The Role of Inversion, Clefting and PP-Fronting in Relating Discourse Elements:
Some Implications for Cognitive and Computational Models of Natural Language Processing

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The Role of Inversion, Clefting and PP-Fronting
In Relating Discourse Elements

Mark Vincent LaPolla

1. Introduction
Languages use various types of syntactic constructions to convey more information than what is expressed by the sum of words in a sentence. One of the more obvious examples of this, in English, are questions, e.g. Wh-Questions, "What is Mary doing?", Yes-No Questions, "Are you coming to the party?", Tag-questions, "Mary is coming, isn't she?" In contrast to this, Turkish uses a question particle to form questions.

1. Selma evde.
   [Selma ev-de]
   <Selma house-at>
   "Selma is at the house."

2. Selma evdeme?
   [Selma ev-de-me]
   <Selma house-at-question>
   "Is Selma at the house?"

Thus languages seem to differ in the types of information carried by syntactic structures.

This paper will explore and discuss the less obvious ways syntactic structure is used to convey information and how this information could be used by a natural language database system to organize and search a discourse space.

The primary concern of this paper will be to present a general theory of processing which capitalizes on the information provided by such non-SVO word orders as inversion, wh-clefting, and prepositional phrase (PP) fronting, and other fronting phenomenon. An attempt will be made throughout the paper to generalize any and all findings. The emphasis of this part will not be computational.

Its secondary concern will be to present a means of indexing a discourse to aid anaphoric resolution in a natural language program; motivated in part by the findings for non-SVO word order and proposed as a means for implementing and characterizing the nature of non-SVO structures. The cognitive aspects of such an indexing procedure will also be discussed. The emphasis here will be computational.

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The general theory of discourse processing presented here will not concern itself with the (detailed) structure of discourse but will be presented abstracted away from such concerns.

In discussing the indexing procedure, an outline of a discourse organization schema will be presented, though the indexing procedure is not bound to any particular theory of discourse or discourse processing.

1.1. Non-SVO Structure

English at its simplest is an SVO, Subject Verb Object, language. However it is not limited to SVO order. Clefts, pseudo-clefts, inversion, topicalization, left dislocation and various types of fronting are instances of deviation from SVO order. Non-SVO orders are not exceptional or found only in obscure literary writing. They abound throughout writing and speech. An interesting question is what do these structures do in English, and how can a cognitive or computational theory use such information?

Some philosophers, linguists, psychologists and computer scientists, (Kamp (1985, 1986), Heim (1982), Shank (1982), believe that language and memory (e.g. discourse space(s)) interact continuously. As a human reads (or listens to) a text\(^2\) he constructs, using "world knowledge", a representation of that text. Non-SVO word order helps the reader (or listener) to construct this representation. It is a heuristic device for creating coherent and cohesive representations of text. In other words, it is a device for finding in long or medium term memory the relevant context, or discourse space, in which to embed and interpret the sentence being processed.\(^3\)

The difference then between SVO structures and non-SVO structures is, generally, non-SVO structures are marked constructions which signal a search for some (discourse) representation (in memory) to which to link, or embed, the predicate of the non-SVO sentences. Or, as will be seen, perhaps it is more correct to say that non-SVO sentences make available contexts in which to embed current discourse. The SVO structures do not do this.

Non-SVO word order is a heuristic devise for creating coherent and cohesive representations of text and for searching existing representations. It is a linguistic device used for changing the discourse focus (Sidner 1978, 1983; Grosz 1978, 1981). It is important to note that no particular discourse representation construction schema is assumed in this claim but rather that this claim holds no matter what type of

\(^2\)From here on out any discourse whether spoken or written will be referred to as a text.

\(^3\)The exact nature of interpreting such structures is not the topic of this paper and will be largely ignored here. What will concern this paper is how the effect of organizing the discourse database might effect a natural language processing theory or program.
construction algorithm is used. Also, what is being proposed here is not a linguistic rule for constructing discourse representations but rather a principle (heuristic) for constructing them and for organizing and searching discourse representations.

Notice that our hypothesis parallels Chafe's (1974,1976) notion of given/new, or rather for us available/unavailable in the discourse context, or common ground. This is to say that the trigger for non-SVO structure, of the fronted variety, is not whether the item is in the speakers immediate consciousness but rather whether it was previously mentioned, or could be inferred, and could be reasonably assumed to be available to the participants in the discourse.

1.2. An Indexing System

In this paper a computational indexing schema will be developed. This is separate from the claims made about non-SVO word order and is not necessary for the implementation of those claims. Therefore this paper actually consists of two parts: the first part is about the nature of non-SVO word order in discourse; the second part is about the indexing procedure. Both of these separate aspects have computational and cognitive ramifications. They also work together to form an integral whole. This section will introduce the indexing heuristic.

The processing of discourse will be assumed to be as follows: as a sentence is processed a representation is made of it. This representation consists of an index, which is a (syntactic and semantic) parse\(^4\) of the first constituent encountered, followed by a parse of the whole sentence. Actually, one could have multiple indices that consisted of the NPs in the sentence, since it seems that these non-SVO structures are sensitive to NPs. Thus every discourse representation is in some way redundantly specified for at least one constituent.

