Composition-based analysis of German three-verb clusters

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Verb clustering is a linguistic phenomenon in which two or more verbs occur adjacently in a sentence. The word order in verb clusters across Germanic languages and dialects varies substantially without any change in meaning. Despite longstanding research on verb cluster formation in syntax, developing a simple and uniform analysis of these clusters remains challenging. This paper proposes a novel analysis of clause-final three-verb clusters in German. Our approach allows more flexible combination amongst the verbs within verb clusters, which enables the generation of some valid German verb orders which are otherwise problematic. This more flexible combination is comparable to the use of *composition* within Categorial Grammar.

I. Introduction

In this paper, a *verb cluster* refers to a sequence of two or more verbs that occur adjacently in a clause. In German, verbs typically cluster in a clause-final position, as given in (1). The descending 3-2-1 order is typical for standard German.[1]

(1) ... dass er das Examen bestehen[3] können[2] wird[1].
that he the exam pass be-able-to will
'that he will be able to pass the exam.'

Deviations from the standard order are found in constructions known as *auxiliary flip* and *Zwischenstellung* 'intermediate order', exemplified in (2), respectively. Regardless of the verb order, the meaning remains unchanged.

(2) a. ... dass er das Examen wird[1] bestehen[3] können[2].
that he the exam will pass be-able-to
b. ... dass er das Examen bestehen[3] wird[1] können[2].
that he the exam pass will be-able-to
Both: 'that he will be able to pass the exam.'

In auxiliary flip, the finite auxiliary 'flips', i.e., it changes its default final position to the initial position of the verb cluster. In Zwischenstellung, a phenomenon associated with Southern German dialects like Franconian (Kroch and Santorini 1991), the finite auxiliary intervenes between the infinitival complements.

From a syntactic perspective, developing a simple, uniform analysis of such verb clusters presents a challenge. Section II provides a brief overview of the relationship between complement inheritance and the composition used in categorial approaches. Section III addresses the issues found in some of the existing HPSG-based accounts of verb clustering.[2] Finally, Section IV proposes a competing account that avoids the complications of existing analyses while accounting for a wider range of grammatical orders in German three-verb clusters.

[1] Verbs in (1) are numbered based on their selectional order. A selecting verb called *governor* selects a verbal complement based on its verb form (Bech 1955). For example, in (1) the finite verb *wird* 'will' selects the bare infinitive *können* 'be-able-to', which in turn selects the infinitive *bestehen* 'pass'.

[2] There is extensive literature on verb clustering in German, including Kiss 1995, Meurers 1999, Müller 1999 and Müller 2021. However, a survey of these proposals is beyond the scope of this paper.

II. Complement inheritance and verb clustering

According to Hinrichs and Nakazawa (1994) (henceforth HN94) the auxiliary flip phenomenon exemplified in (2a.) provides evidence for constituency in verb clusters. This view motivates the binary left-branching analysis of standard German order and its flipped variant for auxiliary flip, depicted in Fig. 1.

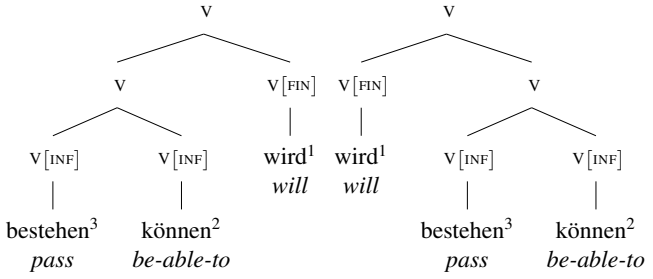

Fig. 1: Binary branching analysis of the standard German order (left) and auxiliary flip (right).

HN94's account is based on *complement inheritance*, a process whereby auxiliary verbs can take on the arguments of the verb they subcategorize for. This is achieved via lexical entries such (3), for the auxiliary *wird* 'will', whose SUBCAT list specifies the requirement for an infinitival verbal complement, and which also takes hold of the latter's SUBCAT list (via the tag $\boxed{1}$) and appends it to the front of its own SUBCAT list (where $\oplus$ is the concatenation operator).

