Predicate clefting and long head movement in Finnish

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Abstract. Head movement constitutes a controversial topic in linguistic theory. Finnish long head movement exhibits an unusual combination of predicate clefting with A-bar movement instead of V-copying. An analysis is developed on the basis of Roberts (1993, 2010) and Chomsky (2008) that relies on a minimal top-down search algorithm that exists as part of a comprehension-based, reverse-engineered minimalist architecture. Exceptional properties of Finnish head movement are explained as arising from its lexicon which furnishes the language with an extensive catalogue of left peripheral discourse-motivated C-features participating in predicate formation. The analysis was formalized and tested by computational tools.

Keywords: head movement; Finnish; predicate clefts; computational modelling; minimalism

1 Introduction

In Finnish, a canonical SVO language, nonfinite verbs can occur in a noncanonical position before the subject and the finite verb (1).[1]

(1) Myy-dä-kö$_1$ Pekka aiko-i _$_1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG
'Was it selling that Pekka was going to do with his possessions?'

I call this phenomenon "long head movement" (LHM) to follow a tradition in the literature in which the term refers to movement of an infinitival over the finite verb.[2] The purpose of this article is to document the properties of Finnish LHM and then

deduce the facts from a formal analysis. The theoretical interest of this endeavor lies in its relevance to the theory of head movement.

The article is organized in the following way. Section 2 documents the properties of the Finnish LHM and the empirical generalizations that capture its behavior. This section is divided into subsections as follows: Section 2.1 establishes the grammatical properties I regard as uncontroversial in the light of the previous literature on Finnish clause structure, while Section 2.2 looks at Finnish LHM against the background of previous research on long head movement. An important topic discussed in this section is a possible remnant VP-preposing analysis of the Finnish facts. Several arguments are presented against it. Section 2.3 documents the empirical generalizations covering the Finnish phenomenon specifically. Section 3 presents the analysis together with a discussion of several hypotheses concerning the nature of head movement. The analysis is presented in two steps. First, it is argued, building on Roberts (2010) and Holmberg (2016), that Finnish long head movement constitutes predicate clefting by A-bar head movement. Exceptional properties of Finnish are derived as a consequence of its lexicon which, perhaps due to its agglutinative profile, allows several overt left peripheral discourse features involved in the computation of operator constructions to participate in predicate formation (12 left peripheral C-features and feature combinations are explicitly investigated). Finnish LHM is further contrasted with local head movement constructions in the same language, which exhibit a strict HMC-compliant signature but no left peripheral features, further supporting the notion that the LHM phenomenon is created by computational operations involved in the handling of the left peripheral CP-cartography.

The analysis is then formalized as a Python based algorithm. This makes it possible to test the logical consequences of the analysis over a large test corpus by using a computer. The formal implementation is described in section 4.1 and the test simulations in section 4.2. The source code together with the inputs and outputs, too large to be included in the main article, are available in the source code repository.[3] I adopted a fairly standard minimalist Y-architecture as a starting point but reverse-engineered it so that the algorithm maps unanalyzed bare input sentences into LF interface objects via a parser. Since the Y-architecture itself is directionless, the system can be implemented either way.

2 Properties of Finnish long head movement

2.1 Finnish head movement

Certain properties of Finnish long head movement can be taken as uncontroversial on the basis of existing literature. The phenomenon is based on a well-known grammatical template in Finnish in which the verb moves to C^0 if and only if it has an overt morphological or prosodic left peripheral feature (Brattico et al. 2013, Holmberg 2014, 2016, Huhmarniemi 2012, Huhmarniemi and Brattico 2013, Vilkuna 1989, 1995). Local head movement involves the same features and the same position. Thus, compare the long head movement in (1) with the local variants in (2).

(2) a. Myy-kö$_1$ Pekka _$_1$ koko omaisuute-nsa?
sell.PRS.3SG-Q Pekka.NOM all possessions-PX/3SG
'Does Pekka sell all of his possessions?'

b. On-ko Pekka _$_1$ myy-nyt koko omaisuute-nsa?
be.PRS.3SG-Q Pekka.NOM sold-PST.PRTCPL all possessions-PX/3SG
'Has Pekka sold all his possessions?'

Since local and nonlocal movement exhibit the same left peripheral features, same syntactic position, and induce the same effects on semantic interpretation, absence of evidence to the contrary we should keep the null hypothesis according to which (1) and (2a-b) are based on the same grammatical mechanism. I return to this matter briefly at the end of this section.

Finnish is considered an agglutinative language with rich derivational and inflectional morphology. For example, it exhibits fifteen nominal case suffixes, productive phi-agreement in number and person both in finite and infinitival domains and relatively free word order. This morphological richness is reflected in the number of suffixes associated with left peripheral Ā-positions. Local and nonlocal head movement to C occur in connection with the yes/no question particle *-kO* (3a), three separate discourse particles *-pA* (3b), *-hAn* (3c) and *-s* (3d) plus their combinations (e.g., 3e-f); corrective or contrastive focus/topic (3g); combinations of prosodic (contrastive) focus with everything else (3h); and possibly also in connection with imperatives (3i). I call these overt markers *C-features* in this article to emphasize the fact that they are related

to the CP-cartography, with a further distinction established later. Twelve C-features and their combinations were examined in detail in this study.

(3) a. Myy-kö$_1$ Pekka _$_1$ omaisuute-nsa?
sell.PRS.3SG-Q Pekka.NOM possessions-PX/3SG
'Does Pekka sell his possessions?'

b. Myy-pä$_1$ Pekka(kin) _$_1$ omaisuute-nsa.
sell.PRS.3SG-PA Pekka(also) possessions-PX/3SG
'(Also) Pekka sells his possessions.'

c. Myy-hän$_1$ Pekka _$_1$ omaisuute-nsa.
sell.PRS.3SG-HAN Pekka.NOM possessions-PX/3SG
'Pekka sells his possessions, doesn't he?'

d. Myy-pä-s$_1$ Pekka _$_1$ omaisuute-si!
sell.IMP.PRS.3SG-PA-S Pekka.NOM possessions-PX/2SG
'Why don't you sell your possessions, Pekka?'

e. Myy-pä-hän$_1$ Pekka _$_1$ omaisuute-nsa.
sell.PRS.3SG-PA-HAN Pekka.NOM possessions-PX/3SG
'Yes, Pekka sells his possessions.'

f. Myy-kö-hän$_1$ Pekka _$_1$ omaisuute-nsa?
sell.PRS.3SG-Q-HAN Pekka.NOM possessions-PX/3SG
'Will Pekka sell his possessions?'

g. MYY$_1$ Pekka _$_1$ omaisuute-nsa!
sell.FOC.PRS.3SG Pekka.NOM possessions-PX/3SG
'Pekka does sell his possessions!'

h. MYY-PÄ (sinä) _$_1$ omaisuute-si!
sell.FOC.IMP-PA (you.NOM) possessions-PX/2SG
'Sell your possessions!'

i. Myy$_1$ (sinä) _$_1$ omaisuute-si!
sell.IMP (you.NOM) possessions-PX/2SG
'Sell your possessions!'

Verb initial constructions create similar effects in other languages, such as in Slavic (King 1995, Lambova 2004, Rivero 1994, Wilder and Cavar 1994), Balkan (Rivero 1994), Early Modern Romanian (Alboiu, Hill and Sitaridou 2015) and Romance (Rivero

1993, Roberts 1994), so the phenomenon should not be regarded as surprising. The Finnish data, putting the problem of locality aside, is compatible with the analysis proposed by Alboiu, Hill and Sitaridou (2015) who argue that in Old Romanian T-to-Focus movement encodes discourse features.

Verb movement to C is not possible in Finnish unless some feature triggers it. Moreover, when the feature is present, movement is under most circumstances obligatory. With the exception of prosodic focus, none of the features listed in (3) can occur in situ. Head movement and phrasal movement to the CP field are also complementary (Huhmarniemi 2012, Holmberg 2016), a property that is again not unusual (e.g., Chung and McCloskey 1987, McCloskey 1979, Pesetsky and Torrego 2001). Thus, Finnish verb-initial clauses express C-features; without C-features they are ungrammatical (Holmberg and Nikanne 2002, Vilkuna 1989).[4] Finnish is not a V2-language. It is also important to note that these examples do not exhibit V-copying, as all gapless variants, such as (4), are ungrammatical.

(4) *Myy-kö Pekka myy-kö omaisuute-nsa?
sell.PRS.3SG-Q Pekka.NOM sell.PRS.3SG-Q possessions-PX/3SG

The element that moves is the same as the one that would occur in the canonical position (minus the occurrence of the C-feature). Finnish does not implement a type of VP-fronting observed in Hebrew (Landau 2006) or Spanish (Vincente 2007) where a copy of the moved head remains in situ.

Finally, the Finnish high complementizer *että* ‘that’ used in some of the examples discussed in this article is located above the fronted verb. This is shown in (5). I will assume that the verb moves to C^0 and the high complementizer is at $Force^0$ selecting C^0. These *that*-clauses are ordinary embedded finite clauses selected by the main verb and do not have any exceptional or otherwise nonstandard properties.

(5) a. Pekka kysyi *että* kuka myy omaisuute-nsa.
Pekka asked that who.NOM sell.PRS.3SG possessions-PX/3SG
’Pekka asked who sells his/her possessions.’

b. Pekka kysyi *että* myy-kö Merja _1 omaisuute-nsa.
Pekka asked that sell.PRS.3SG-Q Merja.NOM possessions-PX/3SG

’Pekka asked if Merja does sell his possessions.’

c. Pekka asked Force^0 T^0+C^0 Spec

The claim that Finnish local and long head movement exhibit otherwise similar properties was not yet supported by a detailed argument. To argue for it, consider (6a-b).

(6) a. *Local head movement*

Myy-kö$_1$ Pekka _ koko omaisuute-nsa?

sell.PRS.3SG-Q Pekka.NOM all possessions-PX/3SG

‘Does Pekka sell all his possessions?’

b. *Nonlocal head movement*

Myy-dä-kö$_1$ Pekka aiko-i _$_1$ koko omaisuute-nsa?

sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG

‘Was it selling that Pekka was going to do with his possessions?’

Both fronted verbs, the finite verb in (6a) and the infinitival in (6b), carry the same C-feature, the yes/no particle *-kO*. This pattern seems to generalize to all examples of local and nonlocal features and to all C-features: whenever one can form (6a), (6b) is also possible, and vice versa. The semantic interpretation associated with the C-feature is the same in both examples, and it furthermore functions to target the content of the moved predicate in the sense that both interrogatives in (6a-b) are interpreted as making a specific question concerning selling, thus the specific content of the predicate that is fronted. The local and nonlocal constructions share also syntactic properties. They both involve movement of a head, after which no further phrases or heads can be fronted. Verb movement affects selection in the same way in both examples, thus both (6a-b) have interrogative force. Both sentences can be combined with the high complementizer *että* ‘that’, and both fronted verbs occur above the preverbal subject. Thus, they are in the same syntactic position. Absent compelling evidence to the contrary, we should take local and nonlocal verb fronting to be based on the same mechanism. I will propose a unified analysis of this type in this article.

Finnish is a canonical SVO language with a partial null subject profile (Holmberg 2005) and nominative-accusative marking. Thus, in most examples discussed in this article the finite verb agrees in number and person with the nominative subject, the

latter which occupies a preverbal subject position. When the argument is not nominative, the verb exhibits either default third person agreement or no agreement. There are no obligatory determiners (but see Laury 1997). Word order is relatively free when compared with languages such as English. This property correlates with rich case marking. It correlates also with discourse interpretation: Finnish is often said to exhibit discourse configurationality (see Holmberg and Nikanne 2002, Vilkuna 1989, 1995). Some empirical examples cited in this article exhibit full agreement also on infinitival heads, such as nouns, preposition, adverbs and non-finite verbs. This is a general feature of Finnish (Huhmarniemi and Brattico 2015, Toivonen 2000, Vainikka 1989). For Finnish syntax in general, see Holmberg et al. (1993) and Manninen (2003).

2.2 Crosslinguistic perspective

2.2.1 Diagnostic properties of LHM

In a seminal paper citing data from several languages, Lema and Rivero (1990) argued that long head movement (LHM) is (i) restricted to root, (ii) not possible in negated clauses, (iii) local (i.e., skips only one head) and (iv) is licensed exclusively by temporal auxiliaries. These restrictions do not apply to Finnish as shown in (7-10).

(7) *Finnish LHM is not restricted to root contexts*

a. Myy-dä-kö$_1$ Pekka aiko-i _$_1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG
'Was Pekka going/planning to sell all his possessions?'

b. Sirkku ihmetteli että myy-dä-kö Pekka aiko-i _$_1$ koko omaisuute-nsa.
Sirkku wondered that sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG
'Sirkku asked whether Pekka was going to sell all his possessions.'

(8) *Finnish LHM is not blocked by the presence of intervening negation*

a. Myy-dä-pä$_1$ Peka-n ei tarvitse _$_1$ ihan koko omaisuut-ta-an.
sell-A/INF-PA Pekka.GEN not.0 need quite all possessions-PAR-PX/3SG
'Pekka does not need to sell all of his possessions.'

b. Päättä-ä$_1$ Peka-n ei tarvitse _$_1$ yhtään mistään.
decide-A/INF Pekka-GEN not.0 need any thing

‘Pekka does not need to decide anything/on any issue.’

c. Matkusta-a$_1$ Pekka e-i halu-a _$_1$.
travel-A/INF Pekka.NOM not-3SG want-A/INF
‘Pekka does not want to travel.’

(9) *Finnish LHM is not sensitive to locality*

a. Myy-dä-kö$_1$ Pekka sanoi että hän aiko-o _$_1$ kaikki tavara-nsa?
sell-A/INF-Q Pekka said that he.NOM plan-PRS.3SG all stuff-PX/3SG
’Did Pekka said that he will sell all his stuff?

b. ?Myy-vän-sä-kö$_1$ Pekka kertoi että hän ajattel-i _$_1$ kaiken omaisuute-nsa?
sell-VA/INF-PX/3SG-Q Pekka told that he.NOM thought-PST.3SG all possessions-PX/3SG
‘Did Pekka told that he thought to sell all his possessions?’

(10) *Finnish LHM is licensed by other elements besides temporal auxiliaries*

a. Myy-dä-kö$_1$ Pekka aiko-o _$_1$ kaikki tavara-nsa?
sell-A/INF-Q Pekka.NOM plan-PRS.3SG all stuff-PX/3SG
‘Is Pekka going to sell all his stuff?’

b. Syö-dä$_1$ Peka-n täytyy _$_1$ kaikki lääkkee-t.
eat-A/INF Pekka-GEN must.0 all medicine-PL.ACC
‘Pekka must eat all the medicine.’

c. Syö-dä-pä$_1$ Pekka e-i halu-a _$_1$.
eat-A/INF-PA Pekka.NOM not-3SG want-A/INF
‘Pekka does not want to eat.’

d. Rakenta-nut-pa$_1$ Pekka o-li _$_1$ pätkän aita-a.
build-PST.PRTCPL-PA Pekka.NOM be-PST.3SG segment fence-PAR
‘Pekka had built a segment of fence.’