For example, the organization of the discourse representation for the sentences, "In the forest stood a house" and "In the park, Mary kissed John", are:

\[
\begin{align*}
\text{Index: } & \text{ house, forest} \\
\text{D.R. : } & \text{ a house stood in the forest}
\end{align*}
\]

and

\[
\begin{align*}
\text{Index: } & \text{ Mary, John, park} \\
\text{D.R. : } & \text{ Mary kissed John in the park}
\end{align*}
\]

\(^4\)The exact representation of the text will be discussed later. For now English will be used to represent what eventually will be a discourse representation of some sort. Parse is being used here in a general sense to mean "give the structure of". The "structure" of course depends on the linguistic theory used to give the parses.
In a computational system, two uses could be made of this system of "indices". The first is to simply use the indices to index the text and to facilitate the search through the text. The second would be to use the indices as nodes in a semantic network. Thus in the discourse fragment, "A house stood in the forest. Outside stood an angel." the index "outside"\(^5\) could be related to either the index "house" or "forest" or both via a "location" arc.

The connection between indices can be done in one of two ways. They can be connected through a direct match, for example in the discourse,

\begin{verbatim}
A house stood in the forest
Index: house, forest
D.R. : A house stood in the forest
In the house lived a girl
Index: house, girl
D.R. : A girl lived in the house
\end{verbatim}

a direct match can be made between "house" in the index of the first sentence and house in the index of the second sentence. Or they can be connected through an indirect match, for example in the discourse,

\begin{verbatim}
A house stood in the forest
Index: house forest
D.R. : A house stood in the forest
Inside lived a girl
Index: inside, girl
D.R. : A girl lived inside
\end{verbatim}

a match could be made between "inside" and "house" only if the discourse processor, or theory, knows that people live "inside" houses and not forests. Or rather if given a choice one should pick the house over the forest.

(Notice that direct matching, or even partial matching, is analogous to anaphoric resolution.)

\(^5\)Or rather the relation "outside" that implies outside of something.
1.3. Outline
The body of this paper will be broken down into three parts:

1. The linguistic motivations for proposing that inversion, clefting and PP-fronting act as organizational cues in the building of discourse representations;


3. A discussion of the computational experiment and results.

Section 2 will discuss Green's (1980) work on inversion and will attempt to account for all of Green's "functions of inversion" under the theory proposed in this paper. Section 3 will discuss Wh-clefts and PP-fronting. In section 4 we will discuss the (computational) implementation of the theory developed in this paper. To do this Kamp's algorithm, taken from Situations in Discourse (1986) will have to be introduced and briefly discussed. Its interaction with the mechanism in this paper will be discussed as well. In section 5 the results will be discussed and conclusions drawn. Also possible avenues of future research will be pointed out.

2. Inversion
In Green's (1980) study of the discourse function of various "classes" of inversion, she assigns each instance of inversion a particular function. This approach, however, is bound to be inadequate. If one tries to compile a list of such functions for various syntactic forms in a language, how does one know if the list is complete? Every time a new function is discovered for a form one must add it to the list. Another problem with this approach is that one never knows if one has been specific enough or general enough. Being too specific in the characterization of such functions creates a very long list and can miss generalizations. Being too general might hide the correct function of a form in language.

In studying English inversion, Green denounces the idea that inversion is a means of relaying old information first and new information last. She supports this statement by citing the use of quoted forms with respect to given/new information, i.e. what is in quotes can come first and is usually new information while the identity of the speaker is often old information. But as we shall see this is not a very strong argument. This section will review and criticize her list of proposed functions.

2.1. Use 1
The first use of inversion Green notes is in sportscaster's speech. In sportscaster's speech, inversion allows the listener to first identify the object being talked about before assigning information to it, whether new or old (Green; p 584):
a. Underneath is Smith
b. High in the air to get the ball was Jim Brady.
c. Bringing the ball up is Marty Westemacher.
d. Back come the Kahoks with the ball.
e. And sitting down is Kevin Jones.

In this case inversion allows the viewer to single out the player on the TV screen before processing his name. This allows the viewer to first pick out the player, make a non-linguistic representation in memory of that player and then add the (new) information given by the sportscaster: the player's name. If inversion were not used the viewer would have to first store the name given by the sportscaster, identify the player, construct a representation of that play and his actions, retrieve the player's name and then assign that information to the representation created by the description of the player's actions. This is a much more difficult and time consuming procedure. In this instance, inversion helps to cut down the amount of processing necessary to construct a representation.

Therefore one could hypothesis that upon hearing/reading the first few elements of a sentence, the listener follows three rules:

1. if the sentence is SVO and does not have any overt signals to search for a previously mentioned item of information, construct a representation of the sentence and add it to the local discourse space.
2. Else search memory for the last mention of the item under construction and add the "new" information, i.e. what is in the predicate, to that local discourse space. Pointers are left pointing to both discourse spaces.
3. Otherwise, construct an entirely new discourse space.

Actually it is unclear where the information should be deposited. For example, a house has been robbed. The police investigate. They ask questions concerning the robbery. Then the father of the household says, when asked who they think could have done it: "As I said before, that boy John is a thief."

