Abstract. The paper summarizes an ongoing investigation of the discourse planning tasks concerned with the sequencing of utterances and their parts. Content selection provides some important constraints on sequencing, most notably those derived from the preconditions and effects of planning operators. However, these operators underconstrain sequencing, especially below the granularity at which they interface with a domain knowledge source. Further constraints are available from the integrative processes of the hearer or reader and from working memory limits. Application of these constraints is a matter for discourse planning because the choices relate to one's communicative goals. The planning task is one of translating functionally relevant relationships between units to be ordered into ordering constraints. A collection of strategies for this task are presented. Some of the strategies were used in an earlier implemented system [Suthers 1993a], and many of which are justified by prior psycholinguistic research. Also discussed include current efforts to extend the work to focus structure in general, and to address the handling of conflicts between strategies.

Approaches to the Sequencing Task

Previous work in generation has handled sequencing decisions in a number of ways. Schematic approaches specify allowable orderings implicitly in terms of the transitions of finite state automata [McKeown 1985]. Non-determinism in these automata has been addressed using focus preferences for selecting from a content pool, these preferences being embodied in a selection mechanism. Other approaches exploited the structure of domain knowledge with mechanisms for traversing data structures representing this knowledge [Paris & McKeown 1986, Sibun 1992]. Planning approaches initially utilised more local yet still schematic specifications of ordering, expressed as preconditions or optional satellites for plan operators [Cawsey 1989, Hovy 1988, Moore 1989]. More recently, partial order causal link (POCL) planning is being applied to discourse planning, with partial ordering derived in a principled manner from the relationships between preconditions and postconditions of plan steps [Young et al. 1994].

Content selection processes provide some important constraints on sequential structure, most notably in the form of satisfaction-precedence relations derived from the preconditions and effects of discourse planning operators. However, these processes underconstrain sequential structure. This is especially true below the granularity at which the operators interface with a domain knowledge source, because the latter is partially responsible for providing collections of related content that can't be specified by domain-independent operators. For example, a specification that some distinguish-
ing attributes of an entity should be expressed might bind to several nonexclusive alternatives, or a specifica-
tion for a description of the constituents of an ob-
ject or process might result in retrieval of a collection
of propositions. Some sequencing decisions above the
granularity of access to domain knowledge may be un-
derconstrained as well, for example the order in which
to express a list of multiple reasons for a conclusion.

Further constraints are available, for example from rea-
soning about the integrative processes of the hearer or
reader and the impact of working memory limits on
these processes. Application of these constraints is a
matter for discourse planning because the choices relate
to one's communicative goals, as discussed below. Se-
quential structure is too important to treat arbitrarily
and too context-sensitive to treat in a schematic man-
ner.

Overall, ordering heuristics have not typically been
made explicit as causally efficacious plan operators. Ex-
plicit ordering operators facilitate the expression and
study of alternate theories of sequential structure, and
have benefits for planning as well. For example, they
enable a planner to tell whether it can achieve a com-
municative goal by ordering its utterances in a certain
way, and they provide a handle for changing strategies
in different discourse situations. Suthers [1993a] treated
sequencing as a distinct planning task and used sequenc-
ing operators that derived ordering constraints from rel-
vant relationships between the elements being ordered.

However, prior planning approaches (including that just
cited) have not made the effects of ordering decisions ex-
plicit. Effects can help choose between conflicting oper-
ators, and must be considered in reasoning about what
communicative goals are achieved by particular order-
ings.

Choice Between Conflicting Operators. When
ordering operators conflict, the operators express prin-
cipled reasons for choosing between alternate sequential
structures. The choice is a matter for discourse planning
because it relates to one's goals. The intended effects
of conflicting ordering operators can be used to select
between them provided that these effects can be related
to contextual factors such as superordinate goals and
stylistic preferences [DiMarco & Hirst 1993, McCoy &
Cheng 1991, Hovy 1990]. For example, a common con-

flict is between a sequential structure that makes a sin-
gle entity salient and a sequential structure that flows
smoothly from one entity to another ("dovetailing"). Entity
salience might be preferred when the entity in
question is a topic of the current segment, while dove-
tailing might be preferred when communicating a re-
lational structure among equally important entities or
to make a transition to a new topic. (A definition of
"topic" is forthcoming.) Or consider the ordering of ex-
amples with respect to the generality they exemplify. If
the examples are presented first, the reader has an op-
portunity to engage in inductive inference towards the
generality, yet may fail to see the relevance of the ex-
amples. Presented after a generality, examples provide
congratulations under which the generality may be
indexed. The choice depends on whether the speaker
or writer is trying to get the hearer or reader to engage
in active induction or trying to ease the comprehension
process.

