Three-verb clusters in Interference Frisian: a stochastic model over sequential syntactic input

Hoekstra, E.; Versloot, A.

Three-Verb Clusters in Interference Frisian: A Stochastic Model over Sequential Syntactic Input

Eric Hoekstra
Fryske Akademy, Netherlands

Arjen Versloot
University of Amsterdam, Royal Netherlands Academy of Arts and Sciences, Netherlands

Abstract
Interference Frisian (IF) is a variety of Frisian, spoken by mostly younger speakers, which is heavily influenced by Dutch. IF exhibits all six logically possible word orders in a cluster of three verbs. This phenomenon has been researched by Koeneman and Postma (2006), who argue for a parameter theory, which leaves frequency differences between various orders unexplained. Rejecting Koeneman and Postma's parameter theory, but accepting their conclusion that Dutch (and Frisian) data are input for the grammar of IF, we will argue that the word order preferences of speakers of IF are determined by frequency and similarity. More specifically, three-verb clusters in IF are sensitive to:

- their linear left-to-right similarity to two-verb clusters and three-verb clusters in Frisian and in Dutch;
- the (estimated) frequency of two- and three-verb clusters in Frisian and Dutch.

The model will be shown to work best if Dutch and Frisian, and two- and three-verb clusters, have equal impact factors. If different impact factors are taken, the model's predictions do not change substantially, testifying to its robustness. This analysis is in line with recent ideas that the sequential nature of human speech is more important to syntactic processes than commonly assumed, and that less burden need be put on the hierarchical dimension of syntactic structure.

Keywords
Syntax, Frisian, Markov chain, sequential input

Corresponding author:
Arjen Versloot, Germanic Linguistics, University of Amsterdam, Spuistraat 134, Room 6.07, 1012 VB Amsterdam, Netherlands.
Email: a.p.versloot@uva.nl

Introduction

1.1 Hierarchy and linearity in verb clusters

Germanic languages (as many others) can include various verb forms in a sentence, which are used to express temporal, modal or other aspects of that sentence. In so-called object–verb languages, such as German, Dutch and Frisian, these verbs are clustered towards the end of the sentence, except for the finite verb in main clauses, which appears in the so-called verb-second position. A typological overview of various contemporaneous and historical varieties of Germanic can be found in Gerritsen (1984, p. 111), for example. A characteristic example from Dutch would be:

(1) *Wij <u>zouden</u> dit artikel eerder af <u>hebben kunnen maken</u>.*
     We should   this article earlier off have   can   make
     'We might have finished this article earlier.'

Generative grammar derives the linear order of the verb cluster from the manipulation of an underlying hierarchical representation. The classical generative analysis of verb clusters proposes that the underlying order in Dutch is left-branching (Evers, 1975, and many subsequent publications by other authors). The order of the cluster *hebben kunnen maken* is produced through a process called verb raising, which derives the order in (1) from its underlying mirror image. For a brief overview of problems with this analysis, see Zwart (2011, pp. 304–311). Some more recent generative analyses have proposed that the underlying order is head-initial, and that the head-final orders have been derived by movement (for example Kaan, 1992, p. 111; Zwart, 1993, p. 336 and subsequent work). Barbiers and Bennis (2010) studied the variation in word order within such clusters in Dutch and Frisian dialects and found that some orders are rare or even absent. They explain this variation by assuming a hierarchical structure within the cluster (p. 31). They conclude:

[…] dat het er op lijkt dat niet alleen de hiërarchische ordening moet worden behouden bij clusterformatie [….] maar ook dat de onderlinge hiërarchische volgorde moet terugkomen in de lineaire volgorde […]. (Barbiers and Bennis, 2010, p. 40)

([…] that it appears to be the case that not only should the hierarchical order be maintained in cluster formation […] but also that the hierarchical order has to be reflected in the linear order […])

According to their account, only the primary left-branching and the entirely mirrored orders–the consequence of complete verb raising–are syntactically 'true' verbal clusters. Other orders are either impossible or the result of a reinterpretation of, for example, participles as non-verbal elements in the sentence. In their view, the surfacing linear order is the result of forces and mechanisms that take place in an underlying hierarchically organised structure.

Some linguists propagate a rather different approach to word order in general, including the order in verb clusters. A central role is assigned to the sequential character of the speech signal, which limits the input for new learners to linearly organised language material and which is the ultimate output format as well. This changes the role of hierarchical structures from being directive, governing structures to being potential, derived structures, emerging from the analysis and interpretation of linear information, with no other goal than to be able to produce new sequential language utterances. As a consequence of the arbitrary habit in European languages of representing the temporal order of the speech signal as a left-to-right sequence, we consider left-to-right processing of language sequences as the logical, relevant order. Solan, Horn, Ruppin, Edelman, and

McClelland (2005) present an unsupervised algorithm that is capable of learning complex syntax, including hierarchical structures. Most importantly, it works with raw text or transcribed speech and does not require corpora tagged with part-of-speech information. Here, the linearity of both language learning and speech production is primary and abstract hierarchies are only needed to control long-distance dependencies. A somewhat different approach can be found in Bod (2009), where linear input data is parsed to recover potential hierarchical structures of sentences, assuming 'that the language faculty has prior knowledge about constituent structure, but no more than that' (p. 786). Both approaches are similar in the sense that the input data is primarily linear and hierarchical structures are only retrieved as far as deducible from statistical linear neighbourhood relations and not from a priori inherent hierarchical syntactic structures.

