Centering in-the-Large: Computing Referential Discourse Segments

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Abstract
We specify an algorithm that builds up a hierarchy of referential discourse segments from local centering data. The spatial extension and nesting of these discourse segments constrain the reachability of potential antecedents of an anaphoric expression beyond the local level of adjacent center pairs. Thus, the centering model is scaled up to the level of the global referential structure of discourse. An empirical evaluation of the algorithm is supplied.

1 Introduction
The centering model (Grosz et al., 1995) has evolved as a major methodology for computational discourse analysis. It provides simple, yet powerful data structures, constraints and rules for the local coherence of discourse. As far as anaphora resolution is concerned, e.g., the model requires to consider those discourse entities as potential antecedents for anaphoric expressions in the current utterance $U_i$, which are available in the forward-looking centers of the immediately preceding utterance $U_{i-1}$. No constraints or rules are formulated, however, that account for anaphoric relationships which spread out over non-adjacent utterances. Hence, it is unclear how discourse elements which appear in utterances preceding utterance $U_{i-1}$ are taken into consideration as potential antecedents for anaphoric expressions in $U_i$.

The extension of the search space for antecedents is by no means a trivial enterprise. A simple linear backward search of all preceding centering structures, e.g., may not only turn out to establish illegal references but also contradicts the cognitive principles underlying the limited attention constraint (Walker, 1996b). The solution we propose starts from the observation that additional constraints on valid antecedents are placed by the global discourse structure. Accordingly, we define the extension of referential discourse segments (over several utterances) and a hierarchy of referential discourse segments (structuring the entire discourse). The algorithmic procedure we propose for creating and managing such segments receives local centering data as input and generates a sort of superimposed index structure by which the reachability of potential antecedents, in particular those prior to the immediately preceding utterance, is made explicit. The adequacy of this definition is judged by the effects centered discourse segmentation has on the validity of anaphora resolution (cf. Section 5 for a discussion of evaluation results).

2 Global Discourse Structure
There have been only few attempts at dealing with the recognition and incorporation of discourse structure beyond the level of immediately adjacent utterances within the centering framework. Two recent studies deal with this topic in order to relate attentional and intentional structures on a larger scale of global discourse coherence. Passonneau (1996) proposes an algorithm for the generation of referring expressions and Walker (1996a) integrates centering into a cache model of attentional state. Both studies, among other things, deal with the supposition whether a correlation exists between particular centering transitions (which were first introduced by Brennan et al. (1987); cf. Table 1) and intention-based discourse segments. In particular, the role of SHIFT-type transitions is examined from the perspective of whether they not only indicate a shift of the topic between two immediately successive utterances but also signal (intention-based) segment boundaries. The data in both studies reveal that only a weak correlation between the SHIFT transitions and segment boundaries can be observed. This finding precludes a reliable prediction of segment boundaries based on the occurrence of

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1Our notion of referential discourse segment should not be confounded with the intentional one originating from Grosz & Sidner (1986), for reasons discussed in Section 2.
SHIFTS and vice versa. In order to accommodate to these empirical results divergent solutions are proposed. Passonneau suggests that the centering data structures need to be modified appropriately, while Walker concludes that the local centering data should be left as they are and further be complemented by a cache mechanism. She thus intends to extend the scope of centering in accordance with cognitively plausible limits of the attentional span. Walker, finally, claims that the content of the cache, rather than the intentional discourse segment structure, determines the accessibility of discourse entities for anaphora resolution.

As a working hypothesis, for the purposes of anaphora resolution we subscribe to Walker's model, in particular the cache, rather than the intentional discourse segment structure, determines the accessibility of discourse entities for anaphora resolution.

| \( C_b(U_n) = C_b(U_{n-1}) \) OR \( C_b(U_{n-1}) \) undef. | \( C_b(U_n) \neq C_b(U_{n-1}) \) | \( C_p(U_n) \) |
|-----------------|-----------------|-----------------|
| CONTINUE (C) | SMOOTH-SHIFT (SS) | RETAIN (R) | ROUGH-SHIFT (RS) |

Table 1: Transition Types

As a working hypothesis, for the purposes of anaphora resolution we subscribe to Walker's model, in particular to that part which casts doubt on the hypothesized dependency of the attentional from the intentional structure of discourse (Grosz & Sidner, 1986, p.180). We diverge from Walker (1996a), however, in that we propose an alternative to the caching mechanism, which we consider to be methodologically more parsimonious and, at least, to be equally effective (for an elaboration of this claim, cf. Section 6).

