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A Bilateral Approach to Givenness: A Hearer-Status Algorithm and a Centering Algorithm*

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0. Introduction.

A number of models have been proposed to account for various information-statuses that a discourse entity may have, e.g. Prince's (1981) Given/New Taxonomy, Ariel's (1990) Accessibility Theory, Gundel, Hedberg, and Zacharski's (1993) Givenness Hierarchy. However, Prince does not address the problem of when an *Evoked* entity is pronominalizable and thus cannot account for the data in 1; Ariel addresses this issue with a *D/M*distinction and GHZ with an *In-focus/Activated* distinction, but neither can account for such data:

(1) This guy$_i$'s sitting in the park, minding his$_i$ own business. After a while, he$_i$ takes out his$_i$ lunch and starts eating. Suddenly, he$_i$ notices a guy$_j$ on the next bench.
   a. He$_i$/#He$_j$ looks at the guy#$_i$/the guy$_j$ and says...[1]
   b'. The guy#$_i$/The guy$_j$ looks at him$_i$/#him$_j$ and says...[2]
   b''. He$_i$/He$_j$ looks at him$_j$/him$_i$ and says...[3]

We believe that such single-hierarchy accounts either ignore crucial issues or else conflate two partially orthogonal phenomena, the information-status which a speaker believes a given entity has in the hearer's mind, irrespective of its role in the utterance being processed, and the activatedness of that entity in the current utterance. We propose instead a bilateral approach consisting of a Hearer-Status Algorithm working in tandem with the Centering Algorithm (Brennan, Friedman, and Pollard 1987, Walker, Iida, and Cote 1994). In what follows, we shall give only a rough sketch of what a Hearer-Status Algorithm might look like, since we feel this is a far more familiar domain to the audience, and we shall spend more time discussing activatedness and how it is handled by the Centering Algorithm.

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[1]When asked which interperetation they found more natural, 11/11 native speakers favored the *he$_i$/guy$_j$* interpretation in the context provided.

[2]Likewise, 11/11 native speakers favored the *guy$_j$/him$_i$* interpretation in the context provided.

[3]Similarly, 9/11 native speakers favored the *he$_i$/him$_j$* interpretation in the context provided; 2/11 native speakers favored the *he$_j$/him$_i$* interpretation in the same context.

1.0. Hearer-status.

As is well known, in languages like English, Hearer-Status is marked, more or less, by the definite/indefinite distinction (e.g. Hawkins 1978, Heim 1983, Fraurud 1992, though their views on what exactly is marked differ). We must say 'more or less' for two reasons. First, the conceptual category of Hearer-status has undergone grammaticization in the formal marking of definiteness, resulting in a lack of isomorphism between form and understanding. Consider, for example, the marking of generics in two otherwise very similar languages, English (2) and French (3):

(2) a. I love roses.
   b. I bought roses.

(3) a. J'adore les roses.
   b. J'ai acheté des roses.

In 2a, the speaker is saying that she loves the class of roses in general and, although she assumes the hearer knows what roses are and therefore already has a filecard for the class, the English version in 2a marks roses with a zero article, which is, if not indefinite, homonymous with the plural indefinite, seen in 2b, where some (sub)set of roses is evoked, a subset assumed by the speaker to be unknown to the hearer and requiring a new filecard in the hearer's knowledge-store. In contrast, the French versions are more straightforwardly marked: the generic, i.e. Hearer-old, roses in 3a has a definite article, the Hearer-new roses in 3b has an indefinite.

Second, the match between Hearer-status and definiteness-marking is not isomorphic because things are more complex than a simple binary distinction. In particular, the category of *Inferrable* entities simultaneously introduces complexity and efficiency into the system. To illustrate this, let us look at the discourse in 4:

(4) a. I bought a book yesterday. The book had a cover. The cover was torn.
   b. John came to my house. My house has several doors. One of the doors opens onto the street and it is this door that John approached. He knocked on the door.

