Implementation of RNR Constructions in the Korean TCCG System*

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Lee, Yong-hun. 2010. Implementation of RNR Constructions in the Korean TCCG System. *The Linguistic Association of Korea Journal*. 18(2). 27-46. The goal of this paper is to provide an implemented grammar for Korean right node raising (RNR) constructions in the Type-inherited Combinatory Categorial Grammar (TCCG) system. In Combinatory Categorial Grammar (CCG), the RNR constructions have been analyzed with four syntactic operations: *type-raising*, *functional composition*, *coordination*, and *functional application*. This paper demonstrates how these four syntactic operations can be implemented in the feature-structure formalism of the TCCG. In the syntactic literature, the RNR construction has been one of the interesting topics because it is known to be related with *ellipsis*. Therefore, it is important to recover the elided parts in the MRS structure (in the semantic interpretations) for the constructions. In order to handle the elided parts in the MRS structure, this paper divides *coordination* into two sub-types, *type-raised coordination* and *non-type-raised coordination*. This paper derives the semantic interpretations of the RNR constructions by the constraints on the *type-raised coordination*. Through the implementation, this paper shows how syntax and semantics of RNR constructions can be implemented in the Korean TCCG system.

Key Words: RNR constructions, Korean TCCG system, type-raised coordination, non-type-raised coordination, MRS

* I am very grateful to three anonymous reviewers for providing useful comments on this paper. All remaining errors are mine.

1. Introduction

The RNR constructions have been one of the interesting topics in the syntactic literature, and there have been many studies on this topic. Korean also has the constructions, and (1) illustrates one example.

(1) *Chelsoo-ka* *Younghee-lul* *kuliko* *Minsoo-ka*
Chelsoo.NOM Younghee.ACC and Minsoo.NOM
Sunhee-lul *po-ass-ta*.
Sunhee.ACC see.PAST.DECL
'Chelsoo saw Younghee, and Minsoo saw Sunhee.'

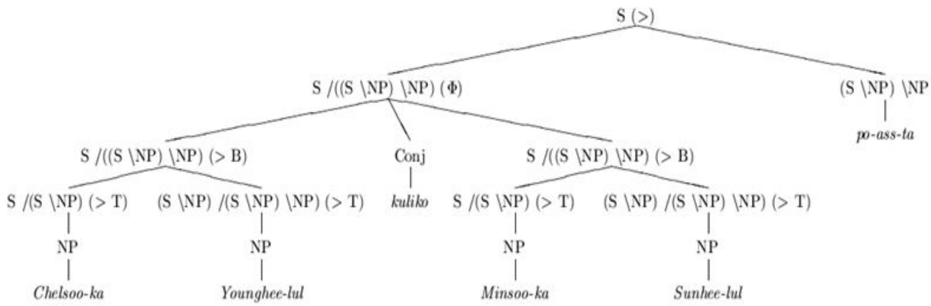
In syntactic literature, the RNR construction has been one of the hottest topics, because it is known to be related with *ellipsis*. For example, the sentence (1) can be derived from the sentence in (2).

(2) *Chelsoo-ka* *Younghee-lul* ~~*po-ass-ta,*~~ *kuliko*
Chelsoo.NOM Younghee.ACC see.PAST.DECL and
Minsoo-ka *Sunhee-lul* *po-ass-ta*.
Minsoo.NOM Sunhee.ACC see.PAST.DECL
'Chelsoo saw Younghee, and Minsoo saw Sunhee.'

In the sentence (2), the predicate of the first conjunct, '*po-ass-ta*', is identical with that of the second conjunct. This predicate can be elided in the first conjunct without change of the meaning, which results in the sentence (1).

There have been many different kinds of analyses for these constructions. Among many analyses, the sentence (1) can be analyzed as in Figure 1 in the CCG system (Steedman, 1996, 2000).

Figure 1. A CCG Analysis for the Sentence (1)



As you can observe, four major syntactic operations are involved in the analysis: *type-raising* (>T), *functional composition* (>B), *coordination* (Φ), and *functional application* (>). After each NP is *type-raised*, the subject NP and the object NP are combined by *functional composition*. After two conjuncts are *coordinated*, the coordinated parts combines with the verb by *functional application*.

The goal of this paper is to provide an implemented grammar for Korean RNR constructions using the TCCG system. The TCCG system is an implemented grammar for Steedman's CCG, which is first implemented by Beavers (2002, 2004) using the Linguistic Knowledge Building (LKB; Copestake, 2002) system. The Korean TCCG system, which is used in this paper, is not just a Korean counterpart of the English TCCG system. It is a simplified and modified TCCG system so that it can conveniently implement various syntactic phenomena in the Korean language. This paper provides an implemented grammar for the RNR constructions using this Korean TCCG system.

