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**PROCESSING OF WH-DEPENDENCIES IN A NULL SUBJECT
LANGUAGE:
REFERENTIAL AND NON-REFERENTIAL WHS.**

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The work presented here is part of a research project on Italian parsing, the goal of which is to provide a cross-linguistic test of sentence processing models.

The comparison of English and Italian is particularly interesting, because the two languages differ in the setting of a syntactic parameter. Some natural languages allow phonetically null subjects in tensed clauses, while others do not. The two types are instantiated by Italian and English (see (1)). Other properties systematically correlate with the null subject property (Perlmutter, 1971; Taraldsen, 1978; Rizzi, 1982):

- Null Subject languages generally have a free process of subject inversion as in (2), while non-Null Subject languages do not;
- Non-Null Subject languages often show COMP-trace effects as in (3), while Null Subject languages do not. In the examples, "pro" indicates the lexically null pro(nominal) subjects. English glosses are given below

the Italian examples; "e" indicates an empty category, not phonetically realized (like a trace). The English translation is in parentheses.

- (1) a. pro telefonerà
pro will telephone. (he/she will telephone)
- (2) a. pro_i telefonerà Gianni_i.
pro_i will telephone Gianni_i. (Gianni will telephone)
- (3) a. Chi_i credi che e_i telefoner?
Who_i do you think that e_i will telephone?
(Who_i do you think e_i will telephone?)

Given that the majority of the studies in psycholinguistics have been done in English, crosslinguistic studies in the field give the possibility of testing whether the processing principles identified to date have been biased by language-specific aspects of English.

The study of Italian is particularly suitable to this goal because, due to the null subject parameter, it has a much freer word order, and consequently more structural ambiguity than English, in strings of the form NP- Verb- NP. This observation has often been used (McClelland and Kawamoto, 1986; MacWhinney, Bates and Kliegl, 1984) to argue that the formulation of syntactic parsing strategies based on English data could have been biased by the rigidity of the structural constraints. Therefore if it turns out that even in Italian the perceiver uses structurally based strategies in the initial parsing of a sentence, it will constitute evidence in favour of the idea that the parsing strategies formulated for English are not due to the structure of the English language, but rather reflect general properties of the human sentence parsing mechanism [1].

I will present two questionnaire studies and one on-line reading time experiment and the processing principle that I propose to account for them. The processing principle focuses on how empty elements are processed. Specifically I argue for the validity of the Minimal Chain Principle (MCP) applied to S-structure, determining the decisions made at ambiguous points and the complexity of unambiguous sentences.

Minimal Chain Principle: avoid postulating unnecessary chain members at S-structure, but do not delay required chain members (De Vincenzi, 1989).

The principle is based on the claim that chains are computationally complex and therefore the parser will always choose the shortest one. In terms of processing times, the MCP predicts that in case of ambiguity between a singleton and a non-singleton chain the parser will prefer the singleton one and that more complex chains will be processed slower than simpler ones.

The MCP uses the notion of chain. The definition of chain (adapted from Rizzi, 1988) is that it is a set of elements non distinct in indices (if they have indices, or non distinct in feature content, or non distinct in category), bearing one and only one Theta-role (agent, patient, recipient, etc.) and one and only one case (such as nominative, accusative, etc), where each element of the chain is in a relation configurationally defined (antecedent government) with the next one.

The shortest chain is therefore a singleton chain, like the "pro" in (1). In (2), there is a non-singleton chain formed by the "pro" in subject position, which is assigned both Th-role and case, along with the Inverted subject in post verbal position (which, instead, is not assigned a Th-role or case in that position, but receives them by virtue of being in a chain with the "pro").

The MCP predicts that in Italian in cases of ambiguities of the null subject position the parser will prefer to postulate a "pro" that is in a singleton chain (as in (1)) to a "pro" that is in a longer chain (as in (2)). Notice that the preference to analyze an element as being in a one-member chain amounts to saying that the parser prefers to analyze an element as being in its deep-structure position, that is in the position where it directly receives a thematic role. In this respect the MCP is reminiscent of Fodor's (1979) "Superstrategy" proposal that the parser "processes a word sequence as if it were the terminal string of a well formed deep structure" (Fodor, 1979, p. 249).

The MCP applies also to the processing of questions. The second part of the MCP says: "do not delay postulating required chain members". "Required" chain members implies that a moved element has been

identified. (4) is an example: the wh-word ("who") is in a position without Thematic-role or case. Therefore, it has to enter in a chain with an element that has both. The principle says that this postulation of the other member(s) of a chain should not be delayed. Experimental evidence from Dutch (Read, Kraak and Boves, 1980; Frazier, 1987b; Frazier and Flores D'Arcais, (1989)) and English (Stowe, 1986; Frazier and Clifton, 1990) show that once a moved element (the "who" in (4), generally called the filler) is identified, then the parser tries to posit a phrasal category that is the same as the one of the filler (in (4), for example, a Noun Phrase category) as soon as possible (in (4), it will be the direct object position, which is occupied by "Ruth").

(4) Who did Joe convince Ruth to come with ___?

This parsing preference has been formulated by Frazier as the Active Filler Hypothesis (AFH):

Active Filler Hypothesis: once an element of a category XP is identified as moved from its argument position, then posit a corresponding empty XP category as soon as the grammar of the language allows you to do so.

The second part of the MCP, then, basically coincides with the Active Filler Hypothesis. It says that the processor does not delay postulating an unavoidable empty element. Notice that while the second clause of the MCP embodies the AFH, the first clause instead embodies the spirit of Fodor's proposal, namely that a string will be analyzed as a well formed deep-structure, postulating movement as last resort. The MCP can then be seen as combining the two principles under the notion of chain: in particular it says that the parser avoids the postulation of non-singleton chains, that is it preferentially analyzes an element as being in a singleton chain, in a position where it directly receives a theta role, i.e. its deep-structure position. However when there is an element that is unambiguously in a non-singleton chain, then the parser will become "active" and will try to postulate the other member(s) of the chain, the gap(s), as soon as possible.

