Opacity Condition and Syntactic Development in Children

Yukio Otsu
M.I.T.

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0. Introduction

The ultimate goal of developmental psycholinguistics is to explain the feat of the human child who, in almost all cases, succeeds in acquiring his mother tongue(s).[1] Recent advances in theoretical linguistics has revealed that the acquired grammar, which is essentially uniform among the speakers of a given community, involves abstract and complex structures. In addition, this feat is accomplised in a relatively short period of time based on data that are not always as neat as foreign language textbooks.

The transformational-generative tradition in linguistics has succeeded in discovering many linguistically significant generalizations. Recently, much work has centered on the problem of universal conditions imposed on grammar. It has been claimed that at least some of these universal conditions constitute part of the linguistic properties that are innate, namely, part of what Chomsky (1965 and other writings) calls the Language Acquisition Device, or the Universal Grammar. Since the Language Acquisition Device restricts the class of possible grammars available for the child, it facilitates explanation of the rapidity of language acquisition in relation to the complexity of the outcome, and also the uniformity of the outcome among the speakers of the same

language.

This paper takes up one such proposal about universal conditions imposed on grammar, namely, the Opacity Condition (OC), and examines experimentally when and how this condition comes to play a role in syntactic development in children, that is, when and how the child gets to know the existence of such a condition. We will briefly discuss the implications of our findings to linguistic theory and the theory of syntactic development in children.

1. Opacity Condition[2]

Chomsky (1973) proposed a set of conditions on transformations, two of which are: the Tensed S Condition (later called the Propositional Island Condition) and the Specified Subject Condition. In the course of the subsequent revision of the theory, these two conditions have undergone much revision, including terminological changes. In this paper, we will adopt a simplified version of Chomsky (1980), which is as follows:

(1.1) Opacity Condition (OC): In $\ldots[_{\beta} \ldots \alpha \ldots] \ldots$, if α is an anaphor in the domain of tense or the subject of β, then α cannot be free in β, β =NP or $\bar{S}$.

Included among the anaphors are reciprocals, PRO, trace, and bound pronouns, but not lexical NPs. The notion "free" is defined as follows:

(1.2) An anaphor α is bound in β if there is a category c-commanding it and coindexed with it in β; otherwise α is free in β. (Chomsky 1980:10)

The notion "c-command" is defined as follows:

(1.3) Node A c(onstituent)-commands node B if neither A nor B dominates the other and the first branching node which dominates A dominates B. (Reinhart 1976:32)

The notion "domain" is defined as follows:

(1.4) When α c-commands β, β is in the domain of α.

Let us take (1.5) to (1.8) for illustration. In each pair, (b) represents a partial syntactic structure of the corresponding (a)-sentence.

(1.5) a. Mary knows that the children love each other.
b. Mary knows $[_{\bar{S}}$ that the children love each other$]$

(1.6) a.*The parents know that Mary loves each other.
b.*the parents know $[_{\bar{S}}$ that Mary loves each other$]$

(1.7) a. Mary wanted the children to love each other.
b. Mary wanted [$_{\bar{S}}$ the children to love each other]

(1.8) a.*The parents wanted Mary to love each other.
b.*the parents wanted [$_{\bar{S}}$ Mary to love each other]

Consider (1.5) first. As is clear from (1.5b), its structure matches that in (1.1), where β is $\bar{S}$, and α is each other, which is in the domain of tense. Thus, the OC stipulates that each other cannot be free in $\bar{S}$, namely, each other must have its antecedent within $\bar{S}$ and that antecedent must c-command it. There is a possible antecedent which satisfies the c-command condition, namely, the children. Thus, (1.5) is grammatical. Let us consider (1.6). Here again, the structure matches that in (1.1), and β is $\bar{S}$, and α is each other. Therefore, each other must find its antecedent within $\bar{S}$ in accordance with the OC. However, in this case, there is no such potential antecedent of each other. The NP in the embedded subject position is Mary, which is not plural, and therefore it cannot be the antecedent of each other. Thus, each other remains as a free variable, and therefore (1.6) is excluded as ungrammatical by convention.

