Making good on a promise

Multidimensional constructions

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Construction Grammar was founded on the promise of maximal empirical coverage without compromising on formal precision. Its main claim is that all linguistic knowledge can be represented as constructions, similar to the notion of constructions from traditional grammars. As such, Construction Grammar may finally reconcile the needs of descriptive and theoretical linguistics by establishing a common ground between them. Unfortunately, while the construction grammar community has developed a sophisticated understanding of what a construction is supposed to be, many critics still believe that a construction is simply a new jacket for traditional linguistic analyses and therefore inherits all of the problems of those analyses. The goal of this article is to refute such criticisms by showing how constructions can be formalized as open-ended and multidimensional linguistic representations that make no prior assumptions about the structure of a language. While this article's proposal can be simply written down in a pen-and-paper style, it verifies the validity of its approach through a computational implementation of German field topology in Fluid Construction Grammar.

Keywords: syntactic analysis, representations, construction grammar, descriptive adequacy

1. The promise of construction grammar

Construction Grammar is a family of linguistic approaches that emerged in the 1980s out of dissatisfaction with the core-periphery distinction of the time. This distinction (Chomsky 1981) meant that linguistic facts were only deemed worthy of investigation if they could be explained by a core of abstract rules. If not, they were considered to be part of a periphery of exceptions, so they ended up in linguistic purgatory. Construction Grammar's big promise, then, was that it would be able to account for *all* of the empirical facts without compromising on formal precision. Its "key overarching claim is that the proper units of a grammar are more similar to the

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notion of construction in traditional and pedagogical grammars than to that of rule in most versions of generative grammar" (Fillmore, Kay, and O'Connor 1988, 501).

If Construction Grammar can cash in on that claim, it may also solve the rift that has existed between descriptive and theoretical linguistics since the Chomskyan revolution. Whereas descriptive linguists need to describe the *constructions* of a language in a way that is as 'framework-free' as possible (Haspelmath 2009), theoretical linguistics aims to characterize the *linguistic knowledge* that a language user must possess to *generate* such constructions (Chomsky 1957). If such linguistic knowledge can directly take the form of constructions rather than abstract rules, a common ground for both descriptive and theoretical needs can be established.

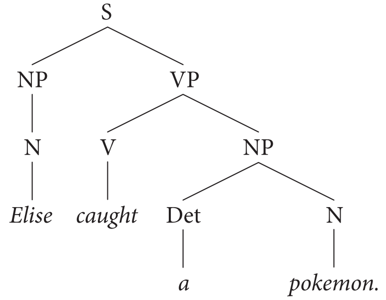
Unfortunately, while the community has developed a tacit understanding of what a 'construction' is supposed to be, critics often believe the term is simply a new jacket for traditional syntactic analyses. If that were true, Construction Grammar would also inherit all of the problems that come with those analyses. This would jeopardize the future success of the constructional enterprise, and with it, the possible reconciliation of descriptive and theoretical linguistics.

The goal of this article is to show that such criticisms are unjustified, provided that constructions are formalized as open-ended and multidimensional linguistic representations. 'Open-ended' means that no prior structures or categories are assumed, and 'multidimensional' means that different linguistic dimensions exist on a par with each other in the same construction. This article demonstrates this approach using an example of German field topology, which has been verified through a computational implementation in Fluid Construction Grammar (Steels 2004, 2011). Interested readers can access a demonstration of the implementation at https://www.fcg-net.org/projects/.

2. A new jacket for mainstream analyses?

When Construction Grammar emerged in the 1980s, the dominant approach to syntactic analysis was *(immediate) constituent analysis* (Wells 1947), as illustrated using the widely adopted tree representation in Example (1).

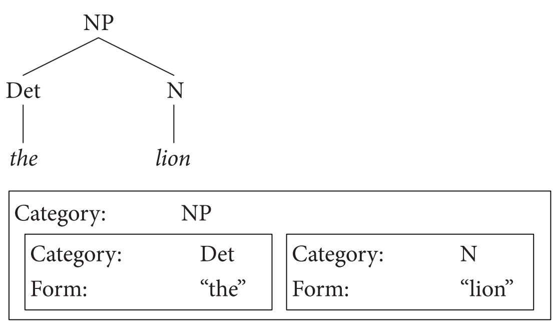
(1)



Constituent trees reached an almost untouchable status since Chomsky (1957), who operationalized *phrase structure grammars* as a way to generate constituent analyses by using phrase structure rules such as S → NP VP. However, such rules can only describe *local* relations between a parent node and its immediate children, so Chomsky argued that they were not expressive enough for the structures of natural languages. He therefore proposed to enrich them with transformations, while others started looking for non-transformational alternatives (Sag et al. 1986). None of these proposals, however, questioned the centrality of constituent analysis.

