PVP Fronting in German and Categorial Grammar

Hiroyuki IZUO

**Keywords:** German word order, incomplete category, parsing, incremental recognition, prediction

**Abstract:** German verbal complex consisting of a main verb and a part of its complements can occur in the sentence-initial position. This verbal complex is called a partial verb phrase (PVP). Using a function-argument framework of categorial grammars (CG) this paper will show that combinatory rules extended for auxiliaries can be applied to the analysis of German PVP fronting. This paper proposes combinatory rules, which will give each category a frame to represent the parsing results, and will contain a prediction mechanism that allows the grammar to recognize the scrambled sentence in relatively free word order language like German. Requiring that German noun phrases as verb’s complements should be type-raised, a German incomplete category fronting like the PVP can be derived. CG and its prediction mechanism are used to analyze the PVP fronting, because this mechanism makes the incremental recognition of free word order efficient. This paper will show that the German PVPs in fronted position have a common categorial structure. The PVP fronting in German appears before an auxiliary. The proposed combinatory rule for PVP is structured by three types of auxiliaries, which make it...
possible to classify the PVP structure into the inner PVP and the outer PVP. Data for PVP supports this premise. Type-raised categories for noun phrases and the separation of the PVP structure into two types according to the property of auxiliaries are good devices to capture the instances of PVP fronting in German.

1 Introduction

The purpose of this paper is to analyze German verbal phenomena, namely partial verb phrase (PVP for short) fronting. The central idea proposed in this paper is that the partial VPs involved in fronting constructions can be parsed incrementally. Incremental parsing means that the analysis of an utterance is constructed bit by bit, i.e. an input string should be scanned from left to right in a piecemeal fashion. By analyzing the derivation process of these verbal phenomena, this paper will argue that the incremental parsing of PVPs in the German Vorfeld, the field of fronted verb arguments and adjuncts, provides an account of an efficient and economical recognition process.

The approach developed here is not compatible with a theory involving movement operations and traces. This paper proposes to apply a Categorial Grammar (CG for short) formalism, and to handle relatively free word order in German. Many languages of the world show more variation of word order than does English which shows almost no variation of word order. In CG, noun phrases can be treated as functors, and applied not only to the verbal elements, but also to other nominal elements. It will be shown that CG can offer a uniform treatment of the constraint on the German PVP fronting. CG will be extended to handle languages with free word order, specifically to handle PVP fronting in German. In fact it is easy to modify combinatory rules of CG to allow to some extent of incremental recognition, which will be demonstrated in section 3.4. The approach in this
paper takes advantage of CG’s ability to combine syntactic elements in an incremental manner. CG allows the operations of composition and type-raising which is useful in handling a variety of linguistic phenomena including PVP fronting and plays an essential role in this analysis.

The paper proceeds as follows: first, it will introduce the German data of PVP fronting. Next, it will add a prediction mechanism to CG account of free word order, giving predicate-argument rules for verbal complex including PVP and auxiliaries. This paper’s approach treats case-marked noun phrases as functors, while allowing verbs to maintain their status as functors in order to handle complement-incorporation. By classifying the subcategorization requirements for auxiliaries, a common CG-structure for PVPs in fronted contexts will be established. Finally, it will be shown that the PVP data can be accounted for explicitly, if three types of auxiliary categories are introduced into the grammar with respect to fronted PVPs. At the same time, this paper will argue that the process of an incremental parsing of PVPs in the German Vorfeld is a process of predicting and selecting possible lexical entries that leads to economical and efficient computation.

2 Partial verb phrase fronting in German

In German matrix clauses, finite verbs appear in the second position and almost any part of speech can precede the finite verb. For example, the most common word order in simple transitive sentences is SVO (Subject-Verb-Object), but OVS is also possible. The nonsubject constituent which precedes the finite matrix verb in German V2 (verb second) sentence is the result of fronting or topicalization. A few examples of German V2 sentences are as follows.

(1) Das Buch wird er lesen.
the book[acc] will he[nom] read
“He will read the book.”

(2) Lesen wird er das Buch.
read will he[nom] the book [acc]
“He will read the book.”

In a V2 sentence, even a double infinitive which comprises of the infinitival forms of a main verb and an auxiliary verb can appear in sentence-initial position. A fronted double infinitive is exemplified in the sentence (3). *Lesen können* in (3) is the double infinitive. *Lesen* is the main verb (H) and *können* is a modal auxiliary (AUX-modal).

(3) Lesen können wird er das Buch.
read be-able-to will he the book
“He will be able to read the book.”

Double infinitive occurs normally in the final position in German V2 sentences, and the auxiliary follows the main verb. These are illustrated in (4a). In subordinate clauses which contain the double infinitive, “auxiliary flip” is justified, i.e. the finite auxiliary can be flipped from the final position and placed in front of the double infinitive, as the subordinate clause in (4b) indicates:

(4) a. Er wird das Buch lesen können.
he will the book read[bse] be-able-to[bse]
“He will be able to read the book.”
b. Ich weiß, dass er das Buch wird lesen können.
I know that he the book will read[bse] be-able-to[bse]
“I know that he will be able to read the book.”
However, the auxiliary verb alone cannot be fronted by itself. For instance, the examples given in (5a,b) show this. This is a property of bare auxiliaries (AUX-bse). These ungrammatical sentences must be eliminated with constraints added into the proposed combinatory rules. The incremental parsing model using prediction operation in this paper will clarify these constraints.

(5) a. *Können wird er das Buch lesen.
    be-able-to will he the book read
b. *Das Examen können wird er bestehen.
    the exam be-able-to will he pass

“He will be able to pass the exam.”

In contrast to the auxiliary fronting in the above example (5), the main verb infinitive can be fronted by itself in a V2 matrix sentence separated from the infinitive auxiliary in the sentence-final position. As a result, the double infinitive is split, as exemplified in (6a,b).

(6) a. Lesen wird er das Buch können.
    read will he the book be-able-to
    “He will be able to read the book”
b. Das Buch lesen wird er können
    the book read will he be-able-to
    “He’ll be able to read the book.”

This possibility to split the double infinitive via the fronting of a base form verb shall be explored by the combinatory rules, which will also make the difference between (3), (4), (5) and (6) clear. This paper will look at double infinitive constituency in a little more detail. Using examples (5b) and (6b), the difference between (5) and (6) will be explicitly accounted for in section

PVP Fronting in German and Categorial Grammar
In the above sentences (2), (3) and (6), an infinitive verb group is fronted. A related phenomenon can be observed in the following data (7). A full verb phrase (VP for short) consists of the main verb and all of the verb complements, e.g. the full VP in the case of (7) is \textit{ihr die Anekdote erzählen} (“tell her the anecdote”). Although in (7), a base form verb \textit{erzählen} (“tell”) and its accusative object \textit{die Anekdote} (“the anecdote”) are fronted without the dative object \textit{ihr} (“her”), this sentence is grammatical. In (7), the fronted verb phrase consists of a head verb infinitive and one of its arguments. A verb phrase consisting of a verb and some of its arguments is called a partial verb phrase (PVP). The phrase \textit{die Anekdote erzählen} (“tell the anecdote”) is a PVP, which occurs as an unsaturated verb phrase. (7) is a sentence that begins with PVP. In German, PVP can be observed in the first position of a V2 sentence.

