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Resolution of Syntactic Ambiguity: the Case of New Subjects*

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Abstract

I review evidence for the claim that syntactic ambiguities are resolved on the basis of the meaning of the competing analyses, not their structure. I identify a collection of ambiguities that do not yet have a meaning-based account and propose one which is based on the interaction of discourse and grammatical function. I provide evidence for my proposal by examining statistical properties of the Penn Treebank of syntactically annotated text.

Introduction

On what basis do people resolve the syntactic ambiguity so common in language? Some researchers (e.g. Frazier and Fodor 1978, Mitchell Corley and Garnham 1992 and references therein) have argued that the sentence processor embodies structurally defined criteria such as Minimal Attachment and Late Closure. Others (e.g. Crain and Steedman 1985, Altmann and Steedman 1988, Trueswell and Tanenhaus 1991) have argued that ambiguity resolution decisions are made online, rather quickly, based on the relative sensibleness of the available analyses. Psycholinguistic research of this issue has focused on a limited collection of structures such as:

- (1) a. The horse raced past the barn fell.
b. The doctor told the patient that he was having trouble with to leave.

Out of context, sentences with structures similar to either of these examples are garden-paths. When such sentences are put in contexts that support the correct reading, the garden-path effect disappears. Some questions remain

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about how quickly such discourse-sensitive sensibleness preferences are brought to bear on the ambiguity resolution process (Mitchell *et al.* 1992). But this issue will not be addressed further here.

One attractive aspect of structural preference theories is that two very simple structural strategies can account for so much data. Aside from the two examples in (1) Minimal Attachment defined in (2) predicts that (3) is a garden-path.

- (2) Minimal Attachment (Frazier and Fodor 1978): Each lexical item (or other node) is to be attached into the phrase marker [in the way which requires the smallest] possible number of nonterminal nodes linking it with the nodes which are already present.
- (3) John has heard the joke about the pygmy is offensive.

Late Closure (4) predicts difficulties with the sentences in (5).

- (4) Late Closure (Frazier and Rayner 1982): When possible, attach incoming lexical items into the clause or phrase currently being processed (i.e. the lowest possible nonterminal node dominating the last item analyzed).
- (5) a. John said that Bill will leave yesterday.
b. When the cannibals ate the missionaries drank.
c. Without her contributions failed to come in. (from Pritchett 1988)
d. When they were on the verge of winning the war against Hitler, Stalin, Churchill and Roosevelt met in Yalta to divide up postwar Europe. (from Ladd 1992)

The claim of this paper is that ambiguity resolution decisions are based solely on the sensibleness of the available readings. I argue that for each structure in (1), (3), and (5), aspects of meaning which must be assumed for independent reasons are responsible for the ambiguity resolution behavior observed in humans.

Existing Accounts

Crain and Steedman (1985) argued that resolution of the ambiguity in (1)b is sensitive to the prior discourse. When there is a unique patient in the discourse, the NP 'the patient' uniquely identifies him/her and there is no need for further restrictive modifiers. Consistent with Grice's (1965) maxim of Manner (be brief), the hearer selects the complement clause analysis of 'that he...'. When there are two patients in the discourse, the NP 'the patient' does not pick out a unique referent, so Grice's maxim of Quantity (make your contribution as informative as required) guides the hearer to construe the continuation 'that he...' as a restrictive relative clause.

When the sentence is presented out of context, the hearer must *accommodate* a situation in which it is felicitous. That is, the hearer must change his/her mental model to support the presuppositions carried by the sentence. The restrictive relative clause reading requires accommodating a more complex situation in which there is more than one patient, so according to a preference for parsimony, the complement clause analysis is preferred.

In another study Crain and Steedman (1985) found that the garden path effect in sentences with structures as in (1)a is reduced/eliminated when the main-verb reading is implausible. This finding was replicated by Pearlmuter and MacDonald (1992). Others (e.g. Trueswell and Tanenhaus 1991) have found other aspects of meaning (e.g. temporal coherence) are also relevant for the ambiguity in (1)a.

