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TESTING CARTOGRAPHIC PROPOSALS ON LOCALITY EFFECTS IN V2: A QUANTITATIVE STUDY

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Abstract In this paper, we explore quantitative and computational methods to compare two theories of locality effects in non-subject fronting in V2 environments. We test the predictions in locality effects in grammatical clauses of (i) a "bottleneck effect" model and (ii) a "standard" featural Relativized Minimality effect model. By using theory-driven frequencies, we aim to observe the generalisation ability of the two models. We explored ten morpho-syntactically annotated treebanks for seven Germanic languages and one treebank for Old French. Our results support the predictions of a model stipulating standard featural Relativized Minimality effects in non-subject fronting.

1 Introduction

The distribution and the properties of the Verb Second word order (henceforth, V2) have been investigated early on in the history of linguistics (since Erdmann 1886, Wackernagel 1892), as well as, in relatively more recent formal-generative approaches, with a special, but not exclusive focus Germanic and Old stages of Romance (Den Besten 1983, Platzack 1983, Müller & Sternefeld 1993, Zwart 1992, Benincà 1995, Vikner 1995, Hinterhölzl 2006, Haider 2010, Ott 2014, Holmberg 2015, Wolfe 2015, 2022).

The locus of the inflected verb has always played an important role with respect to the freedom and the limitations of movements of constituents in Germanic languages. The syntactic space preceding the verb (also *Vorfeld* 'prefield') is described as accessible to only one constituent in root-like contexts. Candidates are both subject elements (as the German example in (1)) and non-subject elements, such as, among many others (see Samo 2019: 27-30), focussed objects (marked in capital letters in (2)) and complements (3). Violation to V2 orders (discussed in the literature as V3 or V*), in which the verb is not located in the "second" position, are generally ruled out, for exam-

ple, by the grammar of German (as in example (4); see Müller 2013 and Samo 2019: 109-134). In embedded contexts, the verb only raises to the "second" position within the embedded clause when there is no overt complementizer. This is the case with *bridge verbs* (cf. Poletto 2014: 6) like *glauben* 'to think' as in (6). However, when the complementizer is realized, the verb remains "final" in West Germanic and does not move to the "second" position, as illustrated in (5).[1]

(1) *Giotto malte dieses Fresko.*
Giotto painted.3SG this.ACC fresco
'Giotto painted this fresco.'

(2) *DIESES FRESKO malte Giotto.*
This.ACC fresco painted.3SG Giotto
'This fresco, Giotto painted.'

(3) *Im Jahre 1301/In Assisi malte Giotto dieses Fresko.*
In year 1301/In Assisi painted.3SG Giotto this.ACC fresco
'In 1301/In Assisi, Giotto painted this fresco.'

(4) **Giotto in 1301 malte dieses Fresko.*
Giotto in 1301 painted.3SG this.ACC fresco

(5) *Der Stadtführer sagt dass Giotto *(malte) dieses Fresko malte.*
The tourist-guide say.3SG that Giotto this.ACC fresco painted.3SG
'The tourist guide said that Giotto painted this fresco.'

1 The space immediately after the verb in "second" position (labelled *Mittelfeld* 'middlefield', from the portion of the sentence between the inflected verb and the lexical verb in West Germanic) is a place of high flexibility of order of constituents with cross-linguistic variability (cf. scrambling Müller & Sternefeld 1993, Frey 2004, Haider & Rosengren 2003, Hinterhölzl 2006, Schoenmakers 2020). Syntactic elements seem to be "freely" dislocated with different degrees of acceptability according to prosodic, semantic or pragmatic factors. Standard cartographic assumptions discussed in this work as Force/FinV2 in Section 2 (Haegeman 1996, Roberts 2004, Benincà & Poletto 2004, Wolfe 2015) consider the limitations (one constituent in the *Vorfeld*) and freedom of movements (scrambling in the *Mittelfeld*) as technically unrelated, whereas other models, such as the one referred in this paper as CriterialV2 (Samo 2019) unifies these two phenomena under the single locality principle of intervention effects (Rizzi 1990, 2004, Starke 2001). Such asymmetry in the models will not be investigated in this paper in details.

(6) *Der Stadtführer glaubt Giotto malte dieses Fresko.*
The tourist-guide believe.3SG Giotto painted.3SG this.ACC fresco
'The tourist guide believes, Giotto painted this fresco.'

In early generative accounts (cf. Den Besten 1983), the inflected verb in V2 environments in West Germanic was located in a CP position in a standard three-layers map (7a).[2] The IP (see Cinque 1999, Tescari Neto 2022 for cartographic analyses) has also been indicated as a candidate landing site, with variability across languages (e.g. Icelandic, Thrainsson 2007) in/across specific contexts (e.g. subject-initial, Travis 1984, Zwart 1997).

The detailed investigation of the CP layer built on cross-linguistic empirical evidence led syntacticians to "relocate" the verb in a fine-grained map of the Left Periphery à-la Rizzi (1997) (henceforth LP, see also Rizzi 2001, 2004, Rizzi & Bocci 2017) given in (7b). This relocation has been a central aspect since the early days of cartographic analyses of V2 (cf. Haegeman 1996, Grewendorf 2002, Poletto 2002, Roberts 2004, Grewendorf 2005, Benincà & Poletto 2004, Wolfe 2015, Samo 2019).

(7) a. $[_{CP}\ [_{IP}\ [_{VP}]]]$

b. $[_{Force}\ [_{Top}\ [_{Int}\ [_{Top}\ [_{Focus}\ [_{Top}\ [_{Mod}\ [_{Top}[_{Qemb}\ [_{Fin}\ [_{IP}\cdots[_{VP}]]]]]]]]]]]$

Studies following the guidelines of the cartographic program and adopting cartographic maps (see introductions on cartography in Cinque & Rizzi 2010, Rizzi & Cinque 2016, Rizzi & Bocci 2017, Rizzi & Samo 2022) generally account for the V2 phenomenon in two ways (see section 2 for details). The main differences between the two models refer to the typology of functional projections attracting the inflected verb (INFL) and how locality effects (cf. Rizzi 1990 and related works) are computed.

The Force/FinV2 model (Haegeman 1996, Benincà & Poletto 2004, Wolfe 2015) postulates that the verb moves first and lands to a complementizer position (Force and Fin in Rizzi 1997's term) followed by the movement of only one constituent from the sentence. The limitation to one constituent is explained by a "bottleneck effect" created in the lower complementizer position (FinP), blocking additional movement of constituents to the LP.

