Optimal Constructions*

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This paper deals with a well-known problem in the discussion of argument linking, the flexibility that we find with particular verbs, and the constraints governing the integration of verbs with so-called argument structure constructions. We will show that traditional approaches as well as construction grammar need additional machinery to deal with variable argument linking. I will present an optimisation approach to variable argument linking that uses construction grammar as format for morphosyntax.

Section 1 introduces the phenomenon. Section 2 introduces the concept of argument structure constructions from construction grammar. Section 3 provides a detailed analysis of the problem and offers an optimality theoretic account. Further aspects are discussed in sections 4 and 5. Section 6 briefly discusses formal aspects of the proposed constructionist model of OT syntax.

1 Variable Argument Linking

That the verb governs the clause is a core assumption in many traditional and contemporary syntactic frameworks (Minimalism, Valency Grammar, Dependency Grammar, LFG, HPSG, a.o.). These accounts implement this guiding idea in various ways, for instance by the assumptions that phrases are headed and that clauses are either verb phrases or extensions of verb phrases. In generative syntax, clauses are usually represented as projections of functional features that correspond to verbal inflection.

On the semantic side, it is the verb that is seen as determining the propositional content of a sentence. In event semantic analyses inspired by Davidson

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(1967), verbs, in particular action verbs, are seen as predicates over events. The original conception of Reichenbach (1947) differed from the Davidsonian formulation in that it treated not the verb in isolation, but the whole sentence as predicate of what Reichenbach called a "fact/event". While in Reichenbach's conception the verb also has a prominent role, it does not have such a dominant role as in Davidsonian or Neo-Davidsonian accounts (the latter following Parsons (1990)). However, Reichenbach's view has not been popular in linguistics since Davidson (1967). Recent developments, especially in construction grammar, are designated to relativise the dominant role of the verb in syntax. The present paper provides further evidence that such a relativisation might be more realistic.

This central role of the verb in standard syntactic approaches carries over to sentential constituent structure. The lexical entry of a verb includes syntactic and semantic information about the *dependents* it is required to cooccur with in a sentence. It is a standard assumption that there is a connection between the meaning of a verb and the dependents it selects. A verb describes some state of affairs in which several participants take part. I will use the term *semantic roles* here for the semantic correlate of syntactic dependency. These participants are usually overtly realised together with the verb within the same clause and it is the morphosyntactic marking (case, prepositions, syntactic function etc.) that serves to identify which constituent has which semantic role.

This semantico-syntactic information, also known as *argument linking*, is assumed to be stored in a verb's lexical entry. In generative syntax, the notion *subcategorisation frame* has been introduced for this central part of lexical entries of verbs by Chomsky (1965) – initially the term "subcategory" meant that the category of verbs is divided into subcategories (like intransitive, transitive and ditransitive verbs, a.o.) by their differing subcategorisation frames. Verbs of different subcategory project verb phrases of different shape.

It is a standard assumption that subcategorisation frames are uniform for the same verb. That is, in every use of a verb, you will find the same set of syntactic dependents with the same argument linking. Consider, for illustration, the example of the German verb *besuchen* ('to visit'):

(1) *Hans besuchte Maria*
H.-NOM visited M.-ACC
"Hans visited Maria"

A (partial) lexical entry for "besuchen" ('to visit') might look like this:

(2)

Argument structure	*Syntax* (in active voice)
Agent (= "visitor")	Agent → *nominative*
Patient (= "visitee")	Patient → *accusative*

The left hand side of the table in (2) displays the predicate argument struc-

ture of the verb (PAS), whereas the right hand side shows subcategorisation information, i.e. the case morphology that is associated with each argument. Additional information will for instance be concerned with syntactic optionality or obligatoriness of arguments.

Let us first turn to the PAS. Semantic role labels like *Agent, Patient, Theme, Goal, Instrument etc.* are *lexeme-independent* concepts. They are usually described in an informal and rather vague way. It is in fact quite difficult to make substantive claims about the semantic intuitions behind these notions.

Dowty (1989, 1991) gave a set theoretic reconstruction of semantic (or 'thematic') roles.[1] It proceeds in two steps. First, the notion of *individual thematic role* is introduced to categorise the semantic roles of individual predicates.

(3) Individual thematic roles
Given an n-place predicate δ and a particular argument x_i, the *individual thematic role* $\langle \delta, i \rangle$ is the set of all properties α such that the entailment

$\Box[\delta(x_1, \ldots, x_i, \ldots, x_n) \rightarrow \alpha(x_i)]$

holds.
(Dowty, 1989, 76)

Individual roles may share certain properties. Such a set of shared defining properties of individual roles typically determines the role labels that are often used, termed as *thematic role types* by Dowty.

