INCLUSION-CHECKING, EXCLUSION-CHECKING AND CUMULATIVITY

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Determiners and other quantificational expressions are commonly regarded as denoting relations between sets. Checking to see if two sets are in the relation denoted by a particular quantifier may involve one or both of two types of procedure: One either checks to see that a certain number or proportion of the members of the first set are also in the other set, or one checks whether a certain number or proportion of the members of the first set are NOT in the second set. Call the first sort of procedure INCLUSION-CHECKING and the second sort of procedure EXCLUSION-CHECKING.

As long as we are concerned only with extensional relations between sets, either sort of procedure will work for any quantifier. For example, the sentence *Every inventor made $10,000* is confirmed if each of the inventors is in the set of things that made $10,000, or equivalently if NONE of the inventors is NOT in the set of things that made $10,000.

If we look at plural quantifiers, however, the facts turn out not to be so simple.

A sentence like *John and Mary earned $10,000* can be true in at least three distinct sorts of situation: John and Mary may have EACH earned $10,000 (the "distributive" case); they may have earned $10,000 together in some joint enterprise (the "pure collective" case); or their combined incomes may have been at least $10,000 (the "cumulative" case). This does not mean, of course, that the sentence is three-ways ambiguous, only that three sorts of situation will satisfy its truth conditions. I will assume in fact that the sentence is two-ways ambiguous, between a distributive reading on the one hand, and a reading which is satisfied by either the collective or the cumulative

situation on the other. I will also assume that the sentence is ambiguous because its verb phrase (not its subject noun phrase) is ambiguous.[1]

Now consider a sentence like *No inventors made $10,000*. If this sentence is true, then there cannot be any individual inventors who made $10,000. There also cannot be any groups of inventors who made $10,000 in a "pure collective" manner: Suppose John and Mary invented the pocket spud-bar and sold the patent for $10,000. In this situation, the sentence is false.[2]

However, the sentence does not rule out the case where two inventors, say, Bill and Sue, each made $5000 in separate enterprises. This is despite the fact that the group of Bill and Sue WILL have to count as having made $10,000 for the purposes of evaluating sentences like *Bill and Sue made $10,000* or *The inventors made $10,000*. In fact it holds generally that a set of inventors whose combined income was at least $10,000 is sufficient to confirm *The inventors made $10,000* but insufficient to falsify *No inventors made $10,000*.

A similar pattern occurs with sentences whose subjects are modified by the quantificational adverb *only*. Suppose John

[1] This ambiguity may be due to modification of the VP by an implicit adverb-like modifier; see Roberts (1987a, b, c) for discussion. On treating distributivity as a property of VPs rather than NPs, see Bartsch (1972, 1973), Scha (1981), Hoeksema (1983), Link (1984, 1987), Dowty (1986), Roberts (1987a, b, c), Lasersohn (1987, 1988, 1989, to appear). On the number of readings assigned to this sort of sentence, see Roberts (1987a), Lasersohn (1988, 1989); for opposing viewpoints see Harnish (1976), Katz (1977:127-128), Scha (1981), Gillon (1987).

[2] Note that it is false because of John and Mary's collective earning of the $10,000, not because of their collective inventing of the pocket spud-bar. The fact that *inventor* is a "relational" noun has nothing to do with this effect; cf. *No chimpanzees have ever built a television set*, which is false if a group of chimpanzees cooperatively build a television.

lifted five pianos, and Mary and Bill also lifted five pianos, in a pure collective manner (i.e. for each of the five pianos, they lifted it together). In this case *Only John lifted five pianos* is false, since Mary and Bill lifted five pianos too. However, if Mary lifted three pianos and Bill lifted two (and they didn't lift any of them collectively), this fact is not by itself sufficient to falsify *Only John lifted five pianos* -- even though it WILL be sufficient to verify *Mary and Bill lifted five pianos*.