(7) \begin{tabular}{l}
\textit{Die Anekdote } erzählen wird er \quad ihr \\
the anecdote[acc] tell \quad will he[nom] to-her[dat]. \\
\end{tabular}

“He will tell the anecdote to her”

This paper proposes combinatory rules for PVP, which will give tools to analyze PVP like (7), and by using these tools it will explore the difference between (3), (4), (5) and (6). The rule used to allow sentences with fronted PVPs is given in section 3. We do not show a trace in the main clause for the fronted PVP. PVP phenomena have already been discussed in literatures of Generative Grammar and HPSG, but no analysis of PVP within the CG framework, using the prediction mechanism proposed in this paper, has been provided before. This paper will not deny the results of the analyses of PVP within the framework of Generative Grammar (den Besten and Webelhuth 1990, Grewendorf and Sabel 1994, Heider 1990, Webelhuth 1990), GPSG (Nerbonne 1989, Uszkoreit 1987b) and HPSG (Hinrichs and
Nakazawa 1994, Nerbonne 1994), but it does show that the analysis based on CG extended by the mechanism for the prediction and the representation of concatenation can be executed in an incremental manner, and can capture the syntactical characteristic of PVP fronting in German, and can explain why PVP fronted to the sentence-initial position can be accepted as grammatical. Prediction operations are adopted on the basis of categorial grammar to prove the claim that the PVP has sufficient ground to occur in the sentence-initial topic position.

3 Combinatory rules

In the beginning of this section this paper will present the CG fragment for German. CG rules are applied to the incremental construction, which makes it possible to parse sentences from left to right by means of prediction. Incremental rules fashioned after the combinatory rule do not need to include traces in main clauses. In this section combinatory rules for PVP fronting will be introduced. Section 3.1 deals with a formal definition for categorial grammars, including the analyses of Steedman (1985, 1988, 1996), Buszkowski (1988), Karttunen (1989) and Moortgat (1988), and reviews a grammar fragment for representing the treatment for free word order. Section 3.2 introduces combinatory rules that will be used for the incremental analysis of German PVP fronting. Finally, in section 3.3, combinatory rules are refined for auxiliaries which play an important role in the construction of the sentence which contains a PVP fronting. In section 3.4, the paper will propose prediction rules which construct a set of possible categories predicted by the functor-argument scheme for each category and by its features.

3.1 An overview of CGs
In CGs, the set of allowable phrase structures is specified by a set of combinatorial rules based on the functor-argument relations which serve to combine syntactic categories while preserving a transparent relation between syntax and semantics. In CGs, the set of categories is defined recursively, and grammatical categories are of two types: functor categories and argument categories. Each head verb has a functor category and should be applied to its arguments, namely to the categories of its complements. This relation creates a head-complement scheme. The functor categories are written with a directional slash notation. A category such as X/Y represents a function looking for an argument of category Y on its right and resulting in the category X, where X and Y are variables over the set of categories. A functor category such as S\NP looks for an argument of type NP on its right and results in the value category of the sentence (S). This category represents an intransitive verb category (IV) or a verb phrase category (VP). Five rules in CG as indicated in (8) are motivated by the analysis of natural language.

(8)  
a. Forward Application: X/Y Y □ X  
   Backward Application: Y X\Y □ X  
b. Forward Composition: X/Y Y/Z □ X/Z  
   Backward Composition: Y\Z X\Y □ X\Z  
c. Associativity: (X\Y)/Z □ (X/Z)\Y  
d. Type-raising : X □ Y/(Y\X)  
   X □ Y\(Y/X)  
e. Division: X/Y □ (X/Z)/(Y/Z)  
   X\Y □ (X\Z)/(Y\Z)

Application and composition are rules, by which two categories can be combined. Application rules allow each functor category to combine with its arguments, while composition rules allow two functors to combine
together. The combinatory rules in CGs are linear, and the application has either forward or backward direction, and the same goes with the direction of the composition. Associativity, type-raising and division are rules, which convert one category into another. The associativity rule says that a function of two arguments can combine with them in each order. Using the associativity rule, a verb which has a functor category can be applied to its arguments in any order. This ensures the same syntactic effect of the flat structure in free word order. In CG, free word order can be made possible by applying the associativity to the verb’s category, or by applying the type-raising to the noun’s category. For example the nominative case noun phrase, abbreviated as NPnom, can be type-raised to S/(S\NPnom), namely to S/VP, and can then work as function. The rule of division can be used, for example, to capture the generalization that every sentence modifier S\S can be divided by NPnom and become a predicate modifier, namely (S\NPnom)\(S\NPnom).

Every verb has a functor category, and its argument categories are specified as subcategorization features of its head verb. A verb’s subcategorization can be represented in its functor category directly. This paper defines, therefore, the verb to be a function which specifies a set of arguments that it can subcategorize for and combine with in any order. In German, verbs act as functors in order to combine with objects with case marking. For instance, German transitive verb (TV for short) looks for an accusative case noun phrase (NPacc) to become VP. The ditransitive verb, which is abbreviated as DTV, for instance geben (“give”), looks for a dative noun phrase (NPdat), and the result of combination of DTV and NPdat functions as TV, because it looks for further NPacc and NPnom to become a sentence. Since German is not strictly verb final, verbs will not specify the direction of their arguments. A vertical slash “|” is used in the functor category to indicate that the position of its argument is undetermined. For example, an expression of category B can occur either on the left or on the
right of an expression of $A|B$. Using functor categories and the vertical slash notation, IV, TV and DTV in German can be defined by case-marked NPs as follows:

\[
\begin{align*}
(9) \quad & a. \quad IV =_{df} S|NP_{\text{nom}} \quad \text{(or } VP =_{df} S|NP_{\text{nom}}) \\
& b. \quad TV =_{df} VP|NP_{\text{acc}} \\
& c. \quad DTV =_{df} TV|NP_{\text{dat}}
\end{align*}
\]

The relatively free word order in German is a direct result of the efficient computability of its lexical categories which contain a rich system of case marking. In CG, noun phrases which contain rich case markings can change their category as argument into functor category. The ability of German case-marked nouns to scramble suggests that case-marked nouns act as functors. This is the reason why this paper represents both verbs and case-marked noun phrases as functors. Type-raising rules are used to convert nouns into functors over the verbs. Then the following type-raising of NP can be activated:

\[
\begin{align*}
(10) \quad & \text{Type raising of NP} \\
& a. \quad NP_{\text{nom}} \sqsubseteq S|(S|NP_{\text{nom}}) =_{df} S|IV \quad \text{(or } NP_{\text{nom}} =_{df} S|VP) \\
& b. \quad NP_{\text{acc}} \sqsubseteq VP|(VP|NP_{\text{acc}}) =_{df} VP|TV \\
& c. \quad NP_{\text{dat}} \sqsubseteq TV|(TV|NP_{\text{dat}}) =_{df} TV|DTV
\end{align*}
\]

The first type-raising (10a) indicates that a noun of a nominative case morpheme becomes a functor looking for an intransitive verb. $NP_{\text{nom}}$ looks for IV or VP to become a sentence. The second type-raising (10b) indicates that the accusative case noun phrase is looking for a transitive verb. In the same way, the dative case noun phrase in (10c) looks for a ditransitive verb. This functor category enables each noun phrase in a German sentence to obtain a new type of predicate-argument structure.
Since case-marked nouns in German subordinate clause should occur before the verb as shown in (11), German noun phrases must be type-raised and have functional properties, which make it possible to combine two noun phrases by applying composition rules. Case-marked nominal elements can be combined with one another by functional composition in any order. By applying the type-raising rule to noun phrases, the proposed CG formalism can model a verb-final structure in German. The following example (11) displays a tree structure for the type-raising rule, which is applied to two noun phrases. The case-marked noun phrases in German can be type-raised and classified as functors, as shown in (10). Figure (11) demonstrates the composition rules for analyzing two nouns in the free word order. Two noun phrases can be concatenated by the composition rule which combines two functors. The functor category, which is a result from the concatenation of two noun phrases, can be applied to the category of the verb. In the following tree diagrams an arrow ‘A → B’ indicates that B is a result of the type-raising of A.

