A Computational Treatment of Korean Temporal Markers,

OE and *DONGAN*

Hyunjung Son
EHESS
54, Boulevard Raspail
75006 Paris France
hyunjung_son@hotmail.com

Abstract

In this paper, we elucidate how Korean temporal markers, *OE* and *DONGAN* contribute to specifying the event time and formalize it in terms of typed lambda calculus. We also present a computational method for constructing temporal representation of Korean sentences on the basis of G grammar proposed by [Renaud, 1992;1996].

1 Introduction

Associated to a NP, Korean temporal markers *OE* and *DONGAN* build time adverbials.

(1) *ach'im ilgopshiOE*
morning/seven o'clock-*OE*
at seven o'clock in the morning

(2) *han shigan DONGAN*
one/hour/*DONGAN*
for an hour

As it is widely known, time adverbials play important roles in sentence meaning processing. Meanwhile, there is a significant divergence in opinions whether time adverbials or tense/aspect is a more efficient indicator leading to a correct temporal representation of sentences. To some [Kim, 1981], [Jo, 2000], [Vet, 1980], [Verkyul, 1989], tense or aspect is the only credible index to consult in establishing temporal interpretation, and the time adverbials are complementary. To others [Renaud, 1996], [Vlach, 1993], time adverbials are regarded as much more reliable than tense/aspect which is too ambiguous to provide coherent instructions about how to locate the event in time. We agree with the second point of view, as we observed that Korean tense markers fail to provide a solid and coherent way to capture the relevant time span. For example, the verbal infix '-*at*-', generally considered as a typical past tense marker in Korean, brings about several time interpretation possibilities such as simple past (3), completion (4), resultant state (5) and progressiveness (6).

(3) *shiwidaega ôje hanshiOE shich'ôngul dulrôssatta*
demonstrators-NOM / yesterday /one o'clock-*OE* / the city hall-ACC/ surround-PA-DEC[1]
The demonstrators surrounded the city hall at one o'clock yesterday.

(4) *shiwidaega mach'imnae shich'ôngul dulrôssatta*
demonstrators-NOM / at last / the city hall-ACC /surround-PA-DEC
At last, the demonstrators surrounded (succeeded in surrounding) the city hall.

(5) *shiwidaega harudongan shich'ôngul dulrôssatta*
demonstrators-NOM/one day-DUR/the city hall-ACC/surround-PA-DEC
The demonstrators have surrounded the city hall for one day.

---

[1] We used the McCune-Reischauer system to transcribe the Korean data. For glossing grammatical morphemes, we use the following abbreviations:
ACC: accusative, AS: attributive suffix, CIRCUM: circumstantial, CL: classifier, DEC: declarative, DUR: durative, INT: interrogative, LOC: locative, NOM: nominative, NS: nominal suffix, PA: past, TOP:topic.

(6)　*ônjebutô*　　*shiwidaega*　　*shich'ôngul dulrôssatssumnikka?*

since when/ demonstrators-NOM/ the city hall-ACC/ surround-PA-INT

Since when have the demonstrators been surrounding the city hall?

Moreover, what triggers these interpretation possibilities is still being discussed among Korean linguists[2].

In the following, we attempt to show how time adverbials can remedy this shortcoming and specify the event time.

2　Semantic description

The assumption underlying our temporal description is that the linguistic time is ordered, discrete, infinite and consisting of instants corresponding to the natural numbers. The linguistic time can be expressed with one of these three notions: instant, extended interval and duration. Instants are unitary constituents of linguistic time and noted by a quintuplet of natural numbers [x1,x2,x3,x4,x5] of which x1 stands for year, x2 for month, x3 for day, x4 for hour and x5 for minute.

(ex) at 3 o'clock on April 5th 2003: instant
　　　　　　　　[2003,4,5,3,0]

An extended interval is a set of consecutive instants determined by a beginning instant and an ending instant.

(ex) on April 5th, 2003: interval
　　　[[2003, 4,5,0,0], [2003,4,5,23,59]]

A duration refers to a temporal distance between two distinct instants.

(ex) for 5 years: duration　　　[5,_,_,_,_]

For the purpose of temporal description of a sentential event, we defined the following types and functional terms on the basis of typed lambda calculus[3]. The symbol λ stands for abstraction and • stands for application[4].

