Temporal Structure on Discourse Level within the Controlled Information Packaging Theory[1]

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Abstract

The temporal structure of events on the discourse level has long been of great interest in both theoretical and computational linguistics. In this paper, we offer a unified approach to the temporal relationships related to a hierarchical discourse structure. We apply the method of pronoun resolution to the interpretation of tense. It is based on an analysis within the framework of the controlled information packaging theory. A unique aspect of our account is that temporal interpretation across discourse segments in global discourse is subject to the same principles as the interpretation of global anaphora, and that there is thus no need to postulate independent principles to account for the discourse behaviour of tense. In this way, we can neatly explain the general view that tense parallels the anaphoric nature of pronouns.

1 Introduction

This paper aims to show how to represent temporal structures in English within the framework of the Controlled Information Packaging Theory (for short, CIPT). The CIPT has been developed as a new approach to describe semantic relations on the discourse level. Recent works on the tense structure of discourse have tried to determine the temporal relationship between events described in successive sentences in narrative discourse (Thompson 1999:123). This study explores temporal relations on discourse level, too.

In natural language, the temporal information is conveyed in various ways; namely, by means of grammatical devices or categories like tense, temporal adverbs, nouns, adjectives, and conjunctions. In actual utterances, the use of tense is supposed to be closely related to the discourse structure. However, it has not been fully understood how this interaction takes place. In this paper we will explore how the discourse structure influences the interpretation of tense on the level of global discourse like the following (Webber 1988: 69):

(1) a. John went into the florist shop.
b. He had promised Mary some flowers.
c. She said she wouldn't forgive him if he forgot.
d. So he picked out three red roses, two white ones, and one pale pink.

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In the discourse, sentences (1b)-(1c) constitute a sub-discourse, but here the main discourse, started at (1a), is continued at (1d).

On the base of this study, we will show how to represent temporal relations of events within the CIPT. This paper extends the previous work, which used d-command constraint proposed as a means for resolving anaphora, and proposes the principle of temporal d-command in order to explain the behaviour of tense on the global discourse level.

2 Related Works

2.1 Kamp and Reyle (1993)

Within DRT, Kamp and Reyle try to represent the temporal structures of a natural language discourse. Their approach is based on the assumption that events and states are ontological primitives. Sentences are supposed to describe either events or states. Every initial sentence of a discourse introduces a reference point in the sense of Reichenbach (1947). If a sentence follows another one, then the temporal relation between the two eventualities depends on whether it describes an event or a state. In case the second sentence describes an event, its eventuality follows the reference point of the preceding sentence. On the other hand, in case the second sentence describes a state, its eventuality always includes the reference point of the preceding sentence. The following example shows how this approach works (Kamp and Reyle 1993:521):

(2) a. A man entered the White Hart.
b. He was wearing a black jacket.
c. Bill served him a beer.

In the first sentence, a reference point is introduced. It precedes the utterance time, because the past tense is used. The second sentence describes a state. Therefore, its eventuality includes the reference point of the first one and it doesn't revise the reference point. The third sentence describes an event again and it's eventuality follows the reference point of the first sentence. The new event described here revises the reference point. The serving event becomes now the new reference point.

To sum up, non-initial sentences without temporal adverbs, need a contextually informed reference point to determine the location of the eventualities they describe (Kamp and Reyle 1993:529). However, when a non-initial sentence does contain a temporal adverb, then it is the adverb which will supply the location. The adverbs can override the effect of the antecedent context, as the following discourse exemplifies.

(3) a. Fred arrived on the first of January.
b. It was raining continuously.
c. But the next day the sun was shining.

The first sentence introduces Fred's arrival as the reference point that is located at the first of January. The second sentence describes a state and it doesn't revise the reference point. The state described by the third sentence is considered to be located at the time designated by the adverb "the next day".

Kamp and Reyle maintain that their basic scheme need to be revised to deal with the so-called *extended flashbacks* such as example (4) (Kamp/Reyle 1993: 594):

(4) a. Fred arrived at 10.
b. He had got up at 5; he had taken a long shower, had got dressed and had eaten a leisurely breakfast.
c. He had left the house at 6:30.