Now let us consider (1.7). Its structure matches that in (1.1), where β is $\bar{S}$, and α is each other, which is in the domain of the subject of $\bar{S}$, that is, the children. Therefore, the OC stipulates that each other cannot be free in $\bar{S}$. There is a possible antecedent which satisfies the c-command condition, namely, the children. Hence, (1.7) is grammatical. The same relationship shows for (1.8), except for the fact that there is no potential antecedent of each other in $\bar{S}$, because the subject of $\bar{S}$ this time is Mary which is not plural. Thus, as in (1.6), each other remains a free variable, and (1.8) is excluded as ungrammatical.

In this paper, we will only take up part of the OC, namely, cases in which β in (1.1) is $\bar{S}$ and α is each other. More materials will be included in Otsu (in preparation).

2. Hypothesis to Be Tested

Henceforth we assume the correctness of the account given in the previous section. In the tradition of language acquisition theories that identify language universals, at least partially, with innate knowledge, we now assume--for the purpose of partial experimental test--the innateness of the OC. But what does the "innateness" of the OC amount to? It might amount to the following:

(2.1) Once the child learns the reciprocal nature of each other and the complementation system in English (both of which are part of his knowledge about a particular grammar, that is, English), and acquires the

processing capacity to put this knowledge into use, he will always honor the OC.

Notice that (2.1) is not strictly implied even if we assume the innateness of the OC. For example, it is also logically possible that the emergence of the OC is maturationally conditioned and it appears later in development. Then even if the OC is innate, the learning of the reciprocal nature of each other and the English complementation system, and the acquisition of the relevant processing capacity would not be a sufficient condition for the emergence of the OC. See Otsu (in preparation) for more discussion. However, we choose, for test, the simplest hypothesis we can think of, that is, (2.1).[3]

In the experiment to be described in Section 4, we included (i) a test for whether young children honor the OC (to be called the OC test), and (ii) a test for whether they know the reciprocal nature of each other and the English complementation system (to be called the EOCS test). Hypothesis (2.1) makes the following prediction about our data.

(2.2) Those who pass the EOCS test will also pass the OC test.

Let us consider how those who fail in the EOCS test will do in the OC test. Since they cannot properly process the test sentences, they will respond randomly--if they respond at all. Thus, if we set a criterion for passing the OC test that far exceeds the probability of passing by random guess, then most of these subjects will not that satisfy that criterion. In fact, we rely on such high criteria in what follows. See Section 5.2. Therefore, we predict as follows:

(2.3) Those who fail in the EOCS test will also fail in the OC test.

Thus, if we classify the results of the experiment in a 2x2 contingency table in the following way, subjects should tend to fall in either the A or D cell:

EOCS \ OC	pass	fail
pass	A	B
fail	C	D

N

TABLE 1

Before we introduce our experiment, we will briefly look at a previous work on the children's interpretation of sentences containing each other reported in Matthei (1978). Considerations of Matthei's experiment will suggest methodological features of our own.

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3. Matthei's (1978) Experiment

3.1 Introduction. Matthei (1978) has taken up the OC[4], and conducted an experiment in order to test children's interpretation of complex sentences containing each other. His major concern is whether there is any developmental stage where the child does not honor the OC. Although his paper is a pioneering study about the relationship between universal conditions imposed on grammar and syntactic development in children, there are some problems in it. We will summarize Matthei's study and point out its problems.

3.1 Brief Description of Matthei's (1978) Experiment

3.1.1 Subjects. The subjects were 17 children ranging from 4;2 (4 years and 2 months) to 6;6 years of age.

3.1.2 Methods and Materials. A row of toy animals and people was set up between the child and the experimenter. There were two of each animal. The child was asked to show the experimenter "what happened" by taking the animal mentioned in the sentence and "making them do it." After a practice session using simple, declarative sentences and one-clause sentences containing reciprocals, the test sentences were given to the subject. As test sentences, four types of matrix verbs, each of which takes a different kind of complement, were used. The following is a list of the four types with examples.