On the other hand, the Criterial V2 model (cf. Samo 2019) considers that the verb moves once the constituent in "first" position has been displaced,

2 Throughout the work, we assume that the notion of cartographic map overlaps with the notion of structure (see Rizzi & Cinque 2016 for an overview on cartography).

creating a Spec-Head configuration in the activated criterial position within the LP (Rizzi 2006, 2015, Rizzi & Bocci 2017). Criterial positions refer to those functional projections, as Topic and Focus, attracting constituents bearing the relevant scope-discourse properties that need to be properly interpreted at the interfaces with the systems of sound and meaning (Bocci 2013). The verb halts at the highest activated criterial head, which ultimately results in the "second" position. Additional elements can fill the LP (from the "third" position onwards, following the verb) and restrictions are to be accounted to standard intervention effects (in the spirit of Rizzi 1990, 2004, Starke 2001, Friedmann, Belletti & Rizzi 2009).

The aim of this work is to test the generalisation ability of cartographic models accounting for locality effects in V2 environments. The two models make different predictions with respect to a phenomenon related to intervention effects, such as the nature of subjects and the nature of a fronted non-subject preceding the inflected verb, such as the examples in (2) and (3).

Specifically, we quantify the predictive power (see sections 2 and 3) of the two syntactic proposals in terms of the distribution of one feature (the pronominal status of subjects in non-subject fronting) exploring a theory-driven approach to frequency of grammatical structures extracted from large-scale databases (in the spirit of Quantitative Computational Syntax; Merlo 2015, 2016, Gulordava & Merlo 2015, 2020, Samo & Merlo 2019, 2021, Merlo & Samo 2022).

To reach our goal, we proceed as follows. Section 2 presents the cartographic models under investigation and their predictions. In section 3 we assess the hypotheses through quantitative data. The materials and methods of our quantitative study are presented in section 4. Results shall be discussed in section 5. Finally, section 6 concludes.

2 Models and their predictions

2.1 No free slots: pre-cartographic Verb Second

In V2 languages, the inflected head superficially fills the "second" linear position in main clauses following exactly one constituent. With complex verbal forms (e.g. auxiliaries, modals, separable particles, etc.) only the hierarchically higher, inflected form targets the "second" position, while the other component (e.g. the lexical uninflected form) remains in a lower position. Different types of syntactic constituents (subjects, arguments, adverbials, etc.) can undergo movement to the left of INFL creating the "classical" V2 structures.

One of the earliest generative account of V2 can be traced back to the work

of Den Besten (1983), in which clear asymmetries between main and embedded clauses are discussed (cf. examples (5) and (6)). In West Germanic (e.g. German, Dutch), the verb is located in the second position in main clauses, whereas the verb remains in a lower functional projection (e.g. verb final) in embedded clauses. In those embedded contexts which are not introduced by an overt complementizer (such as sentences selected by bridge verbs, such as *glauben* 'believe' in example (6)), the verb behaves as in main clauses and moves to the "second" position. On the basis of such evidence, Den Besten (1983) proposed that the verb and the complementizer compete for the same position. The V2 phenomenon was analyzed as a verb movement to a C position (see also Travis 1984, Zwart 1997 for discussion on verb movement within the IP in relevant contexts, e.g. subject-initial).

The absence of V3/V* orders was explained by postulating a lack of a 'free' position higher than SpecCP. The verb and the fronted element move to the highest functional projection within the syntactic architecture (e.g. for a "reduced" split-CP hypothesis, see Hrafnbjargarson 2004, Holmberg & Platzack 2005, Wiklund, Bentzen, Hrafnbjargarson & Hróarsdóttir 2009). The emergence of a fine-grained description of the LP (Rizzi 1997 and related works) obliged cartographers to translate the intuition in Den Besten (1983) into "cartographic" terms.

2.2 *A Bottleneck effect: Force/FinV2*

A wealth of literature on cartography (Haegeman 1996, Benincà & Poletto 2004, Holmberg 2015, Wolfe 2015, 2022) maintained Den Besten's intuition of verb movement to a complementizer position within the C-domain. In a rich LP in the spirit of Rizzi (1997), the C^0 head was translated as $Force^0$ or Fin^0 according to typological properties of the language. Works adopting the typology discussed in Benincà (1995) classify V2 languages in *less-strict* V2 languages (such as Old Romance varieties, allowing higher degrees of violations to V2) as FinV2-languages (where the verb ultimately lands to Fin°) and *strict* V2 languages (e.g. West Germanic) in which the verb is believed to land higher (Force°).

Verb moves first According to Force/FinV2 (Haegeman 1996, Roberts 2004, Holmberg 2015, Wolfe 2015), FinP is endowed with a Generalized EPP feature / Edge Feature(henceforth, EF). The lexical content of INFL (i.e. the finite verb) is attracted by Fin^0 and moved to SpecFinP. According to Mohr (2009: 146-154), if the fronted element bears informational properties (+Topic, +Focus), the dislocated item undergoes a double-step movement, first to SpecFinP

and then to the specifier of the dedicated (criterial) position (e.g., SpecTopicP, SpecFocusP).[3]

Bottleneck effect The fronted element or the "copy" in SpecFinP creates a "bottleneck effect" (Roberts 2004), that blocks any other movement of dislocated constituents to the LP. An additional EF is present in *strict* V2 languages in Force^0. Force^0 attracts the movement of the verb from Fin^0 and triggers the movement of the already fronted constituent to SpecForceP. Violations of V2 in *strict* V2 languages (Meinunger 2020, Wiese 2009, Walkden, George 2017, De Clercq & Haegeman 2021 *inter alia*) are accounted for by a higher layer responsible for generating items that could be higher than the landing site, labeled FrameP (cf. Benincà & Poletto 2004)

The functional projection hosting the (generalized) EF blocks the movement of any other category across the fronted constituent which satisfies the EF feature. The bottleneck is created because of the nature of the fronted XP, that, being "of no particular type in terms of the typology of potential interveners, [...] is able to block any type of movement" (Roberts 1999: 39 from Poletto 2002: 216).

ForceV2/FinV2 and freezing effects Force/FinV2 has been widely adopted in cartography, although it is discussed as violating guidelines of the cartographic approach as noted by Abels (2017, 2020) and in Samo (2019). For example, the movement of the XP bearing multiple features (+Top, +Foc, +Q) to SpecFinP is not expected under a criterial approach Rizzi (2006, 2015) and the movement of a fronted XP to SpecForceP, e.g. from a SpecFocus position, in *strict* V2 languages is a violation of criterial freezing Rizzi (2015).

2.3 Standard locality effects: Criterial V2

XP moves first Rigidly following cartographic guidelines on criterial movment and freezing (Rizzi 2015), Samo (2019) proposes that the V2 constraint should be rethought as the result of a sum of Spec-Head configurations in the spirit of the "Residual V2/Wh-criterion" postulated for English *ex-situ* questions (Rizzi 1991, 1996).

