論　文

Bracketing Paradoxes in Dependency Morphology

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要　旨

依存形態論からみる「ブラッケティング・パラドックス」

本文では，「moral philosopher」みたいなbracketing paradoxを取り上げる。非連続的な表現なので，構成素構造文法にとって，不愉快なものと思われる。どうやって分析できるかを依存形態論的な概念で論じる。中心的な概念とは，chain「チェーン，連鎖」であり，まずその統語論的な応用を導入する。その後，形態論上にも，連鎖があると証明する。

Keywords: bracketing paradox, chain, dependency, morphology, syntax

1. Constituency's limit: Bracketing paradoxes

This paper addresses *bracketing paradoxes* (Pesetsky 1985, Sproat 1988, Spencer 1988). Well known English examples include *personal nouns* (Spencer 1988). The following bracketing paradoxes are instances of morpho-semantic mismatch (Beard 1991):

(1)　a. nuclear physicist
　　b. moral philosopher
　　c. theoretical linguist

In every example above, the attributive adjectives do not scope over the whole nouns, but only over the first parts. For instance, *nuclear* does not scope over *physicist*, but only over *physic(s)*. The case is identical in (1b), and again more complex in (1c).

The examples in (1) are difficult to analyze in morphology because they do not allow for a bracketing consistent with their respective meanings. The following problem arises: Even though *physicist* is one word, one of its parts, namely *physic(s)* must combine with the attributive adjective *nuclear* before it combines with the personal suffix -ist. On the other hand, one would expect *physicist* to be compiled before this word is combined with the attributive adjective. Therefore two ways of bracketing are conceivable:

(2)　a. [nuclear] [[physic][-ist]]
　　b. [[nuclear] [physic]][-ist]

In (2a), the words are compiled, before they form larger constructions. In (2b), the meaning *nuclear physic(s)* is compiled before the personal suffix is attached. Even though it is (2a) that should exhibit proper bracketing, it is (2b) that is believed to be correct. (2b), however, conflicts with the tenet that syntax should apply after word formation, which is clearly not the case in (2b). Example (1b) would be formed along the lines of (1a), namely a bracketing according to (2b) should be the correct one.

(1c), in turn, is even more problematic. The adjective *theoretical* does not scope over *linguist*, but over *linguistics*. However, a suffix such as *-ic(s)* seems to be missing. If true, then the adjective in (1c) would have no overt part to combine with. If one assumed a covert element, then a bracketing paradox would again obtain.

(3)　a. [theoretical] [linguist]
　　b. [[theoretical] [[linguist]] [~~-ic(s)~~]]
　　c. [[[theoretical] [t_i]] [[linguist] [~~-ic(s)~~$_i$]]]

(3a) shows that the adjective and the noun cannot form a proper bracket (as the outer brackets are missing). (3b) shows a covert element (strikethrough) which combines with the adjective even though adjacency does not obtain. Then the lexical

noun is combined. A third alternative is shown in (3c): The suffix and the adjective combine first while being adjacent. Then the personal noun is combined and the suffix is raised (moved). After movement this suffix is elided.

In contemporary proposals the last version has gained currency. In (3c), the suffix moves to a higher position, but in many cases *lowering* is required (Embick & Noyer 2001: 561). The next examples, which are not morpho-semantic mismatches, exhibit such an instance

(4) a. aides-de-camp
b. sisters-in-law

In (4), the plural morphemes are not attached at the periphery of the expressions, even though that should be expected because the singulars *aide-de-camp* and *sister-in-law* are well-formed. In other words, these forms cannot be bracketed in such a way as to exclude the plural morphemes. Here, one assumes that the plural morphemes are combined last and then lower into their positions shown in (4):

(5) a. [aide-s_i-[de-[camp]]]t_i
b. [sister-s_i-[in-[law]]]t_i

In (5), the plural morphemes attach to the entire singular expression, which is compiled first. Then the plural morpheme lowers to attach to the head of the singular expression. Note that a plural morpheme cannot attach to a head if the head lacks the morphological features to allow such an attachment. The plural form of *in-law* is *in-laws*, not **ins-law* because the preposition does not usually license plural forms (a counter example would be *ins-and-outs of (something)*), even though it is the head.

Bracketing paradoxes are regarded as exceptional instances of linguistic structure. They are exceptional insofar as it is impossible to provide a bracketing structure that coincides with the semantic scope exhibited and that adheres to the tenet of an ordered process of word formation and sentence formation, such that the former precedes the latter. This paper argues that it is the concept of bracketing as such that leads to the assumed exceptionality of these paradoxes. The notion of bracketing invests the assumption that in linguistic structure elements that contribute

to meaningful units appear together.

In syntax, phenomena equivalent to bracketing paradoxes are known as *discontinuities*. A discontinuity is characterised by the fact that two elements which form a meaningful unit are separated by other elements not contributing to this respective meaning. One well known instance of discontinuities is the so-called *wh-movement*. Consider example (6):

(6)　a. What did you eat?

In (6a), the question word *what* does not constitute a meaningful unit with the following word *did*. In fact, *what* is the direct object of the verb *eat*, from which it is separated by *did you*. In order to account for this separation, many theories invoke movement. The question word has moved from a position adjacent to its governing verb to the front. Example (6b) displays this assumption using a trace operator.

(6)　b. What$_i$ did you eat t$_i$?

(6b) shows that the question word has moved from its position indicated by the trace t to the front of the sentence. The subscripted elements mark two different stages of a derivation: The trace marks the initial stage, and the question word marks the final stage. Similar structures were shown in (3c) and in (5).

Movement (raising and lowering) is the principal tool for a theory that assumes that elements constituting meaningful units may start out as unexceptional (insofar as they are adjacent, i.e. not separated, at initial stages), but may lead to exceptional, i.e. discontinuous, structures at later stages. The notion of meaningful units consisting of adjacent elements (at initial stages) is known as *constituency*. Meaningful units must form constituents (at least at initial stages). Constituency is one of the most pervasive notions in contemporary linguistics. Even many theories that are mono-stratal and non-generative adhere to constituency.

This paper argues that bracketing paradoxes are not exceptional if viewed from a perspective that does not regard constituency as the sole ordering mechanism of linguistic form. The next section introduces the *chain*, a unit necessary to define the *component*. Constituents are considered as a subset of components, which form a

subset of chains. If so-called bracketing paradoxes are viewed as chains, not as (failed) constituents, then these paradoxes lose their paradoxical flavour and become unexceptional. The third section applies the chain concept to the examples (1–5). A final section concludes this paper.