Niv (1992) argued that the tendency for low attachment of adverbials such as 'yesterday', as in (5)a, results from a general principle of competence to order constituents in the sentence in increasing order of "information volume". Attaching 'yesterday' high is dispreferred as this single-word constituent would have to follow the heavier constituent 'that Bill will leave'. This preference disappears when the adverbial is made heavier, e.g. 'because he became very angry at us.'

Stowe (1989, experiment 1) found that for a certain class of ambiguous verbs, plausibility manipulations can affect the garden path effect in (5)b. For verbs which exhibit causative/ergative alternations, illustrated in (6), reducing the plausibility of the subject to serve as the causal agent (e.g. (7)b) picks out the ergative reading and avoids the garden path.

(6) Causative: John moved the pencil.
Ergative: *The pencil moved.*

- (7) a. *Before the police stopped the driver was already getting nervous.*
b. *Before the truck stopped the driver was already getting nervous*

Recent research on the local ambiguity in (3) has focused on whether subcategorization preferences of the matrix verb affect the garden-path. When the matrix verb is one which tends to take a clausal complement more often than an NP complement, the garden path may be avoided. As with other psycholinguistic facts summarized here, the claims are still controversial, but a recent experiment by Garnsey, Lotocky and McConkie (1992) seems to settle the issue in favor of lexical preference effects.

In summary, there are meaning-based accounts for people's ambiguity resolution preferences for (1)a, b, and (5)a. Lexical preference accounts for some of the observation, in (3) and (5)b, but cannot alone account for the garden paths in (8).

- (8) a. *John finally realized just how wrong he had been remained to be seen.*
b. *When Mary returned some of the presents were missing.*

(8)a has the same structure as (3) and the verb 'realize' is biased toward a sentential complement reading (according to Garnsey *et al.*'s findings, as well as the Brown Corpus). But there is still a perceptible garden-path effect. (8)b has the same structure as (5)b and the verb 'return' occurs more frequently in the Brown Corpus without an object than with one. But again, there is still a garden path effect.

Avoid Subjects

All of the examples above that are not fully accounted for, i.e. (5)c, d, (8)a, b, exhibit a common property — a certain NP, which I will call the *critical NP*, has both a subject and a non-subject analysis. In each of these examples, the non-subject analysis is preferred.

There are a few hints in the literature that readers really do prefer to avoid subjects. One hint comes from a second experiment that Stowe (1989) conducted. In addition to manipulating the agenthood of the subject of the first clause, this experiment also manipulated the plausibility of the critical NP to serve as the direct object. Sample experimental materials are given in (9).

- (9) **Animate:**
 Plausible: When the police stopped the driver became very frightened.
 Implausible: When the police stopped the silence became very frightening.
- Inanimate:**
 Plausible: When the truck stopped the driver became very frightened.
 Implausible: When the truck stopped the silence became very frightening.

Stowe found implausibility effects at the critical NP even in the inanimate sentences, where the readers exhibit commitment to the ergative (intransitive) analysis.

Another hint comes from an experiment by Holmes, Kennedy and Murray (1987). Using experimental materials as in (10), Holmes *et al.* found that in the disambiguation region (either 'to the officer' or 'had been changed') the transitive verb sentence (TR) was read substantially faster than the other two sentences.

- (10) (TR) The maid disclosed the safe's location within the house to the officer.
 (TC) The maid disclosed that the safe's location within the house had been changed.
 (RC) The maid disclosed the safe's location within the house had been changed.

The that-complement (TC) sentence was read slightly faster than the reduced complement (RC) sentence. This finding was subsequently replicated by Kennedy *et al.* (1989). It is quite surprising that the unambiguous condition TC should take longer than the locally ambiguous condition TR. Holmes *et al.*'s speculation that beginning a new clause requires additional processing is consistent with a strategy of avoiding analyzing NPs as subjects.

