DETERMINISTIC MAPPING AND DEPENDENCIES: AN INTERFACE ACCOUNT OF WEAK(ER) CROSSOVER*

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We propose an analysis of *weak crossover* (WCO) in terms of conflicting interface economy principles. These principles apply to representations resulting from a transparent mapping between Rizzi's (2001a) LF syntax for specific vs. non-specific chains and a refined version of Elbourne's (2005) semantics for traces/copies and pronouns. While pronouns are endowed with a referential index, copies of Q-phrases are devoid of it, due to their quantificational nature. In standard WCO, the underspecified index on the trace is compelled by economy to get a value, through *linking* (Higginbotham 1983), from the closest potential index-bearing element, that is the intervening WCO pronoun. This local process of valuation yields a redundancy effect with the process of mapping the underspecified copy into the same variable by a generalized version of Heim & Kratzer's (1998) *Predicate Abstraction Rule* (Delfitto & Fiorin 2009). Overtly moved D-linked *wh*-phrases can circumvent WCO effects (Falco 2007) as a consequence of the LF chains to which these phrases give rise: the NP-restriction moves to a Topic position, thus, under Rizzi's (2001a) mechanism of *shrinking*, its specificity index (Enç 1991) is set free and is made available, as a referential index, for the whole DP. It follows that the intervening WCO pronoun is irrelevant for index-valuation and no redundancy arises in this case. The restriction of covertly moved Q-phrases cannot form an independent chain, as a consequence of the very nature of covert movement. So, the embedded index of the NP-restriction is buried in its original position and the whole DP trace remains devoid of an index, leading to WCO effects.

1 INTRODUCTION

1.1 *The crossover challenges*

The seminal characterizations of crossover did not interpret it as a quantifier-dependent phenomenon. The term *crossover* was originally introduced by Postal (1971) to describe

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the constructions where a *wh*-phrase, in the movement from right to left, crosses over a pronoun (1-b).[1]

(1) a. *Who t* said Mary kissed *him*? — No crossover
b. **Who* did *he* say Mary kissed *t*? — Crossover

Later, Wasow (1972) noticed that constructions where the base position of the *wh*-element is less embedded than the one of the pronoun (2-a) are less deviant than the constructions where this is not the case (2-b).

(2) a. ?**Who* does [*his* mother] love *t*? — *Weak crossover* (WCO)
b. **Who* did *he* say Mary kissed *t*? — *Strong crossover* (SCO)

To describe this difference concerning the severity of the violation, Wasow introduced the term *weak crossover* (WCO) (2-a) as opposed to *strong crossover* (SCO) (2-b).

The perspective was crucially widened by Chomsky (1976) who proved that any meaningful theory of crossover should extend to the distribution of quantifier-bound readings for pronouns. In particular, Chomsky noted that a quantifier does not allow *bound variable* (BV) readings for a pronoun to its left (3-b).

(3) a. *Everyone* loves *his* mother. — No WCO
b. ?**His* mother loves *everyone*.
LF: [*everyone* [*his* mother loves *t*]] — WCO at LF

The parallelism between (3-b) and cases like those in (2-a) with respect to WCO suggests that the universal quantifier moves in the derivation of LF (3-b) to create a structure similar to the one in (2-a).

Since this work, the stakes of the generative endeavor have been raised, giving to the relation between syntactic representations and the interpretive component, thus the study of the Logical Form (LF), crucial importance. At the same time, this move raises an empirical and a theoretical challenge.

Empirically, this shift, and the consequent bipartition between referential and quantificational elements, led to shelving the relevance of fine-grained differences in crossover, namely the fact that WCO is circumvented by specific *wh*-phrases (like *which NP*), as noted in the original works on crossover (Wasow 1972 a.o.). As a matter of fact, in recent literature, data concerning the role of specificity in WCO are rarely found, with the exception of the following contrast quoted from Culicover & Jackendoff 1995:[2]

1 Dependent interpretations are expressed using *italics*, instead of co-indexation, for two reasons. First, the proposal presented here advocates a syntactically and semantically motivated existence of referential indexes. Moreover, the use of indexes would be philologically incorrect, since the first works on crossover precede the advent of Binding Theory and, thus, the use of indexes.
The trace notation is used here as a descriptive device since we adopt Chomsky's (1993) copy theory of traces. Furthermore, at the time of the first proposals on crossover, traces were not standardly assumed as linguistic objects.

2 Actually, precisely this observation led Wasow (1972) to the attempt to reduce WCO to the *backward anaphora* paradigm: if a DP is a possible antecedent for an embedded pronoun to its left, the DP must be definite (i-a) vs. (i-b) (or generic).

(i) a. The portrait of *his* girlfriend always depressed *John*.
b. *The portrait of *his* girlfriend always depressed *someone*. (cf. Postal 1970 a.o.)

(4) a. *Which famous senator* do *his* constituents despise *t*? Specific *wh*-phrase
b. ?**Who* do *his* constituents despise *t*? Non-specific *wh*-phrase
(Culicover & Jackendoff 1995: ex. 39)

Reviving Wasow's (1972) observation, Falco (2007) thoroughly shows that, while WCO is systematically present with quantifiers and operators moved in covert syntax, it does not arise with overtly-moved D-linked *wh*-elements (*weaker crossover*). The problem of how to derive these fine-grained empirical distinctions arises. Putting it more directly, the following question remains unanswered: why can overtly-moved specific *wh*-elements circumvent WCO?

Theoretically, from the LF perspective, we expect that crossover effects in an optimal grammar follow from the devices that encode the BV readings, but this is not the case, under current assumption. Assuming Heim & Kratzer's (1998) implementation, these devices reduce to some version of *quantifier raising* (QR) or *wh*-movement, with an index inserted in the LF-structure as a result of QR.[3] The same index must be realized on the trace of the moved DP. The index produced by QR is interpreted by Heim & Kratzer's (1998) *Predicate Abstraction Rule* (PA), mapping all the elements with index i to x, with x bound by a λ-operator (5). Pronouns bearing the same index i as the Q-trace are thus mapped into the same bound variable, accounting for the BV-reading.

(5) *Predicate abstraction rule* (PA)
Let α be a branching node with daughters β and γ, where β dominates only a numerical index i. Then, for every variable assignment a, $[\![\alpha]\!]^a = \lambda x \in D \,.\, [\![\gamma]\!]^{a^{i \to x}}$.
(cf. Heim & Kratzer 1998: p. 186)

By applying QR and PA, the WCO structures in (6-a) and (6-b) are correctly derived with BV readings, to the effect that their agrammaticality is completely unexpected.

(6) a. *His* mother loves *everyone*
LF: ?*[everyone] i [[his$_i$ mother] loves t$_i$] Quantifier raising
b. ?*Who i did his$_i$ mother love t$_i$? *Wh*-movement

We conclude, therefore, that the familiar view on semantic binding and BV-readings is not enough to derive crossover effects.

The requirement that the trace/copy of the Q-phrase c-command the pronoun in order to license a BV reading of the latter seems to correspond to a correct descriptive generalization. Basically, familiar approaches to crossover have striven to derive this fact. However, if we try to solve this problem from the point of view of optimal design, we are forced to the conclusion that these proposals fail in their search for a non-stipulative account. More perspicuously, the following issue systematically remains unsolved: why should semantic binding entail syntactic binding?