2. Chain-based dependency grammar

Because the ensuing argument is conducted in a dependency grammatical framework, the general notions of this framework need to be introduced. In general, modern dependency grammar is a tradition originating in Tesnière (1959). In the last decades many proposals have contributed to a more precise understanding of dependency grammar.[1]

The next section introduces essential concepts of dependency syntax, and the following section applies these concepts to morphology, a field largely neglected by dependency grammar.

2.1. Dependency syntax

Dependency grammar is foremost a syntactic theory. It is distinguished from constituency-based theories by positing the asymmetrical relationship of dependency as basic. Constituency grammars, of course, posit constituency as basic. In most modern versions of constituency grammar, constituency relationships can be easily captured in dependency grammatical frameworks. Constituency grammars positing binary constituency relationships such as X'-syntax or Merge Minimalism cannot be fully recovered in dependency systems.

Dependency grammar assumes an asymmetrical relationship between words, which are considered the principal syntactic objects. Constituency, on the other hand, is a symmetrical relationship, and it obtains between words and constituents.

[1] This proposal is consistent with Hays (1964), Robinson (1970), Kunze (1975), Matthews (1981), Mel'čuk (1988, 2003), Schubert (1988), Starosta (1988), Lobin (1993), Pickering and Barry (1993), Engel (1994), Jung (1995), Heringer (1996), Groß (1999), Eroms (2000), Kahane (2000), Tarvainen (2000), Hudson (1990, 2007), Ágel et al. (2003, 2006), Matthews (2007), and Groß & Osborne (2009).

This section introduces the basic concepts of dependency grammar, and shows how constituents relate to these concepts. Consider the next example:

(7)	aka-i	tori-wa	yane-no	ue-ni	i-ru.
	red-NPST	bird-TOP	roof-GEN	top-LOC	be-NPST

'[a] red bird is on [the] roof.'

The adjective *aka-i* modifies the noun *tori*. It is marked with the non-past suffix, which also marks attribution. This property is dependent on the presence of a nominal morpheme. The attributive adjective *aka-i* therefore depends on *tori-wa*.

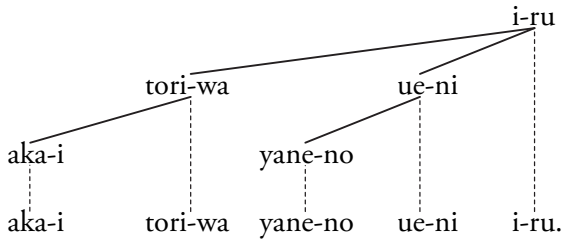
The noun *tori-wa* is marked with the topic morpheme *-wa*. Topic morphemes are only possible in the presence of finite expressions, which is *i-ru* in (7). The topic morpheme *-wa* covers up two case morphemes, namely nominative *-ga* and accusative *-o*. In (7), *tori* is covertly case marked by the nominative.

The noun *yane-no* is marked by the genitive case morpheme *-no*. The genitive case morpheme is dependent on the presence of another nominal, here the locative noun *ue*. Therefore *yane-no* depends on *ue-ni*.

The expression *ue-ni* is a noun case marked by the dative case morpheme *-ni*, which is interpreted as the locative case in (7). The covert case marking of the nominative for *tori* and the dative case marking in locative function for *ue* are part of a valency relationship established by the verb *i-ru*. The valency [*-ga*, *-ni*] is a locative relationship and to be understood as "the item referred to by the nominal marked with *-ga* is located at a location referred to by the nominal marked with *-ni*". Therefore, both *tori-wa* and *ue-ni* depend on *i-ru*.

A dependency tree depicts these dependency relationships in the form of angled edges. Vertical edges serve as visual identifiers of projectivity: These lines ensure that the word order is correct and not tangled. Every word receives one projection edge. A dependency tree for (7) looks like (8):

(8)



red-NPST bird-TOP roof-GEN top-LOC be-NPST
'[a] red bird is on [the] roof.'

The dependency tree (8) shows exactly those relationships established in the preceding paragraphs. Note that there are five words and five nodes in (8). In a dependency tree, the number of nodes is always equal to the number of words. In constituency grammars the number of nodes is always greater than the number of words, because constituency grammars require that nodes form certain types of projective nodes. For example, the attributive adjective *aka-i* and the noun *tori-wa* would constitute the subject noun phrase. This noun phrase would appear as a separate node in the phrase marker and thus increase the number of nodes. As any element present in a structural representation is subject to cognitive processing, phrase markers require more processing power than dependency trees, which always contain less nodes.

The assumption of letting the attributive adjective *aka-i* depend on the noun *tori-wa* is on the whole equivalent with acknowledging the noun as the head of the constituency grammar noun phrase. Insofar, dependency trees are basically equivalent to phrase markers. Differences do exist, however. Dependency grammar does not acknowledge a finite verb phrase (IP or TP), nor does it acknowledge functional heads.

The attributive adjective *aka-i* and the noun *tori-wa* form a *chain*. A chain is a word combination of two or more words connected in the dependency dimension. Because a word may have no dependents, a word is also a chain. There are 15 chains in (8):

(9) aka-i, tori-wa, yane-no, ue-ni, i-ru;
aka-i tori-wa, tori-wa i-ru, yane-no ue-ni, ue-ni i-ru, aka-i tori-wa i-ru,

yane-no ue-ni i-ru, tori-wa ue-ni i-ru, aka-i tori-wa ue-ni i-ru, tori-wa yane-no ue-ni i-ru, aka-i tori-wa yane-no ue-ni i-ru.

A chain would not obtain for *aka-i… ue-ni i-ru* because *aka-i* is not dependent on either *ue-ni* or *i-ru*. There are many word combinations that are not chains in (8).

A *string* is a combination of words that are adjacent. For example, *aka-i tori-wa* is a string because these words are adjacent. This combination is also a chain. Combinations of words that are strings as well as chains are *components*. The word combination *tori-wa… i-ru* is not a component, because it does not qualify as a string even though it qualifies as a chain. The word combination *tori-wa yane-no* is not a component, because it is not a chain, even though it is a string. Like chains, single words qualify as components. There are 11 components in (8):

(10) aka-i, tori-wa, yane-no, ue-ni, i-ru;
aka-i tori-wa, yane-no ue-ni, ue-ni i-ru, yane-no ue-ni i-ru, tori-wa yane-no ue-ni i-ru, aka-i tori-wa yane-no ue-ni i-ru.