If there were only two possible Hearer-statuses in the world, Hearer-old and Hearer-new, then, grammaticization aside, definiteness-marking could be isomorphic with Hearer-status. However, we would wind up having discourses like those in 4, which would be an intolerable state of affairs. What makes the discourses in 4 so intolerable is that, just as speakers have assumptions about what entities hearers already know, they also have assumptions about other sorts of things in hearers' knowledge-stores, and these other things must be taken into account as well in felicitous discourse,

although in more indirect ways than the Hearer-status of entities. For example, the utterer of 4a must be assuming that the hearer knows what a book is, given the use of the NP a book tout court. Now, if someone knows what a book is, s/he must know, *inter alia*, that a book typically has a cover. Furthermore, if the speaker believes the hearer knows that a book typically has a cover, then the speaker should believe that the hearer knows that the book just mentioned probably has a cover. Therefore, telling the hearer that this book had a cover violates basic Gricean principles.

And herein lies the problem of Inferrables: how do you mark an entity for which the hearer cannot be expected to already have a filecard but whose existence (in the discourse-model) the hearer can certainly be expected to arrive at inferentially, on the basis of general knowledge s/he is assumed to have? In English and the other languages we have looked at, the NPs evoking such entities are in fact marked, if they are marked at all, in the same way as NPs evoking Hearer-old entities.[4] Moreover, a statistical analysis of NPs in a naturally-occurring text revealed that the syntactic distribution of NPs evoking Inferrable entities was statistically indistinguishable from NPs evoking Hearer-old entities that had not yet been mentioned in the discourse (Prince 1992).

Thus, ignoring of course idiosyncratic effects of grammaticization, which we assume must be learned separately, just like other 'irregularities' in language, we arrive at a very simple Hearer-status algorithm:

(5) **Hearer-Status Algorithm:**
When evoking an entity which you believe the hearer already 'knows about' or else already has the requisite knowledge and reasoning capability to infer, mark the NP representing that entity as definite.
When evoking an entity which you believe the hearer does not yet 'know about' and cannot infer, mark the NP representing that entity as indefinite.

Obviously, much more has been said, can be said, and will be said about Hearer-status and its formal reflexes but we shall turn now to the notion of activatedness, or 'Discourse-status'.

[4]Of course, if the Inferrable entity is an arbitrary member of a set (itself Evoked or Inferrable), then it is marked as an indefinite, as shown below:

i. [A kindergarten class]$_i$ went on a trip yesterday and [a kid]$_{i'}$ got sick.
[a kid]$_{i'} \in$ [a kindergarten class]$_i$

ii. I approached [the car]$_i$ and saw that [a tire]$_{i''}$ was flat.
[a tire]$_{i''} \in$ [a set of four tires]$_{i'}$
[a set of four tires]$_{i'}$ is-functionally-dependent-on [a car]$_i$

2.0. Discourse-status: Centering Algorithm

Centering is a way of modeling attentional state in discourse; it is intended as a component of a theory of local discourse coherence (Joshi and Weinstein 1981, Grosz, Joshi, and Weinstein 1983, 1986). According to Centering, each utterance U_i in a coherent local sequence of utterances (a discourse segment) $U_1 \ldots U_m$ affects the structure of the discourse model in two ways. First, each utterance evokes a set of discourse entities (file cards) called *Forward-looking centers*, or {Cf}. Second, this set may contain a distinguished member called the *Backward-looking center*, or Cb. The Cb entity is a link from the current utterance to the previous discourse. If an utterance is discourse-segment-initial, then it has no Cb.

The modeling of discourse salience is achieved through the determination of the Cb, in combination with a ranking on the set of Forward-looking centers, {Cf}, according to factors which determine discourse salience. The highest ranked element of {Cf} is the *Preferred center*, or Cp. The Preferred center is a prediction about the Cb of the following utterance. Sometimes the Cp will be what the previous segment of discourse was about, the Cb, but this is not necessarily the case. This distinction between looking back to the previous discourse with the Cb and projecting preferences for interpretation in subsequent discourse with the Cp is a key aspect of the Centering framework.

Below are presented the Centering Rules and Constraints as given in Grosz, Joshi, and Weinstein 1986, which were incorporated into the Centering Algorithm presented in Brennan, Friedman, and Pollard 1987.

2.1. Centering Rules and Constraints.

In addition to the Cb and Cf structures, the Centering framework defines constraints on coherence and specifies a set of rules and constraints for determining the Cb and {Cf} for an utterance. The Constraints are given in 6:

(6) **Constraints:**
For each utterance U_i in a discourse segment $U_1,\ldots,U_m$:
a. There is at most one Backward-looking center, Cb.
b. Every element of the Forward-looking centers list of U_i, {Cf(U_i}, must be realized in U_i.
c. The Backward-looking center of U_i, Cb(U_i), is the highest-ranked element of {Cf(U_{i-1})} that is realized in U_i.

