

First draft, criticism and suggestions are welcome.

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The ECP: A Stringent Principle

1. Introduction

Kai von Stechow & Sabine Iatridou (2003) discussed scopal relations between epistemic modals and other quantificational items and proposed the Epistemic Containment Principle (the ECP) as a constraint that is imposed on Quantifier Raising (QR). They observed that while sentence (1) is ambiguous between two readings depending on the position of the deontic modal *must* relative to that of the (generalized) quantifier *most of our students* at LF, sentence (2) is not susceptible to the same ambiguity.

(1) Most of our students must get outside funding. (F&I's (4))

(2) Most of our students must be home by now. (F&I's (5))

The reason why QR is blocked in (2) is that the ECP does not allow the quantifier *most of our students* to take scope over the epistemic modal *must*. However, the function that the ECP serves is most clearly seen in the case of disambiguating the sentences like the following:

(3) Every student may have left. (F&I's (6))

According to the ECP, the quantifier *every student* cannot take scope over the epistemic modal *may*. As a result, (3) is understood to mean that there might be the case that every student has left by the time of utterance. If the ECP does not apply to this sentence, (3) will have a reading on which the quantifier *every student* takes scope over the epistemic modal *may*, with a meaning that

every student is likely to have left. It seems that the two readings of (3) can never be confusing given the ECP, a constraint on QR.

However, each of the two readings of (3) expresses a possibility that is in nature epistemic. Epistemic possibility is understood in the philosophy literature as follows: *a might be F* is asserted to be true if and only if it is impossible that *a is not F* as far as what the contextually salient community knows¹. The epistemic possibility expressed by (3) is that it is impossible for us to know *every student did not leave*. But the sentence *every student did not leave* is ambiguous: a) for each student, he or she did not leave; b) it is not the case that every student left. Understood this way, epistemic possibility is entailed by both the two readings of (3). Why is it that the ECP gives rise to one of them rather than the other? I don't think we can find an answer to this question from Kai von Fintel & Sabine Iatridou (2003). In fact, I suspect that they took a wrong way to deal with the problem. The ECP is not a constraint on QR, but a universal semantic formulation of epistemic modals. It is a stringent principle, which is beyond what can be read from Kai von Fintel & Sabine Iatridou (2003). The stringency of the ECP is my concern in this paper. A different treatment of epistemic modals will first be proposed: a GQ treatment of epistemic modals; then the ECP will be closely examined within the proposed theoretic framework; consequentially the stringency of the ECP will be confirmed.

2. GQ Treatment of Epistemic Modals

In Kratzer (1977), Kratzer proposed an approach to semantics of modal phrases. An utterance of a sentence in which modal verbs like “must” or “can” occur was claimed to express a proposition as a function taking two arguments: the conversational background for the utterance and the propositional content that is to be modalized.

Consider the following dialogue:

¹ Keith DeRose (1991) gave truth conditions for an assertion of the form, *It is possible that P*: S's assertion “It is possible that P” is true if and only if (1) no member of the relevant community knows that P is false, and (2) there is no relevant way by which members of the relevant community can come to know that P is false.

(4) Mary: Where is John?

Hellen: John might be in Beijing.

Hellen's answer expresses a possibility of John's being in Beijing, which is compatible with what she knows about John. How are we to give a semantic account of this possibility? According to Kratzer, the semantic construction of the modal verb, *might*, in Hellen's answer is given as follows: it is treated to determine a function that takes two arguments one of which is what Hellen knows at the moment of utterance and the other of which is what it means that John is in Beijing. In other words, her answer is construed to express a proposition that is true if and only if the fact that John is in Beijing is logically compatible with (this notion is to be given a detailed explanation later) what Hellen knows about John at the time of utterance.

What John knows is termed a conversational background, which is a characteristic function $f(w)$ of sets of possible worlds that are epistemically accessible from Hellen's world w . Generally, for any world, $w \in W$, there is a corresponding set of accessible worlds. As a result, a set of all those accessible worlds adds up to a power set of W .