Achieving Communicative Goals by Sequential
Structure. Some planners (e.g., POCL planners) can
notice when a goal can be achieved by actions that have
already been planned. However, these planners can only
take advantage of existing actions when the explicit ef-

cfects of a single action meets the goal in question. It
should be possible to extend these planners to use or-
dering operators in an opportunistic manner to identify
ways in which goals can be achieved by felicitous or-
dering of multiple actions, e.g., to achieve communi-
cative goals by implicit relations [Lascarides & Oberlander
1992, Mann & Thompson 1983]. If an operator's effect
matches to an active unsatisfied goal and the opera-
tor's constraints match existing utterance components
or planning can satisfy these constraints with new utter-
ances, then mere installation of the ordering constraint
can be used to achieve the communicative goal. For
example, suppose a discourse planner has the goals of
describing a number of events and the causal relations
between them. Communication of the causal relations
might be achieved implicitly by describing the events in
their causal order.

Sequencing as Exploiting Relationships. The se-
quencing of two elements of a discourse can only be
decided if there exists some relationship between the
elements which has implications for their order of ex-
pression. The sequencing task is relational, not merely
selective. Approaches that treat sequencing as a se-
lective task, for example by using predicates that se-
lect the most preferred element out of a set of remain-
ing candidates, are forced to generate a full ordering
(the sequence of selected items). The structural as-
psects of sequencing are not a natural consequence of
the model. When sequencing is treated as the accumu-
lation of explicit constraints between elements, partial
orderings can be constructed. Derivation of these con-
straints from relationships between the elements to be
ordered addresses the structural aspect of sequencing
directly.

The remainder of this paper will present a number of
sequencing strategies that illustrate how relationships
between elements yield sequencing constraints. But first some notational preliminaries are required.

Notation for Ordering Strategies

Two aspects of sequential structure are distinguished: precedence and juxtaposition. Precedence indicates that one segment should occur sometime before another segment. Precedence is significant when prior communication of the contents of one segment facilitate the intended functionality of the contents of another segment. For example, in technical writing definitions of terms usually precede their use. Juxtaposition indicates that one segment should occur next to another segment in the sequential realization of the explanation. Juxtaposition is significant when the contents of both segments must be in focus of attention at the same time in order for the segments to fulfill their intended communicative function. For example, statements of similarity and difference are usually juxtaposed when making a comparison so that the relative significance of the similarities and differences can be weighed. Any constraint on sequential structure must involve one of precedence or juxtaposition. Succession indicates the simultaneous presence of both constraints (i.e., that one segment should occur immediately before and next to another segment).

Sequential constraints are placed between text plan elements at three granularities. Inter-intentional constraints are placed between intentions to perform rhetorical and communicative acts [Suthers 1993a], and constrain the ordering of the utterance segments that achieve these intentions. For example, an inter-intentional constraint would be used to ensure that a description of the structure of a device precede an account of how the device carries out its function. Inter-propositional constraints are placed between propositions and constrain the ordering of sentences, adjectives, relative clauses, and other surface realizations of the propositions. For example, an inter-propositional precedence constraint between (Parallel plates-1) and (Made of plates-1 metal-1) would allow any of “parallel metal plates,” “parallel plates made of metal” or “The plates are parallel. The plates are made of metal.” but not “metal parallel plates,” “metal plates that are parallel,” or “The plates are made of metal. The plates are parallel.” (Clearly, this constraint leaves other realization decisions open.) Intra-propositional constraints, placed between roles of a proposition, controls voice (i.e., which role filler is expressed as the subject of a clause). For example, an intra-propositional precedence constraint could select between “The plates are made of metal.” vs. “Metal is what the plates are made of.” Juxtaposition constraints between role fillers discourage the insertion of a subordinate clause between the realization of the role fillers.