The number of components is usually smaller than the number of chains, because components must fulfil an additional criterion, namely that of qualifying as strings. Components are thus a subset of chains.

If a component subsumes all dependents of all its nodes, then this component is *complete*. Complete components are *constituents*. Consider the word *tori-wa*: It qualifies as a component because all words qualify as components. It is, however, not a constituent because in order to qualify as such it would have to be complete, i.e. subsume all its dependent nodes. Since there exists a node dependent on *tori-wa*, namely *aka-i*, only the word combination *aka-i tori-wa* qualifies as a constituent, but not the noun itself. The situation is different for *aka-i*, which qualifies as a constituent, because it is complete as it does not have any dependents it could subsume. There are 5 constituents in (8):

(11) aka-i, yane-no, aka-i tori-wa, yane-no ue-ni, aka-i tori-wa yane-no ue-ni i-ru.

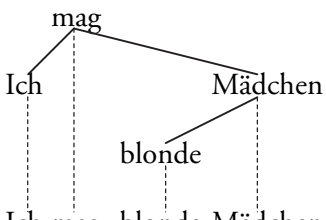
The number of constituents is greatly reduced when compared to chains and

components. Constituents are such a specific subset of components (and chains) that their number is always significantly less than chains or components.

The fact that chains (and components) are considerably more inclusive (i.e. there are usually many more instances of chains and components in a given sentence than constituents), makes most constituency grammarians sceptical of chains. The usual criticism is that most of the numerous chains cannot be attributed any semantic function. This criticism, however, is unfounded. Consider again the set of chains given in (9). The single words qualifying as chains can be attributed their respective semantic functions. The chains *aka-i tori-wa* and *yane-no ue-ni* constitute the two maximal noun phrases in (8). The chains *tori-wa i-ru* and *ue-ni i-ru* are respective nominal heads and their governing verb. The chains *aka-i tori-wa i-ru* and *yane-no ue-ni i-ru* are maximal noun phrases and their governing verb. The chain *tori-wa ue-ni i-ru* constitutes the skeletal valency chain. The chains *aka-i tori-wa ue-ni i-ru* and *tori-wa yane-no ue-ni i-ru* are partial, insofar as one noun phrase is not maximal, but these expressions are well-formed sentences, which are easily understood.

Constituency grammars posit the least inclusive notion as basic. The constituent is the least inclusive of the three notions introduced above, because it is a subset of the component, which is a subset of the chain. As a result, constituency grammars run into problems when faced with certain phenomena. Consider the next German example:

(12)



Ich mag blonde Mädchen, und er brünette.
I like blonde girls, and he brunette
'I like blonde girls, and he brunettes.'

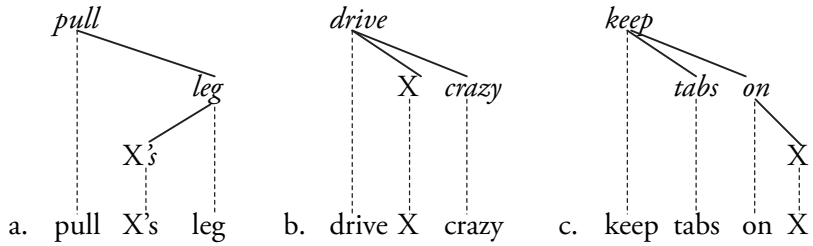
Example (12) is an instance of gapping because the verb *mag* is missing in the second conjunct, and an instance of noun ellipsis because the head noun of the constituent

brünette Mädchen is elided. The elided combination *mag… Mädchen* is not a constituent, nor is it a component. It qualifies, however, as a chain.

It turns out that *all* instances of ellipsis require the elided material to qualify as chains. Constituency grammars must invoke additional mechanisms to account for the fact that a non-constituent has elided. Generative systems usually assume movement. Movement, however, is a cognitively expensive operation. Chain-based dependency syntax, on the other hand, can point to the fact that elided material must qualify as chains.

Further evidence for chains comes from the structure of idioms. O'Grady (1998) was the first to propose that idioms form chains in the lexicon. In the next examples the italicised words form the idioms:

(13)



The symbol X in (13) always represents a necessary element which, however, is external to the idioms. However, only the inclusion of X allows the idioms to qualify as constituents. If X is excluded, the idioms form chains. In (13a) X represents a nominal possessor of the object *leg*. In (13b), X is the direct object of *drive*. In (13c), X is the syntactic object of the preposition *on*. As a result, idioms form chains, but not constituents.

Ellipsis and idiom structure make a strong case for the cognitive existence of chains. If gaps and idioms must qualify as chains, then it stands to reason that the mind/brain computes these items as chains, and not as a cognitively expensive potpourri of movement, traces, and subsequent deletion.

This section has introduced three essential notions of dependency syntax: chains, components, and constituents. Chains are the most inclusive units, constituents the least inclusive units of syntax. The assumption of the existence of chains as syntactic units seems justified because ellipsis requires elided material to

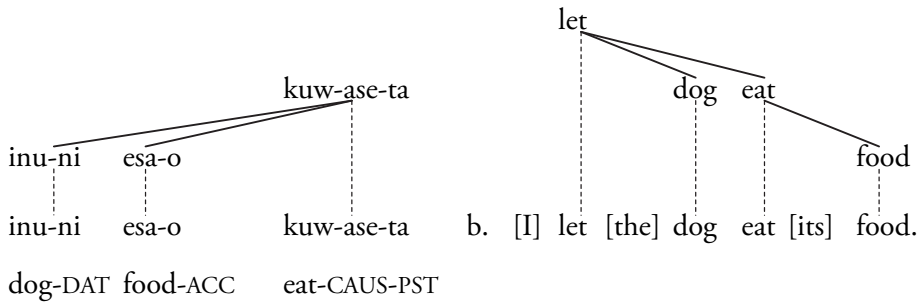
qualify as most inclusive units, namely chains. The same argument was made for idioms. The next section applies these concepts to morphology.

