Raising to object

A graph-theoretic analysis

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In this paper we provide an introduction to a set of tools for syntactic analysis based on graph theory, and apply them to the study of some properties of English *accusativus cum infinitivo* constructions, more commonly known as *raising to object* or *exceptional case marking* structures. We focus on puzzling extraction asymmetries between base-generated objects and 'raised' objects and on the interaction between *raising to object* and Right Wrap. We argue that a lexicalised derivational grammar with grammatical functions as primitives delivers empirically adequate analyses.

Keywords: raising to object, Wrap, Merge, graph theory

1. Introduction

Recent work in generative grammar has proposed that structure building in natural language takes the form of an operation of unordered binary set formation which, given two syntactic objects (SO), delivers the set containing these, and nothing more:

(1) Merge(X, Y) = {X, Y} (*Simplest Merge*; Chomsky, 2021: 19; Chomsky et al., 2023: 14; Epstein et al., 2022: 8)

In this paper we build on previous work (Krivochen, 2023a, b, c) and propose to replace (1) with (2):

(2) Merge(X, Y) = *e*<X, Y>

where (instead of an unordered binary set) *e* is an *edge* joining X and Y in a graph (see also McKinney-Bock & Vergnaud, 2014). We argue that a graph-theoretic definition of Merge has formal and empirical advantages over the 'unordered set formation' version, and provides an analysis of extraction facts and particle Wrap in

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English *accusativus cum infinitivo* constructions that accounts for otherwise puzzling properties.

The remainder of this section presents the framework. **Section 2** introduces the relevant data and considers the advantages and shortcomings of previous analyses. In **2.1** we account for the extraction facts assuming structure building as in (2) combined with the idea that grammatical functions are primitives of the theory. **2.2** applies the analysis to particle Wrap, unifying the configurations to which Wrap can apply.

1.1 Definitions and formal preliminaries

Since we propose that Merge delivers graphs and not sets, we must define what graphs are and what properties they have. A graph G is a set G = (V, E), where V is a set of vertices (or 'nodes', a more common term in syntax) and E is a set of edges: $v \in$ V is a vertex (or 'node'), and $e \in$ E is an edge. There is also an *incidence function i* that associates an edge to pairs of (possibly distinct) nodes. Our edges will be one-way roads, such that e<X, Y> ≠ e<Y, X>. We call these *directed edges*, or *arcs*, and represent them with arrows from *head* (in our example, X) to *tail* (in our example, Y). Graphs whose edges are *arcs* are directed graphs, or *digraphs* for short. The number of arcs stemming from v is the *outdegree* of v, and the number of arcs that reach v is the *indegree* of v.

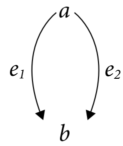
This mode of structure building makes available several relations between arcs and nodes. The most fundamental of these for our purposes will be the two-place asymmetric, irreflexive relation *immediately dominates* and its transitive closure (*dominates**):

Given a, $b \in$ V, *a immediately dominates b* iff there exists an arc A = e<a, b>

In the present context, a immediately dominates b iff a and b are Mergemates.

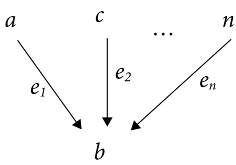
A more complete list of allowed arc relations is provided in Krivochen (2023c: 96) (also Postal, 2010: 10, ff), but for purposes of this paper, in addition to *immediately dominates* between nodes we will make use of *parallel* and *kiss* as relations between arcs. Arcs e_1 and e_2 are *parallel* iff, for a, b, … n nodes, e_1<a, b> ∧ e_2<a, b> (sometimes, parallel arcs are referred to as *multiedges*, e.g., Gross & Yellen, 2014: 3), and they *kiss* iff e_1<a, b> ∧ e_2<c, b>. In this configuration, we say that b has more than one *mother*, or that it is *multidominated*. We have illustrated the simplest case, where only two arcs are involved; however, neither of these relations is strictly binary: binarity is limited to relations between *nodes* (since by definition an arc connects two nodes, a head and a tail), but not between *arcs*. We illustrate *parallel* and *kiss* in (3):

(3) a.



Parallel arcs

b.



Kissing arcs

In (3a), the *outdegree* of *a* is 2, and its *indegree* is 0. In both (3a) and (3b) *a* immediately dominates *b*. These are relations that the formalism makes available. What is most important for us is how linguistic theory can capitalise on them.

1.2 Some properties of the lexicon

Given Merge(X, Y), restrictions on X and Y are imposed not by graph theory, but by the linguistic theory expressed in that formalism. As part of the characterisation of the linguistic theory, we define a set of *expressions* as the basic building blocks of syntax. Within the set of expressions, we distinguish:

– Basic expressions: not derived by the application of any operation. These constitute the alphabet of atomic symbols of the grammar
– Derived expressions: recursively defined in terms of basic expressions given the operations made available by the grammar

In turn, basic expressions are (i) *indexed* by a set of categories and (ii) assigned uniquely identifying addresses. Let us flesh this out. In Ajdukiewicz-Montague style Categorial Grammar (CG), expressions belong to indexed categories which indicate their combinatoric properties: an expression of category X/Y (basic or derived) needs to combine with an expression of category Y (basic or derived) to yield an expression of category X. The set C of categories, closed under the operations allowed in the grammar, is recursively defined as follows (Schmerling, 2018: 28):

C is the smallest set such that:
X, Y $\in$ *C*
For any X, Y $\in$ *C, X/Y* $\in$ *C*

Note that both X and Y may be derived categories. Thus, for example, (X/Y)/(X/Y) is a category, and so is X/(X/Y). Following Schmerling (2018: 105, ff.), we assume categories such as NP (to which both proper and common names belong, for simplicity), S, TV/NP (the category of expressions that must combine with an expression of category NP to yield an expression of category TV), with TV in turn being an abbreviation of IV/NP (the category of expressions that must combine with an expression of category NP to yield an expression of category IV), S/IV (the category of nominative subjects, derived via identity from NP), and other combinations of these. Categories will not play a big role in the analysis to be presented in **Section 2**, but we introduce them here as an important part of the linguistic theory we adopt.

Having (very) briefly dealt with indexed categories, let us proceed to addresses. Suppose that our alphabet Σ contains the expressions {read, books, kill, monsters, …}. These are not the output of any operation: they are basic expressions. The basic expression *kill* belongs to the category of expressions that must combine with a nominal to obtain an intransitive verb phrase: following CG practice we can call this category IV/NP (see e.g. Schmerling, 2018: 105, ff.). The uniquely identifying address of this expression is notated ⦃kill⦄, and the content of this address is the semantic value of *kill*, ⟦kill⟧ (Dowty et al., 1981: 19, ff.; Heim & Kratzer, 1998). In Krivochen (2023b: 85) we referred to the statement that the content of a node's address is a semantic value as an *addressing axiom*. The address of an expression allows us to unambiguously identify that expression independently of context:[1] the address of *kill* is always ⦃kill⦄ regardless of the nodes that it immediately dominates or that immediately dominate it, because the semantic value of *kill* does not depend on its neighbourhood. Addresses unambiguously define regions in the syntactic workspace (cf. Manzini & Savoia, 2011): rather than select lexical terminals from the Lexicon and have syntactic operations apply to them in a separate sandbox, we conceptualise Merge as an operation that applies *to the workspace*, defining selector-selectee relations between regions and imposing a variable metric over the workspace (Krivochen, 2023b).