Definitions of types

i : type symbol denoting the type of individuals
p : type symbol denoting the type of propositions
e : type symbol denoting the type of events
ent: type symbol denoting the type of natural numbers
inst : type symbol denoting the type of instants
inter : type symbol denoting the type of extended intervals
dur: type symbol denoting the type of durations

Type symbols may be omitted when no ambiguity is introduced.

Definitions of functional terms

(λe. moment•e): e→inst
　Applying this function to any argument of type *e*, we obtain the moment of e of type *inst*.

(λe. interv•e): e→inter
　Applying this function to any argument of type *e*, we obtain the interval of e of type *inter*.

(λx. beginning•x): e→inst
(λx. ending•x): e→inst
　Applying these functions to any argument x of type *e*, we obtain the beginning/ending instant of x of type *inst*.

(λx. duration•x): e→dur
　Applying this function to any argument x of type *e*, we obtain the duration of x of type *dur*.

(λx. beg•x): inter→inst
(λx. end•x):inter→inst
　Applying this function to any argument x of type *inter*, we obtain the beginning/ending instant of x of type *inst*. By definition, beg•[A,B] = A and end•[A,B] = B

---

[2] See [Jo, 2000], [Lee, Ch., 1987], [Lee, H., 1993] and [Lee, J., 1982] for more detailed discussion.

[3] [Andrews, 1986 ; 2002], [Hindley et al., 1986] and [Renaud, 1996].
[4] If M and N are lambda-terms, then M•N is a lambda-term.

(λx. length•x): inter→dur

Applying this function to any argument x of type *inter*, we obtain the length of x of type *dur*. By definition, length•[A,B]= |B-A|

(λxλy. x <《t》 y): inst→inst→p

It denotes that x of type *inst* is anterior to y of the same type. When no ambiguity is introduced, «t» will be omitted.

(λxλy. x =《t》 y): inst→inst→p

It denotes that x and y of type *inst* are simultaneous.

(λxλy. x ≤《t》 y): inst→inst→p

It denotes that λxλy. (x <《t》y ∨ x =《t》y).

(λxλy. x ∈ 《t》 y): inst→inter→p

It denotes that x of type *inst* is a member of y of type *inter*. By definition, λxλy. (beg•y ≤ x ≤ end•y)

(λxλy. x ⊂《t 》 y): inter→inter→p

It denotes that x of type *inter* is included by y of the same type. By definition, λxλy. (beg•y < beg•x ∧ end•x < end•y).

(λxλy. x =《t 》 y): inter→inter→p

x and y of type *inter* are simultaneous. By definition, λxλy. (beg•x=beg•y ∧ end•x=end•y).

(λxλy. x ⊆《t 》 y): inter→inter→p

It denotes that λxλy. (beg•y ≤ beg•x ∧ end•x ≤ end•y).

The temporal adverbials with *OE* or *DONGAN* do not bring the same semantic constraints in all the sentences. It can be illustrated by the following examples of *OE* (7-10) and *DONGAN* (11-14).

(7) *ach'im ilgopshiOE nurôngoiga chugôtta.*
the morning /seven o'clock-*OE* / *Nurôngoi*-NOM /die-PA-DEC
At seven o'clock in the morning, *Nurôngoi* died.

The *OE* adverbial of this example indicates the moment when the event described by the nuclear sentence[5] happened.

(sr 7) ∃e∃I die•e•nurôngoi[6] ∧
        moment•e<pt_speech ∧
        I=(7 o'clock) ∧ **moment•e=I**

But in (8) and (9), *OE* adverbials indicate an interval of which an instant is identified with the moment of the event.

(8) *samwol shiboirOE nurôngoiga chugôtta.*
March/the fifteenth-*OE* /*Nurôngoi*-NOM/die-PA-DEC
On the fifteenth of March, *Nurôngoi* died.

(sr 8) ∃e∃I die•e•nurôngi ∧ moment•e<pt_speech ∧ I=(the 15th of March) ∧ **moment•e∈I**

(9) *chinan yôrumOE nurôngoiga chugôtta*
the last summer-*OE*/ *Nurôngoi*-NOM/die-PA-DEC
Last summer, *Nurôngoi* died.

