that NP-movement traces are indeed assigned to sentences, that is rather strong evidence that assignment of syntax is a part of comprehension: Syntactic movement and consequent trace are one of the best examples of a “purely” syntactic device, without any motive within semantic representations.

So having access to semantic information intrinsic to lexical items and from the entire sentence could facilitate syntactic processing in critical ways.

Syntax Last—A Modest Proposal

We have argued that statistically sensitive perceptual strategies may yield direct access to semantic analyses of sentences. At the same time, we have suggested that processing of syntax can be usefully informed by the semantic information in a sentence. Finally, we have just argued that complete syntactic structures are a component of the representation of understood sentences. How can we put all this together?

If syntax is assigned before semantic representations are formed, then perceptual strategies are irrelevant, and the syntactic processor is on its own, free of information from the semantics of the sentence. Suppose, instead, that the correct syntactic structure is assigned after an initial semantic analysis has occurred. The sequence of events in comprehension would be as outlined in (19).

- (19)a. The statistical perceptual strategies provide an initial semantic representation, isolation of lexical items and major phrases, all based on statistically valid superficial cues.

- b. The syntactic generator takes the lexical items, major phrase categories, and the logical form of the semantic representation, as constraints on possible syntactic derivations.
- c. A complete syntactic structure is assigned to the sequence with those constraints, and checked to make sure it accounts for the entire sequence.

That is, perceptual strategies propose, syntactic structures dispose.

There is some evidence that this is how things work. First, the evidence for NP-trace does not occur at the actual trace point, but somewhat later in time. This is unlike the evidence for the on-line reality of WH-trace, which primes its antecedent immediately (WH-trace is left after movement of a WH word, e.g., "what"). Here is how the sequence of processing in (19) might apply to (17c):

- (20)a. The perceptual strategy (10a) analyses the passive as a complex predicate phrase:
[The stubborn shopkeepers] NP BE [attacked by the king] pred

This analysis is not syntactically correct but it does yield a semantic interpretation that is close to correct. That is modeled on the interpretive strategy needed anyway for true lexical passives, as in (18c): namely, to take the subject phrase and assign it as a semantic theme of the verb, and any by-phrase as the semantic agent.

- (20)b. Generate a syntactic derivation that accounts for all and only the words with the semantic analysis: king = agent, predicate = attack, theme = shopkeepers

The candidate derivation that meets these constraints yields:

The shopkeepers were attacked [NP-trace] by the king

- (20)c. Check that candidate syntactically structured sequence against the input.

This scheme predicts that NP-trace will take some time to be assigned, as is the case. It may seem odd to propose that the initial semantic analysis proceeds on the basis of an incorrect syntactic analysis; but it is an interesting feature of NP-trace constructions that they all are homonymous with nonmovement constructions that have similar argument assignments at the semantic level. Thus, lexical passives can be directly interpreted via the semantic structure of their lexical entry (21a); the assignment of agent status to material in a surface by-phrase (21b). That is, even with a by-phrase (21b) is still a stative construction, without syntactic movement, unambiguously clear because *unsatisfy* is not a verb. The agent is assigned the semantic representation based on a general lexical argument structure schema.

- (21)a. The shopkeepers were still unsatisfied
- b. The shopkeepers were still unsatisfied by the price

The fact that this is homonymous with syntactic passives allows the same initial perceptual mapping to occur, even though the final structure must include NP-trace. Similar arguments occur for raising constructions (17a), which are homonymous with PRO constructions. In (22a), the nounphrase is both the surface subject of the main verb and the complement (22a). Applying the corresponding schema to raising constructions (22b) correctly assigns the subject to the comp verb, and incorrectly to the raising verb.

- (22)a. The shopkeepers wanted [PRO] to be happy
- b. The shopkeepers seemed [NP-trace] to be happy

However, that misassignment is ultimately harmless, since the raising verb lexical information will require ultimate assignment of a factive complement as its logical subject. [This does, however, raise a prediction that people may briefly believe that subjects of raising verbs as in (17a) are truly their agent/experiencer—at least, testable in principle.]

The situation is quite different for constructions with WH-trace. These are characteristically not parallel with any other constructions that might be the basis for an initial perceptual schema that could map it onto a meaning. In (23a) the relative clause verb is lacking a required object, which does not correspond to any other construction. Thus, the WH-trace must be filled in immediately in order for semantic analysis to proceed, as in (23b).