The Constraint in 6a says that there is at most one central discourse entity that the utterance is about, and that is the Cb. The Constraint in 6b depends on the definition of *realizes*. An utterance U *realizes* a center Cf if Cf is an element of the situation described by U, or if Cf is the semantic interpretation of some subpart of U (Grosz, Joshi, and Weinstein 1986). Thus the relation *realize* describes zeros, explicitly realized discourse entities, and implicitly realized centers that are entities inferrable from the discourse situation (Prince 1978, Prince 1981, Kameyama 1985). Here, we use the relation *evoke* as a

specialization of the relation *realize*, and only centers realized by noun phrases and zero pronouns, which are explicitly evoked by an utterance, are included in the {Cf}.

Because of the Constraint in 6c, the ranking of the Forward-looking centers, {Cf}, determines which of the discourse entities evoked in the next utterance will be the Cb for that utterance. We will discuss factors that determine the ranking below, but note here that, if the Preferred center of some utterance U_i, $Cp(U_i)$, is realized in U_{i+1}, it is predicted to be the $Cb(U_{i+1})$.

Within the Centering framework, local coherence is meant to reflect the hearer's inference load when interpreting a discourse sequence. One factor that determines local coherence is changes or shifts in the Cb: thus discourse segments that continue centering the same entity are more coherent than those that repeatedly shift from one center to another. This intuition is reflected in the definition of Centering *Transitions*.

Two factors determine which Transition holds between two adjacent utterances U_{i-1}, U_i: whether the Backward-looking center, Cb, is the same from U_{i-1} to U_i, and whether this discourse entity is the same as the Preferred center, Cp, of U_i.[5] The set of Transitions is summarized in 7 (from Brennan, Friedman, and Pollard 1987).

(7) **Transitions:**

	$Cb(U_i) = Cb(U_{i-1})$	$Cb(U_i) \neq Cb(U_{i-1})$
$Cb(U_i) = Cp(U_i)$:	Continue	Smooth-shift
$Cb(U_i) \neq Cp(U_i)$:	Retain	Rough-shift

The Continue Transition seems to correspond to cases where the speaker has been talking about a particular entity and indicates an intention to continue talking about that entity. A Retain Transition holds when the Cb has remained constant over two utterances, but the prediction is that the Cb will change. Retain seems to correspond to a situation where the speaker is intending to *shift* onto a new entity in the next utterance and is signaling this by realizing the current center in a lower-ranked
position on the {Cf}.[6] If the Cb is not continued across two adjacent utterances, then either a Smooth-shift or a Rough-shift Transition holds. A Smooth-shift tends to occur when the speaker has started talking about a new entity and is doing so in a way that indicates that s/he will continue talking about that entity, while a Rough-shift tends to occur when the speaker has started talking about a new entity but is only doing so momentarily. We have found in our examinations of naturally-occurring discourse that Rough-shifts are extremely rare.

The Transitions are ranked according to the hearer's perceived inference load by the Ordering Rule below. In addition, the Pronoun Rule below reflects the fact that the speaker's use of pronouns (including zero pronouns in those languages that have them, cf. Kameyama 1985, Walker, Iida, and Cote 1994, Hoffman and Turan 1993) demonstrates which entities the speaker believes to be currently most salient, the Cb, as the link to the prior discourse, being currently most salient.

(8) **Rules:**

a. **Pronoun Rule:** For each U_i in a discourse segment $U_1,\ldots,U_m$, if some element of $\{Cf(U_{i-1})\}$ is realized as a pronoun in U_i, then so is $Cb(U_i)$.

b. **Ordering Rule:** Transition states are ordered: Continue is preferred to Retain, which is preferred to Smooth-shift, which is preferred to Rough-shift.[7]

The Pronoun Rule in 8a makes the prediction that, if there is only one pronoun, then that pronoun must represent the Cb. The Ordering Rule in 8b reflects the fact that coherence is relative, so that some Transitions are preferred over others. Note also that, although the Pronoun Rule makes the current Cb the most salient entity, the Cp may be different from the Cb and is predicted to be the next Cb. In the next section, we discuss the factors that determine the ranking of the {Cf}.