We said that the content of a node's address is the semantic value of the expression corresponding to that node. The strongest position is to say that a

1. In this sense, the addressing schema used here differs from the Gorn addressing system assumed in some works in TAG (e.g., Sarkar & Joshi, 1997: 610). Originally, in Gorn (1967), the address of a node in a tree structure is a function of the path from the root to that node: suppose that the root node (always assigned address 0) has *n* daughters. Then, these will be addressed 1, 2, … *n*. Any of these nodes may have daughters: they will be addressed 1.1, 1.2, 1.3, …1.*n*; 2.1, 2.2, 2.3, …2.*n*; … And any of these nodes may have daughters of their own, labelled 1.1.1, 1.1.2, 1.1.3…; 1.2.1, 1.2.2, 1.2.3, …. etc. The Gorn address of a node in a tree depends on its position, whereas our addressing system is context-free.

node is assigned an address if and only if the expression it corresponds to has a semantic value. This entails the existence of expressions that have no semantic values, and therefore no addresses: these expressions, which make no semantic contribution to any well-formed expression in which they appear, are called *syncategorematic*. Syncategorematic expressions are not just present in natural language grammars: consider for instance the parentheses in mathematical and logical notation. The equivalence between $(1+2)\times 3$ and the Polish notation version $\times + 1\,2\,3$ shows that ( ) contribute nothing other than helping humans disambiguate the formula. Structuralist syntax and the generative grammar that developed from it, whose heuristic to identify the atoms of grammar was based on segmentation and substitution with categories being generalisations over distributional statements, necessarily have everything for which we can define distributional properties assigned to a category. However, grammatical analysis has often identified expressions that defy an exhaustively Harrisian assignment of expressions to indexed categories. In contrast to Item-and-Arrangement theories (which include structuralism and generative syntax), Item-and-Process theories (which include pure CG) are not committed to the claim that category indices are distributional statements, and therefore allow for expressions that are assigned to no indexed category, and which receive no model-theoretic interpretation (Schmerling, 2018: 151–154). Examples of syncategorematic lexical expressions in English grammar include infinitival *to*, expletives *it* and *there* (which e.g. Rouveret, 2018: 351 recognises as being '*not interpretable at LF*'), and copula *be*.

In addition to single-word categorematic and syncategorematic basic expressions, the lexicon of a grammar contains basic expressions that span more than a single orthographical word: these are multi-word basic expressions (MWE). MWEs have a long tradition in syntactic studies, going as far back as at least Jespersen's (1937) *Analytic Syntax*, and being adopted in Item-and-Process grammars (Bach, 1979; Schmerling, 1983, 2018). Because, as in Krivochen (2023a, b, c), nodes correspond to indexed basic expressions, there is no one-to-one correspondence between nodes and orthographical words: a MWE such as *look up* (meaning 'search') is assigned address ⦃look-up⦄ and corresponds to a single node in a structural description. Then, the string *to look up definitions* contains two categorematic basic expressions, *definitions* and *look up* (the latter an MWE), and a syncategorematic expression, *to*. Only the former are indexed by the sets of categories and addresses, and only these are nodes in the structural description assigned by the grammar to our sample string:

(4) G = <*e*<look-up, definitions>>

This example provides a convenient segue to our next point. Expressions such as *look up definitions* or *read books* are not basic; rather, they are the product of applying some operation to basic expressions. In the simplest case, we can derive *read books* from *read* and *books* by applying Merge:

(5) Merge(*read*, *books*) = *e*<read, books>

Under *Simplest Merge* (cf. (1)), the output of (5) would be the unordered set {*read*, *books*}, which provides no information about predicate-argument structure: there is nothing in the set containing *read* and *books* that indicates that *books* is selected or theta-marked by *read*. Despite Chomsky's (2021: 18) claim that '*EM* [External Merge] *is associated with θ-roles and IM* [Internal Merge] *with discourse/information-related functions*', given structure building as untriggered, free, unordered set formation the nature of this 'association' remains unclear.[2] In the present context, this association is straightforward: as in McKinney-Bock & Vergnaud (2014) and Krivochen (2023a, b, c), edges go directly from a predicate to its arguments, and there is no limit imposed by the formalism to the number of edges that a predicate can be the head of. Restrictions are part of the theory expressed by the formalism, and the theory needs to provide descriptively adequate analyses.

Above we referred to arc relations made available by the formalism (*parallel*, *kiss*), which linguistic theory capitalises on. Consider, for example, a linguistic motivation for *parallel* arcs:

> *one good reason to assume parallel arcs is that for certain types of grammatical relations a single phrase has the possibility of bearing more than one to the same larger constituent.* (Postal, 2010: 18)

The analysis of reflexive anaphora in Krivochen (2023a, c) (building on much work in Relational Grammar, e.g. Perlmutter, 1980: 209; Berinstein, 1984: 3, ff.) has the coindexed expressions in a sentence like

(6) John$_i$ admires himself$_i$

correspond to a single indexed node in the graph that is the structural description of (6): we are simply calling the address ⦃John⦄ (and accessing the same semantic

2. Minimalist Grammars (Stabler, 2011) and some recent proposals such as Zyman (2023) and Neeleman et al. (2023) assume that Merge is triggered by the need to satisfy selectional features, and do not work with unordered sets (Zyman's definition of Merge is explicitly graph-theoretic, although he builds classical trees). We will see, however, that in maintaining classical transformational assumptions about the format of structure building, the representations they produce fall short of accounting for the empirical paradigms analysed here in the same way as their set-theoretic counterparts.

value) twice within a local domain. Under the definition of Merge in (2), the derivation of (6) would be:

(7) a. Merge(admire, John) = *e*<admire, John>
  b. Merge(admire, John) = *e*<admire, John>, *e*<admire, John>

Because of the sequentiality of the derivation, what we end up with is an ordered set of arcs:

(8) G = <*e*<admire, John>, *e*<admire, John>>

Note that the second argument to be composed with the predicate does not Merge with a complex object because arcs, by definition, join two nodes. In this view, syntactic operations always establish relations between basic expressions, never between a basic expression and a derived expression. The order of composition pertains also to semantic interpretation, an idea that has a long tradition not only in CG and Tree Adjoining Grammar (TAG), but also in some versions of Minimalism. For instance, Williams (2011: 4) states

> *…the relation between semantics and derivation is 'perfect', in that semantics is a total mirror of derivation* [sic]

This view is perhaps best implemented in lexicalised TAGs (LTAGs). As Kallmeyer & Joshi (2003: 4) observe,

> *derivations are represented by derivation trees that record the history of how the elementary trees are put together. A derived tree is the result of carrying out the substitutions and adjoinings. Because of the localization of the arguments of a lexical item within elementary trees the proper way to define compositional semantics for LTAG is with respect to the derivation tree rather than the derived tree*

The derivation tree being a record of the derivation, TAGs implement Williams' 'perfect' relation between syntactic derivation and semantics. Our approach provides the additional simplification that the information that TAGs encode in derivation trees can be read off the order between arcs. Indeed, our graphs and TAG's derivation trees do resemble each other, although there are crucial differences: whereas in a derivation tree each node corresponds to the anchor of a lexicalised elementary tree (abridging structure in the corresponding elementary tree), in our graphs each node is necessarily a categorematic basic expression.

As a crucial linguistic assumption, we build on a basic principle in Relational Grammar (RG), of wide adoption in declarative ('constraint-based') frameworks:

> *A clause consists of a network of grammatical relations*
>
> (Perlmutter & Postal, 1983: 9)

where the structural correspondent of the notion 'clause', in the present context, is the *elementary graph*. These (primary) grammatical relations (or 'grammatical functions' GF), which in RG are denoted by integers 1, 2, and 3, are *primitive* in the sense that they are not defined in terms of structural relations (*contra* e.g. Chomsky, 1965: 69) and ordered in a hierarchy (versions of the grammatical function hierarchy are assumed in LFG, HPSG, and pure CG):

1 (Subject) >> 2 (Direct Object) >> 3 (Indirect Object) >>
Obliques ('>>' means 'outranks')

The CG perspective is particularly relevant to us. Building on previous work in Montague Grammar, Dowty (1982) proposes a way of defining GF in terms of order of semantic composition: the first argument to combine with a predicate is the most oblique one, with the Subject being the last GF to be composed. Assuming a Montagovian approach to the syntax-semantics interface, the denotation of a 2-place predicate like *love* is not a function from an ordered pair to a truth value, as it is in classical predicate calculus. Rather, in a sentence like *John loves Mary*, the predicate *love*, of category IV/NP combines with *Mary* (of category NP) to deliver the expression *loves Mary*, of category IV. This effectively makes *love Mary* into a 1-place predicate, a function that applies to the denotation of the expression *John*, with range *true-false*.

