INTERROGATIVE QUANTIFIERS

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1. Constituent questions: single and multiple

We will begin by making a distinction between two kinds of constituent questions: single and multiple. By multiple questions we do not just mean questions like

(1) Which professor recommended which one of his students for the job.

Multiple wh-questions, such as (1), constitute only a subset of multiple questions, at least on the most plausible reading.

(2) a. Which one of his students did each professor recommend for the job?
   b. What is the capital of each European country?
   c. When were your oldest and youngest child born?

Multiple questions involve relations between individuals. Answers to multiple questions express propositions to the effect that such and such individuals stand in a certain relation to each other. For example, answers to questions (1) and (2)a. are of the form "Professor X recommended student Y for the job". The new information contained in the answer is the pairing of the particular individuals. Single constituent questions differ from multiple questions in that they involve properties rather than relations. They are answered by identifying the individual or individuals that have the particular property. The examples in (3) are unambiguously single questions (given that the antecedent of his in (3)a. is which professor), in spite of their similarity to the examples in (2).

(3) a. Which professor recommended each one of his students for the job?
   b. What is the capital of the United States?
   c. When were you and your wife married?

Answers to questions (3)a., for example, are of the form "Professor X recommended each student of his for the job."
We think it is useful to consider the distinction between single and multiple questions in this general way without focusing narrowly on questions of type (1) — multiple wh-questions. Because of the fact that much of the work on questions has been done on English, constructions of this type have come to be regarded as paradigmatic examples of multiple questions when in fact they are not. There are many languages where there are no multiple wh-questions. Modern Irish (see McCloskey 1978), for example, is a language where the syntax of constituent questions effectively prevents two interrogative phrases from ever occurring in the same simple question. The fact that English has multiple wh-questions and that Irish doesn't is nevertheless not an indication that Irish is impoverished in its expressive capacity compared to English. Irish does in fact have multiple questions, but only of the sort illustrated under (2). We will show in this paper that the same can be said about Finnish.

Our present treatment of constituent questions builds on our earlier work on interrogatives. One important improvement is that we can now account for multiple questions where a non-interrogative quantifier (e.g. "each person") takes wide scope over a wh-phrase (e.g. "which one of his students") in the same clause. The examples in (2) are precisely of this sort. In order to show what is difficult about them we will briefly outline the treatment of constituent questions proposed in our earlier papers (Karttunen 1977, Peters 1979).

1.1 Single constituent questions

The diagram in (4) represents a simplified syntactic structure for the question "which professor recommends John". For the time being, let us think of it as a subordinate question, waiting to be embedded to some larger construction, as in "I am not sure which professor recommends John." For the sake of expository convenience we employ in this section an extended version of the "Cooper syntax" of Cooper & Parsons 1976. We have added to it rules for generating constituent questions (Q-phrases) and interrogative noun phrases (QNPs). As the diagram indicates, we assume here that the underlying syntactic structure for the question contains a place-holding dummy pro-NP that is deleted in the presence of the interrogative noun phrase.
Thus the surface structure of "which professor recommends John" is obtained from (4) by deleting the NP "Pro_n" and the variable "x_n" whose role we will explain shortly.

As shown by Cooper & Parsons, a structure such as (4) can be semantically interpreted in a very straight-forward way. Each lexical item in (4) has a meaning represented by its translation to an interpreted formal language (Montague's intensional logic). The meanings of complex phrases are obtained from the meanings of their constituents by a rule appropriate for the particular construction. For example, the translation for the S-node in (4) is formed by combining the translations of the NP- and VP-nodes in accordance with rule (5).

(5) \( S' = NP'(VP') \)

The symbols \( S' \), \( NP' \), and \( VP' \) stand for the translations of the corresponding phrases. In this case, \( NP' \) is identical to the translation of \( Pro_n \), and \( VP' \) is the result of applying rule (6) to the translations of the constituents of \( VP \).

(6) \( VP' = V'("NP'") \)

Here \( V' \) is the same as the translation of "recommend", say, recommend', and \( NP' \) is the same as John'. Consequently, the translation for the S-node in (4) --- is the formula in (7)a. (7)a. in turn is logically equivalent in Montague's system to (7)b. (We are using \( Pro_n' \) and John' as abbreviations for \( \lambda P \ P(x_n) \) and \( \lambda P \ P(j) \), respectively.) Thus either formula in (7) can serve as a translation for the S-node in (4).

(7) a. \( Pro_n'(\text{recommend}'("John'\)) \)
   b. \( \text{recommend}^2'("x_n',j\)) \)

Up to this point the interpretation of (4) is unproblematic, the interesting problems arise in connection with the Q- and the QNP-nodes. In accordance with our earlier work on interrogatives, we assume that Q is the category for all subordinate questions. Besides constituent questions, this
category also contains yes/no questions and disjunctive questions. Phrases of category Q denote sets of propositions. For example, "which professor recommends John" denotes the set of true propositions to the effect that professor X recommends John. In other words, we think of the meaning of a subordinate question as something that picks out, in each situation, the set of propositions which in that situation would constitute a true and complete answer to the question. It follows from this that the meaning of the Q-node in (4) can be represented by formula (8).

\[(8) \lambda p \exists x \ [\text{professor}'(x) \& \forall p \& p = \neg \text{recommend}^2'(x,j)]\]

In Montague's intensional logic (8) designates precisely the set of true propositions expressed by sentences of the form "professor X recommends John". In a situation where professor Fudge, and no other professor, recommends John, (8) designates the unit set containing the proposition that Fudge recommends John.

In order to associate the Q-node in (4) with an appropriate translation that expresses the desired meaning, we must, first of all, decide on what the meaning to assign to the interrogative noun phrase "which professor", and then find a rule that combines the translations of the QNP- and the S-nodes in the right way to produce some expression that is equivalent to (8) above.