The fact that John is in Beijing is understood as a proposition that is formally encoded as a characteristic function of sets of possible worlds in which it is true that John is in Beijing. Logically, a set $\{p\}$ also makes up the power set of W .

Thus, the two arguments are both from the domain of power set of W from which the function of modal phrases is defined. The meaning of *might* is a characteristic function $F(f, p)$ of sets of possible worlds for which p is logically compatible with $f(w)$.

In order for the readers to have a clear idea of what is being discussed, let's take some time to introduce several key definitions given in Kratzer (1977).

Logical consequence: If A is a set of propositions and p is a proposition, then p follows (logically) from A if and only if there is no possible world where all

members of A are true but p is false.

Logical consistency: A set of propositions is consistent if and only if there is a possible world where all its members are true. Otherwise it is inconsistent.

Logical compatibility: A proposition p is compatible with a set of propositions A if and only if $A \cup \{p\}$ is consistent.

The discussions that follow will have much to do with logical consequence and logical compatibility. A proposition follows from what is known. Or it is compatible with what is known. In the same fashion, denotation of a quantifier phrase (QP) follows from what is known or is compatible with what is known.

Kratzerian semantics of modal phrases reminds us of Generalized Quantifier Theory (GQT). GQT tells us that a generalized quantifier (GQ) consisting of a determiner and a set-denoting noun determines a function that takes two arguments from the power set of the domain of discourse E : a set-denoting noun and a set-denoting predicate, if the determiner is one-place determiner. In other words, GQ refers to a characteristic function of sets of entities in E for which the two set-denoting phrases satisfy the relation stipulated by the determiner.

(5) Some poets daydream².

Some, as a determiner, is treated as a function from the set-denoting noun phrase *poets* to a determiner phrase *some (poets)*, which constitutes a generalized quantifier phrase, taken as a function from the set-denoting phrase *daydream* to True if and only if the intersection of denotations of two set-denoting phrases, *poets* and *daydream*, is a non-empty set. The generalized quantifier *some (poets)* is to be understood as a function that takes two arguments: *poets* and *daydream*, which are both from the power set of the domain of discourse E . It is, in fact, a characteristic function of sets of entities that are both poets and daydreamers.

² This example is from Edward Keenan (2002).

There apparently runs parallelism between Kratzerian semantics of modal phrases and GQT. Does this surface parallelism reflect something fundamental to natural language quantification? Seeing that the study of natural language quantification is far from being complete and uncontroversial, we would rather attempt to find out the extent to which the daily use of modal phrase provide documentation to the presupposed semantic theory of modals that is built within the framework of GQT.

Let's reconsider the sentence "John might be in Beijing" in (4). If we think of *might* as a raising predicate³, the LF of the sentence is: *Might (John be in Beijing)*. *Might* is a determiner denoting a function from *John be in Beijing* to *Might (John be in Beijing)*. The whole LF is treated as a GQ that maps a set of possible worlds, which are claimed to be Hellen's epistemically possible worlds, to True if and only if the set of possible worlds in which it is true that John is in Beijing follows from the set of Hellen's epistemically possible worlds.

Generally, a modalized proposition⁴(MP), is a GQ that maps a set of epistemically possible worlds to True if and only if the set of possible worlds in which *p* is true is compatible with or follows from the set of epistemically possible worlds. So semantic value of a MP is reduced to the set of possible worlds for which this new GQ obtains. This new GQ ranges over possible worlds rather than entities in the domain of discourse. The model we use is $\langle W, [[M(p)]] \rangle$. This treatment of MP is called GQ-resolving MP (henceforth GQ-MP).

3. The Examination of the ECP

Now let's see how GQ-MP deals with the problem we encountered in Section 1. The ECP, proposed in Kai von Stechow and Sabine Iatridou (2003) is as follows:

At LF, a quantifier cannot bind its trace across an epistemic modal.

