On the Children's Knowledge of Bound Variables

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It is well known that typically developing children violate the Condition B some significant percentage of the time and that they follow the Condition B later than they follow the Condition A—the phenomenon known as the Delay of the Condition B Effect (DCBE). This fact raises a serious problem to the hypothesis of the UG-Constrained Maturation proposed by Borer and Wexler (1987), which states that at every time, the principles of UG constrain the child's grammar. Unfortunately, this hypothesis wrongly predicts that there is no difference in the acquisitions of the Condition A and the Condition B. One kind of response to this puzzle maintains that children know the Condition B but they lack the knowledge of the principle of pragmatics (Principle P), so they seem to allow the Condition B violations (Chien and Wexler, 1990). A second response holds that children know both of the Condition B and the Principle P but they cannot hold two representations in memory for the purpose of comparing them (Grodzinsky and Reinhart, 1993). The purpose of this paper is to consider whether children know the Principle P or not. Based on Reuland's (2001) approach to the Binding Theory, I will argue that children know the Principle P and that they have ability to comparing two representations in some cases.

1. Introduction

The early studies on the Condition B focused only on the coreference aspect of pronouns and found that in sentences like (1a), children choose the coreference option about 50% of the time; that is, they perform around chance level.

(1) a. Oscar touches him.
b. Every boy touches him.

These early findings thus led to the conclusion that children do not know the Condition B. However, Chien and Wexler (C&W) (1990) discovered a distinction between children's performance on the coreference aspects of the Condition B and their performance on its variable-binding aspects. They found that children disallow a pronoun to be bound by a local c-commanding quantifier in the sentence like (1b), which always requires the bound variable reading and does not allow accidental coreference. Based on this observation, they argue that children know the Condition B, which concerns the bound variable reading, but they do not know the Principle P, which governs the coreference reading. The Principle P proposed by Grodzinsky

and Reinhart (1993) is formalized as below:

(2) *Rule I*: *Intrasentential Coreference (Principle P)*
NP A cannot corefer with NP B if replacing A with C, C a variable A-bound by B, yields an indistinguishable interpretation.[1]

(Grodzinsky and Reinhart, 1993:79)

Let us consider the example in (1a), for example. In order to decide whether *Rule I* allows the pronoun in this sentence to corefer with *Oscar*, we need to compare the following two interpretations:

(3) a. x touches x & x=Oscar
b. x touches y & x=Oscar & y=Oscar

In this case, (3b) does not yield an indistinguishable interpretation and therefore, coreference is not allowed. The interpretation in (3a) is not allowed as well due to the Condition B violation. According to C&W, children perform around chance level because they do not know the *Rule I*.

Reinhart and Grodzinsky (R&G) (1993) points out that this argument wrongly predicts that children accept as grammatical every sentence that the *Rule I* excludes and that it cannot explain why children perform at chance levels rather than below chance. They notice that agrammatic aphasics succeed in binding tasks and fail in coreference tasks just like children, indicating that they suffer a similar deficiency. Moreover, both of children and agrammatic aphasics fail to interpret ambiguous word which requires holding two representations in memory in order to match them with context. Based on this observation, they claim that children and agrammatic aphasics cannot hold two representations in memory for the purpose of comparing them with prior context.

Interestingly, both of C&R and R&G consider that we need to compare two representations to determine the reference of pronouns but they do not consider that the same process is required when we interpret reflexives. However, it is possible to assume that we compare two sentences in (4) to determine which one is appropriate to express our thoughts:

(4) a. Oscar touches himself.
b. Oscar touches him.

[1] Reuland adopts the logical-syntax-based definition of A-binding as in what follows:
(i) α A-binds β iff α is the sister of a λ-predicate whose operator binds β.