In Frank, Bod and Christiansen (2012), Bod and colleagues seem to go a step further, explicitly asking the question 'How hierarchical is language use?' They claim, for example, that a structure such as auxiliary fronting (in English questions such as 'Is the man hungry?'), which is often claimed to be unlearnable without taking hierarchical dependencies into account, 'can be learned from sequential sentence structure alone by using a very simple, non-hierarchical model from computational linguistics: a Markov (trigram) model' (p. 4525). They argue that 'hierarchical structure rarely needs to play a significant role in language comprehension' (p. 4526). Although they do not reject the hierarchical structure of linguistic data out of hand, they take the *sequential* structure as fundamental to human language processing.

Our paper provides a contribution to this issue. It shows that sequential structure, linearity, is highly relevant to processing and production in a way that can be accurately specified. The topic of our investigation is the qualitative and quantitative variation (frequency of occurrence) in verbal clusters in the *Interference Frisian* speech of Frisian-Dutch bilinguals. We claim that this variation can be easily understood if we assume that these speakers produce their sentences on the basis of a Markov chain, a probabilistic linear analysis of the various input sequences. The observed output is explained without recourse to an underlying, hierarchical structure and the concomitant movement or raising operations.

It must be added that this linear explanation is based on data reflecting the linguistic competence of language learners who have imperfectly mastered their first language. Hence this explanation does not necessarily apply to 'normal' language learners, that is, those who have fully mastered their language. All informants came from families in which both parents spoke Frisian. However, Dutch is prominently present in all walks of life, including education and the media, and has a higher social status than Frisian. As a result, the scenario of imperfect learning is the default for younger generations of speakers, even though they have Frisian as their mother tongue.

1.2 A generative analysis of verb clusters in Interference Frisian

Interference Frisian (IF) is a variety of Frisian spoken by younger speakers and heavily influenced by Dutch (Breuker, 1993; De Haan, 1997 and others). Even when we use the term IF here, it is not a stabilised, established variety of Frisian, rather a container term for a range of Frisian language utterances that show more or less extensive impact from Dutch. Koeneman and Postma (2006), henceforth Koeneman & Postma, studied the phenomenon of word order in the verbal cluster in IF. A group of secondary school pupils was asked to provide their grammaticality judgments about a number of test sentences involving verb clusters of three verbs. These clusters invariably contained a finite auxiliary of the perfect tense as their first verb, a modal as their second verb and a main verb as their third verb. In representing verb order, Koeneman & Postma used the notation of Stroop (1970), according to which numbers represent selection relations between verbs. An example from Dutch is provided below:

(2) *Omdat   de vandaal   zijn mes niet   heeft willen   inleveren.*
                                           1 FIN 2 MOD 3 MAIN
     because the vandal   his knife not   has   want   in.hand
     'Because the vandal didn't want to hand in his knife.'

The highest verb in the syntactic tree, the finite verb of the perfect tense, has been assigned the number 1 (*heeft*, 'has'), the modal selected by the finite verb has been assigned the number 2 (*willen*, 'want') and the verb selected by 2 has been assigned the number 3, (*inleveren*, 'hand in'), and is the main verb. The test sentences involved subordinate clauses, since the finite verb 'moves' out of the verb cluster in main clauses due to verb-second. Stroop's notation is shorthand for hierarchical and linear position. For the sake of clarity, we added mnemonic abbreviations glossing the type of verb (FIN for 'finite verb', MOD for 'non-finite modal' and MAIN for 'main verb') to Stroop's notation.

Dutch verbal clusters of the type illustrated by (2) systematically have the hierarchically higher verb in a position more to the left. Their equivalents in Standard Frisian (henceforth Frisian) are the exact mirror image. In the example below from Frisian, the hierarchically higher verb occupies a position more to the right:

(3) *Omdat   de fandaal   syn knyft net   ynleverje   wollen   hat.*
                                                3 MAIN   2 MOD   1 FIN
     because the vandal   his knife not   in.hand   want   has
     'Because the vandal didn't want to hand in his knife.'

The choice of Stroop's notation has the effect that the number 2 is not associated with uniform interpretations across clusters of two and three verbs. To make this clear, compare a two-verb cluster to a three-verb cluster (examples from Dutch):

(4) *Omdat   de vandaal   zijn mes niet   heeft   willen   inleveren.*
                                                 1 FIN   2 MOD   3 MAIN
     because the vandal   his knife not   has   want   in.hand
     'because the vandal didn't want to hand in his knife.'

(5) *Omdat   de vandaal   zijn mes niet   heeft   ingeleverd*
                                                 1 FIN   2 MAIN
     because the vandal   his knife not   has   in.hand
     'because the vandal didn't hand in his knife.'

The verb marked 2 is a modal in the three-verb cluster in (4): by definition, the verb marked 2 is not the main verb in a three-verb cluster. In a two-verb cluster the situation is different. The verb marked 2 is the main verb in a two-verb cluster as in (5); it is not a modal selecting a main verb. Thus, the interpretation of the verb marked 2 is not uniform across clusters: it is a modal auxiliary in a three-verb cluster, whereas, it is the main verb in a two-verb cluster. We will come back to this point below, because it is relevant to our view, according to which two- and three-verb clusters in Dutch and Frisian influence three-verb clusters in IF.

The verb cluster facts of IF can be summarised by the statement that all word orders that are logically possible are accepted by some of its speakers, though some orders are accepted by significantly more IF speakers than others (see 2.1 for more information about the data). In order to account for these data, Koeneman & Postma propose that Dutch sentences are input for parameter resetting of Frisian, thus causing a change from Standard Frisian to IF. The following parameter

settings from Dutch are responsible for influencing linear order in the verb cluster in IF (Koeneman & Postma, p. 131):

(6) P1: 1 > 2
     P2: 2 > 3
     P3: 1 > 3

Koeneman & Postma assume that language learners can only change one parameter at a time. If language learners were allowed to change all parameters at once, then they could in principle change their clusters in one fell swoop from Standard Frisian 321 (MAIN-MOD-FIN) to Standard Dutch 123 (FIN-MOD-MAIN), which does not seem to occur. Logically possible hybrid orders are explained with help of the assumption that only one parameter is changed at a time. Thus 321 can be changed to 231, as it requires one change only, but not to 123, as the latter change requires more than one change in parameter setting. A second parameter may only be changed after a certain amount of time (left unspecified) has elapsed. This is Koeneman & Postma's analysis in a nutshell.