(3.1) a. Verbs that take that complement:
The horses said that the cows jumped over each other.

b. Verbs that take "deleted" that complement:
The horses said the cows jumped over each other.

c. Verbs that take infinitival complement:
The horses wanted the cows to jump over each other.

d. Verbs that take gerundive complement:
The horses noticed the cows jumping over each other.

The inclusion of these various types of matrix verbs was to test whether or not the choice of the matrix verb makes any difference about the interpretation of the test sentences, and, in particular, whether or not the presence of a complement marker, that and to, for example, would help children to apply the OC correctly since such markers would signal the beginning of the embedded clause.

Matthei found in his pilot experiment that the children appeared to find it easier to understand reciprocals when the antecedent is a coordinate NP, the cow and the chicken, for example, than when the antecedent is a simple, namely, non-coordinate, plural NP, the pigs, for example. Based on this observation, Matthei varied the subject NPs in both the matrix clause and the embedded clause so that some were simple plural NPs while others were coordinate NPs.

In order to avoid the "language-as-fixed-effect fallacy" in the sense of Clark (1973), verbs in both the matrix and the complement were inserted randomly into sentence frames so that each child received a different set of sentences.

3.1.3 Results. 64.4% of the total number of responses were ones in which the children would interpret a sentence like (3.2) as meaning that the pigs tickled the chickens and vice versa.

(3.2) The chickens said that the pigs tickled each other.

There was no significant effect of complement types on the children's responses.

3.1.4 Conclusion. Matthei interprets the children's mistake mentioned in the previous subsection as showing that they chose the matrix subject as the antecedent of each other, violating the OC.

3.2 Problems. There are several problems in Matthei's study. In the following, we will claim (i) that his results do not support his conclusion, and (ii) that there are various problems in his experiment.

Matthei's conclusion, which we mentioned in 3.1.4, is factually false. If the child had wrongly taken the matrix subject, the chickens in (3.2), as the antecedent of each other, then the resulting interpretation of (3.2) would be analogous to that of (3.3).[5]

(3.3) Each of the chickens said that the pigs tickled the other.

Thus, if there are two chickens, call them C_1 and C_2, then C_1 said that the pigs tickled C_2, and C_2 said that the pigs tickled C_1. This is not what Matthei's subjects did.

There are other problems. First, a glance at the list of matrix verbs used in the experimental materials reveals that many of them are not factive verbs, for example, say, think, expect, ask, imagine, suggest, and so on. Thus, (3.4) is a perfectly legitimate sentence.

(3.4) The chickens said that the pigs tickled each other, but $\left\{\begin{array}{l}\text{it was not true}\\ \text{that did not happen}\end{array}\right\}$.

Compare (3.4) with the following in which a factive verb remember is used as the matrix verb.

(3.5) *The chickens remembered that the pigs tickled each other, but {it was not true / it did not happen}.

Yet, the instruction given to the subject was to show the experimenter what happened by making the animals do it. Therefore, if the subject knows the factive-nonfactive distinction and is loyal to it, it is conceivable that he would be confused with the instruction.[6]

Second, Matthei used coordinate NPs in some of the test sentences--the reason for which we mentioned before--such as the following:

(3.6) The chickens remembered that the pig and the lamb tickled each other.

However, there are two of each animal in front of the subject, and there is no information given to him as to decide which is, for instance, the pig. Maratsos (1976) shows that even the youngest of his subjects, 32 months old, has some knowledge about the difference between definite and indefinite reference. Thus, it is conceivable that the child who knows the definite property of the would have been confused by the instruction.

