

# Domains of Argument Structure Asymmetries

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## ABSTRACT

The purpose of this paper is to illustrate that the notion of domains of interpretation, and in particular domain of interpretation of pronouns, can be optimally defined in terms of asymmetric relations. It is proposed that asymmetric agreement is a central notion in the interpretation of argument structure in the morphological domain, as well as in the propositional domain, and in the domain of the discourse. It is shown that asymmetric agreement is at play in pronominal anaphora, as it is in binding. If, as we propose, the notion of domain of interpretation is bounded and is based on asymmetric relations, a new approach to pronominal anaphora can be formulated, which is crucially based on the properties of natural language.

## 1. LOCAL DOMAINS

The notion of local domain of computation and interpretation is recently thought of in terms of the notion of phase (Chomsky, [5], [6]). A phase is a unit of the computation: it has an internal structure, it is subject to impenetrability and it is isolable at the semantic and at the sensorimotor interfaces.

We argued elsewhere that phases are part of the derivation of morphological objects, Di Sciullo [8], [9], [10]. Evidence to this effect comes from the fact that an inflectional affix may access only the head of its adjacent phase. For example, in English the affix *-s* may either be the morphological spell-out of verbal or nominal inflectional features, e.g., *read-s*, *letter-s*. Nevertheless only the head of its adjacent phase can be accessible to the inflectional head. The representation in (1) illustrates the accessibility of the head, [7], [10], of a morphological phase Ph<sub>1</sub>, and the non accessibility of its complement. In (1c), the inflectional affix is the head of the higher phase Ph<sub>2</sub>, and the inflectional affix *-er* is the head of the lower phase Ph<sub>1</sub>. The complement of Ph<sub>1</sub>, *read*, is not accessible to Ph<sub>2</sub>, only its head is. Thus, *reader* is an inflected noun.

- (1) a. [[ read ] -s<sub>[+3rd p. -plur, +pres]</sub> Ph<sub>1</sub>] ex: to read  
       □□□□□  
    b. [[ letter ] -s<sub>[+p1.]</sub> Ph<sub>1</sub>] ex: a letter  
       □□□□□  
    c. [[ read ] -er<sub>ph1</sub> -s<sub>[+plur]</sub> Ph<sub>2</sub>] ex: the readers  
       □□□□□□□  
       □□□□□x□□□□□

Morphological phases are more restricted than syntactic phases. Once a morphological phase is derived, neither the root nor the affixal head may be reordered within that phase or outside of that phase, and no constituent may intersperse it. Movement may occur in syntactic phases if an agreement relation is established between a probe and a goal. Furthermore, syntactic phases are propositional, whereas morphological phases are not, [8], [10].

## 2. ARGUMENT STRUCTURE DOMAINS

Domains of argument structure asymmetries are local domains where agreement relations are established between predicates and arguments, e.g., predicate saturation, and between arguments, e.g., argument linking.

Domains of argument structure asymmetries are observed in morphological phases. For example, the affix *-er* must be the head of a morphological phase where an agreement relation holds between its external argument feature [-A] and the external argument feature of the root [+A]. Consequently, the affix may combine with an unergative root, i.e., a root that takes an external argument, (see (2a)), but not with an unaccusative root, i.e., a root that takes an internal argument, (see (2b)).

- (2) a. [ □ sleep [+A] ] -er [-A] ex: John is a sleeper.  
       □□□□□□□  
    b. [[+A] leave [-A] ] -er [-A] ex: #John is a leaver.  
       □□□x□□□

Note that the agreement relation in (2) is not a feature identity, as the argument features are contra valued. Morphological A-feature Linking is subject to the Distinctiveness Condition, (3), as proposed in [10].

- (3) *A-feature Distinctiveness*  
 In a Morphological domain, Linked A-features must be A-distinct.

Syntactic phases are also argument structure domains, where agreement relations are established. Like a morphological phase, a syntactic phase is a local domain for computation and interpretation. Agreement relations hold within a phase and across phases under restricted conditions, [5].