Under derivational assumptions, Dowty's (1982: 84) 'principle of grammatical relations' can be construed in terms of a sequential operation applying to indexed expressions:

> *A verb that ultimately takes n arguments is always treated as combining by a syntactic rule with exactly one argument to produce a phrase of the same category as a verb of n-1 arguments.*

This translates into the present context as the claim that each arc from *admire* to *John* corresponds to a different grammatical relation: *admire* is a basic expression of category IV/NP (the category of expressions that must combine with an expression of category NP to deliver an expression of category IV). The most oblique argument subcategorised by this predicate is a 2, and the least oblique argument is a 1: assuming Dowty's principle above (also Larson, 2014: 3), the derivation in (7) reads as the sequential combination of a predicate with its object and its subject, with this sequentiality being preserved in the order between arcs (cf. (8)). Representationally,

Let G = $\langle (a, b), (a, c), (a, d) \rangle$

> Let *a* be a lexical predicate, and *b*, *c*, *d* be arguments of *a* (e.g., expressions of category N) and $b \neq c \neq d$. Then, *b* is the Subject / 1 of *a*, *c* is the Direct Object / 2 of *a*, and *d* is the Indirect Object / 3 of *a*.

The order of arcs corresponds to the order of grammatical relations, such that if an arc $<x, y>$ is ordered before an arc $<x, z>$ in the description of the elementary graph where expressions *x*, *y*, and *z* appear, the grammatical relation that *y* establishes to the clause anchored by *x* is also ordered before the grammatical relation that *z* establishes to the clause anchored by *x* in the hierarchy of grammatical functions (the two orders are isomorphic, which means that there is a function *f* with an inverse that relates both sets of orders: we can go from one to the other no questions asked). Differently put, for *e, e'* arcs in a graph G, if *e* is ordered before *e'* in G, then the expression that is the tail of *e* outranks the expression that is the tail of *e'* in the GF hierarchy.

In the most strongly lexicalised version of the linguistic theory, all arguments are immediately dominated by the lexical categories that select them: subcategorisation frames are properties of lexical – not functional- expressions. Predication, under present assumptions, is never mediated by a functional category (cf. e.g. Collins, 2023: 6–7): this delivers a system where main clause and small clause predication are unified by making it always a lexical, never a functional, matter. Concretely, a principle such as

> *A head H introduces an argument A iff A externally merges with a projection of H.* (Collins, 2023: 7;[3] see also Larson, 1988: 382, among many others)

is replaced by

> *A predicative basic expression P introduces an argument A iff externally merges with P*

which, given the definition of Merge above, results in:

> <u>Local Dependency Principle</u>
> *Lexical predicates directly Merge with (and thus immediately dominate) their arguments*

3. Versions of this principle are present in a range of Minimalist work. For example, Castillo & Uriagereka (2002: 137) propose a principle of *Local Association*:
Always associate locally to given lexical items.

In this context, Merge is '*motivated by the usual requirements: selectional restrictions of the item that is targeted (C merges with IP, V with CP, and so on) theta-relations […] or checking configurations (movement* […] *to [Spec, IP] for Case/EPP reasons, etc.)*' (Castillo & Uriagereka, 2002: 141). Minus checking configurations, selectional and thematic properties remain crucial for us.

In graph-theoretic terms, this means that there is an edge from a predicate to each of its arguments. In the most strongly lexicalist version of the theory, there are no argument introducing heads other than lexical predicates.[4] An *n*-ary predicate *p* will always have outdegree *n*. In this sense, the grammar is *lexicalised* (Kallmeyer & Joshi, 2003; Frank, 2002), and the domain of locality of the grammar is, precisely, the irreducible subgraph that contains *p*, its arguments, and its functional modifiers.[5] Borrowing terminology from LTAGs, we refer to these irreducible subgraphs as *elementary graphs* (EG), and to the lexical predicate *p* that determines co-occurring arguments as the *anchor* of that elementary graph. To summarise, elementary graphs are minimal recursive units of argument structure (cf. Kroch, 2001: 4), directed graphs where each node is a basic expression and each arc connects a predicate and an argument. For example:

(9) a. John loves Mary
b. G = <<love, John>, <love, Mary>>

(10) a. John seems to love Mary
b. G′ = <<seem, love>, <love, John>, <love, Mary>>

(11) a. John tries to love Mary
b. G″ = <<try, John>, <love, John>, <love, Mary>>

Some noteworthy aspects of these analyses follow. In (9–11) each arc connects two categorematic basic expressions. As expected, (9) contains a single lexical predicate, and thus is an EG. The next case is perhaps trickier, in that classically generative syntax has analysed *seem* as an expression of category V, and *raising to subject* as a rule applying in biclausal structures. In (10b) there is no arc connecting *seem* and any of the nominal arguments: this is only expected if *seem* does not select any nominal argument, but there is an arc between *seem* and the lexical predi-

4. Considering the sentence *John saw John*, Chomsky (2021: 21) says:

> *a single θ-assigner cannot assign two θ-roles to the same element. If that were possible, then the sentence* John saw John, *with two different inscriptions of* John, *could be pronounced* John saw, *taking the predicate-internal subject to be a copy of the object. The verb* see *would then be assigning two θ-roles to* John *(more precisely, to the two copies of* John*).*

In Chomsky's fragment it is *see* that assigns θ-roles to its arguments (as opposed to, say, *see* and *v**). If '*EM is associated with θ-roles*' (Chomsky, 2021: 18), then this means that *see* must EM to both 'inscriptions' of *John*. Else, *see* could not θ-mark *John*. If read literally, Chomsky is endorsing the strong lexicalist analysis.

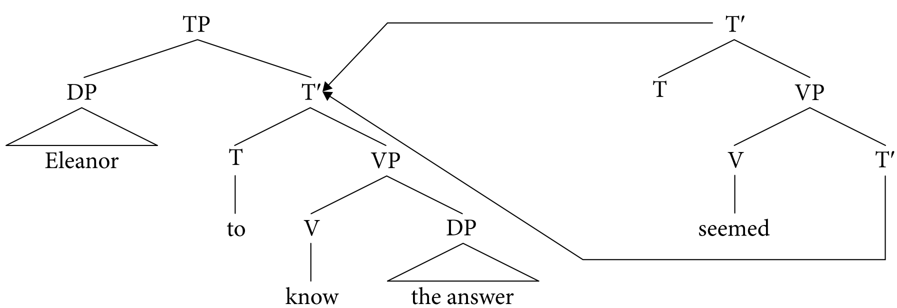
5. In addition to TAG's *elementary trees*, this definition of *elementary graph* is compatible with Chomsky & Lasnik's (1995: 102) notion of *Complete Functional Complex*, and LFG's *Minimal Complete Nucleus* (Dalrymple et al., 2019: 505).

cate *love* (which does select arguments). There is only one elementary graph, with anchor *love* and in which *seem* modifies the anchor as an epistemic modal. In a way, this analysis recapitulates Kroch & Joshi's (1985) proposal that

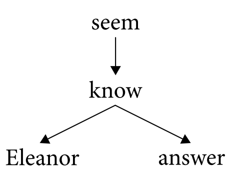
> *The basic contrast between control predicates and raising predicates is that the latter assign no thematic role to their surface subjects. This fact can be captured neatly in a tag by requiring that raising predicates be inserted in an auxiliary tree with no subject* (Kroch & Joshi, 1985: 44)

However, in contrast to the TAG analysis, our definition of *elementary graph* does not allow for *seem* to be an anchor, as it assigns no thematic roles or subcategorise for arguments. Thus, instead of a derivation such as (12), in which an auxiliary tree anchored by *seem* is adjoined to an initial tree anchored by *know*, we have (13), a (diagram of a) single-rooted EG:

(12)

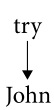


(13)



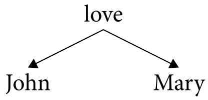
The case of a predicate that does thematically select its subject and takes a non-finite clausal complement is different: *want* subcategorises and thematically marks *John*, which given our assumptions requires there to be an arc from *want* to *John*. In this case, *want* anchors an elementary graph, selecting a nominal argument (and requiring a clausal one):

(14)



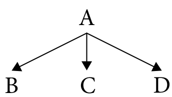
At the same time, *love* thematically marks *John* and *Mary*, anchoring its own elementary graph:

(15)

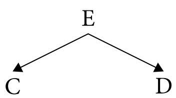


We have two elementary graphs, one of which is anchored by a lexical predicate that selects a clause. How can we put these two EGs together? Given elementary graphs G_1 and G_2, structure composition under current assumptions involves another operation made available by the formalism: *graph union*. The union of G_1 and G_2 is the union of their nodes and edges (symbolically, $G_1 \cup G_2 = (V_1 \cup V_2, E_1 \cup E_2)$). Because nodes are uniquely indexed by the set of addresses, if nodes *a* and *b* on distinct graphs G_1 and G_2 (such that $a \in G_1$ and $b \in G_2$) are indexed by the same address ⦃*a*⦄, the result of graph union ($G_3 = G_1 \cup G_2$) will contract those nodes into one, call it *c*. The composition of lexicalised local graphs under graph union delivers what is known in the literature as *structure sharing* (Karttunen & Kay, 1985). Let capital Latin letters stand for addresses. Then, structure composition as graph union applied to (16a) and (16b) delivers (16c), not (16d) (as Merge would):

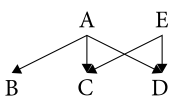
(16) a.