(4) Thematic Role Type
Given a set T of pairs $\langle \delta, i_\delta \rangle$ where δ is an n-place predicate and i_δ the index of one of its arguments (possibly a different i for each verb), a *thematic role type* τ is the intersection of all the individual thematic roles determined by τ.
(Dowty, 1989, 77)

As (4) already indicates, thematic role types are determined by a cluster of (perhaps prototypical, cf. Dowty 1991) properties, as in the following example:

(5) Proto-Patient properties (Dowty, 1991, 572):
a. undergoes a change of state
b. incremental theme
c. causally affected by another participant
d. stationary relative to movement of another participant
e. does not exist independently of the event named by the verb

The standard picture of verb phrase and clause structure that emerges from such conceptions is one where verbs constantly occur with the same dependents bearing the same semantic roles. But the truth is that verbs are quite heterogeneous in this respect. Some verbs indeed require a single subcategorisation

[1] The notions "semantic role" and "thematic role" are used interchangably in this paper. I prefer, nevertheless, "semantic role", as it is the historically more innocent notion.

frame to be fulfilled systematically. But there are also many verbs which are extremely flexible. This holds not only of the syntactic side, but also of the semantic side, i.e. the same set of semantic roles may be linked in different ways with the same verb with the same subcategorisation frame. This is the case that we will focus on first.

Consider the following set of examples with the German verb *schlagen* ("hit"):

(6) Variable semantic role assignment by the German verb *schlagen* within the same construction

a. *Sie hat den Nagel in die Wand geschlagen*
she has the nail into the wall hit
"She hit the nail into the wall."

b. *Sie hat ein Loch in die Wand geschlagen*
she has a hole into the wall hit
"She hit a hole into the wall."

c. *Sie hat den Hammer in die Wand geschlagen*
she has the hammer into the wall hit
"She hit the hammer into the wall."

d. *Der Hammer hat den Nagel in die Wand geschlagen*
the hammer has the nail into the wall hit
"The hammer hit the nail into the wall."

e. *Der Hammer hat ein Loch in die Wand geschlagen*
the hammer has a hole into the wall hit
"The hammer hit a hole into the wall."

f. *Sie hat den Nagel mit dem Hammer in die Wand geschlagen*
she has the nail with the hammer into the wall hit
"She hit the nail into the wall with the hammer."

g. *Sie hat mit dem Hammer ein Loch in die Wand geschlagen*
she has with the hammer a hole into the wall hit
"She hit a hole into the wall with the hammer."

To understand the problems associated with this sample, we first need to clarify the individual roles of the verb. (7) gives an illustration of the kind of action described by *schlagen* ("beat/hit/strike"):

(7) Illustration of the meaning of *schlagen*:

stage 1: before contact **stage 2: contact**

A moving entity M moves towards and finally hits against a target T in an event of the *schlagen* type.

Stage 2 can be identified with the event itself whereas stage 1 describes a

preceding event that is presupposed for an hitting event. Lexical meaning in general is divided into those components that actually express what the predicate denotes and other components that express *lexical entailments* (sometimes also termed as presuppositions, implications or restrictions). In the following schematic discourse representation structure (DRS, Kamp and Reyle 1993), this is denoted with a tripartition. The top level lists the schematic discourse referents, the medium level expresses the core meaning of the verb, and the bottom section contains the lexical entailments.

(8) DRS structure for *schlagen*:

schlagen'(e) →

e e′ x y
e: contact(x,y)
e′ < **e** **e′**: move_towards(x,y) movable(x) solid(y)

In the terms of Dowty (1989, 1991), we can identify the two individual roles M and T and, according to their properties, classify them as belonging to the universal roles theme and goal, respectively.

(9) The semantic roles of *schlagen*:

Ind. Role	Univ. Role
M	THEME
T	GOAL

The sentences in (6-a)-(6-e) all have the same syntactic structure, a verb together with a subject in the nominative, an accusative object and a directional PP. (6-f) and (6-g) have an additional instrument PP.

Subcategorisation frames as in (2) are supposed to determine the linking of semantic roles for every usage of the respective verb. Therefore, the variable linking pattterns we observe in (6) are very problematic in traditional accounts.

