Budding the tree
Towards a theory of structure removal
Appendices

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Appendices

This document contains the two appendices related to the paper *Budding the tree Towards a theory of structure removal*. Appendix A provides a detailed comparison of three approaches to structure reduction currently available, *Remove* (Müller 2017b; a), *Exfoliation* (Pesetsky 2021), and *Bud* (discussed in the main paper). Appendix B illustrates how *Bud* can account for structure pruning in cases of language disorder, root infinitives in child speech and preference for passive plus subject relativization over object relative clauses.

A Remove, Exfoliation and Bud

The core idea of the research presented in this paper is that the grammar of human language is endowed with an architectural operation performing structure reduction. The claim is that this operation is nothing but a special application of Merge driven by the lexical specification of the merging head. Two other proposals in the recent literature reach a similar goal in a slightly different way, namely Remove (Müller 2017b) and Exfoliation (Pesetsky 2021). The procedures deriving reduced structures in the three approaches are given in (1)-(3).

(1) **Bud**

Bud(δ, $\{\alpha, \{\alpha, \beta\}\}$) = $\{\delta, \{\delta, \beta\}\}$

Selectional properties: δ [—β]

(2) **Remove**

Merge($\beta_{[\cdot\alpha_2\cdot]\succ[-\alpha_2-]}, \alpha$) = $\{\beta, \{\alpha\}\}$

Remove($\beta_{[-\alpha_2-]}, \alpha$) = $\{\beta\}$

(3) **Exfoliation**

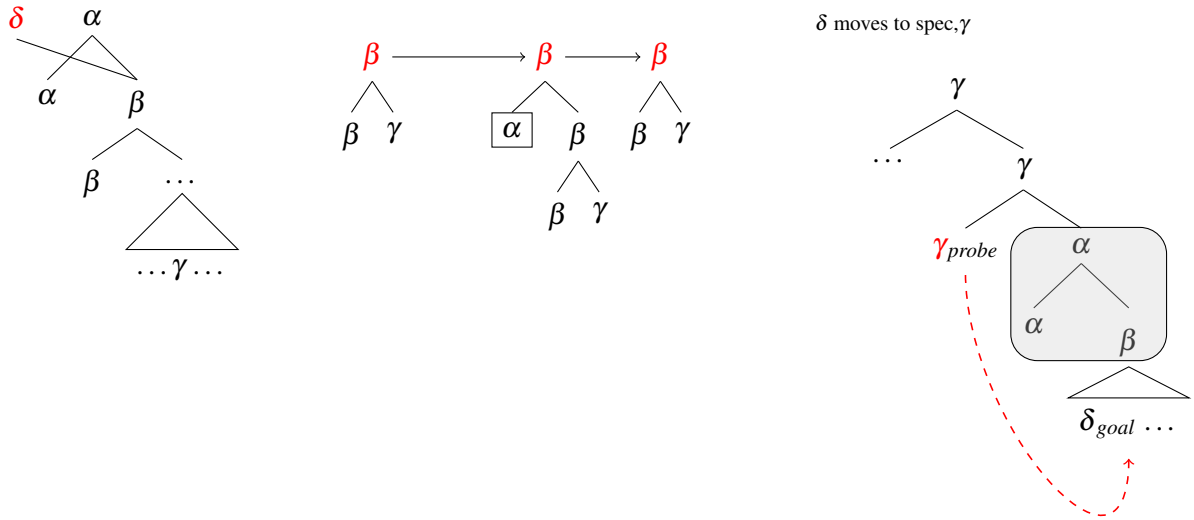
α is a phase boundary

δ occupies the edge of β

γ probes for δ

α is removed

δ moves to spec,γ



Structure reduction is accomplished before the end of a cycle via "negative" features with Remove. In a nutshell, the idea is that the grammar is endowed with two types of features, positive features that trigger merge and structure building, and negative features that remove an already built piece of structure. In the toy example in (2), the entire phrase headed by α is first selected and merged to β because β carries the positively specified $[\cdot\alpha_2\cdot]$ feature. Subsequently, the phrase headed by α is removed from the structure because of the negative feature $[-\alpha_2]$ on β. The availability of negative features is an option to which a numeration can more or less freely have access to.

