Expectation-based Minimalist Grammars

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Abstract

Expectation-based Minimalist Grammars (e-MGs) are simplified versions of the (Conflated) Minimalist Grammars, (C)MGs, formalized by Stabler (Stabler, 2011, 2013, 1997) and Phase-based Minimalist Grammars, PMGs (Chesi, 2005, 2007; Stabler, 2011). The crucial simplification consists of driving structure building only by relying on lexically encoded categorial top-down expectations. The commitment on a top-down derivation (as in e-MGs and PMGs, as opposed to (C)MGs, Chomsky, 1995; Stabler, 2011) allows us to define a core derivation that should be the same in both parsing and generation (Momma & Phillips, 2018).

1 Introduction

Minimalism (Chomsky, 1995, 2001) is an elegant transformational grammatical framework that defines structural dependencies in phrasal terms simply relying on one core structure building operation, Merge, that combines lexical items and the result of other Merge operations forming phrases. (1).a is the representative result of two ordered Merge operations (i.e. Merge(γ, Merge(α, β)) both taking the items α, β and γ directly from the lexicon, while (1).b relies on the so called Internal Merge (Move), namely the re-Merge of an item that was already merged in the structure.

(1) a. [γ [α, β]] Merge only
b. [β [γ [α, $\__{\beta}$]] Merge + Move

As result, Move connects the item at the edge of the structure (β) with a trace ($\__{\beta}$), a phonetically empty copy of the item, in its previous Merge position (or multiple traces/copies, in case of successive cyclic movement).

Both (Conflated) Minimalist and Phase-based Minimalist Grammars ([C]MGs and PMGs respectively) implement a feature-driven approach to Merge and Move, that is, (categorial) features trigger a successful Merge or Move operation, and, once these features are used, they get deleted. Consequently, a feature pair is always responsible for each operation (unless specific features are left unerased after a successful operation[1]).

One crucial difference between PMGs and MGs is that while MGs operate from-bottom-to-top, as indicated in (2), PMGs structure building operations apply top-down as informally schematized in (3)[2]:

(2) Merge($\alpha_{=X}$, ${}_{X}\beta$) = [α [$\alpha_{\cancel{=X}}$ ${}_{\cancel{X}}\beta$]] MGs
Move(${}_{+Y}\alpha$, [… β_{-Y} …]) =
[α [$\beta_{\cancel{-Y}}$ [${}_{\cancel{+Y}}\alpha$ [… β_{-Y} …]]]]

(3) Merge($\alpha_{=X}$, ${}_{X}\beta$) = [$\alpha_{\cancel{=X}}$ [${}_{\cancel{X}}\beta$]] PMGs
Move([$\alpha_{=S\ \cancel{+Y}}$[${}_{\cancel{Y}\ Z}$ β]]) =
[$\alpha_{\cancel{=S}\ \cancel{+Y}}$[${}_{\cancel{Y}\ Z}$ β] ${}_{S}$[… (${}_{=Z}$ [${}_{Z}$ β]) …]]

Another relevant difference between the two formalisms is related to the implementation of Move: MGs use the +/- feature distinction and the same deletion procedure after matching, while PMGs do not use - features and simply assume that both + and = select categorial features, which are deleted after Merge. In PMGs, the + features force memory storage and hence the movement (downward) of the licensed item, until the relevant prominent category identifying the moved item (Z in (3)) is selected. If no proper selection is found, the sentence is ungrammatical. CMG as well dispenses the grammar with the +/- feature distinction and only relies on select features (=X), but it must assume that feature deletion can be procrastinated (see note 1). Despite the fact that, from a generative point of view, all these formalisms are equivalent and they all fall under

[1] This option is necessary to deal, for instance, with raising predicates, and, possibly, successive cyclic movement as discussed in Stabler (2011).

[2] α and β are lexical items, =X expresses a selection categorical feature and X a categorial feature. Lexical items are tuples consisting of selections/expectations (=X) and categories (X, i.e. selected/expected features); for convenience, select features are expressed by rightward subscript, and categories as leftward subscripts. Similarly Move is driven by licensing (-Y, indicated leftward) and licensors (+Y, rightward) features, possibly distinct from categorial features used in Merge (Stabler, 2011).

the so called mild-context sensitive domain (Stabler, 2011), it is worth to appreciate the dynamics of structure building "on-line", namely how the derivation unrolls, word by word.