Two points of criticism are relevant to the argument put forward in this article. First, Koeneman & Postma's analysis does not explain that the six word orders that actually occur have different acceptance rates, nor do they discuss the fact that there is a system in the variation in acceptance rates (see table 1 in section 2). In our view, an adequate model not only predicts the kind of variation, but also the degree of variation.

Our second point of criticism concerns the interpretation of the 2 (standing for the hierarchically second verb) in clusters of two and three verbs. The interpretation of the 2 is not the same for clusters of two verbs as compared to clusters of three verbs. Apart from its conceptual inadequacy, this wavering in the interpretation of the 2 is relevant for an auxiliary hypothesis offered by Koeneman & Postma, which they introduce in order to account for the rareness of clusters with the ordering 213 (MOD-FIN-MAIN) and 231 (MOD-MAIN-FIN). It turns out that these two orders hardly ever occur in the West Germanic dialect continuum, and they are only rarely accepted by speakers of IF. In order to account for the rareness of these orders, Koeneman & Postma (p. 136) suggest that P1 (1>2) has been changed already on the basis of clusters with two verbs. Changing P1 first (1>2) prevents the derivation of the orders 231 and 213. Thus IF would already feature sentences of the type illustrated below, involving clusters with two verbs, before the order is changed in clusters with three verbs:

(7) *Omdat   de fandaal   it knyft   wol   ynleverje.*
     because   the vandal   the knife   1 FIN   2 MAIN
     'because the vandal wants to hand in his knife.'

The problem with this account is that the interpretation of the 2 is not the same in clusters with two verbs compared with clusters of three verbs. The 2 is a modal auxiliary in clusters of three verbs, whereas it is the main verb in clusters of two verbs. This is highly unusual for generative theory, which relies on semantically uniform structures across languages which are manipulated by parameters in order to derive surface differences of the type discussed here. From a purely linear point of view, it is much less surprising that the 2 is defined in a way that is not concerned with the hierarchical or semantic nature of the verb. Basically, Koeneman & Postma covertly have a purely linear interpretation of the 2, which goes against the spirit of the framework in which they are working. In fact, we will make better sense of this aspect of their analysis by fleshing it out in more detail and incorporating it into a linear analysis of verb clusters. More specifically, we follow Koeneman &

Postma in assuming that the order in clusters of two verbs has an effect on the order in clusters of three verbs.

1.3 Road map

This article is structured as follows. Section 2 presents the word order data, which have been taken from Koeneman & Postma, for three-verb clusters in IF. It is shown that the data are more systematic than Koeneman & Postma had supposed. More specifically, there is a system to the acceptance rates for each of the associated word orders, a point which Koeneman & Postma overlooked, in part because their analysis does not lead them to expect the possibility of a correlation between a type of word order and its frequency. Data analysis also makes it clear that there is a correlation between the frequency of individual word orders in IF and their left-to-right similarity to the word orders of two- and three-verb clusters in Frisian and Dutch. In section 3, these analytical insights are formalised into a statistical Markov Chain model in the spirit of Zipf (1935, 1949 and subsequent work by other authors) which is shown to correctly derive the word orders and their associated frequencies. In section 4, the model is tested for robustness with different underlying assumptions.

2   Word order in the verbal cluster

2.1 Data

Verb clusters of three verbs have six logically possible word orders. Koeneman & Postma reported informants' judgments about the acceptability of these six orders. We will interpret the degree of acceptance as a measure of potential production, assuming that speakers judge as grammatical what they use themselves. This is a suggestion, which is based on the concept of grammars being bidirectional: production and perception are the result of the same grammatical system (see, for example, Boersma, 2011). Comparison of frequencies of attestations in corpus data and acceptability judgments show high correlations, with $r > 0.8$ (for example, Bermel & Knittl, 2012, p. 260). The type of survey affects the weight that items receive in the final results. In so-called forced choice tasks, informants are inclined to opt for the most common form, which leads to an over-representation of the more common forms in the dataset. Informants may accept low frequency constructions that appear rarely in daily speech if use is made of a binary acceptability test in which multiple sentences are tested. This can lead to over-representation of uncommon forms. Bermel and Knittl (2012, p. 268), when testing pairs of morphological competitors, state about it: 'Acceptability thus is not a zero-sum game, and in conditions of substantial flux and competition, users' reluctance to give a negative rating to either form may testify to the potentiality inherent in both forms for use, regardless of the rate at which they are realized.' They found this effect even when the acceptability of the items was scored on a Likert scale. Altogether, the correlations between corpus data and acceptability judgments are so high as to warrant the use of acceptability judgments as a proxy for utterance frequencies, while acknowledging that the percentages for the low frequency items may be over-rated.

On the basis of the similarity between perception data and production data, we would like to suggest, without pressing this point, that the analysis presented here holds true of production data as well. In this respect, it must be mentioned that verb clusters which are reported by Koeneman & Postma to be acceptable have also been found in production experiments involving primary school children (Ytsma, 1995, pp. 90–95). In addition, they have been reported for Frisian spoken by adults in De Haan (1996). The upshot of this discussion is that we feel justified in referring to

frequencies, which may equally refer to frequencies of production as to (proportional) frequencies of acceptance (perception), even though, strictly speaking, the data from Koeneman & Postma are based on frequencies of acceptance only.