Structure reduction is triggered by the need of an embedded subject to move with Exfoliation. In the toy example in (3), α is eliminated from the derivation so that δ can move to the specifier of γ. At the end of the procedure, β inherits the phase properties from α.

After this brief illustration of how Remove and Exfoliation mechanically perform structure reduction, I discuss the main similarities and differences between these two proposals and Bud. In doing this, I will show what are the strong and weak points of each approach. I will manly focus on the derivation of passive, since this is the most detailed application of Bud presented in the earlier sections, while I will briefly touch on sentence typing and non-finite complements. As the reader will see, I will also highlight possible cases where the theories make different predictions. When testable, this exercise normally show which theory is superior. However, I do not think that it is so easy to determine whether Bud or Exfoliation are actually superior to Remove, given the radical departure of Remove from standard syntactic models. In this respect, Bud and Exfoliation remain an alternative to Remove. On the other hand, the picture that emerges from the comparison between Bud and Exfoliation will show that Bud can be understood as a possible simplification of Exfoliation. The major simplifications will concern the very definition of reduction and that movement is not a necessary pre-requisite for structure reduction.

A.1 The triggers of reduction

The ability to perform structure reduction is lexically driven in Bud and Exfoliation while it depends on the distribution of negative features for removal, as illustrated in (4).

(4) **The triggers of reduction**

a. **Bud: selectional properties of the head**
BE [— VP] ; HAVE [— *v*P]
Raising predicates [— toP]

b. **Exfoliation: probing properties of the head**
VOICE ⇀ DP (when passive the external argument is skipped)
Raising predicates ⇀ embedded subject

c. **Remove: distribution of negative features**
Passive $v_{[\cdot V\cdot]\succ[\cdot D\cdot]\succ[-D2-][\cdot acc\cdot]}$; *Active* $v_{[\cdot V\cdot]\succ[\cdot D\cdot]\succ[\cdot acc\cdot]}$
Raising predicates$_{[\cdot C\cdot]\succ[\cdot -C-\cdot]\succ[\cdot -T-\cdot]}$

The free distribution of features is part of a larger architectural design of how the lexicon is composed in Müller's (2017b) proposal. Its concrete application to structure removal raises the issue of overgeneration though, an aspect that Bud and Exfoliation do not have, since their ability to reduce structure is part of the lexical properties of specific heads (e.g., auxiliary BE, raising predicates, etc.). However, this very flexibility of Remove becomes useful to account for cases where finite and infinitival complements coexist, like in the alternation between finite complements and control constructions as in (5). The account for these alternations must be stipulated in the lexicon for Bud, in the sense that complement taking predicates must be able to systematically select for either a CP or a toP (or the relevant projection in case less structure is budded). As for Exfoliation, control constructions are discussed as a case of structural reduction induced by the syntactic need to let the subject move to a higher projection either in the embedded or in the higher clause (Pesetsky 2021: Chapter 5).

(5) a. (Tu) pensi che (tu) rientrerai tardi?
you think that you come back late
'Do you think that you will come back late?'

b. (Tu) pensi di rientrare tardi?
you think to come back late
'Do you think to come back late?'

Crucially and independently from the technical way in which the alternation is captured, a variety of factors should regulate which option is chosen each time. Whatever these factors are, they are ultimately responsible for the presence/absence of negative features in Remove, for toP/CP selection in Bud, and for subject extraction in Exfoliation.