³ Wurmbrand, Susi: 1999. "Modal Verbs Must Be Raising Verbs." West Coast Conference on Formal Linguistics (WCCFL), 18: 599-612. Preprint
<http://www.arts.mcgill.ca/programs/linguistics/faculty/wurmbrand/research/files/WCCFL18.pdf>.

⁴ Here we focus on epistemic modality rather than root modality for simplicity.

*Q_i...[Epistemic Modal (...t_i...)]

They gave lots of examples like (6).

(6) Every student must be awake if his light is on. (F&I's (17))

According to the ECP, the proposition expressed by utterance of (6) is that as far as the speaker knows it must be the case that every student is awake if someone in a salient situation keeps his light on. This someone might have nothing to do with every student in the domain of discourse because of the ECP. But the problem is that on the surface level *every student* occurs in a position over the scope of epistemic modal *must*. In order to deal with this problem, Kai von Stechow and Sabine Iatridou (2003) seemed to prefer so-called pseudoscope quantificational items after lots of discussions of many other theories.

I think the puzzle incurred by sentences like (6) is derived from the effort to make semantic accounts conform to syntactic principles. We need to find out a procedure through which an LF formation could generate a surface structure. In fact, semantic structures are supposed to have independent significance in accounting for distinct features of human languages. Sometimes achievements in this connection are outstanding. A good case is GQT.

Now let's use GQ-MP to analyze sentences like (6). (6) expresses a MP that is to be treated as a GQ denoting a function from the speaker's epistemically possible worlds to True if and only if the set of possible worlds in which it is true that *every student is awake if his light is on* follows from the set of speaker's epistemically possible worlds. *Every student is awake if his light is on* is analyzed as a GQ denoting a function from the set of people who are awake to True if and only if the set *every (student whose light is on)* follows from the set of people who are awake. There are many possible worlds in which the set *every (student whose light is on)* follows from the set of people who are awake. Among them, only those possible worlds following from the speaker's epistemically possible worlds constitute the GQ-MP, *Must (every student be awake if his light is on)*.

However, *every student* in (6) still remains untouched. *Every student* is supposed to get its semantic value from the domain of discourse. But this domain of discourse is of intensional nature. Therefore, we interpret denotation of *every student* as the set of possible individuals in the domain of discourse. In (6), they refer to the set of all possible individuals who are students in the speaker's epistemically possible worlds. Notice that the set of possible worlds in which denotation of *every student* obtains does not necessarily equal the set of possible worlds that makes available the denotation of MP, *every student must be awake if his light is on*. That explains why *his* is not coindexed with *every student* in (6). Following Montague (1970), we might as well treat *every student* in the MP *every student must be awake if his light is on*, as he_i . The semantic value of he_i is assigned by the contextually salient conversational background.

It seems that there are more complications. In fact, the quantifier *every student* in (6) determines an independent function from the speaker's epistemically possible worlds to True if and only if the set of possible worlds in which denotation of *every student* obtains follows from the set of speaker's epistemically possible worlds. So there is supposed to be a covert $Must_i$ that is preposed before the GQ *every (student)*: $Must_i$ (*every (student)*). Here the value of i is also determined by the contextually salient conversational background. Then the whole sentence (6), in fact, expresses a new GQ-MP denoting a function from the speaker's epistemically possible worlds to True if and only if both the set of possible worlds in which denotation of *every student* obtains and the set of possible worlds in which *every student is awake if his light is on* is true follow from the set of speaker's epistemically possible worlds.

The fact that the quantifier *every student* in (6) cannot take scope over the epistemic modal as stipulated in the EPC is orthogonal to the observation that *every student* is not coindexed with *his* in (6). Since *every student* in the surface syntactic structure plays two roles: a quantifier within the MP that is treated as he_i and a quantifier outside the MP but within the scope of a covert epistemic modal $Must_i$. It is he_i that is coindexed with *his* in (6). It remains to be settled whether the set of possible worlds in which denotation of *every student* obtains is totally overlapped with the set of

possible worlds denoted by the GQ-MP *Must* (*every student be awake if his light is on*).