Third, we have learned from our pilot experiments that some, if not most, children attempt to act out the matrix portion as well as the embedded portion when the instruction is simply "show me what happened." Thus, if the given sentence is (3.7):

(3.7) The lambs saw the chickens jump over each other,

some subjects attempt to act out the seeing portion as well as the jumping portion. This sometimes happens even if the matrix verb is such as think whose meaning is quite difficult to act out if not impossible. Since what Matthei wanted to know was, for example in (3.7), who jumped over whom, his instruction is not an appropriate one.

The combination of these problems in Matthei's experiment might have confused the subjects and made the task far more complicated than it should have been.

4. Method

4.1 Subjects. We tested twenty-four subjects between 4;4 and 6;10 years of age. We had eight subjects for each age group. They were all monolingual native speakers of English without any apparent language disorders.

4.2 Experimenters. Two native speakers of English conducted the experiment.

4.3 Task. The task is toy-moving, namely, the subject is asked to answer a question, which follows each sentence, by manipulating the toys located on the table in front of him.

4.4 Materials and Procedure. The experiment was conducted at the children's own day care centers and schools. Subjects were tested individually. The experiment took seven to fifteen minutes per subject.

The following toy animals were used: two lions, two cows, two horses, two elephants, one zebra, one bear, one giraffe, and one camel. These are made of plastic, and are easily identifiable and manipulable. The reason for having only one for some animals is that some of the NPs in the sentences used in the experiment are coordinate NPs each of whose conjuncts is singular, for example, the camel and the zebra. As we pointed out earlier, if there are two camels and two zebras in front of the subject, and he is given a sentence like (4.1) without any information as to which of the camels is the camel and which of the two zebras is the zebra, the subject would become confused.

(4.1) The horses remembered that the camel and the zebra jumped over each other.

Thus, we decided to use only one toy for some kinds of animals in order to avoid this problem.

The subjects was asked to identify each animal before the test, and passing this portion is the prerequisite for participating in the test. In fact, none of the subjects failed in this task.

All the animals were kept within a paper-made fence, and each time a sentence was given to the subject the animals that appear in the sentence plus two extra animals were put in an array in front of the subject. For example, when (4.2) was given:

(4.2) The camel and the bear saw the cows pat each other,

there were a camel, a bear, two cows, and two extra animals, for example, two horses, or a zebra and a giraffe, in front of the subject.

Next, there were two practice sentences which test the subject's knowledge about the reciprocal nature of each other. One of these sentences has a simple, that is, non-coordinate, plural NP as the antencedent of each other as in (4.3), and

the other a coordinate NP as in (4.4):

(4.3) The cows jumped over each other.

(4.4) The camel and the zebra pushed each other.

The sentences are both simplex ones. The practice session is not only for testing the subject's knowledge about the reciprocal nature of each other, but also for letting the subject know that he need not use all the animals in front of him when he acts out the sentence.

The test items consist of ten sentences. The matrix verbs used are of the following five kinds, and there are two sentences of each kind:

(4.5) a. Verbs that take overt that complement:
remember, learn

b. Verbs that take "deleted" that complement:
know, forget

c. Verbs that take infinitival complement:
want, expect

d. Verbs that take gerundive complement:
notice, find

e. Perception verbs:
see, hear[7]

Notice that all these verbs except for those in (4.5c) are factive verbs. In the case of the latter among which there are no factive verbs, we added the clause "...and that's what happened" at the end of the sentence as in (4.6) thereby ensuring that the incident stated in the preceding clause did actually happen.[8]

(4.6) The lions wanted the cows to jump over each other, and that's what happened.

This eliminates another problem of Matthei's experiment discussed in the previous section.

Among the two sentences for each kind of complement types given in (4.5), one has a simple, namely, non-coordinate, plural NP as the matrix subject and a coordinate NP as the embedded subject as in (4.7). The other sentence has a coordinate NP as the matrix subject and a simple plural NP as the embedded subject as in (4.8):

(4.7) The lions remembered that the camel and the bear jumped

over each other.

(4.8) The zebra and the giraffe learned that the horses patted each other.

We did this because Matthei reports that the child tends to associate each other more often with a coordinate NP than with a simple plural NP, if everything else is equal.