For instance, taking the MGs lexicon (4), the expected constituents in (1) are built adding items to the left-edge of the structure at each Merge/Move application, as described in (5):

(4) $\text{Lex}_{\text{MG}} = \{\, [{}_{Y}\alpha_{=X}],\ [{}_{X\ -Z}\beta],\ [\gamma_{=Y\ +Z}] \}$

(5) i. $\text{Merge}({}_{Y}\alpha_{=X},\ {}_{X\ -Z}\beta) = [{}_{Y}\alpha\ [\alpha_{\cancel{=X}}\ {}_{\cancel{X}\ -Z}\beta]]$

ii. $\text{Merge}(\gamma_{=Y\ +Z},\ [{}_{Y}\alpha\ [\alpha\ {}_{-Z}\beta]]) =$
$[\gamma_{\cancel{=Y}\ +Z}\ [{}_{\cancel{Y}}\alpha\ [\alpha\ {}_{-Z}\beta]]]$

iii. $\text{Move}\ ([\gamma_{+Z}\ [\alpha\ [\alpha\ {}_{-Z}\beta]]]) =$
$[[{}_{\cancel{-Z}}\beta]\ \gamma_{\cancel{+Z}}\ [\gamma\ [\alpha\ [\alpha\ {}_{\_\beta}]]]]$

The equivalent structure is obtained with PMGs[3] as shown in (7) (notice the minimal difference in the lexicon (6), namely the absence of the "-" features):

(6) $\text{Lex}_{\text{PMG}} = \{\, [{}_{Y}\alpha_{=X}],\ [{}_{X\ Z}\beta],\ [\gamma_{=Y\ +Z}]\, \}$

(7) i. $\text{Merge}({}_{Z\ X}\beta,\ \gamma_{+Z\ =Y}) = [[{}_{\cancel{Z}\ X}\beta]\ \gamma_{\cancel{+Z}\ =Y}]$
${}_{X}\beta \longrightarrow M$

ii. $\text{Merge}([[\beta]\ \gamma_{\ =Y}],\ {}_{Y}\alpha_{\ =X}) =$
$[[\beta]\ \gamma\ [{}_{\cancel{=Y}}\ [{}_{\cancel{Y}}\alpha_{\ =X}]] \qquad M = \{{}_{X}\beta\}$

iii. $\text{Move}([[\beta]\ \gamma\ [{}_{(\gamma)}\ [\alpha_{\ =X}]],\ {}_{X}\beta) =$
$[[\beta]\ \gamma\ [{}_{(\gamma)}\ [\alpha_{\cancel{=X}}\ [{}_{(\alpha)}\ {}_{\cancel{X}}\_{}_{\beta}]]]] \qquad {}_{X}\beta \longleftarrow M$

The result of the two derivations is (strongly) equivalent in hierarchical (and dependency) terms. The simplicity, in pre-theoretical terms, of the two descriptions is comparable: while PMGs need to postulate a memory storage to implement Move (as result of the missing selection of a categorial feature), MGs must postulate independent workspace to build "complex specifiers", for instance before merging a "complex subject" like "the boy" with its predicate (e.g., "runs"). Furthermore, both formalisms must restrict the behavior either of the M buffer operativity or the accessibility to the *-f* features to limits the Move operation (e.g., island constraints, Huang, 1982).

There are however at least two reasons to prefer the top-down orientation with respect to the bottom-up one (Chesi, 2007): first, the order in which the structure is built is grossly transparent with respect to the order in which the words are processed both in generation and in parsing in PMGs, but not in MGs; second, in PMGs, the simple processing order of multiple expectations is sufficient to distinguish between sequential (the last expectation of a given lexical item) and nested expectations (any other expectation): The first qualifies as the transparent branch of the tree (i.e. it is able to license pending items from the superordinate selecting item), while constituents licensed by nested expectations qualify as configurational islands (Bianchi & Chesi, 2006; Chesi, 2015). Moreover, successive cyclic movement can easily be described in PMGs without relying on feature checking at any step or non-deterministic assumptions on features deletion (Chesi, 2015) contrary to (C)MGs. In these pages, I will argue that we can push further this intuition and only rely on (categorial) expectations, encoded in the lexical items, to guide the derivation. This leads to the so call expectation-based Minimalist Grammars (e-MGs).

