Quantifier/Variable-Binding: the Epsilon Account vs. the Conjunctive Paraphrase Account

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YoungEun Yoon. 2001. Quantifier/Variable-Binding: the Epsilon Account vs. the Conjunctive Paraphrase Account. *Language and Information 5.2*, 9–20. Barker (1997) has argued that all the three approaches to anaphora, namely, E-type theories, Discourse Representation Theory, and Dynamic Semantics, are faced with the so-called 'double-bind' problem in the quantifier/variable-binding model of anaphora. Recently, in the same journal, Slater (2000) has claimed that the so-called epsilon account (Slater 1991, 1993, 1994, 1997) handles the problem without any difficulty. However, it will be proposed in this paper that the epsilon account has its own problems in handling the quantifier/variable-binding, and that as argued in Yoon (1998), the so-called 'conjunctive paraphrase' account is the correct solution to the problem, which is intuitively supported as well. **(Ewha Womans University)**

1. Introduction

I have shown in a recent paper (Yoon 1998) that the so-called 'double-bind' problem does not arise in the quantifier/variable-binding model of anaphora if Barker's (1997) troubling data as in the following are handled by the 'conjunctive paraphrase' approach:

(1) If a theory is classical, then if it is inconsistent,
it is usually trivial.

(2) If a donkey is Andalusian, it has a good disposition.
If it likes farmers, it is usually perfectly placid.

Barker (1997) argues that in the above examples, one same variable, 'a theory' in (1) and 'a donkey' in (2) respectively, is bound by two different quantifiers, namely, implicit universal quantifier *always* and explicit *usually*, so the problem of the so-called 'double-bind' or 'otiosity of quantification' problem arises.

Suppose a situation in which all the inconsistent classical theories, say, 10 theories, are trivial except for one theory. In this situation, (1) is intuitively true, but none of the three theories of anaphora, E-type theories, DRT, nor Dynamic Semantics, predicts it. For instance, according to DRT, we are supposed to calculate whether most of the cases(because of the quantifier 'usually') of each of the 10 inconsistent theories are trivial or not. However, there doesn't exist more than one case in each inconsistent theory, in

* This work has been produced as part of the research results of the Brain Korea 21 Project. I would like to thank two anonymous reviewers of this journal for their detailed comments.
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the first place. If an inconsistent classical theory is trivial, that counts as a verifying case, and if not, that one case is enough to falsify (1), since the variable 'a theory' is universally quantified. This is why the double-bind problem is also called 'otiosity of quantification' problem. The second quantification, 'usually,' is useless.

On the other hand, in a more recent paper, Slater (2000) has claimed that the epsilon account successfully solves the double-bind problem by using choice functions, which can have a referring function back to quantifier antecedents, but are not bound by them. However, this account is not only incapable of solving the problem, but also generates its own problems in terms of quantifier/variable-binding by using probability operators.

In the following sections, all these issues will be discussed including the conjunctive paraphrase account, which is proposed to be the correct account, intuitively as well as empirically.

This paper is organized as follows: In section 2 the double-bind problem will be presented more in detail with the troubling data. In section 3 Slater's epsilon account will be introduced, and some crucial problems of his theory will be discussed. In section 4 it will be reemphasized that the double-bind problem should be accounted for by the conjunctive paraphrase approach, as argued by Yoon (1998).

2. Double-Bind Problem in Quantified Sentences

According to Barker (1997), E-type theories, DRT, and Dynamic Semantics do not provide an appropriate account for the following anaphoric relations:

(3) If a theory is classical, then if it is inconsistent, it is trivial.

The 'numberless description' approach (Neale 1990a,b), a revised version of the classical E-type approach, assigns (3) the following two readings, depending on whether the first 'it' in (3) goes proxy for either a singular or a numberless definite description:[1]

(3a) If [an x: theory x](classical x), then if [the x: theory x $\wedge$ classical x](inconsistent x), [the x: theory x $\wedge$ classical x $\wedge$ inconsistent x](trivial x).