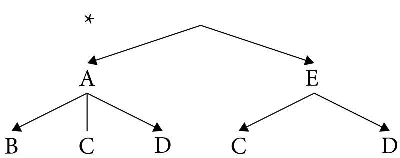
b.



c.



d.



If, as proposed in Krivochen (2023b), addresses uniquely point to locations in the syntactic workspace, the system has no choice but to structure-share as part of graph union.

1.3 Argument structure and semantic interpretation

A word on the domain of thematic role assignment is necessary, since – like TAG's elementary trees, see Frank (2002: 37, ff.)-, EGs are the domains within which thematic and categorial selectional properties of anchors are satisfied. Starting with the simplest case, for an intransitive construal, we have (17) (see Krivochen, 2023c: 170 for some remarks on unaccusativity within this framework)

(17) *e*<V, N> (e.g., *e*<fall, John>)

A transitive structure, predictably, will involve two arcs: one for the V-object relation and one for the V-subject relation. Each of these arcs, corresponding to an instance of Merge, satisfies a selectional feature of the predicate, and provides the configuration under which thematic role assignment takes place. Consider Pesetsky's (1995: 133) definitions of *direct* and *mediated* θ-selection:

> *A theory with θ-selection can express this quite simply. We need to allow internal θ-selection by* [a predicate] *π to be satisfied either (I) by a sister of π or (II) by an object of a preposition in a PP that is the sister of π. Let us call (I) direct θ-selection and (II) mediated θ-selection. Direct and mediated θ-selection are the only two ways in which θ-selectional properties can be satisfied.*

Given Merge as defined in (2), *direct* θ-selection is straightforward: there is an arc from a predicate to each of its arguments. Instead of 'sisterhood' (or set-theoretic 'co-containment'), however, we have 'immediate dominance' (and its transitive closure for *mediated* θ-selection), where the expression corresponding to the head of an arc subcategorises for and thematically marks the expression corresponding to its tail.

Under derivational assumptions, structural descriptions are not just sets of arcs, they are *ordered* sets of arcs. A derivation of a transitive structure would proceed along the following lines:

(18) a. Merge(V, N_1) = *e*<V, N_1> (e.g., *e*<buy, books>)
b. Merge(V, N_2) = <*e*<V, N_2>, *e*<V, N_1>> (e.g., <*e*<buy, John>, *e*<buy, books>>)

The order between the arcs is given, here, by the sequentiality of Merge. Observe that the second argument to be composed with the predicate does not Merge with a complex object because arcs, by definition, join two nodes (binarity being delivered by the formalism). In this view, syntactic operations always establish relations between basic expressions, never between a basic expression and a derived expression. The order of composition is important in the present system, as it pertains also to semantic interpretation (Dowty, 1982).

To summarise, the system described so far contains:

A set of graphs Γ
A set Exp of basic expressions
A set N of nodes

A set E of edges
A set A of uniquely identifying addresses assigned to members of N. Each $n \in$ N is assigned a unique $a \in$ A. For every n, $\{\!|n|\!\}$ is the unique address assigned to n.
A set S of semantic values. For every n, $\llbracket n \rrbracket$ is the semantic value of n.

The interpretation rules in Krivochen (2023c: 88) provide a directly compositional sketch of the syntax-semantics interface for predicate-argument relations:

(19) A semantic interpretation SI function for L is a function from $<$N, A$>$ to S. For Exp = n, SI(Exp) = S.
$e<n_1, n_2>$ (a directed edge between nodes n_1 and n_2, where n_1 is a functor, and n_2 an argument) is the semantic value of n_1 applied to the semantic value of n_2:
$e<n_1, n_2>$ becomes $\llbracket n_1 \rrbracket(\llbracket n_2 \rrbracket)$
$<e<n_1, n_2>, e<n_1, n_3>>$ becomes $(\llbracket n_1 \rrbracket(\llbracket n_3 \rrbracket))(\llbracket n_2 \rrbracket)$
$<e<n_1, n_2>, e<n_1, n_3>, e<n_1, n_4>>$ becomes $(\llbracket n_1 \rrbracket(\llbracket n_4 \rrbracket))(\llbracket n_3 \rrbracket)))(\llbracket n_2 \rrbracket)$

For a simple monotransitive sentence such as *John loves Mary*, we apply the semantic value of the predicate (of category IV/NP) to the semantic value of the first-Merged node (the predicate's internal argument):

(20) $\llbracket love \rrbracket(\llbracket Mary \rrbracket)$

The result is a derived expression of category IV (or, expanded, S/NP: the category of expressions that must combine with an NP to deliver a sentence). As in Dowty (1982), the combination of a transitive predicate with its object delivers an intransitive predicate. In the following step, we apply the output of this operation to the semantic value of the second-Merged node:

(21) $(\llbracket love \rrbracket(\llbracket Mary \rrbracket))(\llbracket John \rrbracket)$

Our system of semantic interpretation makes use of two well-known operations: *functional application* and *predicate modification* (Heim & Kratzer, 1998: §4.3; Kallmeyer & Joshi, 2003: 17, ff.). For purposes of this paper we will not deal with adjuncts, and thus predicate modification will be left aside.

2. A case study: Raising to object

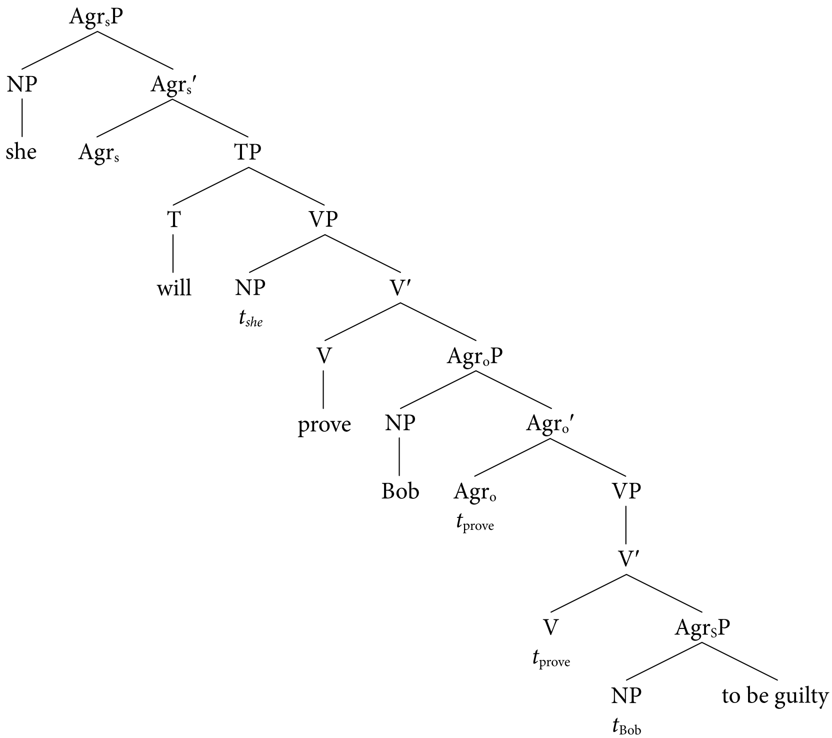
The remainder of the paper will be devoted to the analysis of an English construction that has proven problematic in the history of generative grammar: what in the classical tradition is called *accusativus cum infinitivo*, more recently dubbed Raising to Object (RtO henceforth; see Davies & Dubinsky, 2004 for extensive discussion). In addition to the relatively uncontroversial lexically governed rule of *raising to subject*, whereby the subject of an embedded non-finite clause raises to the position of subject of a superordinate clause, Postal (1974) provides detailed and numerous empirical arguments in favour of the existence of a process in the grammar whereby the subject of an embedded clause becomes the object of its superordinate clause if the upstairs verb belongs to a certain class which includes *believe, consider, prove, expect, hear, see…* (many propositional attitude predicates and perception verbs). Postal distinguishes two kinds of raising verbs: those governing *raising to subject*, he calls *A-verbs*, and those that govern the rule *raising to object*, he calls *B-verbs*. The relevant examples are as in (22):

(22) a. John seems/is likely/appears to be a good fellow (*A-verbs*, raising to subject)
b. They believe/expect/consider John to be a good fellow (*B-verbs*, raising to object)

In Postal's view, neither (22a) nor (22b) has *John* as a constituent of the embedded clause at Surface Structure; furthermore, in (22b) *John* does not start its derivational life in the matrix clause. After the application of a rule of *raising to object*, that NP ceases to form a constituent with the embedded infinitival predicate, and becomes the object of the matrix predicate.