Summarizing, crossover raises an empirical question - why can overtly-moved specific *wh*-elements circumvent WCO? - and a theoretical question - why should semantic binding entail syntactic binding? - of crucial importance for the syntax/semantics inter-

3 We use the Q letter to refer to both *wh*-elements and to quantifiers.

face and for the issue of optimal design. In this contribution, we aim at an empirically adequate and theoretically principled theory of crossover, answering both questions.

1.2 *The form of the solution*

Crossover is usually thought of as a syntactic dependency failure: for some reason, the pronoun fails to be dependent on the trace. The direction of this dependency is represented in (7) through the arrow connecting the dependent pronoun to the trace on which it depends.[4]

(7) ?* λ_i ... $[pro_i]$ ... t_i Standard perspective

However, since the accounts that have been advanced to date fail in deriving this dependency failure in a principled way, the reason behind it remains fundamentally unknown.

We propose to look at crossover configurations from the mirror perspective: it is the Q-trace that must enter into a dependency relation with the pronoun. In itself this dependency is well-formed, but, in crossover configurations, it leads to a redundancy with PA, the interpretive mechanism at stake in these structures, as seen above.

The claim that the Q-trace is better conceived of as dependent on the pronoun follows naturally once we consider the referential indexes proper to the pronoun and to the Q-trace involved. While it is sound to assume that pronouns are endowed with a referential index, interpreted in the semantics through an assignment function, Q-traces, due to their quantificational nature, are better understood as underspecified for such an index. The subscript ∅ adorning the trace in (8) expresses the index underspecification.

(8) ?* λ_i ... $[pro_i]$ ... $t_\emptyset$ New perspective

Crossover can now be seen as a consequence of the process of index-valuation on the Q-trace, having two potential assigners: the intervening pronoun (through *linking*) and the predicate abstractor, through PA (9). This entails that crossover configurations yield unnecessary redundancy in the index-interpretation process: *linking* of the Q-trace to a local pronoun to resolve index-underspecification on the Q-trace does not affect in any way the result of the successive application of a generalized version of PA. Viewed from this perspective, crossover is a case where locality constraints interfere with optimal mapping between syntactic representations and interpretation (cf. Delfitto & Fiorin 2009).

(9) ?* λ_i ... $[pro_i]$ ... $t_\emptyset$ WCO as redundancy

At its core, this is the simple and principled solution we provide to the theoretical challenge formulated above. However, the deepness and scope of this solution will fully emerge only from closely inspecting the nature of the empirical challenge.

4 A dotted arrow is used to indicate the dependency failure and to distinguish it from the *linking* relation denoted by a single-line arrow. Below, a dashed arrow is adopted for the dependency established by a predicate abstractor.

From the point of view proposed, the possibility to escape WCO for specific *wh*-element reduces to the possibility of their trace/copy to be endowed with a referential index, since in that case the intervening WCO pronoun would not count as a potential antecedent and the redundancy causing WCO would not arise (10).

(10) ✓ λ_i … [pro_i] … (t_i) No redundancy

Intuitively, in a semantically motivated theory of referential indexes, there are two types of indexes. On the one hand we have the index on object-referring DPs denoting an entity, as standardly assumed; crucially in Q-phrases this index is underspecified and indicated with ∅ in (11). On the other hand, it is natural to assume that an index denoting a set is present on the 'familiar' NP-restriction of the DPs, as in Enç 1991; this index is indicated with *j* in (11).

(11) $[_{DP}\ Q\ [NP]_j]_{\emptyset}$

It is this second NP index *j* that can be 'transmitted' to the whole DP-trace when it is a specific *wh*-element. Therefore, Q-traces are generally devoid of a referential index, but in the case of overtly-moved specific *wh*-elements, they can somehow inherit the index of their restriction. We contend that this basic insight can be neatly formalized refining Elbourne's (2005) semantics of referential expressions - names, pronouns and definite descriptions - if we combine it with Rizzi's (2001a) LF syntax for specific vs. non-specific chains.

Consider the abstract LF configurations in (12-a) and (12-b), where copies/traces are expressed by using the angled brackets notation. According to Rizzi (2001a), if the *wh*-phrase is D-linked, a chain limited to the restriction of the *wh*-element is formed, since the restriction alone is moved, due to its topical nature, to the relevant position within the left-periphery (12-a). Conversely, the non-specific *wh*-phrases form a chain which does not contain the restriction, since the restriction has not to be interpreted in the left-periphery (12-b). Rizzi's configurational definition of chains enforces a *shrinking* mechanism that redefines the portion of structure that counts as a trace, as illustrated in the LF representations below.

(12) a. $[_{TOP}\ NP]_j$ … [Q ⟨[NP]$_j$⟩]$_{\emptyset}$ … [pro$_j$] … ⟨[Q ⟨[NP]$_j$⟩]$_{\emptyset}$⟩ Specific LF chain
b. [Q ⟨[NP]$_j$⟩]$_{\emptyset}$ … [pro$_i$] … [⟨Q⟩ [NP]$_j$]$_{\emptyset}$ Non-specific LF chain

In the specific configuration (12-a), the restriction coincides with the portion of structure that counts as a trace; in a sense, the specificity index is no longer embedded (it qualifies as the index of the chain), and it is thus available as an index for the whole DP. More particularly, we propose that the index-underspecification on the Q-trace is resolved 'in-situ' in this case, by using the index of the NP-restriction, which is directly available in the same syntactic position as an effect of *shrinking*. This explains why the presence of the WCO pronoun, potentially triggering *linking* to resolve underspecification on the Q-trace, is irrelevant with D-linked *wh*-phrases. This LF-mechanism of index-inheritance is excluded with operators moved in the covert syntax: by hypothesis, covert movement cannot consist of successive cyclic steps (Luigi Rizzi, p.c.), to the effect that *shrinking* cannot give rise to any chain only consisting in the NP-restriction of a full DP. In this way, the original insight on the indexing possibilities receive theory-internal conceptual

and technical support. This is the gist of our answer to the empirical question raised by crossover.

Putting the two answers together, the overall result is that combining a semantically motivated theory of referential indexes with a syntactically motivated chain-formation algorithm at the LF-interface, we arrive at a theoretically principled and empirically adequate theory of crossover in terms of a conflict between the principles governing the valuation of underspecified indexes and the principles governing their interpretation at the LF-interface. This is, in a nutshell, the theoretical contribution to be fully developed in the following pages.

A part from the present introduction and the conclusions, the paper is structured in four sections dealing respectively with the state of the art on BV readings and crossover (§2), the role of specificity in WCO (§3), the syntax/semantics mapping we propose (§4), and the derivation of crossover from interface economy principles (§5). In §2, the fundamental theoretical tools that the received view on crossover makes available are discussed. More precisely, in §§2.1 we introduce the notion of licensing under c-command (Reinhart 1976) and *linking* (Higginbotham 1983), together with the *Independence Principle* (Safir 2004), which will constitute a crucial ingredient of the approach that we would like to propose, while clarifying, at the same time, why the familiar syntactic approaches to WCO based on these traditional ingredients are incompatible with the notion of optimal design. In §§2.2 we introduce the interpretive devices used in the current approaches to semantic binding, and highlight the stipulations on the use of indexes they contain. The following section (§3) is devoted to establishing the empirical generalization that D-linking is relevant not only for the theory of locality, but also for crossover (Falco 2007). This claim is supported by using operational tests of specificity and non-specificity, drawn from the literature. In §4, we propose our view of a transparent syntax/semantics mapping. In particular, in §§4.1, we present Rizzi's (2001a) proposal on the different nature of specific vs. non-specific chains at LF and in §§4.2 we argue that his system can be successfully combined with a semantically motivated use of indexes, implementing a transparent mapping algorithm of the LF chains to the semantics. Finally, in §5, we propose a modified version of the interpretive tools used to obtain BV readings, making a semantically motivated use of indexes, and we show how basic principles of interface economy derive the crossover phenomenology as previously established (§3). In particular, we show how crossover is an effect of the index underspecification in argument position, and how the absence this effect is derived from the presence of a specified index in argument position, due to *shrinking* and in-situ index inheritance. In the end (§6), we conclude summarizing the achieved results, and highlighting some open issues, as well as future developments of the proposal.