As for the QNP, it turns out that it is convenient to let the interrogative quantifier "which professor" have the same meaning as its existential counterpart "some professor". Thus we represent the meaning of the QNP in (4) as in (9).

\[(9) \text{QNP}' = \lambda p \exists x \ [\text{professor}'(x) \& p(x)]\]

This in turn can be obtained from the translations of the interrogative determiner and the noun "professor" in the same way as the translation of "some man" is obtained from the translations of its parts.

The semantic rule for obtaining the meaning for a Q-phrase in a structure such as (4) can now be formulated as shown in (10).

\[(10) Q' = \lambda p \text{QNP}'(\lambda x_n [\forall p \& p = \neg S'])\]

The effect of rule (10) is to assign to the Q-phrase in (4) precisely the meaning we indicate in (8), namely a function from world-time pairs to sets of propositions of the form "X recommends John", where X designates some professor. (Note that the role of the variable \(x_n\) in (4) is just to indicate that this is the variable that gets bound when the translation of the Q-hphrase is constructed by "quantifying in" the interrogative noun phrase.)
This is a somewhat simplified presentation. We would have to complicate the above rules a bit if we were to take into consideration other types of interrogative phrases — for example, phrases like "where", "how long", and "whose student" — but what we have said above is already enough for the purpose of introducing the problems that arise in connection with multiple questions.

1.2 Multiple wh-questions

We do not have any difficulties with multiple wh-questions, that is, with questions like "Which professor recommends which candidate". Within Cooper syntax, this could be derived from an underlying structure such as (11).

![Diagram](image)

Here $Q_1$ is the underlying structure for the single wh-question "which professor recommends $Pro_k$". It differs from the $Q$ in (4) only in that the $S$-node contains a second unbound pro-NP. In order to derive the surface structure of "which professor recommends which candidate" we assume here a second rule of interrogative quantification that deletes a place-holding pro-NP. That is, $Pro_k$ in $Q_1$ is replaced by the QNP "which candidate". The corresponding semantic rule is given in (12).

(12) $Q_2' = \lambda p \ QNP_2'(\lambda x_k \ Q_1'(p))$

By applying (12) to the translations of the QNP "which candidate" and the $Q$-phrase "which professor recommends $Pro_k$" in (11), we obtain a translation which is equivalent to formula (13).

(13) $\lambda p \ \exists y \ \exists x \ [\text{candidate}'(y) \ & \ \text{professor}'(x) \ & \ \forall p \ & \ p \ = \ \text{recommend}'(x,y)]$

And formula (13) is of course just the expression that we want: it designates the set of true propositions of the type "$X$ recommends $Y$", ...
where X is a professor and Y is a candidate.

The basic idea in this treatment of constituent questions is that interrogative phrases are quantified in. The syntactic framework that we have employed above was selected in part because it makes this aspect of the analysis very perspicuous. The first incoming wh-phrase makes a single constituent question out of a declarative clause and multiple wh-questions can be formed by quantifying in more wh-phrases. There is, however, no syntactic motivation for the kind of movement rule we had to postulate for multiple wh-questions. We will show later how it can be eliminated by adopting a different translation method.

2.1 Quantifying into questions: first attempt

Here we come to a point where our present views differ from what was said previously by one of the authors. It was claimed in Karttunen 1977 that the approach to constituent questions which we have just outlined entails that interrogative quantifiers should always have wider scope than any ordinary quantifier in a subordinate question, unless the latter also has scope over the structure which the subordinate question is embedded in. This was supposed to follow from the observation that an ordinary quantifier could gain scope over an interrogative one only by being quantified in, and from the belief that, for semantic reasons, ordinary noun phrases could not be quantified into questions. Let us illustrate the problem by considering example (14).

(14) Which professor recommends each candidate?

Question (14) clearly has two readings which differ with respect to the scope of "each candidate". On the narrow scope reading of "each candidate", (14) is a single question; it calls for answers such as "Fudge recommends each candidate". This reading is simply the outcome of deriving the sentence in the manner shown in (15).

(15)

```
    Q
   /\  
 QNP  X_n
    \ /  
which professor  Pro_n recommends each candidate
```

Under this analysis the QNP-phrase "which professor" is quantified into a declarative sentence. In accordance with rule (10) above it has wide scope
with respect to the NP "each candidate". The problem is that (14) also appears to have a multiple reading which requires answers such as "Fudge recommends John, Dodge recommends Mary, and Hodge recommends Alvin." In some way this reading involves making "each candidate" have wide scope with respect to the wh-phrase. Karttunen 1977 briefly considered the possibility of deriving this sentence in the manner shown in (16) but came to the conclusion that there is no way to make that account to work semantically.

\[(16)\]

\[
\begin{align*}
Q_2 & \quad \text{NP} \\
\text{each candidate} & \quad x_k \\
\text{which professor} & \quad \text{ONP} \\
\text{Pro}_n \text{ recommends } \text{Pro}_k \\
S & \quad x_n
\end{align*}
\]

In (16) the NP "each candidate" will be quantified into the subordinate question "which professor recommends Pro\_k". Because this is a new syntactic rule, one also needs a new semantic rule that specifies how the translation of Q\_2 is obtained from the translations of the nodes it dominates. The most obvious candidate for that rule is (17), but unfortunately the meaning it yields cannot be right.

\[(17) \quad Q_2' = \lambda p \, \text{NP}'(\lambda x_k \, Q_1'(p))\]

The resulting translation for Q\_2 in (16) is equivalent to (18).