Koeneman & Postma reported informants' judgments about the acceptability of the six word orders in Frisian which are logically possible in a verb cluster consisting of three verbs. The informants were 33 Frisian-Dutch bilingual pupils from secondary school. They came from the highest level of secondary education in a three-level system based on intellectual skills. The 33 pupils consisted of 18 second graders (ages 13 to 14) and 15 fourth graders (ages 15 to 16). Each of these pupils met the criterion that both of their parents spoke Frisian. The six word orders in the verbal cluster are the six test conditions which we are interested in. Every test condition was scored six times by 33 informants: N = 198 for every test condition. Thus, the maximum score for a test condition would be 198. The test condition was scored 6 times by providing six sentences, in slightly varying guises, which each embodied the relevant test condition, that is, the relevant word order. An example of some sentence stimuli is given below (Koeneman & Postma, p. 127), followed by an English translation:

Testsin		Soest dit sels sa sizze kinne?	
De plysjeman fertelt dat de fandaal syn mes …	a. moatte hat ynleverje	Ja	Nee
	b. hat ynleverje moatten	Ja	Nee
	c. hat moatte ynleverje	Ja	Nee

Test sentence		Would you say this yourself?	
The policeman told that the vandal his knife …	a. must has hand.in MOD FIN MAIN	Yes	No
	b. has hand.in must	Yes	No
	c. has must hand.in	Yes	No

Variation in the Frisian sentences was created, for example, by varying the modal. In addition, the Frisian test sentences were mixed with Frisian control sentences. In summary, the informants could indicate for each sentence whether they considered it to be acceptable in their Frisian spoken language.

Table 1. Acceptance scores for word order in the verbal cluster.

Test condition	Absolute YES score	Proportion of all YES scores
123 (FIN-MOD-MAIN)	120	32.4%
321 (MAIN-MOD-FIN)	105	28.4%
132 (FIN-MAIN-MOD)	58	15.7%
312 (MAIN-FIN-MOD)	58	15.7%
231 (MOD-MAIN-FIN)	21	5.5%
213 (MOD-FIN-MAIN)	8	2.2%

Table 1 above presents the distribution of accepted word orders in IF as reported by Koeneman & Postma. The first column contains the test condition. The second column contains the absolute number of times that a sentence containing the test condition was accepted. This may be referred to as the acceptance score. The third column gives the acceptance scores for each test condition as a proportion of the total number of all acceptance or YES scores (rather than the total number of all scores):

The maximum score that an order could get was 198, and participants could mark more than one order as being acceptable. The right-hand column presents the proportion of YES scores for each test word order as a percentage of the total number of YES scores (370). Thus acceptance probabilities are normalised to form a probability distribution of verb orders, or more specifically, of the proportion of occurrences in which the order in question was judged acceptable. The reason for doing so is that we will present a model predicting that distribution.

If the informants had accepted all orders, then the proportional acceptability score for each order would be 1/6 (out of all positive scores). That is not the case. Instead, and this has been left unexplained by Koeneman & Postma, there is differentiation in the pattern of frequencies associated with the word orders. This system will be analysed in greater detail below.

2.2 Parent orders

The six word orders that are logically possible neatly fall into three groups. The first group consists of the word orders 123 and 321. These word orders are the word orders that are the norm in the two contact languages which gave birth to IF. Thus, as mentioned in the introductory section, 123 is the order that is the norm in verb clusters in Dutch where verb 1 is a finite auxiliary of the perfect tense:

(8) *Omdat de vandaal   zijn mes niet   heeft   willen   inleveren.*
                                           1 FIN   2 MOD 3 MAIN
      because the vandal   his knife not   has   want   in.hand
      'Because the vandal didn't want to hand in his knife.'

Even though Standard Dutch allows for some alternation in clusters of two verbs, the word order is strictly 123 in three-verb clusters of the type exemplified in (8), which was the focus of the investigation conducted by Koeneman & Postma.

The reversed order, 321, is the order that is the norm in comparable verb clusters in Standard Frisian:

(9) *Omdat de fandaal   syn knyft net   ynleverje   wollen   hat.*
                                           3 MAIN   2 MOD 1 FIN
      because the vandal his knife not   in.hand   want   has
      'Because the vandal didn't want to hand in his knife.'

In the speech of older generation first language speakers of Frisian, this is the only acceptable word order in a three verb cluster (Tiersma, 1999, p. 128).

Thus 123 and 321 may be grouped together as parent orders, the orders which are used in Dutch and Frisian, the two parent languages of IF. Parent orders are also grouped together on the basis of their scores in the acceptance test (see Table 1). They share the property that they are the only orders which each have a probability of about one third. To be more specific, the probability of roughly one third for the 123 order is the probability of randomly sampling a 123 sentence from all the sentences that were accepted in the experiment in the data set. It is a relevant observation that

the two parent orders have practically the same probabilities, and that these probabilities together make up two thirds of the total.

The parent orders derive from the parent languages. The 321 order in IF derives from Frisian, and the 123 order in IF derives from Dutch. The latter implies that IF verb forms (which IF shares with Frisian) are associated with the word order specifications of Dutch verbs. This is a clear indication that speakers of IF have not adequately acquired Frisian. There is, in contrast, no evidence that speakers of IF make similar word order mistakes in their Dutch clusters. In accordance with this, Frisian secondary school pupils are not outperformed by their non-Frisian peers in the subject of Dutch in official exams, nor in other subjects (De Boer, 2009). The reliance of speakers of IF on Dutch grammar directly explains why they produce the 'Dutch' word order 123 when attempting to speak Frisian. In this way, IF is produced.