The police who do not have any previously knowledge of John add this information to the present discourse space. They probably note that the person who said it has reasons for bringing to the listener's attention that he had said this before. His daughter, however, who knows John but did not know her father's opinion of him, adds to her mental representation indexed "John" this information. She also adds this utterance to the current discourse space, i.e. "robbery of house". The man's wife on the other hand already knew about her husband's opinion. It would seem redundant for her to add this information to her mental representation indexed "John". What she probably does is call up the mental representation "John" and leave a pointer pointing to it from the current discourse space "robbery of house", thereby connecting the two representations. So it would seem that things are not as cut and dried as one would suppose.
2.2. Use 2
The second use for inversion which Green cites is its ability to connect pieces of discourse together. This is used frequently in journalism. One can link and expand a previously mentioned proposition by anaphorically referencing it in the grammatical subject slot, thereby smoothly linking the new information in the predicate to the old, previously mentioned information. She also notes that this connective function is used in literary texts or expository prose. She finds that inversion provides a concise form in which news writers can begin a sentence with old information.

In the system being developed in this section, the only difference between the sportscasters' speech and this "connective" function is that the "connecting" in the sportscasters' speech is done to an image rather than a (previously mentioned) concept. In the sportscaster case, the viewer has to create a nonlinguistic representation in his consciousness, i.e. his discourse space. Then when the name of the player is mentioned the viewer assigns the information to the representation. The "connective function" case differs only in the type of representation built.

2.3. Use 3
In her third function, Green expounds upon the notion that what is inverted is not necessarily new information. She shows that inversion can be used to set a scene for an event or as a means to locate actors in a story, e.g. "Outside stood an Angel", "In a little white house lived two rabbits."

Notice how similar this "function" is to the sportscasters' speech (and the newspaper examples). The sportscaster speech uses inversion to identify the player so that the listener can more easily identify the (new) information, i.e. his name, with the player. The scene-setting, and literary connecting, function of inversion identifies a locale in which to place the actors, the characters. From a processing point of view these are the same things. Even Green notes the similarities between the journalist function and the literary connecting function.

13(b) Sprawled in the foreground is George Price.\(^6\)
"Ex. 13b, which is part of the description of an accompanying picture, is very much like the news examples: it identifies a piece of the picture, an individual, by locating him with reference to --more specifically, in the foreground of--something taken to be already salient, the picture as a whole." (p. 588; underlining added.)

In all these cases a discourse representation can be created that uses as its index the first constituent of the inversion. In the sportscaster's speech the representation of the

\(^6\)Green's numbering. Green's numbering will be used for her examples.
sentence(s) would be linked to the image of the player and the (information) "living of the two rabbits" would be assigned to the discourse representation indexed "white house". This last assignment might seem strange but suppose that the house was previously identified as being in a large forest:

**Discourse 1.**

In a large forest stood a house.
In the house lived two white rabbits.

This use of inversion does not seem to signal an extensive search of memory but rather seems to create a more local chain of association: there is a sense in which the second sentence is an elaboration of the stored information about "a house". Compare the short discourse structure above with

**Discourse 2.**

In a large forest stood a house.
Two white rabbits lived in the house.

Intuitively, this discourse seems harder to process than the previous one, (e.g. it doesn't "flow" as nicely). The notice of difficulty of processing is simply that when an a candidate antecedent, or connection, is easily available, much less work is needed. If the candidate is not readily available, e.g. it isn't in focus. Finally compare these sentences with:

**Discourse 3.**

A house stood in a large forest.
In the house lived two white rabbits.

This last discourse seems as easy to process as Discourse 1 (D1). The theory under development here accounts for this.

Discourse 2 (D2) is harder to process than D1 because when processing D2 one must store the concept "two white rabbits lived..", and then search for a previous mention of "house" in which to embed the information. Notice it is not the inversion that makes "the house" anaphoric but rather the use of the definite article. Inversion, in this case, makes the discourse easier to process. For example, Discourse 4 (D4) is ungrammatical if one assumes coreference between the "a house" in the first sentence and "a house" in the second:

---

7 We would still like to maintain that inversion is used to aid anaphoric resolution.
Discourse #4. 8

In a large forest stood a house. 9
In a house lived two white rabbits.

Discourse 3 is as easy to process as Discourse 1 because the inverted element, "a house", becomes the index and the connecting phrase, the index, of the representation of the second sentence is "in the house". An interesting observation is that Discourse 5 seems harder to process than D1, as expected, but easier than D2. The explanation for the latter observation is not at first obvious.

Discourse 5.

A house stood in a large forest.
Two white rabbits lived in the house.

In the case of the above discourse (D5), "a house" is the index of the last representation built. So even though the connecting phrase "in the house" is not in initial position, which accounts for why this discourse is harder to process than D1, there is a "top level" item, i.e. index, "a house", to which the connecting phrase "in the house" can connect. However, in D2 not only is the connecting phrase "in the house" buried in the second sentence, i.e. not in initial position, the item to which it must connect is also buried, that is one must make a greater effort to retrieve the embedded material. Extending this reasoning the theory would predict that D3 would be easiest to process, D1 and D4 the next hardest and D2 the hardest. This claim is a strong claim about the internal structure of discourse representations and could be falsified with psychological experimentation.

The intuitive sense in which a sentence is harder or easier to process is perhaps also related to the idea that the subject is an external argument which participates in a predicate relationship with the entire VP and not just the verb. In this sense the object(s) of the verb are more "deeply embedded" in the sentential predicate than the subject. Thus inversion, PP-fronting, etc., can be viewed as moving an embedded, or internal argument, to a more external position, e.g. adjunct position.