My claim is not that the processor is averse to subjects in general, but rather that it prefers to avoid only a certain class of subjects, namely those which are new to the discourse. Given that all of the examples above are presented out of context, it is clear that all critical NPs are new to the hearer/reader's model of the discourse.

Given and New

Prince (1981) proposed a classification of occurrences of NPs in terms of assumed familiarity. When a speaker refers to an entity which s/he assumes salient/familiar to the hearer, s/he tends to use a brief form, such as a definite NP or a pronoun. Otherwise s/he is obliged to provide the hearer with enough information to construct this entity in the hearer's mind. Prince classified the forms of NPs and ranks them from given to new:

evoked An expression used to refer to one of the conversation's participants or an entity which is already under discussion. (usually a definite NP or pronoun)

unused A proper name which refers to an entity known to the speaker and hearer, but not already in the present discourse.

inferable A phrase which introduces an entity not already in the discourse, but which is easily inferred from another entity currently under discussion. (c.f. bridging inference of Haviland and Clark 1974)

containing inferable An expression that introduces a new entity and contains a reference to the extant discourse entity from which the inference is to proceed. (e.g. 'one of the people that work at Penn')

brand new An expression that introduces a new entity which cannot be inferentially related or predicted from entities already in the discourse.

Prince constructed this scale on the basis of scale-based implicatures that can be drawn if a speaker uses a form which is either too high or too low — such a speaker would be sounding uncooperative/cryptic or needlessly verbose, respectively.

Using this classification, Prince found that naturally occurring texts exhibit a significant tendency to avoid placing new NPs (including inferable and unused) in subject position. If we construe this tendency as a principle of the linguistic competence, we would indeed expect a reader to prefer to treat an out-of-context NP as something other than a subject. I refer to this principle as *Avoid New Subjects*.

Late Closure and Avoid New Subjects

The principle of Avoid New Subjects predicts that in ordinary text the Late Closure Effect exhibited in (5)b should disappear when the critical NP is given in the discourse. To test this prediction, I conducted a survey of the bracketed Brown and Wall Street Journal corpora for the following configuration: a VP which ends with a verb and is immediately followed by an NP. Crucially, no punctuation was allowed between the VP and the NP. I then removed by hand all matches where there was no ambiguity, e.g. the clause was in the passive or the verb could not take the NP as argument for some reason. Of the eleven remaining matches, four are given below. Each is preceded by some context, and followed by illustration of the ambiguity (in brackets), and by a categorization of the critical NP.

1. [An article about a movie describes how its composer approached one of the singers.] When you approach

a singer and tell her you don't want her to sing you always run the risk of offending.

['You don't want her to sing you a song.']

'you' = evoked.

2. From the way she sang in those early sessions, it seemed clear that Michelle (Pfeiffer) had been listening not to Ella but to Bob Dylan. "There was a pronunciation and approach that seemed Dylan-influenced," recalled Ms. Stevens. Vowels were swallowed, word endings were given short or no shrift. "When we worked it almost became a joke with us that I was constantly reminding her to say the consonants as well as the vowels."

['When we worked it out. . .]

'it' = pleonastic.

3. After the 1987 crash, and as a result of the recommendations of many studies, "circuit breakers" were devised to allow market participants to regroup and restore orderly market conditions. It's doubtful, though, whether circuit breakers do any real good. In the additional time they provide even more order imbalances might pile up, as would-be sellers finally get their broker on the phone.

[Even though this example involves a wh-dependency, the fact remains that the NP 'even more order imbalances' could be initially construed as a dative, as in 'In the additional time they provide even the slowest of traders, problems could. . .']

'even more order imbalances' = brand new

4. [Story about the winning company in a competition for teenage-run businesses, its president, Tim Larson, and the organizing entity, Junior Achievement.] For winning Larson will receive a \$100 U.S. Savings Bond from the Junior Achievement national organization.