(Reuland, 2001: 440)

One might exclude this possibility because the Condition B does not allow the bound reading in (4b). However, the bound reading in (4b) is excluded only if we assume that the Condition B is a correct definition within the Universal Grammar. The bound reading of a pronoun itself is allowed by the *Rule I*. Let us consider the following example:

(5) a. Alfred thinks he is a great cook.
b. x thinks x is a great cook & x=Alfred
c. x thinks y is a great cook & x=Alfred & y=Alfred

In order to decide whether the *Rule I* allows the pronoun to corefer with *Alfred* in (5a), we need to compare (5b) and (5c). Then, we find that (5c) does not yield an indistinguishable reading and therefore, we select the bound reading in this case. The possibility of bound reading of pronouns raises a following question. Is it truly unnecessary to compare the sentences in (4)? There is an interesting data which seems to provide a clue to answer to this question. C&W reports that young children tend to make anaphora mistakes by coindexing the reflexives with the nonlocal c-commanding antecedent (in their Experiment 1). The amount of this type of anaphora mistake decreased from 75% to 10% (reflexive = nonlocal c-commanding antecedent G1 to G8: 74.80%, 66.80%, 49.00%, 41.50%, 33.10%, 27.10%, 23.50%, and 10.00%).[2] They consider that these developmental results can be predicted from the Lexical Learning Hypothesis. That is, a certain period of time is expected and required for a child to complete learning task that *herself/himself* was a reflexive. They suggest that this learning is completed around the age of 6;0. However, we need to ask why the youngest children consistently chose a nonlocal antecedent for the reflexive. C&W consider that children's behavior in this experiment is most likely a response bias, rather than a demonstration of linguistic knowledge. Surprisingly, young children still perform around chance level in the experiment which is designed to eliminate the pragmatic bias. The Lexical Learning Hypothesis might explain this result. However, this result might be attributed to the failure in comparing two interpretations as mentioned above.

In the following discussion, I will discuss on this alternative approach and consider whether children know the *Rule I*. I will claim that children know the *Rule I* but they are affected by the complexity in the competition and the economy in interpretation. Moreover, I will argue that young children's inability to establish A-chains causes their tendency to violate the Condition A. The remainder of this paper is designed as follows. Section 2 will introduce Reuland's (2001) approach to the Binding Theory, which assumes the comparison of two representations in the use of bound variables. Then, I will provide an explanation to children's behavior to Binding. In

[2] Children grouped by their age and there are 6-months intervals between each groups. G1 (Group1) consists of children between the ages of 2;6 and 3;0. G8 consists of children from 6;0 to 6;6.

section 3, we will discuss on the knowledge of Binding in individuals with Down syndrome. Then, I will demonstrate that only the approach explored in this paper can explain their behavior. Section 4 concludes the paper.

2. *Rule BV* and Economy in Interpretation

One of the basic binding facts is that pronominals are locally free. The Dutch examples in (6) illustrate this:

(6) a. Osacar voelde [zich wegglijden].
Oscar felt himself slide away
b. *Oscar voelde [hem wegglijden].
Oscar felt him slide away

Reuland (2001) notices that both of anaphors and pronominals in these examples can be translated as bound variables and that both of (6a) and (6b) can be assigned the same interface representation as in what follows:

(7) Oscar λx (x felt (x slide away)).

We must express that (6a) is preferred over (6b) as a source for (7). Pursuing the parallel with the *Rule I*, Reuland develops a precise reconstruction of the distinction between pronominal binding and anaphor binding within the minimalist framework and then proposes the following rule for bound variable representation:

(8) Rule BV: Bound variable representation:
NP A cannot be A-bound by NP B if replacing A with C, C an NP such that B heads an A-CHAIN tailed by C, yields an indistinguishable interface representation.[3]
(Reuland, 2001:462)

[3] A-CHAINs are formed by linking A-Chains and A-chains, as follows:
(i) If (α_1, α_2) is a Chain and (β_1,β_2) is a chain and $\alpha_2 = \beta_1$, then (α_1, α_2/β_1,β_2) is a CHAIN.
(Reuland, 2001: 458)
If linking applies to the objects (α_1, α_2) and (β_1,β_2), the member to be eliminated is α_2/β_1. The ensuing CHAIN is (α_1, β_2). Chain expresses the notion of *checking chain* and formed by checking/deletion, in addition to *chain*.
(ii) (α, β) form a Chain if (a) β's features have been (deleted by and) recovered from α, and (b) (α, β) meets standard conditions on chains such an uniformity, c-command, and locality.
(iii) If (α, β) is a Chain, and both α and β are in A-positions, (α, β) is an A-Chain.
(Reuland, 2001: 457)

Let us consider the derivation of (6a), for example. When V-to-I movement is overt, (9b) results from (9a) by first adjoining *voelde* to I and then moving *Oscar* to Spec IP.