2.2. Dependency morphology

In order to explain bracketing paradoxes, one needs to consider morphological information because one of the problems is that many structures cut into words. Morphology in dependency grammar frameworks is considerably less well established than syntax. While proposals on dependency syntax are plentiful, proposals on the morphology of a dependency grammar are scarce. The only major attempts stem from Mel'čuk (1988) and Hudson (2003, 2007). Both proposals are highly idiosyncratic, insofar as they do not mesh easily with other dependency systems. Mel'čuk's dependency theory is multi-stratal, a feature usually eschewed in dependency grammar. Hudson's system is perhaps the most widely known dependency theory, but does not enjoy wide acceptance within the dependency grammar community. Its network-like structures and its generative aspirations do not sit well with generally acknowledged theories. Anderson (1980) proposed a morphology based on his widely known dependency phonology. And both Harnisch (2003) and Maxwell (2003) re-emphasise the need for dependency grammar to look beyond the word border.

This exhortation is indeed justified. Dependency grammarians have, due to their concentration on Indo-European languages, neglected to take a closer look at more agglutinative languages. The only extensively researched non-Indo-European language within dependency grammar frameworks is Japanese (Rickmeyer 1985). Agglutinative languages tend to pack the grammatical information, that in, e.g., English is parceled into several function words, into one verb. Consider the next examples:

(14)



The English sentence (14b) is the translation of the Japanese sentence (14a). The dependency tree (14a) is not very illuminating, as it seems to indicate that the causee *inu-ni* and the object *esa-o* relate to the complex verb in the same manner. In (14b), one can see that the causee *dog* depends on the causative auxiliary *let*, while the object *food* depends on the lexical verb *eat*.

A dependency morphology should aim to establish asymmetrical dependency relationships not between words, but between morphs. Such a program is faced with two problems: The morphological word structure needs to be established, and the dependency relationship between morphs contained in different words needs to be distinguished from the relationships between words contained in the same word. The former is called *inter-word* dependency, the latter *intra-word* dependency.

One example for an inter-word dependency is that between the genitive case morpheme *-no* attached to *yane*, and the lexical morpheme *ue* in the word *ue-ni* in (8). The genitive case morpheme *-no* is part of *yane-no*, and the lexical morpheme *ue* is part of *ue-ni*. Since *-no* is required in the presence of *ue*, *-no* morphologically depends on *ue*. This morphological dependency establishes the syntactic dependency of *yane-no* depending on *ue-ni*.

An intra-word dependency obtains between morphs contained in the same word. Considering again the above example, one must obtain an asymmetrical relationship between *yane* and *-no*. Evidently, the case for obligatory appearance of one morpheme in the presence of another morpheme is not feasible. The morpheme *yane* is not required in the presence of *-no*. Rather, the morpheme combination *yane-no* distributes like the combination NOUN-*no*, not like the combination *yane*-CASE.

In summary, inter-word dependencies obtain between morphs contained in

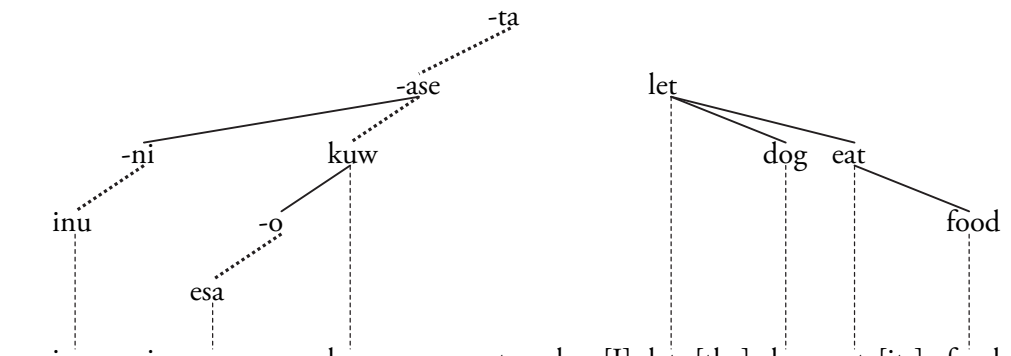
different words. One morph is dependent on the other, if the former is required in the presence of the latter. In contrast, intra-word dependencies obtain between morphs contained in the same word. One morph is dependent on the other, if the combination of these morphs distributes more like the latter, rather than the former.

In the wake of the Zwicky-Hudson-debate (Zwicky 1985, Hudson 1987) on headedness, morphologists have gradually come to consider morphological heads as akin to syntactic heads. The debate is confusing and confused because the aim was to establish the same set of criteria across the board. Many authors felt that this did not work. The main pitfall seems to have been the inability to provide for sufficient distinctions between inter- and intra-word relationships, while ensuring sufficient similarities. Because morphologists at that time adhered to constituency, their morphological constituents were too exclusive to capture the data, and a more inclusive chain-like notion did not occur to them. Nowadays, Distributed Morphology (Halle & Marantz 1993, Harley & Noyer 2003, Embick & Noyer 2007) takes explicit headedness to be their main credence as it operates pre- as well as post-syntactically. As a result, contemporary morphology and morphosyntax theories assume similar structures for words and sentences, namely those that exhibit constituent(-like) structures, and that are projections of heads contained in these structures.

With inter-word and intra-word dependencies sufficiently distinguished, a second look at (14a) is warranted. The serial morphological structure is already provided in the gloss. The intra-word dependencies of nouns and case morphemes has also been provided. The intra-word dependencies of the complex verb *kuw-ase-ta* still remain. The combination *kuw-ase* distributes like VERB-*ase*, therefore *kuw* depends on *-ase*. The combination *-ase-ta* distributes like VERB-*ta*, therefore *-ase* depends on *-ta*.

If one integrates this additional information from morphology into a dependency tree, (14a) can be redrawn as (15a). Intra-word dependencies are shown by dotted edges. The projection edge runs from the lowest morph node contained in a word. Compare (15a) with its English pendent (14b), repeated here as (15b).

(15)



Example (15a) shows a morph dependency tree. There are three projection edges indicating three words. Their respective lowest nodes receive the projection edge. Morphs in intra-word dependencies are connected by dotted edges. Other than (14a), (15a) shows that the causee *inu-ni* and the object *esa-o* do not depend in the same manner on the verb. Rather the causee *inu-ni* depends on the causative morph *-ase*, while the direct object *esa-o* depends on the lexical verb *kuw*. These relationships correspond to the English example (15b), apart from the fact that in Japanese the case morphs must be granted node status. In the English example, the auxiliary *let* is an exponent of both causative and tense, and the nouns *dog* and *food* are both exponents of objective case and the nominals.

Because dependencies between morphs are treated no different than dependencies between words, the notions of chains, components, and constituents, which were introduced for word dependencies in the previous section, can be applied to morph dependencies as well.