According to Kamp and Reyle, all the past perfect clauses of (4) use the arrival time as their "point of reference" in the sense of Reichenbach. However, they form a narrative progression much like the sequences such as (3). It means that the "point of reference" of the second past perfect clause in (4b) is related not only to the arrival time described in clause (4a) but also to the getting-up time described in the first past perfect clause. In this context, they believe that there are two distinct notions of "point of reference".

For the purpose of describing the temporal structures of a natural language discourse, Kamp and Reyle introduce a new term "temporal perspective point (TPpt)" that has a distinct function from the "reference point (Rpt)". The former corresponds to the original notion of "point of reference" of Reichenbach. The latter is used to describe the narrative progression. Based on this observation, Kamp and Reyle propose a revised theory on the tense interpretation. A described situation is first related to a time of location, this time of location is related to a temporal perspective point, and it is this perspective point which is related to the utterance situation (van Eynde 1998: 243). Along this line of description, the present tense is characterized by the relation pair <TPpt coincides with utterance time; described eventuality overlaps with TPpt> and the past tense corresponds to the pair <TPpt before utterance time; described eventuality overlaps with TPpt>.

In our opinion, Kamp and Reyle's approach is complicated and does not seem to be very convincing, because they assume an additional notion of the "reference point" besides the three notions corresponding to the Reichenbach's framework. Furthermore, they don't explain, how this notion would possibly be related to the others. As an alternative, we present a reasonable account in section 4 within the framework of CIPT.

2.2 Kameyama et al. (1993)

Kameyama, Passonneau, and Poesio suppose that it is possible to establish a direct analogy between centering and temporal centering. They illustrate the temporal centering of the example (5) as follows:

a. John went over (t1) to Mary's house.
TCf1=[r1] *TCb1*=NULL
b. On the way, he had (t2) stopped (t3)
by the flower shop for some roses.
TCf2=[r2=r1, r3] *TCb2*=r1
c. He picked out (t4) 5 red ones, 3 white ones, and 1 pale pink.
TCf3=[r4=r3] *TCb3*=r3
TCb-establishment

[**Abbr.:** *TCf* = forward-looking temporal center,
TCb = backward-looking temporal center]

Figure 1: Illustration of Temporal Centering

(5) a. John went over to Mary's house.

b. On the way, he had stopped by the flower shop for some roses.
c. He picked out 5 red ones, 3 white ones, and 1 pale pink.

As shown in Figure 1, utterances (5a) and (5b) are supposed to share the same discourse reference time r1 that connects t2 with t1. The shared discourse reference time r1 is now postulated as a backward-looking temporal center (TCb). In (5c), a new TCb links t4 to t3. Therefore, the TCb-establishment occurs in (5c). The notion TCb here, however, should be regarded as different from the *reference time* as used in Reichenbach(1947) or in Hinrichs(1986), as noted in Kameyama et al. The reason is that if (5c) retains the "same" TCb, this TCb cannot be identical to either t2 of (2b) or t4 of (2c), since t2 and t4 are distinct (t1=t2, t2 < t4).

3 The Framework: CIPT

In this section, we will discuss the two characteristics of the Controlled Information Packaging Theory (CIPT). The CIPT is distinguished from Vallduvi's Information Packaging Theory in two respects (Lee and Lee 2000a).

First, in our CIPT we postulate the fifth information structure, namely SL(slot-link)-F(focus) structure. Second, our CIPT assumes a center controlling file card that includes information about the discourse structure and ordinary file cards. A center controlling card is assumed to have the structure depicted in (6).

(6) A Center Controlling Card (CCC)

Card Number
The set of discourse referents on the same level
Forward-looking center list of the immediately previous utterance
Hyper link with the center controlling card of the immediately higher level
Hyper link with the center controlling card of the immediately lower level

With the center controlling card, we also have to assume that the ordinary file card must have information about the discourse level to which it belongs. Accordingly, we assume that an ordinary file card has the structure given in (7).