[. . .winning Larson over to their camp. . .]

'Larson' = evoked

As can be expected of carefully written prose, none of the matches posed any reading difficulty. Of the eleven critical NPs, four were pleonastic, five were evoked, one was inferable and one was brand new. Prince's givenness scale does not include pleonastic NPs, since they do not refer. For the present purpose, it suffices to note that Avoid New Subjects does not rule out pleonastics. While the numbers here are too small for statistical inference,¹ the data suggest that the prediction of Avoid New Subjects is maintained.

¹Given the high frequency of given subjects, optionally transitive verbs and fronted adverbials, one might expect more matches in a two million word corpus. But examination of the Wall Street Journal corpus

Complement Clauses

In order to be relevant for the ambiguity in (3) Avoid New Subjects must be applicable not just to subjects of matrix clauses but also to embedded subjects. It is widely believed that constituents in a sentence tend to be ordered from given to new. The statistical tendency to avoid new subjects may be arising solely as a consequence of the tendency to place new information toward the end of a sentence and the grammatically-imposed early placement of subjects. If this were the case, that is, Avoid New Subjects is a corollary of Given Before New, then Avoid New Subjects would make no predictions about subjects of complement clauses, given that complement clauses tend to appear rather late in the sentence. I now argue from the perspective of sentence production that it is the grammatical function of subjects, not just their linear placement in the sentence, that is involved with the avoidance of new information.

When a speaker/writer wishes to express a proposition which involves reference to an entity not already mentioned in the discourse, s/he must use a *new* NP. S/he is quite likely to avoid placing this NP in subject position. To this end, s/he may use constructions such as passivization, there-insertion, and clefts.

Avoid New Subjects predicts that this sort of effort on behalf of writers should be evident in both matrix clauses and complement clauses. To test this prediction, I compared the informational status of NPs in subject and non-subject positions in both matrix and embedded clauses. I defined subject position as an NP immediately dominated by S and followed (not necessarily immediately, to allow for auxiliaries, punctuation, etc.) by a VP. I defined non-subject position as an NP either immediately dominated by VP or immediately dominated by S and not followed (not necessarily immediately) by VP. To determine givenness status, I used a simple heuristic procedure² to classify an NP into one of the following categories: EMPTY-CATEGORY, PRONOUN, PROPER-NAME, DEFINITE, INDEFINITE, NOT-CLASSIFIED. The observed frequencies are given in table 1 at the end of this paper.

PRONOUNS are either pleonastic or evoked — they are thus fairly reliable indicators of given (at least non-new) NPs. The category INDEFINITE contains largely brand-new or inferable NPs, thus being a good indicator of new information. Considering PRONOUNS and INDEFINITEs there is a clear effect on grammatical function for

reveals that most fronted adverbials are set off by comma, regardless of potential ambiguity. Of 7256 sentence initial adverbials, only 8.14% (591) are not delimited by comma. Of these 7256 adverbials, 1698 have the category SBAR, of which only 4.18% (71) are not delimited by comma. The great majority of fronted adverbials (4515) have category PP, of which 8.75% (433) are not delimited by comma.

²I am grateful to Robert Frank for helpful suggestions regarding this procedure.

both matrix and embedded clauses.³

	matrix clause		embedded clause	
	subj	non-subj	subj	non-subj
PRONOUN	7580	956	1800	213
INDEFINITE	4157	5269	736	899
	$\chi^2 = 3952.2$ $p < 0.001$		$\chi^2 = 839.5$ $p < 0.001$	

The prediction of Avoid New Subjects is therefore verified.

When a hearer/reader is faced with an initial-segment such as (11), the ambiguity is not exactly between an NP complement analysis versus an S-complement analysis, but rather between an TR (transitive verb) analysis and an RC (reduced S-complement).

(11) John has heard the joke. . .