2.2. Ranking of the Forward-looking centers.

The ordering of the {Cf} is the main determinant of which Transition holds between adjacent utterances. This means that the predictions of the theory are largely determined by the ranking of the items on the {Cf}. We believe that a number of syntactic, semantic, and discourse factors contribute to the salience of an entity, such as lexical semantics, word order, prosody, and syntactic construction, as shown in previous work (Brennan, Friedman, and Pollard 1987, Hudson-D'Zmura 1988, Walker, Iida, and Cote 1994). Here we will use a ranking by grammatical function, partially reflecting the observation of many previous researchers that the subject has a special status in terms of discourse salience:

(9) **Ranking of Forward-looking centers:**
Subject > Object2 > Object > others

[5] Restricting the relation between the $Cb(U_i)$ and the $Cb(U_{i-1})$ to coreference (equality) is probably not adequate. Future work should examine the role of functionally dependent entities and entities related by poset relations to the previous Cb.

[6] However, recent work in Centering suggests that utterances with no Cb are used more frequently than Retain for this function in natural speech (Hurewitz and Linson 1993).

[7] The notion of Smooth-shift was introduced by Brennan, Friedman, and Pollard 1987, where it was called Shifting-1.

This ordering does not reflect the additional factors mentioned above that may contribute to the salience of a discourse entity or the fact that these factors vary from language to language and are attenuated to various degrees by discourse structure. The primary factors, their interaction, and the variation in these factors from language to language must be determined by future work. However, here we incorporate one aspect of word order to determine the {Cf} ordering within complex NPs:

(10) **The Complex NP Assumption:**
In English, when an NP evokes multiple discourse entities, such as a subject NP with a possessive pronoun, we assume that the {Cf} ordering is from left to right within the higher NP.

Thus, if a sentence contains only a subject NP with a possessive NP and a simple object NP, as in 11, the ordering would be i > j > k:[8]

(11) [Her$_i$ mother]$_j$ knows Queen Elizabeth$_k$.

The Complex NP Assumption is, at this stage, merely a working hypothesis and requires further empirical research. Also note that, for English, the ranking of the Forward-looking centers by grammatical function plus the Complex NP Assumption yields an order that is very close to surface order (Hoffman and Turan 1993, Rambow 1993).

2.3. Centering Algorithm.
The combination of the Constraints, Rules and Transitions within the Centering framework makes a set of testable predictions about which interpretations hearers will prefer because they require less processing. Brennan, Friedman, and Pollard 1987 incorporated linguistic constraints on contra-indexing (cf. Reinhart 1976) and morphological filters for gender and number into an algorithm for anaphora resolution: this is the Centering Algorithm used here. While our analysis depends on this algorithm, we will present only a sketch of it; see Brennan, Friedman, and Pollard 1987, Walker 1989, Walker, Iida, and Cote 1990, Walker, Iida, and Cote 1994 for discussion.

The application of the algorithm requires three basic steps:

(12) **Generate** possible Cb-Cf combinations
Filter by constraints, e.g. contra-indexing, selectional restrictions, Centering Rules and Constraints
Rank by Transition-ordering

These steps should be applied in parallel or interleaved to reduce processing. For example, the Contra-indexing Filter should be applied at the Generate step since evidence from psycholinguistics shows that filtering by contra-indexing constraints occurs very early in processing (Nicol and Swinney 1989). The Centering Algorithm has also been applied to German, Italian, Japanese, and Turkish (Rambow 1993, Di Eugenio 1990, Walker, Iida, and Cote 1994, Hoffman and Turan 1993, respectively).

We will now present an extended example from a naturally-occurring narrative to motivate these definitions and demonstrate how the theory works.

3.0. Centering Algorithm in natural discourse.
The excerpt in 13 is a naturally-occurring narrative from the TV show *Cops*. At the beginning of the excerpt, the policeman who is speaking, the policeman he is addressing, and a female discourse entity, Female$_i$, are already part of the discourse model.