The studies that I am going to present are a test of the MCP in the processing of wh-filler gap dependencies in Italian. Wh- questions are filler/gap constructions where the wh-item is unambiguously a

filler. Thus, the parser will know from the time it encounters the wh-item that a link with a sentence internal position is required. In the following I will illustrate how the hypothesis has been tested. In particular, I will describe the structural ambiguity that is present in Italian wh-questions of the form wh- Verb- NP. Then I will illustrate the reasons why we used different types of wh-s, both with respect to their structural representations and to how they can discriminate among different parsing models.

Syntactic structure of wh-questions in Italian.

Italian wh-questions of the form "WH- Verb- NP" have a structural ambiguity that is not present in English. The ambiguity consists in the fact that either the WH or the post-verbal NP can be the subject of the sentence. This ambiguity is due to the fact that in Italian the subject can freely appear in post-verbal position. Let's take (5) as an example of the structure that I will be testing in the experiment, a structurally ambiguous wh-construction with the two equally plausible interpretations (5a) and (5b):

- (5) Chi ha chiamato Giovanni?
 (who has called Giovanni?)
- a. Chi_i e_i ha chiamato Giovanni?
 (Who has called Giovanni?)
- b. Chi_i e_j ha chiamato e_i Giovanni_j?
 (Who has Giovanni called?)

The preferred interpretation according to MCP is (5a) because the wh-filler will be assigned to the leftmost empty phrase position in the sentence, where it will be interpreted as subject. Hence, if the initial wh- should turn out to be the object, the sentence should be difficult to understand.

But even if we found that there is a preferred subject extraction in cases of wh-questions as in (5), the result would not discriminate the MCP from other processing explanations. In fact a parsing strategy that simply says: "take the first NP in the string of words as subject" would get exactly the same predictions that the MCP makes, at least in Italian.

What is crucial then to discriminate between the MCP and the strategy just described is the use of wh-items that occupy the same (initial) position in the string of words, but differ in the properties that they

have with respect to the structural representation of the sentence. In fact the MCP implies the immediate building of a structural representation of the sentence and therefore it leads us to expect on-line effects due to this representation. However a parser that uses the strategy "1st NP = subject" does not imply the construction of a syntactic structural representation, and therefore does not predict that structural differences should alter a subject preference.

The items that we have in mind are "chi" ("who") and "quale-N" (which-N). Much linguistic evidence has accumulated to show grammatical differences between who and which-N, as the following section will illustrate.

Certain differences between "who" and "which-N".

To address the distinction between "who" and "which-N" we will have to briefly digress to examine the notion of referential indices, as introduced by Rizzi (1988). There is a well known difference in extraction between arguments (6a) and adjuncts (6b) in weak islands, such as wh-islands, as illustrated in (6):

- (6)a. Which problem do you wonder how to solve?
 b. *How do you wonder which problem to solve?

This difference has been explained in terms of the Empty Category Principle, a principle which establishes the grammatical well-formedness relations for empty categories, in particular whether the empty categories satisfy the requirement of "proper government" [2]. In (6a) the empty category left by the long-distance movement is in a position in which it is governed by a lexical head (the Verb). In contrast, the adjunct's trace in (6b) is not head-governed or antecedent governed, and so is ungrammatical under the ECP.

However, Rizzi (1988) noticed that there are cases of long-distance movement of arguments that seem to pattern with adjuncts. The verb "weigh" is ambiguous between an agentive reading and a stative reading. The agentive reading, (7a), selects a theme for its Direct Object, while the stative reading (7b) selects a measure phrase.

- (7)a. John weighed apples.
 b. John weighed 200 pounds.

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Both of these objects are strictly subcategorized, and so are arguments. Both can be questioned as in (8):

(8) What did John weigh e?

However, when the "what" is extracted from a wh-island, only the theme reading (7a) remains, as (9) shows:

(9). What did Mary wonder whether John weighed e ?

Note that by using "how many kilos", which requires the measure-phrase meaning for "weigh", we get an ungrammatical sentence.

(10). *How many kilos did you wonder whether John weighed e?

Similar facts obtain with the extraction of the nominal parts of idioms:

(11)a. *How much attention did you wonder whether Sally paid to Bill?

b. How much attention did you say that Sally paid to Bill?

Since both the nominal parts of idioms and the measure phrases are governed by their verb, the ECP cannot explain this distinction. Instead, Rizzi proposes a distinction between "arguments, referential expressions potentially referring to participants in the event, and quasi-arguments, expressions which receive a theta-role but do not refer to a participant." This leads to a distinction between referential theta-roles and non-referential theta-roles. Furthermore, a category receiving a referential theta-role will receive a referential index at D-structure. Also, the content of this position, if moved, can carry its index along. These referential theta-roles enter the definition of binding, and only arguments bearing them can bind their trace.

binding: x binds y iff
(i) x c-commands y, and
(ii) x and y have the same referential index

The distinction between referential arguments on the one hand, and adjuncts and quasi-arguments on the other, will now not be treated under the ECP, but as part of the theory of the relation between operators and traces. Either an operator binds its trace, or it

enters into a government chain with it. This latter is a very local relation, and explains the ungrammaticality of the island violations of non-arguments.

Cinque (1989) has taken this notion of referential indices and used it to explain certain differences that can be found between quantifiers. He has shown a systematic difference between the "who" type of quantifiers, such as "qualcuno" ("someone"), "qualcosa" ("something"), and the "which-N" type, such as "qualche-N" ("some-N"), "molti-N" ("many-N"), and "alcuni-N" ("some-N"). The Clitic left dislocated construction in Italian has been analyzed by Cinque (1989) as a construction that, as opposed to Topicalization, does not involve an operator. The clitic locally binds the object NP. In clitic left-dislocated constructions in Italian, a resumptive clitic is obligatory with an ordinary (non-quantified) NP, as in (12):

- (12) Gianni, *(lo) ho visto.
G., him I saw.

If the left-dislocated phrase is of the "which-N" type (as in (10a)), the same pattern holds, while with the "who" quantifiers (as in (10b)), the presence of the clitic seems optional.