Early Construction Grammar was no different, and Fillmore, Kay, and O'Connor (1988) considered constructions to be similar to phrase structure rules that permit constituent trees, with the exception that constructions can access the whole tree instead of only local parent-child configurations, and that lexical items can also be perceived as constructions. The well-known 'box notation' of Construction Grammar is indeed simply a notational variant of a tree representation, with the outer box representing a parent node, and the inner box representing its children, as shown for the phrase *the lion* in Example (2).

(2)



The constituent-based view of constructions led to interesting explorations of how to operationalize Construction Grammar using tree-based formalisms (e.g. Bod 2009; Lichte and Kallmeyer 2017), and how Construction Grammar is related to constraint-based grammars such as HPSG (Pollard and Sag 1994), which gave birth to Sign-Based Construction Grammar (Michaelis 2009).

A tree-based analysis makes a strong claim about the world's language structures: it assumes that constituent structure forms the backbone of every sentence onto which all other linguistic information must be fitted somehow. This is reflected in both the tree and box notations of Example (2), which use a different representation for constituency (lines or boxes) than for other information (feature-value pairs).

However, there are no empirical reasons to believe that constituent structures are universal (Evans and Levinson 2009). Languages such as Kalkatungu (Blake

1983) and Warlpiri (Hale 1983) show little or no evidence for constituency. Blake (1983, 143–145) writes that in Kalkatungu a sentence of five words such as *This dog bit the white man* can occur in any of the 120 possible mutations. Example (3), quoted from Nordlinger (2014, 229) shows a couple of these permutations, with what corresponds to the English noun phrase *this big dog* printed in boldface.

(3) a. ***cipa-yi thuku-yu yaun-tu*** *yanyi icayi*
this-ERG dog-ERG big-ERG white.man bite
'This big dog bit/bites the white man.'
b. ***cipa-yi thuku-yu*** *yanyi icayi* ***yaun-tu***
c. ***cipa-yi thuku-yu*** *icayi yanyi* ***yaun-tu***
d. ***thuku-yu cipa-yi yaun-tu*** *yanyi icayi*
e. ***cipa-yi*** *icayi yanyi* ***thuku-yu yaun-tu***
f. *yanyi icayi* ***cipa-yi yaun-tu thuku-yu***

Most construction grammarians therefore dropped their commitment to constituent structure. For instance, Goldberg (2013) has explicitly stated that Argument Structure Constructions (that is, constructions that map semantic frames onto grammatical relations) do not directly specify constituent structure. In this view, Examples (4) and (5) can be analyzed as involving the same English Ditransitive Construction, which maps the semantic frame 'X causes Y to receive Z' onto the grammatical relations 'Subject – Indirect Object – Direct Object', even though both examples involve different hierarchical structures.

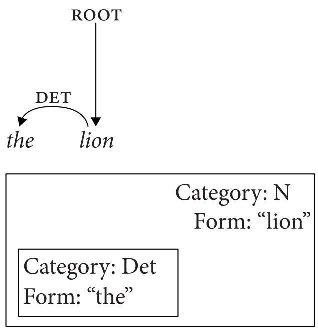
(4) Tsar Nicholas II gave his wife a Fabergé egg.

(5) It is a Fabergé egg that Tsar Nicholas II gave his wife.

Unfortunately, construction grammarians have also been reluctant to spell out the structural properties of such constructions in more detail. This has left their analyses open for misunderstandings and misguided criticisms. For example, because of the lack of an explicit alternative (though see van Trijp 2014), Müller and Wechsler (2014) ignore Goldberg (2013)'s clarification and treat Argument Structure Constructions as phrasal constructions anyways.

One proposal to address this issue has sought to link up construction grammars to dependency analysis (Tesnière 1959), which describes head-dependent relations between words. More specifically, Osborne and Gross (2012) suggest that constructions can be operationalized as the *catenae*, or the subtrees, of dependency trees. They argue that the box diagrams of Construction Grammar can straightforwardly be translated to reflect dependency relations, as shown for the expression *the lion* in Example (6). Here, the outer box (*lion*) is the head node, and the inner box represents its dependent (*the*).

(6)



However, dependency structures use the same formal solution as constituent structures: a two-dimensional tree that uses one type of relation as the backbone onto which all other kinds of information must be fitted. This representational limitation makes it difficult to represent constituent relations, and vice versa, a constituent tree makes it more difficult to represent dependency relations.