A chain was defined as a word itself or as a word combination of words directly connected in the dependency dimension. Substituting “morph” against “word”, every morph forms a chain on its own, and every morph combination directly connected in the dependency dimension also forms a chain. For example, in (15a) the case morpheme *-ni* and the causative suffix *-ase* form a chain because these morphs are directly connected. The morphs *inu*, *-ni*, and *-ase* also form a chain because they are directly connected. The morphs *inu* and *-ase*, however, do not form a chain as they are not directly connected, because *-ni* intervenes. There are 33 chains in (15a).

(16) inu, -ni, esa, -o, kuw, -ase, -ta
inu-ni, inu-ni -ase, inu-ni -ase-ta, inu-ni kuw-ase-ta, inu-ni -o kuw-ase-ta, inu-ni esa-o kuw-ase-ta; inu-ni kuw-ase, inu-ni -o kuw-ase, inu-ni esa-o kuw-ase;
-ni -ase, -ni -ase-ta, -ni kuw-ase-ta, -ni -o kuw-ase-ta, -ni esa-o kuw-ase-ta, -ni -o kuw-ase, -ni esa-o kuw-ase;
esa-o, esa-o kuw, esa-o kuw-ase, esa-o kuw-ase-ta;
-o kuw, -o kuw-ase, -o kuw-ase-ta;
kuw-ase, kuw-ase-ta, -ase-ta

(16) displays an intimidating large list of chains. The criticism that many of these chains do not fulfil any function seems justifiable, but on closer inspection one finds that one can attribute many purported chains with a compositional and analysable function. Space does not permit proof that every chain in (16) has a function, so the following explanation is limited to all chains containing *-ni* to the exclusion of *-ta*.

(17)

a.	-ni	Case[-ni](Causee[_])
b.	inu-ni	Case[-ni](Causee[inu])
c.	-ni -ase	Caus[-ase](Case[-ni](Causee[_]), Verb[_])
d.	inu-ni -ase	Caus[-ase](Case[-ni](Causee[inu]), Verb[_])
e.	-ni kuw-ase	Caus[-ase](Case[-ni](Causee[_]), Verb[kuw])
f.	inu-ni kuw-ase	Caus[-ase](Case[-ni](Causee[inu]), Verb[kuw])
g.	-ni -o kuw-ase	Caus[-ase](Case[-ni](Causee[_]), Verb[kuw](Case[-o]))
h.	inu-ni -o kuw-ase	Caus[-ase](Case[-ni](Causee[inu]), Verb[kuw](Case[-o])))
i.	-ni esa-o kuw-ase	Caus[-ase](Case[-ni](Causee[_]), Verb[kuw](Case[-o](Obj[esa])))
j.	inu-ni esa-o kuw-ase	Caus[-ase](Case[-ni](Causee[inu]), Verb[kuw](Case[-o](Obj[esa])))

(17a) shows the case marker on its own: It marks the case of a causee, which is unnamed, therefore its slot is not filled. (17b) shows the chain with a filled causee slot. (17c–f) show versions of the *-ni… -ase* chain: (17c) shows the raw chain with

unfilled causee and verb slots. In (17d), the causee slot is filled, in (17e) the verb slot, and in (17f) both slots. (17g–j) show the extension of (17e): In (17e) the case slot of the lexical verb is not filled, in (17g) it is filled. In (17h) the causee slot is filled, in (17i) the object slot, and in (17j) both.

If one adds the tense marker *-ta* one gets another eight chains. One would then have to add "Tense[-ta]" to all additional formulae. The whole sentence (15a) forms a chain that can be formalised as (18):

(18)　inu-ni eas-o kuw-ase-ta　Tense[-ta](Caus[-ase](Case[-ni](Causee[inu]),
Verb[kuw](Case[-o](Obj[esa]))))

This discussion should lay to rest any fears that chains may semantically overgenerate or could not be attributed with analysable functions.

Because morph combinations form chains, many of them also form components. A morph component is defined as a morph on its own or as a morph combination that forms a chain as well as a string. There are 22 morph components in (15a):

(19)　inu, -ni, esa, -o, kuw, -ase, -ta;
inu-ni, inu-ni esa-o kuw-ase, inu-ni esa-o kuw-ase-ta;
-ni esa-o kuw-ase, -ni esa-o kuw-ase-ta;
esa-o, esa-o kuw, esa-o kuw-ase, esa-o kuw-ase-ta;
-o kuw, -o kuw-ase, -o kuw-ase-ta;
kuw-ase, kuw-ase-ta, -ase-ta

Because the morph components in (19) form a subset of the morph chains in (16), they can all be attributed compositional and analysable functions.

Finally, morph constituents are complete morph components. Constituents are always considerably less than components. There are only 7 morph constituents in (15a):

(20)　inu, esa;
inu-ni, inu-ni esa-o kuw-ase, inu-ni esa-o kuw-ase-ta;

esa-o, esa-o kuw

The nouns *inu* and *esa* form respective noun phrases. Together with their respective case markers, *inu-ni* and *esa-o* form case phrases. The constituent *esa-o kuw* is a verb phrase, the constituent *inu-ni esa-o kuw-ase* is a small verb phrase, and the whole sentence is a tense phrase. Because the constituents in (20) are a subset of the components in (19), which are a subset of the chains in (15), every constituent is fully interpretable.

This section has introduced the basic notions of a dependency morphology, and it has shown that the syntactic notions introduced in the previous section are applicable to morphs as well. Further, it has been argued that morph chains, components, and constituents express compositional and analysable functions, and thus receive transparent semantic interpretations. The next section turns again to bracketing paradoxes and their treatment within the framework developed in this section.

3. Bracketing paradoxes revisited

After having outlined the essential concepts and notions of a dependency grammar framework, it is now time to attempt an alternative analysis of the bracketing paradoxes given in the first section. Prior to this attempt, however, a look at run-of-the-mill constructions is necessary, in order to show that a constituency-based analysis may even have problems with expressions usually not considered paradoxes. Consider the next example:

(21) metalworker

Example (21) is an English compound. The first noun *metal* modifies the second compound part *work*. The suffix *-er* creates a personal noun. The standard analysis in a constituency-based approach would be to combine the compound parts first, and then attach the suffix. This procedure is formalised in (22):

(22) a. [metal]+work → [[metal]work]

b. [[metal]work]+er　　→ [[[metal]work]er]

This type of analysis has the drawback that the expression *work-er* is not available. Because *work* first combines with *metal*, and because *work* forms the morphological head of *metalwork*, the concept of constituency does not allow to speak only of the head, as the head of a constituent must always subsume all subordinate elements grouped with it. In other words, a constituency-based approach only recognises constituents, of which there are three in (22): *metal*, *metal-work*, and *metal-work-er*.