Binding relations are observed in syntactic phases or propositional domains, as the examples in (4) and (5) illustrate.

- (4) [ [the chief officer] trusts [himself]]  
       □□□□□□□□□□□□□□  
    (5) [ [the chief officer] trusts [ him ] ]  
       □□□□□□□x□□□□□□

Given the Binding Theory (6), [2], [3], binding between an anaphor or a pronoun and its antecedent is determined locally, in a Binding Domain (BD), i.e., a proposition, and it is established on the basis of asymmetric c-command, (10).

- (6) Binding Theory  
    A. An anaphor is bound in its BD.  
    B. A pronominal is free in its BD.

- (7)  $\alpha$  is bound by  $\beta$  iff  
 $\alpha$  and  $\beta$  are featurally related, and  
 $\alpha$  asymmetrically c-commands  $\beta$
- $\alpha$  is free if  $\beta$  is not bound.
- (8) *C-command (constituent command)*  
 $\alpha$  c-commands  $\beta$ , iff each  $\gamma$  that dominates  $\alpha$  dominates  $\beta$ , and  $\alpha$  does not dominate  $\beta$ .
- (9) *Asymmetric c-command*  
 $\alpha$  asymmetrically c-commands  $\beta$ , iff  
 $\alpha$  c-commands  $\beta$ , and  $\alpha$  does not c-command  $\beta$ .

In the Minimalist Program [4], [5], the Binding Theory is an interface legibility condition that contributes to make linguistic expressions interpretable by the external conceptual-intentional system. The Binding Theory makes the correct predictions for the binding of anaphors and pronouns to antecedents within their local BD. Thus, the example in (4) illustrates the fact that a pronominal anaphor like *himself* is bound to an antecedent within its BD, whereas the example in (5) shows that the pronoun *him* is not bound, i.e., it is free, within its BD.

Viewed as a legibility condition Binding Theory (6) must hold at the interfaces to ensure full interpretation. However, while pronouns must be free in their BD, they must be bound by an antecedent outside of their BD, I what we will refer to as the Discourse Domain (DD).

Pronouns must be anaphorically related to an antecedent located outside of their BD. The example in (10a) shows that a pronoun like *him* may be part of an anaphoric relation with an antecedent outside its adjunct prepositional (PP) phase. The example in (10b) shows that the antecedent of *him*, may be in the matrix clause. The example in (11) illustrates that the antecedent of *him* may be located in a non-adjacent propositional domain.

- (10) a. [the president saw [the chief officer] [near [him]]]  
 $\square$ ..... $\square$
- b. [[the president] thinks [that [the chief officer] trusts [him]]]  
 $\square$ ..... $\square$
- (11) [[[the president] talked to the members of the company  
 $\square$ .....  
today. The reactions of the shareholders were unequal. The minutes  
.....  
of the meeting indicate [that [the chief officer] trusts [him]]]  
..... $\square$

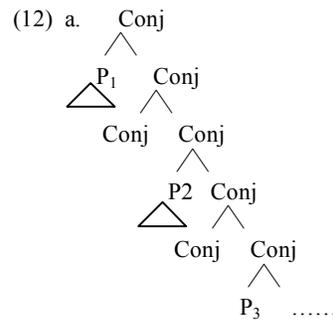
Pronominal anaphora resolution is generally treated in terms of preferences rather than in terms of interface legibility conditions. This is typically the case in so-called knowledge poor approaches (e.g., Kennedy and Boguraev, [13], Mitkov [15]). However, pronominal anaphora must be legible in the domain of a discourse, i.e. in a DD, which is formed of linguistic expressions. Assuming that every element in a linguistic expression must have an interpretation at the semantic interface, the interpretation of a pronoun must be provided by an antecedent in its DD. We posit that pronominal anaphora resolution is basically determined by linguistic knowledge and in particular by the morphological-syntax-semantic properties of argument structure domains (see Carter [1], Hobbs [11], Lappin and Leass [14] for richer syntactic-(semantic) knowledge-based

approaches to discourse pronominal anaphora resolution than knowledge poor approaches).