- (23)a. This is the book that I bought
- b. This is the book that I bought [WH-trace]

Only then can the canonical NVN strategy apply to the relative clause sequence and provide an appropriate semantic analysis. Note that it will not do to model the initial semantic analysis of (23a) on intransitive sentences, since that would yield a seriously incorrect and incoherent semantic analysis, corresponding to something like (24).

- (24) This is the book. I bought.

Unfortunately, the contrast between WH-trace and NP-trace generally coincides with two kinds of experiments in the literature on priming. Up to now, the salience of NP-traces has been assessed primarily by the word-probe-recognition task. Another technique, “cross-modal-priming,” has primarily provided evidence for the salience of WH-trace. In that paradigm the dependent measure is the time to decide that a particular sequence of letters is a word. In the critical case, the letter-sequence appears visually just at the WH-trace point in an auditorally presented sentence [right after *bought*

in (23)]. The results show that words associated with the antecedent of the WH-trace (e.g., *page*) are recognized faster in the critical location than non-associated words (e.g. *gape*). This suggests that WH-traces access their antecedents immediately, as predicted by the syntax-last model. It remains to be shown that the probe-recognition technique elicits immediate priming of WH-trace, or that the cross-modal-priming technique elicits delayed priming for NP-trace: We need experiments that use both techniques on the same core set of sentences.

Let us suppose that the predicted results obtain: WH-trace primes its antecedent immediately in all paradigms, NP-trace primes its antecedent with some delay in all paradigms, and PRO primes its antecedent very little in all paradigms. By itself, this complex of results does not prove that either of the priming effects occurs because of a syntactic as opposed to a semantic reactivation of the antecedent. Consider first the WH-trace studies. The critical probe position occurs characteristically at the point where enough information has been presented to provide a complete semantic proposition. Thus, the associated probe word might be primed by the presence of the WH-trace of a high associate, or to the precedence of a just completed proposition with a high associate in it. Here, we have the same interpretive ambiguity as that involving syntactic modularity, discussed in the first section: Probes that occur after complete propositions may be affected by the conceptual information in the propositions. We need more direct on-line measures of the reactivation of WH-trace other than those that are plausibly subject to semantic integration effects.

Similar ambiguities do not apply to the minimal pairs used to study NP-trace probe recognition priming. In those cases, the probe appears in the same place, relative to complete propositions containing the antecedent, for example, at the end of the sentences in (17) and (18) [or at the end of sentences like those modeled on the Spanish ones in (26) below]. Yet the priming occurs selectively in those cases that include an NP-trace in the syntactic analysis. One might argue that the propositional representations of sentences with NP-trace selectively give extra marking to the critical words, and that the differential priming of NP-trace really comes from the semantic level. On this view, syntactic passives have an extra salient semantic/propositional representation of their surface subjects, while lexical passives do not. This conflicts with the fact that both syntactic and lexical passives can have both agents and objects, and essentially identical propositional structures, as in (15a) and (16a), despite the fact that syntactic passives are true syntactic passives as attested by their unique inability to serve as adjectival predicates (16). Furthermore, the contrast between the effectiveness of NP-trace in priming, and the ineffectiveness of PRO is hard to interpret as a semantic-based difference. In fact, in sentences with PRO the

semantic representation generally has *two* instances of the critical noun-phrase [(as in 18a) and (18b)] since it is the subject of two verbs; the semantic representation of sentences with NP-trace has *only one* instance of the critical noun phrase. Thus, while more studies are still required, especially with auditory materials, there is considerable support for the view that NP-trace does access its antecedent as part of the final stage of sentence comprehension, as predicted by the syntax-last model.

The syntax-last model has a variety of other implications. It is important in that it allows for a resuscitation of the much-maligned analysis by synthesis model of comprehension. The main failing of that model involved restricting the generation space for candidate derivations. The output of the perceptual strategies provides a list of the lexical items, the set of major phrases and a potential semantic organization, vastly constraining the possible candidate derivations. The model also melds well with the current minimalist syntax. In that architecture, sentence generation starts with a listing of the lexical items, which are combined into phrases and then analyzed for meaning: It would not be hard to build a model of how the output of the strategies melds with the operation of a minimalist syntax.

Finally, there are formerly unnoticed kinds of intuitions that are neatly explained if people first apply perceptual strategies to a sequence, form an initial meaning, and then check its syntax. Consider (25a).

(25a) That's the first time that anyone sang to me like that before!