2.3 Hybrid orders

The orders 132, 312 share the common property that the first verb, going from left to right, is identical to the first verb of one of the parent orders (123, 321), whereas the second verb from left to right is not identical to the second verb of a parent order. Thus 132 and 312 may be grouped together as hybrid orders. They begin with their first verb as if a parent order is involved, but they do not continue a parent order. Hybrid orders can also be grouped together on the basis of their acceptance rates (see Table 1). They share the property that they are the only orders which each have a probability of about one sixth. To be more specific, the probability of roughly one sixth for the 132 order is the probability of randomly sampling a 132 sentence from all the sentences that were accepted in the experiment in the data set. The two hybrid orders have practically the same probabilities, and these probabilities together make up one third of the total.

Hybrid orders share with parent orders the 'correct' placement of the first verb: hybrid clusters begin with either 1 (the finite verb) as in Dutch or 3 (the main verb) as in Frisian. Hybrid orders differ with respect to the choice of the second verb, which is unlike what happens in either Dutch or Frisian. However, speakers of IF do not make mistakes in their Dutch verb clusters. IF comes into being because its speakers do not adequately acquire Standard Frisian: they make 'mistakes' in their Frisian clusters. The question arises how exactly they arrive at the acceptance of hybrid orders (cf. the discussion of production and perception at the beginning of section 2).

Our claim is that when attempting to parse or produce three-verb clusters, speakers of IF rely not only on word orders found in three-verb clusters, but also in two-verb clusters. This can be shown to explain the occurrence of hybrid orders. More specifically, the order 312 arises under

Table 2. Left-to-right line-up of 312 with 21.

Cluster type:	Main verb	Finite verb	Modal
312 MAIN-FIN-MOD	3	1	2
21 MAIN-FIN	2	1	

Table 3. Left-to-right line-up of 132 with 12.

Cluster type:	Finite verb	Main verb	Modal
132 FIN-MAIN-MOD	1	3	2
12 FIN-MAIN	1	2	

the influence of the word order 21 in a two-verb cluster, and the word order 132 similarly arises under the influence of the word order 12 in a two-verb cluster. This can be understood by a left-to-right line-up of 312 with 21, as in Table 2 below, and by a left-to-right line-up of 132 with 12, as in Table 3 below.

At the level of abstraction chosen in Table 2, these two cluster types are similar. Both start out with the main verb and continue with the finite verb (see also our discussion of Koeneman & Postma in the Introduction).

The match between the first two verbs is almost perfect, the only difference being that the main verb will take the form of an infinitive in 312 and the form of a participle in 21. This difference is not very salient for speakers of IF for two reasons. First, speakers of IF regularly confuse participles and infinitives, as Koeneman & Postma report. In a number of cases, past participle and ordinary infinitive are distinguished in Standard Frisian only by the pronunciation of a final /n/ in the case of participles, for example in the minimal pair *wolle*, 'want' (ordinary infinitive); *wollen*, 'wanted' (participle) (for information on the grammar of Standard Frisian, see Tiersma, 1999). The same applies to other modals such as *moatte*, 'must'; *kinne*, 'can'; and *sille*, 'shall'; and to some main verbs in spoken Frisian such as *sette*, 'put'; *prate*, 'talk' and other verbs. In Dutch, however, the pronunciation of a /n/ following a schwa is optional. Speakers of IF are influenced by Dutch in this respect, and regularly fail to master the morphosyntactic distribution of the /n/ following a schwa. For this reason, the formal difference between infinitives in 312 and participles in 21 will not be very salient to speakers of IF. Hence, we claim, the word order 312 is inspired by the occurrence of the word order 21. The order 21 is the normal word order for a two-verb cluster in Standard Frisian, and it is a permitted word order in Dutch.

Let us now move on to the left-to-right line-up of 132 with 12.

These two cluster types are similar at the chosen level of abstraction in Table 3. Both start out with the finite verb and continue with the main verb. They are not identical, since the main verb will take the form of an infinitive in 132 and the form of a participle in 12, but this is not a salient difference, as explained above. Hence, we claim, the word order 132 is inspired by the occurrence of the word order 12, the preferred word order for a two-verb cluster in Dutch (Bloem, Versloot, & Weerman 2014), while it is not permitted in Frisian.

2.4 Remaining orders: orders introduced by the intermediate verb

The two remaining orders, 231 and 213, share the common property that the first verb, going from left to right, differs from the first verb in both parent orders. More specifically, these orders are introduced by the intermediate verb, the modal auxiliary marked 2. These remaining word orders, 231 and 213, also group together on the basis of their acceptance rates, which are low.

2.5 Summary of and additional remarks on the draft model

The six logically possible verb clusters in IF can be classified in three groups on the basis of their similarity to verb clusters in the parent languages Frisian and Dutch. Parent orders are identical to the orders of Frisian and Dutch. Hybrid orders begin with the same verb as parent orders, going from left to right, but differ with respect to the second verb, whereas the remaining orders begin with a verb which cannot introduce a three-verb cluster in either Frisian or Dutch. Parent orders each have almost the same frequency of acceptance, hybrid orders each have the same frequency of acceptance (half of that of the parent orders) and the remaining orders both have a low frequency (5.5% and 2.2%). Thus there is a pattern in the correlation between the type of word order and its frequency.

Taking the likelihood of acceptance as a measure of potential production (see the discussion in section 2), we informally drafted a model predicting the production percentages. The draft model is based on the assumption that speakers of IF sample from their experience with Frisian and Dutch two- and three-word clusters when producing a three-verb cluster. For the first verb, this results in P(FIN1) = P(MAIN1) = 1/2 (see section 3). To produce the second verb, they again sample from the four constructions in the equivalent linear position and going from left to right. Note that we assume that if the second verb is identical to the first (that is already produced), it is rejected and a new sample is drawn. The reason for this is that the verb clusters which we discuss all contain two unique elements: they contain precisely one finite verb and precisely one main verb. This is true for both Dutch and Frisian, and we assume that speakers are aware that verb clusters with two tensed verbs do not exist and, similarly, that verb clusters with two main verbs do not exist. As a result, selection of one type of verb (FIN or MOD or MAIN) entails that it cannot be selected again.