2 CHALLENGING THE RECEIVED VIEW

2.1 *Stipulations of syntactic accounts*

The theoretical challenge raised by crossover forces the assumption that there are syntactic dependencies among argument positions subject to restrictions that rule out the crossover cases. Two main families of approaches to the problem of pronominal dependencies have been advanced in the literature, but, despite the fundamental differences, both approaches

must be supplemented with ad-hoc syntactic constraints to account for crossover. Since the constraints deriving the ill-formedness of crossover are not independently justified, they amount to stipulations. Therefore, these syntactic proposals, departing from the optimal view that BV readings are the result of pure semantic binding and being based on conditions devoid of any independent syntactic justification, fail to provide a principled answer to the crossover puzzle, and fall short of explanatory adequacy.

One family of theories of dependencies is based on the traditional symmetric indexing mechanism to express relations. Generally, in these theories, the constraints on the indexing possibilities are expressed through some version of the *c-command licensing principle* (CLP) spelled-out in (13):

(13) *C-command licensing principle* (CLP)
If x depends on y, then y has to c-command x. (Safir 2004: p. 3, cf. Reinhart 1976)

This principle is a generalized version of the c-command condition introduced in the influential thesis of Reinhart (1976). The CLP is a sound principle expressing an important constraint on the mapping between syntax and semantics, and accounts for important aspects of bound variable readings and scope phenomena at LF as a result of PA. As for scope, a λ-operator gets scope over another only if it c-commands the latter at LF; concerning binding, only the expressions c-commanded by a λ-operator can be bound by it.

Under this view, Binding Theory is reduced to the conditions on pronouns as bound variables. Crucially, in this system, the indexing of pronouns responsible for BV readings can obtain only under c-command. Reinhart proposes that only bound pronouns are subject to the grammatical principles of Binding Theory, whereas referential pronouns are not subject to any grammatical principle, but only to pragmatic constraints. More precisely, two referential DPs are not in a relation of binding, but of accidental co-valuation.[5]

The attempts to extend this principle in order to account for crossover (Reinhart 1983, 1987) are orthogonal with respect to the original raison d'être of the CLP. As a matter of fact, in crossover configurations, the pronoun is c-commanded by Q at LF, therefore the CLP alone is not enough to provide any explanation for crossover. In order to derive crossover from the CLP it is necessary to add something to the principle or simply to postulate that it applies at Spell-Out. The first approach has generally consisted in adding a stipulation that forces the pronoun to depend on the trace of the quantifier, but this move is conceptually dubious under the view that pronouns are bound through PA. On the the other hand, forcing CLP to directly apply at Spell-Out (as proposed by Reinhart 1987), produces a clash with the fundamental empirical support for QR and the computation of scope and binding relations after QR has applied. In other words, there is no independent motivation, apart from crossover, for assuming that CLP applies before QR

5 A part the cases of sloppy readings in VP deletion contexts, which are instances of true binding. Consider the following sentence:

(i) John loves his mother and Bill does too.

The sloppy reading is obtained when the elliptic VP refers to Bill, that is 'John loves his mother and Bill loves his mother'. Of course, the non-sloppy, or strict, reading is available as well, in that case *his* refers only to the mother of John.

or for assuming that QR does not apply. To sum up, CLP is orthogonal to the problem of crossover, which remains unexplained.

An alternative to the CLP perspective is advanced by Safir (2004). His system departs from the one above in two fundamental respects: he assumes a mechanism of asymmetric *linking* (Higginbotham 1983), instead of symmetric indexing, and proposes that dependent identity interpretations are restricted by a c-command prohibition, not by a c-command licensing condition: c-command does not license dependencies but rules them out.

(14) *Independence principle* (INP)
If x depends on y, then x cannot c-command y. (Safir 2004: p. 3)

In this system co-valuation of two DPs is encoded by *linking* and grammatical principles are intended as constraints on *linking*.

From this perspective, crossover can be viewed as a failure to create a dependency relation in the syntax, since this dependency would imply a violation of INP. However, in order to create the required configuration we have to rule out the possibility that the pronoun directly depends on the operator (in traditional terms, an Ā-dependency). For example, in (15) the pronoun does not c-command the operator, thus INP is respected.

(15) *Who does he hate x

In order to model crossover in terms of an INP violation, Safir (2004) is forced to introduce the condition in (16), which essentially rules out Ā-dependencies.

(16) *Quantifier dependency condition* (QDC)
x can be interpreted as dependent on a quantified antecedent y only if x is a q-variable of y or x is dependent on a q-variable of y, or there is no q-variable of y.
(Safir 2004: p. 72)

Now, the pronoun can only be dependent on the trace which it c-commands. Therefore, strong crossover is excluded as an INP violation (17).

(17) *Who* does he hate x

WCO is derived as a result of an additional principle, spelled-out in (18).

(18) if a subpart of x is dependent on y, then x is dependent on y. (Safir 2004: p. 71)

This principle is intended to extend the account to the configurations where the offending pronoun is embedded within the constituent that c-commands the Q-trace, that is, WCO configurations. In this way, the account for SCO and WCO is elegantly unified. At the same time, we have a natural explanation for less robust agrammaticality judgements in WCO, since the dependency established between the pronoun and the trace of the operator is an indirect one, therefore a milder violation is expected, as a result of the application of (18).

In our terms, the problem of Safir's (2004) proposal is that QDC stipulates that a pronoun can be turned into a bound variable only by being linked to the Q-trace, raising

the issue of why this should be the case. Whereas INP is a plausible constraint on *linking* and as such it does not constitute a departure from optimal design, QDC (16) and the 'subpart principle' (18) are introduced only to the purpose of deriving crossover effects, for which INP does not suffice, as seen above. It remains thus to be seen whether the challenge posed by optimal design can be met in other ways.

Summarizing, crossover accounts based on CLP and INP are forced to introduce conditions in the syntactic component that are not independently justified and that do not qualify, consequently, as part of an optimal system for creating bound variable readings. More precisely, QDC is not compatible with the idea that BV readings are the result of semantic binding, whereas CLP is a sound and semantically justified principle of grammar, but it is not able to provide an answer to the question raised by crossover, namely why semantic binding should entail syntactic, i.e. binding in 'visible' syntax.

2.2 *Stipulations around semantic binding*

The standardly assumed semantic rules for interpreting structures undergoing QR or *wh*-movement make stipulations on the insertion of indexes that are incongruent with the copy theory of movement (cf. Chomsky 1993: ch. 3). As a matter of fact, in a semantically motivated theory of indexes it is not sound to assume that Q-elements are endowed with a referential index, because of their quantificational, non-referential, nature (see especially Elbourne 2005).