Implementing the Korean RNR constructions in the TCCG system is important because of the following two reasons. First, as shown in the Figure 1, four different syntactic operations are involved in the CCG analysis of the RNR constructions. Therefore, the implementation of the constructions implies the implementation of these four syntactic operations. That is, if we succeed in implementing RNR constructions, we also succeed in implementing four major syntactic operations in the Korean TCCG system. Second, as pointed out in (1) and (2), *ellipsis* is involved in the analysis of the RNR constructions. Through the implementation of these constructions, we may have a hint on how to handle *ellipsis* in the TCCG system, especially with related to the semantic interpretations.

2. Previous Studies on RNR Constructions

2.1 Theoretical Approaches

There have been so many previous studies on the constructions. It is impossible and pointless to review all of them. Therefore, only a few of them are reviewed here. Theoretical approaches to the RNR constructions can be divided roughly into two categories: movement- based approaches and constraint-based approaches.

In Chomskyan syntax, English RNR constructions have primarily been analyzed with movements. Ross (1967) and Mailing (1972) took this approach to English RNR constructions. In these analyses, the raised parts are analyzed with the across-the-board (ATB) movements. Wexler and Culicover (1980) and Bošcović (1996) took a different approach, and they analyzed the constructions with PF-deletion. That is, the elided parts exist in the syntax level, and they are deleted in the PF level.

There have been three types of analyses for the Korean/Japanese RNR constructions. Saito (1987) took a movement analysis using the ATB movements. Abe & Hoshi (1997) took an LF copying analysis. In this analysis, the elided parts are recovered in the LF level. On the other hand, Sohn (2001) analyzed the constructions with PF-deletion.

In the constraint-based approaches, the RNR constructions have been analyzed with the *coordination* rules and constraints on the rule. For example, Beavers and Sag (2004) provided analyses for the argument cluster coordination (ACC) and the RNR constructions. In this analysis, the ACC and RNR constructions are analyzed with the *coordination* rules and structure sharing. This paper also pointed out that *ellipsis* was involved in these constructions and discussed how they could be implemented in the HPSG framework.

2.2 RNR Constructions in the English TCCG System

The grammar engineering tool which this paper took is the LKB system. The LKB grammar development system was developed by many scholars such as Ann Copestake, John Carroll, Rob Malouf, and Stephen Oepen. After the development of the LKB system (Copestake, 2002), there have been several trials to implement the CCG using the LKB system. Because the LKB system was designed as a tool for the development of any typed, feature-based, unification grammar regardless of underlying formal grammars (Beavers, 2002, p. 4), it is also possible to implement the CCG in the LKB system.

The first implementation of CG is done by Copestake, and a small part of it is included in the LKB system. Aline Vallavicemcio (2001) further developed the implemented grammar for CG, which became a basis for the TCCG system. Beavers (2002, 2004) developed a TCCG system for an English fragment, and the system included various syntactic phenomena in English. As mentioned in Beavers (2002, p. 4), his system was theoretically based on Carpenter (1992), Steedman (1996, 2000), Baldridge (2002), and Hockenmaier et al. (2001). In the actual implementation, his system was based on Vallavicemcio (2001).

In the English TCCG system, the sentence which is similar to the Korean RNR constructions is the ACC construction in (3) that includes two type-raised NPs. Beavers (2002) analyzed (3) as in Figure 2.[1)]

(3) Kim gave a dog a bone and a policeman a flower.

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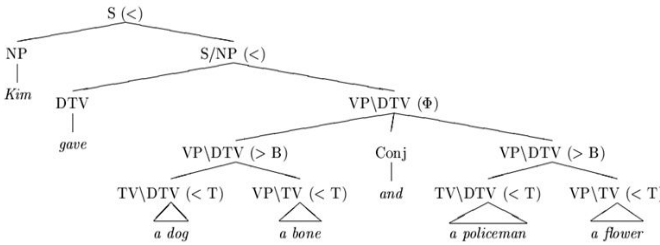
1) Beavers (2002, p. 72) analyzed two sentences, *Kim cooks and Sandy eats pizza* and *Kim hands and Sandy the dog a cat*, as examples of the English RNR constructions. It is a fact that all of four syntactic operations are also used in the English RNR constructions. However, *type-raising* in two languages are different. In English, the subject NPs are type-raised and combined with the verb which is not type-raised. In Korean, on the other hand, both the subject NPs and the object NPs are type-raised, and they are combined with *functional composition*. Therefore, *r_dist* does not appear in the English RNR sentences. Rather, the ACC constructions in (3) have *r_dist*, since two type-raised NPs are combined with *functional composition*. That's why this paper adopts the English ACC constructions in the analysis, rather than the RNR constructions.