The verbs which we used in the embedded clause are the following:

(4.9) jump over, pat, push, tickle[9]

If the results show that the subject chooses the embedded subject as the antecedent of each other, there is an alternative explanation, not invoking the OC. Namely, one can claim that the child is following the strategy (4.10) rather than the OC.

(4.10) Choose the closest plural NP as the antecedent of each other.[10]

In order to test whether or not this is the correct account, we added the two types of sentences exemplified in (4.11) and (4.12) as controls:

(4.11) The lions next to the horses jumped over each other.

(4.12) The lions that the horses pushed patted each other.

In both cases, the horses, despite the fact that it is closer to each other than the lions, cannot be the antecedent of each other. Instead, the lions is the correct antecedent. Therefore, if the child is following (4.10), he will choose the horses as the antecedent of each other, while if he is following the OC, he will correctly choose the lions as the antecedent. Thus, these sentences provide a good test whether the child is following the OC or a strategy based on distance.

Recall that we pointed out earlier that the instruction "show me what happened" is confusingly vague for the subject. Hence, we made the instruction more specific, namely, "show me who V-ed who(m)."[11] In the V-ed position, an appropriate verb form which corresponds to the embedded verb is used. Look at (4.13) for illustration:

(4.13) The lions knew that the zebra and the bear pushed each other.
(Instruction) Show me who pushed who.

No subject showed any difficulty in understanding this multiple

wh-instruction.[12]

In the pilot experiments, we used only these test sentences and controls. We learned that under such a situation the child quickly recognizes that the experimenter will not ask about the matrix clause, and develops a strategy to pay attention only to the embedded clause ignoring the matrix clause. Thus, we added five "catch sentences" whose structure is the same as the test sentences, for which we ask about the matrix clause. For example:

(4.14) The cows saw the bear and the giraffe tickle each other.
(Question) Tell me who saw the tickling.

Thus, we have two practice sentences, ten test sentences, two controls, and five catch sentences. The order of the test sentences and controls was randomized. The positions of the catch sentences were fixed (2,5,8,10,14). The verbs and nouns in all the sentences used in the experiment are arranged randomly from subject to subject in order to avoid the "language-as-fixed-effect fallacy." A list of these sentences is given in Appendix 1.

5. Results and Discussion

The results of the experiment are given in Appendix 2.

5.1 Relatively Immature Subjects.

All the subjects could make the two lions jump over each other when there only these animals in front of them and they were given a practice sentence like (5.1):

(5.1) The lions jumped over each other.

The same thing happened when the subject NP was a coordinate NP. However, subjects 1, 3, and 6 failed when there was an extra animal in addition to the two crucial animals in front of them. They made, for instance, each of the lions jump over the extra animal, and not each of the lions jump over the other, when there were two lions plus an extra animal and they were given (5.1). The same happened when the subject NP was a coordinate NP.

For these subjects, each other means each. Thus, (5.1) would be equivalent to (5.2):

(5.2) The lions each jumped over something.

Therefore, when there are only two lions in front of them, they make each of the lions jump over the other, because there is nothing else over which it can jump. However, when there is an extra animal, say a zebra, they would make each of the lions jump over the zebra. These subjects represent the earliest developmental stage in our sample. In the following discussion, these relatively immature subjects will not be considered.

5.2 Errors in the Catch Sentences. The errors in the catch sentences, for which the experimenter asked about the matrix subject, were either simply to fail to give an answer, to act out using toy animals as if they were test sentences, or to give a wrong answer by picking up the embedded subject. Thus, given (5.3), some subjects either kept silence, made the camel and the zebra jump over each other, or answered "the camel and the zebra (did)."

(5.3) The lions remembered that the camel and the zebra jumped over each other.
(Question) Tell me who remembered the jumping.

We take the failure in this task as showing that the subject does not have sufficient capacity to process the type of sentences we tested, namely, sentences of the form matrix clause + one embedded clause. More elaborate discussion on this point will be found in Otsu (in preparation).