Bound pronouns, in Heim & Kratzer's (1998) formalization, are such inasmuch as they are syntactically bound by λ-operators that correspond, in post Spell-Out syntax, to the indexes created by Q-movement. The same index must then be realized on the trace of the moved QP, and can be optionally present on pronouns contained in the same sentence, giving rise the BV-reading. In this way, (19-a) has the LF in (19-b) derived by applying QR to the subject:

(19) a. *Every girl* thinks *she* is smart.
b. [Every girl] [2 [t_2 thinks she$_2$ is smart]].

These special indexes are interpreted by the PA rule (Heim & Kratzer 1998), repeated in (20):

(20) *Predicate abstraction rule* (PA)
Let α be a branching node with daughters β and γ, where β dominates only a numerical index i. Then, for every variable assignment a, $[\![\alpha]\!]^a = \lambda x \in D \,.\, [\![\gamma]\!]^{a^{i \to x}}$.
(cf. Heim & Kratzer 1998: p. 186)

Through the application of this rule both the Q-trace and the pronoun in the nuclear scope end up being bound by the same λ-abstractor, the essential requirement for BV readings.

The copy theory of movement raises a deep question for the proper functioning of predicate abstraction, since an individual variable of type $\langle e \rangle$ is needed in argument position in order for the structure to be interpretable.[6] By applying QR to (21-a) we obtain (21-b) which is uninterpretable as it stands.

6 According to the copy theory of movement, traces are complete but silent copies of their antecedents. We express the copy/traces using the angle brackets notation.

(21) a. A girl talked to every boy
b. [Every boy] [a girl talked to ⟨every boy⟩] QR under copy theory

Therefore, we are forced to introduce some type-shifting device for altering lower copies and make them interpretable, that is, syntactic phrases of type $\langle e \rangle$, essentially expressing an individual variable. In the traditional theory of traces, as assumed in Heim & Kratzer 1998, semantic interpretable structures are created by simply stipulating that a Q-trace is converted into the variable x bound by the λ-operator. Fox (1999) shows that this rule, which is completely insensitive to the copy theory of movement, is empirically inferior to a copy-sensitive rule.

Elbourne (2005) proposes a neat implementation of a copy-sensitive rule within a framework where pronouns, definite descriptions, and proper names have a common syntax and semantics, that of definite descriptions, as construed in the Fregean tradition. Bound and referential pronouns occur when definite articles take an index as an argument; as arguments of a D, indexes are syntactically realized as phonologically null NPs. Furthermore, in order to account for the bound reading of definite descriptions (to which pronouns arguably reduce), Elbourne proposes that the definite article takes two arguments, one of which is an index, while the other is a normal NP. Therefore, in his system traces and pronouns have the following syntactic format:

(22) [THE i [NP]] Traces and pronouns as definite descriptions

In this framework, the treatment of copies as definite description follows naturally. In fact, Elbourne (2005) proposes the following version of Fox's trace conversion rule:

(23) *Trace conversion rule* (TC)
When moving an NP, replace the lower determiner with [THE i], for some index i, and adjoin λ_i to the target of movement. (cf. Elbourne 2005: p. 119-120)

So, instead of (21-b), we end up with (24).

(24) [Every boy] [λ_2 [a girl talked to [THE 2 [boy]]]] (Elbourne 2005: ex. 110, p.120)

Elbourne's (2005) TC (23) is certainly more copy-sensitive than the original Heim & Kratzer's (1998) rule: it contributes thus to make the syntax/semantics mapping less arbitrary than it is in a theory where traces must be copies of Q-phrases in syntax and individual variables in the semantics. What fills the gap, in a nutshell, is the idea that bound variables can be construed with the syntax and the semantics of definite descriptions (this is in fact Elbourne's main insight). Nevertheless, it should be noticed that (23) continues to make a stipulative use of indexes, in at least two respects. First of all, the presence of an index in the argument position clashes with the Q-copy nature of the argument position, since a Q-element, by its very nature, cannot have a referential index. Here, there is thus no substantial progress with respect to Heim & Kratzer's stipulation that QPs are devoid of index, whereas their traces are indexed. Moreover, remember that in order to create a bound variable, the index on the Q-trace (and on the pronoun) must be the same as the index of the λ-operator in the target position. If this were not the case, the lower copy of the Q-phrase would fail to be interpreted as bound by the upper copy. However, there is nothing in the proposed technical implementation that ensures that this

identity is achieved in a principled way: the upper index is not the index of the upper copy (QPs have no index), but is simply the index created as a result of QR, by resorting to a specific (quite stipulative) interface rule. Elbourne's implementation (23) is quite revealing in this respect: there, the index of the lower copy has simply to be adjoined above in the structure, as the required upper index.

In conclusion, the familiar devices for obtaining bound readings in the semantics make a stipulative use of indexes. Although the TC-rule (essentially corresponding to a type-shifting device) represents an important progress under the view of bound variables as concealed definite descriptions, the insertion of an index in the lower copy (including its identification with the index providing the λ-operator) remains an arbitrary interface rule, as such incompatible, in principle, with optimal design.

Summarizing, our critical assessment of the state of the art has led to two main results. First, the syntactic approaches to the theoretical puzzle raised by crossover are forced to depart from optimal design, according to which the BV-readings of pronouns are based on semantic binding (i.e. on syntactic binding by a λ-operator), and not on A-dependencies (i.e. dependencies from the Q-trace). Second, the familiar view of semantic binding is based on an arbitrary use of referential indexes, incompatible as such with optimal design. In the rest of this contribution, we intend to strive towards optimal design: if the latter forces Q-traces to be devoid of a referential index, it is on this principled feature of Q-traces that we intend to capitalize, by proposing that it is not pronouns that are dependent on Q-traces (as in the approaches reviewed above) but it is rather the other way around. However, the challenge posed by the WCO effects is empirically even more intricate than the present discussion has revealed, and it is to a new class of facts that we have to pay some attention now. Meeting the empirical challenge as a whole will hopefully lead to an increased explanatory adequacy at the theoretical level.

3 REFINING THE EMPIRICAL CHALLENGE: WCO AND SPECIFICITY

The role of specificity in WCO, as we said at the outset, is a commonly overlooked fact in the recent literature, but it plays a fundamental role in our analysis of indexing at the interface. In order to dispel possible doubts, this section is devoted to proving the role of specificity, establishing the fine-grained empirical pattern of WCO.

Falco (2007) revives the classical observation on the role of specificity in WCO (Wasow 1972). He shows that we get sharply different grammaticality judgments in crossover configurations with D-linked and non D-linked *wh*-elements: when a D-linked *wh*-element crosses over a pronoun, the bound reading is (almost) acceptable (25-b), whereas when the moved *wh*-phrase is non-specific, the sentence is completely out (25-a).

(25) Only non-specific *wh*-operators give rise to WCO effects

a. ?**Who the hell* do *his* students admire *t*? Non-specific

b. ?*Which famous professor* do *his* students admire *t*? Specific

(Falco 2007: ex. 2)

In order to establish this claim systematically, Falco uses a series of operational tests of specificity, that is contexts where it has been argued that the specificity of the extracted DP plays a role in determining the grammaticality of the constructions. Here we review

a test of specificity and a test of non-specificity to support the relevance of specificity for WCO.