(3b) If [an x: theory x](classical x), then if [whe x: theory x $\wedge$ classical x](inconsistent x), [whe x: theory x $\wedge$ classical x $\wedge$ inconsistent x](trivial x).

Neither (3a), which is the reading obtained by the classical E-type analysis, nor (3b) is a correct reading. (3a) induces a counterintuitive uniqueness implication, while (3b), which

1. As well known, the classical E-type theory derives a counter-intuitive 'uniqueness' implication as in the following example:

   Every man who owns a dog takes it for a walk every morning.

   According to the theory, the above example is a generalization about the men who own 'exactly one' dog each. However, intuitively, it could also include those men who own more than one dog.

   To solve this problem, Neale (1990a,b) proposes the 'numberless description' approach, which analyzes the definite description to have both 'unique singular' and 'numberless' interpretations. The term 'numberless' means that the first 'it' in (3), for example, could indicate one or more than one entity.

   In (3b), '[whe x: theory x]' represents a numberless description:

   '[whe x: Fx](Gx)' is true iff $|$ F-G $| = 0$ and $|$ F $| \geq 1$

   Hence, '[whe x: theory x]' means that 'one or more than one theory.'

is an additional reading proposed to remedy the uniqueness implication problem, generates an unwanted overgeneralization that its second *if*-clause amounts to be incorrectly interpreted in such a way that all classical theories are inconsistent.

Barker further argues that the E-type analysis also cannot account for the double-bind problem involved in inter-sentential examples like the following:

(4) If a theory is inconsistent, it is not necessarily trivial. If it is classical, it will be.

(5) If a theory is inconsistent, it is not necessarily trivial. If it is classical, usually it will be.

According to another refined version of the classical E-type analysis, namely, the 'implicit situation quantifier' approach (Berman 1987, Heim 1990), the second sentence of (4) is interpreted as the following with an additional 'accommodation' process:

(4a) [Always$_s$: if-(a theory is inconsistent in s)]([Always$_f$: if-(the unique theory in s is classical in f)]($\exists$ f^*[the unique inconsistent classical theory in f is trivial in f^*])).

(4a) is problematic in that for each situation s that satisfies *a theory is inconsistent in s*, there will be at most one extension of it, f^*, that satisfies *the inconsistent theory in s is classical in f*. In other words, the second universal quantification is useless. Despite this otiosity problem, the truth conditions of (4a) come out correct.

However, example (5), which contains a quantifier *usually*, does not escape from this problem:

(5a) [Always$_s$: if-(a theory is inconsistent in s)]([Usually$_f$: if-(the unique theory in s is classical in f)]($\exists$ f^*[the unique inconsistent classical theory in f is trivial in f^*])).

Given a situation in which all the inconsistent classical theories except, say, Theory A, are trivial, sentence (5) is intuitively true while (5a) is false. For (5a) to be true, for each s that satisfies *a theory is inconsistent in s*, if there are extensions f satisfying *the inconsistent theory in s is classical in f*, then most of such fs must have extensions f^* in which the theory is trivial. However, where s is Theory A's being inconsistent, and f is Theory A's being classical, there is no appropriate extension f^* in which it is trivial. Hence (5a) is false. This is the so-called 'double-bind' problem.

Barker (1997) claims that the dynamic approach also has a similar problem. Another example of intra-sentential anaphoric relations, (6), is interpreted as in (6a) by Dynamic Predicate Logic:

(6) If a theory is classical, then if it is inconsistent, it is usually trivial.

(6a) $\exists$ x[theory(x) $\wedge$ classical(x)] $\rightarrow$ [inconsistent(x) $\rightarrow_{usually}$ trivial(x)].

The variable in the *if*-clause 'inconsistent(x)' is not bound by an existential quantifier, and the dynamic effect of the existential quantifier does not exist. If the variable 'inconsistent(x)' is dynamically bound by the existential quantifier, then the double-bind problem does not arise since the two existentially bound variables, namely, 'classical theory(x)' and 'inconsistent(x)', are quantified over by 'usually.' However, in (6a), the 'classical theory(x)' is quantified over by the implicit universal quantifier while the 'inconsistent(x)' is by the overt adverbial quantifier 'usually.' Consequently, (6a) is false in a situation in which all inconsistent classical theories except for, say, Theory B, are trivial, which leads to the double-bind problem.