The criterial model considers that the inflected head INFL moves to every activated criterial position (+Topic, +Focus) in the specific linguistic produc-

3 Mohr (2009: 146) limits the set of elements fronted with "neutral stress and interpretation" in V2 contexts (*contra* Haider 2010: 1 and Grewendorf 2005: 36). Following Mohr (2009), only subjects, dative object DPs in passives, experiencer DPs of impersonal psych-verbs and a subset of temporal and locative adverbs (creating a setting) are able to be fronted without any non-canonical informational properties.

tion (e.g, utterance) until the inflected verb halts at the highest position, ultimately and superficially resulting located in the "second" position of the clause.

Crosslinguistic variability in triggering V2 Following a recent approach to the format of parameters, Rizzi (2017) suggests that functional heads crosslinguistically vary in the syntactic operations triggered once functional projections are activated (e.g. operations of internal merge, external merge or spell-out). The movement of the verb (internal merge) is required by criterial positions in the LP in V2 languages, contrary to languages like Gungbe (cf. Aboh 2004) in which the instruction is to spell-out a particle, or Italian where neither spell-out particles nor movement of already merged heads are required (see also Bonan 2021).

A typology of V2 languages is expected according to the syntactic operations triggered by the different functional projections in the LP (e.g. FocusP and SubjP trigger verb movement, but ModP[4] does not) according to an implicational scale (cf. Poletto 2023). A diagnostic tool to investigate dissimilarities among V2 languages is the quality (and quantity) of violations to the V2 constraint, referred to as V3. For example, Samo (2022a) maps differences across (Swiss) Romansh varieties in triggering "residual V2" in the position of ModP (Rizzi 2004) hosting "highlighted" fronted adverbials: in two out of the five investigated Romansh varieties (Putèr and Vallader), ModP does not require verb movement (resulting in V3 orders). If the adverbial is focussed and targets FocusP or topicalized targetting TopicP, on the other hand, verb movement is required in all varieties.

No bottleneck effect, just standard locality effects According to a criterial approach to V2, multiple heads can simultaneously trigger the movement of INFL, if and only if the fronted XPs do not violate any locality effects in terms of featural Relativized Minimality (henceforth fRM, Rizzi 1990, 2004, Starke 2001; see subsection 2.4).[5] The verb stops its movement in the head of the highest activated criterial position, therefore always resulting in "second" position. The criterial V2 model does not exclude that the LP below the inflected verb (i.e. the initial section of the *Mittelfeld*) can be activated to allow reorderings (cf. scrambling). Scrambled elements share properties

4 ModP represents a functional projection in the LP hosting adverbials and complements that are fronted, but not topicalized or focussed. Rizzi (2004) labels these adverbials as "highlighted". See Samo (2022a,b) for details and crosslinguistic analyses.

5 Criterial freezing effects do not affect heads at all (cf. Rizzi 2006) which can be possible explained by the idea that head movement can be a syntactic operation triggered by functional projections (Rizzi 2017) before the structure is sent to interfaces.

with criterial positions (cf. Rizzi 2015). For example, scrambled elements are "frozen" in place (translating Müller & Sternefeld 1993 into Rizzi 2006's proposal of freezing effects) and sentences containing scrambled constituents cannot be felicitous answers to "What happened?" questions (Lenerz 1977). In a nutshell, a criterial model to V2 does not stipulate a "bottleneck effect", but standard intervention effects (presented in section 2.4).

2.4 *Intervention effects as a diagnostics for predictions*

We compare the predictions of the models under investigation with respect to intervention effects (Rizzi 1990, 2004, 2013a). Intervention effects arise when a local relation is disrupted by the presence of an element bearing certain features which make it a potential participant in that relation. A well-known example is represented by the intervention effects arising in object relative clauses (Friedmann et al. 2009, Sanfelici, Caloi & Poletto 2014 *inter alia*), in which the fronted relativized object (generated in the argument structure of the verb and moved to the LP) crosses an intervening subject. If the two elements are dissimilar in the values of features, for example with respect to the features TYPE (maximal projection vs. pronoun; see details in section 3) and NUMBER (singular vs. plural), parsing improves across populations of speakers. For example, due to the dissimilarity of features, (9) is considered "easier" than (8).

(8) "Similarity"

The painter$_{(Rel),XP,sg}$ *that the bishop*$_{XP,\,sg}$ *met* <*the painter*$_{XP,\,sg}$>.

(9) "Dissimilarity"

The painter$_{(Rel),XP,sg}$ *that they*$_{pron,\,pl}$ *met* <*the painter*$_{XP,\,sg}$>.

Degrees of syntactic complexity emerge, intended as ungrammaticality or slower parsing time in adult, difficulties in acquisition and in populations with language impairment (Grillo 2008, Friedmann et al. 2009, Belletti, Friedmann, Brunato & Rizzi 2012, Sanfelici et al. 2014, Villata, Rizzi & Franck 2016 among many others). According to the theory of intervention effects (Rizzi 1990, 2004, Starke 2001), the crucial property is not the amount of material that can be considered as intervener, but rather its quality (Rizzi 1990, 2004, 2013a, Starke 2001, Krapova & Cinque 2008, Friedmann et al. 2009; see also

Abels 2012). The results of extensive experimental research have demonstrated that the dissimilarity in values of only a selected set of features (those relevant in a language, cf. Belletti et al. 2012) might help adult grammars in parsing grammatical sentences and improve (or disrupt) comprehension of structure containing A′-dependencies (relative clauses, clefts, topics) in child grammars and in specific populations, such as atypical development or in language pathology (Grillo 2008, Friedmann et al. 2009, Belletti et al. 2012, Durrleman, Hippolyte, Zufferey, Iglesias & Hadjikhani 2015, Chesi & Canal 2019, Belletti 2022 and related works).

Non-subject fronting in V2 structure is an example of A′-dependency. Quantitative studies have demonstrated that the complex A′- configurations (e.g. object fronting in relative clauses, cf. Frauenfelder, Segui & Mehler 1980, Belletti & Chesi 2014, Durrleman et al. 2015) occur less frequently than an "expected" frequency (see 3 for details). Some cross-linguistic examples involve relative clauses (Samo & Merlo 2019), clefts (Samo & Merlo 2021), and adverbial fronting (Samo 2022b).[6] The expected distribution (or count) is a theory-driven approach to corpus frequencies built on the basis of a simple computational model according to the predictions of syntactic, in our case cartographic, proposals, in the spirit of Quantitative Computational Syntax (Merlo 2016, Merlo & Ouwayda 2018, Gulordava & Merlo 2020).