(3) wird (*will*) $\mapsto$ $\left[\begin{array}{l}\text{HEAD} \quad verb[fin] \\ \text{SUBCAT} \ \boxed{1} \oplus \left\langle \left[\begin{array}{ll}\text{HEAD} & verb[inf] \\ \text{SUBCAT} & \boxed{1} \\ \text{NPCOMPS} & - \end{array}\right] \right\rangle\end{array}\right]$

There is a strong similarity between complement inheritance and the *composition* operation of some *categorial grammar* (CG) approaches such as CCG.[3] Example composition rules are $\mathsf{A}|\mathsf{B} + \mathsf{B}|\mathsf{C} \Rightarrow \mathsf{A}|\mathsf{C}$ ($>\mathsf{B}$), and $\mathsf{B}|\mathsf{C} + \mathsf{A}|\mathsf{B} \Rightarrow \mathsf{A}|\mathsf{C}$ ($<\mathsf{B}$), both of which allow a functor ($\mathsf{A}|\mathsf{B}$) that requires an argument B to combine with its argument before the latter has combined with its complement C. Such rules might allow the verb

[3] Combinatory Categorial Grammar (Steedman, 2019). See (Steedman, 1985) for a composition based analysis of Dutch verb clustering.

clusters of Fig. 1 to be derived as in Fig. 2.[4] In Fig. 2, the auxiliaries *können* and *wird* are complement inheritance verbs that attract arguments of the embedded verb phrase. While in HPSG complement inheritance is encoded in the valency list of lexical entries through structural sharing denoted by the box 1, in Categorial Grammar this operation is reflected in the derived categories as the result of composition. The cluster in Fig. 2 is analysed in a conventional bottom-up manner, i.e., combining first the hierarchically lowest verb *bestehen* with the adjacent complement *können*. The result of this combination is a verbal constituent whose nominal valency requirement (NP) has been inherited from the main verb. In CG-style analysis this is reflected in the result category $VP_{INF}|NP$, whereas in HPSG, the inherited NP complement resides in the SUBCAT list. Thus, both grammatical frameworks achieve the same result by different means.

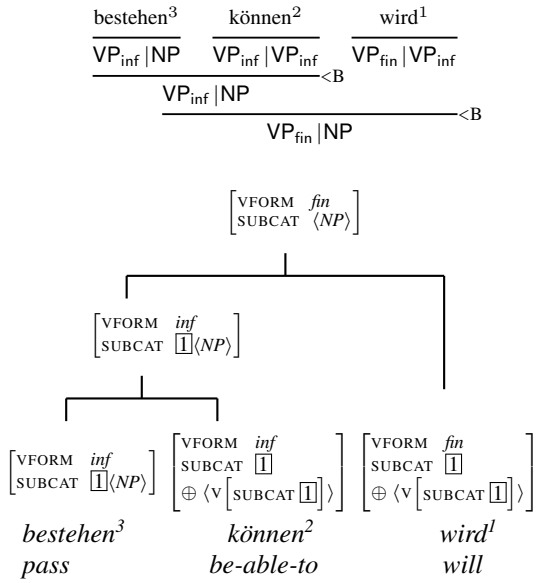

Fig. 2: CG style analysis of the standard German order (top) and a corresponding HPSG analysis (bottom).

The order of verbs in clusters is determined by the binary head feature FLIP marked on verbal complements, as enforced by the LP rules in (4). The main verb *bestehen* in Fig. 1 is marked as [FLIP −], and so must appear to the left of its governor, whereas the infinitive auxiliary *können* is unspecified for FLIP, and so may appear to either side of its governor *wird*, its FLIP value being set by the LP rules during the derivation.

(4)
a. HEAD[LEX +] < COMP[MAJ V][FLIP +]
b. COMP[MAJ V][FLIP −] < HEAD[LEX +]

Verb clusters are built using the head-complement schema in (5). The feature NPCOMP is used in ensuring that verb clusters include only verbal material. The selecting head-verb (H) carries out complement inheritance. Its verbal complement (V) is an embedded verb cluster, comprising ≥1 verbs.