The ordering strategies are expressed in the form of rules for translating other kinds of relationships into ordering relations. The general form of the rules is:

If $S_1$ bears relation $R$ to $S_2$ then $S_1 \rightarrow^{ord} S_2$

where $S_1$ and $S_2$ are segments and $S_1 \rightarrow^{ord} S_2$ is one of the following:

$S_1 \overset{prec}{\rightarrow} S_2$ for precedence ($S_1$ occurs sometime before $S_2$),

$S_1 \overset{juxtaposition}{\rightarrow} S_2$ for juxtaposition ($S_1$ and $S_2$ are next to each other in either order), and

$S_1 \overset{succession}{\rightarrow} S_2$ for succession ($S_1$ and $S_2$ are juxtaposed and $S_1$ precedes $S_2$).

Propositions are denoted by $(P r_1 r_2 *)$ where $P$ is a predicate, the $r_i$ are role fillers, and * denotes 0 or more additional role fillers. No ordering of $r_1$, $r_2$, and * is implied by this notation; in particular * may represent other role fillers that can be expressed before or between $r_1$ and $r_2$ as well as after them. The notation for intra-propositional ordering is

$(P r_1 \rightarrow^{ord} r_2 *)$.

This constrains the realizations of the fillers of $r_1$ and $r_2$ to be sequenced in a manner respecting relation ord. For example, if $(P r_1 \overset{precedes}{\rightarrow} r_2)$ is expressed as a clause, then $r_1$ will be the surface-initial subject.\footnote{In the implemented system of Suthers [1993a], subjects were always surface-initial. Subject and surface-initial are not conflated in forthcoming revisions.}

Two predicates and a function are needed to express some of the ordering strategies:

End-$p(P)$, true when $P$ is a proposition at the end of a chain of ordered propositions:

$P_1 \overset{ord}{\rightarrow} \ldots \overset{ord}{\rightarrow} P_n \overset{ord}{\rightarrow} P$.

Topic-$p(t)$, true when $t$ is the argument of or a constituent of the argument of a rhetorical goal scoping over the propositions to be ordered. For example, in Describe((Structure capacitor-1)) both capacitor-1 and (Structure capacitor-1) are “topics.”

Familiarity($c$) = 1 when a possibly fallible oracle indicates that concept $c$ is assumed to be familiar to the questioner at level $l$, a member of a partially ordered set of levels, perhaps using categories such as in Prince’s [1981] taxonomy. $l = false$ for unfamiliar $c$.

\footnote{The notation fails to constrain the realization of the predicate relative to its role fillers, a deficiency that will be addressed in a future revision.}
Table 1: Rules for Ordering Strategies

| Supplemental Constraints |
|--------------------------|
| **Antithesis**           | If A is an antithesis of T then T \rightarrow A. |
| **Background**           | If B is background for F then B \rightarrow F. |
| **Enrichment**           | If E is an enrichment of S then S \rightarrow E. |
| **Evidence**             | If E provides evidence for assertions in H then E \rightarrow H or H \rightarrow E. |
| **Exemplification**      | If E provides an example of G then G \rightarrow E or E \rightarrow G. |
| **Motivation**           | If M provides a motivation for S then M \rightarrow S. |
| **Preview**              | If P provides a preview of B then P \rightarrow B. |
| **Summary**              | If S is a summary of B then B \rightarrow S. |

| Memory and Processing Constraints |
|-----------------------------------|
| **Topic Initial**                 | If Topic-p(t), (P_1 t * ) is unordered and (P_2 * ) does not contain t then (P_1 t * ) \rightarrow (P_2 * ). |
| **Topic as Subject**              | If Topic-p(t) in (P_1 t * ) then (P_1 t * ). |
| **Dovetailing**                   | If R = (P_1 z \rightarrow y * ), End-p(R), and (P_2 y z * ) is unordered then (P_1 z y * ) \rightarrow (P_2 y \rightarrow z * ). |

| Domain Knowledge Constraints |
|-------------------------------|
| **Natural Ordering**          | If (N z y) where N is a Natural-Ordering and z is in the predecessor role of N, then (N z \rightarrow y ). |
| **Differentia**               | If (Subsumption c s) and s is differentiated within c by (P s * ) then (Subsumption c s ) \rightarrow (P s * ). |
| **Context**                   | If C is context in which S holds then C \rightarrow S. |

| Epistemic Context Constraints  |
|-------------------------------|
| **Familiar First**            | If (P f n * ), Familiarity(P), and Familiarity(f) > Familiarity(n) then (P f \rightarrow n * ). |

*(See Suthers [1993a,b] for exchange-level constraints on model choice.)*

Table 1 lists the strategies. Selected strategies are discussed below.