It was tacitly assumed that the four constructions (Dutch and Frisian two- and three-verb clusters) have identical sampling probabilities. This assumption will be made explicit in the section 3, in which the draft model is formalised.

3   Model for calculating the probability of each word order inside the verb cluster

Our model, as explained above, must accommodate the fact that there are four types of cluster in the parent languages which may affect the choice of verb in IF clusters: Dutch two-verb clusters, Dutch three-verb clusters, Frisian two-verb clusters and Frisian three-verb clusters. We assume that each of these four cluster types exerts an influence on the choice of three-verb clusters in IF, and that the strength of this influence is equally strong for all four types. It has been shown (Slofstra, Hoekstra, & Versloot, 2010; Versloot & Hoekstra [forthcoming]) that the strength of influence of a given element A on an element B correlates with two factors: frequency, on the one hand, and similarity of form and meaning, on the other hand.

As to similarity, the more similar A is to B, the greater the influence of A on B. Thus, A and B must have (almost) the same meaning and there must be some formal similarity; that is, when comparing clusters of verbs, the same verbs must be involved, or a subset of them. Of course, three-verb clusters in IF are more similar to three-verb clusters in the parent languages than to two-verb clusters. This would imply that the influence of three-verb clusters is stronger than that of two-verb clusters. However, this effect is compensated for by the second factor: frequency. The frequency of two-verb clusters is much greater than that of three-verb clusters. We hypothesise that these two factors compensate for each other so that the effect of three-verb and two-verb clusters upon three-verb clusters is roughly the same. We also assume that the influence of Frisian parent orders equals the influence of Dutch parent orders. This reflects the socio-linguistic reality for present-day mother tongue speakers of Frisian. In section 4, we will experiment with different assumptions about the strength of influence of two- and three-verb clusters and the influence of Frisian and Dutch parent orders. It turns out that varying these assumptions does not significantly affect the predictions of our model, thus testifying to its robustness. In the version of the model presented below, the strength of influence of each of the four cluster types is equally strong as represented by a probability of 0.25 or 1/4. We assume that the verb cluster is built up from left to right. Consider first the probability of choice of the initial verb, as in Table 4 below:

From this table, it can be read off what the probability is of a cluster starting with the finite verb: it is 1/2 or 0.5. This is empirically as good as correct. It can be gleaned from Table 1 that the percentage of orders starting with the finite verb (123 + 132) is 32.4 + 15.7 = 48.1%.

Table 4. Probability of choice of the first verb in IF.

	Position 1
Dutch 2-verb cluster	Finite verb 1/4
Dutch 3-verb cluster	Finite verb 1/4
Frisian 2-verb cluster	Main verb 1/4
Frisian 3-verb cluster	Main verb 1/4

Table 5. Probability of choice of first and second verb in IF.

	Position 1	Position 2	Position 3
Dutch 2-verb cluster	Finite verb 1/4	(Main verb 1/3)	
Dutch 3-verb cluster	Finite verb 1/4	Modal 1/3	Trivial: main verb
Frisian 2-verb cluster	Main verb 1/4	(Finite verb 1/3)	
Frisian 3-verb cluster	Main verb 1/4	Modal 1/3	Trivial: finite verb

Similarly, it can be read off what the probability is of a cluster starting with the main verb: it is 1/2 or 0.5. This is empirically as good as correct. It can be gleaned from Table 1 that the percentage of orders starting with the main verb (321 + 312) is 28.4 + 15.7 = 44.1%.

Next consider the calculation of each of the six word orders for a cluster of three verbs. To calculate this, we must consider the probabilities of choice of the first and second verb, and multiply them. The positioning and choice of the third verb are trivial, given that the cluster is constructed from left to right and consists of three verbs. Table 5 below presents a full overview of the probabilities:

Note that the probabilities for position 2 are conditional as far as main verb and finite verb are concerned: this has been indicated by bracketing them. In this respect, our model resembles a Bayesian network. The probabilities for position 2 are, however, not causally related to the state (= the type of verb) of position 1, but they are subject to the general restriction that each state may only appear once in the entire chain.

If position 1 is occupied by a finite verb, the probability of a finite verb in position 2 becomes zero leaving only 3 options: Main verb (through Dutch), Auxiliary (through Dutch) and Auxiliary (through Frisian). Hence, each of the three has a probability of 1/3 or, roughly, 0.33. Similarly, if the first position is occupied by a main verb, then the probability of a main verb in second position becomes zero, and the remaining probabilities become 1/3 or, roughly, 0.33. Note that the probability of an auxiliary in second position is 1/3 + 1/3 = 2/3 or, roughly, 0.67. We can now calculate the probability of each of the six orders of IF, as in Table 6 below:

A correlation between the predicted values and the observed values is quite high: $r = 0.99$. The explained variance r^2 is 0.98. This means that 98% of the variance in empirical results of Koeneman & Postma (Table 1) is predicted on the basis of our model. Koeneman & Postma's model, in contrast, predicts that all orders are equally likely, which is far removed from the actual observed variance. In absolute terms, we may say that 92% of the YES scores are correctly predicted, if we apply the predicted probabilities from Table 6 to the total of 370 YES scores in the data set. Applying an equal likelihood, as follows from Koeneman & Postma's model, 73% of the YES scores are correctly predicted.