There are at least two possible strategies one might use to account for this sort of pattern. One would be to abandon the assumption that the cumulative understanding of a VP like *made $10,000* or *lifted five pianos* does not represent a separate reading from the pure collective understanding, and instead treat verb phrases of this sort as systematically ambiguous. Provided there was some systematic way of distinguishing cumulative VP denotations from collective and distributive VP denotations, we could then exclude cumulative denotations from the range of the relations denoted by *no* and *only*. *No inventors made $10,000* would then receive a well-defined interpretation only if *made $10,000* were interpreted non-cumulatively, and the existence of a group of inventors that had a combined income of $10,000 would not be enough to falsify the sentence. Likewise *Only John lifted five pianos* would only receive a sensible interpretation if *lifted five pianos* were interpreted non-cumulatively, and the fact that Mary lifted three pianos and Bill lifted two would not falsify the sentence.

Another strategy, which I believe will turn out to be more illuminating, is to retain the assumption that the cumulative and pure collective cases correspond to a single reading, and instead reconsider whether inclusion-checking and exclusion-checking are really always equivalent.

Consider how a situation in which John and Mary earn $10,000 in a pure collective manner situation differs from a situation in which they earn $10,000 by virtue of their individual incomes totaling at least this much -- or for that matter, from a situation in which John and Mary each earn $10,000.

If we impose a part/whole structure on the domain of situations S, these sorts of event can be distinguished easily. Let us suppose that if two different things happen in a situation s -- say, John's lifting a piano and Mary's lifting a piano -- then s contains two distinct subsituations, one for John's lifting and one for Mary's lifting. Further, assume that for any two situations s_1 and s_2, there is a third, complex situation $s_1 \sqcup s_2$, the join of s_1 and s_2, which has s_1 and s_2 as parts. Everything that happens in s_1 also happens in $s_1 \sqcup s_2$; so does everything that happens in s_2. Nothing else happens in $s_1 \sqcup s_2$.[3]

Suppose John and Mary lift five pianos in some situation s. Any number of other things can happen in s; it might be a large situation encompassing a wide variety of facts that have nothing to do with John and Mary's lifting five pianos. However, it will contain a subsituation s_0 which consists just of John and Mary's lifting. We can distinguish whether the pianos were lifted distributively, collectively or cumulatively as follows: If John and Mary each lift five pianos in s_0, then s_0 will have distinct subsituations s_1 and s_2 such that John lifts five pianos in s_1 and Mary lifts five pianos in s_2. If John and Mary lift five pianos in a pure collective manner in s_0, then s_0 will not have subsituations in which John lifts any pianos or in which Mary lifts any pianos; all piano-lifting will be at the group level.[4]

[3] A more formal account of the structure of situations appears in the appendix.

[4] Nothing, of course, rules out the case where John and/or Mary lift pianos in s, only in s_0.

If John and Mary lift five pianos in a cumulative manner in s_0, then s_0 will have subsituations in which John lifts one or more pianos and subsituations in which Mary lifts one or more pianos; furthermore, the number of pianos that John lifts and the number that Mary lifts will sum up to five.[5]

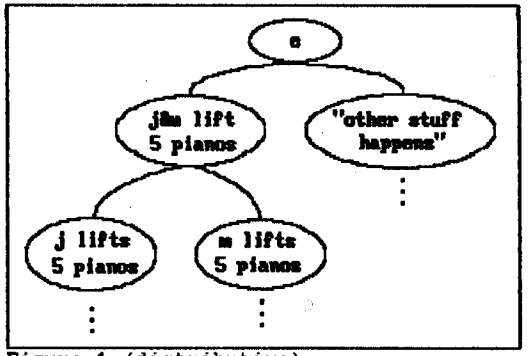

Figure 1 (distributive)

Figures 1 - 3 informally diagram these situation structures.