At this point we could separate the Finnish phenomenon from the standard LHM family and analyse it as belonging to a third, currently unknown category. I will analyse it as a form of A-bar head movement, specifically a type of predicate clefting by A-bar

movement. Subsequent research found however that properties (i-iv) may be too strong on independent grounds. Embick and Izvorski (1997) showed that in Czech 'Aux + $prtcpl_1$ + $prtcpl_1$' clauses both participles can be fronted, violating (iii). In the same paper they argue that LHM applies in root and non-root environments in Serbo-Croatian and Bulgarian. Rivero (1991) notes that the negation condition (iii) does not apply in all Slavic languages. Absent more detailed analysis, then, I will continue to use the term LHM broadly to refer to any construction in which an infinitival verb moves over the finite element.

2.2.2 Remnant (VP-preposing) analysis

Lema and Rivero (1990) show that LHM contrasts with VP-preposing, which is licensed under different auxiliaries and violates (i-iv). Let us consider the hypothesis that (7-10) exhibit some type of remnant movement.

One problem is that in Finnish it is possible to extract a head that has been sandwiched between two heads (11). In the canonical configuration, the fronted verb *vaatinut-pa* 'requested-PA' (PA = left peripheral C-feature) occurs between the auxiliary and the infinitival verb.

(11) Vaati-nut-pa$_1$ Pekka [o-li[_$_1$ [$_{\alpha P}$ myy-dä myös tämä-n auto-n.]]]
request-PST.PRTCPL-PA Pekka.NOM be-PST.3SG sell-A/INF also this-ACC car-ACC
'Pekka had requested to sell also this car.'

A remnant movement analysis would require us to say that αP escaped from the fronted phrase, implying the existence of some type of infinitival complement clause rightward movement. The second problem concerns auxiliary data, which replicates some of the findings of Lema and Rivero (1990). Pure auxiliary verbs, such as *on* 'is', prohibit VP-preposing (12a) but allow for LHM (12b).

(12) a. *[Myy-nyt tavara-nsa]$_1$ Pekka o-n _$_1$.
sell-PST.PRTCPL stuff-PX/3SG Pekka.NOM be-PRS.3SG

b. Myy-nyt$_1$ Pekka o-n _$_1$ tavara-nsa.
sell-PST.PRTCPL Pekka.NOM be-PRS.3SG stuff-PX/3SG
'Pekka has sold his belongings.'

If (12b) instantiates remnant VP-preposing, then the ungrammaticality of (12a) remains unaccounted for. The third problem concerns the distribution of the Finnish left peripheral particles. When a phrase is moved to a left peripheral Ā-position, a left peripheral particle can be suffixed to the right edge of the moved phrase to generate a yes/no question (13a). Overt phrasal VP-preposing does not exhibit this behavior (13b).

(13) a. [Peka-n tavara-t-ko]$_1$ Merja my-i $_1$?
Pekka-GEN stuff-PL-Q Merja.NOM sell-PST.3SG
'Did Merja sell Pekka's stuff?'

b. *?[My-i Peka-n tavara-t-ko]$_1$ Merja $_1$?
sell-PST.3SG Pekka-GEN stuff-PL-Q Merja.NOM

We cannot therefore unify long head movement, if it were VP-fronting, trivially with phrasal A-bar movement. This weakens the theoretical motivation for the VP-fronting hypothesis.

There is a semantic difference between LHM and VP-preposing. If it is mentioned in the previous discourse that Pekka wants to borrow his car to Merja, then it is possible to say (14a) to make a correction that targets the conceptual content of the verb. The reason the fronted verb triggers corrective interpretation is because the C position is associated with corrective focus/topic in Finnish (Vilkuna 1989, 1995). VP-preposing, however, is not available and does not elicit the same reading. The claim that Finnish A-infinitivals are bare VPs, as assumed here, was proposed by Vainikka (1989).[5]

(14) a. MYY-DÄ$_1$ Pekka halu-si $_1$ auto-n Merjalle, e-i laina-ta.
SELL-A/INF Pekka.NOM want-PST.3SG car-ACC to.Merja not-3SG loan-A/INF
'Pekka wanted to SELL the car to Merja, not to loan it.'

b. ?*[MYY-DÄ auto-n]$_1$ Pekka halu-si $_1$ Merjalle, e-i laina-ta.
SELL-A/INF car-ACC Pekka.NOM want-PST.3SG to.Merja not-3SG loan-A/INF

c. *[MYY-DÄ AUTO-N]$_1$ Pekka halu-si $_1$ Merjalle, e-i laina-ta

SELL-A/INF CAR-ACC Pekka.NOM want-PST.3SG to.Merja not-3SG loan-A/INF

d. MYY-DÄ$_1$ Peka-n täytyy _$_1$ kaikki tavara-nsa, e-i laina-ta.
sell-A/INF Pekka-GEN must.0 all stuff-PX/3SG not-3SG loan-A/INF

e. ??[MYY-DÄ kaikki tavara-nsa]$_1$ Peka-n täytyy _$_1$, e-i laina-ta.
sell-A/INF all stuff-PX/3SG Pekka-GEN must.0 not-3sg loan-A/INF

It is interesting to ask against this background what the semantic function of the fronted VPs in clauses such as (15) could be, provided that they must serve some (most likely interpretative) purpose.

(15) [Myy-dä auto-n]$_1$ Pekka halu-si _$_1$ Merjalle.
sell-A/INF car-ACC Pekka.NOM want-PST.3SG to.Merja
'Pekka wanted to sell the car to Merja.'

Although the semantic intuitions are not as clear as one would hope, the VP is neither contrastive/corrective nor is it in the information focus. The topic is Pekka. The sentence feels redundantly noncanonical. One possibility is that VP-preposing does not involve C-features at all. This is supported by the fact that it is possible to combine movement to SpecCP with VP-preposing (16a-b).

(16) a. ?[Pekka-ko]$_1$ [myy-dä auto-n]$_2$ halu-si _$_1$ _$_2$ Merjalle?
Pekka.NOM-Q sell-A/INF car-ACC want-PST.3SG to.Merja
'Was it to Merja that Pekka wanted to sell the car?'

b. [Halu-si-ko]$_1$ [Merjalle myy-dä auto-n]$_2$ Pekka _$_1$ _$_2$?
want-PST.3SG-Q to.Merja sell-A/INF car-ACC Pekka.NOM
'Was it Pekka who wanted to sell the car to Merja?'

In (16a), the grammatical subject moves to SpecCP to check the yes/no feature, while the infinitival phrase 'to sell the car' is at the preverbal subject position SpecTP. In (16b), the main verb checks the yes/no interrogative feature at C, while the infinitival phase 'to sell the car to Merja' is at the preverbal subject position. This leaves Pekka

into a focus position, which to me provides a felicitous interpretation for this sentence (see the translation). VP-preposing is, therefore, independent of the movement to the C-domain. This position is supported further by properties of Finnish internal *wh*-movement. Constituents of the fronted VP can undergo internal A-bar movement in Finnish. The operation is not semantically idle. When the object is fronted inside the VP, a corrective interpretation that targets the object emerges (17a). This is because operators must perform roll-up movement to the edges of their hosting pied-piped phrases in Finnish (Huhmarniemi 2012). But in such cases the contrast/correction targets the moved DP, not the verb (17a-b).

(17) a. [auto-n$_1$ myy-dä _$_1$]$_2$ Pekka halu-si _$_2$, e-i polkupyörä-ä.
car-ACC sell-A/INF Pekka.NOM want-PST.3SG not-3SG bicycle-PAR
'Pekka wanted to sell the CAR, not the bicycle.'

b. ?*[auto-n$_1$ myy-dä _$_1$]$_2$ Pekka halu-si _$_2$, e-i laina-ta.
car-ACC sell-A/INF Pekka.NOM want-PST.3SG not-3SG borrow-A/INF

These data suggest that we must separate VP-preposing without internal movement, call it "bare VP-fronting," from VP-fronting that comes with internal movement. The latter involves criterial checking of a C-feature inside the moved phrase, while the former does not. This supports further the hypothesis that bare VP-fronting does not check C-features.

To make this argument watertight we must consider one additional possibility, a ping-pong movement analysis (18).

(18) [__$_{1,3}$ myy-dä _$_1$]$_2$ Pekka halu-si _$_2$ auto-n$_3$
sell-A/INF Pekka.NOM want-PST.3SG car-ACC
'Pekka wanted to sell the CAR, not the bicycle.'

According to the ping-pong analysis, the direct object undergoes internal movement to the edge of the VP, which is fronted, after which the direct object escapes to the right, leaving the verb to the fronted position. Ping-pong movement is not generally available

in Finnish, however. Examples in (19) show several hypothetical ping-pong constructions where a phrase moves to the right out of a fronted adverbial (19a), nominal (19b) and adjectival (19c) phrase. They are all ungrammatical.

(19) a. *[$_{AdvP}$__$_{1,3}$ Myy-mällä _$_1$]$_2$ Pekka rikastu-i _$_2$ auto-n$_3$
selling-MALLA Pekka.NOM got.rich-PST.3SG car-ACC
Intended: 'By selling the car Pekka got rich.'

b. *[$_{DP}$__$_{1, 3}$ Myynti-ä _$_1$]$_2$ Pekka harkits-i _$_2$ auto-n$_3$.
selling-PAR Pekka.NOM consider-PST.3SG car-ACC
Intended: 'Pekka considered the selling of the car.'

c. *[$_{AP}$__$_{1, 3}$ myyvän _$_1$ kauppiaan]$_2$ Pekka tapas-i _$_2$ auto-a$_3$
selling.A salesman Pekka.NOM meet-PST.3SG car-PAR
Intended: 'Pekka met a salesman who was selling the car.'

A further difference between VP-fronting and long head movement concerns situations in which the moved infinitival has its own thematic subject, although here the data is less clear. VP-fronting (20b-c) seems marginally possible, long head movement ungrammatical (20a). In the examples (20a-b), the infinitival phrase contains a genitive thematic subject *Merja-n* 'Merja-GEN' which by all syntactic tests resides inside the infinitival 'Merja to sell her possessions'.[6] The canonical structure underlining (20a-c) is illustrated in (20d), in pseudo-English for simplicity.

(20) a. *Myy-dä-kö$_1$ Pekka käsk-i Merja-n _$_1$ omaisuute-nsa?
sell-A/INF-Q Pekka.NOM order-PST.3SG Merja-GEN possessions-PX/3SG

b. ??[Myy-dä(-kö) omaisuute-nsa]$_1$ Pekka käsk-i Merja-n _$_1$?
sell-A/INF(-Q) possessions-PX/3SG Pekka.NOM order-PST.3SG Merja-GEN
'Did Pekka ask Merja to sell her possessions?'

c. ?[Omaisuute-nsa-ko$_1$ myy-dä _$_1$]$_2$ Pekka käsk-i Merja-n_$_2$?
possessions.FOC-PX/3SG-Q sell-A/INF Pekka.NOM order-PST.3SG

Merja-GEN

'Did Pekka ask Merja to sell his POSSESSIONS?'

d. Pekka ordered [Merja.GEN [to.sell her.possessions]]

Finally, local and nonlocal head movement are characterized by the same C-features, the same position, and the same discourse interpretation. The hypothesis that Finnish LHM were an instance of remnant VP-preposing would require a remnant VP-movement analysis also for local head movement or instead force us into assuming that what looks to be the same operation, local and nonlocal head movement, dissolves into two different grammatical processes. Both options would require independent justification to be taken seriously.

I conclude this discussion by noting that the analysis proposed later in this article will handle VP-preposing and long head movement as two distinct phenomena. Long head movement will be analysed as a form of predicate clefting motivated by C-features checked and interpreted semantically at an Ā-position, whereas VP-preposing is considered an idle rearrangement operation that the UG accesses in virtue of its formal architecture.

2.3 Conditions on Finnish LHM

2.3.1 Introduction

This section provides several empirical generalizations that characterize Finnish long head movement. Their relevance to the theory of head movement will be addressed in section 3.

2.3.2 Restriction on long-distance movement of finite elements

While infinitival verbs can be extracted from embedded clauses, finite elements cannot (21).

(21) a. Myy-dä-kö$_1$ Pekka sanoi että hän halua-a _$_1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka claimed that he.NOM want-PRS.3SG all possessions-PX/3SG
'Did Pekka say that he wishes to sell all his possessions?'

b. *Halua-a-ko$_1$ Pekka sanoi että hän _$_1$ myy-dä koko omaisuute-nsa?

want-PRS.3SG-Q Pekka said that he.NOM sell-A/INF all possessions-PX/3SG

c. *E-i-kö$_1$ Pekka sanoi että hän _$_1$ halua myy-dä omaisuut-ta-an?
not-3SG-Q Pekka said that he.NOM want sell-A/INF possessions-PAR-PX/3SG

d. *O-n-ko$_1$ Pekka sanoi että hän _$_1$ halun-nut myy-dä omaisuute-nsa?
be-PRS.3SG-Q Pekka said that he.NOM want-PST.PRTCPL sell-A/INF possessions-PX/3SG

Local T-to-C movement of a finite element is possible (22), so this restriction is limited to situations in which the finite element is moved from an embedded clause.

(22) a. Halua-a-ko$_1$ Pekka _$_1$ myy-dä koko omaisuute-nsa?
want-PRS.3SG-Q Pekka.NOM sell-A/INF all possessions-PX/3SG
'Does Pekka want to sell all his possessions?'

b. E-i-kö$_1$ Pekka _$_1$ halua myy-dä koko omaisuut-ta-an?
not-3SG-Q Pekka.NOM want sell-A/INF all possessions-PAR-PX/3SG
'Does Pekka not want to sell all his possessions?'

c. On-ko$_1$ Pekka _$_1$ myy-nyt koko omaisuute-nsa?
has.3SG-Q Pekka.NOM sell-PST.PRTCPL all possessions-PX/3SG
'Has Pekka sold all his possessions?'

Therefore, these data show that it is not finiteness per se that blocks movement in (21), but finiteness in connection with a locality violation.

2.3.3 Island conditions

Finnish LHM is not possible from adverbials (23a), left branches (23b), relative clauses (23c) or conjuncts (23d). In addition, movement out of an interrogative embedded clause is ungrammatical or marginal (24). LHM therefore resembles A-bar movement, which obeys the same conditions (Huhmarniemi 2012). Holmberg (2016:105) was to my knowledge the first to propose that Finnish head movement involves A-bar movement, an idea I develop in this article as well.