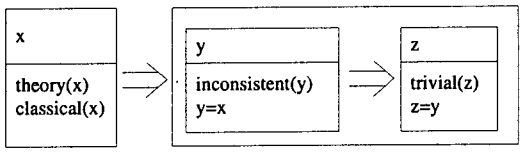
DRT is also argued to have the same problem. Consider the following examples (7) and (8), which have been repeated from (3) and (1) respectively:

(7) (7=3) If a theory is classical, then if it is inconsistent, it is trivial.

(8) (8=1) If a theory is classical, then if it is inconsistent, it is usually trivial.

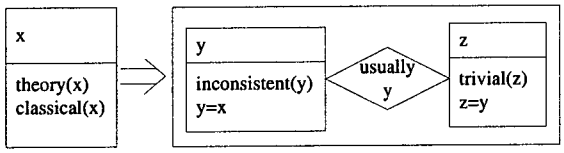
First, consider (7), which is argued to be analyzed as the following by DRT:

(7a)



Although the truth conditions of (7a) are correct, similar to (4a), the quantification introduced by the second arrow is restricted to one case, which leads to the quantification otiosity problem. However, in (8a), which is the interpretation of (8), the correctness of the truth conditions no longer holds.

(8a)



To summarize, Barker (1997) argues that the double-bind problem is a common problem in the quantifier/variable-binding model of anaphora. However, it will be shown in section 4 that double quantification does not occur in quantified sentences such as (7), (8), (4), and (5), and that the conjunctive paraphrase analysis provides an appropriate account for this phenomenon.

Before the conjunctive paraphrase account is presented, the fallaciousness of the epsilon theory, which Slater (2000) argues adequately accounts for the double-bind problem, will be discussed in the following section.

3. Slater's Epsilon Account

The basic idea of the epsilon theory (Slater 1991, 1993, 1994, 1997) is that the kinds of anaphora in examples such as (7), (8), (4), and (5) should be analyzed by using certain choice functions, i.e., epsilon terms, not by using binding relations on variables.

To take an example, the first sentence in (9) is analyzed as in (9a) and the whole discourse (9) is analyzed as in (9b) by the epsilon account:

(9) There is an old man. He is a philosopher.

(9a) $(Ex)(Mx.Ox) \equiv M \in x(Mx.Ox)$

(9b) $(Ex)(Mx.Ox).P \in x(Mx.Ox)$

The classical E-type analysis would have 'he' in (9) go proxy for a definite description, which brings a counterintuitive uniqueness implication. Differently from this analysis, the

epsilon theory relies on a similar idea to Evans's reference-fixing rigid designator view. The epsilon account allows a choice of referent, so in (9) an epsilon term formulates the demonstrative description 'that old man,' which does not presume there is a determinate number of old men, here the unique old man.

If only the first sentence of (9) is taken into consideration, both the classical E-type and the epsilon analyses would give the same interpretation, as in (9a). Since the sentence does not contain any definite pronoun, the indefinite NP 'an old man' is interpreted existentially. As represented on the left in (9a), the E-type theory would have the variable 'an old man' bound by an existential quantifier while the representation given on the right in (9a) by the epsilon theory means 'that old man' chosen by a choice function from the set of one or more than one old man. Consequently, there is no difference in the two analyses in that the sentence is interpreted to mean that there exists one or more than one old man.

However, the two analyses crucially differ from each other when the second sentence of (9) is also considered. As pointed out above, 'he' in (9) would get the definite description analysis by the E-type theory so that (9) is interpreted to mean that there exists exactly one old man and the old man is a philosopher. On the other hand, the epsilon theory does not induce the problematic uniqueness implication. It analyzes (9) in such a way that there exists one or more than one old man and 'that old man' chosen by a certain choice function is a philosopher as represented in (9b).

So far so good. And yet, the problems of the epsilon account show up when Slater tries to apply the theory to intra- and inter-sentential anaphoric chains.