A.2 Reduction and cyclicity

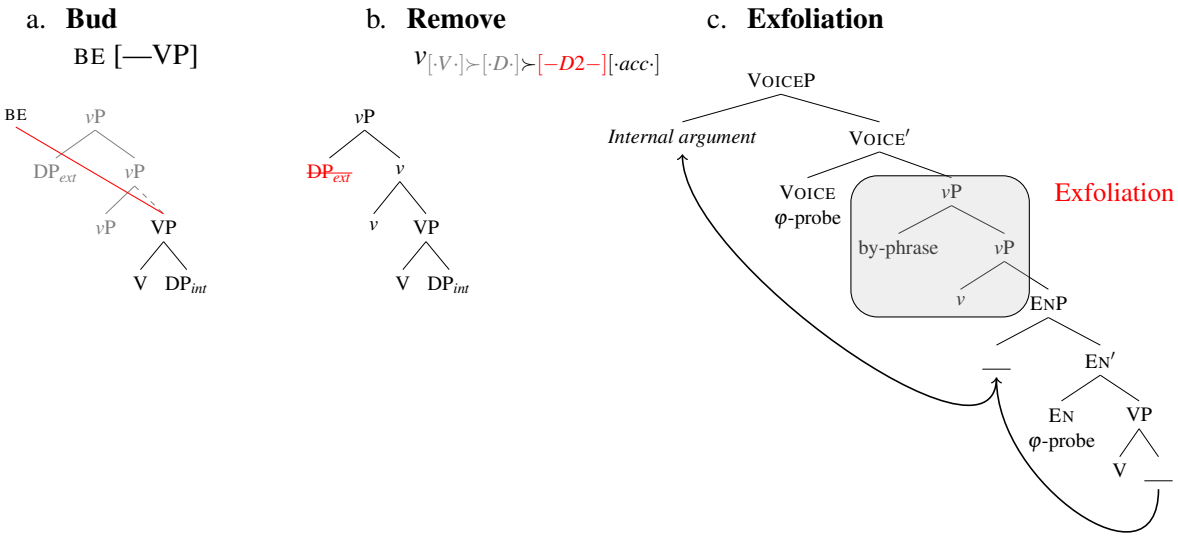
Structure undoing targets portions of fully fledged structures and is driven by properties/features of the triggering head in the three proposals. A point of difference is found in the timing of structure removal. Remove proceeds in a bottom-up fashion, while Bud and Exfoliation act in a top-down fashion. More specifically, feature-driven Remove must be performed before a new head is merged, Exfoliation is always done across phases because by definition the probe is located in a higher phase, while Bud can in principle apply across phases or inside a phase, although this latter case may not be actually detectable (see Section 2.3 of the paper).

These are not mere stylistic differences, in fact they have direct consequences on the concrete implementation of the syntactic derivation. In Section 2.2 of the paper, I mentioned that bottom-up approaches cannot avoid looking-ahead in order to correctly assemble the numeration. This was further illustrated in Section 3.1 of the paper where removal of the external argument is performed at the *v*P level, before the derivation is turned into passive for Remove but not for Bud. The key passages are given in (6). The presence of the passive auxiliary in the CP phase induces bud of the *v*P in (6a), while removal is done during the *v*P phase by the negative [-DP-] feature on *v*, as in

(6b). At the end of the *v*P phase, the bud derivation is still compatible either with an active or a passive continuation. The Remove derivation, on the other hand, is only compatible with a passive derivation, since the external argument has already been removed. In order for that derivation not to crash, something must guarantee at the *v*P phase that in the next phase a passive voice/auxiliary will be introduced. Similar considerations, perhaps even more problematic ones, apply if one tries to derive raising constructions and more generally infinitival complements from a fully-fledged CP in a Remove account. These aspects must be handled by a precise theory of how the workspace works and how a numeration comes to place in an extreme feature-driven approach to syntax like the one developed in Müller (2017b).

The active/passive status of a sentence is determined by the presence/absence of a *by-phrase* in spec*v*P in an Exfoliation approach. Here too, the derivation is already passive before the end of the *v*P cycle.[1]

(6) **Looking ahead: Derivation of Analytic Passive**

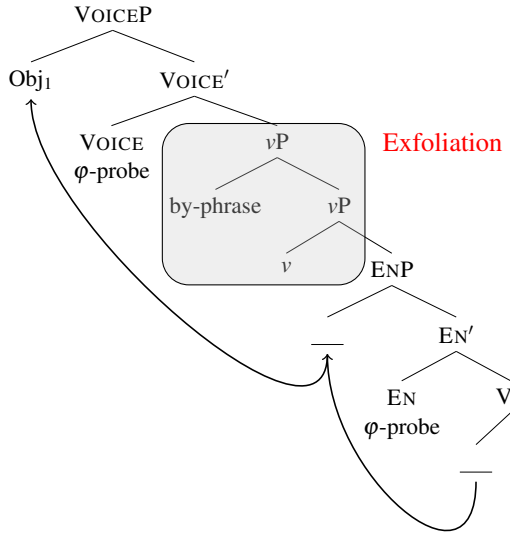


More problematic for Exfoliation is the assumption that the internal argument is moved to spec,EnP, a prerequisite for Exfoliation to be triggered. The problem becomes clear once the passive of double object constructions is considered. Assuming that the higher object is merged in Spec,VP, its movement towards spec,VoiceP via spec,EnP creates a configuration similar to that of *that-trace effect*, without generating ungrammaticality, as illustrated in (7a), since the new phase edge would have both the head and its specifier filled by lexical material. Notice that movement to spec,EnP happens within the *v*P phase and that En inherits phase-hood after exfoliation. The Bud derivation of the passive in double object constructions does not require special assumptions, as shown in (7b).