Not also that those verbs which appear in inverted sentences seem to be ergative verbs. That is the deep structure of the sentence "Outside the house stood an angle" is probably

$[S \in [VP \text{ stood an angle}] [PP \text{ outside the house}]]^{10}$

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8Stars will be used to to indicate the "ungrammaticality" of discourses.

9Underlining indicates coreference.

10This is roughly the structure.
(Heim 1985, personal communication). This might help to explain the greater "availability" of fronted material.

An important point to note is that Green does not consider the scene setting function and the literary connecting function to be the same thing. In the scene setting examples the inverted element is completely new information, whereas in the literary connecting function this does not have to be the case. This is an important point for the theory in this paper as well.

The claim of this theory is not that the inverted element is old information, though in most cases it is, but that it is the important element with respect to embedding of information. When it is new information it sets up a context to which new information can be related, including the information in its own predicate. When it is old information it serves to find the correct context in which to embed the information in the predicate.

In all of the above cases, inversion is used to locate and identify an (old) entity, an event in the sportscaster speech, a (previous) location, or a painting, and give more (new) information about that entity, or create a context in which to embed information.

2.4. Use 4

In the S V O/Q word order of direct quotations, the old information, the speaker, is identified and the new information, what is being said, is related to him. O/Q V S and O/Q S V order, however, would seem to present a problem. With this word order, one is not describing an entity to which the predicate part is adding information. As a matter of fact, this is the very order which Green uses to show that the Praguan notion of old information first is false:

2c 'She's too young to play,' said Mrs. Rabbit.

It is tempting to suppose that the inversions in 2 are all governed by some general pragmatic principle, such as the 'Old information first, new information last' dictum of some Prague School linguists. But it is a trivial matter to show that this is inadequate as a general characterization of inversion. For instance, in context, 2c follows the sentence, 'May we play with her?' cheeped the yellow chicks. What is new is the quotation, what Mrs. Rabbit said—not Mrs. Rabbit, or the fact that she is the one who answered a question addressed to her. (Green, p. 583)

Though the observation is correct, the generalization she draws is not.
If one looks at these sentences within a framework which builds discourse representations, we see that the old information which identifies the speaker is already in the discourse representations or is available to the reader through means other than linguistic ones. For example, many literary texts set up a context of speakers and use line alteration to signal change of speaker. "said X" or "X said" are then interjected as signposts to help disambiguate who the speaker is, or for stylistic reasons. Since the reader already has a good idea of who is supposed to speak next, the "said X" signpost is used more for confirmation than as (new) information. Green herself points out that "...new characters, change of scene, or other relevant facts may be introduced into a narrative in quotation frames, and here it seems unnatural to use a preposed quote" (p. 591).

This same type of analysis can be used for her scene setting function, (last section). As she notes, in the inversion which takes place in those examples, the initial constituent is completely new information. These inversions do not have a connective function; "they do not locate the Postposed Subject Phrases with respect to anything referred to before the adverbal" (p. 500). The effect she notes is that these inversions serve "to introduce protagonists with respect to a background."

Uses 3 and 4 seem to build new entities, in which information can be placed, rather than locate old entities. Generally, it seems that the primary function of inversion is not to locate entities but rather to make available a place, whether new or old, to store information.

2.5. Use 5

The final function/use, the emphatic use, is a by-product of proposing a psychological discourse constructing mechanism that processes linearly. The inverted part of the sentence is processed first and therefore is marked as special, simply because it comes first. It automatically becomes the index for the discourse representation of that sentence and is thus emphasized. Of course there is also emphatic stress and other phonological properties. This is very complex and can not be done justice in the confines of this paper.

2.6. Social Convention vs Processing Impact

In the framework partially developed above, the various meanings and uses for inversion were ignored for a more general approach for characterizing the impact of this structure on the listener. Though this abstraction of language as a process unifies the various types of word order, it does nothing to explain the various meanings, pragmatic and semantic, that these constructions might have.

As Davidson (1980) points out, passives, a non-SVO structure on at least the logical level, can convey a different meaning or mood from their active counterparts. They also have different conditions, from the active, "for use in discourse or are associated with
extra assumptions on the part of the speaker, or 'mean' something slightly different" (p. 43). The problem that these variations in meanings present to the study of discourse need not be investigated here. Nor will the similar problem that multiple "meanings" across languages of passives, and other constructions, be looked at here. This problem is akin to the problem that any sentence, given the proper context, intonation or facial expression(s), and depending on the language and culture, could mean any one of a number of things. The "meaning" and (social) use of a construction, or its lack, needs to be learned for a particular language, situation and society.

What is important is that the passive, in all languages, is somehow marked as different from the active. For English, this means that the grammatical object becomes the grammatical subject and by dint of this fact is made more "important", simply because it is first and in a marked construction. It is also more important in our formulation because it becomes an index and thus influences the structure of the connected representation(s). The structure of a representation influences how effectively one might understand the information contained in it.

3. Clefting and PP-fronting

This section will explore other non-SVO patterns in English and their impact on the ideas under discussion.

3.1. Clefts

In this subsection clefts (wh-clefts from this point on) will be discussed. An example of a wh-cleft is: "What I lost was my keys".

Prince's (1978) analysis of wh-clefts is almost exactly like the analysis given for inversion in this paper. Prince notes that the information contained in the wh-clause of wh-clefts can be equated with old information.