Extraction from a weak island is a specificity test as established most notably by Cinque (1990). Let us take the base paradigm illustrated in (26): in (26-a) the D-linked *wh*-phrase can be extracted from a weak island, while in (26-b) the extraction of an aggressively non D-linked phrase causes ill-formedness.

(26) a. Dimmi *quale degli studenti interrogati* pensi che Gianni non sappia come valutare *t*.
'Tell me *which of the evaluated students* do you think John does not know how to grade *t*.'
b. ?*Mi chiedo *chi diavolo* pensi che Gianni non sappia come valutare *t*.
'I wonder *who the hell* do you think John doesn't know how to grade *t*.'
(Falco 2007: ex. 26a-26b)

In the test (27), we add a potentially offending WCO pronoun. A combined question with weak island extraction and WCO can be used when D-linked phrases are at stake: no WCO effect arises and no weak island violation (27-a). In the non-specific case, the WCO configuration must be tested in isolation (eliminating the weak island), in order to ascribe the agrammaticality to the crossover violation.[7] A WCO effect clearly emerges (27-b), confirming Falco's (2007) hypothesis.

(27) a. Dimmi *quale degli studenti interrogati* pensi che il *suo* insegnante non sappia come valutare *t*.
'Tell me *which of the evaluated students* do you think (that) *his* teacher doesn't know how to grade *t*' Combined case
b. ?*Mi chiedo *chi diavolo* pensi che il *suo* insegnante voglia bocciare *t*.
'I wonder *who the hell* do you think (that) *his* teacher would fail *t*
(cf. Falco 2007: ex. 27a-27c)

Extraction from existential *there* contexts is another syntactic test of non-specificity (Heim 1987; Frampton 1991 a.o.). Consider the base paradigm in (28): in (28-a) the trace of *how many soldiers* can be in an existential there context if the *wh*-phrase is interpreted as a pure cardinal (non-specific) DP, whereas the trace of a specific *wh*-element in (28-b) produces ill-formedness.

(28) a. *How many soldiers* does the commander think there are *t* in the infirmary?
b. ?**Which student* does the professor think there is *t* in the great-hall?
(cf. Falco 2007: ex. 33a-35a)

In the test paradigm in (29) a potentially offending pronoun is inserted in the base sentences. In (29-a), the non-specific case, we propose a combined question with extraction from a *there* context that crosses over a WCO pronoun: as the extraction of these non specific phrases is legitimate from *there* contexts (28-a), we can ascribe the ill-formedness to the WCO violation. In (29-b), a *wh*-phrase that cannot be extracted from *there* contexts (29-a), thus a specific one, does not produce WCO, therefore supporting Falco's claim.

7 For a more exhaustive discussion of this methodological point see Falco 2007: §5.

(29) a. ?**How many soldiers* does *their* commander think there are *t* in the infirmary?
Combined case

b. *Which student* does *his* professor think is *t* in the great-hall?
(cf. Falco 2007: ex. 34a-35b)

On the grounds of this evidence, we conclude that WCO does not arise with D-linked *wh*-elements. In order to express the lack of the expected WCO violation in these cases, while keeping them distinct from Lasnik & Stowell's (1991) *weakest crossover* configurations, we dub this phenomenon *weaker crossover*.

Actually the facts are more complex. As noted by Falco (2007: §§8.2), the generalization concerning D-linking and WCO does not extend to instances of covert movement of D-linked constituents, mainly quantifiers, *wh* in-situ, and focalized elements.

As far as quantifiers are concerned, it suffices to consider the sentence in (30) which involves an overtly partitive quantifier crossing the pronoun when QR-ed. Although the operator clearly constitutes a D-linked phrase, the BV reading is strongly ill-formed:

(30) **His* mother loves *everyone of these children*.
LF: **everyone of these children his* mother loves *t*. (cf. Falco 2007: ex. 51)

As for *wh*-in-situ, consider the minimal pair (31-b) vs. (31-a): in French, a D-linked *wh*-element can be in-situ (31-b) and ex-situ (31-a). The grammaticality judgements show that there is a sharp contrast in acceptability between the two versions of the question with respect to the possibility to circumvent WCO: the D-linked *wh*-element in (31-b) cannot bind the pronoun.[8]

(31) a. *Lequel des étudiants testés son* professeur ne sait pas comment évaluer *t*?
which of the students tested his professor know not how to grade *t*?
Wh ex-situ

b. **Son* professeur ne sait pas comment évaluer *lequel des étudiants testés*?
his professor know not how to grade *which of the students tested*?
Wh in-situ

Finally, notice that the presence of a focalization operator in (32-a) or of the new information focus in (32-b), with main accent on JOHN, induces covert focus movement and WCO effects in spite of the fact that the antecedent (a proper name) is definite (Chomsky 1976).

(32) a. ?**His* mother loves even/only *John*.
LF: [*even/only John*][his mother loves *t*]
b. ?**His* mother loves *JOHN*
LF: [*John*][his mother loves *t*] (cf. Falco 2007: 49-50)

8 Our thanks to Léna Baunaz and Christopher Laenzlinger for their judgements. For the same facts in Modern Greek see Vlachos (2008: ex. 11):

(i) a. *Pjon ithopio tu theatru* thamvase i mitera *tu t*? *Wh* ex-situ
*which actor.*ACC *of theatre* admired the mother.NOM *his t*?
b. *I mitera *tu* thavmase *pjon ithopio tu theatru* *Wh* in-situ
the mother.NOM *his* admired *which actor.*ACC *of theatre*

Summarizing, if we put these empirical observations together, the resulting picture of the WCO phenomena is the following: while operators moved in the covert syntax (after Spell-Out) give rise to WCO irrespective of their specificity, specific *wh*-elements moving overtly (before Spell-Out) do not give rise to WCO (the phenomenon we dubbed *weaker crossover*).

If we look at these facts from the perspective of our analysis of indexing at the interface, the empirical question raised at the outset becomes how to derive the presence of a referential index in weaker crossover and its absence in standard WCO configurations. This question arguably admits a principled answer once we consider the syntax/semantics mapping, which is the topic developed in the following section.

4 MAPPING SYNTAX TO SEMANTICS

4.1 *The syntax of LF chains*

The contrast between weak and *weaker crossover* (33) is parallel to the asymmetries between non-specific and specific *wh*-elements with respect to weak island extraction (34) and reconstruction (35).[9] In these configurations the specificity of the extracted or of the crossing constituent plays a crucial role in permitting extraction from the *wh*-islands (34) and allowing antireconstruction effects (35) on the one hand, and in alleviating WCO effects (33), on the other hand, as we saw above.

(33) ?*Which famous professor* do *his* students admire *t*?
Weaker crossover (cf. Falco 2007)

(34) ?*Which one of the books that you need* don't you know where to find *t*?
Weak island extraction (cf. Cinque 1990)

(35) *Which stories about Diana* did *she* most object to *t*?
Antireconstruction (cf. Heycock 1995: ex. 33)

This parallelism between the role played by specificity in syntactic movement and bound variable readings for pronouns represents an important empirical motivation for the existence of a mapping between the form of syntactic chains and the indexing possibilities of Q-phrases.