\[(18) \quad \lambda p \, \forall y \, [\text{candidate}'(y) \rightarrow \exists x \, [\text{professor}'(x) \& \neg \text{recommend}'(x, y)] \& p = \text{recommend}]\]

This cannot be the right meaning for the reason that the set of propositions it denotes must be empty in any situation where there are two candidates. Recall that each proposition in the set designated by (18) is required to be identical to the proposition that X recommends Y for all assignments of a candidate to Y and some value of X which picks out a professor. But as the values of X and Y in "X recommends Y" change so does the proposition expressed by the sentence. No proposition is identical to the proposition that X recommends Y on more than one pair of values for X and Y. This is the reason why (18) designates the empty set whenever there exist at least two candidates. It thus fails to pick out the set of propositions which intuitively would seem to be the right ones, namely, all and only the true propositions to the effect that "X recommends Y" where X designates a professor and Y is a candidate.
2.2 Quantifying into questions: second attempt

For lack of any better alternative, Karttunen 1977 adopted the view that the multiple question reading of (14) could be accounted for by a version of the 'performative analysis'. One could, in particular, take the view that direct questions are to be regarded as semantically equivalent to declarative structures of the form "I want you to tell me Q", where Q is the corresponding subordinate question. That is, one would derive the wide scope reading in the manner shown in (19).

(19)

Here DQ is the category of direct questions. The members of this category would be semantically of the same type as declarative sentences; therefore, one could easily quantify in an ordinary noun phrases like "each candidate" and get an appropriate meaning. In this case the resulting translation would be equivalent to something like "For each candidate x, I want you to tell me which professor recommends x".

This solution sounds reasonable enough for direct questions but certain kinds of subordinate questions still remain a problem. Let us consider example (20).

(20) I wonder which professor recommends each candidate.

According to Karttunen 1977, the sentence has two available readings; a narrow scope reading for "each candidate", which implicates that all the candidates are being recommended by the same professor, and a wide scope reading, which we paraphrase here as (21).

(21) For each candidate x, I wonder which professor recommends x.

Under the view that ordinary noun phrases cannot be quantified into questions, there is no third intermediate reading, that is, no reading where "each candidate" has wide scope with respect to "which professor" but narrow scope with respect to the verb "wonder" in the higher sentence. We now think that this prediction is incorrect.
There does seem to be such a reading, although the case perhaps isn't as clear as we would like it to be. In order to argue for the existence of this reading, we will have to present a rudimentary analysis of what it is to wonder. Let us say that wondering is a compound awareness of ignorance and thirst for knowledge. Although there undoubtedly is more to wondering than just this, for our present purposes it will suffice to focus on the entailment in (22).

(22) $x$ wonders $\varphi$ :- $x$ doesn't know $\varphi$ and $x$ wants to know $\varphi$

Given (22), we can immediately derive (23) from (21).

(23) For each candidate $x$, I don't know which professor recommends $x$.

If the wide scope reading of "each candidate" in (20) is analyzed as (21) in accordance with Karttunen 1977, then the following sentence should be a contradiction.

(24) I know which professor recommended one of the candidates but I still wonder which professor recommends each candidate.

Contrary to the prediction, (24) does not strike us as being necessarily false. Knowing who recommended one of the candidates does not seem to preclude the possibility of wanting to know, for all candidates, who recommended them. If our intuition is correct, it shows that there really does exist the kind of intermediate reading for (20) where "each candidate" has wider scope than (which professor" but doesn't have scope over "wonder". Another example of the same sort is given in (25).

(25) It is unknown what each candidate has promised, although I happen to know what one of them has promised.

Again, there is no contradiction in (25) on the multiple question reading of "what each candidate has promised" as there would have to be under the assumption that the first clause of (25) has the meaning of "For each candidate $x$, it is unknown what $x$ has promised". On the intended reading "each candidate" must be in the scope of "unknown" but not in the scope of "what". In the latter case, "what each candidate has promised" would be a single question presupposing that all the candidates have made the same promises.
2.3 Quantifying into questions: third attempt

This matter is of considerable interest to us, because we have belatedly discovered that Karttunen 1977 was simply wrong in thinking that one could not formulate a semantic rule for quantifying ordinary noun phrases into questions in the manner suggested in (16). In fact there is a very simple rule that gives the right meaning, namely, rule (26).

\[ Q_2' = \lambda p \neg \text{NP}'(\lambda x_k \neg Q_1'(p)) \]

This rule assigns to the \(Q_2\)-phrase "which professor recommends each candidate", derived from (16), a translation which is equivalent to what we obtained for "which professor recommends which candidate" in (11). The two sentences both come to have the meaning expressed by formula (13) above. -- Note that our interpretation of "which candidate" is the same as that of "some candidate". Considering that "each candidate" is the dual of these, it will be evident from a comparison of rules (12) and (26) that the results are equivalent. Thus our analysis assigns the same meaning to (27)a. and (27)b. on the wide scope interpretation of "each candidate".

(27) a. Which professor recommends which candidate?
b. Which professor recommends each candidate?

We think that this is the right result because there clearly is no situation where the true answers to (27)a. would not constitute the true answers to (27)b. and vice versa. There is of course a residual difference in meaning between the two questions -- this will be discussed later on -- but we are convinced that it is a matter of conventional implicature, not part of the truthconditional aspect of meaning. (See Karttunen & Peters 1976 for an analysis of conventional implicatures of questions). Thus we maintain that (13) does adequately express the truthconditional part of the meaning for both of the questions in (27).

It is important to note that rule (26) gives sensible results only for universally quantified NPs, that is, for NPs with "each", "every", "all", or "the" as their determiner, and for conjoined NPs. Structures similar to (16) but containing an existentially quantified NP, such as "some candidate", "a candidate" etc., or a disjoined NP, e.g. "John or Mary", are peculiar semantically. For the reasons discussed above in connection with (18), the translations associated with the examples in (28) on the putative wide scope reading of the non-interrogative NP designate nothing but the empty set whenever there are at least two candidates.
(28) a. Which professor recommends some candidate?
   b. Which professor recommends many candidates?