Case-marked NPs in German can be merged with one another by composition rules. In (11), two case-marked NPs are merged by function composition. This NP complex has further a functor category, which has information about its argument category and value category. This information makes it possible to predict what types of expressions should be recognized in succeeding stages. However, because case-morphemes in English are invisible on the surface, the NP complex of (morphologically)
non-case-marked NPs in English are unable to get such information explicitly. This can be one of the possible reasons, why English allows almost no variation of word order, why the head verb appears close to the initial position of the assertive sentence in English, and why the PVP fronting is not to be observed in English.

3.2 Categorial grammar and PVP fronting

For the purpose of representing the process of concatenation this paper will extend in this section the combinatory rules for functor categories. In a transformational framework, one discusses fronting phenomena and argues that constituents are moved out of the underlying positions and placed to the front of an inflectional phrase. An analysis offered here would take a different approach to account for free word order, for example PVP fronting in German, without movement. This paper includes combinatory rules in the grammar which generates the fronted PVP and its subject in their scrambled positions. One of the reasons for this is the incremental and predictive processing of the relatively free ordering of subject and other complements of head verb in the German Vorfeld and Mittelfeld. This paper extends the CG framework to explain PVP in the following manner.

The traditional CG formalism as introduced in section 3.1 has no mechanism to represent the result in concatenating two categories. For the purpose of representing the process of concatenations, this paper will extend the combinatory rules as follows. On the value-category of the functor-category it represents each result of the application of the rules, by which two categories are combined, or each result of the conversion of one category into another functor category. It gives combinatory rules with such representation, as shown in (12). If a category C works as functor category A/B, we use a notation of the functor category like A<C>/B, for example we can use the functor category S<NP_{nom}>|IV for the nominative noun
phrase NP_{nom}. This category is equal to S<NP_{nom}>|VP. Using this notation, the above mentioned combinatory rules can be rewritten as follows, where the notation ‘C\_1^\_C\_2’ indicates the concatenation of two categories C\_1 and C\_2.

(12) a. Forward Application: X<C\_1>/Y Y<C\_2> □ X<C\_1^\_C\_2>
   Backward Application: Y<C\_2> X<C\_1>/Y □ X<C\_2^\_C\_1>

b. Forward Composition: X<C\_1>/Y Y<C\_2>/Z □ X<C\_1^\_C\_2>/Z
   Backward Composition: Y<C\_2>/Z X<C\_1>/Y □ X<C\_2^\_C\_1>/Z

c. Associativity: X<C>|Y|Z □ X<C>|Z|Y

d. Type-raising : X<C> □ Y<C>|(Y|X)

e. Division: X<C>/Y □ (X<C>/Z)/(Y/Z)
   X<C>/Y □ (X<C>/Z)/(Y/Z)

If the category of a head verb of a ditransitive verb phrase DTV is H, the notation DTV<H> is used, which can be written in the functor form VP<H>|NP_{acc}|NP_{dat} or S<H>|NP_{nom}|NP_{acc}|NP_{dat}, whose arguments are unsaturated. If this H is combined with all of its complements, including a subject noun phrase, the result is a sentence category, for example S<NP_{nom}^\_VP[H^\_NP_{dat}^\_NP_{acc}]> which shows that a subject noun comes on the left of H and the dative and accusative complements come on the right of H. Generally, S<H>|C^* is the category of the head verb H which takes any number of complements C^* as arguments and then gives as its value a sentence S<H> whose head verb is H. The combinatory rules are applied to each argument-category of the head verb step by step, and these rules make possible to use binary tree structures for the analysis of German sentences. The tree structure (13c-1) is made by the head-complement rule (13a-1) in CG style. The combinatory rules can also be applied to each functor-category of the noun phrase. The tree structure (13c-2) is made by the complement-composition rule (13b). Both of these trees are binary, and will
show the ability to predict the sentence structure incrementally.

(13) Head-Complement Rule and Complement-Composition Rule

a-1. \( X<H|Y_1|...|Y_i|...|Y_n Y_i<C \) □ \( X<H^C>|Y_1|...|Y_n \)

a-2. \( Y_i<C> X<H>|Y_1|...|Y_i|...|Y_n \) □ \( X<C^H>|Y_1|...|Y_n \)

where \( 1 \leq i \leq n \).

b. \( V_1<C_i>|V_2 V_2<C_j>|V_3 \) □ \( V_1<C_i^C_j>|V_3 \)

c-1. \( S<H^C>|Y_1|...|Y_n \)

\( S<H>|Y_1|...|Y_i|...|Y_n Y_i<C \)

\( V<P<C_i^C_j^H> \)

\( V<P<C_i^C_j>|V_2 \)

\( V_2<H> \)

\( V<P<C_i>|V_1 V_1<C_j>|V_2 \)

\( V<P<NP_{acc}>NP_{dat}>|DTV \)

\( VP<NP_{acc}>|TV \)

\( TV<NP_{dat}>|DTV \)

\( NP_{acc} \)

\( NP_{dat} \)

The following example (14) displays a tree structure for the type-raising rule. In the case of (14), the complex of noun phrases gets a functor category \( VP|DTV \), whose value category \( VP \) contains as parsing result a concatenation of two noun phrases, namely \( <NP_{acc}^NP_{dat}> \).

(14) \( VP<NP_{acc}^NP_{dat}>|DTV \)

3.3 Combinatory rules for PVP fronting and auxiliaries

In this section, a rule is proposed which can operate on auxiliary verbs. This rule combines each auxiliary verb with the verbal head of a VP complement of the auxiliary. The rule can be made as described in (15) below. The auxiliary (AUX for short) specifies its functor category only for the head
verb H and H’s complements. AUX combines with H, if the feature set of H contains the feature bse (base form) or prt (past participle form). If H has the category S<H>|C*, i.e. if H should be saturated with all complements C* to make a sentence S, the category composed of H and AUX behaves in the same way as H, because of the argument inheritance by the auxiliary. This means that the result of concatenation of H and AUX has a category like S<H^AUX>|C*, which shows that it has the same member of the H’s complements C*.

(15) Combinatory rule for AUX:

a. (S<H^AUX>|C*)\(S<H>|C*)
b. (S<AUX^H>|C*)/(S<H>|C*)

where:

1) H has the feature bse or prt.
2) The concatenation H^AUX-modal is a modal-V-sign.
3) C* is the complements of main verb H-bse or H-prt in VP.
4) VP also contains the information about the subject, namely about agreement, because the VP’s category is S\NPnom.

By using (15) a verb can be combined, for example lesen (“read”), with a modal auxiliary, for example können (“can”), to get lesen können (“read can”). In German V2 structure, if a head verb H has a feature bse or prt and precedes a finite auxiliary, and not all complements of H are saturated in front of this H, this verb phrase is called partial verb phrase (PVP). In other words the main verb H in PVP subcategorizes for an almost arbitrary subset of its complements.³

Because the auxiliary subcategorizes for a verb, and because of the argument inheritance by the auxiliary, any unsaturated complements of the PVP are raised to become complements of a verbal complex composed of this PVP and the finite auxiliary verb in the matrix clause. This
characteristic of PVP and its complements enable PVPs to be represented by this paper’s combinatory framework. PVPs also have the following properties: If PVP takes its unsaturated complements as arguments, it becomes a VP. If an auxiliary entry subcategorizes for VP, there also exist PVPs which the same auxiliary subcategorizes for. All PVPs must be FOCUS+ and therefore can be found in the fronted position. The following rule (16) will create PVPs which may appear in the fronted position of a German V2 sentence. PVPs created by this rule will include the head verb and some number of the head’s nonsubject complements, i.e. PVP dominates one head verb and one or more (inclusive zero) complements.