The analysis of B-verbs involving NP raising to the matrix object position has been taken up in much subsequent work, including e.g. Lasnik & Saito (1991) and Koizumi (1993) (who assume a landing site for the raised NP in the Specifier of a functional category AgrO, cf. (23)), among many others.

(23)



Unlike the pre-X-bar Standard Theory analyses in Bach (1974) or Akmajian & Heny (1975), in which the raised NP is tucked in the matrix VP (an idea that would be, in a sense, revived in Pesetsky, 2013), the GB/Minimalist analyses necessarily move this NP into a Specifier position. This point will be important in the subsequent discussion.

An alternative analysis has the accusative NP remain as a constituent of the embedded clause throughout the derivation, never becoming a matrix object. This is the analysis favoured by Chomsky (1977 [1973]) and until the mid-2000s (Chomsky, 1981, 1995, 2000). Chomsky's (1977 [1973]) proposal is that the NP remains an embedded subject, delivering what is usually known as a *layered* analysis. Chomsky emphasises that if there was a rule of raising to object in the grammar, it should be possible to subextract a constituent from the raised object, as is always possible to move a constituent from an object position. However, this is not possible:

(24) a. COMP you expect [$_S$ COMP [$_{NP}$ stories about who] to terrify John]
b. *Who do you expect stories about to terrify John?
(Chomsky, 1977 [1973]: 106)

The structure Chomsky provides for a sentence such as *I believe the dog to be hungry*, then, is a garden-variety S complement to V:

(25) $[_S\ [_{NP}$ I] $[_{VP}\ [_V$ believe] $[_S\ [_{NP}$ the dog] $[_{VP}$ to be hungry]]]]
(Chomsky, 1977 [1973]: 88)

Skipping ahead many years, Chomsky (2000: 102, ff.) proposes that the sentential complements to B-verbs are structurally 'defective' in not containing a CP layer: the complement of a B-verb is directly a TP. The analysis in Chomsky (2000) essentially restates a GB rule called *S'-deletion*, whereby the S' node in the embedded clause (corresponding to a modern CP) is deleted, delivering a 'defective' clause with only an S layer (Chomsky, 1981: 66, ff.) and allowing the embedded subject (which cannot be case-marked by [-Tense] INFL) to be governed and case-marked by the matrix verb. In this configuration, the embedded NP subject can also raise to the position of subject of the main clause by means of *raising to subject* if the matrix clause is passivised:

(26) The dog$_i$ is believed t_i to be hungry

In the Minimalist analysis, the subject of a defective TP cannot receive Case from defective non-finite T, and there being no cyclic node between the B-verb and the embedded subject (the phasal projection CP), the matrix *v* head can probe into the embedded clause and Case-mark the embedded subject via Agree. This subject stays in situ, being Case-marked from outside its TP. Chomsky's analysis is known as Exceptional Case Marking (ECM), as it is indeed exceptional that a matrix verb case-marks the subject of its complement clause. Crucially, despite their differences, both the ECM and Minimalist RtO analyses (but not the Relational Grammar or Standard Theory analyses) have the accusative NP in a Specifier position. This point is of central importance in the analysis of the extraction facts.

An adequate analysis of RtO must be able to capture the fact that the behaviour of the accusative NP does not completely fall in line with either embedded subjects or matrix objects. This NP belongs to the upstairs clause for purposes of (at least) the following phenomena (Postal, 1974; Runner, 2006):

<u>Adverb interpolation and Wrap</u>: main clause material can appear after the accusative argument

(27) a. Mike expected Greg **incorrectly** to take out the trash (Runner, 2006)
b. She **made** Jerry **out** to be famous. (V+Prt verb *make out*)

We will look at wrap in **Section 2.2**.

<u>Negative Polarity Item (NPI) licensing</u> (Lasnik & Saito, 1991):

(28) a. The DA proved [**none** of the defendants to be guilty] during **any** of the trials
b. *The DA proved [that **none** of the defendants were guilty] during **any** of the trials.

Only (28a), under RtO, has the NPI and its licenser in a clausemate configuration.

Reflexivisation: verbs that govern *raising to object* allow for reflexive and reciprocal pronominal objects, and never non-reflexive bound pronouns:

(29) a. Melvin$_i$ believes himself$_i$/*him$_i$ to be a crackpot
b. Joel and Ellie$_i$ expect each other$_i$/*them$_i$ to survive the outbreak

If an anaphor and its antecedent must be coarguments, the accusative NP needs to establish a grammatical relation with the matrix predicate.

The empirical facts do not uniformly and unambiguously support a RtO analysis, however. For example, the accusative NP forms a constituent with the embedded clause: most RtO verbs have an alternation in which they take an NP object:

(30) a. I expect Eleanor to forgive me one day
b. What do you expect (*Eleanor)?
c. The students expected high marks in the exam
d. What did the students expect?

RtO verbs such as *consider* do not have an NP monotransitive alternation, and consequently the constituency test above does not give the same results:

(31) a. Joel considers Ellie to be his daughter
b. *What does Joel consider?

Perhaps the most relevant argument against considering the accusative NP as a matrix object comes from extraction. As observed in Postal (1974) and Runner (2006), extraction of a constituent from a raised object (as in (32b)) contrasts with extraction of a constituent from a non-derived object (as in (32a)):

(32) a. Who$_i$ did John hear [stories about _$_i$]?
b. *Who$_i$ do you expect [stories about _$_i$] to terrify John?

Configurationally, it is unexpected that extraction from a passive or unaccusative subject that has raised to object is disallowed (Runner's, 2006: 201 examples and judgments):[6]

(33) a. ?*Which one of us$_i$ do you believe [a picture of $\_{}_i$]$_j$ to have been stolen $\_\_{}_j$? (Passive)
b. ?*Which one of us$_i$ do you believe [a picture of $\_{}_i$]$_j$ to have arrived $\_\_{}_j$ last night? (Unaccusative)

This is so because the base-generation position of passive and unaccusative subjects is Compl-V, a position from which extraction should be allowed (Stepanov, 2007). As Runner notes, accounts of constraints on extraction based on the Condition on Extraction Domains (such that extraction from noncomplements is uniformly banned) make no difference between derived and base-generated objects: all that matters is that at the point of extraction, a constituent is in a certain position. This is particularly important given recent emphasis on the Markovian character of derivations (Chomsky, 2021: 16; Chomsky et al., 2023: 17): operations only have access to the current derivational step, not to the derivational history of a SO; therefore, it should not be possible to block extraction from a phrase that has undergone movement since there is nothing available in the local structure that conveys this information. For all intents and purposes, then, an NP raised to object position should behave like a base-generated object.

A similar problem arises under an 'undermerge' analysis of RtO. Pesetsky (2013) proposes that Internal Merge (i.e., Move) can create not only specifiers, but also complements. Complement-creating Internal Merge is called *undermerge*, an operation he deems available for both heads and phrases. Pesetsky (2013: 27) says that

> *phrasal movement forming a complement of V ("Raising to Object") was proposed by Rosenbaum (1967) and defended by Postal (1974) and others*

It is important to note that the framework in which Rosenbaum and Postal proposed RtO did not have a notion of 'complement' comparable to an X-bar theoretic definition. Aside from the incompatibilities between Pesetsky's *undermerge* and Chomsky's Merge given the Extension Condition and No Tampering Condition (Chomsky, 2008: 138), the puzzle stands: if indeed *undermerge* creates a complement, the extraction facts remain unexplained.