The proposed extension of the centering model builds on the methodological framework of functional centering (Strube & Hahn, 1996). This is an approach to centering in which issues such as thematicity or topicality are already inherent. Its linguistic foundations relate the ranking of the forward-looking centers and the functional information structure of the utterances, a notion originally developed by Daneš (1974). Strube & Hahn (1996) use the centering data structures to redefine Daneš's trichotomy between given information, theme and rheme in terms of the centering model. The \( C_b(U_n) \), the most highly ranked element of \( C_f(U_{n-1}) \) realized in \( U_n \), corresponds to the element which represents the given information. The theme of \( U_n \) is represented by the preferred center \( C_b(U_n) \), the most highly ranked element of \( C_f(U_n) \). The theme/rheme hierarchy of \( U_n \) corresponds to the ranking in the \( C_f \)'s. As a consequence, utterances without any anaphoric expression do not have any given elements and, therefore, no \( C_b \). But independent of the use of anaphoric expressions, each utterance must have a theme and a \( C_f \) as well.

The identification of the preferred center with the theme implies that it is of major relevance for determining the thematic progression of a text. This is reflected in our reformulation of the two types of thematic progression (TP) which can be directly derived from centering data (the third one requires to refer to conceptual generalization hierarchies and is therefore beyond the scope of this paper, cf. Daneš (1974) for the original statement):

1. **TP with a constant theme**: Successive utterances continuously share the same \( C_p \).

2. **TP with linear thematization of rhemes**: An element of the \( C_f(U_{i-1}) \) which is not the \( C_p(U_{i-1}) \) appears in \( U_i \) and becomes the \( C_p(U_i) \) after the processing of this utterance.

| \( C_f(U_{i-1}) \) | \( C_f(U_i) \) |
|-----------------|-----------------|
| \([c_1, \ldots, c_j, \ldots, c_s]\) | \([c_1, \ldots, c_k, \ldots, c_t]\) |

\( 1 < j \leq s \)

Table 2: Thematic Progression Patterns

Table 2 visualizes the abstract schemata of TP patterns. In our example (cf. Table 8 in Section 4), \( U_1 \) to \( U_9 \) illustrate the constant theme, while \( U_7 \) to \( U_{10} \) illustrate the linear thematization of rhemes. In the latter case, the theme changes in each utterance, from “Handbuch” (manual) via “Inhaltsverzeichnis” (table of contents) to “Kapitel” (chapter) etc. Each of the new themes are introduced in the immediately preceding utterance so that local coherence between these utterances is established.

Daneš (1974) also allows for the combination and recursion of these basic patterns; this way the global thematic coherence of a text can be described by recurrence to these structural patterns. These principles allow for a major extension of the original centering algorithm. Given a reformulation of the TP constraints in centering terms, it is possible to determine referential segment boundaries and to arrange these segments in a nested, i.e., hierarchical manner on the basis of which reachability constraints for antecedents can be formulated. According to the segmentation strategy of our approach, the \( C_p \) of the end point (i.e., the last utterance) of a discourse segment provides the major theme of the whole segment, one which is particularly salient for anaphoric reference relations. Whenever a relevant new theme is established, however, it should reside in its own discourse segment, either embedded or in parallel to another one. Anaphora resolution can then be performed (a) with the forward-looking centers of the linearly immediately preceding utterance, (b) with the forward-looking centers of the end point of the hierarchically immediately reachable discourse segment, and (c) with the preferred center of the end point of any hierarchically reachable discourse segment (for a formalization of this constraint, cf. Table 4).
3 Computing Global Discourse Structure