Like inversion, it is sometimes possible to start a discourse with a clefted sentence. Prince points out that the only time it is acceptable to use a clefted sentence discourse initially is when there is an inferable, available, antecedent to which one could build a bridge, (Clark and Haviland 1977) i.e. the inference(s) one must make to get from new information to old. For example, the discourse in 14 is acceptable while the discourse in 15 is not (## marks what follows as discourse initial; * marks ungrammaticality or in this case discourse unacceptability).11

11. These examples are taken from Prince, with her numbering. Page 888.
14. "What we have set as our goal is the grammatical capacity of children—a part of their linguistic competence."
(Klima and Bellugi-Klima 1969:448)

15. Hi! What my name is is Ellen.

Prince explains the grammaticality of 14, taken from an article on syntactic regularities in the speech of children, by referring to the fact that the reader of a linguistic article assumes that its author has a goal in writing the article. Thus the nonlinguistic antecedent of the wh-phrase can be assumed to be in the reader's mind (following Chafe (1674)). Prince points out that in 15 it would be highly presumptuous for the speaker, her, to assume that the hearer is actually thinking that she has a name. Thus with wh-clefting, as with inversion, the context in which one could embed a representation need not be a linguistic one.

If one accepts Prince's arguments for the function of wh-clefting, then the main difference between wh-clefting and inversion is that in wh-clefting one cannot set a scene or create a new discourse space:

17. Discourse condition on wh-clefts: A wh-cleft will not occur coherently in a discourse if the material inside the (subject) wh-clause does not represent material which the cooperative speaker can assume to be appropriately in the hearer's consciousness at the time of hearing the utterance (Prince; page 888)

Thus a college professor may begin a lecture (or course) with the discourse initial utterance in 18a but not the discourse initial utterance in 18b (page 889).

18. a. What we're going to look at today (this term) is...
   b. What one of my colleagues said this morning was...

Prince goes so far as to say that the information, or the bridge, does not have to be in the speaker's consciousness but only need be cooperatively assumable as there. In other words, the wh-cleft must refer to, and be appropriate to, the situation. Therefore the context need only be inferable. This argument parallels both the arguments for the analysis of the sportscaster's speech and the quotation forms developed above.

It seems that the main difference between inversion and wh-clefting is that inversion can create a completely new discourse space and wh-clefting cannot. This distinction seems to be one of degree of constraints on function rather than one of kind of function. However, whether this distinction actually exists is debatable.
It is not clear whether the scene setting function, and other new information first inversions discussed above, actually create a brand new discourse space, given Prince’s arguments for wh-clefts. If one adopts her analysis of discourse initial wh-clefts and applies it to the so called new-information-first inversions, then one could posit that in stories, etc., the reader expects the author to set scenes or introduce characters. Thus the antecedent in those cases would also be meta-linguistically inferable.

In any case the similarities between inversion and wh-clefting are strong enough that one need not propose any new mechanisms for a linguistic, psychological or computational theory to handle clefting but only adopt, or restrict, those proposed for inversion.

3.2. PP Fronting

PP-fronting is used to provide a continuity, a cohesion, in the text. For example, an article by Lawrence (1985) opens with a fronted prepositional phrase which provides a time setting, or relation on the (narrative) time line, for the activity in the sentences which follows:12

Discourse 6.

Long before I was tall enough to ride on the big coaster myself, I spent many pleasant hours persuading my reluctant father to accompany me. (p. 4)

The PP also provides a way to link up the topic (theme) of the article to the opening statement of the article. The theme is the "new adult" Amusement Parks. The article’s initial prepositional phrase picks out a particular item within an amusement park and associates the remembrances of the writer to it.

The next sentence also has a fronted PP. This PP also links the next sentence to the article’s main topic:

Discourse 7.

As an aficionado of amusement parks, I was overjoyed when our whole family finally flew to California to tackle Walt Disney’s extravaganza. (p. 4)

The next paragraph starts out with yet another fronted temporal prepositional phrase, moving the time setting up to the present:

12 Underlining added.
Discourse 8.

More than two decades later, I'm still journeying to parks. (p. 4)

These first few examples of word order deviation all have the characteristic of giving the reading a temporal "focus" and order in a series of events that occur over a number of years.

In order for a discourse processor to understand this text, it would have to have a place to start. The logical starting place would be with the index AMUSEMENT PARK, since this is in the title of the piece. Under this discourse representation index it could build other representations. The first representation that it would build would be about the author since this is the first matrix NP of the first sentence, D6. For the next sentence, D7, it would already know what type of temporal relation to assign to the proposition expressed in the matrix clause. The sentence in the next paragraph is easily processed since it advances the time of the preceding paragraph. Rather than building a representation of items and attaching to this a set of properties, these fronted PPs build an abstract representation of temporal items related by the time of each item.

The general theme of the article is amusement parks. However, since the opening of the article is more a personal recollection rather than expository, the information that needs to be organized is not information about particular objects, i.e. amusement parks, but rather episodes in the author's life. Each episode's temporal relation is specified by the fronted prepositional phrase. In general this is the function of fronted prepositional phrases, the specification of relations. This is a widely used technique; used more than any other non-SVO pattern.

Before going on with the analysis of Lawrence's text, which is rich in fronted material, it would be worthwhile to take a closer look at the sentences discussed already. The general hypothesis is that the first thing that one encounters in a sentence is a link to preceding information, either explicit or implied. The link provides the proper context in which to build the new representation.