Following Ellis' (1996) argument, Slater argues that (10) and (11) are not equivalent:

(10) Every man who bought a donkey vaccinated it.

(11) If there was a man who bought a donkey, then he vaccinated it.

Only if an adverbial modifier like 'invariably' is added to (11), it is equivalent to the universal statement (10). Without this kind of adverbial quantifier, a conditional (11) means that it is probable that a man who bought a donkey vaccinated it. Therefore, the ratio of men who bought a donkey and vaccinated it among men who bought a donkey indicates the degree of probability. It is further argued that only the epsilon calculus can unify the probability and predicate calculi into a single calculus to be able to account for sentences like (11).

Slater also claims that the following two statements are not equivalent:

(12) (12=3) If a theory is classical, then if it is inconsistent, it is trivial.

(13) If a theory is classical and inconsistent, it is trivial.

According to Slater, (12) and (13) are equivalent only when both are attached with 'invariably.' Therefore, (12′) and (13′), which are argued to be tantamount to (12) and (13) respectively, do not mean the same thing:

(12′) Probably, if a theory is classical, then if it is inconsistent, it is trivial.

(13′) Probably, if a theory is classical and inconsistent, it is trivial.

Slater claims that (12′) should mean (12″) while (13′), (13″):

(12″) Most classical theories are either consistent or trivial.

(13″) Most classical inconsistent theories are trivial.

However, intuitively, (12″) is not the reading we obtain from (12′), since if the correlation between a classical theory's inconsistency and triviality is not asserted by (12′), then there is no point in uttering the second *if*-clause and the consequent in (12′). In other words, since (12″) does not assert any correlation between a classical theory's inconsistency and triviality, more than half of the classical theories' being consistent is enough to satisfy its truth, which is counterintuitive.

Now, consider an example from Slater (2000) in which an overt adverbial quantifier *usually* is involved:

(14) If a donkey is vaccinated, then if it has a vitamin deficiency it usually faints.

Slater argues that although Berman and Heim's theory fails to account for examples like (14), his epsilon theory provides a successful account as follows:

(14′) Always [(Ex)(Dx.Vx)⊃ Usually {N∈x(Dx.Vx)⊃F∈x(Dx.Vx)}]

Slater argues that if standard probability theory is used to analyze the quantification over the epsilon expressions, we can get the right truth conditions without much difficulty. According to him, (14′) means that "for every vaccinated donkey the probability is high that it faints if it has a vitamin deficiency" (Slater 2000: 318).

However, first, it is not clear where the universal quantification in (14′) has come from, since only when overt adverbial modifier 'invariably' is added, is universal quantification argued to be obtained in a conditional sentence like (14), which is an 'indefinite proposition' in Ellis' terms (Ellis 1996: 148). That is, it is not clear how the probability operator works in conditional sentences.

Second, (14′) is not the widely-accepted intended reading of (14). What (14) states instead is that in most cases of vaccinating a donkey which has a vitamin deficiency, it happens that the donkey in each case of vaccination faints.[2]

Slater further argues that if the quantifiers are inverted in (14′) as in the following, we get the reading that for many a vaccinated donkey there is certainty that it faints if it has a vitamin deficiency:

(14″) Usually [(Ex)(Dx.Vx) ⊃ Always {N∈x(Dx.Vx)⊃F∈x(Dx.Vx)}]

First, however, Slater does not give the conditional sentence which would get reading (14″), and there does not exist any acceptable candidate sentence with a sequence of quantifications *usually* and *always* in that order:

(15) Usually, if a donkey is vaccinated, then if it has a vitamin deficiency it (?*always) faints.

(16) If a donkey is vaccinated, then usually if it has a vitamin deficiency it (?*always) faints.

(17) Most vaccinated donkeys that have a vitamin deficiency (?*always) faint.

2. I will shortly return to this point in the next section. It will be argued that in (14), only one adverbial quantifier *usually*, not two quantifiers, namely, implicit *always* and explicit *usually*, is involved

If the quantifier *always* is omitted from (15) or (16), it is interpreted as if one quantification is involved, not as if two quantifications, namely, overt *usually* and covert *always*, are involved. Similarly for (17), where a quantificational determiner *most* instead of *usually* is involved, neither covert nor overt *always* can be involved.