Prior to a discussion of the algorithmic procedure for hypothesizing discourse segments based on evidence from local centering data, we will introduce its basic building blocks. Let \( x \) denote the anaphoric expression under consideration, which occurs in utterance \( U_i \) associated with segment level \( s \). The function \( \text{Resolved}(x, s, U_i) \) (cf. Table 3) is evaluated in order to determine the proper antecedent \( \text{ante} \) for \( x \). It consists of the evaluation of a reachability predicate for the antecedent on which we will concentrate here, and of the evaluation of the predicate \( \text{IsAnaphorFor} \) which contains the linguistic and conceptual constraints imposed on a (pro)nominal anaphor (viz. agreement, binding, and sortal constraints) or a textual ellipsis (Hahn et al., 1996), not an issue in this paper. The predicate \( \text{IsReachable} \) (cf. Table 4) requires \( \text{ante} \) to be reachable from the utterance \( U_i \) associated with the segment level \( s \).\(^2\) Reachability is thus made dependent on the segment structure \( DS \) of the discourse as built up by the segmentation algorithm which is specified in Table 6. In Table 4, the symbol "\( =_{str} \)" denotes string equality, \( N \) the natural numbers. We also introduce as a notational convention that a discourse segment is identified by its index \( s \) and its opening and closing utterance, \( \text{Ut} \) and \( \text{DS}_{s} \), respectively. Hence, we may either either identify an utterance \( U_i \) by its linear text index, \( i \), or, if it is accessible, with respect to its hierarchical discourse segment index, \( s \) (e.g., cf. Table 8 where \( U_3 = U_{DS[3, end]} \) or \( U_{13} = U_{DS[1, end]} \)). The discourse segment index \( s \) is always identical to the currently valid segment level, since the algorithm in Table 6 implements a stack behavior. Note also that we attach the discourse segment index \( s \) to center expressions, e.g., \( C_f(s, U_i) \).

\[
\text{Resolved}(x, s, U_i) :=
\begin{cases}
\text{\( \text{IsReachable}(\text{ante}, s, U_i) \)} & \text{\( \text{\&} \text{\( \text{IsAnaphorFor}(x, \text{ante}) \)} \)} \\
\text{\( \text{undefined} \)} & \text{\( \text{else} \)}
\end{cases}
\]

Table 3: Resolution of Anaphora

\[
\text{IsReachable}(\text{ante}, s, U_i) :=
\begin{cases}
\text{\( \text{ante} \in C_f(s, U_{i-1}) \)} & \text{\( \text{if} \)} \\
\text{\( \text{ante} \in C_f(s - 1, U_{DS[\text{begin}, \text{end}]}) \)} & \text{\( \text{else if} \)} \\
\text{\( (3v \in N : \text{ante} =_{str} C_f(v, U_{DS[\text{begin}, \text{end}])} \)} & \text{\( \text{else if} \)} \\
\end{cases}
\]

\[
\begin{cases}
\text{\( \land v < (s - 1) \)} \\
\text{\( \land (-3v' \in N : \text{ante} =_{str} C_f(v', U_{DS[\text{begin}, \text{end}]}) \)} \\
\text{\( \land v < v' \)}
\end{cases}
\]

Table 4: Reachability of the Anaphoric Antecedent

Finally, the function \( \text{Lift}(s, i) \) (cf. Table 5) determines the appropriate discourse segment level, \( s \), of an utterance \( U_i \) (selected by its linear text index, \( i \)). \( \text{Lift} \) only applies to structural configurations in the centering lists in which themes continuously shift at three different consecutive segment levels and associated preferred centers at least (cf. Table 2, lower box, for the basic pattern).

\[
\text{Lift}(s, i) :=
\begin{cases}
\text{\( \text{Lift}(s - 1, i - 1) \)} & \text{\( \text{if} \)} \\
\text{\( s > 2 \land i > 3 \)} & \text{\( \land \)} \\
\text{\( C_f(s, U_{i-1}) \neq C_f(s - 1, U_{i-2}) \)} & \text{\( \land \)} \\
\text{\( C_f(s - 1, U_{i-2}) \neq C_f(s - 2, U_{i-3}) \)} & \text{\( \land \)} \\
\text{\( C_f(s, U_{i-1}) \in C_f(s - 1, U_{i-2}) \)} & \text{\( \lor \)} \\
\text{\( s \)} & \text{\( \text{else} \)}
\end{cases}
\]

Table 5: Lifting to the Appropriate Discourse Segment

Whenever a discourse segment is created, its starting and closing utterances are initialized to the current position in the discourse. Its end point gets continuously incremented as the analysis proceeds until this discourse segment \( DS \) is ultimately closed, i.e., whenever another segment \( DS' \) exists at the same or a hierarchically higher level of embedding such that the end point of \( DS' \) exceeds that of the end point of \( DS \). Closed segments are inaccessible for the antecedent search. In Table 8, e.g., the first two discourse segments at level 3 (ranging from \( U_5 \) to \( U_6 \) and \( U_8 \) to \( U_{11} \)) are closed, while those at level 1 (ranging from \( U_1 \) to \( U_3 \)), level 2 (ranging from \( U_4 \) to \( U_7 \)) and level 3 (ranging from \( U_{12} \) to \( U_{13} \)) are open.