3 Quantifying the predictions

The two models under investigation differ in a series of core ingrendients and predictions, which are summarized and quantified in this section.

Core ingredients of the models

- The two models under investigation differ in the order of movement of the verb and the fronted XP. According to the theory of Force/FinV2, INFL moves first, followed by the movement of an XP because the (generalized) EF feature. On the other hand, following the guidelines of the CriterialV2 model, the fronted XP moves first to meet criterial instructions, followed by INFL movement in order to create a Spec-Head configuration in the activated criterial position.

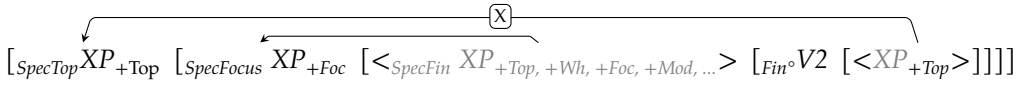
- The second difference between the proposals is related to the landing site of INFL. Force/FinV2 locates the verb into complementizer posi-

6 See Merlo & Stevenson (1998), Yang (2004), Yang, Crain, Berwick, Chomsky & Bolhuis (2017) with respect to the interaction between grammar, grammaticality and frequency. See also Ibbotson (2013) for a usage-based account.

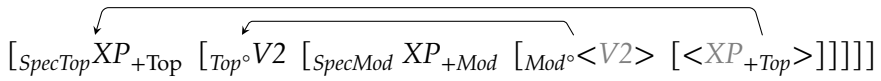
tions (Force, Fin), whereas CriterialV2 maps it in the head of criterial positions (Top, Focus, Mod).

- Both theories make predictions regarding locality issues:
  - The underspecified EF creates a bottleneck effect, blocking the movement of a heterogeneous class of constituents (e.g., the internally merged XP bearing Focus features targetting SpecFocus-Pcan block any constituents because of its copy in SpecFinP, even in a condition of dissimilarity, such as blocking a constituent bearing Topic features), as shown in (11).
  - On the other hand, according to Criterial V2, the fronted constituent only blocks the movement of syntactic items bearing similar features. An XP bearing a Topic feature can only be blocked by another already fronted constituent bearing the same Topic feature. This is summarized in (11), where a Topic element crosses a fronted adverbial in SpecModP and triggers the movement of the inflected verb to Top^0.

(10) Bottleneck effect



(11) Standard fRM



The subject, whether in a subject position (Cardinaletti 2004, Rizzi 2015, see also Poletto 2000) or lower (cf. Frey 2004) represents a (different type of) intervener in terms of locality if a non-subject (whether an argument, a oblique complement or an adverb) moves, as given in Table 1. The nature of the fronted element crossing the subject trigger the relevant type of intervention effects. Studies in psycholinguistics have demonstrated that arguments (object, indirect object) are hindered by the presence of a subject sharing a selected class of features (Friedmann et al. 2009 and related works), contrary to complements or adverbials (cf. Costa, Friedmann, Silva & Yachini 2014).

What kind of syntactic elements are adverbials and complements? Following Cinque (1999) and Schweikert (2005), we consider adverbs filling the IP-domain and non-clitic oblique complements as maximal projections

Bottleneck Effect $[_{\text{SpecForceP/FinP}}\ \text{XP}_{+\text{EF}}\ [_{\text{Force}^\circ/\text{Fin}^\circ}\ \text{V2}\ [_{\text{SubjP}}\ \text{Subject}\ _{+\text{F}}\ [\text{...XP+F...}]]]]$
Standard fRM $[_{\text{SpecFocusP/TopicP/ModP}}\ \text{XP}_{+\text{F}}\ [_{\text{Focus}^\circ/\text{Topic}^\circ/\text{Mod}^\circ}\ \text{V2}\ [_{\text{SubjP}}\ \text{Subject}\ _{+\text{F}}\ [\text{...}\ \text{XP}_{+\text{F}}\ ]]]]$

Table 1 The two cartographic models under discussion. EF = Edge Feature/Underspecified feature, F = relevant feature

(XP), since they are generated in Spec positions within the syntactic functional spine. The intervention explanation is that complements and adverbs do not share any person features (adverbs do not bear any gender or number features as well).

A feature that can mark asymmetries in intervention effects is the feature labelled as TYPE. Its values are maximal projections (also XP) as in German *die Professorin* 'the professor', pronominal heads as in *sie* 'she' or in certain languages *null* when certain requirements are satisfied (e.g. Rizzi 1982, Huang 1982, Haegeman 2013 and related works).

The main element that we take into consideration is the nature of the subject. Subjects can be realized as maximal projection (Subj_{XP}), pronominal (Subj_{PRO}; which cannot be overt in relevant contexts, resulting in a null subject, Subj_{NS}). According to Belletti & Rizzi (2013), pronouns act as interveners to a lesser extent because of their lack of a lexical restriction. We follow the label in Rizzi (2018: 348) and Samo (2022b: 351), considering the feature under investigation absence of the lexical nature as $(-N)$.

Predictions The two models make different predictions with respect to the movement of a non-subject over a subject. Table 2 summarizes the predictions.

- The bottleneck effect stipulates that every fronted constituents triggered by FinP (the constituent in SpecFinP, see example 10) is extremely dissimilar to the intervener (contrary to the blocking effect of additional fronted elements, since the set of feature is bigger). The nature of the fronted element (arguments and non-arguments) does not create asymmetry in terms of locality.
- On the other hand, the criterial V2 uses standard locality effects. Ar-

Model	NonArg < Subj	Arg < Subj
Bottleneck Effect	mild intervention	mild intervention
Standard fRM	mild intervention	stronger intervention

Table 2 The two cartographic models under discussion with respect to the type of intervention effects resulting by the crossing (indicated here by <) of non-arguments (NonArg) and arguments (Arg) over the subject (Subj).

guments should create stronger intervention effects than non-arguments.

Quantifying the predictions The configurations of the predictions made by linguistic models represent independent variables and the frequency of grammatical clauses does act as a dependent variable to test the generalization ability of the proposals. We explore crosslinguistic morpho-syntactically annotated large-scale datasets (cf. Nivre 2015) to operate on a comparative dimension.

The fronting of a constituent in the LP representes a case of A′ movement. Previous studies working under the framework of Quantitative Computational Syntax on relatives (Samo & Merlo 2019), clefts (Samo & Merlo 2021), adverbial fronting (Samo 2022b) extracted grammatical in large-scale corpora showing that the observed counts of configurations in a dissimilarity configuration of a set of morphosyntactic features were higher than the expected counts based on sentences where movement was not involved, while the observed counts in conditions of similarity between the fronted element and the intervener were lower than expected.