### 3. PRONOMINAL ANAPHORA RESOLUTION USING ASYMMETRIC AGREEMENT

In this section we formulate an approach to anaphora resolution based on Asymmetry Theory, Di Sciullo [10], according to which asymmetric relations, such as asymmetric c-command and precedence relations [18], are taken to be the core relations of the language faculty, enabling humans to use efficiently the grammar of natural languages.

Assuming that a discourse is a set of conjoined propositions, and that conjunction relations are asymmetric in natural language [12], [16], [17], the propositions of a discourse are asymmetrically related, (see (12a)). Moreover, given that the propositions in a discourse, and the constituents therein, are linearly ordered, and that precedence is an asymmetric relation, if  $P_1$  precedes  $P_2$ , the constituents in  $P_1$ , such as DPs (nominal expressions) and DPros (pronouns) precede, and thus are in asymmetric relation with, the constituents of  $P_2$ , (see (12b)), where  $>$  stands for the precedence relation.



- b.  $[P_1 \dots DP_1 \dots] > [P_2 \dots DP_2 \dots] > [P_3 \dots DP_3 \dots]$

We define the interface D-Linking condition on pronominal anaphora, (13), in terms of the Link operation of Asymmetry Theory. Like the other operations of this theory, Link, (14), applies under asymmetric Agree, (15). A pronoun is linked to the closest DP it asymmetrically agrees with. Pronominal anaphora resolution is essentially the identification of the closest DP/DPro with respect to which a pronoun stands in a proper sub-set relation.

- (13) D-Linking (Discourse Linking)  
A pronominal must be linked in its DD.
- (14) *Link* ( $\alpha, \beta$ )  
Given two objects  $\alpha$  and  $\beta$ , *Link* ( $\alpha, \beta$ ) creates a new object where  $\alpha$  and  $\beta$  are featurally related.
- (15) *Agree* ( $\varphi_1, \varphi_2$ )  
Given two sets of features  $\varphi_1$  and  $\varphi_2$ , *Agree* ( $\varphi_1, \varphi_2$ ) applies if and only if  $\varphi_1$  properly includes  $\varphi_2$ .

What are the features that are part of asymmetric agreement in pronominal anaphora?

There are three sorts of features legible at the interfaces: phonetic, formal, and semantic. The phonetic features are legible at the phonetic interface, the formal and the semantic features are legible at the semantic interface and are determinant

in anaphora resolution. We focus on the formal and the semantic features in what follows.

The elements that enter into anaphoric relations have the formal feature D (Determiner) and the phi-features Person (Per), Number (Num), Gender (Gen), as well as morphological Case (e.g., nominative, accusative, dative, oblique), which we will not consider here. Both pronouns (DPro) and definite determiners are D, but differ in their phi-features, definite determiners not being specified for person, gender, and for morphological case. DPs differ from DPros, Ns are inherently 3<sup>rd</sup> pers. Argumental DPs and DPros have semantic features that participate in anaphoric relations. DPs have independent reference [+Ir], whereas DPros are [-Ir]. An anaphoric relation has only one [+Ir] feature, the [-Ir] feature of DPros is valued by the [+Ir] feature of the antecedent DPs. Given the Binding Theory, an anaphoric pronoun, such as *himself*, must be bound by an antecedent in its BD, whereas pronouns must be free; given D-Linking, a pronoun such as *him* must be linked in its DD.

The tableau in (16) includes the formal and semantic features that are necessary for pronominal anaphora resolution based on asymmetric agreement. The feature specifications are provided for both strong and weak DPros, such as the pronominal clitics of Romance languages, e.g., *le CLO le voit* (Fr.) ‘the CLO sees him’. We will not discuss weak pronominal anaphora here, which properties also follow from asymmetric agreement, [10]. The semantic features include the independent reference feature ([±Ir]), along with the animate ([±ani]) feature and the part-whole ([±w]) feature. The [±ani] feature differentiates *he* from *it*, and the [±w] feature, differentiates anaphoric, such as *himself*, from non-anaphoric pronouns, such as *he* and *him*, anaphoric pronouns are [+w], non-anaphoric pronouns are [-w].