(5)
V[NPCOMP −] → H[LEX+], V

Note that the head-verb (H) in (5) is required to be *lexical*, i.e. is [LEX+]. Within their account, this constraint is important in restricting clusters to having the 'bottom-up' binary branching structure seen in Fig 1. Whilst such structures allow an elegant solution to auxiliary flip, they appear to be at odds with successful analysis of verb orders found in non-standard varieties of German dubbed *Zwischenstellung* 'intermediate order', illustrated in (6), where the finite auxiliary intervenes between the two verbs of its postulated verbal complement.

(6) dass er das Examen bestehen[3] hat[1] können[2]
that he the exam pass has be-able-to
'that he has been able to pass the exam.'

It is noteworthy that, if the lexical constraint is *removed* from (5), then this schema, together with complement inheritance, would allow for alternative analyses which are not strictly 'bottom up', i.e. where the top-most verb V1 combines with the auxiliary V2, giving a result that can subsequently combine with the main verb V3. This is interesting, as this alternative pattern of combination provides a possible basis for analysing Zwischenstellung. These alternatives for combination also exist for CG with composition, as illustrated in Fig. 3, where the first derivation is an alternative analysis for the standard German order.[5] The second derivation shows a possible analysis for Zwischenstellung order, that involves combining the two auxiliaries before combination with the main verb.

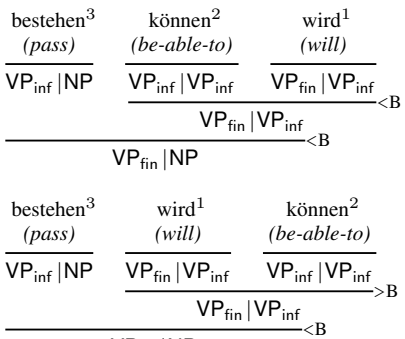

Fig. 3: An alternative CG style analysis of standard German order (left), plus an analysis for *Zwischenstellung* order.

In Sec. IV, we explore the idea of allowing more-flexible composition-like combination within HPSG, as a basis for a

[4]For this example, we ignore word order, and assume a simplified CG with a single 'directionless' connective '|'. As is common in CG, combination steps are presented moving down the page, so that derivations are 'inverted' trees. The derivations are also simplified in showing only a single NP complement for *bestehen*, whereas in the analysis of Hinrichs and Nakazawa (1994), the main verb's SUBCAT list would specify both subject and object NPs.

[5]This is an example of what is called *spurious ambiguity*, i.e. where alternative derivations are possible for the same example, with semantically equivalent results. Spurious ambiguity is common for CGs with composition, or other operations allowing flexible combination. A reviewer questioned whether such flexible combination amongst verbs might admit incorrect instances of partial VP fronting. Such invalid cases are readily blocked within our account, as explained in footnote 8, through our use of the VCOMPL feature, following Kathol 2000.

new analysis of three-verb German verb clusters. Before that, we consider some alternative analyses of German verb clustering, that seek to allow for cases such as Zwischenstellung.

III. Alternative analyses

The structural paradox posed by Zwischenstellung arises from an assumption, common to many frameworks, whereby the word sequence of a phrase is produced by *concatenating* the word sequences of its subconstituents. The method of *word order domains* (Reape 1993) breaks this strict association, allowing ordering processes to operate over smaller units than those produced as constituents.[6] Kathol (2000) analyses various phenomena in German, including verb clusters, in a framework that employs a variant of this method, thereby enabling analysis of Zwischenstellung orders. The account requires additional ordering mechanisms, e.g. the ability to order an item relative to its governor (using a feature GVOR), even where multiple governors and governees appear together as siblings within the same ordering domain. The move to allowing a *non-concatenative* relationship between word order and constituency raises many issues, including for parsing.