The less likely constructions (231 and 213) are more frequent in the observed data than predicted by the model. This reflects the over-representation of less likely word orders in the

Table 6. Predicted probability of each cluster and observed acceptance rate.

Order in IF	Calculation	Predicted	Observed
123 FIN-MOD-MAIN	1/2 * 2/3	1/3, ≈ 33%	32.4%
321 MAIN-MOD-FIN	1/2 * 2/3	1/3, ≈ 33%	28.4%
132 FIN-MAIN-MOD	1/2 * 1/3	1/6, ≈ 17%	15.7%
312 MAIN-FIN-MOD	1/2 * 1/3	1/6, ≈ 17%	15.7%
231 MOD-MAIN-FIN	0 * 1/3	0%	5.5%
213 MOD-FIN-MAIN	0 * 0.33	0%	2.2%

Table 7. Explained variance under four different sets of assumptions.

Predictions for each pair of assumptions	correlation (r)	explained variance (r^2)	p-value for $r = 0$ (two-tail testing)
Impact of 2-clusters = impact of 3-clusters Impact of Dutch = impact of Frisian	0.99	0.98	$p < 0.001$
Impact of 2-clusters = impact of 3-clusters Impact of Dutch = 0.5 * impact of Frisian	0.84	0.71	$p = 0.03$
Impact of 2-clusters = 0.5 * impact of 3-clusters Impact of Dutch = impact of Frisian	0.96	0.92	$p = 0.002$
Impact of 2-clusters = 0.5 * impact of 3-clusters Impact of Dutch = 0.5 * impact of Frisian	0.85	0.73	$p = 0.03$

acceptability judgements, as discussed at the beginning of section 2, similar to the bias found by Bermel & Knittl (2012, pp. 261–264).

4 Testing the robustness of the model

In this section the explained variance of the model will be investigated if different assumptions are made about the impact of Dutch and Frisian two- and three-verb clusters on IF. In Table 7, the first row repeats the predictions of the model under the pair of assumptions outlined above: the impact of Dutch clusters equals the impact of Frisian clusters and the influence of two-verb clusters equals the impact of three-verb clusters. The second row presents the results for the assumption that the impact of all Frisian clusters is twice as large as those of Dutch clusters. The third row presents the results for the assumption that the impact of Dutch and Frisian is the same, but that three-verb clusters in both languages have twice as much impact as two-verb clusters. The last row combines the assumptions of the previous two rows: the impact of Dutch is half of the impact of Frisian and the impact of two-verb clusters is half of that of three-verb clusters. The explained variance for each of these options is given in (the third column of) Table 7.

Table 7 shows that the model is not very sensitive to changes in the assumptions about the impact of Dutch clusters versus Frisian clusters or two-verb clusters versus three-verb clusters. It indicates that our model is fairly consistent in predicting a relative order of likelihood (P), where P(123 or 321) > P(132 or 312) > P(231 or 213). The robustness of the model is due to our assumption that IF clusters are built up from left to right on the basis of the knowledge of IF speakers of Dutch and Frisian two- and three-verb clusters. Since neither Dutch nor

Frisian clusters fill the first position in the verb cluster with a non-finite auxiliary, speakers of IF almost always judge as ungrammatical the option of beginning a cluster with a non-finite auxiliary. This assumption will hold for any weighting that is assigned to the influence of Dutch and Frisian and two- and three-verb clusters. The second position is always filled with a non-finite auxiliary in three-verb clusters in Frisian and Dutch, but the influence of two-verb clusters is responsible for the tendency of speakers of IF to sometimes choose a main verb or a finite verb. The orders 132 and 312 will only become more numerous than 123 and 321 respectively when speakers assign at least twice as much weight to the evidence from two-verb clusters as to the evidence from three-verb clusters when producing new three-verb clusters. Such a weight goes against the basic principle of an input (exemplar) based speech production. These two mechanisms in the model are responsible for the persistently high correlations between the observed acceptance rates and the probabilities as predicted by the model, as evinced in Table 7.

Testing the likelihood that the observed acceptance rates can be predicted by the model is impeded by the fact that the model predicts a likelihood of 0 for two of the six cells (213 and 231), while the data show acceptance rates, albeit low, in these cells. This implies that the absolute observed acceptance rates cannot be predicted from the model. The 29 YES scores for these two orders must be the result of an additional factor in the acceptance judgements of three-verb clusters. An obvious candidate for this additional factor is a purely random choice from the three available verbal elements, MOD, FIN and MAIN. If the 29 YES scores in the 213 and 231 cells are the result of a random choice, we can speculate that the YES scores in the other four cells are also affected by random choice. This means that 29 x 3/370 = 24% of YES scores could be the result of this random choice factor, while the rest of the distribution is successfully predicted by our model (email communication Paul Boersma). Note that we concluded in section 2 that the YES scores for these two cells may be over-rated, reducing the importance of the random choice factor and increasing the contribution of our model.

5   Conclusion

To sum up, the acceptability of three-verb clusters in IF can be adequately predicted from the following assumptions:

1. Speakers of IF have incomplete knowledge of three-verb clusters in Frisian
2. As a result of 1., they take recourse to their knowledge of three-verb clusters in Dutch
3. As a result of 1., they take recourse to their knowledge of two-verb clusters in Frisian and Dutch.
4. Dutch and Frisian clusters and two- and three-verb clusters have roughly the same impact on three-verb clusters in IF.
5. Positions in the verb cluster are filled from left to right.