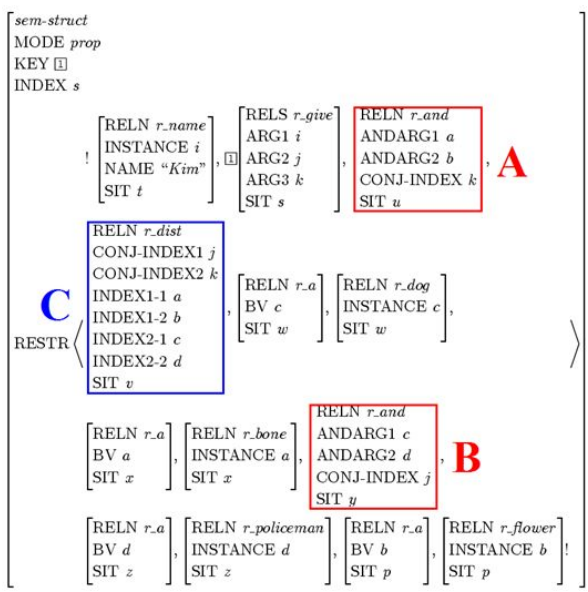
Figure 2. A CCG Analysis for the Sentence (3)



As you can observe in the analysis, all of four major syntactic operations which appears in the Figure 1, *type-raising*, *functional composition*, *coordination*, and *functional application*, also appear in this analysis though the direction of the operations are opposite. Note that *backward type-raising*, *backward functional composition*, and *backward functional application* are used in the English example, while *forward type-raising*, *forward functional composition*, and *forward functional application* are used in the Korean example.

For this sentence, Beavers (2002, p. 63) provides the MRS structure in Figure 3.

Figure 3. The MRS Structure for the Sentence for (3)



In this MRS structure, we have to focus three parts, which are marked by A, B, and C respectively. As you can observe, the RELN value for A and B is *r_and*, which encodes the coordinated relations. From the ANDARG1 and ANDARG2 values of each relation, we found that A is the MRS structure for the coordination of *a bone* in the first conjunct and *a flower* in the second conjunct. Likewise, B is the MRS structure for the coordination of *a dog* in the first conjunct and *a policeman* in the second conjunct. The RELN value for C is *r_dist*, and this additional predicate is provided for indicating that there is a distributivity relationship between the coordinated items. According to Beavers, the sentence (2) has distributed readings. Its meaning is *Kim gave a dog a bone and he gave a policeman a flower*, and it does not imply *Kim gave a dog and a policeman a bone and a flower*. The additional predicate in C encodes this distributivity relationship.

The MRS structure in Figure 3, however, has the following problems. First, the MRS structure itself is too complicated. It is dubious why this kind of complex MRS structure has to be used for semantic interpretation of the coordinated constructions. It would be better to have simpler semantic interpretations for coordinated structures.

Second, there is no one-to-one relation between each lexical item and the elementary predicate (EP). Usually, an EP corresponds to one lexical item in the Minimal Recursion Semantics.[2)] However, in the MRS structure in Figure 3, it is not the case. Though the input sentence has one conjunction *and*, the MRS structure in Figure 3 has two *and* relations, (two *r_and*s). Besides, one more additional predicate is added to the MRS structure for indicating the distributivity relationship between the coordinated items. Therefore, we can say that three EPs are used for one lexical item *and*.

Third, even though we give up the one-to-one relationship between each lexical item and EP, the MRS structure in Figure 3 has redundancy. As you can observe, much information encoded in A and B is also included in the EP of C.

The last and the most important problem is that the syntactic information is also encoded in the MRS structure of 3. If you closely observe the MRS structure of Figure 3, you can find that A precedes B. That is, the EP for the CONJ-INDEX

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2) In order to avoid confusion, I will not use MRS (the abbreviated form) when it refers to Minimal Recursion Semantics itself (Copestake et al., 1999, 2005).

k precedes that of the CONJ-INDEX *j*. The CONJ-INDEX *k* is the index for coordination of *a bone* and *a flower*, whereas the CONJ-INDEX *j* is the index for coordination of *a dog* and *a policeman*. From this MRS structure, you can notice that the EP for coordinated direct objects precedes that of the coordinated indirect objects, even though the order is opposite in the input sentence. This is against a usual convention in the Minimal Recursive Semantics that the order of EPs in the MRS structure follows the word order of the input sentence(s). For this kind of MRS structure, Beavers provided the following explanations. The ditransitive verb *give* belongs to the category ((S\NP)/NP)/NP. If we add the Case information to this category, it will be $((S\backslash NP_{NOM})/NP_{DAT})/NP_{ACC}$. When this ditransitive verb combines with the argument NPs, it combines with the direct object NP_{ACC} first, and then it combines with indirect object NP_{DAT}. Therefore, the EP for the CONJ-INDEX *k* has to precede that of the CONJ-INDEX *j*. Even though we accept his explanations, we may have the following question. Though syntactic operations are closely related with the semantic interpretations, the order of combination belongs to the syntactic part. Should the order of combination be encoded in the MRS structure, where the semantic interpretations are represented? Maybe, the answer for this question is *No*. Then, we have to reconsider the MRS structure in Figure 3.