5.3 Analyses Used to Test the Hypothesis. To test the hypothesis mentioned in Section 2, we tabulated 2x2 contingency tables, as in Tables 2 and 3.

Catch Ss \ Test Ss	pass	fail	
pass	80	9	89
fail	3	13	16
	83	22	105

TABLE 2

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Catch Ss \ Test Ss	pass	fail	
pass	13	1	14
fail	3	4	7
	16	5	21

TABLE 3

These tables display the degree of association between success with the test sentences and success with the catch sentences. In Table 2, each of the 105 cases in Appendix 2 (21 subjects x 5 complement types) is considered. Here, unless a subject got both of the test sentences for each complement type correct, he is considered to have failed. Since there is only one corresponding catch, the criterion for passing is to get it right. Table 3 treats the results more grossly. Here, a subject is considered to have passed the test sentences task if he answereed nine out of the ten test questions correctly. Nine out of ten right is a performance unlikely to be due to chance, having a probability of .011 by the binomial test. A subject is considered to have passed the catch task if he took all the five catch sentences right. Five out of five right has a probability of .031 by the binomial test.

As we discussed in Section 2, by our hypothesis, the children in our sample should tend to fall in either the pass-pass or the fail-fail cell. We can determine whether the patterns found differs from chance expectation by means of chi-square or Fisher test.

5.3 Results of the Analyses. The association between success with the test sentences and success with the catch sentences, shown in Table 2, is significant at the .05 level (χ^2=37.25, 1df) with Yates' correction for continuity. The same association, shown in Table 3, is also significant at the .05 level (p=.025, Fisher test).

5.4 Distance Strategy. Given these results, someone might claim that the subjects who succeeded in the test task were simply choosing the closest plural NP as the antecendent of each other, not depending on such a structural principle as

the OC. It is for testing such a claim that we added control sentences. As is clear from the Appendix 1, the acquisition of the structure $[_{NP}$ NP $[_{PP}$ P NP$]]$ (e.g., the lions next to the tigers) and (SO) relative clauses seems to take place almost at the same time as the acquisition of sufficient capacity to process the test and catch sentences. However, the results show that all of the 16 children who are classified to have passed the test task in Table 3, except subjects 2 and 13, picked up the correct antecedent of each other for at least the control sentence(s) whose structure they appeared to have acquired. If they were following the "distance strategy" mentioned above, they should have failed in all these control cases.[13]

6. Conclusion

The results of our experiment show that there is a developmental sequence as follows:

(6.1) a. each other = each

b. learning of the reciprocal nature of each other

c. learning of the English complementation system and acquisition of the corresponding processing capacity

d. From now on, the child always honors the OC.

This obtained sequence is consistent with our hypothesis (2.1) and thus provides strong support for Chomsky's conjecture that the OC is part of the innate schematism for language acquisition. Of course, we have not proved the innateness of the OC. However, the finding that once the child masters reciprocals and the English complementation system, he immediately honors the OC gives empirical support for that claim that the OC is innately programmed in the child.

7. Footnotes

*This is a preliminary version of part of a chapter of Otsu (in preparation). I would like to thank Susan Carey, Carol Chomsky, Noam Chomsky, Ken Hale, Ed Matthei, Dan Osherson, Tom Roeper, and Marianne Phinney for their comments on the earlier version. I would also like to thank various day care centers and schools (Laboure Center, Salvation Army, Wee Folks, Wee Care, Fun-for-All) for allowing us to conduct this study, including the pilot experiments, with their children. I would like to acknowledge Doremy Tong and Debbie Pekala for conducting the experiment. This study is based on work supported by the National

Science Foundation under Grant No. BNS-7923098.

[1]For the sake of readability, he will be used generically to refer to people of both sexes.

[2]This section is primarily for those who are not familiar with the Opacity Condition.

[3]Notice that our hypothesis (2.1) does not postulate any order between the learning of the reciprocal nature of each other and that of the English complementation system.