In addition to the ECM and RtO analyses, there exists a class of lexicalist analyses, whereby the lexical entry of a B-verb includes a specification that (i) it

6. Our informants report that with pied-piping, (33a, b) improve significantly. Importantly, (32b) is uniformly judged to be ungrammatical regardless of pied-piping.

takes a non-thematically marked object and a non-finite clause as arguments, and (ii) its object, and the subject of the non-finite clause are in some sense identical. The LFG and HPSG analyses of RtO are based on lexically-determined structure sharing (Pollard & Sag, 1994: 137). In LFG, for example, the lexical entry of a RtO verb includes a specification that the *f*(unctional)-structure corresponding to the subject of the embedded clause it takes as a complement is the same *f*-structure that is assigned a GF 'Object' in the matrix clause, as in (34) (cf. Börjars et al., 2019: 111):

(34) *expect* V (↑ PRED) = 'expect<SUBJ, XCOMP>OBJ'
(↑ OBJ) = (↑ XCOMP SUBJ)

The analysis proposed here shares with the LFG/HPSG analyses the reliance on structure sharing, but differs from these in not encoding it lexically. Rather, structure sharing is a consequence of the addressing axiom and the formalisation of structure composition as graph union: there is no need to formulate conditions that make reference to anything beyond a local EG (in consonance with the so-called *Fundamental TAG Hypothesis*, see Frank, 2002: 22). The resulting configuration will allow us to account for the availability of Wrap in RtO without additional assumptions.

A final preliminary note: where Runner (2006: 207) conflates the movement and structure sharing analyses, we must emphasise their differences: in structure sharing we start with a set of syntactic objects and contract them under some definition of *identity*. In movement, under generative assumptions, we start with a single syntactic object, copy it, re-Merge the copy, and assign a PF exponent to the highest copy (Nunes, 2004). Effectively, the transformational analysis multiplies SOs in derived structures, whereas the structure sharing analysis reduces the number of SOs in derived structures.

Much discussion pending due to space limitations, we contend that, given generative assumptions about the interaction between phrase structure and locality conditions, both a movement and an ECM analysis of RtO fall short of providing a satisfactory account of certain extraction asymmetries. In the next section we formulate a graph-theoretic analysis that aims to account not only for extraction facts in RtO, but also for the interaction between RtO and Wrap.

2.1 RtO without raising

In Krivochen (2023a: 39) we argued that in the structural description of a sentence such as

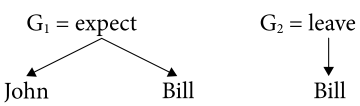
(35) John expects Bill to leave

there is only one node *Bill*, which enters syntactic relations with two lexical predicates, *expect* and *leave* (as opposed to two distinct objects that are identified as Copies at the phase level, as in Chomsky, 2021: 24–25). Each of these predicates anchors an elementary graph:

(36) a. EG_1 = <*e*<expect, John>, *e*<expect, Bill>>
b. EG_2 = *e*<leave, Bill>

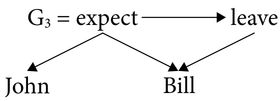
Recall from our discussion in **Section 1** that the order of composition follows the order of Merge: from the most oblique argument to the least oblique one. If there is only one argument, it will necessarily be a subject[7] (a RG 1), but if there are two, the first to be composed with the lexical predicate within an elementary graph will be an object (RG 2) or an oblique (RG 3) depending on lexical specifications. If there are three, we have a subject, an object, and an indirect object (1, 2, 3). In this context, looking at (36) we can determine that *Bill* is a 2 in G_1 (being First Merged with the anchor of that elementary graph) and a 1 in G_2. This information, derivationally encoded at the level of elementary graphs, is not destroyed in the course of the derivation: grammatical relations can be added on top of existing ones (as in the case of reflexivity, where a single expression undergoes Merge with a predicate twice), but – outside an extremely reduced set of processes which include *passivisation* and *dative shift* (Krivochen, 2023c: 368, ff.) – GF information is not lost or rewritten. *Bill* establishes two distinct grammatical relations with two distinct predicates, and these are evaluated locally.

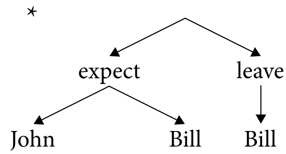
Both lexical predicates dominate a node with address ⦃Bill⦄, and the composition of G_1 and G_2 delivers a new graph, G_3. We may ask how many *Bill* nodes there will be in G_3 given graph union. Recall that nodes are uniquely indexed: as part of graph union, nodes that are assigned the same address are contracted. Therefore, there is no need to multiply the instances of *Bill*. Under graph union, the grammar cannot help but collapse ⦃Bill⦄ in G_1 and ⦃Bill⦄ in G_2 into a single node in G_3:

(37)


Node contraction allows us to obtain a structure like (38a), and makes it impossible to generate (38b) since the calls for the address ⦃Bill⦄ in G_1 and G_2 point to the same region of the workspace (Manzini & Savoia, 2011; Krivochen, 2023b):

7. Cf. RG's *Final 1 Law*, LFG's *Subject Condition*, or generative grammar's *Extended Projection Principle*.

(38) a. 

b. 

There is no special mechanism to deliver node contraction: no 'chain reduction' operation is needed under present assumptions. This analysis allows us to capture some important properties of RtO, which are derived from the 'double life' of the accusative-marked NP argument as both a subject and an object (albeit in distinct EGs). Crucially, when we write 'subject' and 'object' we are not referring to configurationally defined notions (in generative grammar it is usual to conflate 'subject' and 'specifier', and 'object' and 'complement'), but – as in RG, Arc Pair Grammar, and LFG (Perlmutter, 1980: 196, ff.; Johnson & Postal, 1980: 9; Dalrymple et al., 2019: 9, ff.) – to theoretical primitives that syntactic conditions can directly refer to. As Perlmutter (1983: ix) points out,

> *there are significant generalizations, both cross-linguistic and language-internal that can be captured in terms of grammatical relations but not in terms of phrase structure configurations.*

We believe that extraction constraints in RtO belong to this class of generalisation. The precise terms in which such generalisation is encoded are relevant, however. For instance, Runner (2006: 200) says:

> *It is now usually assumed that passive and unaccusative subjects start out as direct objects*

This can mean two things depending on the theoretical glasses we use: (i) unaccusative verbs select an initial 2 which gets promoted to 1 (Perlmutter's, 1978: 160 *unaccusative hypothesis*), or (ii) the NP argument of unaccusative verbs starts its derivational life as an internal argument, in a complement position. These two are very different claims: the former appeals to a primitive notion of grammatical function, whereas the latter refers only to structural positions.

If a configurational approach is supplemented with a primitive notion of GF, a constraint can be readily formulated as part of English grammar:[8]

8. It is possible that this constraint partially overlaps with other conditions. For example, it seems to be the case that *tough-movement* (a label we maintain for expository purposes only) requires that the target phrase be a 2 in every EG in which it enters syntactic relations. Thus, the unavailability of *tough-movement* for a 'raised NP' (Chomsky, 1977 [1973]; Postal, 1974) would follow: *tough-movement* cannot apply to 1s. Some rules seem to require 'uniformity' in the sense that the object they apply to must receive the same GF across all EGs in which it enters syntac-

Opaque 1 Condition
A long-distance dependency cannot involve a non-root node in a subgraph that is the 1 of any predicate in a derived structure

As an example, consider (32b), repeated as (39):

(39) *Who$_i$ do you expect [stories about _$_i$] to terrify John?

We have two lexical predicates, therefore two elementary graphs:

(40) a. EG$_1$ = <*e*<expect, you>, *e*<expect, stories>, *e*<stories, about>, *e*<about, who>>
b. EG$_2$ = <*e*<terrify, stories>, *e*<terrify, John>, *e*<stories, about>, *e*<about, who>>

The subgraph G = <*e*<stories, about>, *e*<about, who>> is shared between the elementary graphs EG$_1$ and EG$_2$, but the expression *stories about who* receives different GF in each of these: it is the 2 of *expect* but the 1 of *terrify* (*John* being the 2). It is EG$_2$ that causes problems: *who* is embedded in the 2 of *expect*, but the 1 of *terrify*. When EG$_1$ and EG$_2$ are composed, this information is not erased, as it can be read directly from configurational relations. The arc whose tail is *stories* (which is the root of a subgraph that corresponds to the structural description of the sequence *stories about who*) is outranked by the arc with tail *you*: the order between arcs in (40a) indicates that *you* is the 1 of *expect*, and the sub-graph with root *stories* is the 2 of that same predicate (which is interpreted as a garden-variety monotransitive V with an NP object). A long-distance dependency involving *stories about who* violates the Impenetrable 1 Condition above (somewhat analogous to the transformational Subject Condition; see also Dalrymple et al., 2019: 656, ff.). A constraint formulated in terms of GF delivers the correct paradigms: an expression E may be a 2 in an EG but a 1 in another, and if these are composed, E does not cease to be a 1 nor a 2. Because structural descriptions are ordered sets of arcs, we can look at the arcs in each EG and know exactly what GF is assigned to which expression.