3. Implementation of the RNR Constructions

3.1 Two Types of Coordination

The implemented TCCG system for a Korean fragment in this paper is based on both Copestake's early implementation of CG and Beavers' English TCCG. However, Beavers' system is the primary basis of implementation and some components in Copestake's system will be incorporated when they are necessary.

In order to solve the problems which were pointed out in the above section, the Korean TCCG system puts two subtype *conjunction-1* and *conjunction-2* under the type *conjunction*, and these two types of conjunctions have different EP structure as in Figure 4.[3)]

Figure 4. The EP Structures for Two Types of Conjunctions

a. *conjunction-1*

$$\begin{bmatrix} \text{그리고\_}rel \\ \text{ARG0 } \boxed{1} \\ \text{ARG1 } \boxed{2} \\ \text{ARG2 } \boxed{3} \end{bmatrix}$$

b. *conjunction-2*

$$\begin{bmatrix} \text{그리고\_}rel \\ \text{ARG0 } \boxed{1} \\ \text{ARG1 } \boxed{2} \\ \text{ARG2 } \boxed{3} \\ \text{ARG1-ARG1 } \boxed{4} \\ \text{ARG1-ARG2 } \boxed{5} \\ \text{ARG2-ARG1 } \boxed{6} \\ \text{ARG2-ARG2 } \boxed{7} \end{bmatrix}$$

Here, ARG0 is the index of the conjunction itself, and ARG1 and ARG2 refer to the first and the second argument of the coordinations, which corresponds to the left and right conjunct respectively. In *conjunction-2*, four more indices are included. ARG1-ARG1 refers to the first argument of the left conjunct, and ARG1-ARG2 refers to the first argument of the right conjunct. Likewise, ARG2-ARG1 refers to the second argument of the left conjunct, and ARG2-ARG2 refers to the second argument of the right conjunct.

The type *conjunction-1* is for the *non-type-raised coordination*, where two S nodes or two simple NP nodes are coordinated. On the other hand, the type *conjunction-2* is for the *type-raised coordination*, which can be used for the analysis of the RNR constructions.

3.2 Implementation of Coordination Rules[4)]

In order to implement the coordinated structures in the Korean TCCG system, we have to a rule for coordination. Steedman provided the coordination rule as follow.

(4) Coordination (Steedman, 1996, p. 31)

$$X : g \quad CONJ : b \quad X : f \quad \rightarrow_{\Phi} \quad X : \lambda b(f)(g) \quad (<\Phi_n>)$$

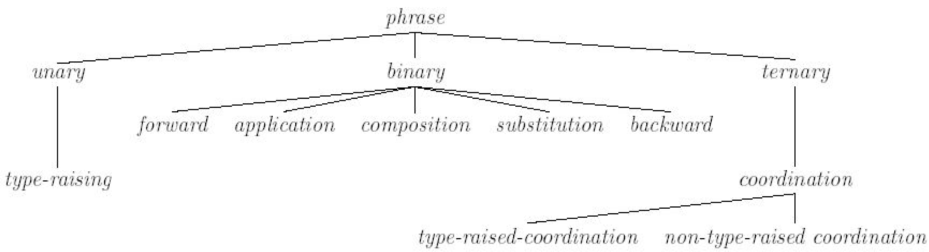
3) Though the EP structure of *conjunction*-2 comes from simplifying the MRS structure in Bears (2004), this EP structure is necessary also in Korean since some constructions such as RNR constructions have distributive readings.

4) Kim & Yang (2006) also implemented co-ordinated structures in Korean. However, their implementations are done within the HPSG framework. Although the basic ideas between this paper and their may be similar, specific rules and actual implementations are different, since two papers take different theoretical frameworks.

Here, note that the left conjunct and the right conjunct have the same syntactic category.

In the Korean TCCG system, this coordination rules are implemented as follows. The type *phrase* is sub-divided into three subtypes: *unary*, *binary*, and *ternary*, as shown in Figure 5. *Coordination* is a subtype of *ternary* since three constituents are involved in the rule.