[4]Matthei's paper is based on, in large part, Chomsky (1973), and talks about the Tensed S Condition (TSC) and the Specified Subject Condition (SSC) discussed there. This difference in theoretical frameworks and terminologies does not affect the present discussion. See, however, Chomsky (1980:12,13) for the difference between the TSC and SSC on the one hand and the OC on the other.

[5]This was pointed out to me by Noam Chomsky.

[6]Although there is a growing literature concerning children's understanding of factivity, the issue of when the child becomes aware of factivity has not been settled. See Macnamara et al. (1976), Bennett and Falmagne (1977), Hopmann and Maratsos (1978), Scoville and Gordon (1980), and the references cited there.

[7]We could have added to this list the verbs that take bare infinitival complement, for example, help and make. This was pointed out to me by Tom Wasow.

[8]In the pilot experiments, we used the clause "...and that's what they did." However, as Tom Roeper has pointed out to me, the presence of a pronoun they might influence the result, and hence the change.

[9]There is a pragmatic constraint on the choice of these verbs. Namely, we were asked by the teachers to avoid "violent verbs" such as kick and hit.

[10]We assume that distance is defined on a terminal string, and not in terms of the number of branches between them, as in Rosenbaum's (1968) Minimum Distance Principle. See Otsu (in preparation) for discussion.

[11]Whom was used only after jump over.

[12]Marianne Phinney and Ed Matthei have pointed out independently that by saying "show me the pushing" for (4.13),

for example, we can avoid using the multiple wh-instruction.

[13] White (1979) gives the following explanation to Matthei's (1978) results:

> [S]uppose that in learning "each other" the child has to realize that it is reciprocal and anaphoric (referring to an antecedent) and bound (controlled by that antecedent). In that case, it is possible that the child reaches a stage where he knows that "each other" is reciprocal and anaphoric but does not realize that it is bound. (p.38)

Thus, such a child will treat each other as ordinary pronouns. He will consider each other in (i) just like them in (ii):

(i) The lions remembered that the tigers jumped over each other.

(ii) The lions remembered that the tigers jumped over them.

Note that the application of the Disjoint Reference rule in the sense of Chomsky (1975 and other writings) to the lions and them in (ii) is blocked because of the OC. Therefore, White claims that since the child in that developmental stage treats each other in (i) like them in (ii) he will pick up the lions as the antecedent of each other in (i) just like them can be coreferential with the lions in (ii). She continues:

> This explains the case of the pigs being made to tickle the chickens [for the chickens want the pigs to tickle--YO]. The fact that the children also made the chickens tickle the pigs suggest they have some understanding of the concept of a reciprocal. [Emphasis added--YO] (p.39)

This is a totally unacceptable explanation, since the child's mistake in question is not taking the matrix subject as the antecedent of each other as we pointed out in Section 3.

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Appendix 1: Sentences Used in the Experiment*

Practice Sentences:

1. The lions jumped over each other.
2. The zebra and the bear tickled each other.

Test Sentences:

3. The lions remembered that the bear and the zebra jumped over each other.
4. The zebra and the bear learned that the horses patted each other.
5. The lions knew the camel and the bear tickled each other.
6. The zebra and the camel forgot the lions pushed each other.
7. The horses wanted the giraffe and the bear to pat each other, and that's what happened.
8. The giraffe and the camel expected the horses to jump over each other, and that's what happened.
9. The elephants noticed the bear and the zebra pushing each other.
10. The bear and the giraffe found the lions patting each other.
11. The elephants saw the camel and the bear jump over each other.
12. The giraffe and the camel heard the lions push each other.

Control Sentences:

13. The lions next to the horses pushed each other.
14. The horses that the lions jumped over patted each other.

Catch Sentences:

15. The giraffe and the bear remembered that the horses pushed each other.
16. The elephants knew the zebra and the giraffe tickled each other.
17. The horses wanted the bear and the zebra to pat each other, and that's what happened.
18. The bear and the zebra noticed the elephants jumping over each other.
19. The camel and the bear saw the horses push each other.