In the following sections, I will sketch a simple formalization for e-MGs (§2), and the generation algorithm (§3). Two parameters, the first dealing with agreement, the second with delayed expectations, will demonstrate how a universal core grammar can be maintained (§4). Before concluding this introduction, a third crucial reason to prefer the top-down approach, is provided, §1.1.

1.1 Single root condition

Another logical reason to prefer the top-down orientation over the bottom-up alternative is related to the unicity of the root node. As anticipated, the creation of complex (binary) branching structures poses a puzzle for (C)MGs: independent workspaces must be postulated, namely [the boy] and the [sings …] phrases must be created before the first can merge with the second:

(8) $[_{\text{VP}}\ [_{\text{DP}}$ the boy$]\ [_{\text{V}}$ sings $[_{\text{DP}}$ a song$]]$

This is the case for any "complex" subject or adjunct (i.e., non-projecting constituents which are simply composed by multiple words) that must be the result of (at least) one independent Merge operation, before this can merge with the relevant predicate (e.g. $[_{\text{V}}$ sings …$]$[4] in (8)). The processing of these constituents represents a major difference between MGs and PMGs derivations.

[3] Move is implemented using a Last-In-First-Out addressable memory buffer M where the items (x) with unselected categories (C) are stored ("$x_{C} \rightarrow M$") and retrieved ("$x_{C} \leftarrow M$") when selected (i.e. "=C").

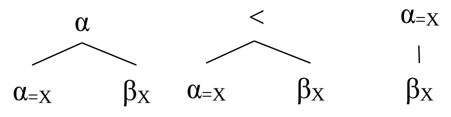
[4] Considering the inflection "-s" as part of the lexical element or by (head) moving the root "sing-" to T is uninfluential here. This sort of head movement will be lexically implemented in e-MGs (e.g. $[_{T\ \mathit{V}}$eats $_{=\mathit{V}}$ …].

While MGs must decide where to start from (and both solutions are possible and forcefully logically independent from parsing or generation, which undeniably proceed "left-right"), PMGs take advantage of the "single root condition" (Partee et al., 1993, p. 439) and avoid this problem:

(9) In every well-formed constituent structure tree, there is exactly one node that dominates every node.

As indicated in (3), the binary operation Merge, simply produce an hierarchical dependency in which the dominating (asymmetrically C-commanding, in the sense of Kayne 1994) item, is above the dominated (C-commanded) one. This is compatible with Stabler notation (10).a-b and plainly solves the ambiguity of the nature of the "label" of the constituent (Rizzi, 2016). In this sense, PMGs (and e-MGs) can adopt directly a more concise description, that is (10).c, totally transparent with respect to the (Universal) Dependency approach (Nivre et al., 2017).

(10) a. MGs b. (C)MGs c. (P/e-)MGs



The higher node (possibly the root) is always a selecting item (a *probe*, in minimalist terms), and it is the first item to be processed. This does not necessarily imply that this item is linearized before the selected category (the *goal*, in minimalist terms): if the selecting node has multiple selections, it must remain to the right-edge of the structure to license, locally, the other(s) selection expectation(s). E.g., if $[\alpha_{=X\ =Y}]$, $[_X\beta]$ and $[_Y\gamma]$, then:

(11) $[\alpha_{\cancel{=X}\ =Y}\ [_{\cancel{X}}\beta]\ [(\alpha_{\cancel{=Y}})\ [_{\cancel{Y}}\gamma]]]$

In this case, <α, β, γ> would be the default linearization, but it is easy to derive <β, α, γ> instead, assuming a simple parameterization on spell-out in case of multiple select features (§4).

2 The grammar

As (x)MGs, e-MGs include a specification of a lexicon (*Lex*) and a set of functions (*F*), the structure building operations. The lexicon, in turn, is a finite set composed by words each consisting of phonetic/orthographic information (*Phon*) and a combination of categorical features (*Cat*), expressing *expectations*, *expectees* and *agreement* categories [5]. In the end, an optional set of Parameters (*P*) (see §4), inducing minimal modifications in the structure building operations *F* and, possibly, to the *Cat* set, under the fair assumption that *F* and *Cat* are universal.