(23) a. *Myy-mällä-kö$_1$ Pekka rikastu-i [_$_1$ koko omaisuute-nsa]?
sell-MALLA-Q Pekka.NOM got.rich-PST.3SG all possessions-PX/3SG
Intended: ‘Was it by selling all his possessions that Pekka got rich?’

b. *Myy-dä-kö$_1$ Pekka tek-i [sopimukse-n _$_1$ koko omaisuute-nsa]?
sell-A/INF-Q Pekka.NOM make-PST.3SG agreement-ACC all possessions-PX/3SG

c. *Myy-dä-kö$_1$ tämä on [paikka jossa voi _$_1$ koko omaisuute-nsa]?
sell-A/INF-Q this is place where can.3SG all possessions-PX/3SG

d. *Osta-a-ko$_1$ Pekka halu-si [_$_1$ ja korja-ta vanha-n auto-n?]
buy-A/INF-Q Pekka.NOM want-PST.3SG and fix-A/INF old-ACC car-ACC

(24) a. ?*Myy-dä-kö$_1$ Pekka kysyi että voi-ko hän _$_1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka asked that can.3SG-Q he.NOM all possessions-PX/3SG

b. *Nukku-a-ko$_1$ Pekka kysyi että kuka aiko-o _$_1$?
sleep-A/INF-Q Pekka asked that who.NOM plan-PRS.3SG

2.3.4 No restrictions on the lexical category of the moved element

I have yet to find a finite or an infinitival verbal form that cannot be fronted. All three finite elements in Finnish (negation, auxiliary and the finite verb) move locally to C (22). A-infinitivals (25a), VA-infinitivals (25b), the participle (25c) and the MA-infinitival (25d) move nonlocally.[7]

(25) a. *A-infinitival*
Myy-dä-kö$_1$ Pekka halu-si _$_1$ kaikki tavara-nsa?
sell-A/INF-Q Pekka.NOM want-PST.3SG all stuff-PX/3SG
‘Did Pekka want to sell all his stuff?’

b. *VA-infinitival*

Myy-vän-sä-kö Pekka usko-i _1 kaikki tavara-nsa?
sell-VA/INF-PX/3SG-Q Pekka.NOM believe-PST.3SG all stuff-PX/3SG
'Did Pekka believe that he was going to sell all his stuff?'

c. *Participle*

Myy-nyt-pä1 Pekka e-i _1 kaikki-a tavaroi-ta-an!
sell-PST.PRTCPL-PA Pekka.NOM not-3SG all-PAR possessions-PAR-PX/3SG
'But Pekka did not sell all his possessions!'

d. *MA-infinitival*

Myy-mässä-pä Pekka o-li _1 vanha-a auto-a-an.
sell-MASSA-PA Pekka.NOM be-PST.3SG old-PAR car-PAR-PX/3SG
'Pekka was selling his old car.'

The deciding factor, therefore, seems to be the presence of an overt C-feature.

2.3.5 LHM is possible only in connection with C-features

LHM is not possible inside infinitivals or phrases that do not project a head able to check C-features. Examples (26-29) show a few possible configurations, all ungrammatical.

(26) *No head dislocation inside adverbials*

a. Pekka yllätti minut [aiko-malla myy-dä omaisuute-nsa.]
Pekka surprised me.ACC plan-MALLA sell-A/INF possessions-PX/3SG
'Pekka surprised me by planning to sell all his possessions.'

b. *Pekka yllätti minut [myy-dä1 aiko-malla _1 omaisuute-nsa.]
Pekka surprised me.ACC sell-A/INF plan-MALLA possessions-PX/3SG

(27) *No head dislocation inside noun phrases*

a. Pekka teki [sopimukse-n myy-dä omaisuute-nsa.]
Pekka made agreement-ACC sell-A/INF possessions-PX/3SG
'Pekka made an agreement to sell his possessions.'

b. *Pekka teki [myy-dä1 sopimukse-n _1 omaisuute-nsa.]
Pekka made sell-A/INF agreement.ACC possessions-PX/3SG

(28) *No head dislocation inside A-infinitival complements*

a. Peka-n täytyy [yrittä-ä myy-dä omaisuute-nsa.]
Pekka-GEN must.0 try-A/INF sell-A/INF possessions-PX/3SG

‘Pekka must try to sell his possessions.’

b. *Peka-n täytyy [myy-dä$_1$ yrittä-ä _$_1$ omaisuute-nsa.]
Pekka-GEN must.0 sell-A/INF try-A/INF possessions-PX/3SG

(29) *No head dislocation inside VA-infinitival complements*

a. Pekka uskoo Merja-n [halua-van yrittä-ä myy-dä omaisuute-nsa.]
Pekka believes Merja-GEN want-VA/INF try-A/INF sell-A/INF possessions-PX/3SG
‘Pekka believes that Merja wants to try to sell her possessions.’

b. *Pekka uskoo Merja-n [yrittä-ä$_1$ halua-van _$_1$ myy-dä omaisuute-nsa.]
Pekka believes Merja-GEN try-A/INF want-VA/INF sell-A/INF possessions-PX/3SG

c. *Pekka uskoo Merja-n myy-dä$_1$ halua-van yrittä-ä _$_1$ omaisuute-nsa.
Pekka believes Merja-GEN sell-A/INF want-VA/INF try-A/INF possessions-PX/3SG

2.3.6 Verum focus interpretation and two auxiliaries

Local movement of a bare auxiliary or negation to the C-position creates a verum focus interpretation, illustrated in (30a-b).

(30) a. E-i$_1$ Pekka _$_1$ myy-nyt omaisuutta-an.
not-3SG Pekka.NOM sell-PST.PRTCPL possessions-PX/3SG
‘Pekka did NOT sell some possessions.’

b. O-li$_1$ Pekka _$_1$ myy-nyt omaisuutta-an.
be-PST.3SG Pekka.NOM sell-PST.PRTCPL possessions-PX/3SG
‘Pekka DID sell some possessions.’

In (30b), there is no implication that the speaker denies the conceptual content of any predicate; instead, the denial targets the truth of the whole proposition. Importantly, when the sentence contains two or more auxiliaries, it is not possible to create these interpretations by moving the nonlocal auxiliary (31).

(31) a. Pekka e-i ol-lut myy-nyt omaisuutta-an.
Pekka.NOM not-3SG had-PST.PRTCPL sell-PST.PRTCPL possessions-PX/3SG
'Pekka had not sold some possessions.'

b. *Ol-lut$_1$ Pekka e-i _$_1$ myy-nyt omaisuutta-an.
had-PST.PRTCPL Pekka.NOM not-3SG sell-PST.PRTCPL possessions-PX/3SG

c. E-i Pekka _$_1$ ol-lut myy-nyt omaisuut-ta-an.
not-3SG Pekka.NOM had-PST.PRTCPL sold-PST.PRTCPL possessions-PAR-PX/3SG
'Pekka had NOT sold his possessions.'

d. Myy-nyt$_1$ Pekka e-i ol-lut _$_1$ omaisuutta-an.
sold-PST.PRTCPL Pekka.NOM not-3SG had-PST.PRTCPL possessions-PX/3SG
'Pekka had not SOLD some of his possessions (he loaned them instead).'

This type of verum focus movement therefore satisfies HMC (Travis 1984). These data show that LHM contrasts with HMC. This contrast can perhaps be rationalized in the following way. When a predicate with an overt left peripheral discourse-motivated C-feature(s) moves to C to create, say, a corrective interpretation, that correction targets the content of the moved predicate, much in the same way as prosodic emphasis can be used in English to focus an *in situ* predicate contrastively. An auxiliary verb, however, does not have enough independent lexical-conceptual content that could be targeted in this way. Therefore, it is possible that the nonlocal effects are connected to the presence of the C-feature on a lexical predicate whose content is targeted for a special C-related interpretation. When the 'C + lexical predicate' complex is missing, for example when the head is an auxiliary, LHM is not possible. I will develop an analysis along these lines in this article.

2.3.7 Movement of an infinitival containing a subject

If the infinitival phrase contains its own thematic subject, long head movement is either ungrammatical or marginal (32-33).

(32) a. *Myy-vän-kö Pekka halu-si Merja-n _$_1$ omaisuutensa?
sell-VA/INF-Q Pekka.NOM want-PST.3SG Merja-GEN possessions-PX/3SG

b. *?Myy-dä-kö Pekka käsk-i Merja-n _1 omaisuutensa?
sell-A/INF-Q Pekka.NOM order-PST.3SG Merja-GEN possessions-PX/3SG

(33) ??Ihail-la-ko Pekka käsk-i poja-n _1 Merja-a?
admire-A/INF-Q Pekka.NOM ask-PST.3SG boy-GEN Merja-PAR
'Did Pekka ask the boys to admire Merja?'

VP-fronting seems marginally possible, although its semantic motivation, as pointed out earlier, is unclear:

(34) a. ??[Myy-vän-kö omaisuute-nsa]$_1$ Pekka halu-si
Merja-n _1 ?
sell-VA/INF-Q possessions-PX/3SG Pekka.NOM want-PST.3SG
Merja-GEN

b. ?[Myy-dä-kö omaisuutensa]$_1$ Pekka käsk-i
Merja-n _1?
sell-A/INF-Q possessions-PX/3SG Pekka.NOM order-PST.3SG
Merja-GEN

This restriction applies to situations in which the subject is part of the infinitival clause. If the thematic subject is part of the main clause, as in (35), long head movement is possible.

(35) Myy-mässä-kö$_1$ Pekka näki Merja-n [_1 vanha-a auto-a?]
sell-MASSA-Q Pekka.NOM saw-PST.3SG Merja-ACC old-PAR car-PAR

2.3.8 Predicate clefting

Finnish long head movement shares certain properties with predicate clefting in Hebrew (Landau 2006) and Spanish (Vincente 2007). Predicate clefting in Hebrew is illustrated by (36).

(36) La'azor, eyn li safek še-Gil hivtiax še-hu ya'azor le-Rina
to-help there-isn't to-me doubt that-Gil promised that-he will-help to-Rina
'As for helping, I have no doubt that Gil promised he would help Rina.'
(Landau 2006:42–43)

Both Finnish LHM and predicate clefting involve Ā-dependencies (nonlocal movement, island effects) and induce discourse effects, focus and topic interpretation in the case of predicate clefting but many more in the case of Finnish C-features (e.g., (3)). There are at least two major differences. Finnish long head movement leaves a gap, whereas Hebrew and Spanish predicate clefting does not. Another difference is that Finnish movement is always associated with overt C-features, whereas the predicate cleft in (36) is a bare infinitival. Despite these differences, the similarities are in my view too striking to be ignored as coincidences. I will analyse the Finnish phenomenon as predicate clefting that employs A-bar head movement instead of overt copying.

3 An analysis

3.1 Theoretical framework

I analyse Finnish long head movement within a standard minimalist EST/Y-architecture which derives phonology-meaning pairs ⟨PF, LF⟩ from a set of lexical items by narrow syntactic operations Merge and Agree followed by a transfer to PF and LF (Chomsky 2000, 2001, 2008; Chomsky, Gallego and Ott 2019). PF and LF diverge at spellout structure into the phonological branch and the semantic branch. Syntactic structure is generated by the application of Merge to syntactic objects α, β, yielding $\gamma = [\alpha, \beta]$. Movement is remerge $\gamma = [\alpha_1 [_\gamma \ldots (\alpha_1) \ldots]]$. The operation is referred to as *phrasal movement* if α is a phrase; *head movement* if α is nonphrasal. It is useful to divide head movement into two separate phenomena, following Harizanov and Gribanova (2018) and Rizzi and Roberts (1989). The first concerns the noncanonical position of the head, illustrated by (37).

(37) Myy-dä-kö$_1$ Pekka aiko-i _$_1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG
'Was Pekka going to sell all his possessions?'

I call this phenomenon *noncanonical head ordering*. Finnish long head movement instantiates noncanonical head ordering in a particularly clear way. Any proposal in which the phenomenon is deemed illusory in the sense that no actual head dislocation has taken place (see Embick and Izvorski 1997 for an example) can, in my view, be ruled implausible.[8] On the other hand, the fronted head is a complex unit consisting of the verbal root *myy-* 'sell', A-infinitival suffix *-(t)A* and the yes/no clitic *-kO*. How these

morphemes have been assembled inside one phonological word constitutes a potentially independent issue (Harizanov and Gribanova 2018). I call this the *problem of morphological decomposition*. Whether morphological decomposition is syntactic cannot be determined trivially from the data reported so far.

Given this background, I will focus the inquiry into three possible approaches to head movement.

The first models noncanonical head ordering and morphological decomposition as one syntactic operation that collects morpheme pieces from the syntactic structure in an iterative roll-up operation and bundles them into complex heads. The resulting complex heads are interpreted as phonological words inside the phonological branch. This approach goes back to Koopman (1984), Travis (1984) and Baker (1988), with a recent analysis that is particularly relevant to the data reported in this article provided by Roberts (2010), discussed further below. It follows that syntax must be furnished with a remerge operation [[α_1, β] [$_{\gamma P}$. . . (α_1) . . .]]. Matushansky (2006) proposed a variation, in which the nonstandard features of the roll-up head movement were eliminated at the expense of increasing the computational power in the phonological branch. Under Matushansky's analysis, head movement is cyclic remerge [α_1 [$_{\gamma P}$ γ^0 . . . (α_1) . . .]] while α is coalesced with an adjacent head γ inside the phonological branch by an operation called m-merger. A radical alternative is that both noncanonical ordering and morphological decomposition are a matter of the phonological branch (see Chomsky 2001, Platzack 2013, Schoorlemmer and Temmerman 2012). Harizanov and Gribanova (2018), developing an earlier proposal by Rizzi and Roberts (1989), argue that morphological decomposition takes place inside the phonological branch while noncanonical head ordering takes place in narrow syntax. I will explore Finnish long head movement from the point of view of these theoretical alternatives.

3.2 Head reconstruction

3.2.1 Noncanonical ordering in the phonological branch?

Let us consider whether noncanonical head ordering could take place inside the phonological branch, as proposed by Chomsky (2001), Platzack (2013) and Schoorlemmer and Temmerman (2012). The assumption would be that the fronted heads are still at their canonical positions at spellout and are dislocated inside the phonological branch and/or at the syntax-phonology interface. The evidence, I think,

shows that this is unlikely. Finnish noncanonical head ordering is regulated by structural constraints such as islands, presence/absence of arguments, embedding, C-features and the number of auxiliary verbs, among other syntactic properties. This supports the first half of Harizanov and Gribanova's thesis (2018) which hypothesizes that noncanonical head ordering is syntactic.

3.2.2 Morphological decomposition in the phonological branch?

Next we examine whether the phonological branch could map heads, if they are first arranged into appropriate local configurations in syntax, into phonological words. Matushansky (2006), building on Toyoshima (2000, 2001), suggests that heads are bundled into phonological words by a postsyntactic m-merger operation bleeding a syntactic spec-head configuration. Harizanov (2019) and Harizanov and Gribanova (2018), building on an earlier proposal by Rizzi and Roberts (1989), assume that the phonological branch performs amalgamation that combines two structurally adjacent heads into a single word. Holmberg (2016) assumes that Finnish head movement involves movement of a complex head to the SpecCP (his SpecFocP) position, a position at which it could be targeted by m-merger, although the details are left unspecified.