(16) DPros and DPs formal and semantic features

	Formal: pers, num, gen	Semantic: Ir, ani, w
DPro		
strong	+ + +	+/- +/- +/-
weak	- + +	+/- +/- +/-
DP	3 <sup>rd</sup> pers. + +	+ +/- +/-

#### 4. PREDICTIONS

Given asymmetric agreement, the set of features of the antecedent must be the superset of the set of features of the anaphor. This makes the correct predictions within the propositional domain, BD. It also makes correct predictions in the domain of the discourse, DD, as the examples in (17) and (18) illustrate.

(17) a. [the chief officer] trusts [himself]]  
 □□□□□□□□□□□□□□□□  
 {+Ir, +ani, +w}                    {-Ir, +ani, -w}  
 {+3<sup>rd</sup>prs,+ sing, +mass}        {+3<sup>rd</sup>prs,+ sing, +masc}

b. [the chief officer] trusts [him]]  
 □□□□□x□□□□□□□□  
 {+Ir, +ani, +w}                    {-Ir, +ani, -w}  
 {+3<sup>rd</sup>prs,+ sing, +masc}        {+3<sup>rd</sup>prs,+ sing, +masc}

c. [[the president] thinks [that [the CLO] trusts [him]]]  
 □...□.....□.....□.....□  
 {+Ir, +ani, +w}                    {-Ir, +ani, +w}  
 {3<sup>rd</sup>prs,+ sing, +masc}        {+3<sup>rd</sup>prs,+ sing, +masc}

In (17a), the BD is the proposition, and the features of the pronominal anaphor *himself* are properly included in the set of features of its asymmetrically c-commanding antecedent [the CLO]. In (17b), the BD of the pronoun *him* is also propositional, and the pronoun is not bound by the local antecedent with which it asymmetrically agrees. In (17c), the pronoun *him* is free in its BD, as predicted by the Binding Theory, and it must be bound outside of that domain, in its DD, given D-Linking. A possible antecedent for this pronoun is the DP in subject position [the president] in the matrix clause.

Consider now the discourse in (18)

(18) [[<sub>LD</sub>[the president] talked to [the members of the company]]  
 □□.....□.....□.....□.....  
 {+Ir, +ani, +w}                    {+Ir, +ani, +w}  
 {+3<sup>rd</sup>prs,+ sing, +masc}        {3<sup>rd</sup>prs,+ plur, +masc}

today. [The reactions of the shareholders] were unequal.

.....□.....□.....  
 {+Ir, -ani, +w}  
 {+3<sup>rd</sup>prs,+ plur, +masc}

[The minutes of the meeting] indicate [that [<sub>BD</sub> the CLO]

.....□.....□.....□.....  
 {+Ir, -ani, +w}                    {+Ir, +ani, +w}  
 {+3<sup>rd</sup>prs,+ plur, +neut}        {+3<sup>rd</sup>prs,+ sing, +masc}

trusts [him]]

.....□□  
 {-Ir, +ani, +w}  
 {+3<sup>rd</sup>prs,+ sing, +masc}

In (18), the pronoun *him* is not bound by its local antecedent [the CLO] with which it asymmetrically agrees in its BD, as predicted by the Binding Theory. Given D-Linking, the pronoun must be linked in its DD. The antecedent of the pronoun is the DP [the president] in the first proposition of the discourse, since it is the closest DP with which the features of the pronoun may enter into a proper inclusion relation. The intermediate DPs do not share the same set of phi-features with the pronoun. Thus, no superset relation can be established between the set of features of the intermediate DPs and the set of features of the pronoun.

#### 5. LINGUISTIC KNOWLEDGE

Syntax-semantic interface properties and the semantic properties of predicates provide further evidence that pronominal anaphora resolution operates in domains of argument structure asymmetries.

##### 5.1 SYNTAX-SEMANTIC INTERFACE KNOWLEDGE

Consider now the examples in (19) to (22).