(16) Combinatory rule for PVP

If a head verb H has a bse or prt feature, and has a category S<\textit{H}>|C∗, then

\[ \text{[1]} \ S<\textit{H}>|C∗ \sqcup S[\text{[1]}]^\textit{H}>/[\text{[2]}] \]

where \( \text{[1]} \sqcup # \text{[2]} = C∗, \) i.e.

a. \( \text{[1]} \) is a list of complements of H, which are saturated on the left of H, and

b. \( \text{[2]} \) is a list of unsaturated complements of H and will appear on the right of H.

c. \( \sqcup # \) is the complement union operator, which combines the PVP’s saturated complements \( \text{[1]} \) and the PVP’s unsaturated outstanding complements \( \text{[2]} \) to form the complements list \( C∗ \) of the head verb.

On the right side of the rule (16), \( \text{[1]} \) is a list of saturated complements of H, and \( \text{[2]} \) is a list of the unsaturated complements of H. (16) is a sort of single phrase structure rule for PVP, but it can also build a VP, if \( \text{[1]} = C^{+}, \) where \( C^{*} = \{ C^{+}, N_{\text{nom}} \}. \) It is also possible that the list \( \text{[1]} \) has zero members. The rule (16) allows not only a PVP, but also VP. However, this
phrase, namely \[1\]^H, should occur on the left side of \[2\], and H should have the feature bse or prt. For example, if a ditransitive verb whose category is represented in (17a) is used, two PVPs can be constructed as shown in (17b). Since the complements list of the head verb is \(<\text{NP}_{\text{nom}}, \text{NP}_{\text{acc}}, \text{NP}_{\text{dat}}\>\), the complements union allows two partial lists of complements as indicated in (17b) for instance. The examples (17b-1) and (17b-2) show that this verbal head of a PVP takes either an accusative object or a dative object as a single complement.

(17) a. Head verb: \(S<\text{H}|\text{NP}_{\text{nom}}|\text{NP}_{\text{acc}}|\text{NP}_{\text{dat}}\)
   
b. PVP: 1. \(S<\text{NP}_{\text{acc}}^\text{H-bse;prt}>/\text{NP}_{\text{nom}}/\text{NP}_{\text{dat}}\)
      2. \(S<\text{NP}_{\text{dat}}^\text{H-bse;prt}>/\text{NP}_{\text{nom}}/\text{NP}_{\text{acc}}\)
      where \(\text{bse;prt}\) means \(\text{bse or prt}\).
   
c. Fronted H as a kind of PVP: \(S<\text{H-bse;prt}>/\text{NP}_{\text{nom}}/\text{NP}_{\text{acc}}/\text{NP}_{\text{dat}}\)
   
d. Fronted VP as a kind of PVP: \(S<\text{NP}_{\text{dat}}^\text{NP}_{\text{acc}}^\text{H-bse;prt}>/\text{NP}_{\text{nom}}\)

This paper proposes to classify the fronted H and fronted VP into PVP as indicated in (17c) and (17d) respectively, because in this case H has feature bse or prt and precedes the finite auxiliary (AUX-finite for short). In order to construct combinatory rules for German PVP, the paper proposes to separate PVP in two types: PVP1 and PVP2. PVP1 is composed of H-bse (or H-prt) and some members of its complements which precede H. PVP1 can be regarded as an inner partial verb phrase because of the base (or past participle) form of its head verb. Compared with PVP1, the partial verb phrase composed of PVP1 and a finite auxiliary (AUX-finite) can be regarded as an outer partial verb phrase (PVP2) because of the finite form of the auxiliary. The category of the finite auxiliary which is able to be combined with PVP1 and to yield PVP2 is indicated in (18).

(18) a. PVP2\PVP1
b. \((S^{<PVP2_[[1]^H-bse;prt^AUX-finite]>/[2]} \setminus (S^{<PVP1_[[1]^H-bse;prt]>/[2]})\)

c. \(S^{<PVP2[[1]^H-bse;prt^AUX-finite]>/[2]}\)

\(S^{<PVP1[[1]^H-bse;prt]>/[2]}\) \quad \text{AUX-finite}

The category (18a) is the abbreviation of the category (18b). The category of the finite auxiliary combines with the category of an inner PVP, namely \(S^{<PVP1[[1]^H-bse;prt]>/[2]}\), which is saturated with some of the complements of H, and then yields the outer PVP, namely \(S^{<PVP2[[1]^H-bse;prt^AUX-finite]>/[2]}\). A tree structure for this rule is shown in figure (18c), which represents a derivation of PVP2 from PVP1 by applying a functor category of the finite auxiliary to PVP1.

3.4 Prediction mechanism and PVP

The PVP occurs in the sentence-initial topic position, because, in PVP, verbal constituents are topicalized with some of their NP arguments. This paper treats such partial verbal constituents via combinatory rules that can combine nominal elements and the head verb in the incremental manner. But these combinatory rules have nothing to do with the discourse restriction on PVPs, which distributes an incomplete verbal constituent to the topicalization construction. However, combinatory rules can be used not only to analyze the sentence structure, but also to predict the sentence structure from left to right in a piecemeal fashion. This characteristic of some combinatory rules will be applied to in this section.

Combinatory rules are capable of predicting which categorial structure can be yielded in the incremental recognition process of a sentence. The functor category A/B should be applied to an argument category B, i.e. an
expression of category B should exist. The success of this application yields its value category A. This means that the functor category A/B predicts the existence of an expression of its argument category B, and at the same time it predicts that a value category A should be established, i.e. a concatenated expression of category A should be realized. In each process of incremental recognition of expressions, not only the category of succeeding input-expressions, but also the category of the concatenated output-expressions can be predicted. This simple prediction mechanism is used to parse German V2 sentences and its fronted PVPs. Based on this idea, the following prediction rules are proposed as a variant of the combinatory rules.

(19) Prediction rules
A, B, B1,..., Bn, and C are categories:

a. A functor category A/B1/.../Bn predicts on its right the existence of a set of argument categories \{B1,...,Bn\}, to which the functor category can be applied incrementally. At the same time A/B1/.../Bn predicts the existence of its value category A.

b. The composition of A/B and B/C yields the functor category A/C, which predicts the existence of an argument category C on its right according to the prediction rule (19a). At the same time A/C predicts the existence of value category A.

Using the function-argument framework of CG, each functor category is used to predict the existence of the expressions in its argument category and those of its value category as well. If this kind of method is used, the prediction from left to right is possible. In addition, this kind of extension of the CG framework is useful in capturing the characteristics of the PVP fronting from other view points than just that of the framework of Generative Grammar and HPSG.
An advantage of this approach is that at the end of the parsing of fronted PVPs, an extra process is not needed to check whether all the arguments of a verb H have been found. If some argument-category of H has not been found in PVP, this category can be predicted on the right of the PVP. The following figures (21), (22) and (23) illustrate the prediction process. In these figures, the arrow in “A ---> B” indicates that the category A predicts a category B, and the arrow in “A ⊩ B” indicates that an input category A is converted into its extended category B, or that B is determined by A. The following figure (20a) indicates that category C is decided by the application of combinatory rules to A and B. Figure (20b) indicates that the category C predicted by category B is unified with category A. Figure (20c) indicates that A predicts a functor category B/A, which can be applied to A, and if the expression of this functor category is recognized, this application yields B. Figure (21) shows a prediction process started from NPacc, where the parentheses (H TV ) indicate the prediction that H TV will be recognized in the parsing result. (22) is a prediction process started from a composition of two noun phrases. (23) indicates that an inner PVP predicts an AUX-finite and an outer PVP. If a finite auxiliary is unified with the predicted AUX-finite and recognized, the outer PVP is realized.