(7) **Passive of Double object constructions** John was given a book.

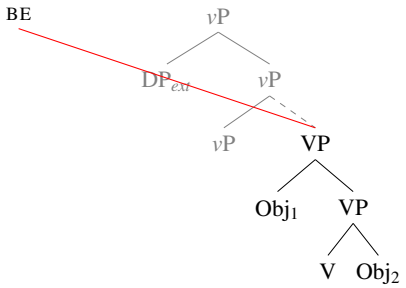
[1] Notice that looking ahead is somehow mitigated if a radical Derivational Morphology approach to lexical insertion is adopted. All approaches to structure reduction requires some sort of late insertion. What is further needed here for Remove and Exfoliation is that the shape of the actual auxiliary morpheme is determined by the syntactic environment in which it occurs. In this case, the features of the auxiliary are completely irrelevant to determine the final exponent. For Exfoliation, a possible lexical insertion rule for English would be AUX ≡ BE, if EnP is the complement of Voice, otherwise AUX ≡ HAVE. For Remove, the rule would be AUX ≡ BE, if spec,*v*P does not have a specifier, otherwise AUX ≡ HAVE.

a. **Exfoliation**



b. **Bud**

BE [—VP]



Let me further notice that the Bud derivation of analytic passive also provides an elegant explanation of key properties of the construction (auxiliary selection, lack of external argument, nominative case appearing on the underlying object), as well as of the typological variation attested in impersonal constructions showing some but not all the properties of analytic passive, including impersonal passive in German, and the analogies between passive and unaccusatives. All these facts are almost completely accidental in the Remove and Exfoliation approach to passive.

A point where the three approaches probably converge is in the treatment of the removed material. It is reasonable to assume that in all approaches removed materials should not contain active syntactic features, hence excluding the possibility for a removed element to act as a syntactic probe, as explicitly proposed for Bud. Pesetsky (2021) briefly mentions that removed materials return to the numeration as in Remove, and the solution developed here in Section 2.5 of the paper and illustrated with the passive by-phrase is also quite similar to the one developed in Müller (2017b). There are, however, a couple of situations in which the theories result in different outcomes. The first one concerns the situation of the external argument of passive constructions, the second one concerns the situation of the T node in infinitival constructions.

Under the Bud derivation of passive, the external argument receives case from the active auxiliary before budding (see Section 3.1 of the paper). With Exfoliation, the external argument is merged in the derivation as part of a *by-phrase*, where it probably receives case directly from the preposition. With Remove, the external argument of a passive construction is removed before any case is assigned to it. This is a necessity in this framework since positive and negative features must complete their operation within the cycle. This means that *v*P undoing leading to passive must be done before the CP phase starts. This, in turn, causes the return to the numeration of a DP with an unvalued case feture, causing the derivation to crash.

Similarly, EPP in T of infinitival constructions is not satisfied with Exfoliation, since by assumption the subject must not move to spec,TP in these constructions. This problem of EPP satisfaction does not arise with Bud and Remove since they both allow for the subject to move to spec,TP before structure reduction is accomplished.

One possibility to solve it is to appeal to "salvation by deletion" as Pesetsky (2021: 15) does for the unsatisfied EPP on T. The underlying idea is that uninterpretable unvalued features that are

not part of a syntactic object do not cause a derivation crash. So, as long as these remain in the numeration the derivation does not crash. The problem, though, is whether the items containing these features are still syntactically active or not. More precisely the problem is whether the presence of such features is enough to let these items re-enter the working space as probing heads.