- (13)a. Qualche errore, Carlo *(lo) ha fatto.
Some error, C. it has made
- b. Qualcuno, Carlo (lo) troverá.
Someone, C. him will find

It seems therefore that the possibility of the clitic is connected to the referential status of the quantifier phrase. The presence of a clitic depends on there being a specific reference for the NP; names, as in (12) and "which-N" type quantifiers, as in (13a), always have this specific reference [3].

The fact that the "who"-type quantifiers used non-referentially behave as intrinsic operators and identify an empty category as a variable at S-structure leads to the prediction that when they are left dislocated they should only be able to connect to their empty category via an antecedent government chain and should be sensitive to weak islands. This prediction is supported by (14):

(14) * Qualcosa mi chiedo chi farà per noi.

Something, I wonder who will do for us.

These two classes of quantifiers differ in wh-movement. As noted by Rizzi (1982) and Engdahl (1980), only "which-N" quantifiers can be extracted from weak islands in Italian and Swedish. (15) shows the distinction with a wh-island for wh-movement:

(15)a. ?? A chi non ti ricordi quanti soldi hai dato?

To whom don't you remember how much money you gave?

b. A quale dei tuoi figli non ti ricordi quanti soldi hai dato?

To which one of your kids don't you remember how much money you gave?

These facts led Cinque to suggest that "who" does not bear a referential index, in the sense of Rizzi above, but that the "which-N" type of quantifier does. This difference is related to the ability to refer to specific members of a pre-established set in the mind of the speaker or in the discourse (cf. also Pesetsky, 1987). This results in the conclusion that "who" must enter into a chain with its trace, but that "which-N" need not.

Cinque leaves open the possibility that a phrase entering a binding relation can always enter the stricter government chain, though not conversely, or that the two modes of connecting a phrase in an A-bar position and its trace are mutually exclusive. Is there any parsing preference for one of these two solutions? The hypothesis that I will be testing here is that a parser that obeys the MCP will always choose a binding relation if possible, because in this way it won't start postulating a non-singleton chain.

Parsing differences between "who" and "which-N".

For parsing purposes the suggestion is that when the parser encounters a quantifier, it knows which "operator-class" it belongs to. So, when it gets a "who", the parser knows that there has to be a chain between the wh- and an empty NP position. The parser, then, according to the MCP, does not delay postulating a gap, a movement trace in the empty pre-verbal subject position and link it with the "who". A preference for subject extraction for wh-questions with "who" is therefore predicted.

If instead the wh-item is a which-N, the lexical information associated with that item states that it does not have to be in a chain with an empty NP position at S-structure. Instead it could be coindexed with a lexically expressed variable (like a resumptive pronoun). Of course, it can turn out that the "which-N" will be an operator at S-structure (i.e. be in a chain with an empty NP position), but it does not need to be so. In other words a "which-N" has the possibility of being in a chain or not being in a chain with another element. For a parser obeying the MCP the default choice is to choose a singleton chain for the "which-N". This choice is a natural consequence of the fact that the parser prefers "minimal" chains, because singleton chains are computationally less costly than non-singleton ones. Let's then follow the parsing of a "which-N" question like (16):

- (16) Quale ragazza ha chiamato Giovanni?
(Which girl called Giovanni?)

The "which-N" is analyzed as being in a Complementizer (non-Argument) position, in a singleton chain. When the verb is reached, the NP subject position is postulated as a "pro", following the MCP. When the post-verbal NP is found it is taken as Direct Object according to the MCP. At this point, because the sentence does not take a sentential complement (and therefore it does not allow coindexation or extraction of the wh from another clause) the "which-N" must be coindexed with an element within the clause. If the post-verbal NP were a variable of the type of a resumptive pronoun, then the "which-N" could bind it and we would have a structure like: "which-N" (object)-pro(subject)- verb- clitic. However a full-NP (an R-expression) cannot be bound and function as a resumptive clitic, due to Binding theory (Chomsky, 1981). The "which-N" can then only be coindexed with the lexically empty subject.

In either case we then predict a subject extraction preference for the whs ("who" or which-N). However this preference differs for the two quantifiers in at least two respects. First, the subject preference for "who" is determined by the syntactic requirement of being in a chain, coupled with the processing principle of the MCP. It could then well be that the requirement of being in a syntactic chain makes the subject preference for the "who" stronger than for the "which-N" and less open to non-structural manipulations. The two questionnaire studies tested exactly this

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hypothesis: is there a subject extraction preference for wh-questions in Italian? And, other things being equal (i.e. plausibility of the sentence), is it stronger for "who" than for "which-N"?

The second observation that derives from our parsing hypotheses is that the subject extraction preference for the "who" is determined early in the sentence, as soon as the verb is identified, while for "which-N" such a decision is taken at the post-verbal position. The on-line experiment will explore some interesting predictions of this different timing.

Questionnaire 1.

The first questionnaire study used wh-questions as in (17) and (18), which are structurally ambiguous in that there can be a subject or an object extraction of the wh (with, correspondingly, an object or a subject extraction of the post-verbal NP) ((17) and (18) are the literal English translation of the Italian sentences):

(17) WHO CALLED JOHN?
 John called someone ___
 someone called John ___

(18) WHICH BOY CALLED JOHN?
 John called a boy ___
 a boy called John ___

Under the processing hypothesis that the parser follows the MCP and that only "who", but not "which-N" enters into a syntactic chain (cf. Cinque, 1988), and that therefore only "who" obeys the MCP, we predicted that there should have been a stronger wh-subject preference for "who" than for which-N. In fact only in the cases of "who" will the parser try to complete the (syntactically) required chain as soon as possible, i.e. at the first available argument position, that is the subject one.

Method.

Subjects. The questionnaire was administered to 45 college students of the University of Padova (Italy), "who" volunteered to participate in the experiment.

Materials. Three transitive verbs were used: "chiamare" ("to call"), "presentare" ("to introduce"), "pagare" ("to pay"). The list of the experimental sentences is given in Appendix 1.