In fact, this sentence is an ungrammatical blend of two grammatical ones. But what is important is the sequence of introspective events you go through when trying to understand it. First, it seems fine (because it triggers well-oiled perceptual schemata with roughly the same meaning); then it gradually starts to rattle as you realize that it does not quite compute into an actual sentence. Example (25b) is even more marked because, while it triggers plausible perceptual schemata, they do not add up to a coherent meaning.

(25b) More people have gone to Russia than I have

SPEAKERS' BELIEFS MAY DETERMINE THE SYNTACTIC STRUCTURE OF INDIVIDUAL SENTENCES

Language researchers often divide on the relation between peoples' conceptual and language structure. Cognitive grammarians propose that linguistic structure is actually a particular realization of belief systems, applied to symbolic behavior, that is, there is no autonomous syntax. Correspondingly, radical (syntactically eliminative) connectionists propose that every

kind of knowledge can play a direct role in ongoing sentence comprehension, with no privileged or isolable position for so-called syntactic constraints. Structural linguists and psycholinguists, on the other hand, claim that syntax is autonomous from semantics within a grammar, and is certainly autonomous from world belief systems in language processing. In general, people on both sides of the issue agree that, if conceptual beliefs interact with syntactic descriptions, it must be within a distributed framework like that proposed by connectionists.

We would like to suggest that the choice is not that stark. Rather, it may be possible to show that beliefs interact with syntactic analyses during comprehension by constraining the possible initial syntactic form and derivation—that is, the syntax is assigned (last, as proposed in the preceding section) but the initial semantic projection constrains the kind of syntax that is assigned. The semantics-first architecture of the comprehension system intrinsically allows the semantic representation to constrain the form of the syntax during processing. This may have surprising results, in which the speaker/hearer's beliefs can change the syntactic analysis of a sentence. Consider the Spanish and English contrast between unaccusative (26a) and unergative intransitive verbs (26b).

- (26)a. John died; Juan-i murio' [NP-i]
- b. John ran; Juan corrio'

The unaccusative/unergative semantic distinction is the same in both languages: Unaccusative predicates are unintentional; they happen "to" the agent; the opposite is true of unergatives.

- (27)a. *John intentionally died this morning; What happened to John is he died this morning.
- b. John intentionally ran this morning; *What happened to John is he ran this morning.

In Spanish, there are strong distributional arguments that the distinction is also syntactic: The surface subject of unaccusatives is raised from object position, leaving an NP-trace behind. (Essentially, the subjects of unaccusative verbs pattern distributionally with the objects of transitive verbs.) Consistent with this, in Spanish, the subject of sentences like (26a) is primed relative to sentences like (26b) (with a probe-word recognition paradigm like the one described above). Yet several studies have failed to find a corresponding priming effect for unaccusatives in English.

This failure may be real—that is, it may reflect the fact that unaccusatives in English are not raising verbs. Indeed, the distributional arguments differentiating unaccusatives and unergatives in English are much weaker than in Spanish. The most stable phenomenon in English is the presence of

small clauses with unaccusatives. In (28a), an analysis with trace would provide the subject of *happy*, and its absence would account for the ungrammaticality of (28b). However, this construction is variable and often appears idiomatically limited rather than productive. So it may be that English speakers do not have sufficient distributional evidence to code unaccusatives as raising verbs. [In this case, constructions like (28a) would be treated as “peripheral,” or possibly as “double-verb” constructions.]

- (28)a. John died [NP-trace] happy
 b. *John ran happy

The conceptual type of action of intransitive verbs may be what is actually at issue. Unaccusative verbs are characteristically telic, that is, they involve a completed action with a fixed point in time. One way to mark telicity syntactically is with a delimiting phrase. The cases in (29a) are not telic because the delimiting phrase is not specific, and hence the act of drinking is not a completed action. In (29b), the specific direct object delimits the verb and makes the construction telic.

- (29)a. John drank. John drank liquids.
 b. John drank the liquid.

In the minimalist syntactic architecture, conceptual features like telicity are either “strong” or “weak.” Strong features must be marked by an overt syntactic device or effect, while weak features remain semantic only. The difference between Spanish and English unaccusatives may be due to the fact that telicity is strong in Spanish, and weak in English. On this hypothesis, in Spanish, telic predicates require an argument in object position to delimit them. Unaccusatives have only one argument; hence, they always start with their surface subject in object position to delimit the verb. English does not require such marking.

But English sentences can have telicity marked by a delimiter, even if it is not required (15a) and (15c), reprinted here as (30a) and (30b).