As expected, in simplex sentences, a long-distance dependency can affect *who* in (41), since it is embedded in an expression that is only a 2:

(41) a. Which villain$_i$ do you expect [stories about __$_i$] in this month's Detective Comics?

tic relations (such as *extraction*, with caveats we must leave aside for reasons of space), whereas others are less strict (such as *passivisation*: we can passivise a clause such that a raised object becomes a subject).

b. About which villain$_i$ do you expect [stories __$_i$] in this month's Detective Comics?

And by the same token, extracting *who* from an initial 1 is filtered out (see also Chomsky, 2008: 147, ff.):

(42) a. *Who$_i$ did [stories about __$_i$] terrify John?
b. *About who(m)$_i$ did [stories __$_i$] terrify John?

In the case of RtO, going back to Runner's examples we have an initial 2 in the downstairs clause that becomes a final 1 in that clause. That clause is then embedded under a RtO-governing predicate, which takes the same indexed expression as the embedded 1 as its 2. Crucially, in our analysis of RtO it is not the case that an expression (a derived expression, in this case) ceases to be a downstairs 1 to become an upstairs 2, strictly speaking: via graph union, the same expression establishes two distinct relations with distinct predicates in distinct elementary structures. This double life of the raised NP is problematic for Chomsky's position: note that if, as suggested in Chomsky (2008: 147) extraction restrictions were defined on 'base structures' and not on 'surface structures', we would expect Runner's examples (repeated here) to be flawless:

(43) a. ?*Which one of us$_i$ do you believe [a picture of _$_i$] to have been stolen?
b. ?*Which one of us$_i$ do you believe [a picture of _$_i$] to have arrived last night?

The only way in which Chomsky's approach can filter out (43a–b) is by considering the final position within the downstairs clause, not the base position within that clause. An additional complication is that – as noted above – complements of RtS/RtO-governing verbs are assumed to be 'defective' in that they are bare TPs, without a CP layer (e.g., Chomsky, 2000: 105; 2008: 143), which makes embedded RtS/RtO clauses non-phasal. This is important because, under standard assumptions about phasehood (such that transitive *v** and C are phase heads, but not unaccusative/passive *v* or TP), we cannot say that the evaluation of the 'base' and 'derived' position of a SO takes place at the phase level: the movement from Compl-V to Spec-T downstairs and raising to object all takes place within the same phase. Consider the (somewhat simplified) structure of an intermediate derivational step in (43b), for concreteness:

(44) [$_{vP}$ you [*v* [$_{VP}$ [$_{DP}$ a picture of…] [$_{V'}$ believe [$_{TP}$ [$_{DP}$ a picture of…] [$_{T'}$ T [$_{VP}$ arrive [$_{DP}$ a picture of…]]]]]]]]

Given Chomsky's version of phase theory and RtO, phase-level evaluation would identify a chain with an occurrence in Spec-VP (in the matrix clause), one in Spec-TP (in the embedded clause), and one in Compl-V (in the embedded clause), if we look at it top-down. The latest derivational step involves having the DP in a position from which extraction should be possible. Suppose that the system can look back at all copies, and determine that the base generation position of the DP was a complement position. Again, (42a, b) would be predicted to be grammatical, RtO notwithstanding. It is the existence of an *intermediate step* (neither the 'surface structure' nor the 'base structure', to use Chomsky's terms) that creates problems, and this step takes place inside the downstairs clause. Observe also that it is not sufficient to exclude extraction from a 'specifier', since if we did (41b) would also be excluded:

(45) Of which car$_i$ was [the (driver, picture) t_i]$_j$ awarded t_j a prize?

Under standard Minimalist assumptions, the DP [the (driver, picture) of which car] moves from a position inside the VP to the specifier of T to satisfy T's EPP feature, yet the output is grammatical.

These considerations support an analysis which (i) makes explicit reference to grammatical functions, rather than phrase-structural positions, and (ii) defines the relevant filter(s) over *derived structures* specifically (RtO involving two clauses), rather than banning certain dependencies regardless of whether they are defined in elementary or derived structures.

2.2 Wrapping around 'raised objects'

Once we have sketched a general analysis of RtO we can examine its consequences for Wrap. We will first define the kind of process that Wrap exemplifies, and then examine its properties. Descriptively, Wrap is the operation that, given a transitive MWE, delivers (46b) from (46a) by 'wrapping' part of MWE around its direct object:

(46) a. she **looked up** the number
b. she **looked** the number **up**

As observed above, Postal (1974: 412, ff.) cites the possibility of a particle to Wrap around the accusative NP as an argument in favour of a RtO rule, since Wrap ('Particle Movement' in Postal's terms) is clausebound:

(47) They **made** John **out** to be a crackpot

One of the main aspects of the graph-theoretic approach sketched here and presented in detail in Krivochen (2023c), building on McCawley (1982), is the distinction between syntactic processes that modify relations between expressions (or create new relations on top of previously existing relations) and processes that only modify word order, without modifying relations. English Right Node Raising and Spanish Clitic Climbing are examples of *relation-preserving transformations* (RPT): syntactic relations are neither created nor destroyed, but word order changes. RtO is also an RPT, although of a different kind: in the derived graph that is the structural description for a sentence such as *John expects Bill to leave*, the node with address ⦃Bill⦄ does not cease to be the downstairs predicate's 1 to become the matrix predicate's 2. These two grammatical relations are superimposed on *Bill*, and read off the order of arcs at the level of elementary graphs. In RtO, a single expression establishes distinct grammatical relations (1 and 2) with distinct predicates, represented by *kissing* arcs. In Right Node Raising and Clitic Climbing, there is a single grammatical relation between an expression and its subcategorising predicate.

We propose that Wrap belongs to the same class of RPT as Right Node Raising and Clitic Climbing. In this sense, our approach differs from the traditional CG perspective (e.g., Huck, 1988), in that Wrap does not involve operations over indexed categories, but only over (phonological) *exponents* of those categories (in Minimalist terms, one would speak of a 'PF operation'). The original formulation of Wrap is due to Bach:

RWRAP: "Right-Wrap"
i. *If a is simple, then RWRAP(a,b) = RCON(a,b).* [Right Concatenation]
ii. *If a has the form $[_{XP}$ X W], then RWRAP(a,b) is* $X^\frown b^\frown W$. (Bach, 1979: 516)

From a perspective closer to ours, Schmerling (2018) formalises Wrap as an *infixation* operation. In Schmerling's categorial system (where syntactic rules apply to phonological substance, there being no level of phonologically uninterpreted trees), the phonological units of the language are built recursively from phonemes:

A syllable (σ) is a finite sequence of phonemes.
A word (w) is a finite sequence of syllables.
A phrase (Φ) is a finite sequence of words.
An expression (e) is a finite sequence of phrases. (Schmerling, 2018: 136)

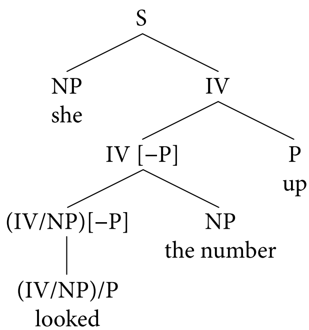
In this context, her formulation of Wrap using the categories above, is the following:

$F_{10}\ (<<w_o,\ldots,w_i>,\ldots,\Phi_j>,<<w_k,\ldots,w_\ell>>=<<w_o,\ldots w_i,w_k,\ldots,w_\ell>,\ldots,\Phi_j>$
(right wrap)
Right wrap, which makes use of right procliticization, applies to a phrase of length n to yield phrases that are also of length n. (Schmerling, 2018: 138)
$S7_a$. *If* $\alpha \in P_{IV/NP}$ *and* $\beta \in P_{NP}$, *then* $F_{10}(\alpha,\beta) \in P_{IV}$. *(Transitive verb-direct object combination by right wrap)* (Schmerling, 2018: 140)

Applying Wrap to a MWE of category IV/NP and its NP object infixes the NP after the first prosodic phrase: this delivers *look NP up* from *look up NP* as well as, say, *take NP to task* from *take to task NP* (in this latter case, obligatorily). No syntactic relations are disrupted in applying Wrap; consequently, no additional operations are needed to recover underlying contiguity (as in transformational grammars).