(10) Variable linking patterns for the individual roles of *schlagen* in (6):
(6-a): M=∅; T=OBJ
(6-b): M=∅; T=PP-DIR
(6-c): M=OBJ; T=PP-DIR
(6-d): M=SUBJ; T=OBJ
(6-e): M=SUBJ; T=PP-DIR
(6-f): M=PP-INSTR; T=OBJ
(6-g): M=PP-INSTR; T=PP-DIR

The following observations can be made when analysing our sample: M can be omitted, but not T. M can be implicit, subject, object or an (instrumental)

oblique. T is either object or a (directional) oblique. Thus, it is also not true that every conceivable linking pattern is possible. The following two restrictions seem to hold for this use of *schlagen*:

i. T *must* be realised, but *not* as subject (unless in the passive, of course).

ii. If both M and T are NPs, then M must be subject.
(a consequence of i.)

The variability of *schlagen* is not restricted to ditransitive structures. The verb can also be used transitively and intransitively, again with interesting restrictions and implications. A transitive use of the verb with two animates denotes hitting or defeating:

(11) a. *Mike schlug seinen Hund*
Mike hit his dog
b. *Bayern München schlug Borussia Dortmund*
B. M. hit B. D.
"Bayern München defeated (beat) Borussia Dortmund."

It is also possible to differentiate intended and accidental hitting by using accusative or dative case for the object. Using accusative in (12) implies intentional hitting, whereas using dative is rather neutral.

(12) a. *Er schlug mich auf den Kopf.*
He hit me-ACC on the head (intentionally).
b. *Er schlug mir auf den Kopf.*
He hit me-DAT on the head (perhaps accidentally).

An intransitive use is possible for sound emission scenarios:

(13) a. *Die Uhr schlägt.*
The clock strikes.
b. *Die Glocken schlagen.*
The bells ring/strike.
c. **Der Besen schlägt.*
The broom hits.
d. *Der Besen schlägt nieder.*
The broom hits down.

One way of understanding (13-a,b) lies in assuming lexical polysemy, i.e. defining a lexical entry for this particular meaning. Nevertheless, not every object that emits sound can be used with *schlagen*. It seems that this use is restricted to cases where some hitting is still involved as with drums or bells (where a clapper hits against the bell), and where therefore M and T still can be identified.[2]

[2]One case of perhaps metaphorical extension is the heartbeat (German *Herzschlag*).

The contrast in (13-c,d) can be explained, if we assume that T may be omitted, but only if it is inferrable. Thus, while this is impossible for (13-c), in (13-d) T can be identified with the ground, due to the particle *nieder* ('down').

To account for this flexibility by simply encoding the empirical findings into multiple lexical entries would on the one hand lead one to overlook generalisations about the constructions the verb occurs with. It would also ignore the explanations in terms of general reasoning that we just gave for (13-a,b) and the contrast in (13-c,d). It would, in particular, be necessary to give precise descriptions for the semantic conditions under which intransitive use is possible, including semantic properties of the nouns featuring as arguments. Such descriptions can easily reach a level of detail that we do not expect from a generally applicable lexical entry.

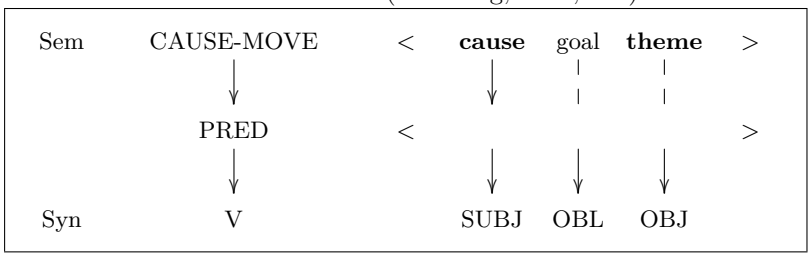
2 Construction Grammar: Argument Fusion

Construction grammar should in principle be able to provide the tools to account for the problem of variable linking that we described in the preceding section. *Argument structure constructions*, as analysed in the work of Goldberg (1995, 2006) and others, have been introduced to model the variation that we find with such flexible verbs.

Let us then assume that the verb's contribution to the syntax and semantics of each of these sentences is the same in each of these cases (with the exception of the meaning of defeating in (11-b) that may count as a metaphorical extension). Then a construction grammar style account of the data rests on the assumption that the different syntactic structures result from the verb being used with different argument structure constructions.

The English counterpart of the construction that we find in (6) is analysed as *caused-motion construction* by Goldberg (1995) and illustrated with the schema in (14).