The expected counts, as in previous studies (Samo & Merlo 2019, 2021, Samo 2022b), are based on imputed counts of distributions in syntactic architectures where no movement is involved. For example, the nature of subjects in canonical main clauses such as SVO sentences.

The impact of intervention created by movement is measured by the observed distribution of a syntactic configuration in which the subject is in a maximal projection (i.e. $+N$; Subj_{XP}) or realized by head-like elements ($-N$; Subj_{PRO}/ Subj_{NS}) in argument (arg) and non-argument (non-arg) fronting compared to the distribution in canonical (can) orders.

Hypotheses Our measure is the difference between the observed distribution of feature, based on the frequency of the value of the nature of the subject that we actually count in non-subject fronting, and the expected distribution, based on canonical clauses.

The two models make different predictions. The locality triggered by the EF (bottleneck effect) should not create any asymmetry between arguments and non-arguments (marked as $\leq\geq$), while standard fRM predicts that argument fronting is harder and therefore a higher difference between observed and expected in pronominal subject environments (marked as $>$) should appear.

Bottleneck effect	$(-N_{\text{Arg}}) - \ (-N_{\text{Can}}) \leq\geq (-N_{\text{NonArg}}) - (-N_{\text{Can}})$
Standard fRM	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) > (-N_{\text{NonArg}}) - (-N_{\text{Can}})$

Additional hypotheses are related to the distance between non-subject fronting and canonical clauses. Standard fRM clearly expect that in all environments of argument fronting the difference should be positive (> 0), while this is not necessary in non-argument fronting (lower than arguments, but approximately $\approx$ closer to 0).

Bottleneck effect	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) \leq\geq 0$
	$(-N_{\text{NonArg}}) - (-N_{\text{Can}}) \leq\geq 0$
Standard fRM	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) > 0$
	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) > (-N_{\text{NonArg}}) - (-N_{\text{Can}}) \approx 0$

Finally, the standard fRM postulates differences between languages. In particular, Samo 2019 postulates that a set of languages (those described as *less-strict* languages, such as Old Romance) might front non-arguments in V2 environments only if focussed or topicalized (see also Samo 2022b for details). Standard fRM expect dimensions of variations crosslinguistically.

Summing up, if the locality in V2 environments is due to standard fRM, what we expect to find on three dimensions is: pronominal subjects should appear (i) more-than-expected in argument fronting (therefore a positive difference between observed and expected), (ii) possibly around as expected in non-argument fronting and (iii) the difference between observed and expected should be higher for argument fronting. However, if the bottleneck effect is at stake, we do not expect clear trends and asymmetries between configurations with respect to the pronominal status of the subject.

Section 4 presents the materials and methods of our quantitative study.

Language	Treebank	Tokens	Trees	Genres
Danish	DDT	100,733	5,512	f, n, nf, sp
Dutch	Alpino	208,747	13,603	n
German	GSD	287,725	15,590	n, r, w
German	LIT	40,335	1,922	nf
Faroese (19th-20th c.)	FarPaHC	40,471	1,621	b, f, nf
Icelandic (> 11th c.)	IcePaHC	983,675	44,029	b, f, l, nf
Norwegian Bokmaal	Bokmaal	310,221	20,044	bl, n, nf
Norwegian Norsk	Nynorsk	301,353	17,575	bl, n, nf
Swedish	Talbanken	96,859	6,026	n, nf
Old French (9th-13th c.)	SRCMF	199,699	18,029	l, nf, po

Table 3 All treebanks are Version 2.11 (last retrieved 01/2023). In this and following tables and figure, languages are grouped in subgroups (West Germanic, Scandinavian, Old Romance). Genres: b = bible, bl = blog, f = fiction, l = legal, n = news, nf = non-fiction, po = poetry, r = review, sp = spoken, w = wiki.

4 Materials & Methods

Materials We decided to work on treebanks annotated through common guidelines of the Universal Dependencies (UD, Nivre 2015, Zeman, Nivre & Abrams 2020) since they easily allow the comparative dimension. We queried a set of ten treebanks. We explored a set of contemporary Germanic languages: Danish (DDT, Johannsen, Martinez-Alonso & Plank. 2015), Dutch (Alpino, Bouma & Van Noord 2017), German (GSD and LIT[7], henceforth referred to German GSD and German LIT in the running text), Norwegian (Bookmal, Øvrelid & Hohle 2016; Nynorsk, Velldal, Øvrelid & Hohle 2017), Swedish (Talbanken[8]). We also queried two treebanks of diachronic stages of two Insular Scandinavian languages – Icelandic (11^{th} - 21^{th} century, IcePaHC, Arnardóttir, Hafsteinsson, Sigurðsson, Bjarnadóttir, Ingason, Jónsdóttir & Steingrímsson 2020 and Faroese (19^{th}-20^{th} century, FarPaHC[9]) – and one treebank of Old French (9^{th} - 13^{th} century; Stein & Prévost 2013). Table 3 reports the treebanks, their size and genre.

7 https://github.com/UniversalDependencies/UDGerman-GSD/blob/master/README.md; https://github.com/UniversalDependencies/UDGerman-LIT/blob/master/README.md.
8 https://github.com/UniversalDependencies/UDSwedish-Talbanken/blob/master/README.md
9 https://github.com/UniversalDependencies/UDFaroese-FarPaHC/blob/master/README.md

Configuration	Example
$-N_{\text{NonArg}}$	German (GSD-train-s1049)
	Normalerweise bin ich sehr skeptisch gegenüber Naturheilkunde
	'Usually, I'm very skeptical about naturopathy'
$+N_{\text{NonArg}}$	Dutch (Alpino-cdb2617)
	Vijf minuten voor de rust opende Meppelink de score
	'Five minutes before the break, Meppelink opened the score '
$-N_{\text{Arg}}$	Swedish (Talbanken-sv-ud-train-1727)
	Följderna blir vi snart varse
	'Consequences, we will soon notice'
$+N_{\text{Arg}}$	Old French (SRCMF-10092)
	Ceste avision vit li rois Mordrains en son dormant
	'This vision, the king Mordrain saw in his sleep'
	La queste del Saint Graal (cf. Marchello-Nizia 1996: 93)

Table 4 Relevant examples for every condition

Methods We performed our query search with *count.grew.pl* in a python environment.[10] The queries retrieved sets of sentences with two set of variables (two values each) and their combination. The first variable is the type of fronted argument (Adverbial/Oblique vs. Argument) in root contexts (dependency *root* governed by the lexical verb) and preceding the inflected verb (auxiliary, copular or lexical). UD syntactic dependencies labels allow us to retrieve adverbial elements extracting the syntactic dependency *advmod* and oblique complements with the syntactic dependency *obl*. Arguments are annotated with the syntactic dependency for objects *obj*, for indirect object *iobj* and, when available, complements with an argument nature *obl:arg* (cf. Merlo & Ferrer 2006) . We retrieved the nature of the subjects by assigning a variable representing the dependent of the syntactic dependency *nsubj* and by restricting the search to subject annotated with the part-of-speech (upos) NOUN, nominal entities, and PROPN, for proper nouns (Subj_{XP}); PRON, prononimal entities (Subj_{PRO}). Null subjects were retrieved by requiring the lack of the subject dependency; Subj_{NS}).[11] The prior counts on canonical orders are

10 All queries and codes are available as supplementary files at the following link: https://github.com/samo-g/testingV2JHS.