More precisely, any e-MG is a 5-tples such that:

(12) G = (*Phon*, *Cat*, *Lex*, *F*, *P*), where

Phon, a finite set of phonetic/orthographic features (i.e., orthographic forms representing words, e.g., "the", "smiles")

Cat, a finite set (morphosyntactic categories, that can be *expect*, *expected* or *agreement* features e.g., "D", "T", "V"… "gen(der)", "num(ber)", "pl(ural)" etc.)

Lex, a set of expressions built from *Phon* and *Cat* (the lexicon)

F, a set of partial functions from tuples of expressions to expressions (the structure building operations)

P, a finite set of minimal transformations of *F* and/or *Cat* (the parameters), producing *F'* and *Cat'*, respectively.

2.1 Lexical items and categories

Each lexical item *l* in *Lex*, namely each word, is a 4-tuple defined as follows[6]:

(13) *l* = (*Phon*, *Exp(ect)*, *Exp(ect)ed*, *Agree*),

Phon, same of *Phon* in G (e.g., "the")

Exp, a finite list of ordered features from *Cat* in G (the category/ies that the item expects will follow, e.g., *=N*)

Exped is a finite list of ordered features from *Cat* in G (the category/ies that should be licensed/expected, e.g., *D*)

Agr(ee) is a structured list of features from *Cat* in G (e.g., *gen.fem*, *num.pl*)

All *Expect*, *Expected* and *Agree* features are then subsets of *Cat* in G. In *Agree*, for instance, a feminine gender specification (*gen.fem*) expresses a subset relation (i.e., "feminine" ⊆ "gender").

[5] As in MGs, lexical items could be specified both for phonetic (*Phon*) and semantic features (*Sem*). In e-MGs, *expectations* (=/+X) and *expectees* (X) correspond to MGs *selectors/licensors* and *selectees/licensees* respectively.

[6] This is the simplest possible implementation. Attribute-Value Matrices, as in HPSH (Pollard & Sag, 1994) or as TRIE/compact trees exploiting the sequence of expectations (Chesi, 2018; Stabler, 2013) are possible implementations.

For sake of simplicity, each *l* will be represented as $[_{\text{Expected(; Agree)}}\ \text{Phon}\ _{\text{=/+Expect}}]$ as in (14):

(14) $[_{\text{D}}\ \text{the}\ _{\text{=N}}]$, $[_{\text{N; num.pl}}\ \text{dogs}]$, $[_{\text{T, V}}\ \text{barks}\ _{\text{=V, =D}}]$

I will refer to the most prominent (i.e., the first) *Expected* feature as the Label (*L*) of the item. E.g., the label *L* of "the" will be *D*, while the label of "barks" will be *T* (unless *T* be removed by some structure building operation leaving V as the most prominent expected feature, see §2.2). Similarly, let us call *S* (select) the first *Expect* feature and *R* the remaining *Expect(actions)* (if any).

2.2 Structure Building operations

Given l_x an arbitrary item such that $l_x = (P_x, L_x/Expd_x, S_x/R_x/Exp_x, Agr_x)$ we can define MERGE as follows:

(15) MERGE($l_{1(S1)}$, $l_{2(L2)}$) =

$$\begin{cases} 1, [l_{1(\cancel{S1})}[l_{2(\cancel{L2})}]] & if\ S_1 = L_2 \wedge \text{AGREE}(l_1, l_2) \\ 0 & otherwise \end{cases}$$

MERGE is implemented as the usual binary function that is successful (it returns "1") and creates the dependency (asymmetric C-command or inclusion, in set theoretic terms) (10).c, namely $[l_1\,[l_2]]$, if and only if the label of the following item (l_2) is exactly the one expected by the preceding item (l_1). A further (parametrized) condition requires Agreement, that is the sharing (inclusion) of the relevant *Agr* features.