The main algorithm (see Table 6) consists of three major logical blocks (\( s \) and \( U_i \) denote the current discourse segment level and utterance, respectively).

1. **Continue Current Segment.** The \( C_f(s, U_{i-1}) \) is taken over for \( U_i \). If \( U_{i-1} \) and \( U_i \) indicate the end of a sequence in which a series of thematizations of themes have occurred, all embedded segments are lifted by the function \( \text{Lift} \) to a higher level \( s' \). As a result of lifting, the entire sequence (including the final two utterances) forms a single segment. This is trivially true for cases of a constant theme.

2. **Close Embedded Segment(s).**

(a) **Close the embedded segment(s) and continue another, already existing segment:** If \( U_i \) does not include any anaphoric expression which is an element of the \( C_f(s, U_{i-1}) \), then match the antecedent in the hierarchically reachable segments. Only the \( C_f \) of the utterance at the end point of any of these segments is considered a potential antecedent. Note that, as a side effect, hierarchically lower segments are ultimately closed when a match at higher segment levels succeeds.

(b) **Close the embedded segment and open a new, parallel one:** If none of the anaphoric expressions under consideration co-specify the
3. Open New, Embedded Segment. If none of the above cases applies, then for utterance \(U_i\) a new, embedded segment is opened. In the course of processing the following utterances, this decision may be retracted by the function \(\text{Lift}\). It serves as a kind of “garbage collector” for globally insignificant discourse segments which, nevertheless, were reasonable from a local perspective for reference resolution purposes. Hence, the centered discourse segmentation procedure works in an incremental way and revises only locally relevant, yet globally irrelevant segmentation decisions on the fly.

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The computation starts at \(U_1\), the headline. The \(C_f(U_1)\) is set to “1260” which is meant as an abbreviation of “Brother HL-1260”. Upon initialization, the beginning as well as the ending of the initial discourse segment are both set to “1”. \(U_2\) and \(U_3\) simply continue this segment (block (1) of the algorithm), so \(\text{Lift}\) does not apply. The \(C_f\) is set to “1260” in all utterances of this segment. Since \(U_4\) does neither contain any anaphoric expression which co-specifies the \(C_p(1, U_3)\) (block (1)) nor any other element of the \(C_f(1, U_3)\) (block (2a)), and as there is no hierarchically preceding segment, block (2c) applies. The segment counter \(s\) is incremented and a new segment at level 2 is opened, setting the beginning and the ending to “4”. The phrase “das dünne Handbuclein” (the thin leaflet) in \(U_5\) does not co-specify the \(C_p(2, U_4)\) but co-specifies an element of the \(C_f(2, U_4)\) instead (viz. “Handbuch” (manual)). Hence, block (3) of the algorithm applies, leading to the creation of a new segment at level 3. The anaphoric “Handbuch” (manual) in \(U_6\) co-specifies the \(C_p(3, U_3)\). Hence block (1) applies (the occurrence of “1260” in \(C_f(U_3)\) is due to the assumptions specified by Strube & Hahn (1996)). Given this configuration, the function \(\text{Lift}\) lifts the embedded segment one level, so the
segment which ended with $U_4$ is now continued up to $U_6$ at level 2. As a consequence, the centering data of $U_5$ are excluded from further consideration as far as the co-specification by any subsequent anaphoric expression is concerned. $U_7$ simply continues the same segment, since the textual ellipsis "Seite" (page) refers to "Handbuch" (manual). The utterances $U_8$ to $U_{10}$ exhibit a typical thematicization-of-the-themes pattern which is quite common for the detailed description of objects. (Note the sequence of SHIFT transitions.) Hence, block (3) of the algorithm applies to each of the utterances and, correspondingly, new segments at the levels 3 to 5 are created. This behavior breaks down at the occurrence of the anaphoric expression "sie" (it) in $U_{11}$ which co-specifies the $C_p$ of the utterance which represents the end of the hierarchically preceding discourse segment ($U_7$), but it co-specifies an element of the $C_f(2, U_7)$. The immediately preceding segment is ultimately closed and a parallel segment is opened at $U_{12}$ (cf. block (2b)). Note also that the algorithm does not check the $C_f(3, U_{10})$ despite the fact that it contains the antecedent of "1260". However, the occurrences of "1260" in the $C_f$ of $U_9$ and $U_{10}$ are mediated by textual ellipses. If these utterances contained the expression "1260" itself, the algorithm would have built a different discourse structure and, therefore, "1260" in $U_{10}$ were reachable for the anaphor in $U_{12}$. Segment 3, finally, is continued by $U_{13}$.