(sr 9) ∃e∃I die•e•nurôngi ∧ moment•e<pt_speech ∧ interval•I ∧ summer•I ∧ **moment•e∈I**

Moreover, *OE* adverbials can introduce a period of recurrent events as in (10).

(10) *iljuirOE so dasôt mariga chugôtta*
a week-*OE*/cow/five/classifier-NOM/die-PA-DEC
Five cows died **every week**.

(sr 10) ∃I interval•I ∧ length•I=(7 days) ∧ ∃J interval•J ∧ ∃*P* (equi-partition•I•*P*•J ∧∀K (*P*•K → |λx. cow•x ∧ ∃e die•e•x ∧ moment•e<pt_speech ∧ interv•e⊆K|=5))[7]

---

[5] We call the independent sentences without modifiers such as temporal adverbials 'nuclear sentence'.

[6] 'die•e•nurôngoi' is equivalent to die(e, nurôngoi) in predicate logic.

[7] [Renaud, 2002] defines the equi-partition function as:
equi-partition•D•*P*•N ≡ (N=(∪•*P*) ∧ | *P* |>2 ∧ ∀K1 K2 ((P•K1 ∧ P•K2 ∧ K1≠K2) → (length•K1=length•K2=D ∧ K1∩K2=∅)))
where ∪•*R* ≡ λx. ∃*R* (*R*•P ∧ P•x)

As for *DONGAN* adverbials, they present the maximal duration of the described event as in (11).

(11) *hanshigan **DONGAN** kwanghoe bihaenggiga naratta*
an hour **/DONGAN** /of *Kwangho* /airplane-NOM /fly-PA-DEC
Kwangho's airplane flew **for an hour**.

(sr 11) $\exists x \exists e$ airplane•x $\wedge$ of•*kwangho*•x $\wedge$
    fly•e•x $\wedge$ ending•e<pt_speech $\wedge$
    duration•e=(1 hour)

In (12), the interval denoted by the *DONGAN* adverbial is included by that of the sentential event. In other words, it is not clear, for the moment, whether the described event reached its end or not.

(12) *kyôul banghak **DONGAN** ukyunun mokgongsoesô ilhaetta*
winter vacation **/DONGAN** /*Ukyu*-TOP/carpenter's shop-LOC/work-PA-DEC
During the winter vacation, *Ukyu* worked at the carpenter's shop.

(sr 12) $\exists e \exists I$ work•e•ukyu $\wedge$ at•e•carpenter's_shop $\wedge$ beginning•e<pt_speech $\wedge$ interval•I $\wedge$ winter_vacation•I $\wedge$ **I⊆interv•e**

DONGAN adverbials also indicate the interval to which the moment of the event belongs, as (13) shows.

(13) *kyôul banghak **DONGAN** nanun shine daehae saenggak'agi chijak'aetta*
winter vacation / **DONGAN** / I-TOP/ about God/ think /begin-PA-DEC
During the winter vacation, I began to think about God.

(sr 13) $\exists I \exists e$ interval•I $\wedge$ winter_vacation•I $\wedge$ begin•e•($\lambda e1 \lambda x.$ think_about•e1•god•x)•speaker $\wedge$ moment•e<pt_speech $\wedge$ **moment•e∈I**

The following example (14) denotes that fishing of Yunsôk has been repeated in a regular way during the interval indicated by the *DONGAN* adverbial.

(14) *shimnyôn **DONGAN** yunsôkun môn badaesô kokijabirul haetta*

10 years /*DONGAN* /Yunsôk-TOP /far ocean-LOC /fishing-ACC/do-PA-DEC
For ten years, Yunsôk fished in the far ocean.

(sr 14) $\lambda D. \exists P$ equi-partition•D•P•int$_{ref}$ $\wedge$
$\exists H$ H=($\lambda J.$ (P•J $\wedge$ $\exists e$ fish•e•yunsôk $\wedge$ in•e•the_far_ocean $\wedge$ ending•e<pt_speech $\wedge$ interv•e⊆J) $\wedge$
$\exists M$ max•($\lambda N.$ N⊆(∪•H) $\wedge$ [inferior•(∪•N), superior•(∪•N)] $\cap$ int$_{ref}$ = ∪•N)•M $\wedge$ length•M = (10 years)[8]

Such a distributional pattern of events disappears when the nuclear sentence is modified by quantification, which is illustrated by (15).