Rizzi (2001b) accounts for the syntactic asymmetries through a theory of LF chains, proposing different structures for specific and non-specific *wh*-elements. In this section we sketch his system and illustrate how the algorithms he postulates derive two crucially different copies/traces in argument position for specific and for non-specific chains. In particular, the *shrinking* mechanism assumed by Rizzi (2001a) derives the presence of a copy involving only the operator in non D-linked cases, whereas it derives, in D-linked configurations, the presence of a copy involving only the restriction. We consider this

9 *Antireconstruction* is a term introduced by van Riemsdijk & Williams (1981) to describe the absence of principle C effects, which are expected if the moved phrase is reconstructed in argument position. Heycock (1995) demonstrates that only specific *wh*-elements display this effect:

(i) a. *Which stories about Diana* did *she* most object to *t*?
b. **How many stories about Diana* is *she* likely to invent *t*? (Heycock 1995: ex. 33)

as a crucial step towards a motivated use of referential indexes with non-referential DPs and a meaningful syntax/semantics mapping. More precisely, while it is semantically incorrect to assume the presence of a referential index on a quantificational DP (both QPs and *wh*-phrases: cf. Elbourne 2005), it is semantically justified to assume that the NP expressing the restriction in quantificational DPs is actually endowed with an index encoding specificity, as explicitly proposed by Enç (1991) (see §§4.2 for the semantics of this index).

Rizzi's (2001a) proposal is based on the copy theory of traces (Chomsky 1995: ch. 3), the use of deletion at LF to satisfy the principle of *full interpretation*, and a strictly representational definition of traces/copies. In his system chains are defined as follows:[10]

(36) $(A_1, \ldots, A_n)$ is a chain if and only if, for $1 < i < n$
  a. $A_i = A_{i+1}$
  b. A_i C–commands A_{i+1}
  c. A_{i+1} is in a Minimal Configuration with A_i (Rizzi 2001a: ex. 15)

Both constructions in (37) are expected to be ungrammatical according to condition (36), given the violation of RM expressed in terms of Minimal Configuration. Nevertheless, as we know, the sentence with a D-linked DP (37-a) is acceptable:

(37) a. ?Which problem do you wonder how to solve ⟨which problem⟩?
  b. *How do you wonder which problem to solve ⟨how⟩? (Rizzi 2001a: ex. 9)

In order to illustrate the account of this asymmetry proposed by Rizzi (2001a), consider the non-specific (38-a) and the specific (38-b) structures in (38). Rizzi proposes that the restriction of non D-linked *wh*-elements must reconstruct in its base position at LF and that only the operator can stay in the left periphery (38-a). On the other hand, the restriction of D-linked *wh*-elements can (and in fact must) stay in the left periphery at LF, due to its topical nature. In (38-b), the non-specific mass noun *money* receives a specific interpretation due to the use of the overt partitive ('of the money that you need').

(38) a. *Quanti soldi non sai come guadagnare ⟨quanti soldi⟩? Non-specific
  'How much money don't you know how to earn?'
  LF: quanti ⟨soldi⟩ non sai come guadagnare ⟨quanti⟩ soldi
  b. ?Quanti dei soldi che ti servono non sai come guadagnare ⟨quanti dei soldi che ti servono⟩? Specific
  'How much of the money that you need don't you know how to earn?'
  LF: quanti dei soldi che ti servono non sai come guadagnare ⟨quanti dei soldi che ti servono⟩ (cf. Rizzi 2001a: ex. 27b-27c)

The deletion of the restriction in the LF representation in (38-a) triggers a *shrinking* mechanism that redefines the portion of structure that counts as trace/copy in the base position:

10 The notion of *Minimal Configuration*, is a reformulation of the classic *Relativized Minimality* (Rizzi 1990):

(i) Y is in a Minimal Configuration with X if and only if there is no Z such that
  a. Z is of the some structural type as X, and
  b. Z intervenes between X and Y. (Rizzi 2001b: ex. 4 and Rizzi 2001a: ex. 8)

only *quanti* has a trace status, while the restriction, being deleted from the left periphery, is not part of the trace structure in the base position. This mechanism accounts for traditional reconstruction asymmetries between the specific and the non-specific cases. Now, to explain the asymmetries with respect to weak island sensitivity ((37) and (38)), Rizzi assumes that DPs can enter into a long distance binding relation not subject to RM.

Crucially for the present perspective, the *shrinking* algorithm in non-specific cases creates a chain involving the operator as illustrated in (38-a), and as can be seen in the LF representation, only the operator-part enters into the constitution of the trace/copy, whereas the restriction is expunged from the portion of structural representation that counts as the trace/copy. Conversely, it may be argued that in the specific cases the *shrinking* mechanism yields the mirror image situation for the trace/copy, as a consequence of the identity requirement on chain-links that applies after *shrinking*.

This result for specific chains can be easily achieved if we follow Rizzi's insight that the restriction is licensed in the left-periphery as Topic, and propose that it undergoes a further movement step to the specifier of the relevant TOP-position, as illustrated in (39).

(39) ?Quanti dei soldi che ti servono non sai come guadagnare ⟨quanti dei soldi che ti servono⟩? Specific
'How much of the money that you need don't you know how to earn?'
LF: [$_{\text{TOP}}$ dei soldi che ti servono] quanti ⟨dei soldi che ti servono⟩ non sai come guadagnare ⟨quanti ⟨dei soldi che ti servono⟩⟩ (cf. Rizzi 2001a: ex. 27-c)

As soon as this movement takes place, the *shrinking* algorithm automatically creates a chain involving only the NP expressing the restriction. There is thus a chain-algorithm according to which the constituent expressed by the trace/copy is limited to the NP-restriction of the DP.

Overtly moved and covertly moved specific phrases are tied to different LF configurations. We assume that this is due to a rather natural interpretation of Rizzi's (2006) *criterial freezing*, and to the assumption that covert movement cannot be successive cyclic in nature (Luigi Rizzi, p.c.). Rizzi's *criterial freezing* is defined in (40).

(40) *Criterial freezing*
A phrase meeting a criterion is frozen in place. (cf. Rizzi 2006: p. 112)

On the one hand, when the *wh*-phrase is overtly moved, further movement of the NP restriction is not subject to *criterial freezing*, since it does not involve the *wh*-operator, and only the latter is responsible for the satisfaction of the *wh*-criterion. On the other hand, the NP-restriction of covertly moved phrases cannot be moved out of the phrase it is part of, since the grammar, by hypothesis, permits only one covert movement step.

Summarizing, combining the LF syntax of Rizzi (2001a) with the hypothesis that displacement of the NP-restriction in overt syntax is allowed by Rizzi's (2006) *criterial freezing*, we obtain the two abstract LF representations in (41-a) and (41-b): non D-linked and covertly moved D-linked Q-phrases form the configuration in (41-b), whereas overtly moved D-linked (41-b) Q-phrases form the configuration (41-a).

(41) a. [$_{\text{TOP}}$ NP]$_j$ … [Q ⟨[NP]$_j$⟩]$_\varnothing$ … [pro$_j$] … ⟨[Q ⟨[NP]$_j$⟩]$_\varnothing$⟩ Specific LF chain
b. [Q ⟨[NP]$_i$⟩] … [pro$_i$] … [⟨Q⟩ [NP]]$_\varnothing$ Non-specific LF chain

Having established the form of the relevant LF chains, in the following subsection we propose a modified version of Elbourne's (2005) theory of indexes, that tightly ties the presence or absence of a referential index on Q-traces to the properties of the LF-chains discussed above. The task is a fine-grained syntax/semantics mapping.