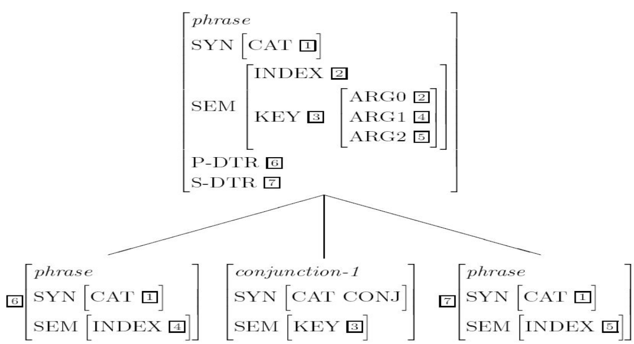
Figure 5. Type Hierarchy for *Phrase*



Then, the type *coordination* is further subdivided into two subtypes: *non-type-raised coordination* and *type-raised coordination*.

First, *non-type-raised coordination* can be implemented as follows.

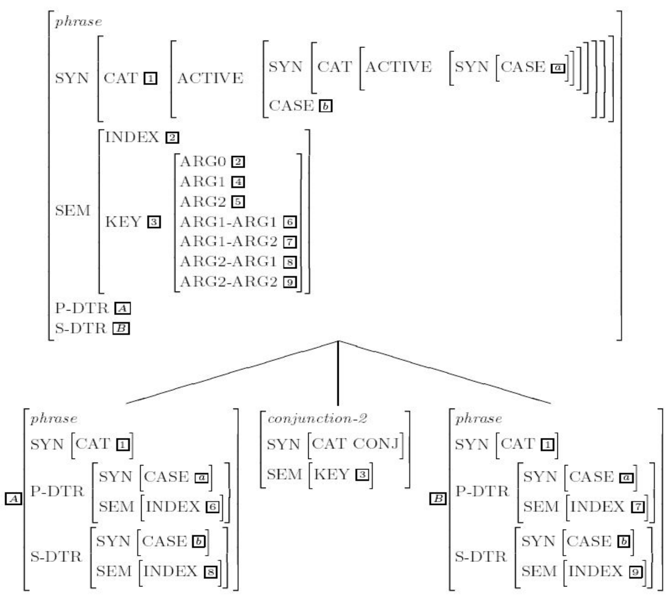
Figure 6. Non-Type-Raised Co-ordination



As you can observe in this rule, *conjunction-1* is used for *non-type- raised coordination*. The SYN|CAT value of the coordinated structure is identical with those of the two conjuncts. This implies that two conjoined constituents have the same category. The KEY value of the coordinated structure inherits that of *conjunction-1*. The ARG1 value has to be identical with the SEM|INDEX value of the left conjunct. Likewise, the ARG2 value of coordinated structure has to be identical with the SEM|INDEX value of the right conjunct. P-DTR (primary daughter) of the coordinated structure has to be the left conjunct, and S-DTR (subordinate daughter) of the coordinated structure has to be the right conjunc t.[5] As noted in the above section, this *non-type- raised coordination* is used when two S nodes or two simple NP nodes are coordinated.

Next, Figure 7 illustrates the *type-raised coordination*. As you can see, this rule is more complicated than *non-type-raised coordination*.

Figure 7. Type-Raised Coordination



Unlike the rule for *non-type-raised coordination*, *conjunction-2* is used for *type-raised coordination*. The SYN|CAT value of the coordinated structure is identical with those of the left and right conjuncts. The KEY value of the coordinated structure has to be identical to that of *conjunction-2*. The ARG1 value of coordinated structure has to be identical with the SEM|INDEX value of the left conjunct.

5) P-DTR and S-DTR roughly correspond to the VAL values in HPSG.

Likewise, the ARG2 value of coordinated structure has to be identical with the SEM|INDEX value of the right conjunct. The ARG1-ARG1 and ARG1-ARG2 values of the coordinated structure have to be identical with the SEM|INDEX values of the P-DTR in the left and right conjunct respectively. Likewise, The ARG2-ARG1 and ARG2-ARG2 values of the coordinated structure have to be identical with the SEM|INDEX values the S-DTR in the left and right conjunct respectively. P-DTR of the coordinated structure has to be the left conjunct, and S-DTR of the coordinated structure has to be the right conjunct.

Since the P-DTR|SEM|INDEX values and the S-DTR|SEM|INDEX values have to be identical with some values in the coordinated structure, this implies that each conjunct in the *type-raised coordination* has to be the result of *functional composition*, which in turn come from *type-raised* NPs. If this condition is not satisfied, the coordination rule in Figure 7 cannot be applied. Accordingly, the *type-raised coordination* rule in Figure 7 can be applied only to the complex structures which are made with two type-raised NPs. Thus, we can analyze and implement the Korean RNR constructions with this rule.