(15) *shimnyôn **DONGAN** yunsôkun môn badaesô kokijabirul se bôn haetta*
10 years /*DONGAN* /Yunsôk-TOP /far ocean-LOC /fishing-ACC/three times/do-PA-DEC
For ten years, Yunsôk had fished in the far ocean three times.

(sr 15) $\exists I$ interval•I $\wedge$ length•I=(10 years) $\wedge$ |$\lambda e.$ fish•e•yunsôk $\wedge$ in•e•the_far_ocean $\wedge$ ending•e<pt_speech $\wedge$ interv•e⊆I|=3

To find a strategy to solve such a multiple ambiguity, we investigated three thousand sentences for each temporal marker [9] and discovered the following facts:

1. The semantic and syntactic properties of the phrase accompanying the temporal markers play an important role to locate the event in time.
2. It is necessary to distinguish mono-occurrent sentences concerning a single event from multi-occurrent sentences concerning a set of different events[10]. The multi-occurrent nature is very often

---

[8] [Renaud, 2002] defines the function used in this formula as follows:

int$_{ref}$ ≡ interval of reference

[∪•I] ≡ [inferior•(∪•I), superior•(∪•I)] where the brackets denote an interval.

max•E•M ≡ (E•M $\wedge$ ¬$\exists$N(M⊂N $\wedge$ E•N))

[9] We took the sentences from *Yonsei malmunchi* corpus built by *Yonsei* Center for Linguistic Information.

[10] [Renaud, 2002].

signaled by bare plurals in nominal phrases, adverb like *ch'arero* 'in turn', and quantification modifiers.

3. When it comes to the multi-occurrent sentences, *DONGAN* adverbials impose constraints on the distribution of events in some cases (see (14)).
4. The quantification negates the distributional meaning brought by *DONGAN* adverbials and gets them to indicate the temporal scope of this semantic operation (see (14) and (15)).
5. As for the verbal infix '-*at*-', its common semantic value is to denote the fact that the beginning of the event is anterior to the point of speech [11] ; λe. beginning•e < pt_speech.
6. The information relevant to the time interpretation is scattered over the whole sentence; in the verbal phrase, quantification modifiers ranging over individuals or events, determiners in the nominal phrases and time adverbials. Therefore, the temporal interpretation of a sentence should be constructed in a compositional way.
7. For the same reason, the aspectual value should be attributed to the nuclear sentence and not to the verbal phrase.

3 Computational implementation

We discovered that Renaud's G Grammar is suitable for the purpose of computational implementation of these facts. This grammar loads information on word definitions as little as possible and charges the rules with detailed description. This principle contributes to gathering the pieces of information scattered throughout a sentence and to establishing a semantic representation of the sentence in a compositional way. Moreover, it enables us to deal with all the other linguistic phenomena in the same way as with the temporal problems. This grammar has been applied to French [Renaud, 1996; 2000; 2002] and Japanese [Blin, 1997] as well.

This grammar is divided into word definitions called 'dico' and composition rules. Each of them consists of syntactic constraint, unification-based feature constraint and semantic constraint written in lambda-terms.

%dico example
dongan(dg_dur, qu:no&multiocc:no,
λiλe. duration•e=i)

%rule example
adv_DG $\rightarrow$ dur, dg_dur
U0::(U1&U2),
S0 <<= λe. (S2•S1•e & ending•e < pt_speech()).

Figure 1. Dico and rules

In composition rules, the symbol '$\rightarrow$' stands for syntactic rewriting and '<<=' stands for β-reduction.

We present here an example process establishing the temporal interpretation of a Korean sentence extended by a *DONGAN* adverbial.

(11) *hanshigan **DONGAN** kwanghoe bihaenggiga naratta*
an hour/ ***DONGAN**/ of *Kwangho*/ airplane-NOM/ fly-PA-DEC
Kwangho's airplane flew **for** an hour.