It follows, especially from assumption 5., that the processing of these types of clusters can be understood entirely from a linear analysis of input data and a linear speech production routine. Our analysis shows, moreover, that varying degrees of frequency in acceptability judgments as a proxy for production ratios may be systematic and their relative proportions in speech production predictable under the current interpretation. This may be construed as evidence that syntactic interferences are at least partly based on similarities and dissimilarities between languages on the surface level, the level of the actual sequential speech utterance. This case alone does not prove that syntactic structures have no internal hierarchy, but it shows at least that bilinguals' linguistic

knowledge of one of their two languages, as reflected in acceptance rates (and, presumably, in frequency of production), consists of knowledge of linearity, similarity and frequency to such a large extent that an appeal to an 'underlying' hierarchical syntactic structure is not necessary, nor is it enlightening.

Funding

References

Barbiers, S., & Bennis, H. J. (2010). De plaats van het werkwoord in zuid en noord [The position of the verb in south and north]. In J. De Caluwe, & J. Van Keymeulen (Eds.), *Voor Magda. Artikelen voor Magda Devos bij haar afscheid van de Universiteit Gent* (pp. 25–42). Gent, Belgium: Academia Press.

Bermel, N., & Knittl, L. (2012). Corpus frequency and acceptability judgments: A study of morphosyntactic variants in Czech. *Corpus Linguistics and Linguistic Theory*, *8*(2), 241–275.

Bloem, J., Versloot, A. P., & Weerman, F. P. (2014). Applying automatically parsed corpora to the study of language variation. *Proceedings of COLING 2014, the 25th International Conference on Computational Linguistics: Technical Papers* (1974–1984). Dublin, Ireland: Dublin City University and Association for Computational Linguistics. [Online: http://www.aclweb.org/anthology/C14–1186]

Bod, R. (2009). From Exemplar to Grammar: A Probabilistic Analogy-Based Model of Language Learning. *Cognitive Science 33*(5), 752–793.

Boersma, P. (2011). A programme for bidirectional phonology and phonetics and their acquisition and evolution. In A. Benz, & J. Mattausch (Eds.), *Bidirectional Optimality Theory* (pp. 33–72). Amsterdam, Netherlands: John Benjamins Pub. Co.

Breuker, P. (1993). *Noarmaspekten fan it hjoeddeiske Frysk* [Normative aspects of present-day Frisian]. Doctoral dissertation, Rijksuniversiteit Groningen, Netherlands.

De Boer, H. (2009). Schoolsucces van Friese leerlingen in het voortgezet onderwijs [School success of Frisian pupils in secondary education]. Doctoral dissertation, Rijksuniversiteit Groningen, Netherlands.

De Haan, G. J. (1996). Recent changes in the verbal complex of Frisian. In: H. F. Nielsen, & A. Petersen (Eds.), *Frisian and Germanic Miscellany. Published in Honour of Nils Århammar on his Sixty-Fifth Birthday*, *7 August 1996*. Odense: Odense University Press. Also in J. Hoekstra, W. Visser, & G. Jensma (Eds.) (2010), *Studies in West Frisian Grammar. Selected papers by Germen J. De Haan*, Amsterdam, Netherlands: John Benjamins.

De Haan, G. J. (1997). Contact-induced changes in Modern West Frisian. *Us Wurk, 46*, 61–89.

Evers, A. (1975). *The transformational cycle in Dutch and German*. Doctoral dissertation, University of Utrecht, Netherlands.

Frank, S. L, Bod, R., & Christiansen, M. H. (2012). How hierarchical is language use? *Proceedings of the Royal Society B: Biological Sciences*, *279*(1747), 4522–4531. [Online: http://rspb.royalsocietypublishing.org/content/279/1747/4522.full.pdf]

Gerritsen, M. (1984). Divergent word order developments in Germanic languages: A description and a tentative explanation. In J. Fisiak (Ed.), *Historical syntax* (pp. 107–135). Berlin, Germany: Mouton.

Kaan, E. (1992). *A minimalist approach to extraposition*. MA thesis, University of Groningen, Netherlands.

Koeneman, O., & Postma, E. (2006). Veranderingen in Friese werkwoordclusters [Changes in Frisian verb clusters]. *Nederlandse Taalkunde*, *11*, 124–145.

Slofstra, B., Hoekstra, E., & Versloot, A.P. (2010). Een voorbeeld van gecamoufleerde taalbeïnvloeding: samenstellingsvormen van sjwa-substantieven in het Fries [An example of camouflaged language contact: the form of compounds with nouns in schwa in Frisian]. *Taal en Tongval*, *61*, 21–44.

Solan, Z., Horn, D., Ruppin, E., Edelman, S., & McClelland, J.L. (2005). Unsupervised Learning of Natural Languages. *Proceedings of the National Academy of Sciences of the United States of America*, *102*(33), 11629–11634.

Stroop, J. (1970). Systeem in gesproken werkwoordgroepen [System in spoken verb clusters]. *Taal en Tongval*, *22*, 128–147.

Tiersma, P. M. (1999). *Frisian Reference Grammar*. Fryske Akademy, Ljouwert..

Versloot, A. P., & Hoekstra, E. (forthcoming). Attraction between words as a function of frequency and representational distance: words in the bilingual brain.

Ytsma, J. (1995). *Frisian as first and second language. Sociolinguistic and psycholinguistic aspects of the acquisition of Frisian among Frisian and Dutch primary school children*. Doctoral Dissertation, Catholic University of Brabant.

Zipf, G. K. (1965). *The Psycho-Biology of Language. An introduction to Dynamic Philology*. Cambridge, MA: MIT Press. (Original work published in 1935).

Zipf, G. K. 1965. *Human Behavior and the Principle of Least Effort. An Introduction to Human Ecology*. New York, NY: Hafner (original work published in 1935).

Zwart, C. J. W. (1993). *Dutch Syntax: A minimalist approach*. Doctoral dissertation, University of Groningen, Netherlands.

Zwart, C. J. W. (2011). *The Syntax of Dutch*. Cambridge, UK: Cambridge University Press.