(9) a. [I [Oscar [voelde [zich I [wegglijden]]]]]
b. [Oscar [[voelde+I] [t_{Oscar} [t_{V} [zich I [wegglijden]]]]]

Then, the formal feature of *zich* (FF_{zich}) adjoins to the matrix V/I complex covertly for Case checking. The pair of (FF_{zich}, *zich*) has the properties of an A-chain, since both positions are L-related and FF_{zich} is nondistinct from an X^{max} (see Chomsky 1995: 270-276 for discussion). The effect of movement is represented as follows:

(10) [Oscar [[FF_{zich} [voelde+I]] [t_{Oscar} [t_{V} [zich I [wegglijden]]]]]

The DP *Oscar* independently moves to Spec IP and checks the verb's *φ*-features. It also enters into the checking relation with FF_{zich}, which contains the 3rd person feature. This operation establishes the dependency between *Oscar* and FF_{zich}. Since Move has already created a dependency between FF_{zich} and *zich*, the result is a dependency between *Oscar* and *zich*. In other words, the dependency between *Oscar* and *zich* is mediated by FF_{zich}. In this way, *Oscar* and *zich* become members of an A-CHAIN.[4]

Let us now return to the contrast in (6). The relevant representations are shown below:

(11) a. Oscar_{φ} voelde [zich_{φ} wegglijden]
b. Oscar λx (x voelde (x wegglijiden))
c. Oscar λx (x voelde (y wegglijden)) & y = Oscar

In (11a), the dependency between arguments is expressed within computational system of human language (C_{HL}) by CHAIN formation indicated by shared φ-features, yielding (11b) as the next step in the derivation. In (11b), the dependency between the arguments is linguistically expressed in the bound variable structure (irrespective of whether it was encoded within C_{HL} or not). In (11c), the dependency is not linguistically expressed at all, but can only be established

[4] As for English reflexives, he assumes that covert adjunction of *self* yields the representation in (ib)
(i) a. DP ... [H [PRON [SELF]]
b. DP ... [SELF+H [PRON [e]]
He does not explain precisely how a CHAIN between *self* and DP is established. However, it is obvious from English translation of (6a) that English reflexives share the same property with *zich* and therefore, I assume that the *Rule BV* applies to English as well.

by accessing the discourse storage. The *Rule I* expresses that the route of interpreting (6b) via (11b) is taken, instead of interpreting (6b) via (11c), even though the derivation from (6b) to (11b) is ultimately blocked. The *Rule BV* expresses that deriving (11b) syntactically from (6a) via (11a) by CHAIN formation is preferred over deriving (11b) from (6b).

In order to derive the ranking involved in the *Rules I* and the *Rule BV*, Reuland distinguishes four types of linguistic processes for representing a relation between arguments as in (12) and assumes that a detectable amount of cost is associated with cross-modular operations.

(12) a. Processes applying within C_{HL}
b. Processes relating syntactic representations to the C-I interface representations
c. Processes applying at the C-I interface
d. Processes relating C-I interface representations to the discourse storage

In the case of coreference, the number of cross-modular operations is 4. If α and β are to be related by variable binding, the number of cross-modular operations is 3; hence this operation is cheaper. The cheapest derivation can be obtained through CHAIN formation. In this case, only 2 cross-modular operations are required. In other words, the cheapest way to assign a value to some element is to create a syntactic CHAIN in the syntax and that the costliest way to do it is by interpreting independently, accessing the discourse storage.