We determine the semantic term of a *DONGAN* adverbial, according to the semantic and syntactic properties of the phrase preceding the temporal marker.
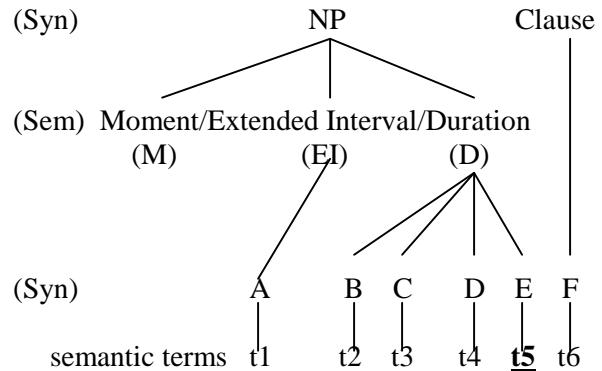

Figure 2. Processing of *DONGAN* adverbials

The time adverbial *hanshigan DONGAN* in (11) includes a NP denoting duration and conforms to the syntactic condition E[12]. Thus, the semantic term of type t5 is assigned to this time adverbial.

We also calculate the semantic term of the nuclear sentence relying on criteria such as quantification modification, mono/multi-occurrent and aspect[13], which get involved in the feature constraint at the levels of both dico and of rules. Since the nuclear sentence of (11) is not modified by quantification, and since it concerns a single event of activity, it receives a semantic term of type c3 in the following figure.
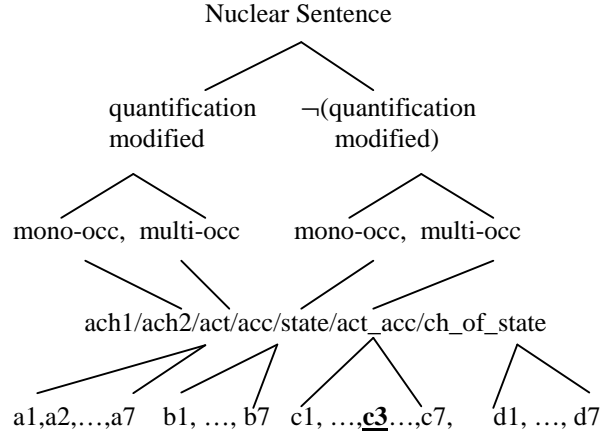
---

	(1)	(2)	(3)
Verb+*go innun chungida* (progressrve verbal form)	-	+	+
Durative NP + *mane*	+/-	+	+
preparatory stage	+	+	-
Durative NP + *dongan*	-	-	-
Resultant state	-	-	-
	ACH1	ACH2	ACC

	(4)	(5)	(6)	(7)
Verbe+*go innun chungida* (progressrve verbal form)	+	-	+	+
Durative NP + *mane*	-	-	+	+
preparatory stage	+	-	+/-	+
Durative NP + *dongan*	+	+	+	+
Resultant state	-	-	-	+
	ACT	State	ACT_ACC	Ch_of_state

Figure 3. Processing of nuclear sentences

At last, the semantic term of the time adverbial and that of the nuclear sentence are joined together by the following rule to put the final semantic representation of (11)[14]:

ph1→ adv_DG, ph
U1::tps2:dur & U2::(qu:no & multiocc:no)
S0<<=cond([[U2::asp:act/stat/act_acc,
   λQ.S2•(λE. (proj•1•S1)•E ∧ Q•E)],
       [U2::asp:ch_of_state, λQλR. S2•(λE.
   Q•E)•(λA. (proj•2•S1)•A ∧ R•A)]]).