Bouma and Noord (1998) offer an alternative solution to the structural paradox, which involves abandoning a standard view of constituency, and instead adopting a *flat structure* for German clauses, in which the verbs of the verb cluster and other complements (NPs, etc) appear as siblings within a single projection. The account again relies on *complement inheritance*, and involves simultaneously linking together the verbs of the cluster so that the SUBCAT requirements of all are inherited up onto the top-most verb, which then serves as a 'super-head' which can combine with all the other complements (including the other verbs) in a single step. To limit the ordering possibilities allowed by such a flat structure, they employ a reduced version of *topological fields*, which distinguishes only *inner* vs. *outer zones*, with the verbs being required to sit within the inner zone (thereby giving the *semblance* of a cluster), and with other complements appearing in the outer zone, either to the left or right side, as determined by a *directionality* feature DIR. The flat structure of verbs within the inner zone allows Zwischenstellung orders to be generated, alongside various other impossible orders, which are excluded by use of a version of Kathol's GVOR feature, for constraining order between governors and governees.

Through our proposal, we hope to show that Germanic verb clusters can be successfully analysed without either adopting a radically 'flat' view of Germanic clause structure, or abandoning the concatenative assumption.

IV. Proposed Analysis

Our proposal seeks to account for the full range of verb orders observed within the verb-clusters of languages such as German and Dutch, whilst avoiding the complicating manoeuvres taken by other analyses, as sketched in the preceding section. Our starting point is the account of HN94, whose use of *complement inheritance* has the potential to allow additional composition-like possibilities for combination which have the potential to allow Zwischenstellung orders to be derived. As noted in Sec. II, these additional possibilities become immediately available, once the *lexicality* constraint on their head-complement schema (5) is removed. Our analysis diverges from HN94 in a number of other ways, which will be noted as we proceed.

$$\left[\begin{array}{ll} \textit{word} & \\ \textsc{phon} & \langle\ \textit{wird}\ \rangle \\ \textsc{syn} & \left[\begin{array}{ll} \textsc{cat} & \left[\begin{array}{ll} \textsc{head} & \left[\begin{array}{ll} \textit{verb} & \\ \textsc{vform} & \textit{fin} \end{array}\right] \\ \textsc{val} & \left[\begin{array}{ll} \textsc{subcat} & \boxed{1} \\ \textsc{vcompl} & \boxed{2} \oplus \langle \left[\begin{array}{ll} \textsc{head} & \left[\begin{array}{ll} \textit{verb} & \\ \textsc{vform} & \textit{inf} \\ \textsc{dir} & \pm \end{array}\right] \\ \textsc{val} & \left[\begin{array}{ll} \textsc{subcat} & \boxed{1} \\ \textsc{vcompl} & \boxed{2} \end{array}\right] \\ \textsc{npcomp} & - \\ \textsc{lex} & + \end{array}\right] \rangle \end{array}\right] \\ \textsc{npcomp} & - \\ \textsc{lex} & + \end{array}\right] \end{array}\right] \end{array}\right]$$

Fig. 4: Partial lexical entry of the auxiliary *wird* 'will'.

Our feature geometry for verbs is illustrated by the lexical entry for the auxiliary *wird* 'will' shown in Fig. 4.[7] Beginning with valency (VAL), we follow Kathol in splitting verbal complementation, as it relates to verb clustering, from other subcategorization, using a list-valued feature VCOMPL.[8] Following HN94, we assume that modals and auxiliaries are complement inheritance verbs, although the use of VCOMPL slightly complicates this process, as illustrated in Fig. 4, where we see separate inheritance of SUBCAT and VCOMPL lists from the verbal complement (via tags 1 and 2). We retain HN94's binary NPCOMP feature, to distinguish between a verbal cluster and the rest of the clause. A complement inheritance verb selecting a verbal complement specifies it as [NPCOMP −]. Verb clusters are constructed by the head-complement schema (7a), while (7b) combines the completed verb cluster, with its saturated VCOMPL list, with nominal complements.

(7) a. $\mathrm{V}[\textsc{npcomp}\ -] \rightarrow \mathrm{H},\ \mathrm{V}$
b. $\mathrm{V}[\textsc{npcomp}\ +] \rightarrow \mathrm{NP},\ \mathrm{H}[\textsc{vcompl}\ \langle\rangle]$

To manage verb order within clusters, we adopt the ordering feature DIR, which takes values L and R, in place of HN94's

[6]Briefly stated, the word sequence of a phrase is determined within a locally-definable *domain*, which is composed from the domains of its daughters. A daughter's domain may be added to the phrasal domain *as a unit*, *OR* its *components* may be added, liberating them from the constraints of constituency, and allowing them to *intercalate* amongst the other elements of the phrasal domain.