Another approach would be to attach the personal suffix to *work* first, and then combine *metal* with *work-er*.

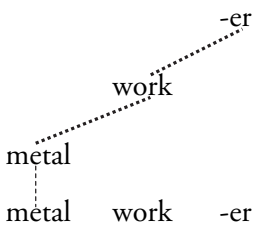
(23)　a. [work]+er　　→ [[work]er]
　　b. metal+[[work]er]　　→ [[metal] [[work]er]]

In (23), the compound *metal-work* is not available, the possible constituents being *metal*, *work*, and *metal-work-er*.

A dependency morphological approach such as the one outlined in the previous section can do better. It recognises the chains *metal*, *work*, *-er*, *metal-work*, *work-er*, and *metal-work-er*. In addition to the constituents that a constituency-based approach allows, a dependency approach can point to additional chains. A dependency approach never runs into the problems that two different sets of units (such as constituents) are derived by beginning the analysis at different points.

A morph dependency tree of (21) looks like (24):

(24)

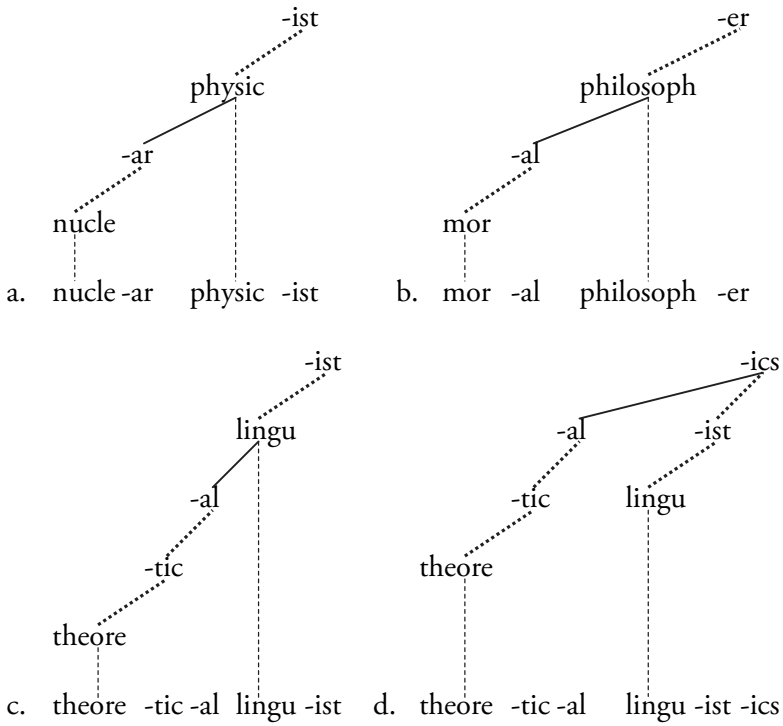


Tree (4) is a maximally transparent, even though it is structurally minimal. Every chain receives a transparent interpretation: *metal-work* is work on or with metals,

work-er is someone who works, and *metal-work-er* is someone who does work on or with metals. Of course, also the simplex chains each receive a transparent interpretation. Note that the chain *work-er* is not available in the constituency-based analyses (22, 23), and that the chain *metal-work* is not available in (23).

The examples (1) from the first section now receive a straightforward and unexceptional explanation. Consider the next morph trees:

(25)



(25ab) show the morph trees for *nuclear physicist* and *moral philosopher*. Because both expressions stem from the Greek-Latinate stratum, their internal structures are shown. The noun *nucle* is the root of *nucle-us*, the attachment of the derivational suffix *-ar* creates an adjective depending on the root *physic*. The chain *nucle-ar physic* denotes the meaning of "nuclear physics". Like example (24), the chain *physic-ist* needs to be available, therefore the derivational suffix *-ist* attaches to the root *physic* in order to create this chain. (25a) contains 10 chains (*nucle*, *-ar*, *physic*, *-ist*, *nucle-ar*, *-ar physic*, *physic-ist*, *nucle-ar physic*, *-ar physic-ist*, and *nucle-ar physic-ist*), the exact

number of components (because the tree is totally ordered), and constituents (*nucle*, *nucle-ar*, *nucle-ar physic*, and *nucle-ar physic-ist*). A similar account holds for (25b).

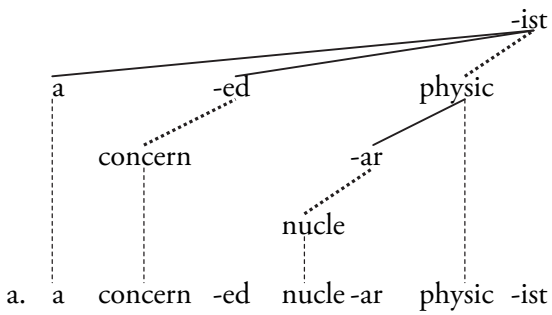
(25c) shows the tree for *theoretical linguist*. Instead of assuming a covert or elided suffix *-ics*, the morph tree (25c) assumes the Latinate root *lingu* from *lingu-a* 'tongue' as a confix. The confixual root *theore* depends via the suffixes *-tic* and *-al* on the root *lingu*. The derivational suffix *-ist* is attached to the latter root. The expression *theoretical linguistics* could then either be constructed by attaching the derivational suffix *-ics* to *lingu-ist*, or analysed as is shown in (25d). There, *theore-tic-al* depends on the suffix *-ics*. Whichever option one chooses, it is important to note that the attributive adjective *theore-tic-al* never depends on the personal suffix *-ist*.

The latter fact is true for all examples in (25). Because the attributive adjectives never form chains together with the personal suffixes, those type of morpho-semantic mismatch that give rise to bracketing paradoxes *never* arise. Furthermore, the structures in (25) are indistinguishable from structures of expressions not regarded as bracketing paradoxes. In other words, in a dependency morphology as the one outlined in section 2.2, the notion of bracketing paradoxes has no place because such cases cannot be distinguished from non-paradoxical cases.