Let us now consider how this approach explains the DCBE. According to Reuland, we need to compare two representations both in the cases of reflexives and pronouns. Therefore, the DCBE cannot be attributed to children's deficiency in holding two interpretations in their memory. However, we find that obtaining the correct interpretation of pronoun is harder than interpreting a reflexive correctly. Specifically, children are required to compare the interpretation obtained by crossing 3 operations with the one attained by crossing 4 operations and to select the latter interpretation when they interpret a pronoun. On the other hand, interpreting a reflexive requires children to compare the interpretation obtained by crossing 2 operations with the one attained by crossing 3 operations and to choose the former interpretation when they interpret a reflexive. In short, the appropriate interpretation for a pronoun is costlier than the other competing interpretation while the correct interpretation for a reflexive is costless than the other competing interpretation. Suppose that children select the interpretation which can be obtained in the cheaper way when they cannot find out which one of competing interpretations is appropriate. Then, we can explain why they allow a local antecedent to bind a pronoun. One might ask whether children really compare two representations when they interpret a pronoun. Certainly, their tendency to select a local antecedent can be explained even if we assume that children do not access the coreference reading. However, we cannot explain why children can obtain the deictic

reading if children cannot access the processes relating C-I interface representations to the discourse storage. C&W reports that children occasionally interpret pronouns and reflexives as a sentence external reference. The amount of this type of incorrect responses ranges from 0% to 11.40% in the case of reflexives and it ranges from 0% to 13.30% in the case of pronouns. This fact indicates that children have ability to obtain the coreference reading since both of deictic and coreference readings can be obtained only by accessing the processes relating C-I interface representations to the discourse storage.[5] Let us then consider why children tend to succeed in interpreting reflexives. In contrast with the case of a pronoun, children might not fail to select an appropriate interpretation for a reflexive because the competition in interpreting it is more costless than the case of a pronoun. Even if they fail, they choose the interpretation obtained by the cheaper process. Therefore, they can interpret reflexives correctly no matter whether they fail or succeed in selecting an appropriate interpretation. In short, the difference in number of cross-modular operations and the economy in interpretation cause the DCBE. I consider that young children's tendency to coindex a reflexive with a nonlocal c-commanding antecedent supports the view that we compare two representations when we interpret a reflexive. Specifically, adults also access this interpretation but they do not adopt it because the interpretation violates the *Rule BV*.[6] However, young children's failure in interpreting reflexives raises a problem at the same time. If children consistently select a cheaper process, even young children should not coindex a reflexive with a nonlocal c-commanding antecedent. Therefore, we need to consider why young children fail to interpret reflexives. In the following section, I will demonstrate that the analysis to the delay of the Condition A Effects in Down Syndrome provides a solution to this problem.

3. Delay of the Condition A Effect in Down Syndrome

In an experiment designed to tap into knowledge of Binding in individuals with Down syndrome (DS), it is found that subjects have specific difficulties in assigning appropriate interpretation to reflexives, as opposed to pronouns. This pattern is the reverse of the DCBE. If

[5] One might ask why some children choose the deictic reading despite the fact that it is the costliest interpretation. It is true that the deictic reading itself relates with the costliest computation. However, it does not require the competition with other representations. Therefore, the deictic reading is much simpler than the non-deictic reading. I assume that even children who assign the deictic reading to pronouns and reflexives know the *Rule I* and the *Rule BV* but they do not know that these elements are targets of these rules.

[6] Trueswell, Sekerina, Mill, and Logrip (1999) argue that children cannot revise initial commitments to interpretation whereas adults are able to use relevant contextual factors to inform parsing commitments and possess the ability to revise early incorrect commitments to interpretation. I consider that this difference is also a crucial factor in the contrast between children and adults in the interpretation of pronouns.

language development in DS is simply delayed but essentially normal, then investigations of the availability of Binding in DS should demonstrate parallels to normal language development. However, Perovic (2002) reports that subjects with DS perform around chance level on conditions involving reflexives while they correctly reject locally bound pronouns and accept coreference interpretation almost 100% of the time. Based on this observation, he argues that the pattern shown in DS is not caused by the unavailability of a Binding Condition but rather a specific deficiency in establishing binding relations. Following Reinhart and Reuland's (1993) framework of the Binding Theory, he claims that the inability of subjects with DS to form A-dependencies in passive constructions supports his analysis. Interestingly, it is well known that normally developing children also have a difficulty in understanding passives. Following this finding, Borer and Wexler (1987) proposes the hypothesis termed "The maturation of A-chains", which roughly states that the ability to form A-chains matures only at around the age 4 or even 5 years.

Notice that both of the *Rule BV* and passive formation involve chain formation.[7] This fact suggests that the Maturation of A-chains Hypothesis explains why young children allow coindexization between the reflexives and the nonlocal c-commanding antecedent as well as the DCBE in DS. To be specific, inability of young children to form an A-chain force them to interpret the following representation as the bound pronoun structures even if the binding relation is encoded within C_{HL}.