It is therefore necessary to verify that Avoid New Subjects is indeed operating in this RC sub-class of sentential complements. A further analysis reveals that this is indeed the case.

	TC		RC	
	subj	non-subj	subj	non-subj
PRONOUN	773	79	1027	134
INDEFINITE	617	555	119	344
	$\chi^2 = 332.6$ $p < 0.001$		$\chi^2 = 627.6$ $p < 0.001$	

If anything, Avoid New Subjects has a stronger effect after a zero complementizer.

Unambiguous Structures

The findings of Holmes *et al.* (1987), that effects predicted by Avoid New Subjects are present even in unambiguous structures, transfer to other unambiguous structures, such as the classical center embedding sentence:

(12) The rat that the cat that the dog bit chased died.

In this sentence three new subjects must be accommodated simultaneously. Of all the examples that I have seen of sentences with a structure as in (12), the easiest one to understand is (13) from Frank (1992).

(13) A book that some Italian I've never heard of wrote will be published soon by MIT press.

Notice that this example requires the simultaneous processing of only two new subjects, the most embedded subject being evoked. When this subject is replaced with a new NP, the sentence becomes harder to process.

(14) A book that some Italian most people have never heard of wrote will be published soon by MIT press.

³For reasons of space I only give results from the Brown corpus, but all assertions I make also hold of the Wall Street Journal corpus.

Also, when a complex, center-embedded NP appears in subject position (15)a, it is harder to process than when it appears in object position (15)b. (15) is based on an example from Gibson (1991) which is in turn based on earlier work by Cowper.

- (15) a. Many bureaucrats who the information that Iraq invaded Kuwait affected negatively work for the government.
b. The government employs many bureaucrats who the information that Iraq invaded Kuwait affected negatively.

I don't wish to claim that the new-subject effect is solely responsible for all of the difficulty associated with center embedding, but it is clear that it is playing an important role.

Conclusion

I have argued for an account of sentence processing wherein the syntactic processor applies the rules of the competence grammar blindly and faithfully. Ambiguity resolution decisions are made by the interpreter when it considers the analyses which the syntactic processor has proposed and evaluates them on the basis of sensibleness. The criteria I have appealed to: Grice's maxims, ordering constituents by the amount of information they convey, and not putting new information in subject position, are all components of our knowledge of language and not the exclusive domain of the process of parsing, nor that of production.

Avoid New Subject predicts that for sentences such as (3), the garden path effect should disappear when the sentence is put in a context in which the NP is given, and its form is felicitous. The design and execution of an experiment to test this prediction remain for future research.

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Brown Corpus:

givenness status	Subjects				Non Subjects			
	TC	RC	TC+RC	matrix	TC	RC	TC+RC	matrix
EMPTY-CATEGORY	0	50	50	0	6	41	47	0
PRONOUN	773	1027	1800	7580	79	134	213	956
PROPER-NAME	201	81	282	2838	32	21	53	539
DEFINITE	890	266	1156	6686	351	182	533	3399
INDEFINITE	617	119	736	4157	555	344	899	5269
NOT-CLASSIFIED	259	107	366	3301	167	79	246	1516
total:	2740	1650	4390	24562	1190	801	1991	11679

Wall Street Journal Corpus:

givenness status	Subjects				Non Subjects			
	TC	RC	TC+RC	matrix	TC	RC	TC+RC	matrix
EMPTY-CATEGORY	4	83	87	0	2	20	22	1
PRONOUN	369	2263	2632	2347	34	90	124	169
PROPER-NAME	167	371	538	3364	29	89	118	377
DEFINITE	610	1686	2296	5385	253	729	982	1959
INDEFINITE	498	805	1303	3847	484	1375	1859	4039
NOT-CLASSIFIED	251	278	529	2402	178	581	759	2138
total:	1899	5486	7385	17345	980	2884	3864	8683

Table 1: Frequencies of NPs by discourse status and grammatical position in two corpora.

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