Let's look at more examples.

(7) #Every student is the tallest person in the department. (F&I's (8))

(8) #Every student may be the tallest person in the department. (F&I's (9))

(7) is not acceptable for the simple reason, but how is it possible (8) is sensible? (8) expresses a MP that could be treated as follows: it is a GQ-MP denoting a function from the set of the speaker's epistemically possible worlds to True if and only if the set of possible worlds in which denotation of *every student* obtains follows from the set of speaker's epistemically possible worlds and the set of possible worlds in which it is true that there is a student who is the tallest person in the department is compatible with the set of speaker's epistemically possible worlds. This GQ-MP treatment is consistent with the intuitive understanding of (8). Among all the students the speaker knows, there might be someone who is the tallest person in the department. Again, notice that there is a covert he_i within the MP, *May* (he_i be the tallest person in the department).

Here comes a question, how do we account for the link between *every student* and he_i in (8)? Whatever relations there are between them, there is no binding relation. The semantic value of he_i is relevant to *every student*, but it is not determined by *every student*. The speaker is not sure who, among every student he knows, may be the tallest person in the department, but he has a complete knowledge of whom *every student* refers to with the utterance of (8).

However, the following sentences seem to give us an impression of binding across the epistemic modals.

(9) Every student thinks that he may well be a genius. (F&I's (22) a)

(10) Every student thinks that Mary may/must like him the most. (F&I's (22) b)

The utterance of (9) expresses a proposition, but not a MP. The speaker knows for sure what every

student thinks about, whereas every student in the domain of discourse is not so sure whether he or she is a genius or not. In (9), the GQ *every (student)* determines a function that is from the set of persons who think to True if and only if the set of *every (student)* follows from the set of persons who think. It is actually a set of students who think. Each member of this set may well be a genius. So there is no epistemic modal to block the binding relation between *every student* and *he* in (9).

But this is not a good explanation, for it does not capture the understanding of (10) on which *every student* binds *him* across the epistemic modal *may/must*. We might analyze (10) as follows: (10) is composed of two propositions, (10a) *every student thinks* and (10b) *Mary may/must like him the most*. (10b) is a GQ-MP determining a function from what the speaker knows to True if and only if the set of possible worlds in which there is someone Mary likes the most follows from the set of speaker's epistemically possible worlds. So there is supposed to be another MP with a covert *Must_i* before the MP *may/must (Mary like him_i)*. I.e., *((Must_i (Mary like him)) (may/must (Mary like him_i)))*. We further analyze *(may/must (Mary like him_i))* as follows: the set of possible worlds in which *Mary likes him_i the most* is true is compatible with or follows from the set of possible worlds that are epistemically possible from the speaker's world. Therefore, we see that *him* in (9b) also plays two roles: someone Mary likes the most and *him_i* as in *Mary likes him_i*, the value of which is determined by a contextually salient conversational background. That is to say, someone Mary likes the most is anaphorically dependent on *every student* in (9a), but not *him_i* as in *Mary likes him_i*.

In fact, in (9), it is the same case with *he*. It is someone who is a genius that is bound by the quantifier *every student*, but not *he_i* as in *he_i is a genius*.

Kai von Stechow and Sabine Iatridou (2003) argued that a quantifier cannot *take* a scope over an epistemic modal rather than a quantifier cannot *have* a scope over an epistemic modal. From above analysis of epistemic modals, we have seen that it is not necessary to make this concession. Epistemic modals do have a property of taking the widest scope.