Each subject saw all the experimental sentences, plus other sentences with different constructions, like declaratives and embedded wh-questions, for a total of 40 sentences. Subjects received a booklet with one sentence on each page. The task was to indicate with a mark one of the two alternative interpretation.

Results. Each subject's data was coded giving the score of 1 to the cases where the wh was taken as subject and the score of 0 when the post-verbal NP was taken as subject. The percentage of choices of the wh-subjects are the following:

who-subject: 66%

which-N subject : 50%

There was a significant difference between "who" and "which-N" ($F(1,44) = 4.006, p < .04$), in that the "who" had a higher subject extraction preference than the which-N.

Discussion. The results confirm the prediction that the "who" has a preference for a subject extraction and that this preference is higher than for the which-N. Under our hypothesis, this is due to the fact that the "who" has to enter into a syntactic chain and that the processor, following the MCP, tries to complete this chain as soon as possible. However an alternative explanation of the results based on discourse factors is possible. It is usually the case that, within a sentence, the subject is the discourse topic, that is old information, normally signalled by a definite NP (cf. Firbas, 1966; Halliday, 1970). It is then possible that in cases of ambiguity subjects uses the definiteness information and take the more definite NP in the sentence to signal the subject. Considering, as is often done in the literature (cf. Stockwell, Schachter & Partee, 1973), "which-N" as a more definite NP than "who", then "which-N" should have a higher subject preference than the "who". This is obviously not what we got.

However, the discourse hypothesis can be further refined: as Reinhart (1982) pointed out, it is likely that at the beginning of a discourse or in the absence of a preceding discourse (as is the case with the questionnaire), an indefinite expression is taken as topic. This latter view does correctly predict a stronger preference for taking the "who" as discourse topic/subject than for the which-N, as the results of this study in fact show.

To tease apart the structural and this latter discourse hypothesis, we then ran another questionnaire, this time varying, beside the wh-type, also the definiteness of the post-verbal NP:

Questionnaire 2

The second questionnaire used sentences as in (19) and (20), which are similar to (17) and (18), with an added manipulation of the definiteness of the post-verbal NP, which has either a definite (a) or an indefinite (b) determiner:

(19) A WHO CALLED THE BOY?
B WHO CALLED A BOY?

(20) A WHICH GIRL CALLED THE BOY?
B WHICH GIRL CALLED A BOY?

The structural hypothesis would predict a main effect of wh-type, i.e. a stronger wh-subject preference for "who" than for which-N, beyond any discourse preference to take a definite or indefinite NP as subject. The discourse hypothesis would instead say that the more indefinite expression should be taken as subject more often than a definite one, and therefore that the sentences with a post-verbal indefinite NP (i.e. 1B and 2B) should have a lower wh-subject preference than the sentences with a post-verbal definite NP.

Method. The questionnaire was administered to 32 native speakers of Italian, college students at the University of Padova. The task and the verbs used were the same as for questionnaire 1. A list of the experimental items is given in Appendix 2.

Results. The results showed the following percentage of preference for taking the wh as subject:

A WHO CALLED THE BOY?	89 %
B WHO CALLED A BOY?	97 %
A WHICH GIRL CALLED THE BOY?	65 %
B WHICH GIRL CALLED A BOY?	89 %

The statistical analyses showed a main effect of wh-type ($F(1,31)=19.821$, $p<.001$), in that the "who" had a stronger subject extraction preference than the which-N. There was a main effect of definiteness ($F(1,32)=16.936$, $p<.001$), with an higher percentage of preference to take the wh as subject when the post-verbal NP was indefinite than when it was definite.

There was also a significant interaction ($F(1,32)=6.902, p<.001$), in that the preference for having the "who" or the "which-N" as subject was differently affected by the definiteness of the post-verbal NP. In particular a post-hoc Duncan test showed that only in the "which-N" case was there a significant difference between the definite/indefinite condition ($t(k=2), p<.01$).

Discussion. The results confirm the structural hypothesis that there is an overall preference to take the "who" as subject. They disconfirm the discourse hypothesis that indefinites are preferentially taken as subjects. They disconfirm the hypothesis that the difference between "who" and "which-N" can be characterized as a discourse preference. Nevertheless they show a discourse effect that interacts with the structural factor: when a definite NP is present, a reader tends to take it as signalling the subject. This result confirms the idea the subjects are usually old information/discourse topic. However this preference is present only when the wh expression is the "which-N", which does not enter in a syntactic chain and, therefore, seems more open to nonstructural manipulation.

Reading time experiment.

The last study was a reading time experiment that used structurally ambiguous but pragmatically disambiguated Italian wh-questions. The reason to perform an on-line study was to further test the structural hypothesis. As we previously noticed, this hypothesis makes an interesting prediction in cases where we trace the time-course of sentence processing, under the assumption that a speaker/hearer computes a syntactic analysis of the sentence by constructing a single constituent structure representation roughly as the words of a sentence are encountered. This assumption has been referred to as the garden-path theory of sentence comprehension since it claims that the processor is sometimes "led down the garden path". The processor sometimes constructs an incorrect analysis of some portion of the sentence on the way to arriving at a correct analysis that is tenable for the entire sentence. This happens at choice points, points at which the parser faces an ambiguity because the well-formedness rules of the language permit more than one structural analysis of the lexical string.

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Following the garden-path theory I tested the MCP in syntactically temporarily ambiguous constructions, where the grammar does not provide the relevant information when the parser is faced with a structural choice. The parser, then, will show what parsing principles it obeys. In particular the materials were always constructed in such a way that the ambiguous string is followed by a disambiguating segment. The string was presented in two different conditions, with the disambiguation either toward the preferred analysis (according to the MCP) or toward the nonpreferred resolution of the ambiguity. The logic is that in the condition where the disambiguation forces the resolution of the ambiguity that is unpreferred according to the MCP there should be longer processing time due to a reanalysis of the ambiguous segment [4].