(7) An Ordinary File Card

Card Number
Special information about the discourse objects

Hyper link with the center controlling card of the same discourse level

This idea of the center controlling card enables us to deal with the anaphor in global discourses.

Considering the search of the antecedent of pronouns appearing in the global dialogue, we proposed the discourse command constraint as in (8) (Lee and Lee 2000a).

(8) **Discourse command constraint**

In a discourse the antecedent of a pronoun must be able to discourse command the pronoun.

The discourse command (d-command) is defined as in (9).

(9) **Discourse command**

In a discourse, an expression A *discourse commands* an expression B iff one of the following is satisfied:

(i) A and B belong to the same level of the dialogue.

(ii) B belongs to the level of dialogue lower than the level of dialogue to which A belongs.

Let us now see how the discourse command constraint is used to predict the antecedent of a pronoun on the global discourse level. Consider an example.

(10)

U1: E: So you have the engine assembly finished.
Now attach the rope to the top of the engine.

<Sub-dialogue>
By the way, did you buy gasoline today?
U2: A: Yes, I got some when I bought the new lawn mower wheel.
I forgot to take my gas can with me, so I bought a new one.
U3: E: Did it cost much?
U4: A: No, and I could use another anyway to keep with the tractor.
</Sub-dialogue>

U5: E: OK.
U6: Have you got it attached yet?

According to the discourse command constraint, the antecedent of a pronoun must be sought in the current or higher level of dialogue. In this dialogue the pronoun 'it' in U6 has the nominal phrase 'the rope' of U1 as its antecedent. This can be predicted by the discourse command constraint.

4 A New Account: the principle of temporal d-command

Now we will show how to represent temporal relations of events within the CIPT. In order to explain the behaviour of tense on the global discourse level, we propose the principle of temporal d-command as a means for resolving temporal anaphor.

In order to talk about the parallel between anaphor and tense as well as the analogy between centering and temporal centering, we have to, beforehand, clarify which temporal entity has an

anaphoric property. Concerning this question, it certainly is the classical notion "point of reference" of Reichenbach that has the anaphoric property, we suppose. However the notion itself has two different discourse functions, as pointed out by Kamp and Reyle as well as by Kameyama et al. (1993: 73). We fully agree to this viewpoint, but we'd like to propose a different kind of solution. As mentioned earlier, the notion of the "point of reference" of Reichenbach has two kinds of distinct functions in alliance with Kamp and the others.

Regarding the question "what kind of function it has," however, we don't share with them. We think that it is related to the "point of event" on the utterance level, and that it indicates a temporal orientation on the discourse segment level. To avoid any undesirable confusion, we are going to introduce a new term "temporal anaphor (At)" for the use of the term "point of reference" on the utterance level and another new term "temporal discourse center (DCt)" for the use of the term "point of reference" on the discourse segment level. The temporal anaphor is regarded as an orientation to the temporal relation. Furthermore, we assume that exactly one "temporal anaphor" is assigned to an utterance, and the "temporal discourse center" changes dynamically.

Based on these considerations, we will show how the temporal relations of the following discourse is described (Hwang and Schubert 1992).

(11) a. John and Mary went to buy a lawnmower.
b. Somebody had stolen theirs the day before.
c. They had seen the thief go away.
d. John had run after him to no avail.
e. All the lawnmowers were too expensive.
f. They decided they couldn't afford a new one.