(20) a. C b. B ---> C c. B
    A     ||     A
    B

(21) S<PVP1[NPacc^(H TV )]>/NPnom
    VP<NPacc>/TV ---> TV
    ⊩ NPacc
4.1 PVP fronting and applied prediction rules

In order to recognize the PVP fronting incrementally, the combinatory rule must be applied to all H’s complements, which stand before H, from left to right. The prediction is executed from bottom to top as indicated by the tree diagram (26) for an accusative noun phrase NP_{acc}, which appears in the following examples (24) and (25) in the sentence-initial position. If NP_{acc} is type-raised to a functor category VP<NP_{acc}>/TV, the accusative noun phrase eine Anekdote predicts TV and VP<NP_{acc}>, and this VP<NP_{acc}> predicts further existence of NP_{nom} and S as indicated in figure (26). Figure
(26) shows a possible range of prediction made by an accusative noun phrase *eine Anekdote*.

(24) Die Anekdote erzählen wird er ihr.
the anecdote[acc] tell will he[nom] to-her[dat]
“He will tell the anecdote to her”

(25) Eine Anekdote erzählen kann er seinem Enkel.
“He can tell his grandson an anecdote.”

(26) The transitive verb TV predicted by NP_acc as shown above in (26) will be replaced by DTV, if the next input-string *erzählen* is recognized as a ditransitive verb. This verb phrase *eine Anekdote erzählen* is regarded as an inner partial verb phrase PVP1 because of the base form of its head verb. This PVP1 composed of only two categories - namely, NP_acc and H, can easily predict the possible structure of a sentence with a high probability. PVP1 which is realized by *eine Anekdote erzählen* predicts further existence of AUX-finite, because PVP1 can also be a category PVP2/AUX-finite. After the recognition of the finite verb AUX-finite, a nominative noun phrase NP_nom would probably be the next input category. The following figure (27) shows the possible tree structure of a sentence predicted by this PVP1.
According to this prediction tree, every category predicted until now, namely AUX-finite, NPnom and NPdat, will be unified with the categories of expressions which will be recognized from left to right incrementally, namely with each category of *wird, er*, and *ihr* respectively.

(27)

The main verb *erzählen* in PVP1 will also select the dative object as shown in the following example (28). PVP1 *ihr erzählen* (“to-her tell”) in (28) is as valid as the earlier example *die Anekdote erzählen* (“the anecdote tell”) in (24) and (25), because this PVP1 will have a common prediction structure to those shown in the figure (27), i.e. the sentence (28) has the same efficiency as that of (24) with respect to the prediction for the incremental recognition.

(28) Ihr              erzählen wird er die Anekdote.
    to-her[dat] tell    will he[nom] the anecdote[acc]
    “He will tell her the anecdote.”

(29) Ihr die Anekdote erzählen wird er.
    to-her[dat] the anecdote[acc] tell    will he[nom]
    “He will tell the anecdote to her.”

Although all complements of the head verb *erzählen* in (29) are saturated
in front of this verb, the head verb *erzählen* has a base form. Therefore, this verb phrase *ihr die Anekdote erzählen* is classified into PVP1. But the order of constituents in PVP should not be arbitrary. This was exemplified in the above footnote 3. The grammaticality of PVP should be determined by German word order rules. Uszkoreit (1987a) claims that the word order rules for constituents of the Mittelfeld should hold across the partial verb phrase in the sentence-initial position. Although the category of ditransitive verbs such as *erzählen*, namely S<|NP_{nom}|NP_{acc}|NP_{dat}, states that nominal constituents should be selected by the head verb, the initial position of (29) is occupied by two noun phrases, namely *ihr* and *die Anekdote*. By applying the type-raising and composition to these nominal phrases, we can compose a functor category as underlined in (30). This category takes a verbal category DTV directly as argument. This predicted DTV is unified with the recognized ditransitive base-form verb *erzählen* and composes a PVP1 as underlined in (30). PVP1 can be converted to PVP2/AUX-finite, as mentioned already. Thus, PVP1 can predict AUX-finite and PVP2. This finite verb AUX-finite predicts a subject NP_{nom} and a sentence S. Therefore, PVP1 in (29) shows a prediction structure as follows.