The predicted difference in the time-course of the subject extraction preference for the "who" and "which-N" is the following: with the "who" the subject extraction preference is determined early in the sentence, as soon as the verb is identified. With "which-N", instead, the coindexing decision is taken at a point where lexical information about the verb and about the post-verbal NP has been accessed. It might well be that in wh-questions where plausibility factors determine the likelihood that an NP is taken as agent, plausibility influences the initial decision about the extraction site for the "which-N" cases. For example, in sentences like (21) and (22) world-knowledge indicates that the "doctor" is the most likely agent of the sentence. Therefore the wh-items are taken as theme in both sentences:

- (21) Which boy cured the doctor?
 (22) Who cured the doctor?

However this decision should have different effects in the "which-N" and "who" cases. Given that the subject extraction preference for the "which-N" is taken after the post-verbal NP is reached, the thematic processor can reject the Direct Object analysis of "the doctor" and propose the one where "the doctor" is agent even before the parser gets to the coindexing of the "which-N" and the subject position. In the "who" cases, instead, the coindexing of the wh-quantifier with the subject position is done before the direct object NP is reached. Therefore when the thematic processor evaluates the post-verbal NP as agent, the coindexation of "who" and the subject position has been already done, and must be undone. The prediction is therefore

that in cases where plausibility determines the structural decision of the parser, we should detect a subject extraction preference for the "who" only, not for the "which-N".

Method.

Subjects. The subjects were 32 college students of the University of Padova (Italy) who volunteered to participate in the experiment.

Materials. The experiment used 18 wh-questions that were structurally ambiguous between a subject and an object interpretation of the wh. I will present the experiment divided in two sub-parts, (1) and (2).

Experiment (1) used 12 pairs of sentences with "which-N" of the basic form: Which N- Verb- NP2. Experiment (2) used 6 pairs of sentences of the basic form: who- Verb- NP. The post-verbal NP carried a plausibility disambiguation toward a subject or an object reading of the wh. In some (6 out of 18) of the wh-subject cases the disambiguation was also marked morphologically, with a plural post-verbal NP. The list of the experimental sentences is in Appendix 3. An example of the conditions is given in (23) and (24). The literal English translation is given in parentheses. The (a) cases have a wh-subject interpretation, while the (b) cases have a wh-object interpretation. The task was self-paced reading. Each time the subject pressed a "go" button, the successive segment of the sentence appeared on the screen of a micro computer (moving-window display), and the previous segment disappeared. In (23) and (24) slashes indicate segmentation. The segments between double slashes are the disambiguating ones. The disambiguating segment was followed by two segments. The reason for doing this is to avoid the confounding of final sentence reading effects with the disambiguation effects.

Each wh-question was followed by a comprehension task (indicated as Q in (23) and (24)), which consisted of a sentence in a declarative form. It was presented on the screen, all at once, immediately after the subject pressed the button at the end of the last segment of the wh-question. The comprehension sentences were always passive, to make them unambiguous. They consisted of an assertion about the presupposition of the wh-question. The subjects had to answer YES or NO, pulling the corresponding lever on the response-box. A

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YES response meant that the (comprehension) sentence corresponded to the presupposition of the wh-question.

The comprehension sentences for each experimental item queried the role of the direct object NP of the question. In the (a) cases (wh-subject extraction) the comprehension sentence had as subject in one case the post-verbal NP of the wh-question (YES answer), and in the other an NP that was not in the wh-question (NO answer). In the (b) cases (wh-object extraction) for the YES responses the comprehension sentence had as subject the noun phrase of the which-N, or "someone", "something" for "who" or "what". For the NO responses the subject of the comprehension sentence was an NP that was not in the wh-question [5].

- (23) WHICH-N
- a. Quale bambina/ ha curato// l'uccellino// con
abilità e pazienza/ ammirevoli?
Q'. L'uccellino é stato curato da una bambina, SÍ O NO?
Q". Il cagnolino é stato curato da una bambina, SÍ O
NO?
- b. Quale bambina/ ha curato//il pediatra// con
abilità e pazienza/ ammirevoli?
Q'. Una bambina é stata curata dal pediatra, SÍ O NO?
Q". Una bambina é stata curata dal chirurgo, SÍ O NO?
- a. Which young-girl/ cured// the little-bird// with
skill and ability/ remarkable?
Q'. The little-bird has been cured by a young-girl, YES
OR NO?
Q". The little-dog has been cured by a young-girl, YES
OR NO?
- b. Which young-girl/ cured// the pediatrician// with
skill and ability/ remarkable?
Q'. A young-girl has been cured by a pediatrician, YES
OR NO?
Q". A young-girl has been cured by a surgeon, YES OR
NO?
- (24) BARE-WH's:
- a. Chi/ ha derubato// la banca// all'angolo/ di via
Fiume?
Q'. La banca é stata derubata da qualcuno, SÍ O NO?
Q". La gioielleria é stata derubata da qualcuno, SÍ O
NO?

- b. Chi/ ha derubato// il ladro// all'angolo/ di via Fiume?
Q'. Qualcuno é stato derubato da una zingara, SÍ O NO?
Q". Qualcuno é stato derubato da un ladro, SÍ O NO?
- a. Who/ robbed// the bank// at the corner/ of Fiume street?
Q'. The bank has been robbed by someone, YES OR NO?
Q". The jewellery has been robbed by someone, YES OR NO?
- b. Who/ robbed// the thief// at the corner/ of Fiume street?
Q'. Someone has been robbed by a thief, YES OR NO?
Q". Someone has been robbed by a gipsy, YES OR NO?

Besides the 12 experimental sentences, there were 74 filler sentences. The filler sentences were declarative sentences, questions, and some structurally unambiguous wh-questions (like: which N- NP- V). Each subject saw no more than one version from each sentence pair, and each subject was exposed to all conditions.

Results. The data are presented in Table 1 (who) and in Table 2 (which-N). The mean Reading Times (RTs) were computed for each segment, after eliminating times (less than 1%) that were longer than 3000 msec or shorter than 100 msec. Reading Times associated with erroneous answers to the questions were discarded. Analyses of Variance (Anova) were conducted on the RTs for each segment with both subjects and items as random effects. In the item analysis (F2) we always did an analysis of covariance to adjust for differences in the length of the items. The Anovas were conducted separately for wh-words and wh-phrases due to the fact that they had different numbers of items.