When looking at cross-linguistic data, however, it becomes clear that dependency and constituent structures are not mutually exclusive: most languages use structures that display a mix of both: languages such as Wambaya (Nordlinger 1998) show signs of primitive constituent structures, while languages such as German offer more robust evidence for constituents while keeping phrasal ordering pragmatics-based. Some languages, such as Riau Indonesian (Gil 2013), show no clear evidence for either strategy. Studies from historical linguistics confirm that dependency- or constituent marking may emerge, develop and decay over time. For example, the Germanic languages have developed constituent structures over a span of several centuries (Van de Velde 2009), but have been losing their case systems for marking dependencies (Barðdal 2009). Both language typology and diachrony therefore indicate that we need expressive tools that allow us to describe the complex interplay between both structures.

In sum, if we assume that constructions describe tree structures, whether these are constituency- or dependency-based, they would indeed only function as a new jacket for existing practices that have proven to be problematic.

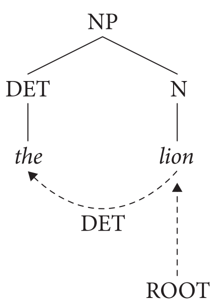
3. Open-Ended and multidimensional constructions

The new-jacket criticism ignores the advances that have been made in recent decades by the construction grammar community. First, there is a more sophisticated understanding of what a construction is supposed to be, which goes along the lines of Fried and Östman (2004):

> Constructions can represent very simple configurations that could be almost equally well captured by phrase-structure trees. But constructions can also be quite complex, representing much larger and more intricate patterns containing several layers of information [...]. It is particularly the latter kind of constructions that emphasizes the unique character of Construction Grammar as a **multi-dimensional framework in which none of the layers is seen as 'more basic' than any other; constructions differ only in the extent to which they make use of these resources.** (Fried and Östman 2004, 19; emphasis added, RvT)

In other words, constructions are conceived as multidimensional structures with each dimension living on a par with the others. Indeed, it is straightforward to imagine how dependency- and constituency-structures may co-exist, as shown in Example (7).

(7)



There is already a rich tradition of *functional* linguistics that considers multiple dimensions simultaneously, including frameworks such as Functional Grammar (Dik 1997) and Role and Reference Grammar (Van Valin 1993). However, as Haspelmath (2009) argues, such frameworks still impose their architectures as universals onto language descriptions. More problematically, most functional approaches separate linguistic information into different layers. This forces linguists to make ad-hoc decisions about which information goes into which layer, while time and again, languages resist "the attempt of linguists to make it neat and clean" (Croft 2003, 50).

This brings us to the second major advancement. Recognizing the problems with existing frameworks, typologists have engaged in important debates about how to sharpen our field's descriptive methods in order to approach every new language in an unbiased way (e.g. Croft 2010; Haspelmath 2009). With the development of Radical Construction Grammar, Croft (2001) has established a constructional perspective that may be the closest we can get to the 'framework-free' ideal of language typology.

Both advances – what a construction should be and how constructions should be used for language descriptions – require us to think in a radical different way about how to make constructions formally precise, which is exactly what Steels

(2004) did. Instead of trying to develop a common framework for the world's languages, he turned the problem upside down and asked the question: how can new grammatical constructions emerge from scratch? Steels realized he needed a formalism that would be able to cope with the rise and fall of grammatical systems, and more importantly, a formalism that would be adaptive enough to handle structures that the researcher could not foresee. He therefore implemented the first design of a construction-based formalism, which later became Fluid Construction Grammar (FCG; Steels 2011). Through computational simulations of cultural language evolution, Steels (2004) then showed how dependency and constituent structures may emerge and interact with each other.

But what makes the FCG formalism different from the aforementioned functional frameworks? First, Steels made sure his formalism did not assume any prior knowledge about categories or linguistic structures. There is no predefined constituent structure or dependency structure, not even as options from which a language may choose. This means that his solution can scale to include other dimensions as well. Secondly, each relevant dimension is simultaneously represented in the same construction instead of being separated into a different layer. In sum, Steels found a way to overcome the problems of traditional linguistic representations, which is exactly what we need if we want to formalize the more sophisticated understanding of what constructions are.

4. How does it work? An example from German field topology

An interesting example for illustrating Steels' solution is German word order. One popular approach to German word order is *Field Topology* (Drach 1937), which divides a German sentence into at least five linear 'fields':

(9) Prefield – Left Bracket – Middlefield – Right Bracket – Postfield

The core of this topological structure is the German verbal complex, which is spread into a sentence frame consisting of the Left Bracket (for the finite verb) and the Right Bracket (for the non-finite verb or verb particle). As illustrated in Figure 1 from Micelli (2012), German is relatively liberal as to which fillers can occupy the other fields, but interesting generalizations can nevertheless be described based on a mix of constraints from syntax and information structure. Crucially, however, field topology does not depend on dependency relations such as Subject and Object, or an English-like phrase structure (Haspelmath 2009). Indeed, we can consider the topology of a German sentence as an additional dimension that we need to represent in order to correctly describe German syntax.