11 Although the majority of the V2 languages discussed here are typologically described as non-null subject languages (Dryer 2013), we conducted a search for null subjects to identify instances of null expletives (see also Mohr 2002), such as the naturally occurring example ex-

Language	Main clauses	Non-ArgV2	ArgV2
Danish	2737	720	63
Dutch	7439	2116	323
German	8210	3555	266
German LIT	1146	406	38
Faroese (19th-20th c.)	857	505	31
Icelandic (> 11th c.)	18851	12556	992
Norwegian Bokmaal	11861	2844	151
Norwegian Norsk	10228	2752	150
Swedish	3252	1025	51

Table 5 Languages, main clauses, V2 environments with fronted non-arguments and V2 environments with fronted arguments

based on the entire distribution available in the relevant treebank to maximize probability (see details in Samo 2022b). Table 4 shows the pattern and one example for each pattern. Results are presented in section 5.

5 Results and discussion

Table 5 provides an overview of the size of the configurations in Germanic languages. Detailed counts of the data (e.g. obl vs. adv, $\text{argument}_{\text{XP}}$ vs $\text{argument}_{\text{PRO}}$) are available in the supplementary file. A preference for non-argument V2 context is numerically observed crosslinguistically.

Asymmetries between the syntax of Old French V2 and Germanic emerge in the data retrieval (for the syntax of Old French, see Larrivée 2021 and Wolfe 2022 and references therein), since it is possible to find a larger set of V* orders. Indeed, the selected query find all the occurrences of adverbials preceding the inflected verb in V2 environments, representing target sentences (verb in bold) such as in *et puis* ***prent*** *le glaive et l'escu Lancelot* 'and afterwards Lancelot takes the sword and the shield' (SRCMF-10033) or *Longuement* ***parlerent*** *ensemble entre le preudome et Lancelot.* 'Longly, the noble and Lancelot talked together' (SRCMF-10189). The query for non-argument also detected cases of V2 in which the inflected verb is preceded by particles, such as *si* in *Si* ***entrent*** *tuit ensemble ou chastel* 'So, everybody entered the castle together'

tracted from German *Auf Fax und Telefonanrufe wird nicht reagiert* 'Fax and telephone calls are not answered' (German-GSD, test-s34). Please note that, for the rest of the work, we will consistently refer to these contexts as pronominal due to the similar type of triggered intervention.

Language	Trees	Non-ArgV2/V*	ArgV2/V*
Old French (9th-13th)	18029	10158	5377

Table 6 Number of trees in Old French SRCMF treebank, fronted non-arguments in main clauses (V*) and fronted arguments in main clauses.

(SRCMF-10707). Although the particle *si* can be considered an adverbial or a left peripheral base-generated marker (see details in Wolfe 2018), we calculate these examples as non-argument fronting. Similarly, the query for argument fronting optimally detects target sentences such as in cases of the type *bon consel* ***aroie*** *je cier* 'lit. Good advise, I have dear = I take into consideration good advises' (SRCMF-15962).

However, due to the *less-strict* nature (in the spirit of Benincà 1995) of Old French, our query also retrieved cases in which both non-arguments (e.g. obliques) and arguments (mainly prononimal/clitic) are fronted in V* contexts such as in [*Par son consoil*] [*nos*] ***revestoit*** *ma dame de ses robes veires* 'By her counsel, my lady gave us her vair robes to wear' (SRCMF-14065, English translation from Wright 2015: 86). We apply an independence assumption to the distribution of non-arguments and arguments in V* context, adding either to the relevant category. As discussed in details in Samo (2022b: 356), among the goals of this typology of quantitative cartographic studies, the automatisation process should be kept clear for its replicability crosslinguistically, leaving detailed manual analyses to future studies. Raw numbers with respect to Old French data are given in table 6.

Table 7 provides an overview of the distributions of conditions accross treebanks. Table 7 already visually suggest that there are asymmetry between canonical contexts and non-subject contexts, with a clear increase of prononimal subjects in the latter.

We can turn now to test hypotheses, repeated below.

Bottleneck effect	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) \leq\geq (-N_{\text{NonArg}}) - (\text{-N}_{\text{Can}})$
	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) \leq\geq 0$
	$(-N_{\text{NonArg}}) - (-N_{\text{Can}}) \leq\geq 0$
Standard fRM	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) > (-N_{\text{NonArg}}) - (-N_{\text{Can}})$
	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) > 0$
	$(-N_{\text{Arg}}) - (-N_{\text{Can}}) > (-N_{\text{NonArg}}) - (-N_{\text{Can}}) \approx 0$

Language	$+N_{Can}$	-N_{Can}	$+N_{NonArg}$	$-N_{NonArg}$	$+N_{Arg}$	-N_{Arg}
Danish	0.545	0.455	0.429	0.571	0.372	0.628
Dutch	0.580	0.420	0.593	0.407	0.467	0.533
German GSD	0.763	0.237	0.566	0.434	0.430	0.570
German LIT	0.626	0.374	0.497	0.503	0.332	0.668
Faroese	0.468	0.532	0.378	0.622	0.329	0.671
Icelandic	0.476	0.524	0.438	0.562	0.274	0.726
Norwegian Bokmal	0.550	0.450	0.454	0.546	0.209	0.791
Norwegian Nynorsk	0.582	0.418	0.486	0.514	0.355	0.645
Swedish	0.424	0.576	0.359	0.641	0.275	0.725
Old French	0.362	0.638	0.176	0.824	0.162	0.838

Table 7 Languages and distribution of conditions. Can = Canonical, NonArg = Non-Argument Fronting, Arg = Argument Fronting

Figure 1 summarizes the results. In all languages under investigation, as predicted by a theory of standard fRM, we observe that that the pronominal subject in argument fronting is higher than non-argument fronting ($z = -45.99,\ p < .000001$) and in both cases higher than expected.