(14) The *caused-motion construction* (Goldberg, 1995, 160):



The top row in this schema lists the semantic roles that the construction introduces: that of the predicate ('cause-move') and its three arguments ('cause', 'goal', 'theme'). Technically speaking, the construction has four roles to assign, or slots to fill, that of the predicate and those of three semantic roles. The construction already determines the syntactic realisation of the four roles, as we see in the bottom row in (14). The middle row is left for the verb and the

semantic roles it provides. Thus, it is fixed that the verb is linked to the predicate role 'cause-move', but it is open how the verb's arguments are inserted into the slots. The dashed vertical lines under the goal and theme role signal that a role may be provided by the construction, whereas an arrow signals the requirement to fuse this construction role with an argument of the verb.

For the German caused-motion construction, it is obvious that each of the three semantic roles can be provided by the construction, as the following examples show.

(15)

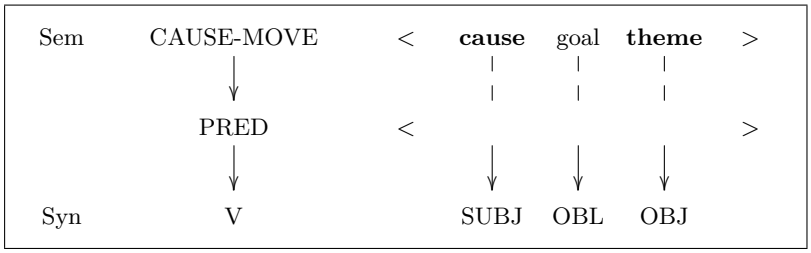
	Peter	*pustete*	*den*	*Staub*	*von*	*der*	*Kiste*
	Peter	blew	the	dust	off	the	box
constr. role:	cause	PRED	theme		goal		
verb role:	blower		—		—		

(16)

	Peter	*schlug*	*den*	*Hammer*	*in*	*die*	*Wand*
	Peter	hit	the	hammer	into	the	wall
constr. role:	cause	PRED	theme		goal		
verb role:			M		T		

In (15), only the subject is linked to a semantic role of the verb, whereas in (16), it is not. Therefore, the schema for the German caused-motion construction should be represented, following this format, as in (17).

(17) The German *caused-motion construction*:



The issue of whether this might also be a better choice for English will be left open here. Compared to the standard picture of the verb being the only determining factor, the picture drawn by construction grammar leads to complications, two of which I will focus on in this paper:

(a) How are verb and construction meaning integrated? — The introduction of argument structure constructions makes the theory of the syntax-semantics interface more complicated, compared to the traditional view using only subcategorisation frames.

(b) How are additional syntactic ambiguities resolved? — One and the same syntactic pattern may result from using a verb's subcategorisation frame, or from using different constructions or combinations of constructions.

We will discuss the first question immediately and postpone the second question to section 4. Goldberg claims that the semantic roles of verb and

construction within a sentence have to be fused according to some compatibility measure:

(18) Principles of *argument fusion* (Goldberg, 1995, 50)

a. The Semantic Coherence Principle: Only roles which are semantically compatible can be fused.

b. The Correspondence Principle: Each participant role that is lexically profiled and expressed must be fused with a profiled argument role of the construction.

Principle (18-b) is basically about the linking of roles to SUBJ and OBJ. If a participant role (i.e., a semantic role contributed by the verb) is profiled (i.e. required to be realised as subject or object), then it must be realised as a profiled role of the construction (i.e., as subject or object). The concept of profiled roles goes back to earlier work by, e.g. Fillmore (1977) and Langacker (1987). Its most important assumption is that the core grammatical functions have a particular semantic or pragmatic function associated with them: "[...] direct grammatical functions [i.e., in English subject, direct and indirect object, R.V.] serve to distinguish certain arguments semantically and/or pragmatically; that is, direct grammatical functions profile particular roles as being either semantically salient or as having some kind of discourse prominence, for instance, being particularly topical or focused [...]." (Goldberg, 1995, 49)

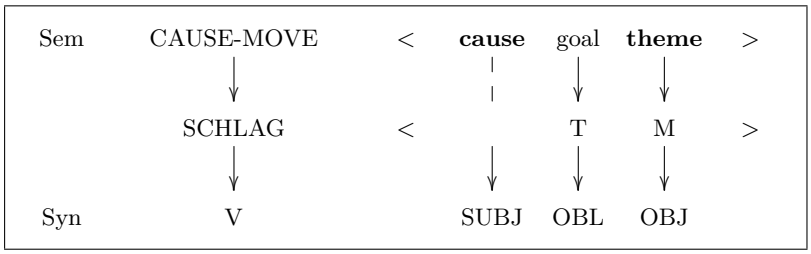
When a verb has a profiled role, this role has to be linked to one of the core grammatical functions. This is also the main heuristic criterion for detecting the profiling status of an argument. Another criterion is obligatoriness – a role that can be omitted may not be profiled.