3.3 Implementation of Other Syntactic Operations

In order to implement the RNR constructions in the Korean TCCG system, we have to implement three more syntactic operations. The first one is *type-raising*, which is shown in (5).

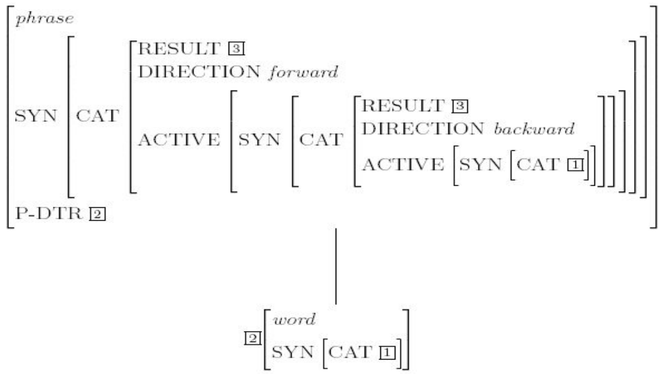
(5) Type Raising (Steedman, 1996, p. 37)

a. $X : a \quad \rightarrow_T \quad T / (T \backslash X) : \lambda f.fa$ (> T)

b. $X : a \quad \rightarrow_T \quad T \backslash (T / X) : \lambda f.fa$ (< T)

For the analysis of the RNR constructions in Korean, the *forward- type-raising* in (5a) is necessary to be implemented. Figure 8 shows the implementation of this rule.

Figure 8. Forward Type Raising



The *forward-type-raising* is a subtype of *forward* and *type-raising* in Figure 5. The SYN|CAT value of the NP node has to be identical with the SYN|CAT|ACTIVE|SYN|CAT|ACTIVE|SYN|CAT value of the type-raised NP node. The SYN|CAT|DIRECTION value and the SYN|CAT|ACTIVE |SYN|CAT|DIRECTION value decide the direction of *type-raising*.

The second syntactic operation that we have to implement is *functional composition*, which is shown in (6).

(6) Functional Composition (Steedman, 1996:43, 2000:55)

a. $X / Y : f \quad Y / Z : g \quad \rightarrow_B \quad X / Z : \lambda x.f(gx) \quad (> B)$

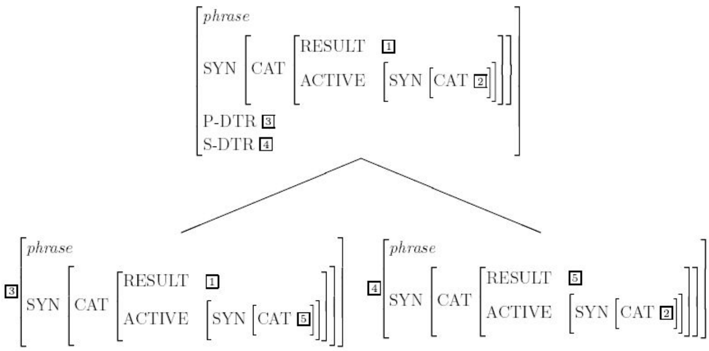
b. $X / Y : g \quad Y \backslash Z : f \quad \rightarrow_B \quad X \backslash Z : \lambda x.g(fx) \quad (> B)$

c. $Y \backslash Z : f \quad X \backslash Y : g \quad \rightarrow_B \quad X \backslash Z : \lambda x.g(fx) \quad (< B)$

d. $Y / Z : g \quad X \backslash Y : f \quad \rightarrow_B \quad X / Z : \lambda x.f(gx) \quad (< B)$

For the analyses of the RNR constructions in Korean, the *forward-functional-composition* in (6a) is necessary to be implemented. Figure 9 schematizes the implementation of this rule.

Figure 9. Forward Functional Composition



The *forward-functional-composition* is a subtype of *forward* and *functional-composition* in Figure 5. The SYN|CAT|RESULT value of the result of the operation has to be identical with the SYN|CAT| RESULT value of the first conjunct. The SYN|CAT|ACTIVE|SYN| CAT value of the result of the operation has to be identical with the SYN|CAT|ACTIVE|SYN|CAT value of the second conjunct. The most important fact is that the SYN|CAT|ACTIVE|SYN|CAT value of the first conjunct has to be identical with the SYN|CAT|RESULT value of the second conjunct. Through these constraints on the rule, we can properly implement the *forward-functional-composition* in (6a).

The last syntactic operation that we have to implement is *functional application*, which is shown in (7).