We think that the inability of our solution to assign a sensible wide scope, i.e., multiple question, reading to these cases is a point in its favor. As far as we can tell, the kind of argument that we gave above for the existence of an intermediate reading in connection with example (24) only works for NPs like "each candidate", "Mary and Alvin", "all the candidates", etc. Examples like (29) simply do not seem to have any reading in ordinary English under which "some candidate" would have wide scope with respect to "which professor" and yet be in the scope of "wonder".

(29) I wonder which professor recommended some candidate.

Let us now summarize the discussion up to this point. We started by trying to clarify the notion of multiple question and reviewed our earlier treatment of constituent questions. One important improvement in our current description is that we can show that (27)a. and (27)b. are both multiple questions. Questions with universally quantified ordinary NPs that take scope over an initial wh-phrase are semantically in the same category as questions with multiple wh-phrases. This is an interesting result in the light of the fact that there are many languages that do not have anything corresponding to multiple wh-questions. Provided that they have questions of type (27)b. — as Irish, for example, does — such languages are not in any important way deprived of expressive capacity because they lack multiple wh-questions. In the next section of the paper we will examine multiple constituent questions in Finnish where the facts are quite interesting in the light of what we have found out about English.

3. Multiple questions in Finnish

At first glance it appears that multiple constituent questions in Finnish are very similar to multiple wh-questions in English. For example, "Tell me which boy likes which girl" translates into Finnish with two occurrences of the interrogative determiner "Mikä", as shown in (30).

(30) Kerro minulle Mikä poika pitää mistäkin tytöstä.
    tell me which boy likes which girl
    (Nom.)               (Elat.)
Another way of translating the same English sentence into Finnish is (31).

(31) Kerro minulle mistä työstä mikin poika pitää.
tell me which girl which boy likes
(Elat.) (Nom.)

The most obvious difference between (30) and (31) is word order. In Finnish either one of the two interrogative noun phrases can be preposed, whereas in English there is no such option in this case. Another interesting feature of these examples is that in both cases the second one of the two interrogative determiners carries the suffix "-kin". -- Compare "mikä" in (30) vs. "mikin" (< "mikä"+kin") in (31); "mistä" in (31) vs. "mistäkin" in (30). -- It is a general characteristic of Finnish multiple constituent questions that all interrogative phrases except the initial one carry the "-kin" suffix.¹ Since the order of the major constituents is not as rigidly determined as in English, there are at least three ways of saying in Finnish "Tell me which speaker had what to say on which subject", as shown in (32).

(32) a. Kerro minulle millä puhujalla oli mitäkin sanottavaa
    tell me which speaker had what to say
    (Part.)
    mistäkin asiasta.
on which subject.
    (Elat.)

b. Kerro minulle mitä milläkin puhujalla oli sanottavaa
    what which speaker had to say
    (Part.) (Adess.)
    mistäkin asiasta.
on which subject.
    (Elat.)

c. Kerro minulle mistä asiasta milläkin puhujalla oli
    tell me on which subject which speaker had
    (Elat.) (Adess.)
    mitäkin sanottavaa.
    what to say
    (Part.)

¹ One can also find multiple questions in Finnish where all interrogative phrases are unsuffixed, for example, "Kuka sanoi kenelle mitä?" -- "Who said what to whom?" As far as we know, interrogatives of this type only occur as independent utterances, not as embedded questions. Furthermore, they seem to be echo-questions, that is, utterances whose function in conversation typically is to ask for a repetition of a previous utterance by the addressee. We will not try to analyze this class of interrogatives in the present paper.
3.1 Overview of Finnish interrogatives

In the above examples we have consistently translated the word "mikä" in all of its various case forms as "which" or "what". We will continue to do so throughout this discussion, although it is somewhat misleading. The non-initial, suffixed occurrences of "mikä" could just as well be translated as "each". But before we proceed further with this, let us first get an overview of the Finnish interrogative system. We will use the term 'primary interrogative' for the unsuffixed interrogative determiners, noun phrases, and adverbs that occur in the initial position and 'secondary interrogative' for the suffixed forms that occur non-initially. Chart (33) contains the primary and secondary forms of some common interrogatives.

<table>
<thead>
<tr>
<th>Category</th>
<th>Primary interrogatives</th>
<th>Secondary interrogatives</th>
<th>Gloss</th>
</tr>
</thead>
<tbody>
<tr>
<td>NP/Det</td>
<td>kuka</td>
<td>kukin</td>
<td>who/which (human)</td>
</tr>
<tr>
<td>NP/Det</td>
<td>mikä</td>
<td>mikin</td>
<td>what/which</td>
</tr>
<tr>
<td>Loc. Adv.</td>
<td>missä</td>
<td>missäkin</td>
<td>where</td>
</tr>
<tr>
<td>Time Adv.</td>
<td>milloin</td>
<td>milloinkin</td>
<td>when</td>
</tr>
<tr>
<td>Manner &amp; Det. Adv.</td>
<td>miten</td>
<td>mitenkin</td>
<td>how</td>
</tr>
</tbody>
</table>

Secondary interrogatives occur only in conjunction with primary interrogatives; they cannot form constituent questions by themselves, nor do they occur in declarative sentences. Thus (34)b. and (34)c. are ungrammatical in Finnish.

(34) a. Mitä hän sanoi? What did he say?
    b. "Mitäkin hän sanoi?
    c. "Hän sanoi mitäkin.