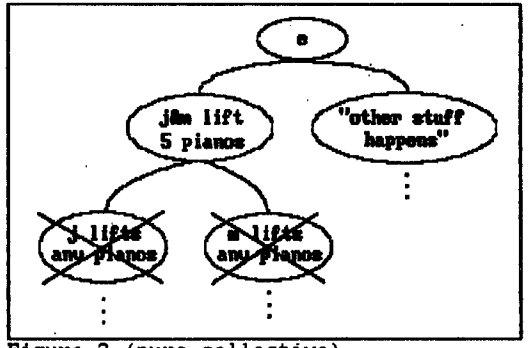

Figure 2 (pure collective)

As a first stab at relating situation structure to natural language semantics, we might suggest something like the following: Sentences denote sets of situations; specifically, each sentence denotes the set of situations it is true in. Verb phrases denote functions mapping situations onto sets of groups

[5] This format for distinguishing among distributive, pure collective and cumulative situations has independent motivation from the analysis of adverbials like *together*, comitative PPs, or *as a group*; these show a semantic alternation between "collectivizing" readings (as in *John and Mary lifted the piano together*) and locative readings (as in *John and Mary sat together*). By assuming situation structures as outlined above, it is possible to give formally parallel definitions for both readings; see Lasersohn (1988, to appear).

and/or individuals; for example, *earn $10,000* will map a situation *s* onto the set of groups and/or individuals which earn $10,000 in *s*, *lift five pianos* will map *s* onto the set of groups and/or individuals that lift five pianos in *s*, and so on. Transitive verbs denote functions from situations to functions from groups and/or individuals to sets of groups and/or individuals; *lift* will map *s* onto a function which maps, say, John onto the set of groups and or individuals that lift John in *s*. Quantificational noun phrases denote functions from situations to sets of possible VP denotations; for example *every man* will map a situation *s* onto the set of possible VP denotations such that a function *f* is in the set if *f*(*s*) contains every man. Referential noun phrases denote groups or individuals, or may be raised to denote sets of possible VP denotations in the standard way. These denotation domains can be represented type-theoretically or set-theoretically as in the following table. Here *s* is the type of situations (not possible worlds), *e* is the type of individuals and groups, and *t* is the type of truth values; *S* is the set of situations and *E* is the set of individuals and groups:

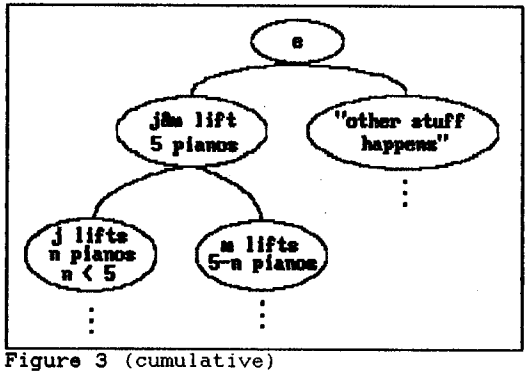

Figure 3 (cumulative)

CATEGORY	TYPE	DOMAIN
S	$\langle s, t\rangle$	$\text{pow}(S)$
VP	$\langle s, \langle e, t\rangle\rangle$	$\text{pow}(E)^S$
TV	$\langle s, \langle e, \langle e, t\rangle\rangle\rangle$	$(\text{pow}(E)^E)^S$
NP[+Q]	$\langle s, \langle\langle s, \langle e, t\rangle\rangle, t\rangle\rangle$	$(\text{pow}(\text{pow}(E)^S))^S$
NP[−Q]	e	E

These type assignments should be fairly unsurprising to readers familiar with Montague Grammar. Compositional rules of an equally unsurprising sort can now be used to derive the set of situations denoted by a sentence from the denotations of its parts.

However, this assignment of denotation domains has a defect, in that it will not allow quantifiers like *no* and *only* to select between collective and cumulative situations in the necessary way.