A.3 Top-down reduction

Although both Bud and Exfoliation remove structure in a top-down fashion, they perform the operation in a slightly different way. In fact, while the removed portion never enters in the search domain of a budding head, it is part of the search domain with Exfoliation. The consequence of this difference is that the to-be-removed piece of structure never induces minimality with Bud as shown in (1), while in principle it can do so with Exfoliation as shown in (3). In a certain sense, "obstacle removal" is an indirect consequence of Bud, while it is the driving force of Exfoliation. This aspect makes Bud and Exfoliation superficially very different. In fact, Exfoliation is always movement driven, while Bud is completely independent from movement. This difference leads to opposite predictions at least in two cases, with "*in situ* languages" and in cases of reduction without apparent movement. First, if structure reduction is always movement driven, it should not be observed in those languages where the relevant projection does not normally trigger movement. In other words, structure reduction should not be observed with "*in situ* languages" for Exfoliation while it remains an option for Bud. One concrete example comes from languages with non-promotional passives discussed in Section 3.1 of the paper (see Table 3 and the relevant examples in (31) of the paper. Another example comes from Dholuo, a Nilo-Saharan language spoken in Kenya and Tanzania. The example in (8) shows that the passive subject **Onyango** is in post-verbal position (Cable 2012: 654). Cable (2012) argues that this post-verbal position is within the VP and provides various facts concerning binding to support the claim.

(8) Ne ok one **Onyango** gi Ochieng'.
PAST NEG see.PASS Onyago by Ochieng'.
'Onyango was not seen by Ochieng'.'

If passive involves structure reduction as claimed by all three approaches, then it is not clear how Exfoliation can derive it in this particular case.[2]

The second case of divergence between Bud and Exfoliation is represented by infinitival constructions in which there is no clear evidence of movement from the embedded subject. These are restructuring and control constructions. While the former are not discussed in Pesetsky (2021), two possible ways of deriving obligatory control are offered both involving movement. The first way is shared with non-obligatory control and requires a special stipulation forcing the top-most phase head (*for*) and its specifier (i.e., the moved subject of the embedded clause) to be both pronounced or both silent. When they are both silent, obligatory control of the most common type is derived. The second way involves movement of the embedded subject into the matrix clause, similar to raising constructions and requires to assume a movement theory of control (Hornstein 1999). Although both assumptions could be controversial (see Landau 2013 for a summary of arguments against the movement theory of control), they have the merit of keeping a unified motivation to the underlying syntax of infinitival sentences. Interestingly, Pesetsky (2021) discusses data from Icelandic, reported in Sheehan & Hartmann (2020) showing that the two derivations can be detected.

Before concluding this section, I would like to mention one more case where sentence reduction might be involved, namely imperative sentences and their use in the so called Imperative and Declarative constructions (Kaufmann 2012; Fintel & Iatridou 2017). Imperative sentences have at

[2] The case of Dholuo seems to be different from cases of post-verbal subjects in Italian where it has been claimed that spec,TP is filled by a null expletive pronoun. Indeed, Cable (2012) explicitly excludes this option for Dholuo, excluding alternative ways of satisfying the movement requisite for Exfoliation to apply.

least two of the hallmarks of reduced structures: they normally do not have an overt subject (cf. 9a) and the imperative verb precedes object clitics like infinitival constructions (cf. 9b). Crucially, though, they can be coordinated with a full declarative CP (cf. 9c). These examples open an analysis of imperative sentences as fully fledged CPs that are reduced during the derivation. However, here too, it does not seem that overt movement of the subject is required and even if this is the case it would probably occur within the same phase, preventing Exfoliation to apply.

(9) **Imperatives as reduced structures**

a. (Tu) corri!
'Run!'

b. Da-glie-lo!
Give-to.him-it
'Give it to him!'

c. [Train consistently] and [$_{CP}$ you will run a good marathon]

A.4 Bud ≈ Exfoliation ≠ Remove

Remove and Exfoliation theorize a model of syntax that includes both structure building and structure undoing operations. The cases of analytic passive and raising constructions discussed in Sections 3 and 4 of the paper show that Bud has the potentials to account for more or less the same range of phenomena as Remove and Exfoliation. At the theoretical level, postulating the presence of an operation that formally mirrors Merge results in a symmetric architecture of syntax, which perfectly fits a fully feature driven syntax. This is the case of Remove, where the operation is encoded in the free/optional presence of negative features among the bundle of syntactic features that constitutes lexical items. Exfoliation and Bud are not so radical, in fact limiting structure reduction to a number of lexically specified heads. This makes the question of whether the three operations are variants one of the other less central, at least with respect to Remove, whose formal implementation seems to be based on different grounds than Exfoliation and Bud.