The secondary form of the word for "which/who" -- "kukin" -- is an apparent exception to the principle just stated. This is because interrogative twin meaning "each/each person". Unlike its determiner or as a noun phrase. Thus we can have pairs such as (35)a. -- a declarative sentence -- and (35)b. -- a constituent question.

    b. Kuka tarvitsee apua? Who needs help?

As one might expect there is an ambiguity whenever "kukin" appears in a constituent question because it could be interpreted either as a secondary interrogative or a primary interrogative. The

interrogative "which/who" or as a non-interrogative "each/each person". An example of this is given in (36).

(36) a. Kerro minulle mistä aiheesta kukin opiskelija puhuu. 
tell me about which topic each/ student talks. 
which

b. Tell me what is the topic that each student talks about.

c. Tell me which student talks about which topic.

On the non-interrogative reading of "kukin", translated as (36)b., the sentence is a single constituent question and it implies that all students are talking about the same topic. Under the other interpretation, (36)c., the question calls for multiple answers pairing students and topics.

The existence of these two variants of "kukin" is not a mere accident. It is actually quite revealing of the nature of secondary interrogatives. In this respect, however, "kunkin" is an exceptional case. None of the other secondary interrogatives in (33) have non-interrogative twins; they are strictly limited to occurring in constituent questions in positions following an initial primary interrogative.²

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² All the secondary interrogatives have another use as well, which lies outside the scope of the present paper. Together with the primary question words, they form constructions which resemble free relatives in English; for example:

(i) Tuuli puhaltaa milloin mistäkin suunnasta. 
wind blows when from which direction

"The wind blows (unpredictably) from different directions at different times."

Because constructions such as "milloin mistäkin suunnasta" in (i) have no parallel in English, they are difficult to translate, although their meaning is quite straightforward. Essentially (i) says that the wind can blow from any direction. The best way to interpret such constructions may be to regard them as a universally quantified version of a type of coordination which is also found in English. Compare (i) with

(ii) Tuuli puhaltaa milloin lännestä, milloin idästä. 
wind blows when from west when from east

"The wind blows sometimes from the west, sometimes from the east."

Although we have not worked out a complete analysis of this interesting class of constructions, it appears that our treatment "milloin", "mikä", etc. in interrogatives is compatible with their semantics here. (Note especially that "mistäkin suunnasta" in (i) has the meaning of a universal quantifier.).
3.2 "Mikin/kukin" vs. "mikään/kukaan"

Having now eliminated the ambiguity of "kukin" as possible source of confusion, let us now take another look at the chart in (33). The secondary interrogatives are all derived -- with minor morphological changes -- from their primary counterparts by adding the suffix "-kin". This same suffix occurs in Finnish in numerous other functions, and typically there is an alternation between "-kin" and "-kaan". This alternation is conditioned very much like the "some/any"-alternation in English with "-kaan" playing the role of the negative polarity "any".

But contrary to what one might expect, the regular "-kin/-kaan" alternation does not affect secondary interrogatives. Thus we have, for example, the form "mihinkin" -- "to which" -- in (37) in spite of the presence of negation in the same clause.

(37) Kerro minulle kuka ei vastannut mihinkin kysymykseen.
   tell me who not answered to which question
   (Nom.) (Ill.)

Tell me who didn't answer which question.

Although the "-kin" suffix in secondary interrogatives is not subject to the "-kin/-kaan" alternation, the corresponding "-kaan" forms actually do exist. They are not interrogative, however, but ordinary determiners, noun phrases, and adverbs, similar to "any", "anyone", "anywhere", etc. in English. This is illustrated in the following examples.

(38) a. Kukaan ei tullut.
   anyone not came
   No one came.

b. Mikään ei toimi.
   anything not works
   Nothing works.

c. Juna ei pysähtynyt missään.
   train not stopped anywhere
   The train stopped nowhere.

d. Hän ei palannut milloinkaan.
   she not returned ever
   She never returned.

There are two alternative analyses for the "-kaan" forms in (38). One could regard them as expressions whose meaning involves existential quantification. In that case "kukaan", "mikään", etc. would have to be assigned narrow scope with respect to negation in (38). Alternatively, one could view them as involving universal quantification, in which case they would take wide scope over negation. The glosses and translations given in (38) were designed to bring out this uncertainty. Most of the arguments given by W. Ladusaw 1979 for treating the negative polarity "anyone" (as opposed to
the free choice "anyone") as an existential quantifier apply with equal force to the Finnish "kukaan", "mikään", etc. For example, the yes/no question "Tuliko kukaan?" (Did anyone come?) has to be answered affirmatively if even one person came. If "kukaan" were analyzed as having the meaning of a universal quantifier, one would expect the question to mean "Did everybody come?" Because of this and other similar arguments, we think that the "kaan" forms in (38) involve existential quantification. This is not a satisfying conclusion, because the non-interrogative "kukin", which one would expect to be the affirmative counterpart of the negative existential "kukaan", has the meaning of a universal quantifier, as we pointed out earlier in connection with (35)a. In any case, to supplement the chart in (33), we now must add a list of negative, non-interrogative quantifiers, determiners, and adverbs.

<table>
<thead>
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<th>Category</th>
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<th>Gloss</th>
</tr>
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<tbody>
<tr>
<td>NP/DET</td>
<td>kukaan</td>
<td>(not) anyone/any</td>
</tr>
<tr>
<td>NP/DET</td>
<td>mikään</td>
<td>(not) anything/any</td>
</tr>
<tr>
<td>Loc. Adv.</td>
<td>missään</td>
<td>(not) anywhere</td>
</tr>
<tr>
<td>Time Adv.</td>
<td>milloinkaan</td>
<td>(not) ever</td>
</tr>
<tr>
<td>Manner &amp; Time Adv.</td>
<td>mitenkään</td>
<td>(not) in any way</td>
</tr>
</tbody>
</table>

Since there is no restriction against using the above forms in constituent questions, we have (40) as well as (37). --Note that (40) is a single question, not a multiple one like (30).