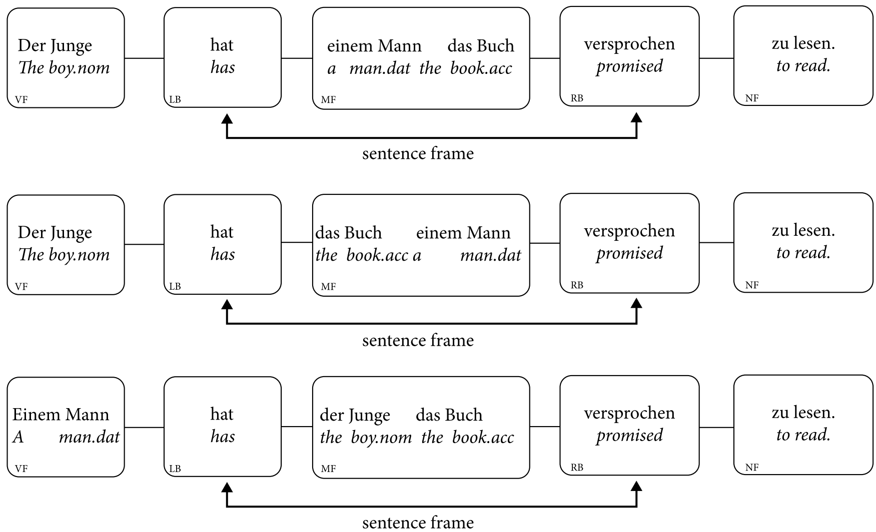


Figure 1. This Figure from Micelli (2012) shows three different permutations of the same German sentence expressed in a field topology analysis

To operationalize such a multidimensional analysis, we first need to decide what the relevant linguistic *units* are. Depending on the desired granularity, anything can be a unit: morphemes, words, phrases, clauses, topological fields, and so on. Secondly, we need to represent the relations between each unit, and here lies the most important innovation of Steels (2004): instead of committing to a particular organization, which would trap us into the problem of prioritizing one structure over the others, Steels *describes* each relation as feature-value pairs. In other words, there is no longer a fixed backbone onto which we have to fit all of the other information.

More specifically, each unit is described as an independent 'box' using feature-value pairs, as shown in Example (10), which represents a German clausal unit in a traditional Attribute-Value Matrix (AVM) notation (a), as well as its visualization in FCG's web interface (b).

(10) a. AVM-notation:

Clause–unit		
CATEGORY	*Clause*	
TOPOLOGY	FRONT-FIELD	*ff–unit*
	LEFT-BRACKET	*lb–unit*
	MIDDLE-FIELD	*mf–unit*
	RIGHT-BRACKET	*rb–unit*
	POSTFIELD	*pf–unit*

b. FCG visualization:

clause-unit
category clause field-topology: (front-field ff-unit) (left-bracket lb-unit) (middle-field mf-unit) (right-bracket rb-unit) (postfield pf-unit)

As can be seen, the clause's field topology is described as a feature called TOPOLOGY, whose value is the list of fields, which are also represented as feature-value pairs. However, instead of directly representing each field as a *nested* feature-value pair, the value of each field is simply the *name* of a unit. When a unit name is used in the value of a feature, it serves as a 'pointer' to that unit in very much the same way as you can click a hyperlink in order to visit a webpage. Just like you can have multiple hyperlinks to the same page, you can have multiple pointers to the same unit coming from different sources.

Example (11) shows another unit that uses the same solution, but this time for representing constituent structure. This unit, called the FF-UNIT (front-field), is a German nominal phrase that has two CONSTITUENTS. Instead of directly nesting those constituents in the FF-UNIT, unit names are used as pointers to the relevant positions in the linguistic structure.