Table 7: Sample Text

| (1) | Brother HL-1260 |
| (2) | Ein Detail fällt schon beim ersten Umgang mit dem großen Brother auf: One particular - is already noticed - in the first approach to the big Brother. |
| (3) | Im Betrieb macht er durch ein kräftiges Arbeitsgeräusch auf sich aufmerksam, das auch im Stand-by-Modus noch gut vernehmbar ist. In operation - draws - it - with a heavy noise level - attention to itself - which - also - in the stand-by mode - is still well audible. |
| (4) | Für Standard-Installationen kommt man gut ohne Handbuch aus. As far as standard installations are concerned - gets - one - well - by - without any manual. |
| (5) | Zwar erläutert das dünne Handbüchlein die Bedienung der Hardware anschaulich und gut illustriert. Admittedly, gives - the thin leaflet - the operation of the hardware - a clear description of - and - well illustrated. |
| (6) | Die Software-Seite wurde im Handbuch dagegen stiefmütterlich behandelt: The software part - was - in the manual - however - like a stepmother - treated: |
| (7) | bis auf eine karge Seite mit einem Inhaltsverzeichnis zum HP-Modus sucht man vergebens weitere Informationen, except for one meagre page - containing the table of contents for the HP mode - seeks - one - in vain - for further information. |
| (8) | Kein Wunder: unter dem Inhaltsverzeichnis steht der lapidare Hinweis, man möge sich die Seiten dieses Kapitels doch bitte von Diskette ausdrucken - Frechheit. No wonder: beneath the table of contents - one finds the terse instruction, one should - oneself - the pages of this section - please - from disk - print out - -- impertinence. |
| (9) | Ohne diesen Ausdruck sucht man vergebens nach einem Hinweis darauf, warum die Auto-Continue-Funktion in der PostScript-Emulation nicht wirkt. Without this print-out, looks - one - in vain - for a hint - why - the auto-continue-function - in the PostScript emulation - does not work. |
| (10) | Nach dem Einschalten zeigt das LC-Display an, daß diese praktische Hilfsfunktion nicht aktiv ist; After switching on - depicts - the LC display - that - this practical help function - not active - is; |
| (11) | sie überwacht den Dateiendtransfers vom Computer. it monitors the file transfer from the computer. |
| (12) | Viele der kleinen Macken verzieht man dem HL-1260 wenn man erste Ausdrucke in Händen hält. Many of the minor defects - pardons - one - the HL-1260, when - one - the first print outs - holds in [one's] hands. |
| (13) | Gerasterte Grauflächen erzeugt der Brother sehr homogen ... Raster-mode grey-scale areas - generates - the Brother - very homogeneously ... |

5 Empirical Evaluation

In this section, we present some empirical data concerning the centered segmentation algorithm. Our study was based on the analysis of twelve texts from the information technology domain (IT), of one text from a Ger-
man news magazine (Spiegel), and of two literary texts (Lit). Table 9 summarizes the total numbers of anaphors, textual ellipses, utterances, and words in the test set.

Table 8: Sample of a Centered Text Segmentation Analysis

Table 9: Test Set

Table 10 and Table 11 consider the number of anaphoric and text-elliptical expressions, respectively, and the linear distance they have to their corresponding antecedents. Note that common centering algorithms (e.g., the one by Brennan et al. (1987)) are specified only for the resolution of anaphors in \( U_{i-1} \). They are neither specified for anaphoric antecedents in \( U_i \), nor an issue here, nor for anaphoric antecedents beyond \( U_{i-1} \). In the test set, 139 anaphors (28%) and 116 textual ellipses (48.3%) fall out of the (intersentential) scope of those common algorithms. So, the problem we consider is not a marginal one.