(30)

```
S<VP[NP_{dat}|NP_{acc}|H:Vertex](AUX-finite)](NP_{nom}>)
S<PVP2[NP_{dat}|NP_{acc}|H:Vertex](AUX-finite)]/NP_{nom} -------> NP_{nom}
S<PVP1[NP_{dat}|NP_{acc}|H:Vertex](AUX-finite)]/NP_{nom} = PVP2/AUX-finite ----> {AUX-finite, NP_{nom}}
```

```
VP<NP_{dat}|NP_{acc}>DTV ----> DTV
TV<NP_{dat}|DTV
| NP_{dat}
| ihr
| die Anekdote

DTV-bse

DTV-bse

DTV

DTV-bse

DTV-bse

DTV-bse
```

```
4.2 PVP fronting and the double infinitive

In PVP1 in (29), all complements of the head verb are saturated. On the contrary, no complements are saturated in front of the main verb in PVP1 of the following example (31). Note that the combinatory rule for PVP as indicated in (16) should also work well for cases of double infinitive fronting like (31), since PVP1 in (31), namely *lesen können*, is the case of the unsaturated double infinitive PVP fronting. The double infinitive comes normally in the sentence-final position as shown in (32). In this case an accusative complement is saturated in the sentence-initial position.

(31) *lesen können* wird er das Buch.
read be-able-to will he the book
“He’ll be able to read the book.”

(32) Das Buch wird er *lesen können*.
the book will he read be-able-to
“He’ll be able to read the book.”

Before analyzing the PVP with fronted double infinitive in (31), this paper will begin to analyze the case of double infinitive in the sentence-final position as shown in (32).

Because the auxiliary *wird* combines with the double infinitive as exemplified in (31) and (32), *wird* is called the finite double-auxiliary and the notation *AUX-double:finite* is used for the category of *wird*, where *double:finite* indicates *double and finite*. If the first two categories which appear in the initial position of (32) are recognized, i.e. a type-raised category of an accusative noun phrase *das Buch* (VP<NP<acc>|TV =df S<VP[NP<acc]>|NP<nom>|TV), and the category of the finite double-auxiliary *wird* (AUX-double:finite), the prediction of the sentence structure of (32) can
already be fulfilled. The following figure (33) shows this prediction process. Since the auxiliary *wird* subcategorizes for double infinitive, TV predicted in (33) shall be a double infinitive, namely a concatenation of two categories, viz. TV-bse^AUX-bse. At this stage of recognition, the possible structure of sentence (32) can be composed almost completely from bottom to top as indicated in the graph of the tree diagram (33). The fact that the first few words in the initial position of German V2 sentence can predict the sentence structure demonstrates that the V2 word order and PVP fronting is efficient to recognize the sentence structure.

Now the sentence (31) will be accounted for, repeated here for convenience: (31) *Lesen können wird er das Buch*. The following tree diagram (34) for the sentence (31) shows incremental processing triggered by the double infinitive in the sentence-initial position. This figure shows a prediction process given by the fronted double infinitive. The first two words, namely *lesen* and *können* can predict the possible structure of the sentence efficiently. Since the fronted verb *lesen* has a base form, it predicts the existence of an auxiliary in the next position. Since any complements of *lesen* are not saturated on its left, the base form verb *lesen* alone plays a role as PVP1. After the input of an auxiliary *können*, a double infinitive *lesen können* is composed again as a fronted PVP1. This double infinitive predicts...
further existence of a double-auxiliary such as *wird* in finite form (AUX-double:finite). At this stage of prediction a set of categories which is underlined in figure (34) is obtained. This set of categories represents a basic structure of the sentence (31) and predicts that expressions of AUX-double:finite, NPnom and NPacc should follow as the next input symbols.

(34)

4.3 *PVP fronting and the split*

Ambiguity arises when a modal auxiliary, which subcategorizes for a VP-complement, appears with an auxiliary such as *werden* that participates optionally in modal flip. Although the double-auxiliary *werden* in the subordinate clause can be flipped from the final position and placed in front of the double infinitive, it may not fall in the middle of a double infinitive. The following examples (35) and (36) are grammatical. However, the example (37) shows that the double infinitive in the subordinate clause is split and ungrammatical.

(35) dass er das Buch lesen können wird

that he the book read be-able-to will
“that he’ll be able to read the book”

(36) dass er das Buch wird lesen können

(37) *dass er das Buch lesen wird können

But the following sentence (38) shows that the double infinitive in the V2 sentence can be split. In (38) a base form infinitive with an accusative NP complement - namely, das Buch lesen, is fronted away and a modal auxiliary können is left in the final position.

(38) Das Buch lesen wird er können.
    the book read will he be-able-to
    “He’ll be able to read the book.”

The following example (39a) shows that the category of the finite modal auxiliary muss (“must”) is also AUX-double, because it follows the double infinitive verstehen können (“understand can”). (39b) shows that the double infinitive is split, because the finite modal auxiliary muss follows the topicalized PVP ein Axiom verstehen (“an axiom understand”), but at the same time the modal auxiliary können stays in the sentence-final position.

(39) a. dass er ein Axiom verstehen können muss
    that he an axiom understand be-able-to must
    “that he must be able to understand an axiom."

b. Ein Axiom verstehen muss er können.
    an axiom understand must he be-able-to
    “He must be able to understand an axiom."

Are these examples (37), (38) and (39b) evidence for concluding that the double infinitive cannot be a constituent for the case that a base form verb, optionally with some complements, is fronted away from a base form
auxiliary which is left in the final position? This phenomenon will be discussed in this section.

When an auxiliary, such as \textit{werden}, which subcategorizes for a double infinitive, appears in the initial position, and a VP-complement-taking auxiliary appears in the final position as shown in (40), this ambiguity does not arise. The double infinitive, such as in (40), can be regarded as a constituent.\footnote{This phenomenon will be discussed in this section.}

\begin{equation}
\text{Wird er das Buch lesen können?} \\
\text{will he the book[acc] read be-able-to} \\
\text{“Will he be able to read the book?”}
\end{equation}

However, when a double infinitive appears in the final position as in (40), this double infinitive cannot predict the sentence structure incrementally any more, but can only verify the predicted categories. Even in this case, the prediction of the sentence structure can also be realized by a few words which appear in the initial part of the sentence. First, this prediction process will be observed, and then the paper will show that our combinatory rules for PVP fronting can also predict the split of the double infinitive.

The following figure (41) shows the range of prediction realized by an auxiliary \textit{wird}, which appears in the initial position and participates optionally in the construction of the double infinitive. The finite form auxiliary \textit{wird} predicts the existence of a subject noun phrase (NP\textsubscript{nom}), which can be raised to S<NP\textsubscript{nom}>/VP and this functor category predicts the existence of S and VP. Since the auxiliary \textit{wird} participates in the construction of the double infinitive, the predicted VP will contain the concatenation of a base form main verb (H-bse) and a base form modal auxiliary (AUX-modal:bse). Between the nominative noun phrase (NP\textsubscript{nom}) and the double infinitive (H-bse^AUX-modal:bse), there can also be complements (C*) of the main verb. Figure (42) shows that the range of
The prediction of (41) is certified by the nominative pronoun *er* which follows *wird*. Figure (43) shows that the whole basic structure of the sentence (40) is to be predicted by a few words in the sentence-initial position, namely *wird er das Buch*, because an accusative complement *das Buch* and the auxiliary *wird*, which participates optionally in double infinitive, predict the existence of a transitive double infinitive (TV-double).

(41) A range of the prediction by *wird*

(42) A range of the prediction by *wird* *er*

(43) A range of the prediction by *wird* *er das Buch*
Sentence (38) is repeated here for convenience. (38) *Das Buch lesen wird er können.* In this sentence, a base form VP is fronted away from a base form auxiliary. In (38), *das Buch lesen* forms a PVP, but does not form a double infinitive. A fronted PVP in (38) seems to suggest that the base form auxiliary *können* in the sentence-final position and the base form main verb *lesen* in the fronted PVP cannot form a constituent. But if the combinatory rules are used, the split parts of the double infinitive can be related with each other easily. The category of the fronted partial verb phrase *das Buch lesen* in (38) is PVP1, namely S<PVP1[NP[acc^H-bse]/NP[nom]]. This PVP1 can be type-raised to PVP2/(PVP2\PVP1), which is able to be equal with the category PVP2/AUX-double:finite, because PVP2\PVP1 can be the category of those finite auxiliaries which optionally subcategorize for a double infinitive.