4.2 *The semantics of Q-traces*

In a semantically motivated theory of referential indexes, there are two types of indexes. On the one hand, there is the index on referential DPs, as in Elbourne 2005, where pronouns, names and definite descriptions all have the abstract logical format of definite descriptions: [the i [NP]] (§§2.2). On the other hand, there is the index on the NP restriction of quantificational DPs, expressing specificity, as in Enç 1991. In Enç's view, specific phrases are equivalent to partitives (e.g. *two of the girls*): every DP has a double indexing (i, j): i denotes the DP referent and j a 'familiar' set in which i is included (the index of *girls* in the partitive indefinite *two of the girls*). We propose to reinterpret Enç's (1991) index j as the same sort of referential index that Elbourne posits for referential DPs. It has logical type $\langle e, t\rangle$ and gets interpreted as $\lambda x.g(j) = x$. By enriching Elbourne's (2005) format with insight that NP-restrictions bear an index, traces of specific quantificational DPs are assigned the following syntactic format:

(42) [the i [NP j]] Specific Q-trace syntactic format - first approximation

Let us consider now the analysis of indexing that we would like to propose. As we saw in §§2.2, Heim & Kratzer (1998), Fox (1999) and Elbourne (2005) simply posited that the TC they assumed to model type-shifting for the copy/trace is able to add an index to the copy in-situ, identifying this index with the index created by displacing the DP, as is required for a correct application of PA. However, why should the copy of a Q-phrase be endowed with an index?

Under a neo-Fregean theory of definite descriptions, such as Elbourne's, all is required in order to shift a DP of type $\langle et, t\rangle$ into a DP of type $\langle e\rangle$ is the substitution of Q with THE and the creation of an index slot. Assuming that this index slot is underspecified for an index value has the important conceptual advantage that we can stick to the semantically motivated hypothesis that Q-phrases (and, crucially, their copies) cannot express a referential index. In other words, we get rid of the concealed stipulation that the lower copy of Q-traces is 'magically' endowed with the referential index with which the higher copy cannot be endowed, if our theory of indexes has to adequately serve the syntax/semantics interface. Certainly, the TC rule affects lexical material and creates an index slot within the lower Q-copy, crucially, however, it does not induce a referential index on the Q-copy.[11] In this way, conceptually, we stick to the fundamental hypothesis that Q-phrases are not inherently endowed with indexes expressing a referential value. Proposing that the TC rule cannot directly induce a referential index on the lower Q-copy means in fact that the referential index cannot be inherent to the copy of a Q-phrase: all the TC rule can do is creating an index slot: the specification of the index value must be the product of independently available mechanisms of the grammar (such as *linking*).

11 Note that we assume that TC applies crucially at the interface, that is after each instance of QR has been performed, as a manifestation of the 'syntax by phases' also underlying, conceptually, Rizzi's *criterial freezing*.

Indexing lower Q-copies is not done 'magically': it is a complex interface process, and crossover is the manifestation of this complexity. In particular, we propose that TC is not allowed to directly 'value' the index slot, for the very reason that TC is defined as the minimal set of operations that is necessary to perform type-shifting. As a result, all we get is an underspecified index position. To express the underspecified index position that is produced by our revised version of Elbourne's TC, applying to the lower copy of the displaced quantificational DP, we use the symbol ∅. Therefore we arrive at (43).

(43) [THE ∅ [NP j]] Specific Q trace syntactic format

What about the index *j* associated to the NP-restriction? We suggest that it can be naturally interpreted as property-like, exactly as Elbourne's (2005) first index, used with all referential expressions, having the LF of definite descriptions. Notice that, in fact, whenever a DP is interpreted specifically, the NP-restriction is interpreted as being constrained by a contextually relevant implicit property. We propose that this property is what *j* expresses, to the effect that the restriction receives the following logical format:

(44) λx. NP(x) $\wedge$ g(j) = x. NP-restriction logical format

As one can easily see, this amounts to interpret [NP j] by means of the usual *predicate modification rule* (45):

(45) *Predicate modification rule*
If α is a branching node and $\{\beta, \gamma\}$ the set of its daughters, then, for any assignment a, if $[\![\beta]\!]^a$ and $[\![\gamma]\!]^a$ are both functions of type $\langle e, t\rangle$, then $[\![\alpha]\!]^a = \lambda x \in D$. $[\![\beta]\!]^a(x) = [\![\gamma]\!]^a(x) = 1$. (cf. Heim & Kratzer 1998: p. 95)

This model constitutes thus a natural way to extend Elbourne's use of indexes to capture the role of specificity. We contend that it also provides a natural way to make use of Rizzi's (2001a) *shrinking* to enable a copy in situ of a specific *wh*-phrase to have its underspecied index slot *valued* without being linked to an externally available pronominal position.

If we look at the configurations in (41-b) and (41-a), we notice that in (41-a) we have a three-membered chain only consisting of the NP-restriction. In this sense, the trace/copy of the *wh*-phrase can be said to directly 'express' the NP-restriction and the index that goes with it (the j index discussed above). In a sense, the *j* index is no longer simply embedded in the complex structure [the ∅ [NP *j*]], but may be assumed to be freely available in the trace/copy position, as a result of the chain established with the NP-restriction in TOP and the consequent application of Rizzi's *shrinking*: the trace/copy position directly expresses the NP-restriction.

Given these structural conditions, we propose that the underspecification on the ∅ index-slot is resolved by identifying ∅ with the *j* index: since *j* has been freed from its original embedded position and is directly expressed by the trace/copy position, it qualifies as the most local potential antecedent for ∅, under natural assumptions. At the same time, we have already seen that this process of index-copying in-situ does not face any semantic obstacle, since the *j* index can be correctly interpreted in both positions positions (it has the same semantics in both positions). The structure we end up with has thus the form below in (46).

(46) [THE j [NP j]]

(46) is roughly interpreted, within this extended Elbourne's framework, as 'the unique individual x that g assigns to j and is such that is NP and is assigned to j by g', intuitively a sound reading for the purposes of a BV-interpretation (remember that in Elbourne's framework the trace/copy must be a definite description §2.2).

Moreover, the shrinked chain headed by the NP-restriction in TOP ensures the presence of the index j in the operator position associated with the moved *wh*-phrase: the difference with respect to Q-movement is actually that we do not need to assume that movement produces an index, since we can exploit the j index associated to the NP-restriction, via *shrinking*. It is this index that PA interprets as the variable bound by the λ-operator, all other things remaining equal. In essence, the presence of shrinked chains with specific *wh*-phrases provides the right structural environment to resolve the index underspecification resulting from the application of TC to the trace/copy without having to resort to *linking* to intervening pronouns, predicting thus, correctly, the absence of WCO effects with D-linked *wh*-phrases.

This result cannot be obtained with quantificational DPs and non-specific *wh*-phrases. The former are subjected to QR and it follows without stipulations that QR cannot feed movement of the NP-restriction to the Topic-layer. As for covert *wh*-movement, notice that in (41-b) *shrinking* applies to delete the NP-restriction, to the effect that there is no way to rescue the j index from its embedded position and to use it to resolve the underspecification of the first index in the trace/copy. If the restriction is not allowed to move as such to the TOP position in the left periphery, its index is buried into the NP and is not made available to the whole DP.