Table 10: Anaphoric Antecedent in Utterance \( U_x \)

Table 12 and Table 13 give the success rate of the centered segmentation algorithm for anaphors and textual ellipses, respectively. The numbers in these tables indicate at which segment level anaphors and textual ellipses were correctly resolved. The category of errors

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3Japan – Der Neue der alten Garde. In Der Spiegel, Nr. 3, 1996.

4The first two chapters of a short story by the German writer Heiner Müller (Liebesgeschichte. In Heiner Müller. Geschichten aus der Produktion 2. Berlin: Rotbuch Verlag, 1974, pp. 57-63) and the first chapter of a novel by Uwe Johnson (Zwei Ansichten. Frankfurt/Main: Suhrkamp Verlag, 1965.)
covers erroneous analyses the algorithm produces, while the one for false positives concerns those resolution results where a referential expression was resolved with the hierarchically most recent antecedent but not with the linearly most recent (obviously, the targeted) one (both of them denote the same discourse entity). The categories $C_f(s, U_{i-1})$ in Tables 12 and 13 contain more elements than the categories $U_{i-1}$ in Tables 10 and 11, respectively, due to the mediating property of textual ellipses in functional centering (Strube & Hahn, 1996).

| $U_{i-1}$ | IT  | Spiegel | Lit | $\Sigma$ |
|-----------|-----|---------|-----|---------|
|           | 94  | 15      | 15  | 124     |
| $U_{i-2}$ | 62  | 8       | 8   | 78      |
| $U_{i-3}$ | 16  | 0       | 0   | 16      |
| $U_{i-4}$ | 14  | 0       | 0   | 14      |
| $U_{i-5}$ | 8   | 0       | 0   | 8       |
| $U_{i-6}$ to $U_{i-10}$ | 14 | 1 | 0 | 15 |
| $U_{i-11}$ to $U_{i-15}$ | 7  | 0 | 0 | 7 |

Table 11: Elliptical Antecedent in Utterance $U_i$

The centered segmentation algorithm reveals a pretty good performance. This is to some extent implied by the structural patterns we find in expository texts, viz. their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text). In contrast, the literary texts in the test exhibited their single-theme property (e.g., "1260" in the sample text).

There has always been an implicit relationship between the local perspective of centering and the global view of focusing on discourse structure (cf. the discussion in Grosz et al. (1995)). However, work establishing an explicit account of how both can be joined in a computational model has not been done so far. The efforts of Sidner (1983), e.g., have provided a variety of different focus data structures to be used for reference resolution. This multiplicity and the on-going growth of the number of different entities (cf. Suri & McCoy (1994)) mirrors an increase in explanatory constructs that we consider a methodological drawback to this approach because they can hardly be kept control of. Our model, due to its hierarchical nature implements a stack behavior that is also inherent to the above mentioned proposals. We refrain, however, from establishing a new data type (even worse, different types of stacks) that has to be managed on its own. There is no need for extra computations to determine the "segment focus", since that is implicitly given in the local centering data already available in our model.

A recent attempt at introducing global discourse notions into the centering framework considers the use of a cache model (Walker, 1996b). This introduces an additional data type with its own management principles for data storage, retrieval and update. While our proposal for centered discourse segmentation also requires a data structure of its own, it is better integrated into centering than the caching model, since the cells of segment structures simply contain "pointers" that implement a direct link to the original centering data. Hence, we avoid extra operations related to feeding and updating the cache. The relation between our centered segmentation algorithm and Walker’s (1996a) integration of centering into the cache model can be viewed from two different angles. On the one hand, centered segmentation may be a part of the cache model, since it provides an elaborate, non-linear ordering of the elements within the cache. On the other hand, centered segmentation may replace the
7 Conclusions

We have developed a proposal for extending the centering model to incorporate the global referential structure of discourse for reference resolution. The hierarchy of discourse segments we compute realizes certain constraints on the reachability of antecedents. Moreover, the claim is made that the hierarchy of discourse segments implements an intuitive notion of the limited attention constraint, as we avoid a simplistic, cognitively implausible linear backward search for potential antecedents. Since we operate within a functional framework, this study also presents one of the rare formal accounts of structural regularities at deeper levels of investigation illustrated by access mechanisms for centering data at different levels of discourse segmentation.

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