However, the problem we need to deal with at this time is how we give an account of the fact that

QP is treated outside the MP. A rough guess is that any declarative sentence must have at least a noun phrase to express a complete proposition. The noun phrase(s) is/are analyzed as the framework of the proposition at LF according to GQT. The proposition, *every student left*, is treated as a GQ, referring to the set of persons who left that includes every student in the domain of discourse. When we say, “every student may have left”, we mean that the fact that there is a set of persons who left that includes every student in the domain of discourse is possible as far as what we know about them. The idea is formulated with GQ-MP as follows: $must_i$ (*every (student)*) is compatible with $must_i$ (*may (he_i left)*). Therefore, it is in the spirit of GQT that we are enabled to make NP independent from MP. Even so, QP is still within the scope of a covert epistemic modal.

In order to show this, more examples will follow.

(11) Somebody from New York is likely to win the lottery. (F&I’s (64), from Fox (2000))

In (11), *is likely to* is to be treated as an epistemic modal. (11) expresses a MP that is treated as a GQ-MP denoting a function from the set of speaker’s epistemically possible worlds to True if and only if the set of possible worlds in which the denotation of the quantifier *somebody from New York* obtains follows from the set of speaker’s epistemically possible worlds and the set of possible worlds in which it is true that somebody from New York is to win the lottery is compatible with the set of speaker’s epistemically possible worlds. In addition, our theory goes so far as to make a point that the fact that there must be somebody from New York in the speaker’s knowledge is at least compatible with the fact that there is such a possibility that somebody from New York is to win the lottery. That is to say, there exists at least one possible world in which both the fact that there must be somebody from New York and the fact that somebody from New York is to win the lottery obtain. The paraphrase in line with the above analysis is like what follows: as far as what the speaker knows, there must be somebody from New York (who bought the ticket), but it is not known who this somebody exactly is. Also the speaker knows that it might be the case that some specific person will win the lottery and it is possible for somebody from New York to be that specific lucky person.

(12) Nobody may have pushed him. (F&I's (74))

(12) can be given two interpretations as follows.

Interpretation I: The MP conveyed from (12) is treated as a GQ-MP that is taken as a function from the set of the speaker's epistemically possible worlds to True if and only if the set of possible worlds in which denotation of *no(body)* obtains follows from the set of the speaker's epistemically possible worlds and the set of possible worlds in which *he_i pushed him* is true is compatible with the set of the speaker's possible worlds. The GQ-MP *must_i (no (body))* is at least compatible with the MP *may (he_i pushed him)*. This formal analysis tells us that as far as what the speaker knows there must be some empty set of persons and there might be the case that someone from that empty set of persons pushed him. I.e., there is a possibility that no one pushed him.

Interpretation II: The MP expressed by the utterance of (12) could be analyzed as a GQ-MP taken as a function from the set of the speaker's epistemically possible worlds to True if and only if the set of possible worlds in which it is true that nobody pushed him is compatible with the set of the speaker's epistemically possible worlds. In order for it to be true that nobody pushed him, there is supposed to be an empty set of persons who pushed him. It is, within the speaker's knowledge, a possibility that no one pushed him.

The two interpretations converge to the same conclusion that there is a possibility that nobody pushed him because the empty set of persons does not change its properties from possible world to possible world. There is no lucky case with other quantifiers.

4. The Stringency of the ECP

The examination of the ECP in the previous section has led us to the conclusion that epistemic modals unexceptionally take scope over any other quantificational items. This conclusion is made valid within the theoretic framework of epistemic modals proposed above. Let's now give a general formulation of this framework.

The MP, in fact, determines a function from p to $M(p)$, which is treated as a GQ over possible worlds, i.e., a set of possible worlds in the speaker's epistemic domain. This GQ , in turn, determines a function from the set of the speaker's epistemically possible worlds, W_{epis} , to True if and only if the following conditions are fulfilled: (a) the set of possible worlds denoted by $M(p)$ follows from W_{epis} ; or else (b) the set of possible worlds in which denotation of a certain QP obtains follows from W_{epis} ; (c) the set of possible worlds in which p is true is compatible with W_{epis} or follows from W_{epis} depending on whether the modal operator M expresses an epistemic possibility or an epistemic necessity; (d) the condition (a) or (b) is at least compatible with the condition (c), i.e., at least there is a possible world in which both (a) and (c) are fulfilled or both (b) and (c) are fulfilled.