Summarizing, the approach we propose here strives to catch the reasons for which D-linking is relevant both for the theory of locality and for crossover. In order to do so, we have developed Rizzi's (2001a) insight that there is a connection between referential indexes and D-linking, in the sense that copies/traces of specific DPs are subject to in-situ resolution of index-underspecification, via Rizzi's *shrinking*. Crucially, in our reinterpretation, *shrinking* a DP to its NP-restriction makes the internal index associated to the NP-restriction available for the process of valuation of the underspecified referential index induced on the trace/copy by TC.

5 DERIVING CROSSOVER FROM ECONOMY

On the basis of the proposed combination of Elbourne's theory of referential indexes with Rizzi's analysis of LF chains, we can now revise the technical functioning of the interpretive tools for obtaining BV readings and proceed to formalize the economy principles that derive crossover.

As we saw above, the default hypothesis should be that the TC rule consists in the minimal amount of operations necessary to perform type-shifting from $\langle et, t\rangle$ to $\langle e\rangle$. This entails that the lower copy's original determiner is replaced with a structure including a definite determiner and an underspecified index slot, that must be specified in the course of the computation. The revised LF-sensitive TC rule TC* in (47) is obtained.

(47) TC*: [Det [NP]$_j$] $\Rightarrow$ [the $\emptyset$ [NPj]] LF-sensitive TC: no *shrinking*

On the other hand, we have seen above that the index on the restriction can lead, via *shrinking*, to a process of in-situ resolution of the DP-index underspecification. This explains the absence of WCO effects with the syntactic constituents that do not allow deletion of the NP-restriction in the left-periphery (triggering NP-movement to the TOP-position). The LF of the lower copy after application of the TC rule, *shrinking* and underspecification resolution in situ will be as follows. In this case, the LF-sensitive TC* rule produces the result in (48).

(48) TC*: [Det $\langle$[NP]$_j\rangle$] $\Rightarrow$ [the j [NP j]] LF-sensitive TC: *shrinking*

In order to explain why indexes left underspecified can lead, in this new framework, to legitimate BV readings, we adopt the following *generalized* version of PA (49), dubbed PA*. It essentially encodes the insight that the semantics maps underspecified indexes into the same variable associated to the index created by movement and encoding λ-abstraction.

(49) Generalized Predicate Abstraction (PA*)
Let α be a branching node with daughters β and γ, where β dominates only a numerical index i. Then, for every variable assignment a, $[\![\alpha]\!]^a = \lambda x.[\![\gamma]\!]^{a[i\rightarrow x \wedge \varnothing \rightarrow x]}$.
Generalized PA

Given this perspective, crossover is a phenomenon due to conflicting grammatical requirements concerning the resolution of underspecified indexes: on one side, resolution must be as local as possible (forcing *linking* to a locally intervening pronoun); on the other side, local underspecification resolution via *linking* violates economy of interpretation, since PA does not make any distinction between valued and unvalued indexes. To put it shortly, the conceptual roots of crossover lie in the fact that grammar does not tolerate index underspecification and requires local valuation of underspecified indexes, yielding unnecessary redundancy from the point of view of the systems of interpretation. Let us see how this insight can be technically implemented.

Notice first that in the system we have proposed there are two mechanisms of index valuation. On the one hand, we assume *linking* (Higginbotham 1983; Safir 2004) as exemplified in (50): a linked DP bearing a non-specified index receives the same index as the DP it is linked to.

(50) Linking:
a. $[_{DP}$ [the i] NP] ... $[_{DP}$ [the $\varnothing$] NP]
b. $\Rightarrow$ $[_{DP}$ [the i] NP] ... $[_{DP}$ [the i] NP]

On the other hand, the generalized rule of predicate abstraction PA* we introduced above (49), maps all underspecified indexes to the value of the λ-abstractor.

At this point, it is the conflict between the two following economy principles that is responsible for the deviant status of crossover configurations. The first principle concerns locality of index valuation (51): an underspecified index should find a value by entering the most local dependency available, unless resolving index under-specification

less locally allows deriving a different interpretation, as is is actually the case when the pronoun is not interpreted as a bound variable.

(51) Resolve index under-specification as locally as possible, unless avoiding resolution leads to a different interpretation.

The second principle expresses the constraint that a linked DP cannot be interpreted as bound by a higher predicate abstractor, because this would imply the redundant use of both *linking* and PA* in a configuration in which the use of PA* alone could have provided the very same interpretation, given the treatment of underspecified indexes by PA* (52).

(52) DP interpretation can involve either PA* or *Linking*, but cannot involve both.

To exemplify how the conflict between these principles derives crossover let us consider the WCO configuration in (53).

(53) $[_{DP}$ everyone] i [[his$_i$ mother] loves $[_{DP}$ [the $\emptyset$] one's mother]]

Leaving the trace unlinked to he$_i$/his$_i$ leads to the violation of (51), because skipping this dependency in favor of a less local one would not lead to a different interpretation. *Linking* the trace to he$_i$/his$_i$ leads to the violation of (52): the underspecified index is identified with the index of the intervening pronoun and the index of the upper λ-abstractor, but nothing would change, *modulo* the interpretation so obtained, if the index on the lower copy were left underspecified.

What happens in the *weaker crossover* configurations? Consider the representation in (54)

(54) [TOP degli studenti interrogati] dimmi [quale ⟨degli studenti interrogati⟩]$_j$ *j* pensi che il suo$_j$ insegnante non sappia come valutare [THE j [NP j]].
'Tell me [which of the evaluated students]$_j$ do you think (that) his$_j$ teacher doesn't know how to grade t$_j$'

In this case the principles of economy on index specification (51) and (52) are not involved, because the trace position is endowed with an index, thanks to the mechanism of in-situ resolution (in a sense, the copy/trace is inherently endowed with an index). Therefore, *linking* is not relevant in this case and no redundancy with respect to PA* can arise.[12]

12 We kept SCO out of our discussion. Note that specific *wh*-antecedents do not circumvent SCO:

(i) a. **Who* does *he* think [*t* will win the match]? Non-specific
b. **Which famous boxer* does *he* think [*t* will win the match]? Specific

We propose that the independent principle (ii) is responsible for ruling SCO out, irrespective of the specificity of the antecedent:

(ii) If a DP α c-commands a DP β, β can depend on α only through a binding relation, not *linking*.

6 CONCLUSIONS

The analysis proposed in the present contribution combines the conceptual advantages of a semantically motivated use of referential indexes (based on Elbourne's theory) with a fine-grained view of index-endowment and index-underspecification resolution at the interpretive interface. The copies of specific DPs are indexed in-situ and do not lead to any conflict between *linking* to intervening pronouns and semantic binding by a higher λ-operator. This result is elegantly obtained by combining Rizzi's analysis of LF-chains (and more particularly the insight that the NP-restriction of specific DPs is 'criterially' related to a Topic position in the left-periphery) with Enç's and Elbourne's insights concerning the role and the logical type of the indexes that are constitutive of the LF of DPs at the interface. For copies of non-specific DPs, crossover effects are simply the expression of the unavoidable conflict between the requirement that underspecification be resolved as soon as possible (imposed by economy of grammar) and the requirement that a given interpretation (in this case the BV-reading of pronouns) be obtained by means of the simplest available track (imposed by economy of interpretation). Weak crossover is an interesting manifestation of non-optimal tuning between principles of grammar and principles of interpretation.

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