The case of temporal and locative prepositional or adverbial phrases on the surface looks like a special one. Rather than finding an available context, they serve to temporally or spatially relate the (new) information contained in the sentence to previous spatial or temporal references. Though the structure looks different it is actually the same: a relation. One is a temporal or locative relation and the other a relation in topic. Thus the mechanism used for constructing the relations between wh-clefts, inverted elements and front PPs and their antecedents, whether overt or implied, can be the same. Furthermore the effect of the various prepositional phrase frontings is the same too. It allows the listener, reader, to construct the relation to the previous
discourse before having to process the new information. The non-SVO pattern signals the reader that a relation to previous material needs to be constructed. If fronting were not used the reader would have to hold in short term memory the processed information of the matrix clause, construct the relation and only then assign the stored value/proposition — a much harder task.

To see the difficulty of such a task lets look at the first two paragraphs in Lawrence's text, edited so that all sentences have SVO structure:

Discourse 9.

I spent many pleasant hours persuading my reluctant father to accompany me long before I was tall enough to ride on the big coaster myself. I was overjoyed when our whole family finally flew to California to tackle Walt Disney's extravaganza as an aficionado of amusement parks.

I'm still journeying to parks more than two decades later.

Compare D9 with D10, the version with fronting:

Discourse 10.

Long before I was tall enough to ride on the big coaster myself I spent many pleasant hours persuading my reluctant father to accompany me. As an aficionado of amusement parks I was overjoyed when our whole family finally flew to California to tackle Walt Disney's extravaganza.

More than two decades later, I'm still journeying to parks. (page 4)

The edited text seems less coherent and harder to process, though it is processable. This last point emphasizes the heuristic nature of the thesis presented here. It is not necessary to use such constructions in language but their use facilitates the processing of the texts and presumably the construction of their representations. Perhaps they also influence the type of structure being built. This is a strong empirical hypothesis that could be falsified.

Getting back to Lawrence's text, in a new section, she starts talking about particular amusement parks. She links the flow of the text together with fronted locative prepositional phrases. She sets the topic as AMUSEMENT PARKS TODAY and REPRODUCTIONS OF ERAS in her first two opening sentence:

---

Underlining added.
Discourse 11.
Amusement parks today are taking great pains to appeal to all your senses. Careful reproductions of different eras and different countries come complete with matching "natives," authentic food, even the correct smells and sounds. (p 4.)

From there she has a series of sentences starting with locative prepositional phrases that one would assume are examples of these two discourse topics:

Discourse 12.
At Busch Gardens, The Old Country in Williamsburg, you'll find yourself in 17th century Europe. At the Dark Continent, you are bartering in a bazaar in Marrakesh. At Universal Studios in Hollywood, you're on location on a studio backlot. (p 4)

Actually, this section of discourse is much more complicated than it looks. The properties that she assigns to the first prepositional phrases "At Busch Gardens", "At the Dark Continent" and "At Universal Studios" are not meant to be assigned to an abstract location but to the actual places. However, looking at the text only one would assume that these sentences are kin to sentences like:

At a fish market, one buys fish.

Rather than sentences like:

Within the Walt Disney World complex, there are quiet candle-lit retreats such as the Gulf Coast Room and Lake Buena Vista. (p. 4)

Rather than telling one of the things one can do at these places they imply that there are things like bazaars and 17th century Europe at them. These inferences are another aspect of discourse processing that will not be dealt with here. The main point here is that the PPs "At Busch Gardens", "At the Dark Continent" and "At Universal Studios" connect the sentences in D12 to the index of the discourse, sentence, that directly precede them: "Careful reproductions of different eras and different countries..."

This article has many instances of prepositional phrase fronting and few instances of other types of non-SVO patterns. The only other example is an inversion:

Discourse 13.
One fast-growing form of entertainment you may not have expected to find in an amusement park is art. (Lawrence p. 5)

What is fronted is a repetition of the article's topic: entertainment. "Art" is merely an example which it would seem is assigned as the property of "One fast-growing form
of entertainment you may not have expected to find in an amusement park" rather than vice versa. Art is not the topic of conversation so the structure that we need to build is not one in which the concept "art" would be the index of any representation(s). "Forms of entertainment" is the "topic" and one of these forms is "art".

**Discourse 14.**

That song booming out of the muzak in the air-conditioned top-floor bar of the Continental while we sat by the window and watched incoming artillery hitting the rice paddies about five miles south across the Saigon River is one of my clearest memories of those last, weird weeks of the thirty-year war in Vietnam. (Thompson p. 52)

D14, taken from an article in Rolling Stone magazine (1986) written by Hunter S. Thompson, even though it has SVO structure, appears to be a counter example to the general hypothesis that the first thing one comes to, especially an NP with a deictic or anaphoric pronoun like "that", is a link back to explicit or implied information, since the NP begins a new section of the article without an obvious antecedent. Songs are not previously mentioned in the article.

On closer inspection, one sees that the antecedent is in the preface to the section: a quote from Don McLean's "American Pie". The interesting thing here is that on first reading of the article I had missed the preface, since I am not normally inclined to read quotes in section paragraphs. This was bothersome at the time since I could not easily integrate the sentence into my discourse representation of the article. On a second reading I was bothered enough to look hard for an antecedent. I found the quote and was better able to integrate sentence D14 into my discourse representation. The important point is that the reader expects enough information to be able to build a coherent representation of a text that progresses in a connected fashion.