(13) '...what really happened was, while she$_i$ was getting ready for the date, she$_i$ ran out of hair gel. And uh, that time she$_i$ called [her$_i$ sister]$_j$. And uh [[her$_i$ sister]$_j$'s answering machine] came on. And she$_i$ yelled into it: it was an emergency for her$_j$ to pick up the phone right away. [Her$_i$ sister]$_j$ not being home, she$_i$ hung up. [Her$_i$ sister]$_j$ came home a short time later, heard [her$_j$ messages], heard [her$_j$ sister]$_i$ calling for help. She$_j$ then called [her$_j$ father], who called the Milton police, who then called us and started this whole episode here. And uh, everything turned out okay, everyone$_{i+j+...}$'s happy. And she$_i$ could have used a little more gel.' (Collected by B. Linson.)

This discourse is about an event that involves two sisters, Female$_i$ and Female$_j$. These two discourse entities are indistinguishable by both the pronominal forms and the noun phrases used in this narrative: since *sister-of* is a symmetric relation, the definite description *her sister* applies equally well to either of the two. As we will see below, which entity is referred to by a pronoun and which is referred to by the NP *her sister* varies throughout the narrative depending on Centering status.

In what follows, we will discuss small sequences of the narrative repeated for convenience below. The fact that Female$_i$ is currently activated when the narrative excerpt begins is reflected in the fact that Female$_i$ is the Cb in 14:

(14) ...what really happened was, while she$_i$ was getting ready for the date, she$_i$ ran out of hair gel.
Cb: Female$_i$
{Cf}: Female$_i$, the date, hair gel
Transition: Continue

[8]This assumption is in conflict with Hobbs' assumption that level of embedding in surface structure is a factor that determines discourse salience (Hobbs 1976a).

(15) And uh, that time she$_i$ called [her$_i$ sister]$_j$
Cb: Female$_i$
{Cf}: Female$_i$, Female$_j$
Transition: Continue

(16) And uh [[her$_i$ sister]$_j$'s answering machine] came on.
Cb: Female$_i$
{Cf}: Female$_i$, Female$_j$, answering machine
Transition: Continue

After the utterance in 15, there are two female discourse entities in the discourse model, Female$_i$ and Female$_j$. Female$_i$ is the discourse entity who has run out of hair gel. In 15, the Transition is Continue because Cb(15) = Cb(14) and Cb(15) = Cp(15).

Utterance 16 shows that the variation between the use of forms such as *her* and *her sister* does not depend on either Evoked or In-focus status, or on commonsense inference. If it did, then we might expect that 16 would have been realized as *her answering machine* rather than *her sister's answering machine*.

Parenthetically, to see the difference between Continue and Retain, note that, for the speaker to effect a Retain in 15 and realize the same content, he would have had to say something like the slightly awkward utterance given in 15', with the state of the Centering component of the discourse model after 15' as shown:

(15') And uh, that time [a sister of hers$_i$]$_j$ got a phone call from her$_i$
Cb: Female$_i$
{Cf}: Female$_j$, Female$_i$
Transition: Retain

This utterance defines a Retain because Cb(15') = Cb(14), but Cb(15') ≠ Cp(15'). It might have been appropriate for the speaker to produce an utterance like this if he intended to start talking about Female$_j$ as the Cb. However in the context given, the use of a Retain can only confuse the hearer as to who is being talked about.

The excerpt in 17 follows the one given in 16 and contains a type of indirect discourse ('free indirect discourse'), a paraphrase of what was yelled into the phone provided by the narrator, and the use of the pronoun *her* reflects that fact (Kuno 1972). Note also the loose inferential relations between the act of calling, the answering machine, and the phone.

(17) And she$_i$ yelled into it: it was an emergency for her$_j$ to pick up the phone right away.
Cb: Female$_i$
{Cf}: Female$_i$, answering machine, Female$_j$, phone
Transition: Continue

(18) [Her$_i$ sister]$_j$ not being home, she$_i$ hung up.
Cb: Female$_i$
{Cf}: Female$_i$, Female$_j$
Transition: Continue

In 19, the scene changes to the home of Female$_j$. Arguably, this indicates the start of a new discourse segment, reflected also by the fact that Female$_j$ is realized here for the first time in matrix subject position and consistent with the prosodic fact that the phrase-final fall in 18 is close to the bottom of the speaker's range (Lehiste 1970, 1979). First, we will present an analysis where the segment starting with 19 is part of the same segment as 18. Then, in 19'-21', we present an analysis where there is a segment break after 18.