The hypothesis that the C-morpheme in Finnish is attached to its host in the phonological branch from two adjacent heads runs into a problem with phrasal movement. The exact same C-features occur in connection with virtually any word inside a phase pied-piped to SpecCP (see Huhmarniemi 2012, Holmberg 2014). Consider (38a-e) and the checking configuration (39) that is overtly involved in all examples like this.[9]

(38) a. [Peka-n omaisuuden-**ko**] Merja aiko-i myy-dä_1?
Pekka-GEN possessions-Q Merja.NOM plan-PST.3SG sell-A/INF
'Was it Pekka's possessions that Merja planned to sell?'

b. [Peka-n-**ko** omaisuuden] Merja aiko-i myy-dä _1?
Pekka-GEN-Q possessions Merja.NOM plan-PST.3SG sell-A/INF
'Was it Pekka's possessions that Merja planned to sell?

c. [Peka-n isä-n-**kö** omaisuuden] Merja aiko-i myy-dä _1?
Pekka-GEN father-GEN-Q possessions Merja.NOM plan-PST.3SG

sell-A/INF

'Was it Pekka's FATHER's possessions that Merja planned to sell?'

d. [Peka-n nuoremman-**ko** veljen] Merja tapas-i _1?
Pekka-GEN younger-Q brother Merja.NOM met-PST.3SG?
'Was it Pekka's YOUNGER brother that Merja met?'

e. Aiko-i-**ko** Merja _1 myy-dä Peka-n omaisuuden?
plan-PST.3SG-Q Merja.NOM sell-A/INF Pekka-GEN possessions
'WAS Merja planning to sell Pekka's possessions?'

The checking configuration for (38a-d) is (39), in which a head inside the pied-piped phrase XP is checked by corresponding C-features.

(39) [$_{XP}$ …H(ko-han…) …] C(Q…)…
…H^0-*kO-han* (-*kO-han*)

The checked features do not need to occur at any specific position inside XP, such as at its head. Let us consider the adjacent head analysis. According to it, H^0 (the host stem) and Q (C-feature) correspond to two separate but adjacent heads, say H^0 and Q^0. The problem is that because the C-features are not tied to any lexical category, the data requires a plethora of selection rules such as QP → Q + DP, QP → Q + NP, QP → Q + AP, QP → Q + Num, QP → Q + QP, DP → D + QP, NP → N + QP, and so on. We must write these rules for all C-features (e.g., (3)) and furthermore find some way to capture the observation that if one of these heads occur in connection with some head, then they must all occur in connection with the same head. Further rules are required to correlate phrase-internal C-elements with the features of the sentence-initial C head responsible for clause typing and selection. These complications can be avoided by a criterial checking analysis: one element inside the pied-piped phrase, no matter what its lexical category, hosts all C-features; these features are related to clause-typing and other C-features, not to phrase-internal heads; almost any head can carry them as long as they are all carried by one head. Thus, the simplest way to capture (38) is, arguably, (39). This mechanism was implemented in the formal analysis proposed later in this article.

This leaves us with the possibility that the word-internal morphemes A/INF, v and V are amalgamated in phonology. Example (40) shows what the syntactic spellout configuration would look like under one such analysis. We are assuming that the T-v-V complex moves to C^0 and the Q-morpheme is handled in syntax, but the package marked with ⌊——⌋ is bundled in phonology.

(40)	Myy-kö$_1$	Pekka	[T [v [V	auto-n	Merjalle?]]]
	sell.PRS.3SG-Q	Pekka.NOM	⌊——⌋	car-ACC	to.Merja

This analysis presupposes, however, that prior to phonological amalgamation some operation evacuates all phrasal elements from all positions between the amalgamated heads. Consider, for example, the following Finnish noncanonical OVS sentence (41)(discussed at length by Holmberg & Nikanne 2002, whose analysis I follow here).

(41)	Tämä-n	auto-n	my-i	Pekka	Merjalle.
	this-ACC	car-ACC	sell-PST.3SG	Pekka.NOM	to.Merja
	‘As for this car, it was sold by Pekka to Merja.’				

The postverbal subject remains (or at the very least, can remain) at SpecvP while the direct object is topicalized. The configuration ‘T-DP-v-V’ prevents amalgamation between T and v unless the subject DP is evacuated prior to the operation or unless the amalgamation operation is possible over a distance. The latter solution overgeneralizes unless restricted in some fashion, whereas the former solution requires that we evacuate all intervening elements by some operation that remains to be specified. While it is possible to pursue both options, it seems to me that neither analysis leads automatically to a simpler theory.

In conclusion, then, giving up the standard theory does not lead automatically into a more elegant alternative. This leads me to believe that when it comes to the phenomena analysed in this article, the safest bet for the time being is to assume the standard theory.

3.2.3 Roberts (1993, 2010) and Holmberg (2016)

I will assume from now on that head movement is a narrow syntactic operation creating and operating with syntactically complex heads. Finnish data supports, furthermore, the hypothesis that we must make room for A-bar head movement. This position is argued for by Roberts (2010:193-212) on the basis of predicate clefting in other languages, all exhibiting the A-bar signature, and it was first suggested by Holmberg (2016:105) for

Finnish, but without detailed analysis.[10] I will provide an analysis in this article. The discussion is divided into two segments. The first presents the key analytical principles and shows how they are supported by the data. The second presents the formalization. This division is motivated by the fact that the formalization was implemented as a computer program and therefore involves technical assumptions as well as substantial amount of code and raw data that are necessary for performing the calculations but are not essential for the main hypothesis.

3.3 Condition on head reconstruction

My analysis builds on the Roberts-Holmberg hypothesis according to which narrow syntax contains a head movement component that performs A-bar movement. I approach the problem within the standard Y-architecture but depart from it by defining a notion of head chain that links complex heads with reconstructed gap(s). Chains as such are directionless and can be modelled from either perspective.

Suppose that the phonological branch presents syntax with complex words $(H_1(H_2, \ldots))^0$ containing morphemes H_1, H_2, …. in some form that minimally preserves the order of the morphemes inside the phonological word in the input. Suppose, in addition, that the highest head H_1^0 is merged to the structure on the basis of its position in the input, while the residuum $(H_2\ldots)^0$ reconstructs. These assumptions are illustrated in (42).

(42)

Myy-dä-kö	Pekka	halua-a	_1	koko	omaisuute-nsa?
sell-A/INF-Q	Pekka	want-PST.3SG		all	possessions-PX/3SG
Q(__)^0			A/INF(V)^0		

Notice, in particular, how the highest morpheme Q is merged to a position indicated by the surface string while the rest is reconstructed. At this point we do not examine how the input configuration is created but assume that it is; this matter will occupy us in section 4. With these assumptions in place, I propose (43) for deriving all the head reconstruction data.

(43) *Head reconstruction*

Head $(H_1, \ldots)^0$ is reconstructed from $(H_0\ (H_1,\ldots))^0$ into position X, $\{_{XP}X, \alpha P\}$, such that:

(A) the reconstructed head $(H_1, \ldots)^0$ satisfies selection at position X, and
(B) X is the first position satisfying condition (A) reached by a top-down search starting from the position of the complex head and entering α in $\{_{\alpha P}\ \alpha\ \beta\}$ if α is complex, otherwise β. If α is a barrier, the search terminates.

Let us notice few things about (43) before looking at the data. The principle is provided in English and is therefore ambiguous in a number of ways. I adopted a methodological framework in this study in which the formalization is provided in a machine-readable way and thus it exists in the form of a computer code. Analysis (43) expresses the main idea of the algorithm and allows us to abstract away from the implementation details.

The principle involves no movement triggers, such as uninterpretable probe-features. This is because the input to (43) is a structure where all syntactic objects are already at their final spellout positions. Head reconstruction can therefore be triggered by the fact that the object arriving from the phonological system is a complex head. The analytic problem is, instead, to find the gaps. Similarly, there are no probe-goal relations that define chains; rule (43B) prevents search from entering left branches and left/right adjuncts and captures a notion of minimal top-down search that constitutes the core of what I will use to replace the standard locality metric. It will also derive several island conditions.

Rule (43B) requires that the search follows labelling until either there is nothing left or a barrier is encountered. Barriers terminate search at certain heads on the basis of their feature content (called "feature intervention" at the level of implementation). This notion is required to simulate some island effects and to distinguish HMC-compliant movement from the Finnish LHM.

In every example cited in this article the fronted head must be reconstructed into a gap in which it could be selected by a higher head. This gives the correct notion of head gap in the dataset. Consider the three possible reconstruction positions in (44a-c), marked by $\__1$.

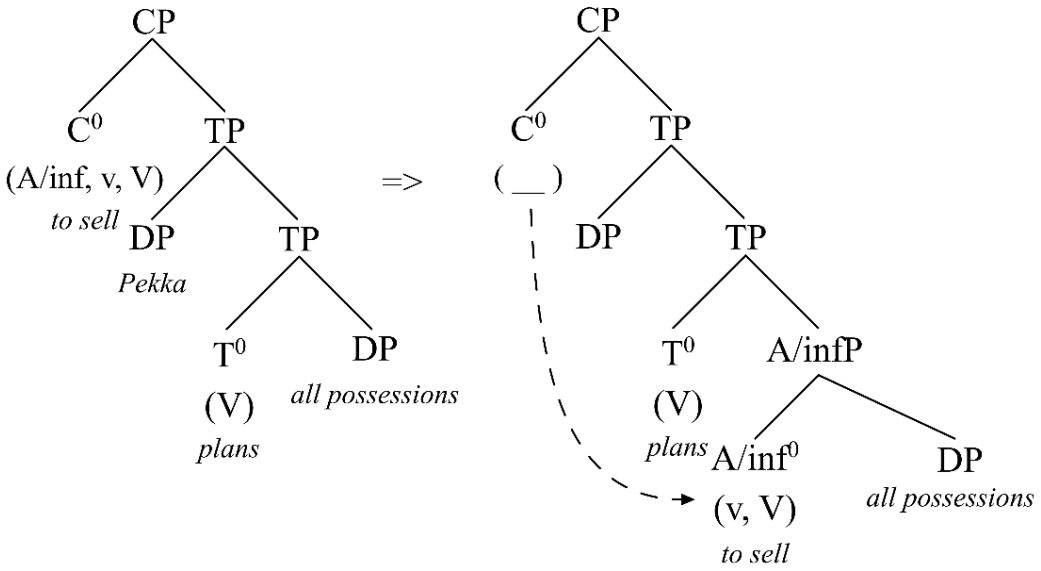
(44) a. Myy-dä-kö$_1$ Pekka aiko-i $\__1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG
'Was Pekka going to sell all his possessions?'

b. Myy-dä-kö$_1$ Pekka $\__1$ aiko-i koko omaisuute-nsa?
sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG

c. Myy-dä-kö$_1$ Pekka aiko-i koko omaisuute-nsa _$_1$?
sell-A/INF-Q Pekka.NOM plan-PST.3SG all possessions-PX/3SG

The first head requiring reconstruction is *myy-dä* (A/INF(v, V))^0. The correct gap position is the one where it can be selected by the finite verb *aikoa* 'plans', satisfying rule (43A). In (44b), the reconstructed head is selected wrongly by the finite/interrogative C, so this position is ruled out. Example (44c) is ruled out by (43B): the first position is closer to the starting point. Once the first gap is correctly targeted, (v, V)^0 can be extracted from A/inf(v, V)^0 and V from (v, V)^0 by the same operation. The first step is illustrated in (45).

(45)



Rule (43B) requires search to follow selection. This prevents reconstruction into left branch phrases (subjects and left adjuncts) and right adjuncts, as shown in section 2.3.3 and (46). It correctly rules out (46a-b) and allows (46c).

(46) a. *Myy-dä-kö$_1$ [Peka-n sopimus _$_1$ omaisuus] oli väärennös?
sell-A/INF-Q Pekka-GEN agreement.NOM possession was fake
Intended: 'Was Pekka's agreement <u>to sell</u> the possessions a fake?'

b. *Myy-dä-kö$_1$ [Peka-n aiko-essa _$_1$ omaisuut-ta] tapahtui virhe?
sell-A/INF-Q Pekka-GEN plan-ESSA possession-PAR occurred error
Inteded: 'Did an error occurred while Pekka was <u>selling</u> the possessions?'

c. Myy-dä-kö$_1$ [Pekka [aikoi _$_1$ kaiken omaisuute-nsa]]?

sell-A/INF-Q Pekka.NOM planned all possessions-PX/3SG
'Was Pekka going <u>to sell</u> all his possessions?'

This implements a version of the minimal search posited in Chomsky (2008:146) but interprets it as a reconstruction process that is implemented as a literal search procedure. The operation descends the projectional spine of the phrase structure in an effort to sanitize it from complex heads.

Consider the restriction on reconstructing finite verbs into embedded clauses, shown in (47) and discussed in section 2.3.1.

(47) a. Myy-dä-kö$_1$ Pekka sanoi että hän halua-a $_1$ koko omaisuute-nsa?
sell-A/INF-Q Pekka claimed that he.NOM want-PRS.3SG all possessions-PX/3SG
'Did Pekka said that he wishes to sell all his possessions?'

b. *Halua-a-ko$_1$ Pekka sanoi että hän $_1$ myy-dä koko omaisuute-nsa?
want-PRS.3SG-Q Pekka said that he.NOM sell-A/INF all possessions-PX/3SG

c. *E-i-kö$_1$ Pekka sanoi että hän $_1$ halua myy-dä koko omaisuut-ta-an?
not-3SG-Q Pekka said that he.NOM want sell-A/INF all possessions-PAR-PX/3SG

d. *O-n-ko$_1$ Pekka sanoi että hän $_1$ halun-nut myy-dä koko omaisuute-nsa?
is-PRS.3SG-Q Pekka said that he.NOM want-PST.PRTCPL sell-A/INF all possessions-PX/3SG

Examples (47b-d) have the property that the first position where the finite verb could be selected is in the main clause, as shown in (48). The 'intended' but unreachable position is marked by X, the wrong local position targeted by the model by $_1$.

(48) a. *Halua-a-ko$_1$ Pekka $_1$ sanoi että hän X myy-dä koko omaisuute-nsa?
want-PRS.3SG-Q Pekka said that he.NOM sell-A/INF all

possessions-PX/3SG

b. *E-i-kö$_1$ Pekka _$_1$ sanoi että hän X halua myy-dä koko omaisuut-ta-an?
not-3SG-Q Pekka said that he.NOM want sell-A/INF all possessions-PAR-PX/3SG

c. *O-n-ko$_1$ Pekka _$_1$ sanoi että hän X halun-nut myy-dä koko omaisuute-nsa?
be-PRS.3SG-Q Pekka said that he.NOM want-PST.PRTCPL sell-A/INF all possessions-PX/3SG

If the head can only be fitted into the first position where it can be selected, then the lower positions are never targeted. The same phenomenon can be seen in examples in which an infinitival verb could be reconstructed either to the main clause or into an embedded clause. The lower site is not accessible (49) if a higher site exists.