Second, similarly for (14″), Slater is not clear about the source of the universal quantification *always*. Without a modifier 'invariably,' the existence of the universal quantification cannot be explained.

Third, again, it is not the generally accepted reading of the sentence which involves a sequence of quantifications *usually* and *always* that *always* quantifies over the probability of each of many a vaccinated donkey which has a vitamin deficiency. Therefore, at least a persuasive explanation for adopting this new interpretation for quantified sentences should be given.

To summarize, in this section, it has been shown that Slater's epsilon theory combined with the probability calculus is problematic in several aspects. First, the function of the probability operator is not really well-defined. When and how the operator plays a role in a quantified sentence is not clearly explained. Second, related with the first problem, the relation between the probability operator and the implicit universal quantifier is not clear. As observed in (12, 12″) on the one hand and in (14, 14′) on the other hand, when either the probability operator or the implicit universal quantifier should be in operation in the sentence seems to be arbitrarily decided. All in all, the theory does not define systematically the mechanisms of the probability calculus. Third, the epsilon account predicts the existence of unacceptable quantified sentences such as (15-17).

In the next section, I will present the conjunctive paraphrase analysis, which is proposed to persuasively account for the so-called double-bind problem in the quantifier/variable-binding model of anaphora.

4. Pseudo Double-Bind Problem

Yoon (1998) proposes that Barker's double-bind problem does not exist in the first place. As can be observed in the following examples (18-21), more than one quantifier cannot be involved in one double-*if* clause sentence. Examples (18-21) represent the four possible combinations of the two quantifiers *always* and *usually*.[3]

First, consider (18):

(18)

a. If a theory is classical, then if it is inconsistent, it is trivial.

b. **Always**, if a theory is classical, then if it is inconsistent, it is trivial.

c. If a theory is classical, then if it is inconsistent, it is **always** trivial.

d. ?***Always**, if a theory is classical, then if it is inconsistent, it is **always** trivial.

e. ?***Every** classical theory that is inconsistent is **always** trivial.

3. Most of the native speakers of English I consulted with expressed discomfort with (18a). After first commenting that using a double-*if* clause in one sentence sounds awkward, some of them stated that (18a) should be like the following, which is what we get in line with the conjunctive paraphrase approach:

If a theory is classical and inconsistent, it is trivial.

Most of them also commented that in (18d,e), one of the two quantifiers is redundant.

(18d,e) contain two overt quantifiers, which leads to the unacceptability of the sentences. Intuitively, one of the two quantifiers is redundant. As for (18a), which does not have any overt quantifier, it is interpreted to contain one, but not two, implicit universal quantifier. (18b,c) are interpreted in the same way as (18a).

Similarly, consider (19):

(19)

a. If a theory is classical, then if it is inconsistent, it is **usually** trivial.

b. ?***Always**, if a theory is classical, then if it is inconsistent, it is **usually** trivial.

c. ?***Every** classical theory that is inconsistent is **usually** trivial.

Again, (19b,c), which contain two overt quantifiers each, are unacceptable. (19a) is not interpreted to involve two quantifiers, i.e., implicit universal quantifier and explicit *usually*, but it is interpreted to involve only one quantifier *usually*.[4]

We can make similar observations in the other two possible combinations. Only those sentences which involve only one quantifier are acceptable:

(20)

a. **Usually**, if a theory is classical, then if it is inconsistent, it is trivial.

b. ?***Usually**, if a theory is classical, then if it is inconsistent, it is **always** trivial.

c. ?***Most** classical theories that are inconsistent are **always** trivial.

(21)

a. ?***Usually**, if a theory is classical, then if it is inconsistent, it is **usually** trivial.

b. ?***Most** classical theories that are inconsistent are **usually** trivial.