**Supplemental Constraints**

The most obvious constraints on sequential structure are those derived from the inclusion of supplemental material. Supplemental material facilitates the understanding or acceptance of other segments of an explanation in specific ways, the success of which is often affected by order of presentation. Suthers [1993a] used a collection of supplemental relations, these being "rhetorical" relations that are primarily intentional rather than informational [Moore & Pollack 1992] and in which one can pre-identify a "nucleus" that is more essential to the goals of the discourse than the other relata. Ordering strategies are associated with each supplemental relation in Table 1. Some relations give rise to an unambiguous ordering, and thus have only one rule in the table. The ordering implications of others are complicated by possible differences in tutorial strategy and individual differences in learning style. One advantage of separating ordering decisions from supplemental relationships is the ability to model stylistic differences by changing ordering strategies independently of supplemental strategies.

**Background.** Background material is that which functions to enable the comprehension of nuclear foreground material. Thus background functions best if it precedes the foreground. Succession is not necessary as long as the delay between background and foreground is small enough that the background will not have been forgotten when the foreground is encountered.
Exemplification. Strategic variation is possible in the ordering of examples and illustrations. An explainer can encourage a questioner to engage in inductive inference by giving examples before the generalizations or concepts that they exemplify, as expressed by the $E \rightarrow G$ constraint of version b of the rule. Alternately, the example can be given immediately after the concept or generalisation being exemplified, as expressed by the $G \rightarrow E$ constraint of version a. Under this strategy, the questioner does not have to guess the generalisation and will appreciate why the example was introduced. When multiple examples are present other ordering strategies are available for inter-exemplar ordering: see Mittal & Paris [1993] and Rissland [1978].

Motivation. A motivation segment is intended to point out the utility of another segment of an explanation so that the hearer will appreciate the relevance of the motivated segment enough to take it seriously. Motivation to attend doesn't work retroactively, so the motivating segment should occur prior to the motivated segment. Succession is preferred, but not necessary.

Previews and Summaries. By definition, a preview precedes the main body of an explanation. To serve the function of preparing the questioner for the sequence of utterances to follow, a previewed text should be the immediate successor of the preview, because a preview sets up an expectation that the subsequent segments will be those mentioned in the preview. Violation of this expectation with intervening material can cause confusion. A summary is similar to a preview in that both provide skeletal characterization of the main body of an explanation, though summaries can refer back to content that was not available at the time of a preview. The pedagogical utility of a summary is in repetition and consolidation. Succession is not as important for summaries. In fact, a summary might be used because there is some extra material between the segments related by the summary relation: the summary functions to refocus on the main points after the digression.

Memory and Processing Constraints

The ordering operators of this section rely on a few processing assumptions that have been supported in the psycholinguistic literature. Memory (retention and retrieval) is better for "integrated" items, i.e. those that the subject can relate to other prior knowledge [Keenan et al. 1984, Kintsch & van Dijk 1978]. New integrative links are constructed in a limited working memory during comprehension [Kintsch & van Dijk 1978]. There is a cost (allocation of attention, probability of error) associated with changing the contents of this working memory, and the longer an item is kept in working memory the more likely it is to be encoded in long term memory. Finally, subjects attempt to identify thematically central entities and use these as the default locus of integration when attempting to integrate new material [Carpenter & Just 1977].

Comments on "topic" and "theme" may be helpful at this point. Lavid & Hovy (unpublished working paper) define "theme" as "that element that informs the listener as discourse unfolds how to relate the incoming information to what is already known." The topic predicate is not intended as a generally applicable definition of thematic elements outside its use in the ordering rules. It merely provides candidates for being made thematic elements though appropriate ordering and other devices.

When a questioner asks a question, the topics of the query are brought into the focus of attention. Their focal status motivates the relevance of assertions made and concepts introduced by the explainer in the response. If assertions or concepts that had no apparent relation to the topics were introduced, the questioner might be unable to integrate them and could become confused due to the conversational implicature of the apparent change in subject. For example:

"What killed the dinosaurs?"

"Many rocks at the KT-boundary have an unusual concentration of iridium ... (The iridium poisoned them? The speaker doesn't want to talk about dinosaur demise?)"

In contrast, the following explanation changes focus of attention from the question's topic to other concepts and propositions in a well connected manner:

"The dinosaur extinctions may have been caused by a huge meteorite. Evidence for such a meteorite is provided by an unusual concentration of iridium found in KT-boundary rocks. ..."