However, despite the superficial differences, the latter two approaches are more similar than what *prima facie* appears from their procedural implementation. Specifically, if one identifies the underlying trigger of Exfoliation not in the requirement of the embedded subject to escape a criterial position, but in the features of the probing head, then Bud and Exfoliation become very similar.[3] The only difference, then, would be the actual trigger of the operation, which is a probing feature for Exfoliation and a selection feature for Bud. As discussed in Section 2.3 of the paper, a complete assimilation of SELECT and AGREE runs into problem related to the *Phase Impenetrability Condition*. The solution offered for Bud is to differentiate labels from other active features allowing the former to be visible throughout the derivation. Pesetsky (2021: 12, example 20) weakens the impenetrability condition by allowing the search of a goal across a CP boundary. A total assimilation of Bud and Exfoliation is then possible and possibly welcome as Bud does not incur in the problematic cases of backward control, looking ahead in passive and lack of EN-trace effect in double object passive constructions.

Unfortunately, reducing Exfoliation to Bud does not come without a price. One of the factors that makes Exfoliation particularly appealing is the explanation of the finite-infinitival alternations in sentence typing. Shifting the trigger from the goal to the probe makes the explanatory power of the account less effective, although Bud greatly simplifies the requirements and the application

[3] One may even go further and try to assimilate the pruning imposed by Bud to the effect of negative features caused by Remove. Although quite appealing, this is not immediately possible because Bud can skip several projections before finding its target, as long as minimality is respected. On the other hand, Remove would require a series of negative features to perform the same operation.

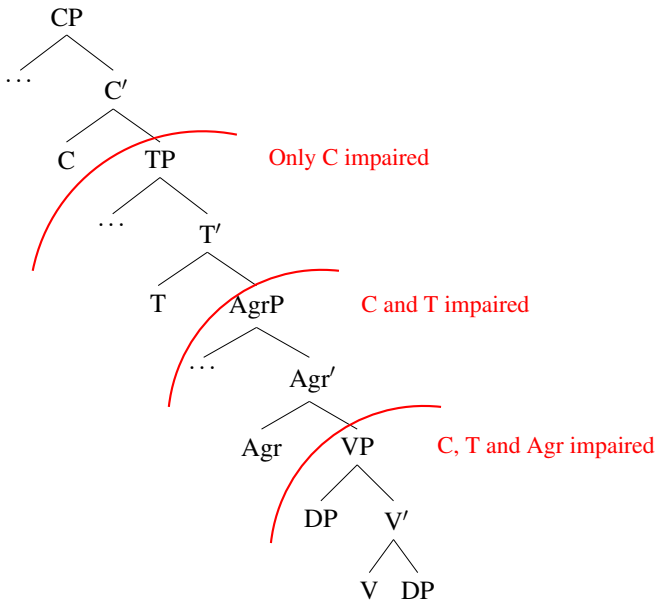
of structure reduction. The simpler nature of Bud is further discussed in Appendix B in light of situations in which typical resources are somehow limited.

B Language, Cognitive resources and the Optimal design

One important aspect of Bud is the simplicity of its requirements paired with the fact that budded derivations and their structures are not just reduced but *de facto* simpler than their full variants. In other words, structural reduction operated by Bud returns a simplified structure in terms of hierarchical complexity (lower number of nodes), lexical materials (e.g., no external argument) and movement options (shorter movements). In this section, I will briefly explore some potential ramifications of Bud, expanding the view from phenomena that belong to the typology of possible grammars to include some aspects of language production that interact with factors like processing, memory limitation, acquisition and language disorders like agrammatic aphasia. In fact, if Bud is part of the architecture of language, its traces should be visible in a-typical linguistic situations. I briefly illustrate three cases: agrammatic aphasia, root infinitives in early stages of acquisition and preference of relativization of a passive subject over object relativization. The common point is that in "atypical grammars", Bud is used instead of merge to the root to remove the topmost part of a derivation, which presumably overloads the memory buffer. The ultimate result is that rich numerations can cut the edge of a structure every time the growth limit is reached for these grammars.