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Table 1

Average Reading Time (RT) for Correct Responses in each segment in the different experimental conditions, Who-questions. The critical disambiguating segment (# 3) is underlined.

segment #	1	2	<u>3</u>	4	5	RT	% correct
cond. 1 Who-subj	670	690	706	828	1160	2961	.926
cond. 2 Who-obj	646	698	1001	1044	1433	2630	.655

Table 2

Average Reading Time (RT) for Correct responses in each segment in the 2 different experimental conditions, "which-N" questions. The critical disambiguating segment (# 3) is underlined.

segment #	1	2	<u>3</u>	4	5	RT	% correct
cond. 1 Which-subj	836	771	868	900	1274	2560	.838
cond. 2 Which-obj	833	743	790	895	1265	2532	.786

For the bare-wh (who), Anovas performed on the third segment (the disambiguating one) and on the fourth one showed the conditions with wh-subject extraction were read faster than those with wh-object extraction (main effect of grammatical role (3rd segment $F(1,31)=5.40$, $p<.02$), $F(1,19)=3.64$, $p<.07$), (4th segment $F(1,31)=5.07$, $p<.02$), $F(1,19)=5.66$, $p<.02$) [6].

Subjects were more accurate in answering questions following a wh-subject sentence than questions following a wh-object sentence ($F(1,31)=28.79$, $p<.001$), ($F(1,10)=8.92$, $p<.01$).

For the "which-N" cases (Table 2) the Anovas did not show any significant difference between the subject and object extraction cases ($p > .22$).

Discussion. The results confirm the hypothesis that the syntactic parser obeys the MCP. In particular, they confirm that when a filler that requires a chain with an empty category is found, the parser tries to complete the chain, postulating an NP trace at the first available empty NP position. This conclusion is supported by the finding that there is a preferred subject extraction for "who" in the reading times and in the response accuracy to the comprehension questions.

In so far as the results support the MCP, they also support the fact that the parser proceeds through the building of a syntactic structural representation of the input string. In particular the questionnaire studies showed that the preferred interpretation of ambiguous strings cannot be described in terms of a pragmatic factor such as definiteness. While this factor certainly has an effect on the interpretation, it seems to play the role of an evaluation on an initial structural preference, in that it had a bigger effect in the cases where a structural preference did not come into play [7].

The results disconfirm the prediction of a parser that does not follow MCP, but instead follows a word-order strategy like "1st NP subject" in that for the "which-N" there wasn't any subject extraction preference. The canonical strategy, in fact, would have predicted a subject preference for whatever element is in sentence initial position, e.g., the subject position in declarative sentences. It is important therefore that such a finding has been established for a language like Italian, a null-subject language for which it has been claimed that structural factors are less important than say English, due to its freer word order.

The asymmetry found in the processing of "who" and which-N, while supporting Cinque's analysis of the difference between the two quantifier classes, seems also to support the view that the two modes of connecting between operator and variable are mutually exclusive [8]. The difference found between "who" and "which-N" poses the question whether there is any reason to expect it only in Italian or in all the languages that have a distinction between bare wh's and

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quantified NP's, or a distinction between discourse-linked and non discourse-linked whs, if this difference is reflected at S-structure.

Furthermore the parsing difference found between bare quantifiers and quantified NP's leads us to a refinement of what constitutes an "active filler" for the parser, namely only those elements that enter into syntactic chains at S-structure. In this respect we expect that any element that unambiguously has to be in a chain at S-structure will trigger an "active filler" parsing mechanism. For example, the topic of clitics is interesting. Do they connect to their argument position through a chain or binding? If referentiality is the important notion, perhaps they are not uniform in this respect, in that the partitive clitic ne should not be able to have a referential index. Rizzi however suggests that all clitics are in chains and under his hypothesis then they should all behave the same way, regardless of their referential status.

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Notes

1. MacWhinney, Bates and Kliegl (1984) showed that the preferred interpretation of an Italian structurally ambiguous sentence like "the pencil kicked the cow" is the one where "the cow" is the agent. The same sentence in English is structurally unambiguous and it is interpreted by English speakers with "the pencil" as agent. This result has been taken to indicate that in Italian semantic constraints override the structural (word order) constraint (although when there was an agreement marker, subjects gave the only grammatically possible interpretation, despite semantic implausibility).

However notice that the MacWhinney et al. data are based on sentence final interpretation and in that respect every processing models account for the fact that in cases of structural ambiguities semantic constraints determine the final interpretation. However the question is still open whether the initial interpretation, the one computed on-line, while each word is received, is determined by such factors, or whether there is an initially syntactic analysis that is based on syntactic preferences.

2. "Proper government" is a condition on the licensing of linguistic elements that contains reference to both structural relations, configurationally defined, and to what counts as a governor.

Proper government: X properly governs Y iff X governs Y and X is either X^0 (i.e. a verb, a noun, a preposition) or NP_1 , where $Y = NP_1$.

Government: X governs Y iff Y is contained in the maximal X' -projection of X, X'^{max} , and X'^{max} is the smallest maximal projection containing Y, and X c-commands Y.

3. The presence or absence of the clitic in sentences like (13b) correlates with a difference in interpretation. As Cinque says: "If the speaker has

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something or someone specific in mind, (i.e. if the bare quantifier is used referentially) the clitic is required. If the interpretation is 'something or other' the clitic is impossible." Many of the "who" type quantifiers may be forced to have the specific reference by context or the presence of a clitic (in (13b)). However it is important to note that in wh-questions as the one I have used in the questionnaires and in the experiment, "who" itself may never bind a resumptive clitic, though "which-N" may, as the following contrast shows:

- a. * Chi_j vorresti portartelo_j all'MIT?
 * Who_j would you like to bring-him_j with you at MIT?
- b. ?? Quale studente_j vorresti portartelo_j all'MIT?
 ?? Which student_j would you like to bring-him_j with you to MIT?