This example illustrates the next three rules: the response starts with a proposition about the topic, the topic is in the subject position, and new concepts are introduced by their relation to prior concepts.

Topic Initial and Topic as Subject. The "topic initial" rule specifies that propositions involving a topic entity $t$ are to be expressed before propositions not involving a topic. As illustrated above, in situations where the topic has been pre-identified, this rule ensures continuity with the recipient's expectations. In other situations, first-mention aids the subject's identification of the topic [Kieras & Boviar 1981, Gernsbacher & Hargreaves 1988], helping to ensure that facts about a particular entity among the many mentioned are remembered.
The "topic as subject" rule marks the topic as the surface-initial subject of any clause it occurs in. Repetition in the subject position is another way to facilitate the hearer's or reader's identification of the topic [Kieras & Boviar 1981]. This rule can also help smooth over violations of the following "dovetailing" rule by returning to a concept that is presumably easy to reactivation.

**Dovetailing.** This strategy relies on a combination of "argument overlap" [Kintsch & van Dijk 1978] and "given-new" [Haviland & Clark 1974]. The inter-propositional $P_1 \leftrightarrow P_2$ constraint introduces a proposition $P_2$ when it involves a concept or proposition that has been brought into immediate focus of attention by another ordering decision to express $P_1$ (i.e., there is argument overlap). The intra-propositional $y \leftarrow z$ constraint makes the surface-initial subject of each proposition be the role filler by which it was introduced (i.e., proceeds from given to new). Dovetailing is intended to minimize working memory changes and maintain the connectedness of the subject's evolving conceptual model or "text base."

Dovetailing can be iterated on $z$ in $P_2$ to produce chains. However, overapplication of dovetailing risks obtaining stream-of-consciousness texts which lack thematic development. Topic salience and dovetailing can be in conflict. One manifestation of this conflict is the conflict between McKeown's [1985] preference of "change" over "maintain" over "return" in order to avoid having to reintroduce entities one has more to say about (based on Sidner [1979]) and Gordon et al.'s [1993] preference of "continuing" over "returning" over "shifting" in order to maintain local coherence. Further work is required to identify how the choice of one strategy over the other depends on register and task demands, and to examine the interaction with other factors such as location in the discourse. For example, the author expects that topic salience will be preferred in contexts where the theme is being established (e.g., early in a document, paragraph, or other new discourse segment) while dovetailing might be preferred once the theme is established and a transition to a subordinate theme is needed.

**Domain Knowledge Constraints**

Now we consider constraints derived from relationships in the domain knowledge being expressed.

**Natural Orderings.** Temporal and causal relations are normally experienced in a particular direction, for example from prior to posterior events or from cause to effect. The assumption that our cognitive apparatus is adapted to more easily use these relations in the "forward" direction suggests that predicates categorized as "natural orderings" [Bienkowski 1986] be expressed with the prior event or cause as the subject, for example "X caused y" is preferred to "y is caused by x," all other things being equal. This strategy is consistent with psycholinguistic evidence indicating that reverse causal and temporal ordering inhibits comprehension [Irwin 1980] and disrupts thematic processing [Townsend 1983]. It also facilitates the hearer's identification of implicitly expressed temporal relations [Lascarides & Oberlander 1992]. Related strategies are available for spatial descriptions [Linde 1974, Sibun 1992].

**Differentia and Context.** The "differentia" relation holds between two propositions when one proposition $(P \; s \; *)$ differentiates a subclass $s$ from other subclasses of a class $c$. An explainer chooses the statement $(P \; s \; *)$ from amongst all the possible predicates one could apply to $s$ because $P$ distinguishes $s$ from the other subdivisions of $c$ that the questioner might know about. The questioner cannot recognize or assess this significance of $(P \; s \; *)$ unless he or she has been informed of the "contrast class" against which the claim $(P \; s \; *)$ is being made. This rule suggests that the contrast class $c$ be introduced first, for example:

"An electric field is a kind of force field that applies a force to a charged object."

is preferred over

"An electric field applies a force to a charged object and is a kind of force field."

Mere precedence is insufficient because the genus provides the context in which the differentia is meaningful. Succession places them both in focus of attention at once. This strategy can be generalised to the level of sibling communicative acts or rhetorical intentions [Suthers 1993a], and to other context/statement relationships, as suggested by the "Context" rule in Table 1.