Consider the following pair of examples:

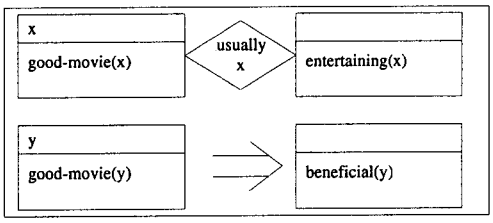
(22) A good movie is **usually** entertaining, and **always** beneficial.

(23) A good movie is **usually** entertaining, and it is **always** beneficial.

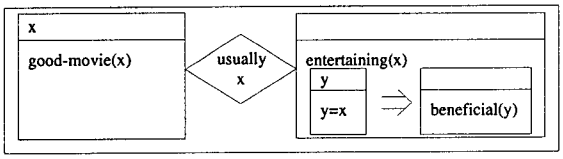
What (22) and (23) have in common is that both of them involve two quantifiers, *usually* and *always*. They should be analyzed as in (24), not as in (25), in terms of DRT, since both of them are intuitively interpreted to involve two different variables:

4. One native speaker commented that sentences like (19b,c), in which two different quantificational adverbs are contained, could possibly be uttered when the speaker modifies what she has said. In other words, she could change the quantification from *always* to *usually*, as a correction of speech. Consequently, it can be inferred that (19b,c) cannot be interpreted to involve two different quantifications at the same time.

(24)



(25)

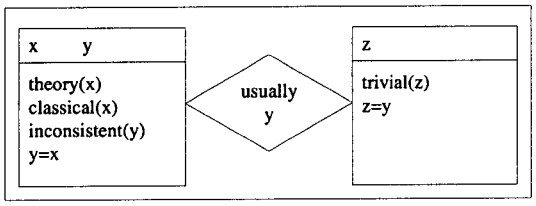


Although (22) involves ellipsis and (23) contains an anaphor, in both, not one but two different variables are involved. As for the latter, it is an example of pronoun of laziness. Relating the observation in (22-23) with what has been observed in (18-21), it can be argued that one same variable in one proposition must be quantified by only one quantifier.[5]

Given this observation, again I argue that double-*if* clause sentences, both intra- and inter-sentential anaphora examples, must be analyzed by the so-called conjunctive paraphrase approach, as argued by Yoon (1998).[6] To illustrate the basic idea of the approach, consider (26), which has been repeated from (8), and its DRT analysis in line with the approach:

(26) (26=8) If a theory is classical, then if it is inconsistent, it is usually trivial.

(26′)



5. One reviewer presents the following sentence as a counterexample to my argument that one same variable in one proposition is quantified over by only one quantifier:

   Every classical theory that is inconsistent is trivial in most cases.

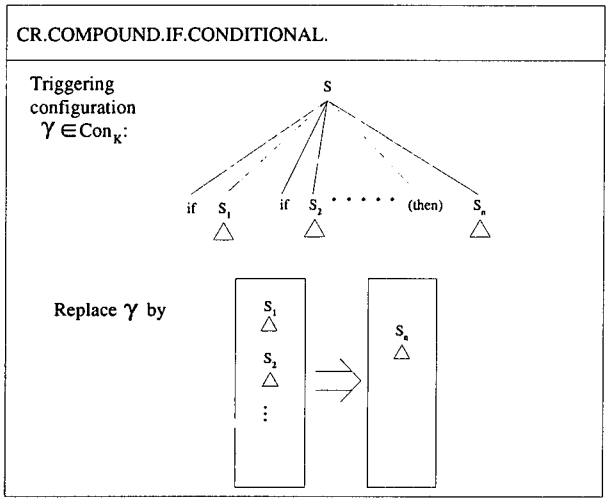
   It could be argued that the quantifier 'most' does not quantify over the 'theory' variable but over some event or situation variable in the above example. Or it could be argued that the speaker is changing the quantification from 'every' to 'most,' as a correction of speech, as in (19b,c).