- (19) a. The president bought a Mercedes. They are solid cars.  
 b. I need a rewritable CD. Where did you put them?
- (20) a. #I saw the president's Mercedes. They are solid cars.  
 b. #I need the rewritable CD. Where did you put them?
- (21) a. The Mercedes is a nice car. They sell well to corporates.  
 b. The rewritable CD is popular. They sold well this year.
- (22) a. The Mercedes is a nice car. It sells well to corporates.  
 b. The rewritable CD is popular. It sold well this year.

These examples in (19) show that an indefinite DP, [a Mercedes], [a rewritable CD], can be the antecedent of a plural pronoun. The examples in (20) show that this is not the case for a definite singular DP, [the president's Mercedes], [the rewritable CD]. The examples in (21) and (22) show that a definite DP that denotes a type can be the antecedent of a plural or a singular pronoun.

Pronominal anaphora resolution crucially relies on the semantic features of the antecedent and the pronoun. Indefinite DPs, like plural DPs, denote sets of individuals. They can thus be the antecedents of plural pronouns. Similarly, the set of individuals denoted by conjunct DPs can be the antecedent of a plural pronoun, as the example in (23a) illustrates, even though only one of the conjuncts can be the antecedent of a singular pronoun, as the example in (23c) illustrates.

- (23) a. The president and the CLO came in. They were confident about the outcome of the meeting.  
 b. #The president and the CLO came in. He was confident about the outcome of the meeting.  
 c. The president and the CLO came in. He was confident about the outcome of the meeting as was the CLO.

The examples above illustrate that pronominal anaphora resolution, while targeting arguments in different domains, cannot be established without the identification of the syntax-semantic interface properties of DPs and DPros.

## 5.2. SYNTAX-SEMANTIC KNOWLEDGE

An expletive pronoun may occupy the subject position of a proposition in a discourse, as in the example in (24). In English and in French, the formal features of an expletive pronoun are {+3<sup>rd</sup>pers, -ani}, since it is not specified for number and gender.

- (24) [The company X] was making progresses. [It] seemed as if the market was not ready for a breakthrough. However, the new X-software sold very well.

The expletive in the second sentence in (24) will not be part of an asymmetric agreement relation with the phi-compatible DP in the subject position in the preceding sentence if expletives differ semantically from pronouns and full DPs. Expletives do not denote sets of individuals, contrary to pronouns and DPs. Thus a DP cannot be the antecedent of an expletive, since the former cannot be a subset of the latter.

The expletive *it* and the pronoun *it* have the same form, they can only be differentiated by the lexical properties of the predicate which they are dependent. Thus, the pronoun *it* in (25) is an expletive, because the predicate *seem* does not have an external argument, and is a raising verb (see (25b)); whereas the pronoun *it* in (26) is not an expletive, as the predicate *indicate* selects an external argument, and thus the verb is not a raising verb (see 26b).

- (25) a. It seems that the market is ready for a breakthrough.  
 b. The market seems to be ready for a breakthrough.
- (26) a. It indicates that the market is ready for a breakthrough.  
 b. \*The market indicates to be ready for a breakthrough.

The examples in (27) illustrate further that the syntax-semantic properties of the predicates play a role in the pronominal anaphora relation.

- (27) a. The president congratulated the CLO. He was not expecting such a reaction.  
 b. The president frightened the CLO. He was not expecting such a reaction.

Thus, in the case of *congratulate*, the internal argument is the experiencer, and in the case of *frightened*, the experiencer is the external argument. The external argument of *expect* is also an experiencer, consequently the DPro in the local argument structure domain of *expect* will take as its antecedent the object of *congratulate* in (27a), i.e., *the CLO*, and the object of *fear* in (27b), i.e., *the president*.

## 5.3 LINGUISTIC KNOWLEDGE AND REAL-WORLD KNOWLEDGE

Linguistic knowledge determines the core properties of discourse pronominal anaphora, whereas real-world knowledge is parasitic on the linguistic knowledge. The examples in (28) and (29) illustrate this point.