(49) a. *?Myy-dä-kö Pekka pyysi _$_a$ että Merja-n täytyy _$_b$ koko omaisuute-nsa?
sell-A/INF-Q Pekka asked that Merja-GEN must.0 all possessions-PX/3SG
(Higher site available because *pyysi* + *myydä* 'to ask to sell' is possbile.)

b. Myy-dä-kö Pekka sanoi X että Merja-n täytyy _$_b$ koko omaisuute-nsa?
sell-A/INF-Q Pekka said that Merja-GEN must.0 all possessions-PX/3SG
(Higher site unavailable because *sanoi* + *myydä* 'say + to sell' is not possible.)

Similar examples can be created by using A-infinitivals (50), which I find marginal.

(50) ??Lähte-ä-kö$_1$ Peka-n täytyy halu-ta _$_1$ mukaan?
leave-A/INF-Q Pekka-GEN must.0 want-A/INF with.us
'Pekka must want to LEAVE with us?'
(Higher site available because *täytyy* + *lähteä* 'must leave' is possible.)

Let us consider the ban on head movement inside infinitivals, as shown in (51).

(51) a. Peka-n täytyy [yrittä-ä myy-dä omaisuute-nsa.]
Pekka-GEN must.0 try-A/INF sell-A/INF possessions-PX/3SG
'Pekka must try to sell his possessions.'

b. *Peka-n täytyy [myy-dä$_1$ yrittä-ä _$_1$ omaisuute-nsa.]
Pekka-GEN must.0 sell-A/INF try-A/INF possessions-PX/3SG

Rules (43A) and (43B) are satisfied by the head chain in (51b), but the clause is ungrammatical. This follows from the analysis however because reconstruction leaves the highest morpheme into the position where it was encountered in the input. Applying the analysis to (51b) produces (52), which is rejected and correctly judged ungrammatical due to the multiple selection violations.

(52) *Peka-n täytyy [A/INF myy- A/INF yrittä- omaisuute-nsa].
Pekka-GEN must.0 to sell to try possessions-PX/3SG

If, on the other hand, the moved infinitival comes with a C-feature, then that feature will generate a corresponding null C head in situ, which violates the selection requirements of the modal verb.

3.4 Long head movement and genitive subjects

Movement of an infinitival verb over its own thematic subject when the subject is part of the infinitival clause is impossible or produces marginal sentences (53)(section 2.3.8).

(53) *?Myy-vän-kö$_1$ Pekka usko-i Merja-n _$_1$ omaisuutensa?
sell-VA/INF-Q Pekka.NOM believe-PST.3SG Merja-GEN possessions-PX/3SG

Genitive DPs differ from nominative, accusative and partitive DPs in that the former, unlike the latter, cannot occur in noncanonical postverbal positions (Brattico 2016).[11] The chain creation algorithm (43) reconstructs the infinitival to the position shown in (54), which leaves both DP arguments into their postverbal positions. The genitive DP cannot reconstruct into SpecvP from this position and the result does not survive LF legibility.

(54) C(Q) Pekka uskoi -vÄn v myy- [$_{DP}$Merja-n omaisuute-nsa]
C(Q) Pekka believed VA/INF v sell Merja-GEN possessions-PX/3SG

Thus, the genitive data is captured if we assume an independently motivated principle of Finnish which bans rightward movement of genitive arguments.

3.5 Head movement constraint

The head movement constraint (HMC) is not explicitly stated in the analysis. Finnish Neg-to-Force movement is, however, constrained by HMC. Example (55a) shows that the negation can adjoin to the high complementizer *että* 'that', but the operation is not possible if an interrogative intervenes (55b-c).

(55) a. Pekka sanoi ett-e-i_1 hän $\__1$ myy kaikkia tavaroi-ta-an.
Pekka said that-not-3SG he.NOM sell all stuff-PAR-PX/3SG
'Pekka said that he will not sell all of his possession.'

b. Pekka kysyi että miksi hän e-i voi myy-dä kaikkia tavaroi-ta-an.
Pekka asked that why he.NOM not-3SG can sell-A/INF all stuff-PAR-PX/3SG
'Pekka asked why he could not sell all of his possessions.'

c. *Pekka kysyi ett-ei$_1$ miksi hän $\__1$ voi myy-dä kaikki-a tavaroi-ta-an.
Pekka asked that-not why he.NOM can sell-A/INF all-PAR stuff-PAR-PX/3SG

HMC is also attested in verum focus and polarity focus constructions in Finnish (section 2.3.7). There is a possible generalization behind these observations. The high complementizer in (55) is higher than C, thus it does not express C-features (section 2.1). Moreover, I have yet to find an instance of nonlocal head movement in connection with any head besides those expressing overt C-features. Assuming Finnish verum focus or polarity focus does not target the conceptual content of the moved predicate, the facts are compatible with a hypothesis that only C-features are involved in LHM. In addition, both HMC-compliant head movement and the core instances of A-movement target the closest head or the closest phrasal position, respectively, suggesting strict locality. Furthermore, the reason we do not see LHM in a language such as English

could be because English verbs do not carry C-features (only phrases do). The same reasoning applies to the more formal V2-phenomenon characteristic of some Germanic languages, which is not involved in checking discourse features. To separate formal T-to-C movement from the discourse motivated operation targeting the conceptual content of the moved predicate, I will use the term C*-feature in the case of the latter. Provided these background assumptions, we can then note that rules (43A) and (43B) apply also to local head movement: the head is reconstructed into a position selected by the higher head and search follows labelling and targets the first position available. From this point of view the difference between HMC and LHM is that the former cannot skip heads. Following this analysis, I assume that every head constitutes a barrier for head movement with the exception of movement triggered by C*-features. Thus, the notion of barrier in the rule (43B) will be relativized with respect to the features triggering the operation. This hypothesis is mirrored at the level of implementation, where I assume that C*-features are processed by a special purpose operator-variable module handling all features of this type, whether they appear in connection with phrases or heads.[12]

3.6 Arguments and heads

One complication is presented by examples of the type (56).

(56) [Myy-kö$_1$ [Pekka _$_1$ omaisuute-nsa?]]
sell.PRS.3SG-Q Pekka.NOM possessions-PX/3SG
C(T,v,V)^0

The chain creation algorithm (43) yields (57).

(57) [Myy-kö$_1$ [_$_1$ [Pekka omaisuutensa?]]]
sell.PRS.3SG-Q Pekka.NOM possessions-PX/3SG
C(__)^0 T(v,V)
└──────┘

The problem is that T will have no subject, leaving its EPP feature unchecked (for Finnish EPP requirement, see Holmberg and Nikanne 2002). We can solve this issue by assuming that a finite head requiring a mandatory specifier (=checking of the EPP feature) must be reconstructed into a position in which it satisfies the rule (43A) *and* its own EPP requirement. T now descends into the correct position below the subject (58).

(58) C^0(__) [Pekka] T^0(v,V)

This condition, which was added to the notion of selection in the rule (43A), derives (57) and many examples of its kind in the dataset. The problem, though, is that now the chain creation algorithm can end up finding no acceptable solution. This happens for example if the grammatical subject occurs in a noncanonical position, say further to the right. To solve this issue, I assume a last resort principle which reconstructs the head locally (e.g., C(T) → [C [T…]]) if no legitimate position is found.

In sum, then, rule (43) seems to suffice the derive the data. On the other hand, the hypothesis must ultimately be justified by a chain of deductive steps linking it with the observations, not by informal sketching.[13] This matter is addressed in the next section.

4 Formalization and testing

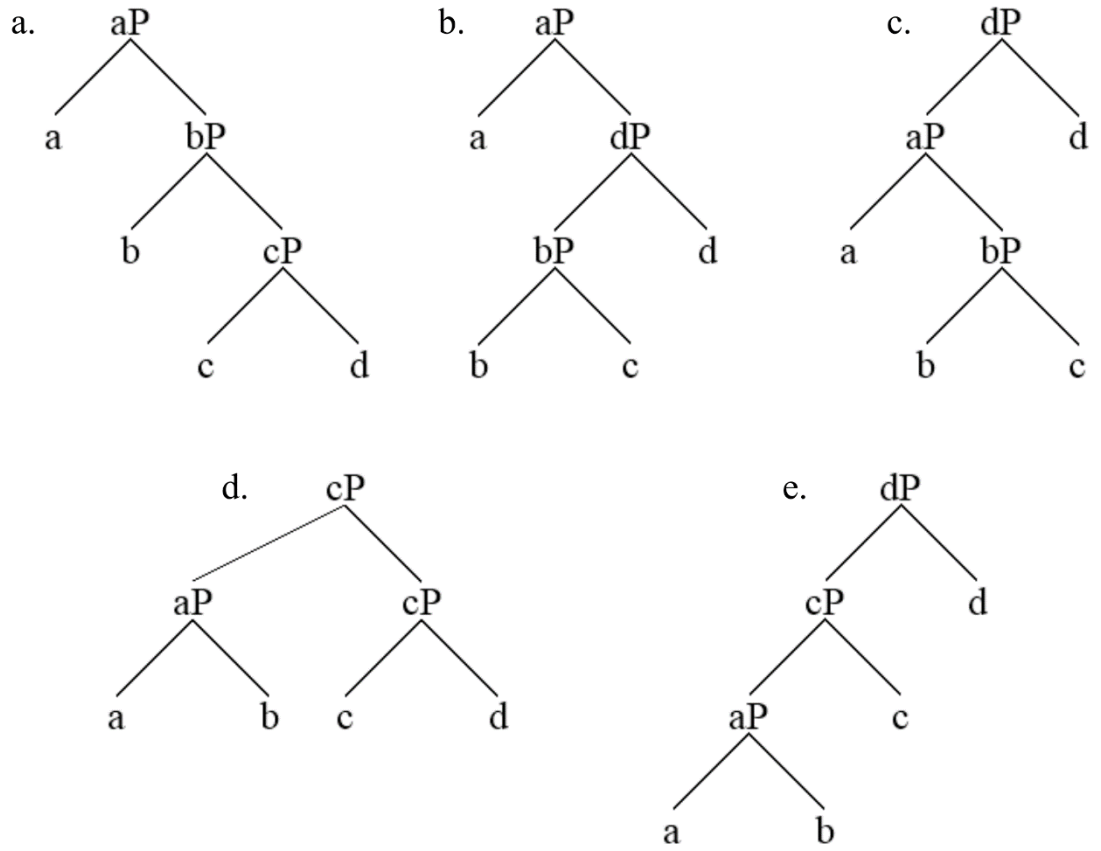
4.1 The model

The analysis was formalized as a Python program and tested over a set of test sentences. This section describes the formalization; simulation experiments are described in section 4.2.

There are two ways to use deductive calculation for the justification of a linguistic hypothesis or theory. One is to write an algorithm that enumerates expressions and/or structural analyses and then verifies that the output set is correct. This would correspond to a literal generative grammar. The second method, adopted here, is to formalize the theory as a recognition algorithm that decides of any input sentence whether it is grammatical or not and, if the former, provides it with a set of structural analyses and semantic interpretation(s). The second method is arguably easier to use than the first because it allows one to test the input sentences in isolation without generating anything else, but the tradeoff is that it requires a parser.

The parser used in this study maps linear strings of phonological words incrementally into a set of binary bare phrase structure objects called spellout structures which preserve the linear order of the input string under a left-to-right depth-first linearization algorithm.[14] To illustrate, an input string $a * b * c * d$ containing empty ad hoc lexical items *a*, *b*, *c* and *d* is mapped into a set of phrase structure objects shown in (59a-e).

(59)

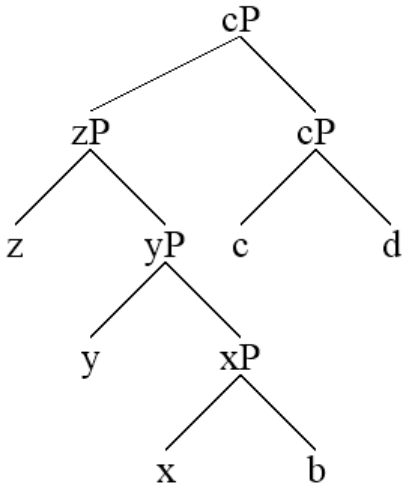


Structures (59) are asymmetric binary branching bare phrase structure objects with labels determined by a recursive top-down labelling algorithm.[15] The output of the labelling algorithm is explicit in all output produced by the algorithm, as it is in (59). If the input word is complex, it is first decomposed by using a surface vocabulary which maps phonological material from the input into morphological decompositions and lexical items (e.g., *admires* → V#v#T#3sg). These will eventually appear in narrow syntax as complex heads presupposed by (43). Complex heads are marked in the output of the algorithm by $H(X, Y, \ldots))^0$, with X, Y, ... being contained inside H^0, in that order.

All elements will appear at their surface positions at any given spellout structure (e.g., 59). For example, an interrogative pronoun will occur at a fronted position in a language that exhibits *wh*-movement. The algorithm will reconstruct elements occurring at noncanonical positions to their canonical positions by creating top-down chains. The operation is called *transfer*. The head reconstruction rule (43) posited in this article

takes place during transfer. It takes the input structure and extracts individual lexical items out of complex heads by using an algorithmic version of (43). To illustrate, we provide *a* with an ad hoc decomposition *x#y#z* in the surface vocabulary and use solution (59d) as a seed, which yields (60).

(60)

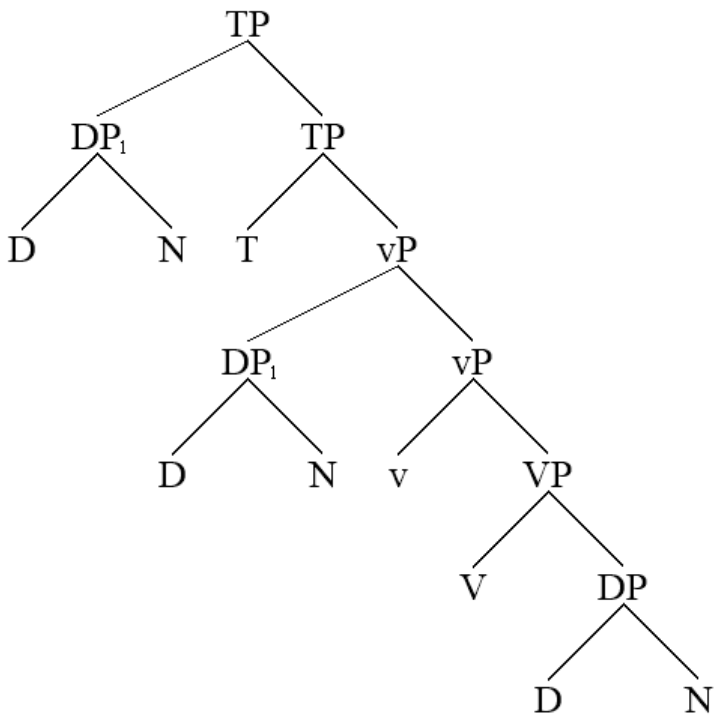


Since these ad hoc lexical items do not have any features, let alone selection features, reconstruction adopts the last resort option (section 3.6). The result would have been the same however had we provided in the lexicon that *z* selects *y* and *y* selects *x*. Notice that *b* is pushed downwards as the new heads populate the structure. This follows from (43).