Suppose we are trying to evaluate a sentence like *No inventors earned $10,000*. If John and Mary are inventors, part of what we will have to do in determining if this sentence is true or false is check to see if the group of John and Mary earned $10,000. If so, we have to check HOW they earned it. If they earned it collectively, then the sentence is false; if they only earned cumulatively, then the sentence may be true.

But to check if they earned it cumulatively, we have to find the minimal situation in which *John and Mary earned $10,000* is true, and see if it has subsituations in which *John earned $N* or *Mary earned $N* are true, for some $N \leq 10{,}000$. This is clearly a non-compositional procedure; it derives the semantic value of one expression (the sentence *No inventors earned $10,000*) partly on the basis of the semantic values of expressions which do not form constituents of it (the sentences *John earned $N* and *Mary earned $N*, for all $N \leq 10{,}000$).

A compositional treatment can be given if we make a change in the assignment of denotation domains, however. Suppose that each verb phrase α denotes a function mapping any situation *s* not onto a single set, but onto a pair of sets. The members of the first set, which I will call the INCLUSION SET of the predicate relative to *s*, and represent as $[\![\alpha]\!](s)_1$, will be the groups and individuals that have the property expressed by the predicate (in *s*). The members of the second set, which I will call the

EXCLUSION SET of the predicate relative to s, and represent as $[\![\alpha]\!](s)_$, will be the groups and individuals that do NOT have the property expressed by the predicate (in s). Inclusion and exclusion sets are thus reminiscent of "positive and negative denotations", as suggested, e.g., by Kamp (1979) or Cooper (1983). Let us also extend this pairing down to the level of transitive verbs: Each transitive verb α will denote a function mapping any s onto a pair of functions, which we might refer to as the "inclusion" and "exclusion" functions of the verb relative to s, again represented as $[\![\alpha]\!](s)_t$ and $[\![\alpha]\!](s)_$, respectively. These functions map onto the inclusion and exclusion sets of potential verb phrases in the expected way: The inclusion function of the verb *lift* (relative to some s) will map John, for example, onto the set of groups and/or individuals that lift John in s, i.e. onto the inclusion set of the VP *lift John* relative to s. The exclusion function of the verb will map John onto the exclusion set of *lift John* relative to s.

The new domains are as in the following table. (Standard type notation cannot represent these domains, so type labels are not given. The domain for noun phrases will be discussed below.)

CATEGORY	DOMAIN
S	$\text{pow}(S)$
VP	$(\text{pow}(E) \times \text{pow}(E))^S$
TV	$((\text{pow}(E) \times \text{pow}(E))^E)^S$
NP[+Q]	$(\text{pow}((\text{pow}(E) \times \text{pow}(E))^S))^S$
NP[-Q]	E

A transitive verb and its object will combine by the following rule:

> For any transitive verb α and (non-quantificational[6]) noun phrase β, $[\alpha\ \beta]$ is a verb phrase and denotes that function f such that for all s, $f(s)$ $(= \langle f(s)_t, f(s)_ \rangle)$ $= \langle [\![\alpha]\!](s)_t([\![\beta]\!]), [\![\alpha]\!](s)_([\![\beta]\!]) \rangle$.

Now, as long as the inclusion and exclusion sets of a predicate complement each other exactly, nothing is to be gained from this sort of pairing at all. The advantage of splitting predicate denotations along these lines is that it permits these two sets NOT to complement each other, and therefore gives us the means to allow a group or individual simultaneously to count as having a particular property (in the sense of being a member of the inclusion set of a predicate expressing that property) and to count as not having that same property (in the sense of being in the exclusion set of the same predicate). In particular, it allows us to capture the fact that a group which has a property only cumulatively will verify a sentence where the predicate combines with a subject noun phrase like *John and Mary* or *the inventors*, but will not falsify a sentence where the predicate combines with a noun phrase like *no inventors* or *only John*.