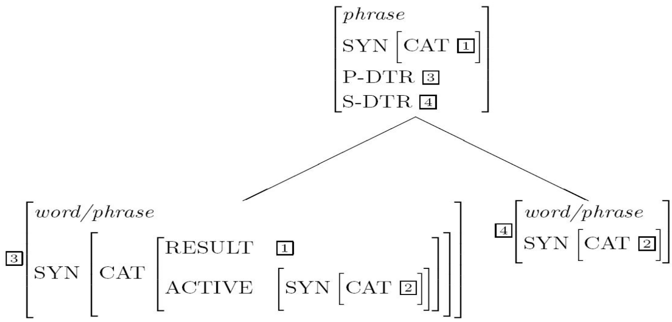
(7) Functional Application (Steedman, 1996, p. 13)

a. $X / Y \ : f \quad Y \ : a \rightarrow \quad X \ : f\ a \qquad (>)$

b. $Y \ : a \quad X \backslash Y \ : f \rightarrow \quad X \ : f\ a \qquad (<)$

For the analyses of the RNR constructions in Korean, the *forward-functional-application* in (7a) is necessary to be implemented. Figure 10 shows the *forward-functional-application* in (7a).

Figure 10. Forward Functional Application



The operation *forward-functional-application* is a subtype of *forward* and *functional-application* in Figure 5. The SYN|CAT value of the result of the operation has to be identical with the SYN|CAT|RESULT value of the first daughter. The SYN|CAT|ACTIVE|SYN|CAT value of the first daughter has to be identical with the SYN|CAT value of the second daughter. Through these constraints on the rule, we can properly implement the *forward-functional-application* in (7a).

4. Results of Implementation

Now, let's see how coordinated structures and the RNR constructions can be implemented in the Korean TCCG system. The first one is for *non-type-raised coordination*. Let's see the following sentence.

(8) *Chelsoo-ka* *kuliko* *Minsoo-ka* *Younghee-lul*
Chelsoo.NOM and Minsoo.NOM Younghee.ACC
po-ass-ta.
see.PAST.DECL
'Chelsoo and Minsoo Younghee saw Sunhee.'

Here, two NPs are coordinated in the subject position. Because two simple NPs are coordinated, *non-type-raised coordination* in Figure 6 is applied. Figure 11 and Figure 12 illustrates the parse tree and the MRS structures of the sentence (8).

Figure 11. The Parse Tree for the Sentence (8)

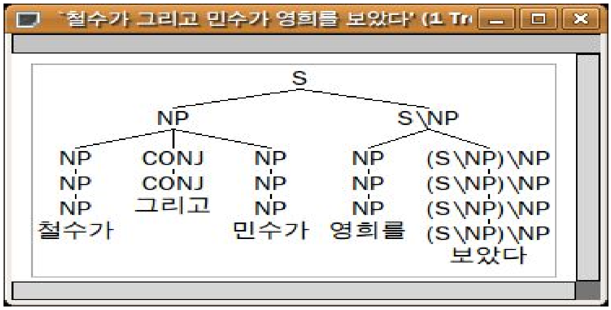
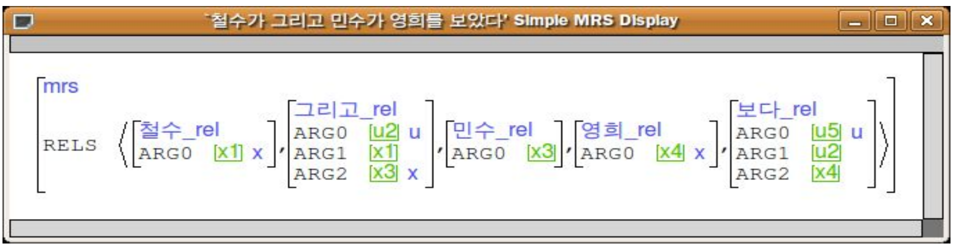


Figure 12. The MRS Structure for the Sentence (8)



As you can observe in Figure 12, the ARG1 value of the *kuliko_rel* (*x1*) is identical with the ARG0 value of the *Chelsoo_rel*, and the ARG2 value of the *kuliko_rel* (*x3*) is identical with the ARG0 value of the *Minsoo_rel*. The ARG1 value of the *po-ta_rel* (*u2*) is identical with the ARG0 value of the *kuliko_rel*. This means that the first argument (ARG1) of the *po-ta_rel* has a coordinated structure, which is composed of two conjuncts *Chelsoo_rel* and *Minsoo_rel*. Note that the second argument (ARG2) of the predicate *po-ta_rel* (*x4*) refers to *Younghee_rel*. This MRS structure properly captures the meaning of the sentence (8).