The auxiliary functions necessary to implement Agreement are AGREE and UNIFY and can be defined as follows:

(16) AGREE($l_{1(L1)}$, $l_{2(L2)}$) =

$$\begin{cases} 1 & if\ L_1 \wedge L_2 \in P\{Agr\} \rightarrow Unify(l_1, l_2) \\ 0 & otherwise \end{cases}$$

(17) UNIFY($l_{1(agr1)}$, $l_{2(agr2)}$) =

$$\begin{cases} 1, a, \forall a : Agr_1 \cap \forall b : Agr_2 & if\ a \subseteq b \\ 1, b, \forall a : Agr_1 \cap \forall b : Agr_2 & if\ b \subseteq a \\ 0 & otherwise \end{cases}$$

Unification is simply expressed as an inclusion relation returning true and the most specific feature for any possible featural intersection between l_1 and l_2 *Agr* features[7]. Notice that Agreement is a conditional, parametrized option (§4.1): if the *L* categories belongs to the Agreement set (*Agr*) in Parameter (*P*) of the grammar G, unification will be attempted, otherwise agreement will be trivially successful. The fact that agreement is parasitic on Merge is straightforward in the D-N domain: in most Romance languages, in which gender and number are shared between the determiner and the noun, we assume that D selects N. This is less evident in the Subject – Predicate case, in SV language, where the predicate should select (then proceed) D. In this case, agreement should be checked only when the subject re-merges (since the first merge position is above T) with T (*case checking,* see §4.1). This solution is logically sound assuming that movement and agreement are correlated and can be parametrized (Alexiadou & Anagnostopoulou, 1998). In this sense, the re-merge must be preceded by the MOVE operation that stores in memory an item which is "not fully" expected by the immediately previous MERGE:

(18) MOVE($l_{1(M1)}$, $l_{2(R2)}$) =

$$\begin{cases} 1, Push(M_1, l_{2(Phon_2=\emptyset,\ Exp_2=R_2, Agr_2)}) & if\ R_2 \neq \emptyset \\ 0 & otherwise \end{cases}$$

The definition of MOVE tells us that an item (l_2) must be moved (pushed[8]) into the memory buffer (M_1) of the superordinate item (l_1) if it still has expected features to be selected ($R_2 \neq \emptyset$). Notice that item moved in M_1 is not an exact copy of l_2: the used features (including *Phon*) will not be stored in memory. This definition produces the expected derivation only if it applies right after MERGE, that is, once the item l_2 is properly (at least partially) selected; in this case, if l_2 still has *expected* features to be licensed, it must hold in the memory buffer of the selecting item, waiting for a proper selection of what becomes, after a successful Merge, the new l_2 label.

This is then the expected top-down derivation in SV languages: S (a DP) must first be selected by a superordinate item (presuppositional subject position, situation topic, focus etc.)[9] then it gets stored in the *M* buffer of the selecting item in virtue of the unselected *D* features, then re-merged as soon as a proper predicate, expressing the relevant *T* category requiring agreement (*T* can be included

[7] UNIFY(num, num.pl) = num.pl; UNIFY(∅, num.pl) = num.pl; UNIFY(gen.f, num.pl) = gen.f, num.pl, since *gen* and *num* are distinct sets and *num* is ∅ in the first item, while *gen* is ∅ in the second. On the other hand, UNIFY([gen.f, num.sg], num.pl) would fail.

[8] PUSH and POP are trivial functions operating on arrays: insert (PUSH) / remove (POP) an item to/from the first slot.

[9] We have various options to implement this selection: a specific feature (focus, topic, presupposed etc.) can be added to the relevant item (but this would lead to a proliferation of lexical ambiguity, e.g. [D the …] vs [FOC D the …]) or we assume that certain superordinate items can select specific categories, without deleting them (e.g. [+D *ε* FOC]). Here I will pursue this second alternative.

in the parameterized *Agreement* category in certain languages), is merged and properly selects a *D* argument (or it selects a *V* that later selects *D*).