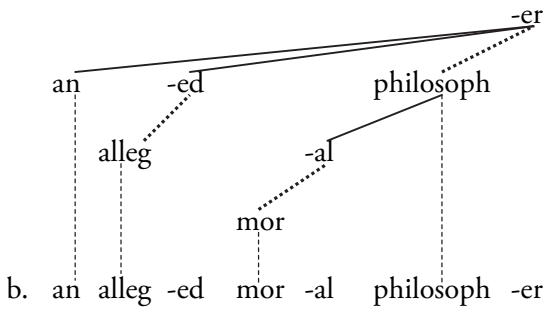
The notion of bracketing paradox is akin to a cognitive illusion: One can only perceive the purported phenomenon within a certain framework (a specific cognitive set-up); once the framework is changed, the illusion dissolves. The principle cause of the bracketing paradox illusion is the notion of the constituent. As was shown in section 2, the constituent is the least inclusive unit of syntax and morphology. A less inclusive unit allows less discrimination of phenomena than a more inclusive unit. Less discrimination may lead to lead to faulty assumptions, skewed results, and misperceptions. Bracketing paradoxes are such a misperception.

The strength of the dependency morphological model is even more apparent when one enlarges the expressions (25a–c) with attributive adjectives that must depend on the personal suffixes for semantic reasons. Consider the next examples:

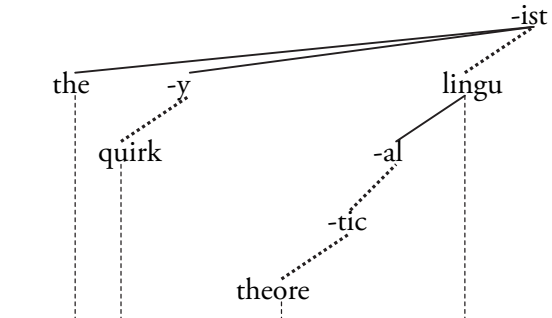
(26)



a. a concern -ed nucle -ar physic -ist



b. an alleg -ed mor -al philosoph -er



c. the quirk -y theore -tic -al lingu -ist

The examples in (26) are remarkably unexceptional when shown in morph dependency trees. In (26a), the determiner *a* and the attributive adjective *concern-ed* modify a person, not a discipline, therefore they must depend on the personal suffix *-ist*. The same accounts for the article *an* and the adjective *alleged* and their dependencies on *-er* in (26b). There, it is not some kind of moral philosophy that is

in question, but the status of a person as a moral philosopher. In (26c), what is quirky is the linguist as a person, not the kind of theoretical linguistics this linguist conducts. The structures in (26) lead to iterated bracketing paradoxes in any constituency-based approach.

A final example from German identifies a curious phenomenon, which may help to shed more light on the structure of the German noun phrase, which enjoys the dubious honour of being considered as quite intractable. Other than English, German has retained explicit genus for its nouns. Every German noun belongs to a specific genus class. A small minority can belong to two classes, which then must be masculine or neuter (feminine genus can never be combined). In these rare cases, the meanings of the different genus tend to differ. One such example is *Moment*, which can be *der Moment* 'moment' or *das Moment* 'element, fact(or), moment [phys.]'.

Whenever two or more nominal morphs combine, the genus of the complex, derivational noun, is equal to the genus of the last nominal morph. Since nominal genus is expressed as inflectional morphs attached to articles and attributive adjectives, these morphs must be in a dependency relationship with that morph that constitutes the presence in which these genus must appear. They must therefore depend on this morph. Genus is regarded as an inherent feature of German nouns, or differently put: Genus is one exponent of a German noun. Consider now the next example:

(27) a. theore -tisch -er Physik -er
theor[y] -tic -NOM.m physics -PERS
'theoretical physicist'

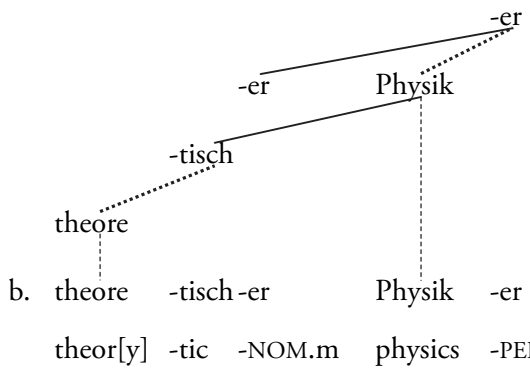
Traditionally, (27a) is a bracketing paradox. The attributive adjective *theore-tisch-er* modifies only the noun *Physik*, not the noun *Physik-er* or the personal suffix *-er*. The problem, however, is that while the attributive adjective modifies the lexical noun *Physik*, this noun is feminine. But the genus marker attached to the adjective is, beyond any doubt, an exponent of masculine genus. Based on the semantics of the expression (27a), one would expect *theoretische Physiker*, which is possible but plural.

It must be kept in mind, that genus morphs, such as (the first) *-er* in (27a), are always exponents of multiple morphemes: They always express a specific genus, and a

specific case. This property distinguishes them from pure case morphs, which are only exponents of case. Of the latter, there are two types: *-e* expresses [-CASE] and *-en* expresses [+CASE]. Genus morphs are necessary when nouns have dependents *and* when nouns themselves are not overtly case-marked. Whenever genus and case morphs appear together, the former precede the latter.

In a dependency morphological approach, such as the one employed here, the problem finds a straightforward structural representation. The next tree shows the structure of (27a):

(27)



b. theore -tisch -er Physik -er

theor[y] -tic -NOM.m physics -PERS

'theoretical physicist'

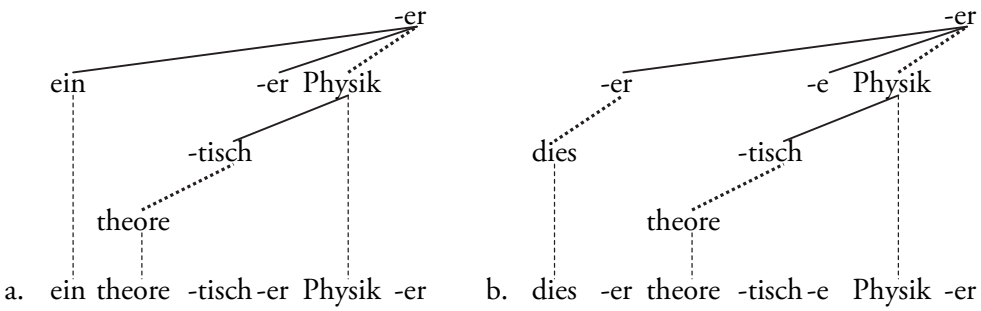
The most important feature of the morph tree (27b) is the edge between the genus morph *-er* and the phonetically identical derivational personal suffix *-er*. The justifiable assumption is that the former depends on the latter, because it must appear in the presence of the latter. Genus is inherent in the personal suffix, but contextual in the genus morph. Because these two morphs are not part of the same word, their relationship must be an inter-word dependency. Therefore they receive a straight dependency edge.