4. The prediction given here, i.e. that one analysis of an ambiguous string will be preferred over another, rests on a serial model. However, parallel processing models are also compatible with syntactic parsing preferences, if the alternative analyses are ranked, though computed simultaneously (cf. Altmann and Steedman, 1988; Gorrell, 1987).

5. The introduction in the comprehension sentence of an NP that was not present in the question was necessary given the use of pragmatic plausibility disambiguation in the wh-question. Therefore if in the "NO" response cases we had used an NP from the question we would have had comprehension sentences that were semantically anomalous, such as "The girl has been cured by a bird" for example (18i). These kinds of sentences could have been answered merely on plausibility grounds without any relation to how the experimental wh-question had been interpreted.

6. There was also a significant effect of length ($F(2,19)=16.47, p<.001$) (which was statistically corrected for in the item analysis).

7. It should be pointed out that while I have considered the difference between "who" and "which-N" in terms of syntactic factors, it is not excluded that other differences exist between these two quantifiers in terms of some semantic factor, other than definiteness.

For example Kroch (1990) proposes an interesting alternative account for the difference between "who" and "which-N" type of quantifier. In particular he proposes a more semantic account, in that for example, the unacceptability of extraction out of wh-island of measure phrases (cf example (10) in the text) is due to the presuppositions that these questions have, rather than to the wh-phrases not having referential roles:

- (1)a. How many books did Bill ask whether the company was interested in publishing?
 b. There was a set of books for which Bill asked whether the company was interested in publishing them.
- (2)a. *How much money was John wondering whether to pay?
 b. There was a sum of money about which John was wondering whether to pay it.

The existential presupposition of the sentence in (1a) is (1b) and for (2a) it is (2b). Kroch observes that the existential presupposition of (1) is semantically and pragmatically well formed, but not so for (2). In fact (2b) will be pragmatically odd due to the fact that "John might well wonder how much to pay, but there is no unique sum with the property that he is wondering whether to pay IT" (Kroch, 1990, p.5). Kroch's approach is therefore that the referentiality requirement is a semantic/pragmatic one and that it should not be used to constrain extraction syntactically.

A remark is in order here: the parsing data presented here follow nicely from a difference at the S-structure level, given independent evidence that the filler-gap effects we obtain in experimental procedures are due to syntactic effects (cf. Stowe, 1986; Crain and Fodor, 1985). However under a hypothesis that the difference between the quantifiers is in terms of their presuppositions, then the present data are not easily accounted for, because the "who" and "which-N" questions we used had equally plausible presuppositions.

There also is a further difference between "who" and "which-N" that does not seem easily accountable for on Kroch's terms.

It is a well known fact that in sentences like (3) there cannot be a coreference between the referent of the possessive pronoun and the referent of "who" (in

other words, the pronoun cannot be bound by the wh-operator). This fact, known as weak cross-over, holds only for variables as (4) shows:

(3) Who/i does his/j mother like e/

(4) His/i mother likes John/i
*i

It seems that there is a contrast between (5) and (6), in that it is easier to get the bound reading in (6) than in (5):

(5) Chi amano le sue sorelle? (Who do his sisters love?)

(6) Quale ragazzo amano le sue sorelle?
 (Which boy do his sisters love?)

8. It is interesting to notice that the way in which I treat the parsing of "which-N" bears a close resemblance to the way non-trace coindexing (like coindexing of pronouns or lexical anaphors with an antecedent) is treated by Berwick and Weinberg (1984). For them, the coindexing of pronouns and lexical anaphors is not part of the "parsing" (i.e. the constituent structure building) process per se: "By this we mean that it is defined over the already built syntactic tree. Coindexing can be thought of as a search procedure imposed on a fixed parse tree that takes place after relevant parsing decisions have been made. It is not part of the construction of the tree itself" (Berwick and Weinberg, 1984, p. 171). The way in which we treat the coindexing of "which-N" is strikingly similar: the "which-N" will be coindexed with whatever element bears the same referential index as the "which-N".

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Appendix 1

Experimental sentences for Questionnaire 1.

Chi (who) questions:

Chi ha chiamato Valentina? (Who called Valentina?)
Chi ha presentato Giovanni? (Who introduced Giovanni?)
Chi ha pagato Mario? (Who paid Mario?)

Quale-N (which-N) questions:

Quale amica ha chiamato Valentina?
(Which girl-friend called Valentina?)
Quale ragazza ha presentato Giovanni?
(Which girl introduced Giovanni?)
Quale ragazzo ha pagato Mario?
(Which boy paid Mario?)

Appendix 2

Experimental sentences for Questionnaire 2.

Chi (who) questions:

Chi ha chiamato il suo amico? (Who called his friend?)

Chi ha chiamato un suo amico? (Who called a friend of
his?)

Chi ha presentato il ragazzo? (Who introduced the boy?)

Chi ha presentato un ragazzo? (Who introduced a boy?)

Chi ha pagato la ragazza? (Who paid the girl?)

Chi ha pagato una ragazza? (Who paid a girl?)

Quale-N (which-N) questions:

Quale amico ha chiamato il ragazzo?

(Which friend called the boy?)

Quale amico ha chiamato un ragazzo?

(Which friend called a boy?)

Quale studentessa ha presentato la ragazza?

(Which student introduced the girl?)

Quale studentessa ha presentato una ragazza?

(Which student introduced a girl?)

Quale ragazza ha pagato la sua amica?

(Which girl paid his girl-friend?)

Quale ragazza ha pagato una sua amica?

(Which girl paid a girl-friend of her?)

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Appendix 3

WHICH-N: 12 pairs of wh-questions. In each pair the (a) cases have a wh-subject extraction, the (b) cases have a wh-object extraction.