(40) a. Kerro minulle kuka ei vastannut mihinkään kysymykseen.
   tell me who not answered any question
   (Nom.) (Illat.)

   b. Tell me who did not answer any question.

It is puzzling that the distribution of pairs like "kukin" vs. "kukaan", "mikin" vs. "mikään" is far from being complementary, which is what one would expect given the regular "-kin/-kan" alternation in Finnish. We conclude somewhat reluctantly that "kukin" (both the interrogative and its non-interrogative twin) and "mikin" (interrogative) have the meaning of a universal quantifier, while "kukaan" (non-interrogative) and "mikään" (non-interrogative) are existential quantifiers. Besides the meaning of the non-interrogative "kukin", this conclusion rests on the observations discussed in the next section.
4. Comparison of multiple questions in Finnish and English

Up to this point we have worked from the assumption that multiple questions in Finnish are similar to multiple wh-questions in English. We have also assumed that the distinction between primary and secondary interrogatives is of no particular semantic import. To some extent this is certainly justified. In many cases there is no perceptible change in meaning even if we interchange the primary and secondary interrogatives in a question. For example, the two Finnish sentences in (41) both seem to mean exactly what their English translations mean although the interrogative phrases have been switched around.

(41) a. Kuka on naimisissakenenkin kanssa?
    who is married who with
    (Nom.) (Gen.)

    b. Kenenkanssa kukanaimisissa?
    who with who is married
    (Nom.) (Gen.)

    c. Who is married to whom?

4.1 "Which" vs. "each"

However, this is not always the case. It is possible to construct pairs of examples of this kind which contrast in certain situations. We will illustrate this first by using English examples. Let us imagine the situation pictured in (42).

(42)    A         E         I
        B         F         J
    customers
        C         G         K
        D <clerk 1  H <clerk 2  L <clerk 3
    check-out counters

The diagram pictures a scene in a supermarket. The letters represent twelve customers who are lined up in front of three check-out counters waiting for their turn to be served by one of the three clerks. Suppose that we want to find out which customers are presently being served and by which clerks. In other words, we want to ask a question to which the correct answer is (43).

(43) Clerk 1 is serving customer D, clerk 2 is serving customer H, and clerk 3 is serving customer L.
Let us consider how we would elicit the desired information in English. There are of course many ways to do this, but let us compare the three questions in (44).

(44) a. Which customer is each clerk now serving?
   b. Which clerk is now serving each customer?
   c. Which clerk is now serving which customer?

In order to get anywhere with the first two questions, we have to rely on our addressee to be able to figure out from the context that he is supposed to interpret them as multiple questions. In other words, "each clerk" in (44)a. and "each customer" in (44)b. are intended to have wide scope. If the former, for example, were to have narrow scope, then we would be trying to get answers like "All clerks are now serving customer X". That is not a possible answer to the question we are asking here. Eliminating the unwanted single question readings in (44)a. and (44)b. leaves us with distinctions that are rather subtle and therefore difficult to verify. However, nearly all of our informants agree with us -- sometimes after prolonged reflection -- that the first and the last questions in (44) are unobjectionable but that there is something wrong about using (44)b. in this particular situation. (44)b. implicates something false, namely, that all customers are being served by some clerk, when in fact only three of them are. On the other hand, it is the case that all clerks are serving some customer or other. This state of affairs is consistent with (44)c. and (44)a. on the wide scope reading of "each clerk". (44)a. and (44)c. are better questions to ask than (44)b. in this situation because there is no conflict between the facts and the conventional implicatures (presuppositions) of the question. -- Note that (44)c. is the most neutral of these three questions in the sense that it does not even implicate that all the clerks are busy. One indication of this is that the corresponding passivized question, (45), is just as good in this situation as (44)c. is.

(45) Which customer is now being served by which clerk?

In order to avoid misunderstandings, let us emphasize that we do not think that the multiple question readings in (44) express different questions -- whatever is the correct answer to one will also be the correct answer to the others. The difference in meaning lies entirely in what they conventionally implicate about the situation they pertain to.
4.2 "Mikä" vs. "mikin"

In the light of these English examples, it is interesting to find out that the two ways of asking the same question in Finnish, (46)a. and (47)a., contrast exactly in the manner of (44)a. and (44)b.

(46) a. Kerro munulle mitä asiakasta mikin myyjä nyt palvelee.
    tell me which customer which clerk now serves
    (Part.) (Nom.)

b. Tell me which customer each clerk is now serving.

(47) a. Kerro minulle mikä myyjä nyt palvelee mitäkin asiakasta.
    tell me which clerk now serves which customer
    (Nom.) (Part.)

b. Tell me which clerk is now serving each customer.

The secondary interrogatives "mikin" in (46)a. and "mitäkin" in (47)a. give rise to the same kind of implicatures as the word "each" in the corresponding English translations. Thus (46)a. implicates that every clerk is serving some customer and (47)a. implicates that every customer is being served. Since the latter implicature is false, only the former question would fit the situation that we have described. 3

4.3 "Each" vs. "mikin"

While there is this similarity between "each" and the secondary interrogative "mikin", there is also an important difference, and for this reason, we continue glossing "mikin" as "which". "Each" forms general purpose universal quantifiers that can take scope over questions and declaratives alike. Because of this, sentences like (46)b. and (47)b. are ambiguous in English between single and multiple question readings. On the other hand, "mikin" and

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3 As in English, the distinction between (46)a. and (47)a. is very subtle in Finnish. Many speakers are uncertain about what difference there is, if any, between examples of this sort. Looking at several examples of the same sort usually helps. -- The following case brings out the same contrast as the supermarket example in the text.