The following conditions seem appropriate for relating the inclusion and exclusion functions associated with a given transitive verb. First, if a group or individual is not in the inclusion set obtained by applying a transitive verb to its object argument, then it should be in the exclusion set:

> CONDITION ONE. For all situations s, and all groups and individuals x, y, where α is a transitive verb: If $x \notin [\![\alpha]\!](s)_t(y)$, then $x \in [\![\alpha]\!](s)_(y)$.

Second, if a group is in the inclusion set only by virtue of having a property cumulatively, then it is also in the exclusion set. To see if it is in the inclusion set cumulatively, check to see if any of its members or proper subgroups stand in the relation expressed by the verb to any members or proper subgroups

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[6] I assume now that non-quantificational noun phrases denote groups or individuals directly, and that quantificational noun phrases are introduced by a separate quantifying-in rule.

of the group denoted by the object in all subsituations of s of the appropriate sort:

> CONDITION TWO. For all situations s, and all groups and individuals x, y, where α is a transitive verb:
>
> If (1) $x \in [\![\alpha]\!](s)_{\uparrow}(y)$,
>
> and (2) for all subsituations s' of s such that $x \in [\![\alpha]\!](s')_{\uparrow}(y)$ there exists some w, a member or proper subgroup of x, and some z, a member or proper subgroup of y, such that $w \in [\![\alpha]\!](s')_{\uparrow}(z)$,
>
> then $x \in [\![\alpha]\!](s)_(y)$.

To see how this works, suppose that the group of John and Mary cumulatively earns \$10,000 in s, say because John earns \$5000 and Mary earns \$5000. I will assume that this means they each earned a group of 5000 individual dollars.[7] Suppose that the group does not earn any money at all apart from what its individual members earn, i.e. that the only way the group earns money in s is cumulatively. Then for any subsituation s' of s in which the group earns \$10,000, it will also be the case in s' that John earns \$5000 and that Mary earns \$5000; more specifically it will be the case that John earns a subgroup of the group of dollars that the group of John and Mary earn, and so does Mary. Condition Two therefore requires that the group of John and Mary be in $[\![\textit{earn}]\!](s)_(y)$, where y is the group of 10,000 dollars that John and Mary earn in s. Of course the group of John and Mary will also be in $[\![\textit{earn}]\!](s)_{\uparrow}(y)$.

We can treat quantificational noun phrases as denoting functions from situations to sets of possible VP denotations. Specifically, let an NP of the form [*no* α], where α is a common

[7] Dollars as abstract units of monetary value, not individual dollar bills, of course. An alternative analysis would treat sums of money as individual objects rather than groups, and nouns like *dollar* as denoting measure functions on these sums of money. Condition Two would then have to be reformulated to make reference to the part/whole relation on monetary sums (and probably other part/whole relations as well), in addition to the group membership and subgroup relations.

noun, denote a function mapping each situation s onto the set of possible VP denotations $\{f \in D_{VP} \mid [\![\alpha]\!] \subseteq f(s)_\}$, that is, onto the set of possible VP denotations whose exclusion sets include every member of the common noun denotation. Let an NP of the form [*only* α], where α is a non-quantificational noun phrase, denote a function mapping each s onto the set $\{f \in D_{VP} \mid E - f(s)_ = \{[\![\alpha]\!]\}\}$, where E is the domain of individuals and groups.

A sentence of the form [α β], where α is a quantificational noun phrase and β is a verb phrase, will denote the set of situations $\{s \in S \mid [\![\beta]\!] \in [\![\alpha]\!](s)\}$. Where α is a non-quantificational noun phrase, we let [α β] denote $\{s \in S \mid [\![\alpha]\!] \in [\![\beta]\!](s)_{\uparrow}\}$. (Equivalently, type-lift α to the level of quantificational noun phrases, letting its new denotation be that function which maps any s onto the set $\{f \in D_{VP} \mid x \in f(s)_{\uparrow}\}$ -- where x is the denotation of α at its lower type -- and apply the general rule for combining quantificational noun phrases with verb phrases.)