PP-fronting, like wh-clefting and inversion, allows the reader to connect the current phrase, or sentence, being processed to an appropriate, and most likely salient, antecedent. For example Green (1980) comes to the same conclusion about inversions in sportscasters' speech. She notes that sportscasters use inversion when broadcasting play-by-play. Identifying the player by his action and then naming him:

**Stealing it and then losing it** was Dave Bonko.

**Back come the Kahoks with the ball.**

**And in comes number 51, and that will be Mike Matakitis.**

**Into the game for the New Trier West is Brenner.**

The reason she gives is that "this is helpful to the TV viewers, since they don't have scorecards identifying the players..." (Green 1980; p. 585) She goes on to say that in this way the viewer can single out the player on the screen before receiving his name.
(This also gives the sportscaster time to look up the player's name if need be.) Furthermore she notes that sportscasters use this inverted style even when the player are well known or there numbers are clearly visible. This observation fits in nicely with the model being built here.

4. Implementation and Representation

This section will discuss a computational implementation of the ideas developed above and expand upon the notion of indexing briefly presented above. Though the index schema is the main aspect of this section, the search mechanism itself is motivated by the above linguistic research.

In the previous sections a ready made discourse representation for each sentence was assumed. But in order to implement this theory computationally a method for constructing discourse representations must be chosen. One of the advantages of the theory presented in this paper is that any consistent and coherent representation constructing algorithm can be used.

Hans Kamp's Discourse Representation (DR) theory, independently duplicated by Irene Heim, will be used. Hans Kamp's formulation will be chosen because of its algorithmic formulation. The theory as such will be assumed to be correct and will not be critically discussed here.

Section 4.1 will briefly discuss DR theory. Only an outline of the general theory will be given. The algorithm used in the implementation is given in Appendix I. Section 4.2 will discuss the implementation.

4.1. Discourse Representation Theory

DR theory was chosen as the mechanism for creating the sentential discourse representations needed for an implementation of the theory presented in this paper because as a theory it stays closer to the actual linguistic representation than any other discourse representation.

DR theory makes no claims as to how to resolve anaphora but simply restricts the domain from which anaphors may be resolved. DR theory restricts the possible choices of antecedents in many ways. The one that will concern us here in this paper is a simple one. DR theory states that any indefinite introduced into the discourse introduces a new 'reference marker' and is therefore a first occurrence of that element. Furthermore a definite article signals that the item was previously mentioned and is believed to be in the 'common ground'. So for example, in the simple discourse:

\[\text{John bought a car}
\text{He liked it.}\]
both "John" and "a car" are treated as first occurrences (though in actuality names are definite and are assumed to be in the common ground. For our purposes they will be treated as indefinite on the first occurrences and definite thereafter.) However, since "he" and "it" are definite, their reference needs to be resolved. This can be done in a simple way using gender: 'John'(masculine) = 'he'(masculine); 'car'(neuter) = 'it'(neuter). However this runs into difficulty when there is referential occlusion (Simmons 1984.) For example, in the discourse:

John bought a car.
Fred wanted it.
So he stole it (from him)

in order to disambiguate the anaphora, one needs to know something about 'want' and 'steal'. Basically, following Alterman (1985), one needs to know that 'want' has as a goal 'possession' and 'steal' has as its consequence 'possession'. But it is not necessary to use Alterman's powerful relations all the time. Frequently one can resolve anaphoric reference without using the powerful and expensive machinery of Alterman's seven coherence relations.

DR theory assumes that all sentences being processed in a discourse belong to the same discourse and makes no provisions to segment different discourse structures and further restrict possible anaphoric relations. Instead it appends, and integrates, the next discourse representation, i.e. the next sentence, into the present structure.

DR theory combines the more traditional approach to semantics, truth conditional semantics, and what a language user understands when processing a sentence. Basically, what DR theory says is that a representation for "A professor has a book"

<table>
<thead>
<tr>
<th>x y</th>
</tr>
</thead>
<tbody>
<tr>
<td>professor(x)</td>
</tr>
<tr>
<td>book(y)</td>
</tr>
<tr>
<td>has(x,y)</td>
</tr>
</tbody>
</table>

is true if there is an A in the world such that x = A and there is a B in the world such that y = B, where A is a professor, B is a book and "A has B".

The truth conditional aspects of this theory will not be of concern here. It will be assumed that whatever discourse structures are built are true by virtue of the fact that they are built. That is to say no checking as to the state of a world and the satisfaction of the sentence with respect to this would will occur. That is not to say that in a cognitive or computational model truth is not important but simply that it is beyond the scope of this paper. Instead what will concern us more here is the algorithm for the
construction of the Discourse Representation Structures. A subset of the algorithm, taken from *Situations in Discourse* will be assumed in the next sections.

Before discussing the implementation of such a system, a few new construction rules for locative PPs will have to be added to those given in SID. For syntactic simplicity I will assume that all modifying PPs attach to S.

**CRa:** Add an event reference marker P and equate it to the VP

For the PP rule one would need the construction rule:

**CRb:** Do the CR for the NP then add the constraint $d(x,P)$, where $d$ = the prep, and $x$ is a reference marker obtained as a result of the CR for the NP and $P$ is the event reference marker from CRa.