Assume that there are two jobs. For each job exactly one candidate has been chosen from a number of applicants. Under these circumstances, (i) is a reasonable question in Finnish, because it only implicates that both positions have been filled; (ii) is not because it implicates that every applicant has been appointed to some position.

(i) Kuka tuli valituksi mihinkin virkaan?
   Who was appointed to each position?

(ii) Mihin virkaan kukin tuli valituksi?
   To which position was each person appointed?
4.3 "Each" vs. "mikin"

While there is this similarity between "each" and the secondary interrogative "mikin", there is also an important difference, and for this reason, we continue glossing "mikin" as "which". "Each" forms general purpose universal quantifiers that can take scope over questions and declaratives alike. Because of this, sentences like (46)b. and (47)b. are ambiguous in English between single and multiple question readings. On the other hand, "mikin" and other secondary interrogatives of Finnish are specialized quantifiers that can only take questions in their scope. (As we noted above, "kukin" has a declarative twin.). Consequently, there is no ambiguity in (46)a. or (47)a. These can only be interpreted as multiple questions; there is no single question reading available.

Another difference is that quantifiers formed with "each" cannot be used in English to quantify into yes/no questions or disjunctive questions. We have no explanation for this, it is simply a fact that examples such as (48) are not ambiguous.

(48) Did John serve each customer?

(48) can only be interpreted as the interrogative counterpart of "John served each customer." It is not obvious why this should be so. Given the rules we introduced earlier to account for the two readings of "Which professor recommends each candidate?" — see (16) above — (48) should also have another interpretation. The putative second reading would be the result of quantifying "each customer" into a yes/no question "did John serve Pro?". According to rule (26), the resulting question should have nearly the same meaning as "which customer did John serve?". Since (48) clearly has no such interpretation, some restriction is needed in our description of English to rule out the unwanted reading.

The secondary interrogatives in Finnish behave somewhat differently. Questions corresponding to the missing interpretation of (48) are at least marginally acceptable in spoken Finnish. Furthermore, examples such as (49)a. seem to mean exactly what they should mean on the assumption that "mitäkin" has the meaning of a universal quantifier.

(49) a. ?Onko sinulla mitäkin sanottavaa? have+QP you what to say ("Do you have what to say?")
b. Mitä sanottavaa sinulla on?
what to say you have

c. What do you have to say?

In spite of the presence of the question particle "-ko" on the preposed verb, which normally is a mark of a yes/no question, (49)a. has the meaning of a constituent question; it expresses the same question as (49)b. and its English counterpart (49)c. This is what our analysis predicts, on the assumption that secondary interrogatives in Finnish can be quantified into yes/no questions, and not just into constituent questions as "each customer", etc. can be in English. However, because the status of examples like (49)a. is unclear, this issue requires further study.⁴

5. Quantifiers and variable binding operators

In the last part of this paper we will go on to discuss a new method of interpreting sentences with interrogative and non-interrogative quantifiers. One of the shortcomings of the method we have used so far is that it compels us to postulate syntactic transformations whose only motivation is a semantic one. One reason for assuming the deletion and movement operations indicated in our diagrams is that the meanings that belong to the targets of these operations have to be kept apart and made to interact with the meaning of the rest of the structure in a specific way. Another reason is the requirement of one-to-one correspondence between underlying syntactic representations

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⁴ Some informants report that (49)a. would not be any worse without the "-kin" suffix ("Onko sinulla mitä sanottavaa?") and that it would mean just what (49)a. means. Another interesting problem is the connection between (49)a. and other apparent yes/no questions containing "-kin", such as

(i) Tuliko sinulle paljonkin vääkeä?
came-QP there a lot of +"kin" people
("Did a lot of people come there?")

(ii) How many people came there?

Because of its form, one would expect (i) to be a yes/no question but conversationally it has the force of (ii), i.e. a cooperative addressee will respond to it as if it were the corresponding constituent question ("Kuinka paljon vääkeä sinne tuli?"). It is unclear whether this is a pragmatic fact -- something having to do with the conventions of use -- or whether it is a matter of semantics proper. Does (i) actually mean what (ii) means? Whatever decision is made about cases like (i), it has some implications for (49)a.
and meanings, which is characteristic of the way formal languages are constructed. As Cooper & Parsons 1976 have argued, there is no compelling reason to uphold this principle when dealing with natural languages; it is not a precondition for interpreting a language model-theoretically.

5.1 NP-storage

In the following, we will make use of an innovation developed by Robin Cooper 1978, which is based on the recognition that in general an expression may have more than one meaning. Accordingly, the rules that assign meanings to larger constructions on the basis of the meanings of their parts are stated in terms of sets of meanings rather than single ones. Cooper's most important innovation was to provide a way for the meaning of a noun phrase to be placed off to the side so to speak, in "storage" and a variable meaning used temporally in its place; the stored NP-meaning is quantified in at some later point. In this way scope ambiguities arise in sentences such as "Everyone loves someone" without the necessity of assigning more than one syntactic structure, since the meaning of "someone" can either be stored temporarily or not stored at all. Consider the structure in (50).

\[ S \quad NP \quad V \quad NP \]
\[ everyone \quad loves \quad someone \]