Once all transfer operations are done, an LF legibility test is performed that filters out uninterpretable solutions (e.g., from the set 59). For example, **John admires* does not pass LF legibility because a mandatory lexical selection feature of the verb is not satisfied in any candidate solution arriving from the spellout structure to LF via transfer. A structure that passes LF legibility is *accepted*; a structure that does not is *rejected*. Accepted solutions constitute the final set of analyses provided by the algorithm; if the set is empty, the input is judged ungrammatical.

Let us consider a more realistic example, derivation of *John ∗ admires ∗ Mary*, with the lexical items supplied with realistic decompositions and selection features (e.g., *admires* ~ admire#v#T#3sg). The algorithm produces (61) as output.

(61)



The ultimate primitive lexical items (e.g., D, N, T, v, V) are sets of features, the most important features being the lexical category and selection features targeting the lexical categories of complements and specifiers as provided by the labelling algorithm. Both *John* and *Mary* are decomposed into D#N and extracted into [D(_$_1$) N_1] by (43), with D selecting N. The finite verb *admires* is decomposed into T-v-V, with T, v and V being primitive items, again selecting each other in the manner illustrated in (43). The grammatical subject is reconstructed from SpecTP into SpecvP. The spellout structure from which (61) is created by the application of (43) and phrasal reconstruction is shown in (62).

(62) *John* * *admires* * *Mary* (Input string)
[D(N) ^{0} [T(v, V)^0 D(N)^0]] (Spellout structure, input to the analysis)

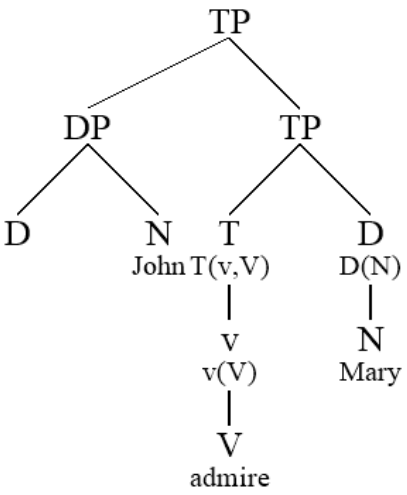
Let us consider the internal structure of the complex heads themselves. All algorithms that apply syntactic rules to grammatical objects must determine whether the targeted object is a head or phrase. I adopted (63) for this purpose.

(63) *Definition for phrasal constituent*

α is a phrasal constituent (hence in the domain of phrasal syntactic rules)
if and only if it has two daughters; otherwise it is primitive.

A primitive lexical item is not phrasal in virtue of having zero daughter constituents. Thus, *a*, *b*, *c* and *d* in the example (59) are treated as primitive constituents, while *a*P, *b*P, *c*P and *d*P are phrasal constituents, having two constituents each. Complex heads are nonphrasal constituents that are not terminal, thus they must have exactly one daughter (=the constituent it contains). The rule applies iteratively.[16] These daughters are visible in the output of the algorithm, as shown in (64) which represents the spellout structure for the input sentence *John admires Mary*.

(64)



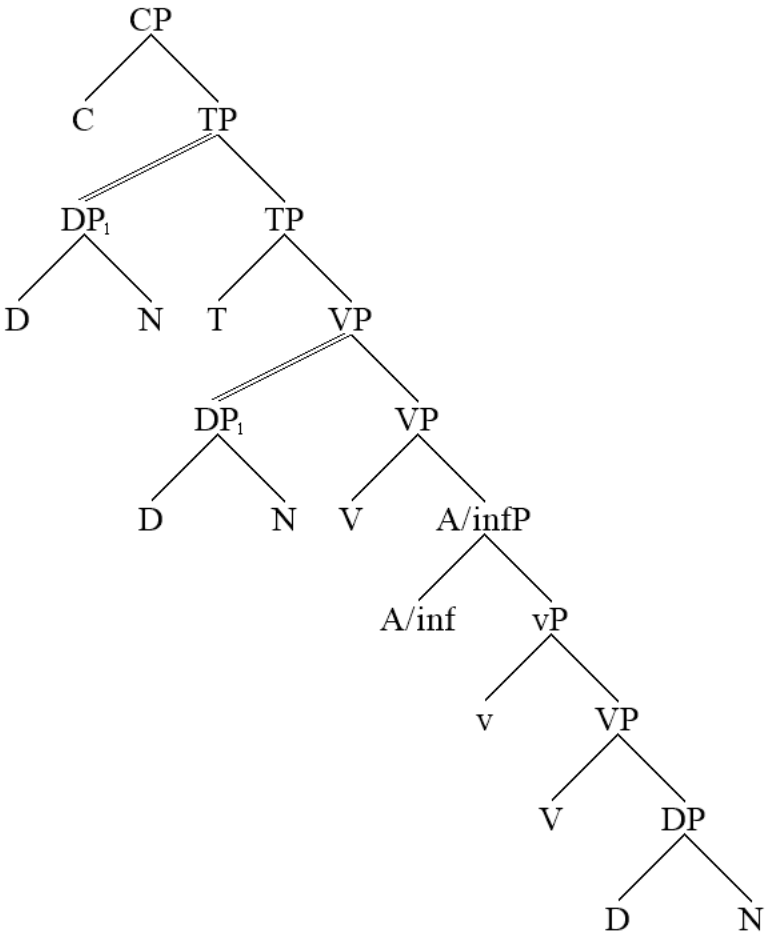
For the purposes of the analytical principle (43), however, any system could do as long as it satisfies two conditions: (i) it must create complex syntactic heads and (ii) preserve the linear order of the morphemes in the input. If (i-ii) are satisfied, rule (43) works as intended. Thus, (62) is not essential when evaluating (43), but it is necessary in the sense that some concrete formalization must be adopted for testing purposes.

We can now run the model with input sentences that involve head reconstruction as defined by the rule (43). Example (65) illustrates the output of the algorithm in the case of a complex long head movement construction in Finnish, where C/op stands for any C*-feature and is provided by the surface vocabulary (i.e., contrastive focus, yes/no

question, familiarity particle, see (3)). (66) is based on the raw image generated by the algorithm.

(65) Myy-dä$_1$-kö Pekka halua-a _$_1$ omaisuute-nsa?
sell-A/INF-Q Pekka.NOM want-PRS.3SG possessions-PX/3SG
'Pekka wants to SELL his possessions?'

(66)



The heads (and phrases) have been reconstructed correctly. The internal part of the complex head C(A/inf, v, V) is correctly reconstructed below the main verb V, and so on, iteratively, until no complex heads exist. Moreover, (66) is the only solution returned by the algorithm; all other derivations were rejected.

The model is described in more detail in the Appendix. The simulations, when applied to a set of test sentences covering all empirical materials discussed in the present article plus others, are discussed in next section. Before discussing the

simulations, however, I will touch upon an important theoretical matter raised by an anonymous *LI* reviewer.

The phrase structure objects generated by the inverse algorithm (e.g., 61, 66) resemble or are for the most part identical to those coming out of the standard cyclic engine. This raises the question of whether the direction of the derivation matters at all. In one sense it does not. The standard theory as well as the present model define grammatical dependencies that are inherently directionless. I consider that it does not matter which way the dependencies are defined as long as they are the correct dependencies. It does not follow, however, that the inverse of the present model corresponds to any specific bottom-up theory available in the current literature (or vice versa). I will illustrate this point next.

Let us consider the phase theory as an example. The notion of phase plays a fundamental role in the minimalist architecture of language proposed in Chomsky 2000, 2001 and beyond, and it operates also in Robert's (2010) analysis of the A-bar head movement. The essence of the phase theory is that the derivation is broken down into independent grammatical packets. These packets are called phases. The architecture is further regulated by the phase-impenetrability condition, which renders the phases inaccessible for future operations. The derivation effectively forgets its past, one phase at a time. What the phases are is an empirical question, but for the purposes of the present discussion we can follow Chomsky 2000, 2001 and include at least CPs and vPs. Thus, in Robert's analysis a head that moves over a phase boundary in the surface sentence must perform intermediate movement to the phase boundary so that it is still available when the next phase is considered. The head moves successive-cyclically.

Adding this theory to a reverse-engineered minimalist architecture turned out to be a challenge. The reconstruction process that builds phrase structure objects form left to right (hence often from top to bottom) extends the structure at the right edge, therefore C and v cannot render the lower parts inaccessible. The lower parts are typically still in the derivation's future. Upper parts could be sealed off if both heads and phrases were first reconstructed downwards into the phase boundaries,[17] yet this quickly runs into problems because the parser does not know in advance what the intended structure is and thus which segments it can put aside and forget as finalized CPs or vPs. For example, if the previous words were *the * new * car * Mary * wants* and the next word

is *was*, the parser should treat the result as a DP + T structure (as in *the new car Mary wants was on sale*), but if the next word is *to*, a different continuation is more likely (*the new car Mary wants to buy…*). At which point can the algorithm seal a previous fragment as a finished CP or vP without looking what the next word is? This problem becomes worse when working with a language such as Finnish that exhibits relatively free word order. Thus, it is not possible to take a mirror image of some grammatical mechanism such as the phase theory and simply assume that the inverted version exhibits well-defined grammatical behavior. Moreover, since it is difficult (or perhaps altogether impossible) to embed the standard phase theory into the left-to-right architecture, I was forced to search for alternative analyses for the locality restrictions exhibited by head reconstruction in the dataset. Thus, the consequences are quite far-reaching and not just a matter of finding notational reformulations for the existing components of the theory.

Another problem to which the present model provides a novel angle is the nature of the semantic effects associated with head movement. Before addressing the semantic interpretation specifically, it is important to point out one crucial difference between the present model and the standard system (e.g., Roberts 2010). Most bottom-up theories conceptualize head movement as copying. The moving head leaves a copy in situ, adjoins to a higher head, which then moves as a package, again leaving a copy. A strict inversion of the rule (43) would behave differently. It *inserts* reconstructing heads into the structure, thus its mirror image corresponds to a derivation in which the moving heads would disappear from their canonical positions as they move higher (the mirror image of inserting is removing). Although it is questionable whether a bottom-up derivation that ‘compresses’ the syntactic structure in this manner could work,[18] it is interesting to observe that the comprehension perspective seems to force us into such position. The only head there is in the input is the one that contains the components requiring reconstructing, and it is this object that the algorithm, and by extension also the human language faculty/hearer, must use as a starting point for populating the canonical head positions. It seems inevitable, in other words, that the canonical positions must be literally manufactured into existence.

Let us consider then the issue of semantic interpretation, keeping the above point in mind. One consequence of the head reconstruction algorithm proposed here is that it

reconstructs and sanitizes all complex heads from the structure before the derivation arrives at the LF-interface. Since no copying takes place, the syntax-semantic interface never sees complex heads. An important impetus that motivated this approach was Chomsky 2001 where it was observed that the "semantic effects of head raising in the core inflectional system are slight or nonexistent" (p. 37). The same point is reiterated in Chomsky, Gallego and Ott 2019:249-250. While this is sometimes seen as motivating a phonological analysis of head movement (rejected here on independent grounds), it can also be considered as justifying a weaker assumption according to which the LF interface has no access to complex heads.[19] Roberts (2010:7-28), however, cites evidence that some head movement operations do induce semantic effects (relying, in particular, on a manuscript that became Lechner 2008). In addition, I have argued in this article that in Finnish verbal predicates can be targeted for a special left peripheral semantic interpretation created by the C*-features, while the moved head represents the scope of the C* operator. Similar scope effects, although more local, are mentioned by Roberts and Lechner in the works cited above. It appears, then, that head movement might not be completely idle with respect to semantic interpretation.

Yet, no copying was required to capture the scope effects, and the LF interface is not aware that any complex heads ever existed. Consider that under the comprehension framework the scope of an operator is often determined on the basis of an overt element that the speaker has put into the scope position in the input string received by the hearer. It cannot be "intended" into some place. Once the element has been reconstructed from that scope position to its canonical thematic position, the operator-variable module can bind the operator with the scope marker. In the case of head movement, specifically, the C*-element that remains in situ according to the rule (43) functions as the scope marker for the reconstructed predicate (see figure 1, next section, for how this is visible in the output of the model). The whole mechanism works without head copying. This compromise solution could also go some way towards explaining the lack of (other) semantic effects, as noted by Chomsky. Consider the standard verbal spread T + V. In this case head reconstruction takes place because a phonological word occurred in the input that is mapped to T(V) in the lexical component. From the point of view of the LF interface the result would be the same if the same items were mapped to two

independent heads, hence the operation remains invisible for the syntax-semantic interface and semantic effects are, exactly as we would like to have it, absent.

In sum, then, although the properties of the language faculty/UG can be pursued either by generation or recognition, the two approaches are not empirically equivalent or trivial notational variants.

4.2 Simulation experiments

This section describes the simulation experiments performed with the algorithmic version of the analysis.

Running the algorithm with each input sentence in isolation does not provide a good overview of the operation and success rate of the model as a whole. All input sentences were therefore collected into a test corpus and a script was created that applied the algorithm automatically to all sentences in that file. A test corpus of 610 sentences was used in this study. It contains virtually every example discussed (or equivalent) plus several others that were used for control purposes and to check that the model does not overgeneralize. All sentences were normalized, and in some cases the words were disambiguated in order to avoid unnecessary garden pathing. Table 1 summarizes the contents of the test corpus. The original test corpus file, which contains the same organization and numbering as table 1, is available online.

Table 1. Test corpus. Grammatical constructions (610 in total) used in the simulations. Each sentence is provided a numerical identifier by the algorithm (#).