[7]To ensure clarity in our presentation, the value of DIR in Fig. 4 is explicitly stated as ±, which has the same effect as leaving the value unspecified in the lexical description.

[8]Kathol motivates this choice in relation to verbal-complex fronting in German. Thus, for a cluster consisting of verbs $\mathrm{V}_1 \ldots \mathrm{V}_n$, where V_n is the main verb at the bottom of the chain, a frontable complex should consist of a connected chain of verbs $\mathrm{V}_i \ldots \mathrm{V}_n$, that includes the main verb, and which may also include some ($\geq$0) of its other complements. Such complexes can be identified by the specification [VCOMPL ⟨⟩], ensuring the connectedness of the fronted verb cluster, even where the SUBCAT is non-empty. In our account, our use of VCOMPL has the additional benefit of allowing us to lexically constrain where flexible combination is allowed, as will be noted later.

FLIP feature.[9] The LP rules (8) apply, so that the DIR value marked on a verbal complement determines its position relative to its governor, i.e. so a verb marked [DIR R] must appear to the right of its governor, and one marked [DIR L] to its left. As with FLIP, this approach allows ordering constraints to arise from different sources. Thus, a verb's lexical entry might specify its DIR value, fixing its ordering relative to its governor. Alternatively, a verb that seeks a verbal complement may specify a value for DIR in the latter's description on VCOMPL. If both of these sources are unspecified, then DIR's value will be set by an LP rule during analysis, as at least one of the LP rules must apply. In standard German verb clusters, the main verb always precedes the governor, a fact which is captured in the following lexical entry for *bestehen* 'pass' in Fig. (5) by its instantiation as [DIR L].

(8) a. $\text{HEAD} < \text{COMP} \begin{bmatrix} \textit{verb} \\ \text{DIR} \quad \text{R} \end{bmatrix}$

b. $\text{COMP} \begin{bmatrix} \textit{verb} \\ \text{DIR} \quad \text{L} \end{bmatrix} < \text{HEAD}$

$$\begin{bmatrix} \text{PHON} & \langle\ \textit{bestehen}\ \rangle \\ \text{HEAD} & \begin{bmatrix} \textit{verb} \\ \text{VFORM} \ \textit{inf} \\ \text{DIR} \quad \text{L} \end{bmatrix} \\ \text{VAL} & \begin{bmatrix} \text{SUBCAT} & \langle\ \textit{NP}_{nom},\ \textit{NP}_{acc}\ \rangle \\ \text{VCOMPL} & \langle\ \rangle \end{bmatrix} \\ \text{NPCOMP} & - \\ \text{LEX} & + \end{bmatrix}$$

Fig. 5: Lexical entry of the main verb *bestehen* 'pass'.

A lexical entry for the true infinitive *können* 'be-able-to' is shown in Fig. 6, which again implements complement inheritance. Note that its DIR value is *unspecified*, so that its value can be determined later, based on context.

$$\begin{bmatrix} \text{PHON} & \langle\ \textit{können}\ \rangle \\ \text{HEAD} & \begin{bmatrix} \textit{verb} \\ \text{VFORM} \ \textit{inf} \\ \text{DIR} \quad \pm \end{bmatrix} \\ \text{SUBCAT} & \boxed{1} \\ \text{VCOMPL} & \boxed{2} \oplus \langle \begin{bmatrix} \text{HEAD} & [\text{VFORM}\ \textit{inf}] \\ \text{SUBCAT} & \boxed{1} \\ \text{VCOMPL} & \boxed{2} \\ \text{NPCOMP} & - \\ \text{LEX} & + \end{bmatrix} \rangle \\ \text{NPCOMP} & - \\ \text{LEX} & + \end{bmatrix}$$

Fig. 6: Lexical entry of the modal verb *können* 'be-able-to'.