- 1a. Quale regista ha licenziato le comparse durante le riprese in montagna?
- 1b. Quale regista ha licenziato il produttore durante le riprese in montagna?
- 1a. Which director fired the walkers during the filming in the mountain?
- 1b. Which director fired the producer during the filming in the mountain?
- 2a. Quale bambino ha visitato l'acquario due giorni prima delle vacanze estive?
- 2b. Quale bambino ha visitato il medico due giorni prima delle vacanze estive?
- 2a. Which boy/ visited/ the aquarium/ two days before/ summer vacations?
- 2b. Which boy/ visited/ the doctor/ two days before/ summer vacations?
- 3a. Quale animale ha divorato la verdura nei campi intorno al villaggio?
- 3b. Quale animale ha divorato il leone nei campi intorno al villaggio?
- 3a. Which animal/ devoured/ the vegetables/ in the fields/ around the village?
- 3b. Which animal/ devoured/ the lion/ in the fields/ around the village?
- 4a. Quale cameriera ha sgridato il cane mentre gli ospiti ascoltavano in silenzio?
- 4b. Quale cameriera ha sgridato la padrona mentre gli ospiti ascoltavano in silenzio?
- 4a. Which waitress/ scolded/ the dog/ while the guests/ listened in silence?
- 4b. Which waitress/ scolded/ the land-lady/ while the guests/ listened in silence?
- 5a. Quale ragazzina ha ritratto il cavallo durante la gara di pittura estemporanea?
- 5b. Quale ragazzina ha ritratto il pittore durante la gara di pittura estemporanea?
- 5a. Which girl/ portrayed/ the horse/ during the competition/ of painting?
- 5b. Which girl/ portrayed/ the painter/ during the competition/ of painting?

- 6a. Quale ladro stava pedinando le vecchiette ieri sera in via Cesarea?
- 6b. Quale ladro stava pedinando la polizia ieri sera in via Cesarea?
- 6a. Which thief/ was chasing/ the old-ladies/ yesterday evening/ in Cesarea Street?
- 6b. Which thief/ was chasing/ the police/ yesterday evening/ in Cesarea Street?
- 7a. Quale dirigente ha corrotto i cassieri durante le trattative per l'acquisto della società?
- 7b. Quale dirigente ha corrotto la mafia durante le trattative per l'acquisto della società?
- 7a. Which executive/ corrupted/ the cashiers/ during the dealing/ to acquire the society?
- 7b. Which executive/ corrupted/ the mafia/ during the dealing/ to acquire the society?
- 8a. Quale presidente ha eletto i rappresentanti dei deputati con una mossa a sorpresa durante l'ultima seduta alla Camera?
- 8b. Quale presidente ha eletto l'assemblea dei deputati con una mossa a sorpresa durante l'ultima seduta alla Camera?
- 8a. Which president/ elected/ the deputies' representatives/ with a surprise move/ during the last session at the Congress?
- 8b. Which president/ elected/ the deputies' assembly/ with a surprise move/ during the last session at the Congress?
- 9a. Quali lavoratori hanno danneggiato i nuovi macchinari in modo imprevedibile ed inaspettato?
- 9b. Quali lavoratori hanno danneggiato le nuove leggi in modo imprevedibili ed inaspettato?
- 9a. Which workers/ damaged/ the new machines/ in an unpredictable/ and unexpected way?
- 9b. Which workers/ damaged/ the new laws/ in an unpredictable/ and unexpected way?
- 10a. Quale bambina ha curato l'uccellino con abilità e pazienza ammirevoli?
- 10b. Quale bambina ha curato il pediatra con abilità e pazienza ammirevoli?
- 10a. Which girl/ cured/ the bird/ with ability/ and patience admirable?
- 10b. Which girl/ cured/ the pediatrician/ with ability/ and patience admirable?

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- 11a. Quale calciatore ha ceduto il negozio di sport per una cifra astronomica?
11b. Quale calciatore ha ceduto la squadra per una cifra astronomica?
- 11a. Which soccer-player/ sold/ the sport-shop/ for an amount/ astronomic?
11b. Which soccer-player/ sold/ the team/ for an amount/ astronomic?
- 12a. Quale mucca ha smarrito il sentiero lo scorso mese all'alpeggio?
12b. Quale mucca ha smarrito la cooperativa lo scorso mese all'alpeggio?
12a. Which cow/ lost/ the path/ last month/ in the mountain?
12b. Which cow/ lost/ the co-op/ last month/ in the mountain?

WH-WORDS: 6 pairs of questions with "who". In each pair, the (a) cases has a wh-subject extraction, the (b) cases have a wh-object extraction.

- 1a. Chi ha derubato la banca all'angolo di via Fiume?
1b. Chi ha derubato il ladro all'angolo di via Fiume?
1a. Who/ robbed/ the bank/ at the corner/ of Fiume street?
1b. Who/ robbed/ the thief/ at the corner/ of Fiume street?
- 2a. Chi ha ucciso i bambini nel campo profughi di Beirut?
2b. Chi ha ucciso la bomba nel campo profughi di Beirut?
2a. Who/ killed/ the children/ in the refugee camp/ in Beirut?
2b. Who/ killed/ the bomb/ in the refugee camp/ in Beirut?
- 3a. Chi ha divorato il pollo arrosto con incredibile voracità?
3b. Chi ha divorato il leone affamato con incredibile voracità ?
3a. Who/ devoured/ the roasted chicken/ with incredible/ voracity?
3b. Who/ devoured/ the hungry lion/ with incredible/ voracity?

- 4a. Chi ha pagato il conto con un assegno a vuoto?
4b. Chi ha pagato il debitore con un assegno a vuoto?
4a. Who/ paid/ the bill/ with a check/ bounced?
4b. Who/ paid/ the debtor/ with a check/ bounced?
- 5a. Chi ha buttato per terra i miei libri ieri mattina
quando ero fuori a far compere?
5b. Chi ha buttato per terra il forte vento ieri
mattina quando ero fuori a far compere?
5a. Who/ threw down/ my books/ yesterday morning/ when
I was out shopping?
5b. Who/ threw down/ the strong wind/ yesterday
morning/ when I was out shopping?
- 6a. Chi ha assassinato il presidente della repubblica
con il tacito appoggio dei gruppi economici?
6b. Chi ha assassinato lo squadrone della morte con il
tacito appoggio dei gruppi economici?
6a. Who/ assassinated/ the president of the republic/
with the silent consensus/ of the economics
lobbies?
6b. Who/ assassinated/ the death squad/ with the silent
consensus/ of the economics lobbies?