The Figure 2. below illustrates the temporal flow of the discourse:

a. John and Mary went (t1) to buy a lawnmower.
DCt1=NULL, *Ept1*=t1, *At1=NULL*
b. Somebody had stolen (t2) theirs the day before.
DCt1=t1, *Ept2*=t2, *At2*=t1
c. They had seen (t3) the thief go away.
DCt1=t1, *DCt2*=t2, *Ept3*=t3, *At3*=t2, t1
d. John had run after (t4) him to no avail.
DCt1=t1, *DCt2*=t3, *Ept4*=t4, *At4*=t3, t1
e. All the lawnmowers were (t5) too expensive.
DCt1=t1, *Ept5*=t5, *At5*=t1
f. They decided (t6) they couldn't afford a new one.
DCt1=t1, *Ept6*=t6, *At6*=t1

[**Abbr.:** *DCt* = temporal discourse center,
At = temporal anaphor,
Ept = point of event]

Figure 2: Illustration of Temporal Flow

For instance, the "point of event" of the utterance (11c) is supposed to be related with the "point of event" of the utterance (11a) on the one hand and with the "point of event" of the utterance (11b) on the other. This fact can be predicted if we assume that the "point of event" of the utterance (11c) follows the "temporal discourse center" of immediate higher discourse level as well as the "temporal discourse center" of current discourse level, i.e. the "point of event" of the utterance (11b). The former relation is based on the use of the past perfect and the latter based on a default rule that holds between two

sequences of events, proposed by Kamp and Reyle. According to the default rule, when two consecutive utterances both describe events, the event described by the first utterance precedes the event described by the second one, if no causal connection can be found. In order to take into account the fact that the "temporal anaphor" of an utterance can be linked to both the "temporal discourse center" of immediate higher discourse level and the "temporal discourse center" of current discourse level, we need to establish the following principle:

(12) **The principle of temporal d-command**

In a discourse, the temporal anaphor must be d-commanded by a temporal discourse center.

Now we revise the structure of the center controlling card (CCC), in order to integrate the above principle into the CIPT. At least, a CCC has to contain the information about the temporal discourse center as follows:

(13)

Card Number
The set of discourse referents on the same level
Forward-looking center list of the immediately previous utterance
temporal discourse center
Hyper link with the center controlling card of the immediately higher level
Hyper link with the center controlling card of the immediately lower level

Furthermore, an ordinary object card describing an event or a state should look like the scheme (14):

(14)

Card Number
Special information about the discourse objects *temporal anaphor*: *point of event*: *point of utterance*:
Hyper link with the center controlling card of the same discourse level

The novel aspect of the eventuality card is that it has information about the temporal anaphor, the point of event, and the point of utterance.

Now we are going to show how the CIPT works. After the analysis of the utterance (11a), we would have the following cards, one CCC (15a), three object cards (15b)-(15d) and one eventuality card (15e):

(15) a.

1
11, 12, 13, 14
[11,12,13,14]
tl
NULL
NULL

b.

11
John(11)
→ 1

c.

12
Mary(12)
→ 1

d.

13
lawnmower(13)
→ 1

e.

14

go_to_buy(11+12,13) *temporal anaphor*: null *point of event*: "t1" *point of utterance*: 3:15:30-34
→ 1

As represented in (15a), the CCC contains no information on its fifth and sixth column, because a new discourse unit has just begun with (11a). The CCC has the information that the previous utterance has 4 forward-looking centers, namely "John", "Mary", "lawnmower" and the event of going_to_buy. The ordinary cards (15b)-(15e) have the common information that their CCC is the card 1. The eventuality card (15e) contains the information that the temporal anaphor is "null". The reason is that "temporal discourse center" at the moment of constructing the eventuality card is "null" contrary to the information of the updated (15a). The CCC that is constructed immediately after processing the utterance (11a) has "t1" that is the same as its "point of event" as "temporal discourse center". As the next step, we would get the following cards after processing the utterance (11)(b):

(16) a.

2
15, 13,16
[15,13,16]
"t2"
→ 1
NULL

b.

15
unspecified_person(15)
→ 2

c.