**"Epistemic Context" Constraints**

Suthers [1993a,b] discusses how the "epistemic context" (the knowledge available to the explainer and questioner and the knowledge shared in prior dialogue) influences the choice between alternate domain models on which to base an explanation. Some of the "preferences" presented in these publications address sequential concerns. For example, when preferences to "say something new," "minimize new propositions," and "elaborate on focal models" are applied together in a dialogue about some phenomenon, incremental construction of increasingly elaborate domain models of the phenomenon will result [Suthers et al. 1992]. In general, the epistemic context
Familiar First. New concepts can be introduced in relation to familiar ones using any domain relation. Suppose concept f is familiar and n is new. Then any proposition (P f n *) will do the job, provided the predicate P itself is familiar. (An unfamiliar predicate won't be much help in integrating an unfamiliar concept.) The strategy assumes an ordering of familiarity levels. If f is more familiar than n, it installs an intra-propositional constraint that f should be expressed surface-initial, yielding expressions of form “F is P-related to n.” (not “n is P^-1-related to f”). Once familiar-first has been applied, dovetailing can be used to introduce other unfamiliar concepts.

The assumption behind familiar-first is that it is easier to retrieve a known concept and integrate a new concept in relation to it than it is to construct a new concept from scratch and subsequently retrieve a known concept to which it can be integrated. However, at and below the clause level the delay between the introduction of n and f may be so small that this strategy does not have a discernible effect. Also, if n is a topic, “topic as subject” may be more relevant to the speaker’s goals. These are questions for empirical work.

Closing Comments

The sequencing of expository texts and speech should be chosen to enhance the intended functionality of each textual unit and to facilitate the questioner’s integration of the communicated information. This aspect of the planning task is usefully seen as one of translating functionally relevant relationships between textual units into ordering constraints. The strategies presented in this paper were derived from examination of example explanations and found to be necessary to enable an automated explanation generator to produce coherently sequenced explanations [Suthers 1993a]. (Space constraints necessitate leaving a full example to the work just cited.) Many of the strategies were subsequently found to correspond to results in the psycholinguistic literature.

As discussed previously, the strategies can conflict. Suthers [1993a] handled conflicts with a simple preference ordering. This approach is inadequate because conflict resolution is expected to depend on contextual factors such as the speaker or writer’s goals and the relationships of the elements to be ordered with respect to discourse segment boundaries. The author is currently planning psycholinguistic experiments to test the impact of the strategies through reading time and recall studies, with particular concern for how the resolution of conflicts between topic salience and other heuristics should be sensitive to discourse context. Another question for future work is the extent to which the sequencing task fits top-down models of planning such as DPOCL [Young et al. 1994] vs. requiring a distinct mechanism for the application of conflicting heuristics.

The modeling of working memory limits and memory decay in DPOCL operators would require generalizing the POCL notion of a “threat” to be a matter of degree rather than absolute. The author suspects that important generalities will be easier to capture if factored out and expressed as explicit sequencing operators rather than manifested in variations of multiple decompositional operators.

The foregoing work is being extended to include the subordination structure of an utterance as well as its sequential structure. “Focus trees” [McCoy & Cheng 1991, Hovy & McCoy 1989] will be used to represent the combined sequential and subordination structure, with partial orderings placed between siblings at each level of the hierarchy. The nodes of a focus tree represent units of a text at various granularities ranging from intentionally defined segments of the sort discussed by Gross & Sidner [1986] down through clausal propositions to predicates and entity references. “Focusing operators,” including versions of the sequencing heuristics of this paper rewritten in the focus tree notation, will manipulate the tree structure by subordinating one or more subtree to another or by installing cross-links between siblings to constrain possible traversals. This reformulation is expected to be an improvement for several reasons. It allows the expression of heuristics for the subordination aspects of focus structure, not just sequencing, and thematic development can take place at multiple granularities. Only one ordering relation, precedence, is required. Juxtaposition is handled by grouping within a subordinate structure rather than by a different ordering relation that requires special interpretation. An availability metric can be defined in terms of distance to search back through the tree. Finally, the notation can be used in the analysis of texts, and promises to support application of the sequencing heuristics to text revision as well as text generation.

Acknowledgements

This research was conducted while supported by grant MDR-9155715 from the National Science Foundation Applications of Advanced Technology program. The author thanks the anonymous reviewers for thoughtful comments.
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