Main group	#	Construction type	Place where discussed or sentence examples + other possible comments
1. Baseline tests	3-88	1.1.2 Basic declarative clauses	Intransitive, transitive, ditransitive
		1.1.3 Negation	Finnish tenseless negative auxiliary
		1.1.4 Aux + past participle	'Pekka.NOM be.PST V.PST.PRTCPL...'
		1.1.5 Want + A/infinitival	'Pekka.NOM want-3SG to...'
		1.1.6 Modal + A/infinitival	'Pekka.GEN must.0 to...'
		1.1.7 Neg + Modal + A/infinitival	'Pekka.GEN not.3SG must.0 to...'
		1.1.8 Neg + Want + A/infinitival	'Pekka.NOM not want to...'
		1.1.9 Says + that	§1, ex. (5)
		1.1.10 Infinitival complement with genitive subject	'Pekka.NOM order boys.GEN to...'
		1.1.11 Adverb tests	'Pekka.NOM V_{intr} AdvP'
		1.1.12 N + infinitival	'Pekka made [an agreement to...]'
		1.1.13 Noncanonical OVS order	§3.2.2, ex. (41)
		1.1.14 Pro-drop	'Admire.1SG Merja.PAR'
		1.1.15 1.1.2-1.1.8 with locative PP argument	'Pekka meets Merja [PP in Helsinki].'
		1.1.16 C* feature in connection with phrasal pied-piping	§5.2.2, ex. (38-39)
		1.2.1 English sentences (strict HMC language)	Intransitive, transitive, ditransitive
		1.2.2 Want + to-infinitival	*John wants to meet Mary*
		1.2.3 Ungrammatical	**John admires*, §4.2, below (60)

2. Local T-to-C	89-236	2.1.1 Local T-to-C	§2, ex. (2-3, 5-6), §3.5, §2.3.4
		2.1.2 Neg-to-C	§2.3.2, ex. (22b)
		2.1.3 Modal-to-C	§2.2.2, ex. (14d-e) are similar
		2.1.4 Want-to-C	§2, ex. (2b), §2.3.2, ex. (22c)
		2.1.5 Aux-to-C	§2.3.2, ex. (22c)
		2.1.6 Groups 2.1.1-2.1.5 with formal C-feature	§3.5, formal C-feature = C/fin
		2.1.7 Groups 2.1.1-2.1.5 with noncanonical OVS order	Robustness tests
		2.1.8 Groups 2.1.1-2.1.5 with intervening PP argument	Robustness tests
		2.1.8 T-to-C with pro-drop	Robustness tests
		2.2.1 *V-initial clauses in Finnish	§2.1, EPP-violations
		2.3 Aux-to-C in English	Note: Aux is disambiguated
		2.4 *V-to-C in English	**Meet$_1$ John does __$_1$ Mary*
3. Basic LHM	237-383	3.1.1 V-over-Neg	§2.2, ex. (10c), 'V-over-Neg+A/inf'
		3.1.2 V-over-Aux(be)	§2.2, ex. (10d), §2.2.2, ex. (11-12)
		3.1.3 V-over-want (finite main verb)	§1, ex. (1), §2.2., ex. (10a)
		3.1.4 V-over-Modal	§2.2, ex. (10b), §2.2.2, ex. (14d-e)
		3.1.5 Groups 3.1.1-3.1.3 with noncanonical OVS order	Robustness tests
		3.1.6 V-over-T with pro-drop	Robustness tests
		3.1.7 V-over-T with intervening PP argument	Robustness tests
		3.2.1 *LHM with formal C-feature or with no feature	§3.5
		3.2.2 *LHM with infinitival subject	§2.2.2, ex. (20), §2.3.7, ex. (32-35), §3.4
		3.2.3 *LHM with second auxiliary	§2.3.6, ex. (31)
		3.2.4 *LHM with Aux + prtcpl + prtclp	§2.3.6, ex. (31d), wrongly judged?[a]
		3.3.1 *LHM in English	e.g., **Meet$_1$ John wants to _$_1$ Mary*
4. LHM over two V-elements	384-447	4.1.1 Neg + Modal + V, with Modal moving	Sandwiches, some marginal[b]
		4.1.2 Neg + Modal + V, with V moving	§2.2, ex. (8)
		4.1.3 Neg + want + V, with want/V moving	Some marginal[b]
		4.1.4 Above with noncanonical OVS order	Some marginal[b]
		4.2.1 *Group 4.1.1 with formal C-feature	§3.5
		4.2.2 *Groups 4.1.1-4.1.3 with no C-feature	§3.5, EPP-violations
5. Super LHM	448-478	5.1.1 that + want + infinitival	§2.2, ex. (9)
		5.2.1 *Finite verb out of embedded *that*-clause	§2.3.2, ex. (21), §3.3, ex. (47-48)
		5.2.2 *Group 5.1.1 with no C*-feature	§3.5
6. VP-fronting	479-488	6.1 VP-fronting in Finnish	§2.2.2[c]
		6.2 *Ungrammatical VP-fronting	§2.2.2[c]
7. Islands	489-534	7.1 *Right-adjunct CED violation	§2.3.3, ex. (23a)
		7.2 *Left branch CED-violation	§2.3.3, ex. (23b), §3.3, ex. (46)
		7.3 *Extraction from DP	§4.3
8. HM inside infinitivals	525-528	8.1 Inside DPs	§2.3.5, ex. (27)
		8.2 Inside right-adjoined adverbial phrases	§2.3.5, ex. (26)
9. Head ordering	529-557	9.1 *V + Neg	Correct is Neg + V
		9.2 *V..., *Neg + V + Aux	Correct is Neg + Aux + V
		9.3 *Neg..., *V..., *Modal + V...	Correct is Neg + Modal + V
		9.4 *Permutations of Neg + V + V + LHM	-
		9.5 *Head final constructions	'Pekka.NOM V Merja Neg'
10. C-features on a wrong position	558-610	10.1.1 C*-feature on V in situ	§2.1
		10.1.2 C*-feature on second V in situ	§2.3.3, ex. (28-29)
		10.1.3 C*-feature on third V in situ	§2.1
		10.1.4 C*-feature on in situ adverbial	§2.1
		10.1.5 C*-feature on second element	§2.1, §4.2, ex. (69)
		10.1.6 C*-feature as prefix	*[hAn]#V

[a] There is evidence (e.g., lack of participle recursion) that the participle verbs in the serial verb construction used in the relevant examples are not syntactically identical and that their surface identity is accidental. The algorithm judges them as instances of the same participle verb, however.
[b] I find the Neg + Modal + V order marginal or ungrammatical when the modal moves over the negation. There seems to be a semantic issue in combining the negative polarity item and the fronted modal verb with a C*-feature. Constructions of the type 'Aux + Modal + V' (with Modal moving over Aux) are grammatical or only slightly marginal.
[c] Categories 6.1 and 6.2 illustrate how the current model judges VP-fronting. VP-fronting requires a study of its own due to many complications and difficulties in judging the test sentences.

The output of the algorithm is recorded into several machine-generated raw data files. One output file lists each input sentence together with the phrase structure solution(s) returned by the algorithm, performance metrics, and certain aspects of semantic

interpretation. The contents of this file are illustrated in figure 1. The input sentence in this example is a Finnish sentence *myy-dä$_1$-C/op Pekka haluaa _$_1$ omaisuutensa* ‘sell-A/INF$_1$-C/OP Pekka wants _$_1$ possessions-PX/3SG’ where C/op stands for any C*-feature.

== Figure 1 about here ==

The second output file, written by the algorithm at runtime, reports a detailed step-by-step derivation for each sentence and justifications for all decisions, including justification for rejection. A small segment of this data for the same input sentence is provided in figure 2. Derivational log files are large text files (15 megabytes of plain text in the present study).

== Figure 2 about here ==

The whole design of the study is summarized in figure 3.

== Figure 3 about here ==

Once the main script has been executed, the researcher has to verify the correctness of the output. The analysis described in this article was verified in this way. Thus, the model judged grammatical sentences as grammatical, ungrammatical as ungrammatical; furthermore, each grammatical sentence was provided with a syntactic and semantic interpretation that was verified for correctness and linguistic plausibility. Local and nonlocal head movement in connection with (1) C*-features (examples #89-163, 237-288, 384-439), (2) formal T-to-C head movement (#164-173), (3) noncanonical word order (#174-192, 289-317), (4) extra PP argument (#193-214, 318-340) and in connection with (5) pro-drop (#215-227) were correctly derived. Super-LHM, in which the head is A-bar moved from within an embedded clause, are derived correctly (#448-462), with ungrammatical variants filtered out (#463-478). English sentences exhibiting LHM are rejected (#378-383). In English, neither the surface vocabulary nor morphological decomposition can interpret verbal heads with C*-features. Thus, only HMC-compliant head reconstruction is available (#235, 236). In such cases the

algorithm cannot find a position for any head that needs reconstruction over several heads; the last resort strategy is adopted which leads into rejection at the LF interface due to selection violations caused by wrongly positioned heads. Finnish sentences in which the C*-feature occurs in any other position expect at the left periphery are rejected due to the generation of a corresponding C-head into a wrong position (#558-610). Recall that the highest morpheme inside any complex head, in this case the one carrying the C*-feature, is merged on the basis of its position in the input. Reconstruction into left branches (e-g., subjects) and into right branches (adverbials) is impossible because minimal search follows labelling (#489-524). If there is no C*-feature, the sentence is correctly judged ungrammatical (#341-360, 440-447). The special case of genitive thematic subject, discussed in Section 3.4, was correctly derived as ungrammatical (#361-374). Implied head movement inside clauses without C*-features is rejected (#525-539, 540-557). Further details concerning the simulation results are available in the Appendix.

5 Conclusions

Several left peripheral C*-features are involved in predicate formation in Finnish. The data examined in this paper suggest that C*-marked predicates exhibit A-bar head movement. This supports Roberts (1993, 2010) and Holmberg (2016), who argued that A-bar movement extends to head movement. An analysis along those lines was proposed that further adopts a notion of minimal search from Chomsky (2008): inverse head chains involving C*-features are constrained by a minimal top-down search defined by selection/labelling. The data suggests that noncanonical head ordering and morphological decomposition are syntactic phenomena. Local head movement differs from long head movement in that only the latter involves C*-features. It was argued that the ultimate explanation for long head movement in Finnish is lexical: due to its agglutinative nature its lexicon is supplied with a variety of C*-features (12 in total were examined in this study) that can be used in predicate formation.

The proposed computational approach allows one to test a grammatical theory efficiently. The model computes regular input sentences at the speed of ~100ms per sentence on a standard commercial grade computer without optimization or parallel processing. It is therefore both possible and feasible to test linguistic hypothesis rigorously over very large sets of test sentences. Yet, the results are similar and in many

cases identical to structures generated by the standard bottom-up engine. Does the choice between recognition and generation matter? Perhaps the least interesting approach is to regard the comprehension algorithm as an alternative but also a practical way for defining a set of grammatical sentences while maintaining observational, descriptive and explanatory adequacy. As such, it constitutes an auxiliary research tool. A more interesting approach is to aim for a unified, and thus for a more constrained theory of the human language faculty that accounts for both production and comprehension. Both concerns motivated the study reported in this article.

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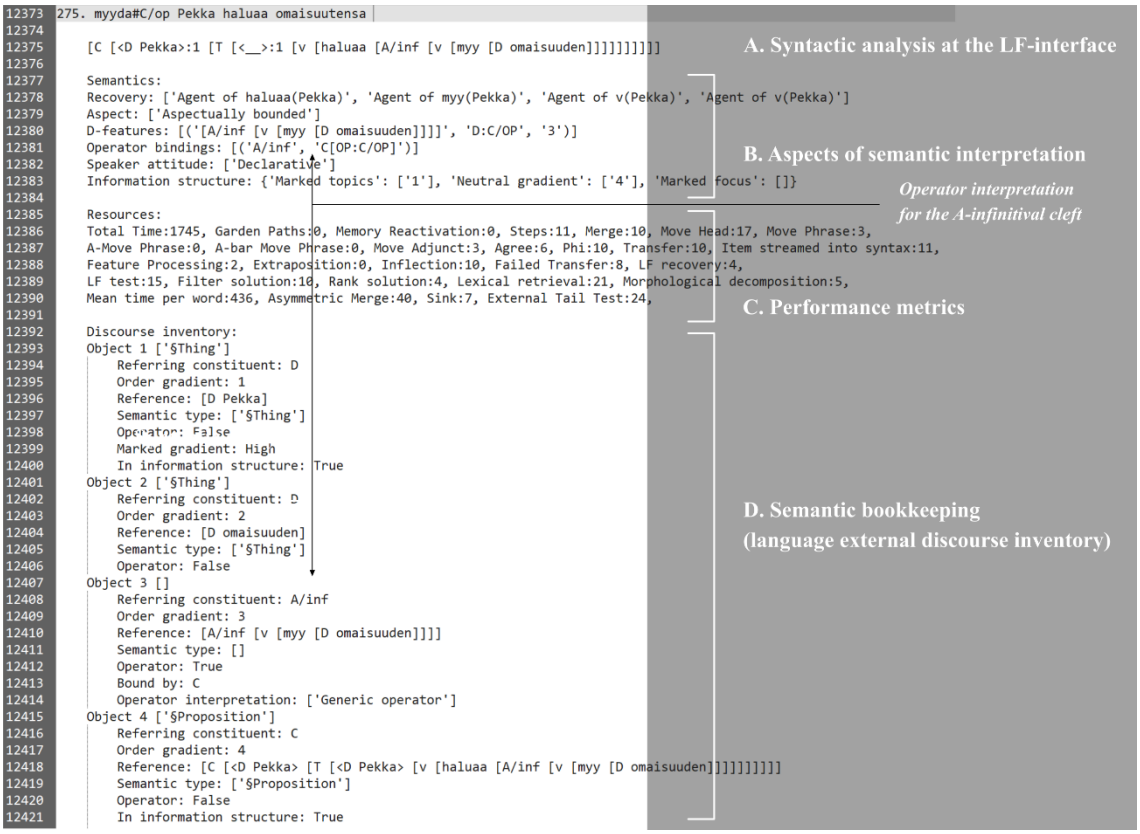
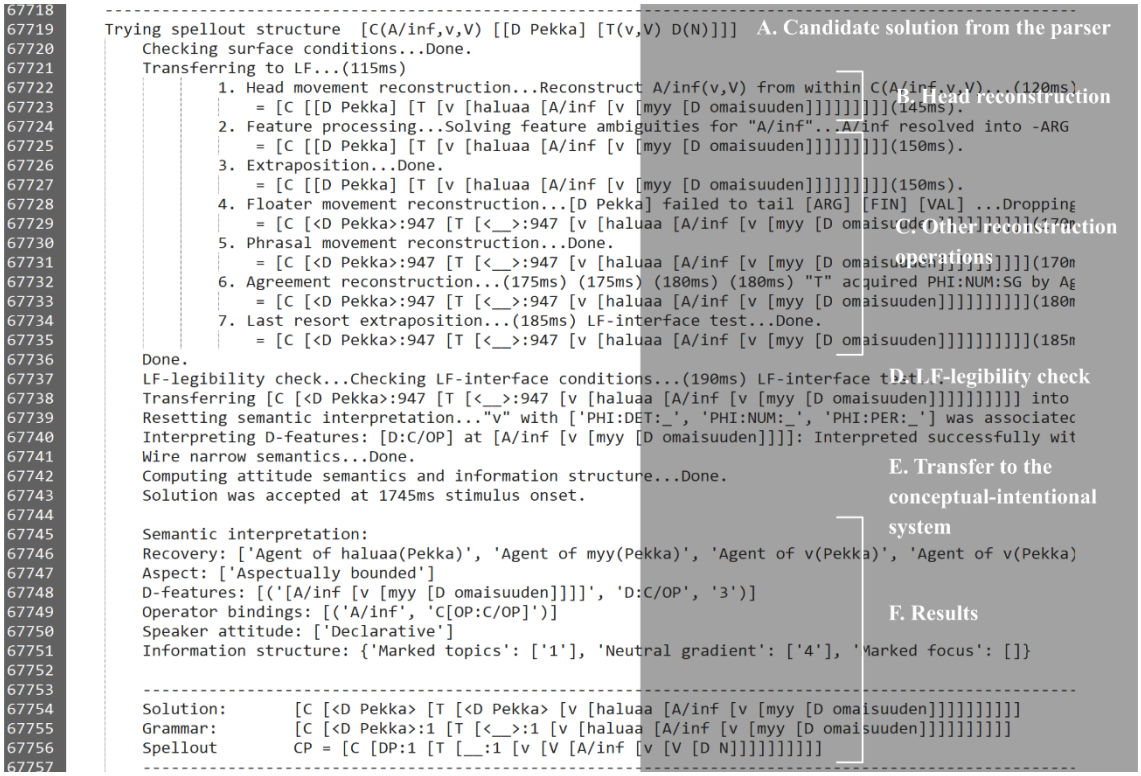