- (30)a. The shopkeepers were ruined for years by the flood
 b. The shopkeepers were ruined at midnight by the flood

Example (30a) marks the sentence as stative, and hence a lexical passive. In (30b) the action is delimited, which in turn marks the verb as a specific act, and hence a syntactic passive [see the discussion of (15) and (16) above]. This makes a striking prediction, which we have not yet tested: Cases like (30b) will prime their antecedent more than cases like (30a). (The priming contrast we have found between lexical and syntactic passives used materials without specific or generic delimiters of any kind.)

It has long been accepted that lexical passives like *ruined* can have a double life: That is, they are ambiguous between being lexical and syntactic passives. The fact that this is related to telicity (and not to the mere presence of an apparent agent with a by-phrase) raises the possibility that true syntactic passives can be transformed into lexical ones, in local contexts which clearly “detelicitize” them. In (31b), the adverb *repeatedly* specifies that the action occurred characteristically, specifically without delimitation. This modification clearly makes the entire verb phrase a potential adjective as in (31d) and possibly (31f). That is, the former syntactic passive, *attacked*, is now licensed to appear in the frames diagnostic for lexical passives. Does this mean that it does not have a syntactic derivation involving trace? We do not know, but it is certainly worth testing.

- (31)a. The shopkeeper was attacked [NP-trace] yesterday
- b. The shopkeeper was attacked [NP-trace?] repeatedly.
- c. *The attacked shopkeeper. . . .
- d. The repeatedly attacked shopkeeper. . . .
- e. *The shopkeeper looked attacked
- f. The shopkeeper looked repeatedly attacked

An equally startling prediction derives from the fact that unergative verbs can take on short clauses when they are made telic by a delimiting phrase. Thus, (32b) and (33b) are acceptable, in association with phrases that make the unergative verbs telic.

- (32)a. *John ran in circles happy
- b. John ran home [NP-trace?] happy
- (33)a. ?The boat floated towards the dock rudderless
- b. The boat floated to the dock [NP-trace?] rudderless

The question is: Does making the verb telic also induce a raising analysis, with a trace left behind.

Experiments are required to contrast the priming of subjects in sentences like those in (30a), (30b), (31a), (31b), (32a), (32b), (33a), and (33b) to see. If telicity does control priming in such cases, this will demonstrate a powerful local effect of conceptual structure on syntactic organization. It will also show that whether the structures in Example (31) through (33) are treated syntactically as raising depends on the speaker/hearer's belief about the nature of the modifying phrase. In those cases, the belief is triggered by specific lexical items: *at midnight* versus *for years* in (30); *yesterday* versus *repeatedly* in (31); *home* versus *in circles* in (32); *to* versus *toward* in (33). It is hard to see how these distinctions can be semantically coded in such a way as to be represented lexically or in the grammar; rather it is our conceptual analysis of the delimiters that determines the structure. This is clar-

ified by an example like (34), in which whether the structure is telic or not depends entirely on your belief about the conceptual application of the preposition *around*.

(34) Then, Phineas flew around the world [NP-trace] happy

If you believe that Phineas planned to fly around the world once, as a goal, then (34) is telic and OK. But if you believe that Phineas is city-hopping in a random way, then (34) is a-telic and ungrammatical.

The combination of the syntax-last architecture and minimalist syntactic description at least affords a way to handle such phenomena while preserving the structural integrity of the syntactic derivation. On this view, the initial perceptually proposed semantics either projects telicity or it does not: If it does, then there must be a corresponding projection in the syntax, requiring "checking" (i.e., movement in more traditional terms). Thus, the belief determines the initial tree form, and consequently the presence or absence of movement.

Of course, all this line of argumentation requires that we demonstrate that the telicity of constructions indeed controls whether an NP-trace is present in the representation. We are working on that. But, however it comes out, the preceding discussion at least offers a possible way in which conceptual beliefs can interact closely with segregated syntactic descriptions.

There are other implications of a processing model in which correct syntax is assigned after an initial lexical and semantic analysis. We are just beginning to study them. Aside from whether the scheme is correct or not, we hope we have convinced you that it is at least a logical possibility.

People may understand sentences before they parse them correctly.

CONCLUSION

The relation between pattern frequencies, semantics and syntax remains the central problem of language processing. Almost any set of simplifying assumptions about how to study that integration and how it works is likely to be incomplete or wrong. The damn thing is probably much more complex than our models will allow.

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