Suppose that John and Mary are inventors, hence that the group of John and Mary is in $[\![\textit{inventors}]\!]$.[8] Now if the group of John and Mary cumulatively earns \$10,000 in s, then the group will be in $[\![\textit{earned \$10,000}]\!](s)_$, and by the rules above will not count as a counterexample to the sentence *No inventors earned \$10,000*. However, the group will also be in $[\![\textit{earned \$10,000}]\!](s)_{\uparrow}$, so the sentence *John and Mary earned \$10,000* will be true in s. Hence it can simultaneously be true that John and Mary earned \$10,000, that John and Mary are inventors, and that no inventors earned \$10,000.

In the semantics just outlined, inclusion-checking and exclusion-checking are no longer equivalent, because they check for membership in non-complementary sets. In fact, a prediction is made that inclusion-checking quantifiers will never be

[8] I assume that $[\![\textit{inventor}]\!]$ is the set of individual inventors, and $[\![\textit{inventors}]\!]$ is the set of all individual inventors and groups of inventors.

sensitive to the difference between collective and cumulative predication, while exclusion-checking quantifiers will always be sensitive to this distinction.

Counterexamples are not easy to find, but one particular class of situations deserves comment. In cases where a group of individuals is considered to act as a team, the group as a whole "gets credit" for the actions of its individual members much as though the team performed those actions collectively. In certain circumstances this assignment of "team credit" bears a resemblance to cumulative predication. As an example, imagine a piano-lifting contest. John and Mary form one team, and Bill forms a team by himself. During the contest, Bill lifts five pianos, John lifts two pianos and Mary lifts three. Extending credit for John's actions and Mary's actions to the team, we can say that John and Mary lifted five pianos.

As far as inclusion-checking and exclusion-checking are concerned, groups that have a property because of the assignment of team credit follow the pattern of groups which have the property collectively, rather than the pattern of groups which have the property cumulatively. In the above example, for instance, it seems false that only Bill lifted five pianos, because another team, John and Mary, also lifted five pianos.

Note that cumulative understandings may be available for groups to which team credit is not assigned. Suppose that John and Mary form one team, and Bill forms one by himself, and Sue forms another one by herself. Each individual lifts two pianos. In this situation it is true that Bill and Sue lift four pianos. However, because they do so only cumulatively, and not by team credit, the only team to lift four pianos is the team of John and Mary, and the sentence *Only John and Mary lifted four pianos* is true.

It seems, then, that team credit events should be represented model-theoretically like collective events, so that the event of a team performing some action will not have subevents in which the members of the team perform that action. If we define the structure of events in terms of the relation of

logical consequence, as suggested in the appendix below, this sort of representation will follow naturally.

In effect, the proposal given in the appendix defines the structure of situations in bottom-up fashion. First, a set of atomic situations is defined, corresponding one-one to the set of true, logically independent, simple propositions. This set of atomic situations is then closed under a lattice-theoretic join operation to generate the structure of situations as a whole, with truth of propositions being preserved upward through the lattice-structure.

Since, e.g., the proposition that the team of John and Mary lifted a given piano is logically independent of the propositions that John lifted it and that Mary lifted it, this first proposition will correspond to a separate atomic situation, which does not have John's lifting or Mary's lifting as subsituations. The minimal situation in which the team lifts four pianos will simply be the join of four atomic situations -- one each for the four pianos -- and again will not have John's liftings or Mary's liftings as subsituations. In other words, this situation will have the structure of a collective lifting situation rather than a cumulative one, and the fact that the team lifted four pianos is correctly predicted to falsify sentences like *Only Bill lifted four pianos*.