The correspondence principle and the coherence principle together serve to explain partial productivity of argument structure constructions: a verb that profiles a goal argument as direct object cannot be used in the caused-motion construction because the roles associated with the direct object by construction and verb are incompatible.

In our case of *schlagen*, it seems that neither of the two roles can be seen as profiled. Both can be omitted or be realised by an oblique form. If we assume that this is indeed the case, then this also explains the flexibility of this verb. As Goldberg states it, fusion of compatible roles is an option, but not a necessity. But this does not answer the question how each of the examples in (6) arrives at its particular argument linking. Obviously, argument linking is underspecified by the lexical entries of verb and construction.

The theory of argument linking (and the syntax-semantics interface in general) is therefore incomplete, as long as variations like those in (6) have not been accounted for. We will see that this is a case well suited for an optimisation approach. For a first approximation, let us start with a scenario where verb and construction roles are completely fused:

(19) Complete argument fusion of the verb *schlagen* with the *caused-motion construction*:



This is the correct pattern for (6-c) only. In order to derive the other patterns in (6) it is necessary to assume fusion as an option, i.e. as a constraint that may be violated in order to fulfil more important demands. (19) describes only the default option. To sum up this section, I will make the following assumptions:

- Argument fusion, as defined by Goldberg, is a violable constraint, i.e. it describes a default and may be fulfilled in many cases, but need not obligatorily be fulfilled.
- Because of this, there actually is a wider range of options for the integration of verb and construction meaning.
- These patterns then all compete as *candidate interpretations* in an optimality theoretic competition.
- The interpretations of the clauses in (6) then are the optimal candidates of this OT competition.

3 Analysis

The label of the central predicate of the caused motion construction, "CAUSE-MOVE", already suggests that such events have two subevents, a causing subevent and a motion subevent, of which holds that the former causally effects the latter. A further subevent, describing the result, is often, though not always, included. For German, it might even be the case that the resultative interpretation is obligatory. Consider the following examples:

(20) a. ?*Sie schlug ihre Hand gegen die Wand*
she hit her hand against the wall
b. *Sie schlug mit ihrer Hand gegen die Wand*
she hit with her hand against the wall
c. *Sie schlug gegen die Wand*
she hit against the wall

(20-a) is slightly odd and might rarely be used for the reason that it seems to imply that the result (the hand touching the wall) requires hitting. This is quite unnatural – if you want your hand to touch the wall you need not hit it against it. (20-b) has no such result implication and sounds much more

natural. It may have an iterative interpretation, i.e. describe a succession of hittings. The same seems to be true of (20-c) which can be seen as synonymous to (20-b). Thus, while (20-b,c) are only caused-motion constructions, (20-a) is a resultative caused-motion construction.

So let us assume, for the German caused-motion construction, that we in fact are dealing with three subevents: the motion, the cause of the motion and the result of the motion.

For the integration of verb and construction meaning, there is an obvious choice then, namely, whether the verb describes the causing or the motion subevent. It may not describe the result. In our sample in (6), we find both options realised. The verb denotes the motion subevent in (6-c), whereas in all other cases in (6) it is the causing subevent.

The schema for the caused-motion construction proposes (6-c) to be the rule. But motions can cause other things, of course, including other motions, so this observation is not really unexpected from a conceptual point of view. In (6-c), the subject refers to the force that causes the hitting of the hammer into the wall. Her action of holding and moving the hammer is the causing subevent. In all other cases, the resulting motions and states (mainly that something is located in the wall) are the subevents that are caused by the hitting.

Assume that (6-c) in fact represents the best and simplest way to combine the caused-motion construction with *schlagen*. Why is it inapplicable in some examples? The answer is that this would lead to implausible semantic representations, following general reasoning that can be sketched for these cases as follows:

- A *nail* is a bad candidate for M, because we cannot hit it into walls directly, by holding it in our hands, or between our fingers, unless we are dealing with a very soft wall, and even in that case we would not *hit* it, but rather press, push or pin it.
- A hole cannot move and it has no mass, so it cannot be M by definition.
- A hammer, as in (6-c) is a perfect candidate for M, so there is no need to assume that there is an *implicit argument*, another maybe even bigger hammer, that is used for hitting the smaller syntactically realised hammer into the wall.