Figure 4. *DONGAN* sentence construction rule

As we mentioned above, one of the most important advantages of G Grammar consists of its capacity to establish semantic interpretations in a compositional way. Even if we presented only the final step of semantic processing, our Korean parser constructs a semantic representation at each step[15].
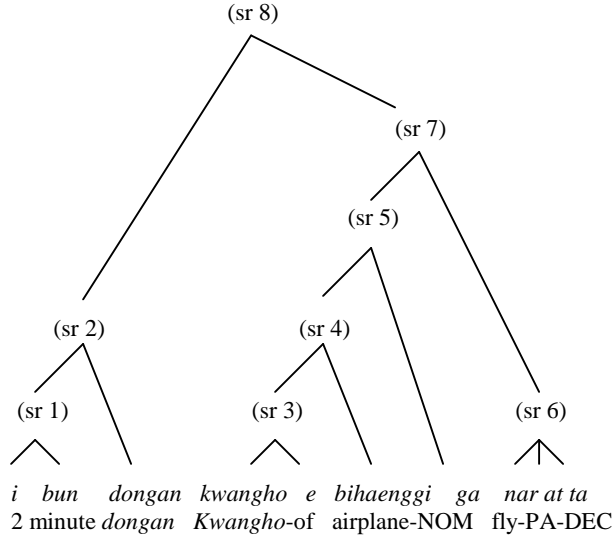
Figure 5. Parsing tree of the example (11)

```
(sr1) [0,0,0,2,0]
(sr2) lb(_24864,duration * _24864 =
[0,0,0,2,0] & ending * _24864 <
[2003,2,14,19,32])
(sr3) lb(_16476,lb(_15622,of *
kwangho * _15622 & _16476 * _15622))
(sr4) lb(_18330,exist * y * (of *
kwangho * y & airplane * y & _18330 *
y))
(sr5) lb(_18330,exist * y * (of *
kwangho * y & airplane * y & _18330 *
y))
(sr6) lb(_1682,lb(_1720,exist * e *
(fly * e * _1720 & beginning * e <
[2003,2,14,19,5] & _1682 * e)))
(sr7) lb(_4814,exist * y * (of *
kwangho * y & airplane * y & exist *
e * (fly * e * y & beginning * e <
[2003,2,14,19,7] & _4814 * e)))
(sr8) lb(_25184,exist * y * (of *
kwangho * y & airplane * y & exist *
e * (fly * e * y & beginning * e <
[2003,2,14,19,33] & (duration* e =
[0,0,0,2,0] & ending * e <
[2003,2,14,19,33] & _25184 * e))))
```

Figure 6. List of semantic representations presented in Figure 5.

The sentences extended by an *OE* adverbial are represented in the same way as those by a *DONGAN* adverbial, as will be seen in the following.

(8) *samwol shiboirOE nurôngoiga chugôtta.*
March/the fifteenth-*OE* /*Nurôngoi*-NOM/die-PA-DEC
On the fifteenth of March, *Nurôngoi* died.

Relying on the semantic and syntactic constraints of the phrase preceding *OE* at the same time, we determine the semantic term of the *OE* adverbial.
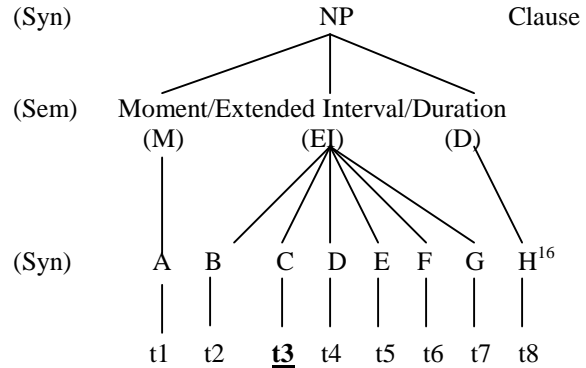

Figure 7. Processing of *OE* adverbials

Since *samwol shiboirOE* of (8) denotes an extended interval and it conforms to the syntactic condition C, this adverbial is attributed the semantic term of type t3.

The semantic representation of the nuclear sentence of (8) is established in the same way as explained above in Figure 3. At last, taking the semantic terms of the *OE* adverbial and of the nuclear sentence, the following rule serves to construct the final representation of the whole sentence[17].