On the other hand, the genus morph is clearly a part of the word *theore-tisch-er*. The surprising result is that the genus morph in (27) does not entertain any intra-dependency relationships with the other morphs with which it constitutes the word *theore-tisch-er*. The genus morph is only *phonetically* part of the attributive adjective, but not a morpho-syntactical part.

The assumption of a genus morph not entertaining intra-word dependency

relationships, but only inter-word dependency relationship could lead to a new approach to the German noun phrase structure. The next example adds articles to (27a).

(28)

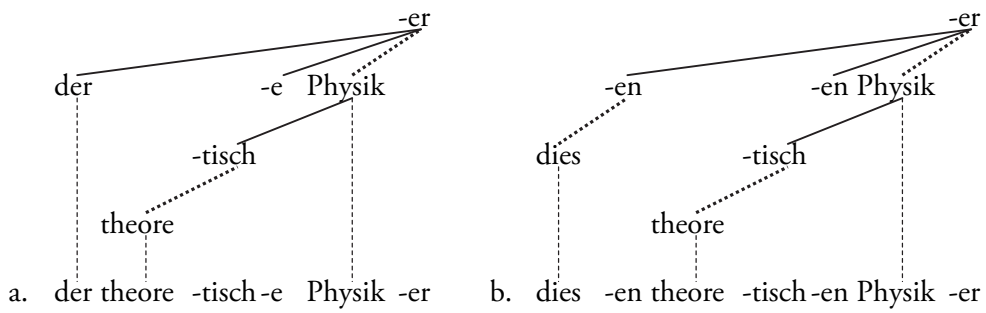


In the nominative case (stipulated here), the indefinite article does not take a genus morph. Instead, attributive adjectives, if present, require the attachment of a genus morph. This is shown in (28a), where the genus morph depends, like the indefinite article, on the personal suffix. Note that the attachment of a genus morph does not require that the genus morph entertain an intra-word dependency relationship with another morph of the word that contains both morphs.

The situation in (28b) is more complicated. Unlike the indefinite article in (28a), the demonstrative article *dies* in (28b) must depend on the genus morph. In addition, the genus morph in (28b) is, like in (28a), dependent on the personal suffix. Because the genus morph *-er* appears the attributive adjective may not receive another genus morph, but must receive a case morph, here *-e*. This case morph closes off the slot for a specific type of dependents, namely adjectival attributes. While multiple attributes are possible, they must all receive the same case morph.

Definite articles or determiners express multiple exponence: Not only do they express definiteness, but also all those properties usually expressed by genus morphs. The genus morphs have fused with the definite article morphs and have become unanalysable. The next examples show a definite article, and an accusative marked example.

(29)



In (29a), the definite article *der* not only marks definiteness, but also marks the same properties of the genus morph *-er* in (28). In (29b), the morph *-en* appears twice, but it is not the same. The first morph is the genus morph, the second one is the case morph expressing [+CASE].

One final remark is necessary. It was claimed in section 2 that every chain could be attributed a transparent function or meaning. The chains *-er… -er* in (27b) and (28), the chain *-en… -er* in (9b), the chains *-e… -er* in (28b) and (29a), and the chain *-en… -er* in (29a) still require an explanation.

The chains *-er… -er* in (27b) and (28) express the necessary grammatical properties of the whole noun phrase. Every required feature is expressed: Case (nominative) and genus (masculine) is expressed by the inflectional (the first) suffix *-er*, and the projective head of the noun phrase is expressed by the derivational suffix (the second) suffix *-er*. The difference to the chain *-en… -er* in (29b) is that the latter expresses accusative case instead of nominative case. The chains *-e… -er* in (28b) and (29a) express a case property required in the presence of another case feature: This case feature is either expressed by a genus morph or by a case morph attached to the noun (such as genitive in singular non-feminine nouns, or as dative in certain plural nouns). The co-occurring case property is called [-CASE] here, and it has purely attributive function. The strong case feature is expressed in the chain *-en…-er* in (29a): Like in (28b), the presence of [+CASE] requires the presence of a genus morph. [+CASE] expresses any case other than the nominative or any case phonetically identical with it. This information is summarised in Table 1.

Table 1: Chain meaning/functions in (7–9)

Example	Chain	Meaning/function
(27b), (28)	*-er … -er*	[NOM.m]+[PERS]
(29b)	*-en … -er*	[ACC.m]+[PERS]
(28b)	*-e … -er*	[-CASE]+[PERS]
(29a)	*-en … -er*	[+CASE]+[PERS]

Table 1 shows that indeed every chain can be attributed with a specific meaning or function. Note that these chains are not available in a constituency-based approach, because they fail to form constituents.

4. Conclusion

This paper argued that the so-called bracketing paradoxes dissolve under a dependency morphological approach. Section 1 outlined several instances of bracketing paradoxes often cited in the literature. The proposed solutions within constituency-based approaches, notably lowering, were explained and criticised. Lowering adds a considerable load to processing, a cost a dependency-based approach does not incur.

Section 2 gave an overview over dependency-based syntax and morphology. Section 2.1 was mainly concerned with the introduction of the notions of chain, component, and constituent in a dependency-based framework. Section 2.2 applied these notions to a morpho-syntactical and morphological approach. It was shown that, in particular, chains also obtain in morphology.

Section 3 constitutes the main argument of this paper, as this section reconsiders bracketing paradoxes under the developed chain-based dependency approach. It was shown that the putative bracketing paradoxes vanish under a chain-based representation. Iterated paradoxes were also addressed and shown to be unproblematic. Finally, the mystifying distribution of inflectional suffixes of dependents within German noun phrases were also explained within dependency morphology. It offered the surprising hypothesis that these inflectional suffixes were

dependents of the head noun, even though they are, phonetically, part of the modifiers, such as articles and attributive adjectives.

The central criticism was also made in Section 3, namely that bracketing paradoxes are the result of applying the least inclusive unit to linguistic structure, and thereby begetting something akin to a cognitive illusion. Only chain-based dependency grammar shows things as they are.

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