Friedmann & Grodzinsky (1997) used the structure in (10) to explain how aphasic patients instantiate different degrees of syntactic deficits. These depend on how much of the structure is affected. The idea is that structures are pruned at different levels in some cases of aphasia. Specifically, agrammatic aphasics show either a selective impairment of the CP structure or incremental impairment of CP and TP, etc. depending on the size of the structure that is impaired.[4]

(10) **Tree Pruning in agrammatic aphasics** (Adapted from Friedmann & Grodzinsky 1997: 421)



This explanation capitalizes on the account offered by Rizzi (1994) of root infinitives at the early stages of language acquisition. The core of the explanation is that the depth of a tree, representing

[4] A different interpretation based on feature underspecification is offered in Wenzlaff & Clahsen (2004). This view of the phenomenon is more in line with a Remove analysis of structure reduction.

its complexity, generates too much burden for the working memory. Pruning is the most accessible solution to send something to the interfaces.

A high degree of complexity is also at the core of the explanation for the observation that passive subject relatives are very often preferred over object relatives (Belletti & Contemori 2010; Belletti & Rizzi 2012). To illustrate, Belletti & Rizzi (2012) report that in a production task both children and adults have a preference for (11a) over the target construction in (11b). In this latter case, complexity is represented by the intervention of the subject of the relative clause in the active counterpart.

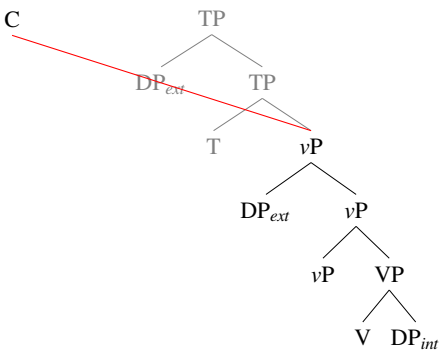
(11) a. Vorrei essere il bambino che è coperto dalla mamma.
Want be the baby that is covered by mom
'I would rather be the child that is covered by the mother.'

b. Vorrei essere il bambino che la mamma copre.
Want be the baby that the mom cover
'I would rather be the child that the mother covers.'

A Bud approach provides a unified explanation to these three phenomena. One can safely assume that the relevant functional elements are available in the workspace in the case of children and agrammtic aphasics. What they cannot do is expanding the tree beyond a certain projection. This means that once the limit is reached, any external merge would simply trigger Bud of the same XP, hence preventing the structure from growing. This particular account does not entirely rely on grammatical aspects but shares the burden of the explanation on computational aspects which become relevant when/if the size of the structure to be computed exceeds a certain threshold of complexity.

To illustrate, root infinitives would be the result of the last head of the CP phase budding right below the projection responsible for finiteness, say TP, as shown in (12). In a nutshell, the idea is that working memory limitations prevent the child to retain the whole structure. Despite the selectional requirement, merge/bud reduces the structures so that the sentential phase is completed, and "an imperfect" structure is sent to spell-out. Notice that until the C level can expand further, even wh-movement would be impossible. I assume that something similar might happen also to agrammatic aphasics.

(12) **Bud**
C [—TP]



Crucially, this mixed account also offers the key ingredient to better understand why passivization plus relativization is preferred over direct object relativization. Indeed beside avoiding intervention, the ultimate structure of a passive sentence is simpler than that of an object relative. In other words, cutting is computationally less expensive than moving objects around subjects. As a *Glossa* reviewer correctly noticed, however, the relative complexity between (11a) and (11b) cannot be

assessed during sentence building. In fact, by the time the relativization process starts, the that-clause is already built. Therefore passivization inside the relative clause cannot prevent object relativization without looking-ahead in the derivation. Let me add in passim that the preference for (11a) over (11b) should not be derived mechanically by an on-line comparison for the simplest derivation, otherwise (11b) would never surface. The preference for (11a) should emerge from more general cognitive principles and perhaps stylistic choices. Thus, the grammar of Italian allows for both strategies, however, the speaker may unconsciously use either one or the other depending on a number of factors among which computational economy is one. In this respect, relativization of a passive subject is different from root infinitives and pruned structures where computational resources are probably the major if not the only driving force.

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