---

[16] *OE* adverbials take the following syntactic structures:
A. Instant NP +*OE*
B. Interval Noun + *OE*
C. Interval NP + *OE*
D. Attributive Clause + Interval NP + *OE*
E. Attributive Clause + Interval Noun + *OE*
F. Deictic/anaphoric determiner + Interval NP +*OE*
G. Deictic/anaphoric determiner + Interval Noun + *OE*
H. Duration NP + *OE*
[17] See [Son, 2002] for more detailed description of *OE*.

ph1→ adv_OE, ph
U1::tps2:inter & U2::(qu:no & multiocc:no)
S0 <<= cond([[U2::asp:ach1/ach2, λQ. S2•(λE. (proj•1•S1)•E ∧ Q•E)],

   [U2::asp:acc, λQ. S2•(λE. (proj•2•S1)•E ∧ Q•E)],

   [U2::asp:act/stat/act_acc/ch_of_state, λQ. S2•(λE. (proj•3•S1)•E ∧ Q•E)]])

Figure 8. *OE* sentence construction rule

4   Conclusion

In this paper, we showed how *OE* adverbials and *DONGAN* adverbials contribute to constructing the temporal interpretation of Korean sentences. We also formalized the semantic properties of these temporal markers with typed lambda calculus before we integrated them into the Korean parser that we built on the basis of Renaud's G Grammar. We showed the effectiveness of this grammar in representing compositionally semantic interpretations of Korean sentences.

In the future, we will study the Korean time adverbials with *MANE* and zero particle. The first temporal marker is believed to signal the telicity of the event and the second appears very frequently in informal discourses.

References

[Andrews, 1986] Andrews P.B., 1986, *An Introduction to Mathematical Logic and Type Theory*, Orlando: Academic Press Inc.

[Andrews, 2002] Andrews, P.B., 2002 *An Introduction to Mathematical Logic and Type Theory*, Dordrecht: Kluwer Academic Press.

[Blin, 1997] Blin, R., 1997, *Interrogation sur la manière en japonais: Une approche formelle*, Paris: EHESS Dissertation.

[Hindley at al., 1986] Hindley, J. & Seldin, J.P., 1986, *Introduction to Combinators and λ-Calculus*, Cambridge: Cambridge Univ. Press.

[Jo, 2000] Jo, M.J., 2000, *A Study on the Aspect of Korean* (in Korean), Seoul: Yonsei Univ. Dissertation.

[Kim, 1981] Kim, S.-D., 1981, 'Aspect of Korean'(in Korean), *Aesan Hakbo* 1, Aesan Hakhoe.

[Lee, Ch., 1982] Lee, Ch., 1982, 'Aspects of Aspect in Korean', *Language* 7, Korean linguistic Society.

[Lee, Ch., 1987] Lee, Ch., 1987, 'Temporal Expressions in Korean', in Bertuccelli-Papi Verschueren, J. et al.(eds.), Amsterdam: John Benjamins.

[Lee, H., 1993] Lee, H. S., 1993, 'Tense or aspect : The speaker's communicative goals and concerns as determinant, with reference to the Anterior –ôss- in Korean', *Journal of Pragmatics* 20.

[Lee, J., 1982] Lee, J.-R., 1982, 'A Study of aspectual forms of Modern Korean'(in Korean), *Korean Linguistic Research* 51, Society of Korean Studies.

[Reichenbach, 1966] Reichenbach, H., 1966, *The Elements of Symbolic Logic*, Now York: The Free Press.

[Renaud, 1992] Renaud, F., 1992, 'Générateurs automatiques d'analyseurs linguistiques', *Intellectica* 13-14.

[Renaud, 1996] Renaud, F., 1996, *Sémantique du temps et lambda-calcul*, Paris: puf.

[Renaud, 2000] Renaud, F., 2000, 'Adverbes itératives et quantification', *Revue de Sémantique et Pragmatique* 8.

[Renaud, 2002] Renaud, F., 2002, 'Durativité et Négation', ms.

[Son, 2002] Son, H., 2002, 'Formal Description of 'NP+*OE*' with Lambda-Calculus and Unification Mechanism'(in Korean), *Annual Meeting of Korean Society for Language and Information*.

[Verkuyl, 1989] Verkuyl, H.J., 1989, 'Aspectual Classes and Aspectual Composition', *Linguistics and Philosophy* 12.

[Vet, 1980] Vet, C., 1980, *Temps, aspect et adverbes de temps en français contemporain*, Genève: Librairie Droz.

[Vlach, 1993] Vlach, F., 1993, 'Temporal Adverbials, Tense and the Perfect', *Linguistics and Philosophy* 16.