(13) Oscar λx (x voelde (x wegglijiden))

If children do not need to compare the bound anaphor reading with the bound pronoun one when they interpret a reflexive, they might not be able to interpret it at all because of their deficiency in formation of A-chains. On the other hand, the analysis developed here correctly predicts that they show the tendency to allow *x* to be A-bound. Therefore, young children's behavior provides supporting evidence to the analysis presented in this paper.

Having established the evidential basis for the claim developed here, it is important to examine whether previous approaches can explain the facts presented in this section. The Lexical Learning Hypothesis adopted by C&W seems to explain young children's behavior successfully because they make mistakes in both cases of reflexives and pronouns. However, the fact that subjects with DS succeed in the experiments about pronouns almost 100% of the time might raise a problem to this hypothesis. If children's learning task is completed around the age of 6;0., a

[7] Specifically, passives require A-chains and reflexives need an A-CHAIN. This seems to indicate that passives and reflexives involve different operations. However, Reuland suggests that CHAINs can be reduced to chains.

subject with DS whose verbal mental age is under 6:0 should fail to interpret pronouns. R&R's analysis also fails to explain the DCBE in DS. They assume that the binding conditions and the *Rule I* are the principles of UG and that only *Rule I*-governed structures are beyond children's computational capacity. To explain the DCBE in DS, they need to make a contradictory hypothesis. That is, only Condition A-governed structures are beyond the computational capacity of subjects with DS. It might be possible to assume that binding conditions and the *Rule I* belong to the different modules (syntax and pragmatics, respectively). Following this assumption, children have a problem about pragmatics while subjects with DS are deficient in syntactic principles. This analysis still needs to explain why subjects with DS do not show deficiency in the interpretation of pronouns. It is not plausible to assume that they know the Condition B but they lack the Condition A because both of the Condition A and the Condition B are principles of the UG. Therefore, it seems that R&R cannot provide a solution to this problem under any assumption.

4. Ambiguity and Economy in Interpretation

We have seen that the children select the interpretation which can be obtained in the cheaper way when they cannot find out which one of competing interpretations is appropriate. The Economy Principle has an effect on interpretation as well when the competition is not beyond the computational capacity. It is well known that young children display a strong preference for the isomorphic interpretation over the non-isomorphic interpretation in the sentences containing negation and quantified noun phrase (Gualmini (2004), Lidz and Musolino (2002), Musolino (1998), Musolino, Crain, and Thornton (2000)). According to Gualmini (2004), children can access the non-isomorphic interpretation when negation is used felicitously and otherwise, they show the preference for the isomorphic interpretation. I consider that children compare two interpretations and then select the costless interpretation when the felicity condition is not satisfied. The isomorphic interpretation is more costless and therefore, it is preferred over the non-isomorphic interpretation since the latter interpretation requires some covert syntactic operation. In short, children's preference for the isomorphic interpretation reflects the effect of the Economy Principle. Tunstall (1997) and Villalta (2003) observes that even adults prefer the interpretation corresponding to the LF that minimally differs from the surface structure and argue that the parser obeys the Economy Principle. That is to say, the Economy Principle forces the parser to first compute the costless representation when the sentence is ambiguous. It is reasonable to consider that both of parser and syntax obey the Economy Principle since both of them are dominated by Faculty of Language. Therefore, these findings strongly support the current view that the linguistic expressions are the optimal realizations of the interface conditions, where optimality is determined by the economy conditions of UG (Chomsky (1995)).

5. Conclusion

I have argued that both of reflexives and pronouns require computation of two representations and that the Economy Principle governs their interpretations. Then, I have demonstrated that only the analysis presented in this paper can provide a unified account for the DCBE and the DCAE in DS. As for the DCBE, children know both of the *Rule I* and the *Rule BV* but the number of cross-modular operations affects their behavior. The cost posed by the process of acquiring coreference is beyond children's computational capacity. Concerning the DCAE in DS, subjects with DS know both of the *Rule I* and the *Rule BV* as well but their behavior is affected by their deficiency in establishing A-chains.

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