6. The conjunctive paraphrase analysis is also supported by the following logical equivalence relation:

   $p \rightarrow (q \rightarrow r)$ $(p \wedge q) \rightarrow r$

As can be seen, the two *if*-clauses are combined into the antecedent of the conditional sentence and the quantifier *usually* is quantified over the classical inconsistent variable. The following new DRS construction rule(=CR) for sentences with compound *if*-clauses is needed to account for this proposal:[7]

(27)



CR (27) will ensure that the second *if*-clause acts as an addition to the first *if*-clause instead of introducing another conditional sentence.[8]

Yoon (1998) also discusses the question of why we use compound *if*-clauses instead of single *if*-clauses. Consider the following examples:

(28)

a. If an applicant is female and she is good-looking, she is usually hired.

b. If an applicant is male and he is competent, he is usually hired.

(29)

a. If an applicant is female, then if she is good-looking, she is usually hired.

b. If an applicant is male, then if he is competent, he is usually hired.

As proposed above, (28a) is semantically equivalent to (29a), and (28b), to (29b). However, Yoon (1998) proposes that one member of each pair is pragmatically different from the other in the sense that the situations are different in which they are felicitously used, similar to the difference between active sentences and their passive counterparts.

Suppose a situation for (28-29) in which a company's preferences for job applicants' qualifications are being discussed, and male and female applicants are being compared.

7. The construction rule in (27) is for compound-*if* conditionals that contain more than two *if*-clauses in one conditional sentence.
8. For detailed discussions and analyses on inter-sentential anaphora examples as well as more intra-sentential anaphora examples, refer to Yoon (1998).

Suppose further that the company's preferences for male applicants' qualifications are different from those for female applicants' qualifications. Say, for female applicants, good-looking ones are preferred while for male applicants, competent ones are preferred. In this situation, (29a,b) are more appropriate than (28a,b), since the former sentences show perspicuously the contrast in preferences for job qualifications between female and male applicants.

To summarize the main points of this paper, first, it has been argued that the so-called double-bind problem in quantified sentences is a pseudo problem which does not exist in the first place. Barker (1997) just assumes that any *if*-clause introduces a quantification operator so that the double-*if* clause introduces two quantification operators, which leads to the otiosity of quantification or double-bind problem.

Slater (2000) just follows Barker's assumptions, and tries to solve the problem in terms of the probability operator. That is, in order to avoid one variable bound by two quantification operators, Slater has the second quantification involved in intra- and inter-sentential anaphoric chains indicate the degree of probability. In other words, in order to eliminate the otiosity of the second quantification, i.e., the problem of a single entity being vacuously quantified, Slater proposes an analysis that assigns the single entity a degree of probability.

It is obvious that the interpretations of the quantified sentences predicted by Slater's analysis are different from those of the previous quantifier/variable-binding model theories of anaphora. Whether Slater's predicted interpretations are the right ones or wind up being equivalent to the previous theories' interpretations is yet to be examined. However, it has been observed in section 3 that Slater's account based on the probability calculus predicts the existence of unacceptable quantified sentences, and that the roles of the probability operator and the implicit quantification operator are not clearly defined so that some arbitrary interpretations are produced.

Given this, what is proposed in this paper is that one same variable is not doubly quantified. Therefore, the second *if*-clause in double-*if* sentences does not introduce a quantification operator. Instead, it is interpreted to add another condition to the antecedent of the conditional sentence. The usage of this syntactic structure is to represent a more perspicuous contrast between the condition introduced by the second *if*-clause and that of the counterpart sentence as in (29), similar to the usage of passive constructions, which are often used to put emphasis on the agent argument or, to the contrary, to avoid mentioning it.

Consequently, it could be said that the so-called conjunctive paraphrase analysis is the simple result of the workings of the quantification operator in the quantified sentences.

5. Conclusions

To summarize, the main focus of this paper has been to argue against Slater's (2000) claim that his epsilon account solves the double-bind problem in quantified sentences which the other theories, namely, E-type theories, Discourse Representation Theory, and Dynamic Semantics, cannot deal with. The epsilon theory has been shown to have problems and cannot be a solution to the double-bind problem.

Yoon's (1998) account for the so-called double-bind problem in quantified sentences in terms of the conjunctive paraphrase approach has been also discussed.

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Submitted on: May 28, 2001
Accepted on: October 21, 2001