To start our OT reconstruction of this problem, let us assume a constraint on such general world knowledge plausibility:

(21) *Plausibility*: An interpretation is a bad candidate, if it contradicts general world knowledge.

If we understand world knowledge as encyclopedic knowledge, in particular, excluding the actual context of utterance, then a second constraint on contextual fit is necessary:

(22) *Context*: An interpretation is a bad candidate, if it does not fit the actual context of utterance.

I further assume the following definition of the violable constraint on argument fusion:

(23) *Fusion*: When constructing an event representation, fuse every lexical role with a compatible construction role, if there is one.

Not fusing individual roles of a verb leads to implicit arguments, i.e. arguments that are understood but not realised. In terms of classical OT, thus, implicit arguments violate a constraint of the DEP family of faithfulness constraints: a semantic element (in an output candidate) has no syntactic correspondent (in the input). Faithfulness, thus, can be understood as enforcing argument fusion and representational economy in semantics. We will nevertheless use the more specific Fusion constraint here. Section 5 will provide more arguments in favor of the formulation in (23).

The constraints are ranked. Whereas it is clear that Fusion is ranked lower than the others, we can leave open whether Context and Plausibility need to be ranked against each other. The ranking must be the following:

(24) Context Plausibility $\gg$ Fusion

The role of Fusion can be exemplified by the following minimal pair:

(25) a. The balls are rolling away!
b. The books are rolling away!

(25-b) can only have the interpretation that the books are located on some rollable vehicle, like a cart. This is enforced by the fact that books are not rollable by themselves. However, such an interpretation is usually blocked for examples like (25-a). As balls can roll by themselves, there is no need to assume a more complicated scenario where e.g. the balls are located on a cart. Thus, Fusion blocks the assumption of a cart for (25-a), whereas plausibility enforces such an additional discourse referent for (25-b).

Let us have a look at the cases in (6) now. We start with (6-a), here repeated as (26).

(26) *Sie schlug den Nagel in die Wand*
She hit the nail into the wall

At least each of the linking patterns in (6) is a possible candidate.

(27)

She hit the nail into the wall	Plausibility	Fusion
☞a. M = ∅ (e.g. hammer) ; T = `Obj`		*
b. M = `Obj` ; T = `dir. PP`	*!	
c. M = ∅ (e.g. her hand); T = `dir. PP`	*!	*
d. M = `Subj` ; T = `Obj`	*!	
e. M = `Subj` ; T = `dir. PP`	*!	
f. M = ∅ ; T = ∅	*!	**

The tableau in (27) still looks not very exciting. The competitors of the winning linking pattern are all ruled out by Plausibility. Let us have a closer look at them. Candidate (b) is an implausible situation with a prototypical small nail: moving a small nail by hand against a wall is usually not conceived as a hitting. M must obviously have a certain impact on T in a hitting event (this should add to the lexical entailments of the verb). The picture would change in an event with a non-prototypical very huge and solid nail. In such a case, Plausibility would not be violated by candidate (b) and it would even be preferred over (a). Candidate (c) is a scenario where she hits her hand against the wall thereby causing somewhat mysteriously that the nail ends up in the wall. This linking pattern fails to establish a plausible causal connection between the hitting and the nail's motion into the wall. It is hard to imagine a context that could make this candidate plausible. Candidates (d) and (e) are scenarios where she uses her own body instead of a hammer. Again, such a use of the body is obviously implausible and it is hard to imagine a realistic scenario for these candidates. Candidate (f) leaves both M and T implicit: she hits something against something else, both are distinct from the nail and the wall, and this somewhat mysteriously causes the nail's motion into the wall. Again, this is an implausible scenario. It also leaves in the dark the actual reference of M and T.

It seems, hence, that only candidates (a) and (b) are plausible at least in some contexts. The tableau in (27) in fact must be understood as valid only for its own specific context: presentation of the single sentence out of the blue without any additional information. We use prototypical interpretations not only for the verb but also for nouns like *nail*. Nonprototypical interpretation of this noun will change the linking pattern.