*The verbs and nouns in all the sentences used in the experiment are arranged randomly.

OPACITY CONDITION AND SYNTACTIC DEVELOPMENT IN CHILDREN

YUKIO OTSU

Appendix 2: Results of the Experiment

Subjects		Practice		Test Sentences															
				that			φ			to			ing			perception		
No.	Age	①	②	③	④	⑬	⑤	⑥	⑯	⑦	⑧	⑰	⑨	⑩	⑱	⑪	⑫	⑲
1	4:4					V			V									
2	4:7	V	V	V	V	V	V	V		V	V		V	V	V	V	V	V
3	4:8			V		V	V	V	V	V		V			V	V	V	V
4	4:9	V	V	V	V	V	V	V	V	V	V		V	V	V	V	V	V
5	4:9	V	V								V							V
6	4:10						V						V					V
7	4:10	V	V															V
8	4:11	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
9	5:3	V	V					V				V	V	V	V			V
10	5:3	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
11	5:5	V	V		V				V		V				V		V	V
12	5:6	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
13	5:6	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
14	5:8	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
15	5:10	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
16	5:10	V	V	V	V	V	V	V	V			V	V	V	V	V	V	V
17	6:3	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
18	6:4	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
19	6:4	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
20	6:4	V	V		V	V	V	V	V	V	V	V	V	V	V	V	V	V
21	6:6	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
22	6:6	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
23	6:6	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V
24	6:10	V	V	V	V	V	V	V	V	V	V	V	V	V	V	V		

Notes:

1. V indicates success. Blank indicates failure.
2. Circled numbers at the top of the above table corresponds to the sentence types exemplified in Appendix 1.
3. For the error patters, see Appendix 3.

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Appendix 2 (cont.)

Controls		Errors	Subject No
(13)	(14)		
		A, B, C	1
			2
		A, C	3
V			4
		A	5
		A, C	6
		A, B, C	7
V			8
	V	A	9
V	V		10
		A, B, C	11
V			12
			13
	V		14
	V		15
V	V	B	16
V	V		17
V	V		18
V	V		19
V		C	20
V	V		21
V	V		22
	V	C	23
V	V		24

Appendix 3: Error Patterns

A3.1 Errors in the Practice Sentences. See 5.1.

A3.2 Errors in the Test Sentences. There are three types of errors. First, some subjects failed to act out the reciprocality, although they succeeded in the practice sentences. For example, given (A1):

(A1) The lions remembered that the zebra and the camel jumped over each other,

they failed to make each of the zebra and the camel jump over the other, and made instead either the zebra or the camel jump over the other. This type of error is indicated as A in the error column of Appendix 2.

The second type of error is to take the first conjunct of the coordinate matrix subject and the embedded subject, or the matrix subject and the second conjunct of the coordinate embedded subject, and make them jump over each other, for example, depending on the form of the given sentence. For instance, given (A2) and (A3):

(A2) The camel and the zebra remembered that the lions pushed each other,

(A3) The lions remembered that the camel and the zebra pushed each other,

some subjects made the camel and the lions push each other for (A2), and made the lions and the zebra push each other for (A3). This type is indicated as B in Appendix 2.

The third type is to take the matrix subject and make them do the action among themselves. For example, given (A2), some subjects made the camel and the zebra push each other. This is indicated as C in Appendix 2.

We should note here that in most of the cases the subjects repeated the given sentences spontaneously, and their repeated version correctly matched what they acted out using toy animals. Thus, some children repeated (A2) as "the camel and the zebra pushed each other," and made the type C error.

A3.3 Errors in the Control Sentences. The errors in all the cases were to make the lions, for example, jump over each other, given (A4) or (A5):

(A4) The tigers next to the lions jumped over each other.

(A5) The tigers that the lions patted jumped over each other.

A3.4 Errors in the Catch Sentences. See 5.2.