No particular effect of genres has been detected. For example, if we calculate a coefficient C given by the difference of the observed minus the expected between arguments and non-arguments ($C = ((-N_{Arg}) - (-N_{Can})) - ((-N_{NonArg}) - (-N_{Can}))$), German GSD ($C = 0.13$) and German LIT ($C = 0.16$) show similar results. Elements of microvariation arise between Norwegian Bokmål ($C = 0.24$) and Norwegian Nynorsk ($C = 0.13$) which need to be further investigated (in the spirit of Vikner 1995).

The results for Dutch ($-N_{NonArg} = -0.013$), (diachronic stages of) Icelandic ($-N_{NonArg} = 0.037$) and Swedish ($-N_{NonArg} = 0.051$) strong support standard fRM effects' predictions ($-N_{NonArg} \approx 0$). Non-argument fronting is equivalent to what it is discussed in canonical clauses, possibly due to their lesser ability of being blocked by standard locality effects (cf. Costa et al. 2014, see also adjunct clefts in Samo & Merlo 2021).

Finally, we observe that Old French subjects in argument and non-argument fronting behave extremely similar ($C = 0.013$). This requires an in-depth explanation. A tentative analysis is that possibly the non-argument elements are fronted when focussed or topicalized (e.g. similarly to what happens, on a smaller scale, in contemporary Eastern Swiss Romansh varieties, cf. Samo 2022a), resulting in different required computations of locality compared to movements to ModP (cf. "highlighted", Rizzi 2004) and movements towards

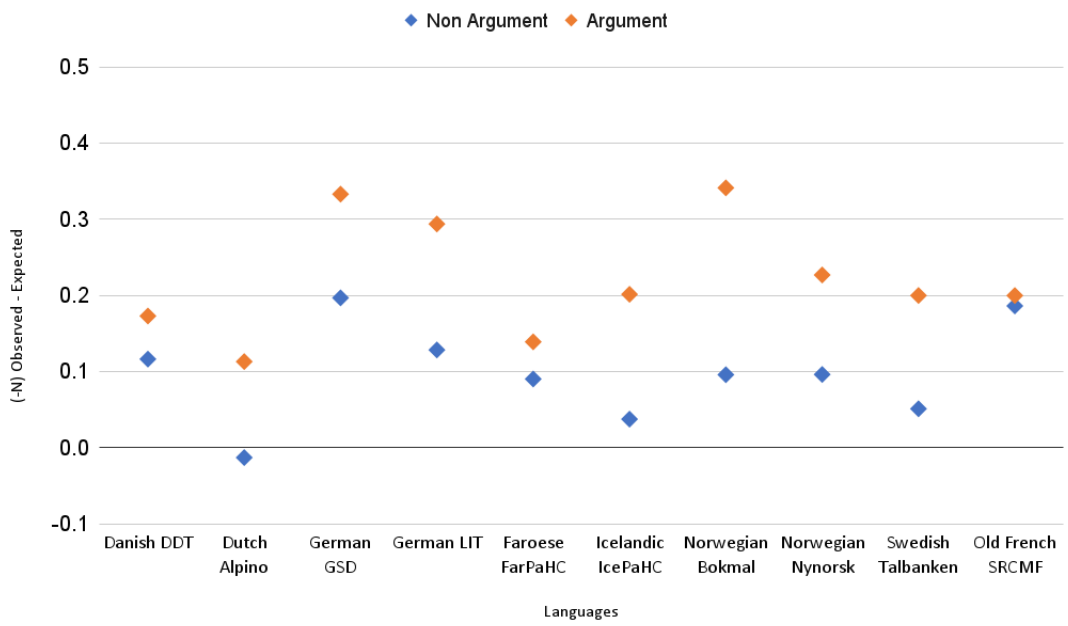


Figure 1 Differences between the observed counts $(-N)$ in non-argument fronting and argument fronting and the expected counts $(-N_{\text{can}})$ across languages. The closer to 0, the more similar to canonical contexts. Positive values mean that the observed distribution is higher than the expected one.

FocusP or TopicP.

In a nutshell, and as the results in figure 1 show, non-argument fronting behave similarly to argument fronting (see Mohr 2009 for object fronting in Germanic). In this light, V2 in Old French might be interpreted by adopting a strong Information Structure scenario (in the spirit of Larrivée 2021), which can also be applied for other varieties of Old Romance (see Rossi & Poletto 2022 and reference therein for Old Italian).

The results seem to confirm the predictions of standard fRM: pronominal subjects do appear (i) more-than-expected in argument fronting (therefore a positive difference between observed and expected), (ii) around as expected in non-argument fronting (see Dutch data) and (iii) the difference between observed and expected is higher for argument fronting than non-argument fronting in all languages. Summing up, our results and our methodology are in line with the predictions that locality effects found in grammatical A′-constructions in V2 fronting can be ascribed to standard fRM effects more than a bottleneck effect postulating a non-standard and peculiar type of locality computation (in line with the discussion in Abels 2017, 2020 and Samo 2019). Future studies should enlarge this methodology to contemporary languages described in the literature as having V2-like in a heterogeneous set of structures such as Estonian (see the detailed discussion in Vihman & Walkden 2021) or Modern Eastern Armenian (Giorgi & Haroutyunian 2020). We believe that the intense study of locality, and preferences in grammatical clauses, might provide a "further explanation" in understanding functional sequences (Rizzi 2013b: 213) and linguistic variability.

Non-V2 languages as a control group As noted by an anonymous reviewer, the strenght of the approach would be reinforced if we also compare the results from non V2 languages in terms of XP_{Arg}/XP_{NonArg} targetting the LP. One should expect that the intervention effects found in these languages when such XPs cross over an XP/pro subject to be comparable with the results of this study. We implement this study exploring Surface Universal Dependencies (SUD, Gerdes, Guillaume, Kahane & Perrier 2018, 2019, 2021), taking three languages (and three treebanks) as representatives of three subgroups of V2-types: German GSD for West Germanic, Swedish Talbanken for Scandinavian and Old French SRCMF for Old Romance. As non-V2 languages we have decided to focus on the non-V2 Germanic language English and languages in which locality issues are well studied − French (Durrleman, Marinis & Franck 2016), Hebrew (Friedmann et al. 2009) and Italian (Belletti et al. 2012).