The general problem this discussion hints at is that there might in fact be no general case of argument linking. Linking patterns change with contextual and other specifications. Therefore, the classical picture of argument linking, where for each verb a general pattern of role-to-case linking is defined, is radically called into question. In the picture that emerges from the discussion above, there are only particular cases with variable linking patterns that depend not only on the verbs but also on other elements that appear in the clause, as well as contextual cues and encyclopedic knowledge. The general case of argument linking is better described by the mechanism of optimisation that I have sketched up to here and will be further developed below.

A case where candidate (b) is the straightforward winner is (6-c) with the hammer as accusative object.

(28)

She hit the hammer into the wall	Plausibility	Fusion
a. M = ∅ (e.g. hammer) ; T = `Obj`		∗!
☞b. M = `Obj` ; T = `dir. PP`		

Candidate (a) where the hammer is being hit into the wall with another hammer is a somewhat unusal but conceivable scenario, so it might not violate Plausibility, but still, this candidate loses because of its extra implicit argument.

Things change when we look at (6-b) where "a hole" is the accusative object.

(29)

She hit a hole into the wall	Plausibility	Fusion
a. M = ∅ (e.g. hammer) ; T = `Obj`	∗!	∗
b. M = `Obj` ; T = `dir. PP`	∗!	
☞c. M = ∅ (e.g. hammer); T = `dir. PP`		∗
d. M = `Subj` ; T = `Obj`	∗!	
e. M = `Subj` ; T = `dir. PP`	∗!	
f. M = ∅ ; T = ∅	∗!	∗∗

4 Syntactic ambiguity

There might be a third option for the *fusion* of construction meaning and lexical meaning, *no fusion*. A possible instance is exemplified by (30):

(30) *Maria schlug den Bettler ins Gesicht*
M. hit the beggar-ACC in the face

As the beggar does not undergo motion into his own face in the event described here, it is obvious that this is not a caused-motion construction at all, although we have its constituent structure. The individual role T is realised by the directional PP and M is unrealised, presumably Maria's hand.

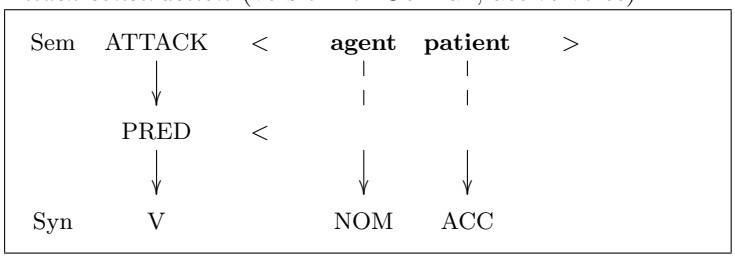
What goes on here is that the verb is combined with a different construction, but that the result of this combination yields the same syntactic constituent structure as its combination with the caused-motion construction.

Let us call this other construction the *attack construction*, exemplified by clauses as in (31):

(31) Mary hit/kicked/pushed/... John

Let us assume a schematic representation of this construction in a Goldberg style notation as in (32):

(32) *Attack construction* (version for German, active voice):



What is missing here, from (30), is the directional PP. It is presumably a construction of its own here (see below). The integration of verb and construction is now quite surprising. The verb *schlagen* describes the mode of the attack, but neither the subject nor the accusative object seem to realise one of the roles of the verb. M is unrealised, and T is the PP.

A more attractive alternative, though, that I assume here is that T has been linked twice, both to the accusative object and to the PP. One motivation for this move is a restriction that clearly seems to hold in this construction, namely, that the directional PP has to realise a body part of the accusative object. It might even be possible to recursively add arguments as in "He hit me on my head, on my face, on my nose" , where still only one single hit is described and each added directional PP is more precise about T (my nose is part of my face which is part of my head which is part of me). As already stated, such directional PPs have to be analysed as constructions in their own right. Without going into detail here, I will use the term *body part PP* for this construction.

The case we discuss here is well suited to explore the OT model that is needed a bit further. Obviously, we need to distinguish between two levels of syntactic analysis. One is the level that we may call constituent structure, where the clause is analysed into the set of phrases and words it contains. At this level, the construction combination 'attack construction + body part PP' is indistinguishable from the (resultative) caused-motion construction.

The optimisation of argument linking is part of semantic optimisation (Blutner et al., 2006, see, e.g.). With respect to the lexical material that we find in a clause there rarely occur ambiguities, because the lexical items are simply the words it contains and these can directly be read off of the phonetic/phonological form of the clause. I.e., while there might be ambiguity about syntactic structure, in the standard picture of syntactic parsing, there is no doubt about the words that we find in a sentence.