This apparatus allows us to perform composition in a way discussed earlier in Section II, enabling a 'right-branching' analysis for the Zwischenstellung order shown in Fig. 7 on page 5. In this analysis, (7a.) allows the two complement inheritance verbs to combine into a verbal complex, which subsequently combines with the main verb. The corresponding combination is blocked in HN94 by the lexical constraint on schema (5).

Setting aside the analysis of word order constraints, this apparatus can generate all possible orders for three-verb clusters, as illustrated in (9), where each order is listed alongside the possible bracketing of verbs that can produce that order. We can see that some orders, i.e. (9a,f), have more than one bracketing, i.e. allow spurious ambiguity. Other orders have only one bracketing, but notably some can only be derived using flexible combination, i.e. (9c,e). However, not all of the orders are grammatical. The attested set of orders depends on factors such as construction type (e.g., Ersatzinfinitiv) and/or the speaker's dialect. Thus, an essential question arises whether this apparatus allows us to define constraints that yield the desired orders while blocking the unattested ones. In the case of German, the constraint is straightforward; we specify the direction value [L]eft on the main verb, as in Fig. 5 which immediately rules out any orders that violate that requirement. The orders that remain include the Zwischenstellung order, as in Fig. 7, along with the standard German order and auxiliary flip, as depicted schematically in Fig. 8 on page 5.

(9)
a. $123 \Longrightarrow 1[23]$ and $[12]3$
b. $132 \Longrightarrow 1[32]$
c. $213 \Longrightarrow [21]3$
d. $231 \Longrightarrow [23]1$
e. $312 \Longrightarrow 3[12]$
f. $321 \Longrightarrow [32]1$ and $3[21]$

V. Future work

A fundamental evaluation of this approach revolves around our ability to manage the varying word orders observed in coherent dialects of Germanic languages within three-verb clusters. In German, we can account for the grammatical orders by ensuring that the main verb remains positioned to the left. In Dutch, the order within a verb cluster depends on the construction type and the region in which it is used. For example, the orders *2-1-3 and *3-1-2 are unattested in Auxiliary-Aspectual/Modal-Verb constructions.[10] Notably, their generation requires flexible combination which we can potentially block by specifying within the finite verb that the VCOMPL list of its complement is empty, as illustrated in the lexical entry of *heeft* 'has' below.

$$\begin{bmatrix} \text{PHON} & \langle\ \textit{heeft}\ \rangle \\ \text{HEAD} & \begin{bmatrix} \textit{verb} \\ \text{VFORM} \ \textit{fin} \end{bmatrix} \\ \text{VAL} & \begin{bmatrix} \text{SUBCAT} & \boxed{1} \\ \text{VCOMPL} & \langle\ V \begin{bmatrix} \text{SUBCAT} & \boxed{1} \\ \text{VCOMPL} & \langle\rangle \end{bmatrix} \rangle \end{bmatrix} \\ \text{NPCOMP} & - \\ \text{LEX} & + \end{bmatrix}$$

[9]This feature is adapted from Bouma and Noord (1998), although we use values L and R, in place of their 'arrow' values. This feature is preferred as we seek a general scheme to account for all the Continental West Germanic languages, and their dialects, whereas the meaning of FLIP arises from the rather specific idea of 'flipping away' from standard German order.

[10]In the SAND project (Barbiers et al. 2008), the investigated types of Dutch three-verb clusters are Modal-Modal-Verb, Modal-Auxiliary-Verb, and Auxiliary-Aspectual/Modal-Verb clusters.