(11) a. AVM-notation:

[*ff–unit*
CATEGORY *NP*
CONSTITUENTS { *der–unit* , *Junge–unit* }]

b. FCG-visualization:

ff-unit
category: np constituents: (der-unit junge-unit)

We can translate the units and their feature structures into a graph (or network) representation, which is visualized in a simplified way by Figure 2 for the sentence *Der Junge hat einem Mann das Buch versprochen zu lesen* ('The boy has promised the man to read the book'). As can be seen, multiple dimensions intersect with each other: field topology (full lines with the symbol '<' for precedence constraints), constituent structure (unlabeled dotted lines), and dependency structure (labeled,

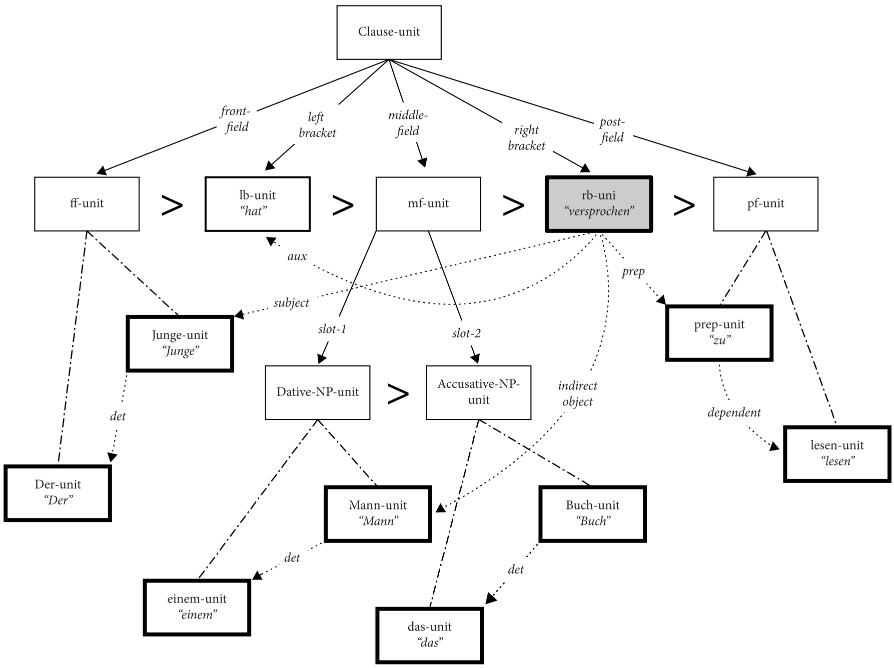


Figure 2. This Figure shows a simplified visualization of multiple intersecting dimensions in a German sentence: Topological structure (full lines with '<' for linear precedence), constituent structure (unlabeled dashed lines) and dependency structure (dashed arrows with dependency labels). The boxes of lexical units have broader strokes than non-lexical units for clarity's sake, with the sentence's root (*versprochen*) marked by a grey box

dotted arrows). The multiple overlapping dimensions often allow the same unit to be accessed from different entry points. The word *Junge* ('boy'), for example, can be accessed as the constituent of a nominal phrase, or it can be accessed from the main verb through a dependency relation.

One important clarification is that Figure 2 represents a multidimensional *sentence structure*, and not the *constructions* that are needed for building such a structure. Constructions are operationalized with the same strategy of units and feature-value pairs (see Steels 2017 for formal details) in order to allow them to represent any recurrent pattern of a language without architectural restrictions. Due to space limitations, this squib can unfortunately not offer any details about how those constructions can then be combined with each other for building multidimensional analyses, but interested readers can inspect them fully through an web demonstration at https://www.fcg-net.org/projects/.

Multidimensional structures can soon become unwieldy and difficult to understand. However, in order to get the empirical facts straight, it is important to embrace the complexity of grammatical structures and to find solutions. One useful analogy can be found in other complex structures with overlapping dimensions, such as a house. A house has both structural properties (its foundations and walls) and services (electricity, plumbing, ventilation, ICT) that are different but not completely independent from each other. Just like sentences, a house is so complex that an architect cannot communicate all of the relevant details about it in a single blueprint. Instead, they will use different perspectives such as multiview drawings and isometric projections, and computational tools for managing the complexity and avoiding errors. In the same way, linguists can keep using different 'perspectives' on the same complex structure that emphasize certain information while hiding others, but use computational tools for verifying the validity of the analysis and for managing the intricate relations between each perspective.

5. Conclusion

Construction Grammar was founded on the promise that it would be able to account for all empirical facts without compromising on formal precision. Indeed, the field has made important advances in order to deliver on its promise: a more sophisticated understanding of what a construction is supposed to be (Fried and Östman 2004, 19; Goldberg 2013), and a constructional perspective that can serve as a common ground for descriptive and theoretical linguistics (Croft 2001). This article has illustrated how these advances can be translated into precise formalizations (based on Steels 2004, 2011), and has thereby refuted some misunderstandings that still exist about constructions. This formalization, which allows different dimensions to co-exist in the same construction, was illustrated through an example from German field topology, but extends to other grammatical structures as well.

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