The content of the memory buffer is transmitted (inherited) through the last selected expectation, namely when the expecting and the expectee items successfully merges and the expecting item has no more expectations ($R_1 \neq \varnothing$). If the expecting item has expectations, then the expected item constitutes a nested expansion, and the inheritance mechanism is blocked:

(19) INHERIT($l_{1(M1)}$, $l_{2(M2)}$) =
$$\begin{Bmatrix} 1, M_2 := M_1 & if\ \text{MERGE}(l_1, l_2)\ \wedge R_1 \neq \emptyset) \\ 0 & otherwise \end{Bmatrix}$$

The M buffer of the last selected item that does not have other expectations (namely a right phrasal edge, i.e., $S=\varnothing$) must be empty (i.e., $M=\varnothing$). If not, the derivation fails (i.e., it stops) since a pending item remains unlicensed:

(20) SUCCESS($l_{x(Sx,\, Mx)}$) =
$$\begin{Bmatrix} 1, & if\ S_x = \emptyset\ \rightarrow M_x = \emptyset) \\ STOP & otherwise \end{Bmatrix}$$

3 The generation algorithm

We can now define the full-fledged generation algorithm to drive the top-down derivation. Consider *cn* to be the *current node*, *exp* the list of pending expectations and *mem* the ordered list of items in memory, we initialize our procedure by picking up an arbitrary node from *G.Lex* as *cn*. Being *cn* the root node of our derivation(al tree) and *w* the array of words we want to generate:

```
GENERATE(cn, w)
 while cn.exp
  while cn.mem
    if MERGE(cn.exp[0], cn.mem[0])
      POP(cn.exp)
      POP(cn.mem)
    else break
  if MERGE(cn.exp[0], w[0])
    if w[0].exped
      MOVE(cn, w[0])
    if w[0].exp
      cn = w[0]
      INHERIT(exp[0], w[0])
      SUCCESS(w[0])
      POP(w)
      if not cn.exp
          while cn.exp
               cn = cn.father
  else fail
```

Informally speaking, we loop into the set of expectations of *cn (cn.exp)*, first attempting to Merge items from (*cn.*)*mem* (if any), as in the active filler strategy (Frazier & Clifton, 1989), then consuming words in the input (being *w[0]* the first available word). Remember that each word has *exp(ect)ed* features (the first being the label *L*), *exp(ectations)* and *agr(eement)* features. *Cns* have their own *mem* that can be inherited only by the last expected item, and, except for the root node, a *father*.

The derivation is then a depth-first, left-right (i.e., time-based) strategy to generate a sentence given a grammar, a root node, and a sequence of lexical items to be integrated (it is easy to imagine a dynamic function incrementally proposing words to be integrated, given the history of the derivation or, at least, the last expectation).

3.1 Lexical ambiguity only

Ignoring Parameters, the generation procedure in e-MGs should only face lexical ambiguity: the same *Phon* in *w[n]* might be associated to multiple items *l* in *Lex* with different features; the default option is to initialize a new derivational tree for any ambiguous item in *Lex*. Given an ambiguity rate *m* in *Lex*, the generation procedure would have an exponential order of complexity O(n^m). We can however mitigate this, either by selecting the element(s) bringing the coherent expected cat (this implements a categorial priming strategy, Ziegler et al., 2019) or to use a statistical oracle following Stabler (2013) to limit the possible alternatives.

The current implementation leaves the user the choice of picking up one item instead of another for ad-hoc comparisons, since the goal of this framework is mainly comparative. It is however important to stress that lexical ambiguity is the only source of ambiguity in this default procedure: syntactic ambiguity is totally subsumed by the lexicon, being the source of structural differences only the set of categorial expectations processed.

Notice, moreover, that the lexicon can include phonetically empty categories. This is not a problem for the generation procedure, that consumes input tokens one by one, and then consider a phonetically empty category on a par with phonetically explicit ones, namely it should be provided as incoming input. The parsing procedure is then minimally different since it must postulate a phonetically empty item but this only happens when the relevant category (and agreement features) of the phonetically empty item are expected and unmatched by the current input.

4 Parameters

A set of parameters extends the power of e-MGs in a relevant way both excluding unwelcome structures (non-agreeing constituents) or including various kinds of "discontinuous" phrasal structures that cannot be implemented in a (explanatorily) satisfactory way, but that are attested in different languages. *Parameters* minimally operate on *F* and *Cat* to show the impact of various linguistic assumptions, in terms of generative power, without altering the general architecture of G and the dynamics of the derivation. Below two possible parameters dealing with Agreement and "reconstruction". A relevant set of cases is presented to exemplify the behavior of the e-MG generation procedure in linguistic terms.