So, for example, the DRS for the sentence "a man kissed a girl in a park" is:

```
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>man(x)</td>
</tr>
<tr>
<td>girl(y)</td>
</tr>
<tr>
<td>kissed(x,y)</td>
</tr>
<tr>
<td>P = kissed(x,y)</td>
</tr>
<tr>
<td>park(z)</td>
</tr>
<tr>
<td>in(z,P)</td>
</tr>
</tbody>
</table>
```

where this sentence is true if there is an A such that $x = A$ and there is a B such that $y = B$, where A is a man, B is a girl and "A kissed B", and there is a C such that $z = C$, and C is park and the locative relation "in" holds such that "in C event P occurred", where event P is "A kissed B".

I make no claims about this particular representation of locatives. It is not crucial to the theory of discourse organization in this paper. However, this semantic treatment will be assumed for the locatives for the sake of the (computational) implementation of the above theory.

**4.2. The Experiment**

In the above sections we motivated and developed an analysis of the organization of discourse representations. Basically the analysis claims

1. that each discourse representation, no matter how it is represented, i.e. what particular theory or formalism, were indexed via their (focused) NPs and
that non-SVO word structure was a signal to search through the indices to locate the structure in which to embed the representation currently being processed.

There are two aspects of this analysis that we will focus on in this section: the creating of indices and the searching of the indices. The more complicated aspects of building and embedding, or relating, the structures to one another will be ignored for the sake of exposition.

A simple experiment was performed to explore the computational usefulness of the proposed indexing system. Three programs were written in Symbolics Prolog. Each program processed a set of twenty-six sentences and created discourse representations. To create the discourse representations the DRS construction algorithm found in Kamp (1986) was used. Added to this were straightforward rules for creating DRSs for locative prepositional phrases. The task for each program was to resolve simple anaphora by searching through the discourse representations for the antecedent. A straightforward feature matching technique was used to do this. If one were trying to resolve the reference for a pronoun and a full NP then only the features of the lexical item, e.g. masculine, singular, was matched. If the reference for a full NP was being resolved then the whole lexical item was searched for.

The first program only constructed discourse representations. It did not construct index lists as well. Thus whenever anaphoric resolution was called for by the DRS construction algorithm, this (the first) program had to search through the entire data base until a match was found. The second program created index lists but they were only searched when the sentences being processed had non-SVO structure. The third program created index lists as well but it only searched the indices. That is, the heuristic always applied.

Each DRS was a flat list. Each index list was also flat. Before each run of the program the machine was cold booted.

The data was a list of 24 sentences. The last sentence contained the only fronted PP, which referred back to the first sentence. The results of this experiment are discussed in the next section.

4.3. Results
In pilot experiments the DRS list was allowed to have complex structure. In other words, the DRS list was a list of lists of lists etc. The index list on the other hand was flat, i.e. a list of lists (or DRSs). The processing in the case of the complex structure was speeded up by a factor of 3, overall, when the heuristic was applied at all times (in the third program). In the case of the second program only the processing of the non-SVO sentence, the last sentence in the corpus was speeded up. However in subsequent
experiments the DRS lists were all converted into flat lists. The effect was less dramatic but significant none the less. Below is given a table of the results for all 3 runs.  

<table>
<thead>
<tr>
<th>Time (secs)</th>
<th>Time for entire Corpus</th>
<th>% of speed up as compared to First Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Program</td>
<td>.023</td>
<td>.66</td>
</tr>
<tr>
<td>No heuristics</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Second Program | | | Speed up: |
| Heuristic on | .0187 | .659 | 19% on Non-SVO 1% overall |
| Non-SVO structure | | | |

| Third Program | | | Speed up: |
| Heuristic at All times | .019 | .54 | 16% on Non-SVO 19% overall |

It is obvious from the above table that always searching indices is far superior to searching the larger discourse structures. It is also significant that when the heuristic is only applied to Non-SVO structures, i.e. the last sentence of the corpus, the speed up is significant. (The difference between the second and third program with respect to the last sentence, the non-SVO sentence is not significant and is due to machine related factors.) Therefore it seems that it is worthwhile building a separate list of NPs and searching that list at least for resolving anaphora and using it not only for the (linguistically) motivated non-SVO structure search but all the time as well.

5. Conclusion

In this paper, it was shown that one can characterize the basic function of non-SVO (fronting) structures as a device for aiding the construction of discourse representations and also as a device for aiding the resolution of anaphora. As part of this characterization a heuristic indexing device was motivated. The indexing heuristic consisted of creating and searching a list of the NPs for each sentence, rather than the entire discourse structure.

It was suggested that indexing could facilitate the construction of discourse representations and the resolution of anaphora in a natural language processing program. The latter of these two suggestions was investigated. It was found that indeed a significant decrease in processing time occurred.

14 The times given in table 1 are rounded to the nearest thousandth of a second. However all percentages were computed with original microsecond numbers and then rounded.
The first of the two above hypothesis about the indexing procedure was not empirically investigated. One avenue of interesting research would be to see if the information provided by non-SVO word order could help in the construction of more complicated discourse representations and if such representations would help in areas like question-answering.

A second avenue would be to test the general psycholinguistic claims made about non-SVO (fronting) word orders apart from the indexing schema. Experiments could be set up to test the hypothesis that non-SVO word order some how signals a search of the discourse space.

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References