One of the meanings for this sentence can be obtained without using the storage mechanism at all. On that interpretation, the rules discussed earlier (see (5) and (6) in section 1.1) give "everyone" scope over "someone": for every person X there is some person Y whom X loves. The other reading can be derived by storing the meaning of "someone" off to the side and by using in its place a variable meaning of the appropriate type, say \(\lambda P \ P(x_1)\). Along with the meaning of "someone" the store must also contain an indication of what variable the stored NP meaning is eventually going to bind. Under this interpretation, the meaning of the NP "someone" in (50) can be construed as an ordered pair consisting of a "meaning proper", the variable meaning, which interacts with the meanings of other phrases in the regular way and a store containing the yet unused noun phrase meaning with its "address". This is shown in (51).
(51) \( \langle \lambda P \ F(x) \rangle, \langle \lambda P \ \exists x \ [\text{person}'(x) \ & \ P(x)] , x_i \rangle \)

The rule which interprets the VP in (50) essentially operates only on the first member of (51). The stored NP-meaning is simply carried on unchanged. At the level of the S-node the meaning of "someone" finally is brought down from the store by a convention whose effect is to take the first member of the ordered pair, abstract over the variable specified by the stored address, and apply the stored NP-meaning to the result. In this manner, the S-node in (50) comes to have a second interpretation: there is some person X such that every person Y loves X.

This storage apparatus provides a framework for the solution of many interesting problems about quantifier scope in natural language. Ladan 1979 has made good use of it in accounting for a wide range of polarity phenomena. We shall modify somewhat Cooper's idea about storing meanings so that it can be used in some new ways. To understand the changes we will make, it is useful to look in a bit more detail at what meaning attaches to the stored combination of NP-meaning and "address." Cooper himself does not discuss how ordered pairs such as \( \langle \lambda P \ \exists x \ [\text{person}'(x) \ & \ P(x)] , x_i \rangle \) which he places in storage can be assigned a unified meaning. Instead he regards them simply as having a pair of meanings — the first being a quantifier (in a sense we will explain presently) and the second serving merely to identify a variable which will eventually be used to define a function by lambda abstraction. Our procedure is instead to assign a unified meaning to what is stored, treating it as a variable binding operator in its own right. This will permit the "storage retrieval" mechanism to operate in a much more uniform manner, and has other advantages also. The particular meaning that we assign to such variable binding operators (henceforth abbreviated vbo's) depends in a regular fashion on the meaning of the quantifier to which the vbo is related.

5.2 Variable binding operators of valence \(<t,t>\)

In order to make it clear just how such vbo's are assigned meanings, let us briefly review a few facts about meanings in general and NP-meanings in particular. A meaning for an expression \( \exists \) is in general a function whose inputs are assignments of values to variables (together, in a fuller account, with assignments of values to deictic expressions such as the pronouns "I" and "you", the present and past tense, certain adverbs such as "here" and "now", etc.). This meaning function for \( \exists \) yields as output the intension that \( \exists \) has given the particular assignment of contextually variable factors which
its input specifies; thus, for example, the meaning of "everyone loves Pro\(_i\)" maps any assignment \(g\) to the proposition that the individual \(g(x_1)\) -- which \(g\) associates with Pro\(_i\) -- is universally loved. We will denote the intension of \(\exists\) on the assignment \(g\) by the notation \([[\exists]]^g\). Such intensions are, of course, just functions that map world-time pairs \(<w,t>\) to \(\exists\)'s denotation in the possible world \(w\) at the time \(t\) (the context being as specified by the assignment \(g\)). For this denotation we write \([[\exists]]^g,<w,t>\); for instance, the denotation \([[\text{everyone loves Pro}_i]]^g,<w,t>\) is the truth value 0 for (for falsehood) if \(g(x_1)\) is Jimmy Carter and \(w\) and \(t\) are the actual world and present time as of this writing.

We are following Montague in regarding such noun phrases as "someone" or "every sailor" as denoting restricted individual quantifiers; this is what translating them as \(\lambda P \exists x [\text{person'}(x) \& P(x)]\) and \(\lambda P \forall x [\text{sailor'}(x) \rightarrow P(x)]\) amounts to. (One should not confuse this sense of the term "quantifier" with another that is current in the linguistic literature, according to which quantifiers are determiners like "every" and "most", which denote relations between sets -- "every(P)(Q)" holds iff \(P\) is a subset of \(Q\) and "most(P)(Q)" holds iff the cardinality of \(P\) intersect \(Q\) exceeds that of \(P\) intersect the complement of \(Q\).) Any quantifier, in the sense used here, must in effect denote a collection of sets of individuals since its job is to specify what sets of objects in the domain of quantification meet the condition defining that quantifier. Thus \([[\text{someone}}]]^g,<w,t>\) (\(=[[\lambda P \exists x [\text{person'}(x) \& P(x)]]]^g,<w,t>\)) is (technically, the characteristic function of) the set of (characteristic functions of) all sets having at least one member that is a person (as determined in context \(g\) and world \(w\) at time \(t\)). Our reasons for adopting this analysis of noun phrase semantics include those given in Cooper 1977.\(^5\) To mention just one of them here, the object NP "a Ferrari" functions straight-forwardly as a quantifier in producing the so-called non-specific interpretation of

(52) John wants a Ferrari.

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\(^5\) We are departing in a now standard way from the analysis in Montague 1973 by eliminating intensionality at two inessential places: taking the variable \(P\) to range over sets rather than properties -- Montague chose the latter purely for the sake of a minor bit of mathematical elegance -- individual concepts -- Thomason 1974 showed Montague's decision was not necessary to solve the problem that motivated it and Bennett 197 showed that it created other unfortunate problems for Montague.
On this interpretation, sentence (52) is true just in case one of John's wants would be satisfied were he to get any set of things including a Ferrari among them, i.e., to get any set that would belong to the collection denoted by the quantifier "a Ferrari". Thus one can take the verb "want" to express a relation between individuals such as John and things like the intension of the NP "a Ferrari".

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