4.1 Agree categories

Agreement is a cross-linguistically parametrized option inducing specific featural unification between two distinct items. A list of categories requiring agreement is provided in the *P(arameters)* set of an e-MG, as well as the specific conditions in which agreement holds. For instance, in Italian, as in many other Romance languages, DPs fully agree in gender and number. To express this, we include *gen(der)* and *num(ber),* in association to *D*, *A*[10] and *N* categories in *Agr* (henceforth, *Agr* features in *l,* e.g. [$_{\text{num.sing, gen.fem}}$], are abbreviated, i.e. [$_{\text{s, f}}$]):

(21) *P.Agr = {D.{num, gen}, A.{num, gen}, N.{num, gen}}*

This is sufficient to accept (22).a but not (22).b:

(22)	a.	La	prima	notizia
		[$_{\text{D; s, f}}$ the]	[$_{\text{A; s, f}}$ first]	[$_{\text{N; s, f}}$ news]
	b.	La	*prime	notizia
		[$_{\text{D; s, f}}$ the]	[$_{\text{A; p, f}}$ first]	[$_{\text{N; s, f}}$ news]

Similarly, subject-verb agreement and object-past participle (*V.pp*) agreement is expressed as follows:

(23) *P.Agr* = {*T.{per, num}, V.pp.{num,gen}*}

In SVO languages, S will first be licensed higher than T (unless aux-S inversion applies), then T-S agreement should be checked (*case checking*), then the subject S should reach the thematic role. These three operations are implemented simply including the relevant features in the lexicon as in (24):

(24) [$_{\text{C}}$ ε $_{\text{+D, =T}}$], [$_{\text{T; 3, s}}$ ha $_{\text{+D, =V}}$], [$_{\text{V}}$ cantato $_{\text{=D}}$],
has *sung*
[$_{\text{D; 3, s}}$ Maria]
Mary

Exemplifying the derivation (following the procedure presented in §3), the root node C (phonetically empty) is selected first as the current node *cn* (initialization step), then [$_{\text{D}}$ Maria] is merged, satisfying the *+D* expectation of C[11]. The *expect* feature *+D* does not delete the *expected* D feature (see note 9), therefore [$_{\text{D ...}}$ Maria] is inserted in the memory buffer of C (since *Maria .expected = D*). [$_{\text{T ...}}$ ha $_{\text{+D, =V}}$] is then merged, satisfying the last expectation of C (i.e., =T). Since T is the last expected item, it inherits the content of the superordinate memory buffer C (i.e. [$_{\text{D}}$ Maria]). In virtue of the +D expectation of T, [$_{\text{D}}$ Maria] is remerged and since both T and D categories are in *P.Agr*, agreement must be verified between [$_{\text{T; 3, s}}$ ha] and [$_{\text{D; 3, s}}$ Maria]. The check is successful, but still [$_{\text{D ...}}$ Maria] remains in memory (because, again, of the *+D* expectation of T), and it is transmitted to V, which, in the end, is the last expected category of T. Now the *=D* expectation of V finally removes [$_{\text{D}}$ Maria]) from memory and licenses it as a V argument.

On a similar vein we can implement object clitic – past participle agreement. Notice however that the simple specification of the relevant categories in *P.Agr* would predict that the past participle always agrees with the object, also when it just appears in a post-verbal position. This is an incorrect prediction as shown in (25).b:

(25)	a.	Maria l'ha	cantata
		M.	it$_{\text{CLf.s}}$ has sung$_{\text{f.s}}$
	b.*	M.	ha cantata una canzone
		M.	has sung$_{\text{f.s}}$ [$_{\text{f.s.}}$ a song]
	b'.	M.	ha cantato una canzone
		M.	has sung$_{\text{m.s}}$ [$_{\text{f.s.}}$ a song]

[10] The nature of adjectival modification cannot be fully addressed here. For simplicity, we assume that intersective adjectives (e.g. "beautiful", as well as restrictive relative clauses and adverbial adjuncts) get licensed by the superordinate item without expectation, while others (e.g. "ordinals") are expected by D (we can use more precise categories following the cartographic approach, Cinque, 2002). This induces a tolerable level of lexical ambiguity (either we assume [$_{\text{D}}$ the $_{\text{=A}}$], [$_{\text{D}}$ the $_{\text{=N}}$] or [$_{\text{A}}$ ε $_{\text{=N}}$]; the second option, [$_{\text{D}}$ the $_{\text{=A}}$] + [$_{\text{A}}$ ε $_{\text{=N}}$] in case of DP only composed by D and N, seems more coherent with the cartographic intuitions and reduces lexical ambiguity).