(19) [Her$_i$ sister]$_j$ came home a short time later,
Cb: Female$_i$
{Cf}: Female$_i$, Female$_j$
Transition: Continue

(20) 0$_j$ heard [her$_j$ messages],
Cb: Female$_j$
{Cf}: Female$_j$, messages
Transition: Smooth-shift

(21) 0$_j$ heard [her$_j$ sister]$_i$ calling for help.
Cb: Female$_j$
{Cf:} Female$_j$, Female$_i$, help
Transition: Continue

If we take 19 to be a continuation of the same discourse segment as that given in 18, Female$_i$ is still the Cb of 19. There are two possible Transitions for 20, Continue and Smooth-shift. The Smooth-shift that is shown is predicted by the framework to be less preferred than a Continue, as the interpretation of *her* would be Female$_i$ with a Continue. However, a combination of the VP coordination and the commonsense inference that only the sister who had been left a message can listen to her messages helps generate a Smooth-shift at 20. Once this Smooth shift occurs, Female$_j$ is the Cb and the Cp, the most highly ranked entity on the {Cf}. Since Female$_j$ is the Cb, the NP *her sister* can now be used to refer to Female$_i$ in 21.

On the other hand, if 19 starts a new discourse segment, the analysis would be as given in 19'-21':

(19') [Her$_i$ sister]$_j$ came home a short time later,
Cb: [?]
{Cf}: Female$_j$, Female$_i$

(20') 0_j heard [her$_j$ messages],
Cb: Female$_j$
{Cf}: Female$_j$, messages
Transition: Continue

(21') 0_j heard [her$_j$ sister]$_i$ calling for help.
Cb: Female$_j$
{Cf}: Female$_j$, Female$_i$
Transition: Continue

Here, 19' doesn't have a Cb since it begins a new segment, and Centering operates only within a discourse segment. Then 20' instantiates Female$_j$ as the Cb, partially due to the fact that 20' is a coordinated VP and, therefore, the subject must be the same as in 19'. This may also be partially due to the change of scene, the fact that Female$_j$ was realized as a subject, and the commonsense inference that the sister who was left messages must be the one to listen to them. In terms of Transitions, if there was no Cb in 20', the choice in interpretation is between two Continues, since whichever entity is realized will be the highest ranked entity from 19' realized in 20' (the Constraint in 6c). Again, since Female$_j$ is the Cb in 20', the NP *her sister* can now be used to refer to Female$_i$ in 21'.

An interesting prosodic fact is that *her$_j$* in 20' is realized with a pitch accent while the pronouns in the earlier part of the discourse are all destressed. While more research is needed, it would be consistent with the Centering framework for new Center instantiation to be marked by accenting the pronoun (Terken 1985). Under either analysis above, 20,/20' is the point where Female$_j$ becomes the Cb.

The remainder of the discourse segment, as shown in 22-24, first continues with Female$_j$ as the Cb but then presents a chain of entities in a narrative sequence of events:

(22) She$_j$ then called [her$_j$ father],
Cb: Female$_j$
{Cf}: Female$_j$, father
Transition: Continue

(23) who called the Milton police,
Cb: father
{Cf}: father, Milton police
Transition: Smooth-shift

(24) who then called us and started this whole episode here.[9]
Cb: Milton police
Cf: Milton police, police, episode
Transition: Smooth shift

Finally, 25 sums up and repeats the state of affairs at the start of the narrative:

(25) And uh, everything turned out okay,
everyone's happy.
And she$_i$ could have used a little more gel.

4.0. Conclusion.
This paper has shown how using a bilateral approach to givenness which treats Hearer-status independently of Discourse-status can account for the distinction between different types of Evoked or Activated discourse entities. We have proposed a simple Hearer-status algorithm and have used the Centering framework to model Discourse-status. The distinctions in Centering between the Cb and the Cp and among the Transitions Continue, Retain, Smooth-shift, and Rough-Shift define a preference ranking of interpretations.

We have tried to show that, once an entity is established as the Cb, then this entity is the one that may be referred to with a pronominal form, while entities lower ranked on the {Cf}, although equally 'activated', may well be realized as full NPs.

[9]The coordinate VPs in 23 are counted as a single utterance because they are the type of asymmetric coordination that denotes a single event (Schmerling 1975).

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