If the category PVP1, namely PVP2/AUX-double:finite, is applied to the category of the double-auxiliary *wird*, then PVP2 will be established. If the notation PVP1-double is used to represent a PVP1 which contains a double infinitive, and the notation PVP2-double to represent a complex PVP2 which contains a double infinitive, the category of the double-auxiliary can be defined in general as indicated in (44a), which shows that the finite double-auxiliary can be combined with fronted PVP1-double to make a PVP2-double. AUX-double:finite is the abbreviation of the functor category PVP2-double\PVP1-double. According to the combinatory rule for PVP in (16) the PVP1-double can be represented in (44b-1), and the PVP2-double in (44b-2). Therefore, this AUX-double:finite can also be represented in (44c).

(44) The category of double-auxiliaries

a. PVP2-double \ PVP1-double

b-1. S<PVP1[[1]^H-bse^AUX-bse]/[2] (= PVP1-double)


where [1] [2] = C*

c. (S<PVP2[[1]^H-bse^AUX-bse^AUX-double]/[2]) \ (S<PVP1[[1]^H-bse^AUX-bse]/[2])
By applying the division to the category AUX-double:finite, a category of
the split double infinitive can be constructed with respect to the PVP. If the
AUX-bse is removed from PVP1-double and from PVP2-double, i.e. from the
categories (44b-1) and (44b-2), the categories as indicated in (45a) and
(45b) are achieved respectively. The empty double angle bracket indicates
that the AUX-bse is missing.

\[(45)\]

a. $S<PVP1[[1]^H-bse^\langle \rangle]^/[2]/AUX-bse$  \quad (= PVP1-double/AUX-bse)

b. $S<PVP2[[1]^H-bse^\langle \rangle ^{AUX-double}]^/[2]/AUX-bse$  \quad (= PVP2-double/AUX-bse)

The category of the fronted PVP1 _das Buch lesen_ in (38) is
$S<PVP1[NP_{acc}^H-bse]>/NP_{nom}$. Because the category of the succeeding
auxiliary _wird_ demands the PVP1-double optionally, the category of _das
Buch lesen_ shall be also PVP1-double. But _das Buch lesen_ misses a base
form auxiliary. In this case the category of _das Buch lesen_ shall be PVP1-
double/AUX-bse, namely the category (45a).

How can the category of AUX-double:finite, namely PVP2-double\PVP1-
double be applied to this chipped category of _das Buch lesen_, namely PVP1-
double/AUX-bse? The combinatory rule “division” can be applied to the
category AUX-double:finite, namely to PVP2-double\PVP1-double, then a
category as indicated in (46a) can be achieved. This category (46a) is the
abbreviation of (46b), as shown in (45a,b). If the fronted PVP1 _das Buch
lesen_ in (38) is a PVP1-double with the split double infinitive, then the
category of this expression is not $S<PVP1[NP_{acc}^H-bse]>/NP_{nom}$, but
$S<PVP1[NP_{acc}^H-bse^\langle \rangle ]>/NP_{nom}/AUX-bse$, to which the functor
category of divided AUX-double:finite (46b) is able to be applied. As a result
of unification, (46c) becomes the concrete AUX-double:finite which shall be
applied to the PVP1 made of _das Buch lesen_.
By using divided AUX-double:finite, namely (46b), a category of the fronted partial verb phrase can be achieved which contains the split double infinitive. But a constraint is needed: The division by AUX-bse should not be carried out arbitrarily, but it should be applied only to the category realized by AUX-double:finite that subcategorizes for PVP1-double on its left. If the category (46b) is used for divided AUX-double:finite, it is possible to construct the PVP2-double of (38) that contains the split double infinitive, whose AUX-modal:bse appears in the final position of the sentence, as indicated in the following figure (47). This figure shows that the three words in the initial position predict the whole basic structure of (38). The large braces in (47) indicate that the words er and können shall be recognized afterwards, i.e. their categories shall be unified with the categories predicted by PVP2, namely das Buch lesen wird, afterwards.

Using the evidence of a PVP fronting, this paper has illustrated that even in the case of the PVP which contains the split double infinitive, double infinitive can still be a constituent. If the double infinitive auxiliary wird is concatenated with the fronted PVP1 which contains no AUX-modal, its
category can be changed by division for the purpose of recognizing the fronted PVP1-double away from a governing auxiliary. This category change supports the evidence that double infinitive can be a constituent for cases of the PVP fronting which contains the split double infinitive. Even though the double-auxiliary in the V2 clause may fall between the elements of a double infinitive, the double-auxiliary *wird* in the subordinate clause may not be placed in the middle of a double infinitive, as indicated in (37). The reason why the latter case is not allowed can be explored by using the combinatory rules with prediction mechanism as follows. To explore the ungrammaticality of (37) and the difference of the three types of embedded clauses (35), (36) and (37), the grammar model proposed in this paper can be used. These embedded clauses are repeated here for convenience:

(35) dass er das Buch lesen können wird  
that he the book read be-able-to will  
➥ “that he’ll be able to read the book”

(36) dass er das Buch wird lesen können

(37) *dass er das Buch lesen wird können

The first few words in the initial position of embedded clauses can also predict categories which will appear later. Combinatory rules modified to involve the prediction mechanism make it possible to recognize the structures of embedded clauses in German efficiently. Trees (48), (49) and (50) show that the NP complexes of the first two case-marked nominal elements yield a functor category S/TV which predicts a transitive verb phrase TV. The efficiency of recognition depends on the appearance of AUX-double. When the AUX-double:finite, namely *wird*, appears directly on the left side of the double infinitive *lesen können* as in the subordinate clause (48), this one word *wird* of the category AUX-double:finite predicts the occurrence of a double infinitive directly. In the same manner, when a
double infinitive *lesen können* appears first, these two words shall predict the occurrence of AUX-double:finite, which should follow them. In both cases the prediction process can progress successfully. However, with respect to the efficiency of prediction, the case of the flipped auxiliary, namely (48) where the prediction is executed by one finite auxiliary *wird*, is more efficient than the case of (49), where the prediction can be executed by two infinitives.

(48)

(49)

Example (37) shows that the double infinitive is split and ungrammatical. The following tree diagram (51) shows the reason why (37) is ungrammatical. (51) shows that the auxiliary *wird* can have two roles in this case. If *wird* plays a role as future auxiliary indexed by (□) in the tree, this *wird* functions as the sentence-final finite auxiliary and completes the subordinate clause. On the contrary, if *wird* plays a role as AUX-double:finite indexed by (□) in the tree, this *wird* shall predict the existence of the
double infinitive. However this prediction fails, since no double infinitive can occur any more. On account of the constraint which is given above, repeated in (50), the division by AUX-bse cannot be applied to AUX-double:finite in the tree (51) any more, because there is no PVP1-double fronting on the left of *wird*.

(50) *The division by AUX-bse should not be carried out arbitrarily, but it should be applied only to the category realized by AUX-double:finite that subcategorizes for PVP1-double on its left.*

(51)

![Diagram](image)

4.4 Constraints on PVP

The acceptability of PVP in the fronted position varies with verbal elements in PVP. The following partial verb phrase in (52) contains a modal auxiliary *können*, but the main verb *bestehen* stands in the sentence-final position away from the fronted PVP. In order to explain the ungrammaticality of (52), the category of the modal auxiliary in base-form in PVP1 must be seen. A main verb H in PVP1 should be locked in a particular position, i.e. it should appear between its complements, and its governing auxiliary AUX-modal:finite or AUX-modal:bse as indicated in figure (53a,b). AUX-modal:finite in (53a) has the functor category PVP2\PVP1. However, (53b)
shows that AUX-modal:bse in PVP1 should have the functor category PVP1\PVP1.

It is still necessary to allow an auxiliary to inherit arguments from the PVP1. But if the fronted elements construct no PVP1, this AUX-modal:bse has no chance to be combined with these fronted elements. Since the noun phrase *das Examen* alone cannot construct a PVP1, *können* cannot combine with this fronted noun phrase to make a higher PVP1.