(a) and (b) are corresponding to the two interpretations of (3). If (3) is understood to mean that there might be the case that every student left, (a) is the proper condition to be fulfilled. It is to be known for sure to the speaker that there might be the case that every student left. However, if (3) is construed to say of every student that he or she may have left, (b) is the required condition. As far as what the speaker knows, there exists a set of possible worlds in which denotation of *every (student)* obtains.

(d) is a weak condition that imposes a necessary constraint on compositionality of the matrix MP. In the case of (3), on one reading, there is at least one possible world in which the speaker knows of the possibility of every student leaving and of course his or her knowledge is compatible with the fact that every student left. On the other reading, there is at least a different possible world in which the speaker knows who every student is and he or she also knows someone from them may have left.

Throughout the framework as laid out above, anything that constitutes the propositional content of the MP is either compatible with the speaker's knowledge or follows from the speaker's knowledge. In other words, there is nothing propositional that is independent of the speaker's knowledge. This further confirms the stringency of the ECP: no quantificational items take scope

over epistemic modals.

5. The Nature of the ECP

From the previous discussion, we have found that there are two things that follow from the set of the speaker's epistemically possible worlds: denotation of GQ-MP and the set of possible worlds in which denotation of a QP obtains. On this account, there is supposed to be a covert modal operator $must_i$ that takes scope over the matrix MP or over a certain QP, which is formulated as follows:

(13) $Must_i (M(p))$

(14) $((Must_i (QP)) (M(p)))$

(14) is questionable because it is far from clear what relation obtains between $(Must_i (QP))$ and $M(p)$. According to the condition (d) in Section 4, there might be a logical compatibility relation between $(Must_i (QP))$ and $M(p)$. So (14) could be revised as a matrix MP that is composed of two sub-MPs $(Must_i (QP))$ and $M(p)$, i.e.,

(15) $M_i(Must_i (QP)) (M(p))$

But we are not sure of the exact nature of this matrix MP: an epistemic possibility, an epistemic necessity or something uncertain.

Let's take a look at another example from Kai von Fintel and Sabine Iatridou (2003).

There is a group of people who were exposed to an infectious agent. An anonymous test tells us that half of the people are healthy, but it does not tell us exactly who among them are healthy. (12) is a report of the situation to the people involved.

(16) Half of you are healthy. But everyone may be infected. (F&I's (10))

In order for the report to be consistent, the second sentence of (16) is supposed to be interpreted as follows: among every person in this group, each of you is likely to be infected. We will analyze it in line with (15). The GQ-MP, *must_i (every (one))*, determines a function from the set of the speaker's epistemically possible worlds, W_{epis} to True if and only if the set of possible worlds in which denotation of the QP, *every(one)*, obtains follows from W_{epis} . The QP, *every(one)*, refers to all the people in the group. The set of possible world in which there is such a group of people follows from W_{epis} . Another GQ-MP, *may (he_i be infected)*, also determines a function from W_{epis} to True if and only if the set of possible world in which it is true that there is a person who is infected is compatible with W_{epis} . At last, the matrix GQ-MP is a function from *must_i (every (one))* to True if and only if *may (he_i be infected)* is compatible with *must_i (every (one))*. I.e., The possibility of some person getting infected, as is known to the speaker, is compatible with the epistemic necessity of the speaker's knowledge of *everyone*. There is at least a possible world in which some person from the group of *everyone* might get infected. It is consistent with our intuitive understanding of (16).

The fact that M_i and $Must_i$ take the widest scope in (13) and (14-15) respectively exhibits the nature of the ECP: for a declarative sentence, it is always possible to find out an epistemic modal that takes the widest scope in it. As a matter of fact, the ECP suggests a language universal with respect to epistemic modals. Most human languages have epistemic modals or other means of expressing epistemic modality, which suggest one of propositional attitudes ascribed to users of the language.

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