[11] This instantiates the topic of the predication in a general sense. The features on C can be parametrized: with the +D feature associated to C (or below) we obtain the SV parameterization (this is different from *head directionality*).

To capture this, we need to restrict (certain) agreement configurations to elements that are moved/remerged, namely *V.pp* will be an agreement category only when merged with an item taken from memory (i.e., the clitic in (25).a).

We express this by adding a superscript in *P.Agr* relevant categories: i.e. *V.pp*^{M}. It is important to consider sub-specifications of V since we don't want V to agree with the subject of an unergative predicate, (26).a' vs (26).b:

(26) a. Maria ha corso.
M.$_{f,s}$ has run$_{m,s}$
a'.*Maria ha corsa.
M.$_{f,s}$ has run$_{f,s}$
b. Maria è caduta.
M.$_{f,s}$ is fallen$_{f,s}$
M. has fallen

This can be captured, not only by marking those inflections in which the relevant agreement features are overt (i.e. *V.pp*, namely past participle) but also considering that the external argument and the internal one are licensed by two different categories, *v* and *V* respectively (Kratzer, 1996), and only the second is relevant in terms of agreement (this is also necessary for selecting the correct auxiliary, have, (26).a, vs be, (26).b).

4.2 Delayed expectation

Both remnant movement (Haegeman, 2000), was-für Split (Brattico & Chesi, 2020) and reconstruction (Bianchi & Chesi, 2014) seem to require some sort of "late expansion" of some complement. When the "delayed expectation" parameter is on, this becomes an option, and an expectation (possibly nested) can be procrastinated. If the item bearing such expectation has only one expect feature, the only available possibility is to wait for its re-merge and then expanding such expectation at that time. Certain (non-presuppositional) subjects that do not behave as islands and seem transparent to sub-extraction, require this option to be active. A significant contrast is reported in (27):

(27) [$_P$ Of which sculpture] is [$_D$ one copy _$_P$]
a. *absolutely [perfect _ $_D$]?
b. already [available _$_D$] ?

In (27).a the subject [one copy $_{=P}$] is expected outside the predicative nucleus [perfect] (presuppositional subject) and there it can't receive its argument [$_P$ of which masterpiece] (it is in a nested position). In (27).b, reconstruction is possible under the stage level predicate [available], but the P expectation of [one copy $_{=P}$] must wait to be fulfilled after the subject is reconstructed as an argument of the predicate.
Similarly, to capture the relevant dependency in inverse copular constructions we need this option:

(28) La causa della rivolta sono le foto del muro
The cause of the riot are the pictures of_the wall

According to (Moro, 1997) [$_D$ cause] is in fact the predicate and [$_D$ picture], the subject of such predicate. To integrate *picture* in the correct position we need to include the relevant expectation under the predicate, i.e., [$_D$ cause $_{=D, =P}$][12], then to wait for the =D projection (*delayed expectation*) after the predicate is remerged after the copula (that selects a D qualifying as predicate, that is, bringing another D expectation). It is worth to notice that neither agreement parameterization nor *delayed expectation* increase the generative power of the grammar (Chesi, 2007), but *delayed expectation* introduces and extra level of syntactic ambiguity that it proportional to the number of expectations of each lexical item.

5 Conclusions

The e-MGs formalization here proposed, together with the core generation algorithm, is a transparent proposal for comparing syntactic predictions under a simple parametrized framework. The generation algorithm is sufficiently specified to operate independently from parsing-specific assumptions and however provides interesting metrics to compare the predicted difficulty not only globally (as in De Santo, 2020; Graf et al., 2017) but also "on-line" that is, on a word by word basis. This is possible simply counting the number of merge operations necessary before completing the expectation of a given item (the integration cost), the level of nesting (non-trivial embedding in the tree structure) and the amount of shared feature in memory (relativized minimality cost as discussed in Chesi & Canal, 2019).

[12] Being the subject the "external argument" it should come first than =P, which is the expectation triggering Merge of the "internal argument" [$_P$ of the riot].

Implementation:
https://github.com/cristianochesi/e-MGs

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