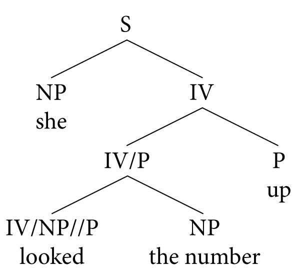
As discussed in Huck (1984), there are at least two ways to analyse how *look up* wraps around its object in Bach's (1981) *generalised CG*. The first takes the verb *look*, assigned to the category of expressions that combine with a P to produce a transitive VP (i.e., (IV/NP)/P)), and combines it with *the number* before combining this derived expression with *up*. Until it does, the information that *up*, assigned to the category P, is necessary percolates up the tree locally, by means of a feature [-P]:

(48)



The second analysis exploits a property of generalised CG, whereby given a category A//B, B can appear anywhere to the right of A//B in a derived expression, and still combine with A//B to produce an expression of category A (Bach, 1981: 5). In contrast, A/B requires immediate adjacency with B to produce A. This effectively allows for unbounded discontinuity, in that the preposition could now appear arbitrarily far to the right of the verb, wrapped around more than one indexed category:

(49)



An important difficulty for the unbounded analysis is that Wrap around a 2 *and* a 3 (call it 'Long Wrap') is not allowed:

(50) a. *John **sent** the manuscript to the publisher **out**
b. *John **sent** the publisher the manuscript **out**
c. John **sent** the manuscript **out** to the publisher
d. John **sent** the publisher **out** the manuscript

Wrap must be restricted to applying to an IV/NP expression and the object NP it is directly combined with.

Huck's categorial analysis, which departs from the traditional usage of (planar) trees in allowing for crossing branches (cf. Zwicky & Isard, 1963: 1 A.4), maintains a distributionally based assumption that we drop: in his trees, *look* and *up* are distinct nodes and both are assigned to a category ((IV/NP)/P and P, respectively). In other words, Huck's analysis seems to include no notion of MWE. However, as stated in the introduction, we do admit basic expressions that go beyond the limit of a single orthographical word. The *up* in *look up* is a separate expression of category P only when *look up* means 'to raise one's gaze upwards': *look up* in this case is a derived expression of category IV (V + $P_{Locative}$), drastically distinct from the MWE *look up* of category IV/NP.[9]

It is uncommon for references in generative grammar to deal with the Wrap facts and provide an analysis of wrapped V-Particle-NP constructions (even when the Wrap facts are noted, e.g. Lasnik, 2019). Transformational generative analyses of RtO (cf. (23)) present a problem: they need to formulate Wrap as a PF operation that applies in two very different configurations. Even assuming that *look up* is treated as a MWE (which is not usually the case in generative grammar), we must admit that Wrap can apply in either a Head-Complement (for simple monotransitive verbs) or a Head-Spec of Complement (for RtO verbs) configuration:

(51) a. Head-Complement: $[_{VP}\ [_{V}$ heat up] NP] → $[_{VP}$ heat NP up]
b. Head-Specifier of its Complement: $[_{VP}\ [_{V}$ make out] $[_{AgrOP}$ NP [Agr $[_{VP}\ t_{V}$ $[_{IP}\ t_{NP}$ to…]]]] → $[_{VP}$ make NP out $[_{IP}\ t_{NP}$ to…]]

9. Consider, e.g.,

i. Mary looked up
ii. Where did Mary look? (intended answer: up)
iii. Mary looked up the stairs
iv. *Mary looked the stairs up (no wrap)
v. Mary looked up a word
vi. *Where did Mary look a word? (intended answer: up)
vii. Mary looked a word up (wrap)

This structural heterogeneity is undesirable in that Wrap applies to configurations that do not form a natural class.

Under present assumptions, if we have a MWE RtO verb, such as *make out*, this V will immediately dominate the structure-shared NP:[10]

(52) EG_1 = <*e*<make-out, they>, *e*<make-out, John>>
EG_2 = <*e*<John, crackpot>>

The same will be the case for a MWE monotransitive V, like *look up* (cf. (48–49)):

(53) G = <*e*<look-up, Mary>, *e*<look-up, number>>

The basic relation made available by the formalism is *immediate dominance*, holding for Mergemates. The graph theoretic approach allows us to unify the configurations where Wrap is licensed and provide a general definition:

A can Wrap around B iff
i. A is a MWE, and
ii. A is of category IV/NP and B is of category NP,[11] and
iii. A is the head of an arc with tail B

And because there is an arc *e*<A, B> only if A and B are Mergemates, the only required relation to account for Wrap is the fundamental relation delivered by the formalism.

3. Conclusions

In this paper we introduced a framework for syntactic analysis based on the following principles, none of which seems to us to be particularly controversial on its own:

- Instead of unordered sets, the fundamental structure building operation (‘Merge’) delivers directed edges between predicates and arguments: as a result, the connection between EM and argument structure is directly compositional. Structural descriptions are directed graphs with no planar embedding.
- Grammatical functions are primitives of the theory, as in RG and its heirs, LFG, and HPSG.

10. As in Schmerling (2018), copula *be* is analysed as syncategorematic.

11. Cf. (i), which illustrates the impossibility of wrapping around a clause:
i. *They **made** [$_{CP}$ that John is a liar] **out**

- Syntax is strongly lexicalised: local domains (which we called *elementary graphs*) are defined by the presence of a lexical predicate, its functional modifiers, and the arguments it selects. Paraphrasing the *Fundamental TAG hypothesis*, all syntactic dependencies are defined at the level of elementary graphs.
- Elementary graphs can be composed to form complex derived structures which contain more than one lexical predicate. The composition of local domains takes the form of *graph union*, an option delivered by the formalism.
- Within the alphabet of the grammar, we distinguish *basic* and *derived* expressions. The set of (categorematic) basic expressions that the grammar works with is indexed by a set of uniquely identifying context-free addresses which point to regions of the syntactic workspace. The content of an expression's address is the semantic value of that expression.
- Expressions with the same address in distinct elementary graphs contract if these elementary graphs undergo union (delivering *structure sharing*). Grammatical relations, determined at the level of elementary graphs, are not distorted by graph union/structure sharing.

The theory proposed here is strongly grounded on RG and Arc Pair Grammar in its graph-theoretic foundations and the primitive character of grammatical functions, borrows from Minimalist syntax the commitment to derivations (delivering Minimalist desiderata such as binarity and 'Minimal Yield' as a consequence of the formalism, without additional stipulations, cf. Chomsky, 2021), and adopts the strictly local and strongly lexicalised character of TAGs. Unlike RG/APG arcs, our edges always connect two basic expressions, and grammatical functions are read from the order between arcs, in turn given by the sequentiality of structure building. Advantages of this model include a straightforward manner of structure composition delivered by the formalism, a direct connection between syntax and semantics, and the possibility of encoding information about grammatical function in the order between arcs. The syntax-semantics interplay is mediated by the semantic interpretation rules presented in **Section 1**: each arc corresponds to either functional application or predicate modification (analogously to TAG's derivation trees; Kallmeyer & Joshi, 2003: 17, ff.) depending on the categories of the expressions involved: as in Dowty (2003: 36, ff.), combination between X/Y and Y, for all X, Y, is interpreted as functional application (*e*<X/Y, Y>), whereas combination between X and X/X is interpreted as predicate modification (*e*<X/X, X>). Configurationally, predicates always dominate their arguments.

As an application of the formal model, we sketched an analysis of English RtO constructions that (i) exploits the primitive nature of grammatical functions and the fact that structure composition does not modify locally defined relations to provide an account of extraction effects that makes reference to grammatical functions defined within *elementary graphs*, and (ii) unifies the configurations to which Wrap applies, delivering a single analysis for wrapping in RtO and monotransitive structures.

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