APPENDIX ON SITUATION STRUCTURE

Formally, we may define the structure of situations much like a structure of data sets. Assume a formal language L like predicate logic with operations but without quantifiers or variables, and a model $\langle E, F \rangle$, where E is a boolean algebra and F is an interpretation function of the standard sort. We take '$x + y$' to denote the "group", or boolean join, of x and y, and understand F to assign the value 1 to a formula '$P(x + y)$' iff the group of x and y has property P COLLECTIVELY; distributive and cumulative understandings will be handled by a separate assignment of formulas to situations.

Let S be a non-empty set, understood as a set of situations, and for each $s \in S$ let $T(s)$ be a subset of L, intuitively the set of formulas which hold true in s. S is an admissible structure of situations iff it meets the following three conditions: (1) For each connective-free sentence p of L such that $F(p) = 1$, there exists some $s \in S$ such that $T(s) = \{p\}$. (2) If $s_1, s_2 \in S$, then $s_1 \sqcup s_2 \in S$, where: (i) $T(s_1) \cup T(s_2)$ is a subset of $T(s_1 \sqcup s_2)$; (ii) if $P(x_1,\ldots,x_n), P(y_1,\ldots,y_n) \in T(s_1) \cup T(s_2)$, then $P(x_1 + y_1,\ldots,x_n + y_n) \in T(s_1 \sqcup s_2)$; (iii) $T(s_1 \sqcup s_2)$ is closed under conjunction and logical consequence; (iv) nothing else is in $T(s_1 \sqcup s_2)$. (3) Nothing else is in S.

We require that each (affirmative) English sentence denote a set of situations A, such that for some $p \in L$, $A = \{s \in S \mid p \in T(s)\}$. For additional details see Lasersohn (1988).

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Postposed Subjects

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0. Introduction

Although in recent years the phenomenon of free-subject inversion has received a great deal of attention, most of this has concentrated on investigating it as a potential property of the null-subject parameter. Yet postposed subjects observe unexpected interpretive restrictions with respect to pronominal binding, as illustrated in (1) and (2), which make them interesting on their own, independently of the Null-subject parameter. (Asterisks are used to indicate unacceptable coreference.)

(1) Cuando no la invitan, Ana se ofende.
*Cuando no la invitan, se ofende Ana.
'When they don't invite her, Ana takes offense."

(2) Quién cree que Ø dijo que él es inteligente?
*Quién cree que Ø dijo que es inteligente él?
'Who thinks that he said that he's intelligent?'

In the first example, a postposed lexical subject, in contrast to a preverbal one, cannot function as antecedent for a pronoun contained in a preposed adverbial clause. In the second example, a postposed subject pronoun cannot be bound by a wh-operator, regardless of the degree of embedding of the clause containing it, in contrast to a preposed subject pronoun, which may be bound in identical context.

This paper attempts to give an account of the facts just observed in terms of the interaction of the Binding principles and the Focus operator. It is argued that Spanish postposed subjects must be variables bound by the Focus operator. These subjects are essentially analyzed as focused elements. Thus, it is proposed that the difference between **Juan llamó** and **Llamó Juan** in (3), with nuclear stress in the last word in both cases, is that the sentence with postposed subject must have an LF representation as 'x: Juan, llamó x', roughly paraphrased as 'the x such that x called is Juan'.

(3) a. Juan llamó.
b. Llamó Juan. x: Juan (llamó x)

The restrictions of postposed subjects with respect to pronominal binding follow from the analysis of Focus as obligatory movement at LF (Chomsky 1976, May 1985). This analysis characterizes the unacceptable sentences of (1) and (2) as weak- and strong-crossover configurations, involving the Bijection Principle, and Principle C of the Binding theory, respectively. This and other cases of strong-crossover configurations are identified, on the assumption that the Binding principles apply in their generalized definitions, as proposed by Aoun (1986).

The analysis of postposed subjects as focused phrases lends empirical support to the interpretive distinction 'attributed' vs. 'speaker's emphasis' in terms of embedded vs. nonembedded focal structure, developed by