16

steal(15,13) *temporal anaphor*: t1 *point of event*: "t2" *point of utterance*: 3:15:40-45
→ 2

As shown in (16a), the CCC has the information that the previous utterance has 3 forward-looking centers, namely "somebody", "lawnmower" introduced in (11a), and the event of stealing. On the fifth column, the CCC has the information that its immediate higher level is the level about which the CCC "1" has relevant information. The ordinary eventuality card (16c) has the information that the "temporal anaphor" of the stealing event is "t1" following the principle of temporal d-command. The reason is that "t1" is the unique temporal discourse center of the current or higher level. Immediately after processing the utterance (11b), the CCC has "t2" as "temporal discourse center". Using the same methodology, we would have the following cards, one CCC (17a) and one ordinary card (17b), after we have analysed the utterance (11f):

(17) a.

1
11, 12, 13, 14, 25, 26, 27, 28
[11, 12, 27, 28]
"t1"
NULL
→ 2

b.

28
decide(11+12, 27) *temporal anaphor*: "t1" *point of event*: "t6" *point of utterance*: 3:20:30-34
→ 1

By means of the information on the cards, we can resolve the temporal anaphor "At6". According to the principle of temporal d-command, the "temporal discourse center" of the immediate higher discourse level and the "temporal discourse center" of the current discourse level have to be the antecedent of the temporal anaphor "t6". Because there exists only one "temporal discourse center" of the current discourse level, "t1", it must be the antecedent. But there is no "temporal discourse center"

of the immediate higher discourse level, because the discourse level 1 to which the utterance (11f) belongs is the highest discourse level.

5 Conclusion

A number of factors affect the interpretation as to whether successive past tenses are anaphorically related, and if they are, what the relative order of the associated events is. The determinant factors have been argued to be discourse structure, aspectual type, surface structure, and common sense knowledge (Kameyama et al. 1993). Among these factors, we have mainly discussed the discourse structure in this paper.

We have argued that the choice of the antecedent of a temporal anaphor is subject to the principle of temporal d-command. Furthermore, we showed how the temporal relations of a global discourse can be neatly described within the framework of the CIPT.

There remains a problem: namely, how to fully integrate other factors, such as aspectual type and world knowledge into the framework of the CIPT.

References

van Eynde, F. 1998. Tense, Aspect & Negation. In: F. van Eynde / P. Schmidt (eds.) *Linguistic Specifications for Typed Feature Structure Formalisms.* European Commission.

Hinrichs, E. W. 1986. Temporal Anaphora in Discourses of English. *Linguistics and Philosophy* 9: 63-82.

Hitzeman, J. and M. Moens, and C. Grover 1995. Algorithms for analysing the temporal structure of discourse. *Proceedings of the 7th Conference of the European Chapter of the Association for Computational Linguistics:* 253-260.

Hwang, Chung Hee and L. K. Schubert 1992. Tense trees as the 'fine structure' of discourse. *Proceedings of the 30th ACL:* 232-240.

Kameyama, M. and R. Passonneau and M. Poesio 1993. Temporal centering. *Proceedings of the 31st Annual Meeting of the Association of Computational Linguistics,* (Columbus, Ohio): 70-77, ACL, June 1993.

Kamp, H. and U. Reyle. 1993. *From Discourse to Logic.* Dordrecht: Kluwer.

Lee, Ik-Hwan and Minhaeng Lee 2000a. On the Discourse Analysis in Korean Dialogues. *Proceedings in PACLIC14:* 207-218.

Lee, Ik-Hwan and Minhaeng Lee 2000b. Anaphora Resolution and Discourse Structure: A Controlled Information Packaging Approach. In: *Language and Information* 4(1): 67-82.

Partee, B. 1984. Nominal and Temporal Anaphora. *Linguistics and Philosophy* 3: 243-286.

Reichenbach, H. 1947. *Elements of Symbolic Logic.* New York: Macmill.

Thompson, E. 1998. The temporal structure of discourse: the syntax and semantics of temporal *then. Natural Language and Linguistic Theory* 17: 123-160.

Vallduvi, E. 1994. The Dynamics of Information Packaging. E. Engdahl, ed., *Integrating Information Structure into Constraint-Based Categorial Approaches:* 4-26. HCRC Publications, University of Edinburgh.

Webber, B.L. 1988. Tense as Discourse Anaphor. *Computational Linguistics* 14: 61-73.