- (28) The President's party was a success. They celebrated until 2 AM.
- (29) The CEO talked to the CLO. He became a millionaire within a time-frame of four years.

In (28) the antecedent of the pronoun *they* is the DP [the President's party] in the preceding c-commanding proposition, since *party* refers to a group. Real-world knowledge, e.g., one property of a successful party is that it lasts a long time, enforces the anaphoric relation based on the linguistic knowledge.

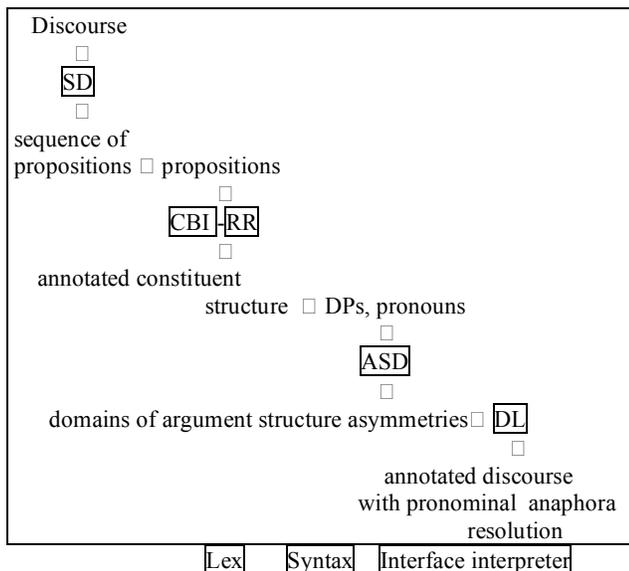
In (29), the pronoun *he* has two possible DP antecedents: the DP subject [the CEO] and the DP object [the CLO], and asymmetric agreement holds between each one of the DPs and the pronoun *he*. Given that CEOs are more likely to become millionaires than CLOs, real-world knowledge enforces the linguistic knowledge that, all things being equal, the subject rather than the object is the antecedent of an anaphora. Real-world knowledge is not basic in pronominal anaphora resolution. Independent results point to the same conclusion Lappin and Leass [14] report that real-world relations

marginally improve the syntax-based RAP algorithm's performance (by 2%).

## 6. AN ARCHITECTURE FOR A DISCOURSE ANAPHORA INTERPRETER

The tableau in (30) identifies the parts of a Discourse Pronominal Anaphora Interpreter (DAI) using asymmetric agreement. The DAI includes a Sentence Delimiter (SD) that sequentially identifies each sentence of a discourse, preserving the asymmetric precedence relation between the propositions. The DAI analyses each proposition from left to right with the following modules. The Constituent Boundary Identifier (CBI) and the Relation Recoverer (RR) identify the formal and semantic feature structure of the DPs and the DPros (strong and weak) and the asymmetric c-command relations between them. The Argument Structure Delimiter (ASD) identifies the domains of argument structure asymmetries. The Discourse Linker (DL) implements the operations of Asymmetry Theory including the Link operation, based on asymmetric agreement. The output yields an annotated discourse with pronominal anaphora resolution.

(30) Architecture of Discourse Pronominal Anaphora Interpreter (DAI)



The DAI relies on morphological-syntax-semantic properties and asymmetric agreement, and identifies necessary and possible antecedents for pronouns in linguistically determined domains of argument structure asymmetries.

## 7. SUMMARY

Like the Binding Theory is an interface legibility condition enabling the linguistic expressions to be interpretable by the conceptual-intentional system, D-Linking is a discourse interface legibility condition that requires pronouns, i.e., elements that lack independent reference, to be linked to the closest antecedent with which it asymmetrically agrees. This linking relation is obtained under asymmetric agreement relation, as it is the case for the binding relation. Both D-Linking and Binding are bounded relations, they are determined on the basis of local domains of argument structure

asymmetries. Pronominal anaphora resolution crucially relies on the identification of these domains, where asymmetric agreement holds between pronouns and antecedents.

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