(52) *Das Examen können wird er bestehen.

the exam be-able-to will he pass

“He will be able to pass the exam.”

(53) a. PVP2

PVP1

C* H

PVP2\PVP1 =AUX-modal:finite

b. PVP2

PVP1

C* H

PVP1\PVP1 =AUX-modal:bse

(54) Das Examen können Sie bestehen.

NPacc AUX-finite NPnom TV

VP|TV TV S|VP

VP|TV S|TV

S

As shown above in (54), the combination of *das Examen* and *können* is possible, because the modal auxiliary *können* is finite in this case. The category of *das Examen können* is VP/TV, and this category can be combined further incrementally with the type-raised subject noun NPnom and the transitive verb TV. But *das Examen können* in (52) has another character, because *können*, which stands before the finite AUX-double:finite
wird, has a base form. In (52) the AUX-double:finite wird appears after das Examen können which has the category VP/TV. This category means that a TV is missing in VP. This type of category is different from PVP, i.e. it has a different type from those which are defined in (18) and (44); therefore das Examen können in (52) should not be classified into PVP1. The AUX-double:finite wird requires a PVP1-double as its argument-category, therefore wird cannot combine with this verbal complex das Examen können. This is the reason why AUX-double:finite wird cannot appear after das Examen können in (52).

Some constraints must be added into the rule for PVP fronting to prevent the appearance of auxiliary without a main verb in the sentence-initial position. The following constraints that prohibit extraction of a main verb from a PVP are the sufficient conditions to prevent an ungrammatical PVP like (52). The PVP rule visualized in the tree diagram (53) prohibits to unite a base form auxiliary AUX-modal:bse and the main verb’s complements C* directly, while they skip over the main verb H.

One should separate the AUX-modal:bse from the main verb H and even from AUX-double:finite. The difference between them can be explored as follows:

(a) As it has already been stated, by using AUX-modal:bse the category AUX-double:finite, namely PVP2-double\PVP1-double can be divided into (PVP2-double/AUX-modal:bse)\(PVP1-double/AUX-modal:bse). This category indicates that the AUX-modal:bse which is lacking in PVP1 can also be an argument of a functor category PVP2/AUX-modal:bse. As shown in the tree diagram (53a), even if AUX-modal:bse is lacking in the PVP1, the existence of the basic PVP1 is still guaranteed by C* and H.

(b) But if the AUX-double:finite is divided by H for the purpose of realizing the sentence (52), a category (PVP2-double/\H)/(PVP1-double/\H) is achieved. Its argument category PVP1-double/\H indicates however that H is lacking in PVP1, which is not allowed by (53). It is impossible to divide the AUX-
double:finite by H, because the PVPI cannot be realized without H.

According to different types of auxiliaries indicated in the trees (53a) and (53b), namely (a) the finite form auxiliary in the concatenation H-bse:prt^AUX-finite, (b) the base form modal auxiliary in the concatenation H-bse^AUX-modal:bse, and (c) the finite form double-auxiliary AUX-double:finite, the partial verb phrase can be separated in two types, i.e. PVP is structured in the inner PVP1 and in the outer PVP2. Therefore, the condition indicated by (53) in the definition of the categories AUX-finite, AUX-modal:bse and AUX-double:finite for the PVP fronting rule is adopted. This condition should generally be applied to the fronted PVPs in German.

5 Conclusion

This paper has described the PVP fronting in German by extending CG account. Using CG formalism extended to handle free word order language, the PVP fronting has been accounted for. Current research uses a mechanism to analyze the PVP fronting incrementally on the ground of the CG formalism and its combinatory rules. Combinatory rules have been introduced and extended to contain prediction operations. This prediction mechanism in the extended CG is used to make the recognition of free word order efficient. The points in the paper which merit some additional investigation are these: If the use of type-raising rule for NPs is allowed as well as the composition rule for any argument, a PVP composed of any number of topicalized NPs and of a main verb can be computed incrementally. Scrambling can be captured by using type-raised categories, and this analysis is consistent with incremental processing. This investigation shows that the incremental computation with prediction mechanism is an adequate linguistic formalism in capturing some aspects of free word order, for instance in capturing the fronted PVP in German. A formalism such as CGs, which derive sets of prediction from functor
categories, is better suited. With the prediction mechanism added, certain restrictions on the hierarchical structure made by three types of auxiliaries appearing in the fronted PVP have been explored. According to three types of auxiliaries, namely the finite form auxiliary, the base form modal auxiliary and the finite form double-auxiliary, PVP is structured in the inner PVP1 and in the outer PVP2. Type-raised categories for noun phrases and the separation of the PVP structure into two types according to the property of auxiliaries are good devices to treat the instance of PVPs in German, which show incomplete categories and relatively free selection of complements.

The grammar model proposed in this paper shows that combinatory rules modified to involve the predicting mechanism make it possible to predict categories which will appear later. The incremental recognition process by the prediction mechanism proposed in this paper should reflect the characteristics of language processing by humans. For example, “garden path sentences”, such as *The horse raced past the barn fell*, are grammatical, although they are hard to understand, because there are two readings, but it is not until the final position of the sentence that the two readings become clear. The grammar model in this paper can show that the structures of “garden path sentences” can also be predicted by the first few words in the initial position of this sentence. If the two categories of *raced*, namely *verb* and *modifier* are stacked, and at first the category *verb* is used, because it has a higher possibility to be selected, and after the failure of the recognition of the last word *fell*, the so-called backtracking is executed to select the second category *modifier* in the stack. This type of processing of “garden path sentences” is not efficient, but reflects the one aspect of human language processing.
Notes

1 Hinrichs and Nakazawa (1989).
2 Because CGs are (weakly) equivalent to context-free phrase-structure grammars, combinatory rules also create hierarchical structures for phrases and sentences.
3 I use an expression “an almost arbitrary subset of its complements”, because the word order in PVP is under constraint of German word order rules. In comparison with the ungrammaticality of the PVP such as *die Anekdote ihr erzählen, the verb phrase ihr die Anekdote erzählen is a grammatical PVP. This difference of the grammaticality is determined by German word order rules, according to these rules the pronominal NP (here ihr) should precede the nonpronominal NP (here die Anekdote).
4 PVP can be formed from a head verb with some sequence of its complements, but the PVP’s complement daughters in German are not always in a fixed order. The unordered sequence is made possible not only by the type-raising, but also by the associativity in CG. The associativity relaxes the manner in which the complements are picked up by the head verb H of PVP.
5 The category PVP2/AUX-finite is at the same time PVP2/(PVP2\PVP1) because of AUX-finite =df PVP2\PVP1. This category is the same category as the result of the type-raising of PVP1.
6 Hinrichs and Nakazawa (1989).
7 Hinrichs and Nakazawa (1994) states that in the case of substitute infinitives auxiliary flip is obligatory, whereas auxiliary flip triggered by true infinitives is merely optional.
8 Hinrichs and Nakazawa (1989, 1994).
9 Not only AUX-double:finite and AUX-modal:finite, but also the perfective haben is able to have the category PVP2-double\PVP1-double.

References


Uszkoreit, Hans. 1987b. Word Order and Constituent Structure in German. *CSLI
Lecture Notes no. 8, Stanford: Center for the Study of Language and Information.

PVP Fronting in German and Categorial Grammar

ドイツ語における不完全動詞句の文頭配置とカテゴリーエ文法

泉尾洋行

本稿は、ドイツ語の文において、動詞句がその一部の補足語を充足しないまま文頭に置かれる象を、カテゴリーエ文法により分析したものである。分析は、カテゴリーエ文法の「句節順」関係の枠組みから構成される結合規則に基づき、こうした動詞句の統語範囲の特性を特にそれに関与する助動詞に関して明確にした。本稿の構成は、まずドイツ語にみられる不完全動詞句の文頭配置を例示し、次にそれの分析のためにカテゴリーエ文法を増進的解析と予測処理にむけて拡張し、それによる不完全動詞句の具体的分析を行った。分析により本稿は、ドイツ語の名詞句をその格素性に応じて範囲を変換することにより、名詞句が動詞の項となるだけではなく、名詞句同士が互いに結合できることを範囲構造上可能にし、これにより不完全動詞句に見られる比較的自由な語順の処理も増進的に遂行できることを示した。さらに助動詞の範囲を不完全動詞句に関して分類することにより、不完全動詞句の構造を二つの階層に分け、そのことにより、不完全動詞句の文頭配置の諸形の文法的差異を説明できることを示した。さらに、増進的解析を予測に基づいて遂行するという観点に立てば、文頭に不完全動詞句が配置されるという一見すると変則的である語順が、実は文頭近くの少数の語句により文全体の構造を予測させてしまう働きをもち、人の言語理解を容易にする認知的に理にかなった語順であることを、予測に基づく増進的解析過程の樹形表示により示した。