Modal-Modal-Verb and Modal-Auxiliary-Verb clusters in Dutch disallow a different pair of orders, namely *2-1-3 and *2-3-1. The generalisation here appears to be that, when the second verb 2 appears to the left of the finite verb 1, then the main verb 3 must in turn appear to its (i.e. 2's) left. This requirement is encoded by the following lexical entry for *kunnen* 'can'. An alternative lexical entry can be specified to cover the cases where *kunnen* appears to the right of the finite verb, i.e. which is prespecified to be [DIR R].

$$\begin{bmatrix} \textsc{phon} & \langle\ \textit{kunnen}\ \rangle \\ \textsc{head} & \begin{bmatrix} \textit{verb} \\ \textsc{vform} & \textit{inf} \\ \textsc{dir} & \textsc{l} \end{bmatrix} \\ \textsc{val} & \begin{bmatrix} \textsc{subcat} & \boxed{1} \\ \textsc{vcompl} & \boxed{2} \oplus \langle\ V \begin{bmatrix} \textsc{dir} & \textsc{l} \\ \textsc{subcat} & \boxed{1} \\ \textsc{vcompl} & \boxed{2} \end{bmatrix} \rangle \end{bmatrix} \\ \textsc{npcomp} & - \\ \textsc{lex} & + \end{bmatrix}$$

Thus, while the lexical specification varies among dialects, the LP/ID schemata remain consistent in our approach, offering the possibility of a standardized analysis of verb clusters across Germanic languages.

VI. Conclusion

In this paper, we explored the idea of integrating more flexible modes of combination into HPSG by proposing a composition-based analysis of German clause-final three-verb clusters. We showed that greater flexibility in structure assignment enables the analysis of the 'intermediate order' in German, which has presented challenges for influential HPSG-based accounts. We hope to have demonstrated that introducing composition into HPSG can simplify existing analyses while accounting for a broader range of grammatical orders in Germanic verb clusters.

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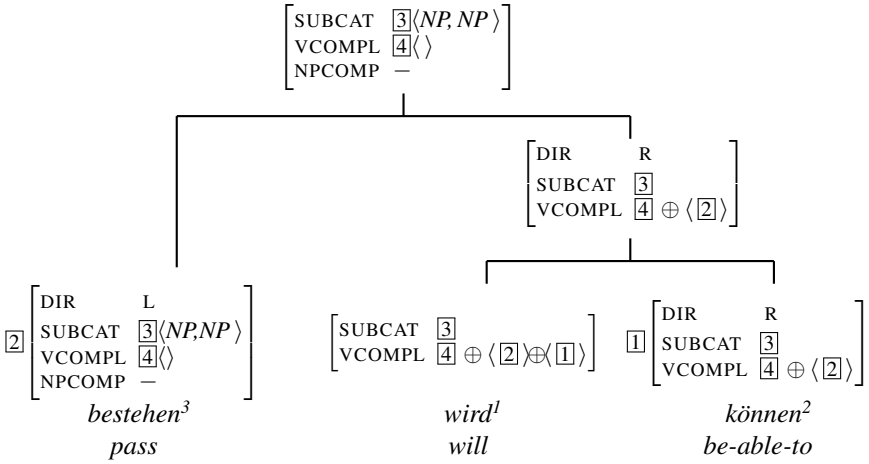

Fig. 7: Flexible combination analysis of Zwischenstellung order.

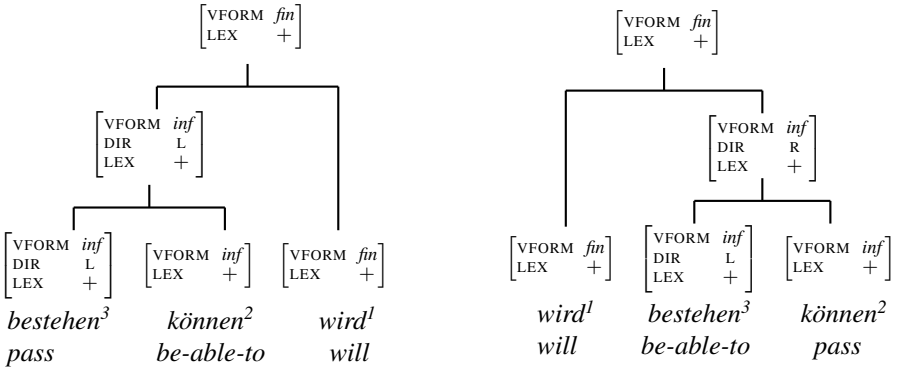

Fig. 8: Analysis of standard German order (left) and auxiliary flip (right).