The explored treebanks are the English EWT (251,529 tokens, 16,662 trees;

genres: blog, emails, reviews, social media web, Silveira, Dozat, de Marneffe, Bowman, Connor, Bauer & Manning 2014), the French GSD (389,262 tokens, 16,342 trees; *genres*: blogs, news, reviews, wiki; Guillaume, de Marneffe & Perrier 2019), the Hebrew IAHLTWiki (103,390 tokens, 5,039 trees; *genres*: wiki, Zeldes, Howell, Ordan & Moshe 2022), the Italian VIT (259,625 tokens, 10,087 trees; *genres*: news, nonfiction; Alfieri & Tamburini 2016).

We focused our investigation on a set of syntactic dependencies of SUD, with a set of queries that do not take into consideration (contrary to the previous study) the obligatory adjancency with the inflected verb. Subjects were retrieved using the syntactic dependency for subjects (subj). The values of TYPE of the subjects was determined by restricting the search to specific part-of-speech categories: nouns (*noun*) and proper nouns (*propn*) for XP, pronominal forms (*pron*) for pronouns. The absence of dependency SUBJ was adopted for retrieving null subjects.

Adverbs were identified by the syntactic constituents tagged as modifier (MOD) and a upos for adverbs *adv*. Complements included all oblique constituents (COMP:OBL) and the dependency (UDEP) dedicated for undiscriminable arguments/adjuncts. Finally, arguments were restricted to syntactic constituents labeled as objects (COMP:OBJ), indirect objects (COMP:IOBJ) and the dedicated dependency for dislocated constituents (DISLOCATED). We only take into account XP arguments (POS: *noun*, *propn*), since clitics in French and Italian preceding the verb represent noise. Canonical clauses queries do not involve the movement of the element in an initial position. Also in this case, we performed our counts by exploring http://count.grew.fr/count in a Python environment.

Results are summarized in Figure 2. We observed consistent and expected results across all languages analyzed. Dissimilarity plays a bigger role in argument fronting than non-argument fronting ($z = 47.67$, $p < .000001$). The results for Hebrew exhibit a parallel pattern to Old French, with Hebrew having a value of $C = 0.017$ and Old French having $C = 0.031$). [12] In Hebrew, adverbial fronting may trigger verb movement in a V2-like fashion, potentially involving "a criterial position higher than Fin" (Friedmann, Belletti & Rizzi 2021: 6, fn 10). Diachronic trends can also be observed, likely attributable to V2-phenomena, between Old French and French ($C = 0.359$). Asymmetries can be detected between French and Italian ($C = 0.182$), which vary in several parameters, including the null-subject parameter (cf. Rizzi 1982). Further exploration of micro-variability and the factors contributing to these asymmetries will be left for future work.

12 It is worth noting that the methodology used for the SUD data in this paragraph marginally differs from the methodology discussed in section 4.

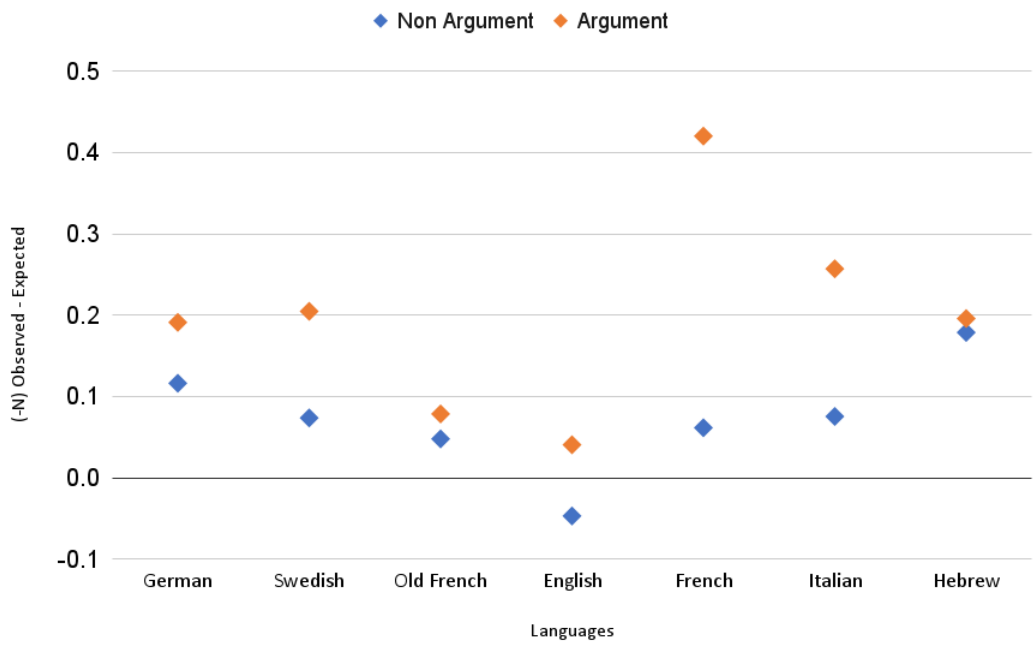


Figure 2 Differences between the observed counts $(-N)$ in non-argument fronting and argument fronting and the expected counts $(-N_{can})$ across V2 languages (German, Swedish, Old French) and non-V2 languages (English, French, Italian, Hebrew). The closer to 0, the more similar to canonical contexts. Positive values mean that the observed distribution is higher than the expected one.

Multifactoriality and language change The nature of standard fRM targets the issue of multifactoriality in linguistic variability in V2 environments, since the classes (and the hierarchy, as in Laenzlinger & Soare 2017) of features involved might explain restriction and freedom of movement across constituents (cf. Abels 2012). In line with Poletto (2023), we believe that language change in V2 languages might be due to a hierarchy of features and positions affecting constituent bearing these features. For example, fronted adverbs in less-strict V2 languages may target FocusP or TopicP, whereas in strict V2 languages, they can target FocusP, TopicP, or ModP, in line with recent discussion on microvariation in Rhaeto-Romance (cf. Samo 2022a).

We believe that the simple and precise methodology discussed here can be explored adding the diachronic dimension as an additional variable, since computational models do integrate observational data and the qualitative descriptions in syntax.

6 Conclusions

In this paper, we presented two competing theories regarding locality phenomena in non-subject fronting in V2 environments.

In particular, the two models made different predictions in terms of locality. Exploring quantitative tools, we tested the generalisation ability of the two models. Our results suggest that the observed locality effects in grammatical clauses, particularly in cases of non-subject fronting, may be more closely associated with standard fRM effects rather than a bottleneck effect.

Future studies shall enlarge the number of languages, syntactic configurations and features, keeping the automatisation process clear for its replicability. We believe that quantitative and computational methods represent a tool that should be exploited by theoretical syntacticians in order to compare, select and refine models.

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