Then, how the RNR constructions can be implemented in the Korean TCCG system? Figure 13 and Figure 14 illustrates the parse tree and the MRS structures of the sentence (1).

Figure 13. The Parse Tree for the Sentence (1)

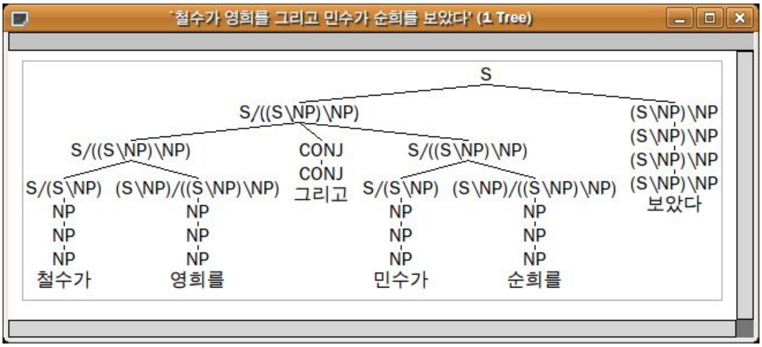
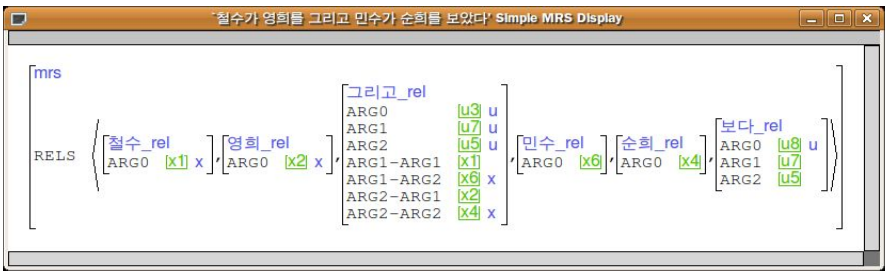


Figure 14. The MRS Structure for the Sentence (1)



As you can observe in Figure 14, the ARG1-ARG1 value of the *kuliko_rel* (*x1*) is identical with the ARG0 value of the *Chelsoo_rel*, and the ARG1-ARG2 value of the *kuliko_rel* (*x6*) is identical with the ARG0 value of the *Minsoo_rel*. Likewise, the ARG2-ARG1 value of the *kuliko_rel* (*x2*) is identical with the ARG0 value of the *Younghee_rel*, and the ARG2-ARG2 value of the *kuliko_rel* (*x4*) is identical with the ARG0 value of the *Sunhee_rel*. The ARG1 value of the *po-ta_rel* (*u7*) is identical with the ARG1 value of the *kuliko_rel*, which is composed of two conjunct ARG1-ARG1 and ARG1-ARG2. This means that the first argument (ARG1) of the *po-ta_rel* has a coordinated structure, which is composed of two conjuncts *Chelsoo_rel* and *Minsoo_rel*. Likewise, the ARG2 value of the *po-ta_rel* (*u5*) is identical with the ARG2 value of the *kuliko_rel*, which is also composed of two conjuncts ARG2-ARG1 and ARG2-ARG2. This means that the second argument (ARG2) of the *po-ta_rel* also has a coordinated structure, which is composed of two conjuncts *Younghee_rel* and *Sunhee_rel*. Along with this MRS structure, we can properly capture the meaning of the sentence (1), which is an example of the RNR constructions.[6)]

5. Conclusion

In this paper, we tried to implement the RNR constructions in the Korean TCCG system. Four syntactic operations are used in the CCG analysis of Korean RNR constructions: *type-raising*, *functional composition*, *coordination*, and *functional application*. In order to properly implement the constructions, this paper divided *conjunction* into *conjunction-1* and *conjunction-2*. This paper also divided *coordination* into two subtypes: *non-type-raised coordination* and *type-raised coordination*. *conjunction-1* is used for *non-type-raised coordination*, and *conjunction-2* is used for *type-raised coordination*. For the proper implementation of the Korean RNR constructions, *conjunction-2* and *type-raised coordination* were used.

In addition to *type-raised coordination*, we implemented three more syntactic operations: *type-raising*, *functional composition*, and *functional application*. Along with these four syntactic operations, we were able to implement the syntax and semantics of the Korean RNR constructions in the TCCG system. Through the implementation of the MRS structures of the constructions, we could capture the fact that each argument of the predicate has a coordinated structure.

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6) Although it is not shown in this paper, the implemented grammar in this paper can also provide a correct analysis for the RNR constructions where the object NPs precedes the subject NPs (e.g. *Younghee-lul Chelsoo-ka kuluko Sunhee-lul Minsoo-ka po-ass-ta*).

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