Figure 1. Screenshot from the output generated by the algorithm, with some added commentary. The algorithm provides each input sentence with a syntactic analysis (or several, if ambiguous)(A), selected aspects of semantic interpretation including thematic roles and control, aspect, discourse interpretation, operator bindings, speaker attitude and information structure (B), performance metrics (C) and semantic bookkeeping (D). Line 12831 contains a list of operator bindings which in this case link the fronted A-infinitival *myy-dä* 'to.sell-A/INF' to its clausal scope (C-element) and represents the clefting operation targeting the predicate 'to sell'. This interpretation is generated by the operator-variable module that handles also phrasal A-bar movement.




```
67718   ----------------------------------------------------------------------------------------------------
67719   Trying spellout structure  [C(A/inf,v,V) [[D Pekka] [T(v,V) D(N)]]]
67720       Checking surface conditions...Done.
67721       Transferring to LF...(115ms)
67722               1. Head movement reconstruction...Reconstruct A/inf(v,V) from within C(A/inf,v,V)...(120ms)
67723                   = [C [[D Pekka] [T [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]](145ms).
67724               2. Feature processing...Solving feature ambiguities for "A/inf"...A/inf resolved into -ARG
67725                   = [C [[D Pekka] [T [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]](150ms).
67726               3. Extraposition...Done.
67727                   = [C [[D Pekka] [T [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]](150ms).
67728               4. Floater movement reconstruction...[D Pekka] failed to tail [ARG] [FIN] [VAL] ...Dropping
67729                   = [C [<D Pekka>:947 [T [<__>:947 [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]](170m
67730               5. Phrasal movement reconstruction...Done.
67731                   = [C [<D Pekka>:947 [T [<__>:947 [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]](170m
67732               6. Agreement reconstruction...(175ms) (175ms) (180ms) (180ms) "T" acquired PHI:NUM:SG by Ag
67733                   = [C [<D Pekka>:947 [T [<__>:947 [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]](180m
67734               7. Last resort extraposition...(185ms) LF-interface test...Done.
67735                   = [C [<D Pekka>:947 [T [<__>:947 [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]](185m
67736       Done.
67737       LF-legibility check...Checking LF-interface conditions...(190ms) LF-interface test...Done.
67738       Transferring [C [<D Pekka>:947 [T [<__>:947 [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]] into
67739       Resetting semantic interpretation..."v" with ['PHI:DET:_', 'PHI:NUM:_', 'PHI:PER:_'] was associatec
67740       Interpreting D-features: [D:C/OP] at [A/inf [v [myy [D omaisuuden]]]]: Interpreted successfully wit
67741       Wire narrow semantics...Done.
67742       Computing attitude semantics and information structure...Done.
67743       Solution was accepted at 1745ms stimulus onset.
67744
67745       Semantic interpretation:
67746       Recovery: ['Agent of haluaa(Pekka)', 'Agent of myy(Pekka)', 'Agent of v(Pekka)', 'Agent of v(Pekka)
67747       Aspect: ['Aspectually bounded']
67748       D-features: [('[A/inf [v [myy [D omaisuuden]]]]', 'D:C/OP', '3')]
67749       Operator bindings: [('A/inf', 'C[OP:C/OP]')]
67750       Speaker attitude: ['Declarative']
67751       Information structure: {'Marked topics': ['1'], 'Neutral gradient': ['4'], 'Marked focus': []}
67752
67753       ------------------------------------------------------------------------------------------------
67754       Solution:       [C [<D Pekka> [T [<D Pekka> [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]]
67755       Grammar:        [C [<D Pekka>:1 [T [<__>:1 [v [haluaa [A/inf [v [myy [D omaisuuden]]]]]]]]]
67756       Spellout        CP = [C [DP:1 [T [__:1 [v [V [A/inf [v [V [D N]]]]]]]]]
67757       ----------------------------------------------------------------------------------------------------
```

Figure 2. Screenshot from the derivational log file, with added commentary. The file was generated by the algorithm at runtime and records all linguistically meaningful computational operations executed during the derivation. The input sentence is the same as in figure 2. Only part of the derivation is shown. The spellout structure arriving from the parser is at line 67719 (A) which then undergoes head reconstruction (lines 67722-67723)(B) and other reconstruction operations (phrasal reconstructions)(C). The result is evaluated at the syntax-semantic interface for grammatical well-formedness ('LF legibility') and, if the object passes, is interpreted semantically.

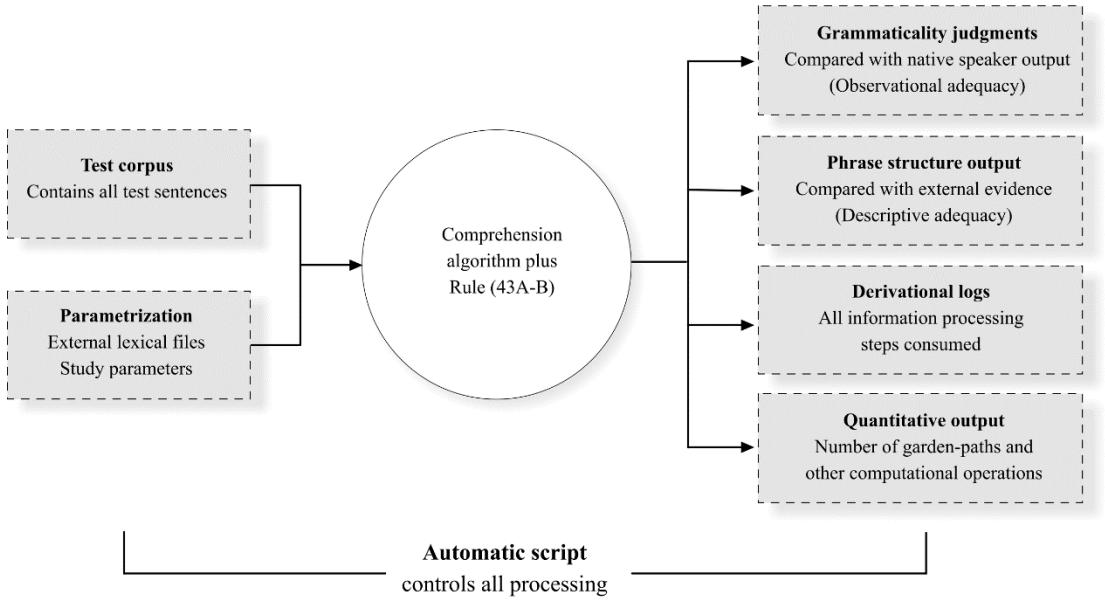


Figure 3. Methodological framework. A main script handles all processing. It takes sentences from the test corpus together with possible parametrization (e.g., the lexicon, configuration files), feeds these materials to the algorithm implementing the analysis, and provides several types of outputs that are evaluated by the researcher.

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[1] Abbreviations: 0 = no agreement or default agreement; A/INF = A-infinitival (corresponding loosely to the English to-infinitival); ESSA = ESSA-adverbial, roughly ‘while doing something’; FOC = corrective/contrastive focus/topic, often expressed by prosodic stress; GEN = genitive Case; HAN = a second position discourse clitic; IMP = imperative verb; NOM = nominative case; MA, MALLA, MATTA, MASSA, = MA-adverbials and infinitivals; PA = the second position discourse clitic *-pA*; PAR = partitive Case; PRS = present (finite) tense; PRTCPL = participle verb; PST = past tense; PX = infinitival agreement marker (also called possessive suffix); Q = yes/no question particle *-kO*; VA/INF = VA-infinitival.

[2] The definition given here is meant to be interpreted descriptively. I will show in this article that Finnish head movement can be partitioned into two groups: one exhibiting the Head Movement Constraint (Travis 1984)(HMC) and another the LHM property as defined here. It is possible that the second group dissolves into further subgroups, but no finer distinctions were needed for the analysis of Finnish.

[3] The source code repository is www.github.com/pajubrat/parser-grammar. For replication purposes the user should download the branch *long-head-movement-(Study-4d)*. There is a further online Appendix associated with this article that discusses some of the implementation details.

[4] There is a group of verb-initial clauses that do not involve V-movement to C, but the phenomenon is exceptional and irrelevant here.

[5] An anonymous *LI* reviewer points out that ‘want’ could take an infinitival CP complement, making this specimen unsuitable for detecting VP-fronting, and recommends the use of a restructuring verb. The claim that A-infinitivals are bare VPs comes from Vainikka (1989). In addition, the complement of the proposed restructuring verb is the same A-infinitival. On the other hand, if A-infinitivals are not VPs, then any VP-fronting analysis of these constructions would be impossible on such grounds alone. However, it does not necessarily matter for the remnant movement analysis what the fronted phrase is, only that a phrase of some type is fronted. Indeed, the algorithm proposed later in this article analyses the complement as an A-infinitival phrase, so the structure is ultimately assumed to be ‘want [A/inf^0 + VP]’, departing also from Vainikka’s hypothesis.

[6] This claim is based on the following considerations. First, as argued by Vainikka (1989, 1993, 2003, 2011), the genitive constitutes a structural specifier case in Finnish. It occurs systematically at the specifier positions of many functional heads such as adpositions (*minun lähellä* ‘I.GEN near’), adjectives (*minun löytämä* ‘I.GEN found’), nouns (*minun kirja* ‘I.GEN book’) and almost all deverbal infinitivals. In these positions, it often triggers optional or obligatory infinitival agreement in person and number with the local head (e.g., *minun lähellä-ni* ‘I.GEN near-1SG’). Second, this construction contrasts with infinitival constructions in which the second argument is part of the main clause, is assigned the direct object case, and satisfies direct object tests in Finnish (e.g., *Pekka näki heidät nukkumassa* ‘Pekka saw them.ACC sleeping’). The genitive argument does not satisfy these object tests.

[7] For Finnish infinitivals, see Vainikka (1989) and Koskinen (1998). The A-infinitival (glossed as A/INF) corresponds best with the English to-infinitival, while the VA-infinitival (glossed as VA/INF) is more propositional in its syntactic and semantic behavior, is selected by verbs such as ‘believe’ and ‘think’ and is best translated to English by means of a finite clause.

[8] The question is whether Embick and Izvorski’s line of argument could be applied to Finnish. Finnih LHM is too nonlocal to be consided a grammatical illusion. This does not constitute a criticism of Embick and Izvorski 1997, who do not discuss Finnish.

[9] These sentences are ambiguous, but the issue is not relevant to the issue at hand. Only one possible interpretation is provided in the translation.

[10] The stated justification for the A-bar head movement hypothesis in Holmberg (2016) is not long head movement but the fact that the head competes with other mechanisms employing A-bar operations, such as *wh*-movement. The matter was discussed in section 2.1 of the present article.

[11] For Finnish genitive case, see Vainikka 1989, 1993, 2003, 2011.

[12] The special purpose module is used at the syntax-semantic interface to interpret operator features underlying Ā-dependencies, including those formed by A-bar head movement as posited in the present study. In addition, it provides formal definitions for the core notions involved in these computations, capturing the idea that the module 'understands' operator-variable dependencies. I interpret it as a special purpose system for semantic interpretation, perhaps an isolated processing pathway. The architecture was inspired by Chomsky's (2008) "duality of semantics" approach. It is described in some more detail in the online Appendix.

[13] This methodology is routinely used in the more advanced sciences but rarely in linguistics. Yet in linguistics too one would ideally want to "construct a formalized general theory of linguistic structure" (Chomsky 1957:5) that is "perfectly explicit" in that it "does not rely on the intelligence of the understanding reader but rather provides an explicit analysis of his contribution" (Chomsky 1965:4). Modern computers provide in my view an ideal tool for connecting linguistic hypotheses with their data. One such approach is reported in the next section.

[14] The parser processes the input incrementally from left to right and generates a set of phrase structure representations by applying an inverse Merge operation (called Merge^{-1}) that merges incoming elements to the right edge of the existing partial phrase structure. This operation is preceded by a lexico-morphological module that maps phonological words into lists of primitive lexical items. The syntactic module uses recursive backtracking for ambiguity detection and garden path recovery. The model is based on earlier work by Phillips (1996) and is documented in Brattico 2019. See the online Appendix for further details.

[15] The labelling algorithm can be expressed in pseudo-code as follows: 'Return α if α is primitive; if not applicable, suppose α = [A B] and return A if A primitive, but if not, return B if B is primitive; if not, apply the rule recursively to B if B not a right

adjunct; if it is, apply the rule recursively to A'. Intuitively the algorithm looks for the most prominent primitive element inside α.

[16] This definition leaves room for word-internal phrasal constituents, but the algorithm presented here does not have access to any derivational path that produces such objects.

[17] It is assumed in the phase theory that the phase edges can be accessed by operations that are in the derivation's future. Sealing off an upper part of a CP or vP boundary, in accordance with a strict mirror image of the cyclic phase theory, would require any element still waiting for downward reconstruction to be reconstructed to the phase boundary before closing the phase.

[18] A derivation of this type could be seen as performing some type of grammatical compression for the sensorimotoric interface, as removing heads eliminates both head and phrasal positions from the structure.

[19] An additional concern is that complex heads are difficult to process at the syntax-semantics interface because they can and often have conflicting lexical features. The lexical features of T and V, for example, do not typically create consistent lexical requirements.