When we use constructionist approaches, this changes. The basic units of structure building are no longer identical to words and morphemes, but might be any kind of more or less complex chunks of linguistic material.

Constructions therefore may only indirectly be read off from the surface of the clause and there might therefore be various structurally different *lexical* analyses for a clause that are all equally faithful to the observed surface form. Candidate structures in the analysis proposed here therefore vary in the lex-

ical material (constructions) they contain, their syntactic and their semantic representations.

Thus, the candidate set for the argument linking in (30) has candidates using the caused-motion construction as well as the combination of attack construction and body part PP, as well as further syntactic analyses.

5 Fusion or representational economy?

In our introduction of the Fusion constraint in section 3, we discussed whether fusion should be seen as a constraint on representational economy, i.e. a constraint of the Dep family that penalises implicit arguments. The preliminary formulation that we used treated it as a markedness constraint that penalises implicit arguments not in general, but under the condition that a possible fusion of roles has not taken place:

(33) *Fusion*: When constructing an event representation, fuse every lexical role with a compatible construction role, if there is one. (repeated from (23))

In this subsection, we will discuss a case that helps to decide whether (33) is the best formulation, or whether it should be phrased as a faithfulnes constraint.

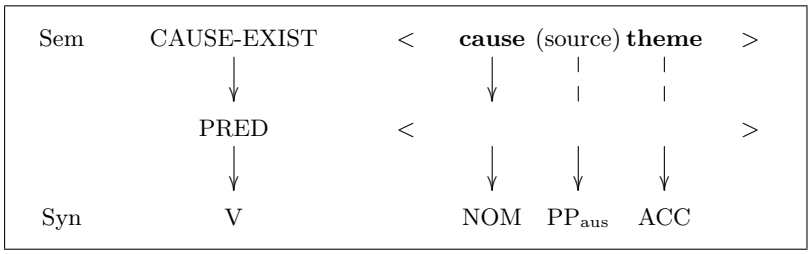
German, like English, has a family of constructions that can be called *creation constructiuons*. These are transitive constructions with or without an additional PP that express the action of creating something. The verbs used with this construction need not necessarily intrinsically mean creation. An example is the German verb *falten* ('to fold') that denotes an activity where some entity is manipulated, but this need not lead to the creation of a new entity – or the transformation into a new entity.

(34) *Maria faltet einen Flieger*
M.-NOM is folding a (paper) plane-ACC

We observe the syntax of a simple transitive clause here, a subject in the nominative, the finite verb and an accusative object. But there arises, in principle, an ambiguity that depends on whether the clause is interpreted as denoting creation or not. In the creation meaning, something, for instance a sheet of paper, is folded such that it takes on the shape of a plane, i.e. a paper plane is being created.

I assume the following schema for the creation construction:

(35) The *creation construction* (active voice):



The source argument is optional. It can be realised with a PP using the preposition *aus* ('from, out of').

In the implausible non-creation reading, there is a pre-existing plane – a real plane – that is being folded, i.e. is being collapsed by folding. We are also dealing with an ambiguity on the side of the noun *Flieger* here, it may denote a paper plane or a real plane.

For a pre-existing paper plane, the folding interpretation is plausible, but still the creation interpretation is preferred. This might have to do with what Pustejovsky (1995) called the *qualia structure*. Following Aristotelian ideas on categories, Pustejovsky proposed that part of lexical entries is the qualia structure where four "essentail aspects of a word's meaning" (Pustejovsky, 1995, 76) are specified: the constitutive aspects (relation between an object and its parts), the formal aspects (that which distinguishes it within a larger domain), the telic aspects (its purpose and function), as well as the agentive aspects (factors involved in its origin or bringing about) (ibid.).

For the noun "paper plane", it is thus specified in its lexical entry that folding is the activity for bringing it about (agentive aspect). Let us assume an OT constraint that rewards an interpretation that is motivated by the qualia structure of involved lexical items.

(36) *Qualia:* a candidate fulfils this constraint if it describes an aspect of the qualia structure of a lexical item that occurs in the input.

In our example, the creation reading is preferred over the simple folding reading, because, folding is a typical activity for creating a paper plane, while simple folding is just some action that is possible a pre-existing paper plane. Qualia should be ranked lower than Plausibility and Context.

(37)

	input = (34)	Plaus.	Qualia	Fusion
☞	a. creation (paper plane)			
	b. simple folding (paper plane)		*!	
	c. simple folding (real plane)	*!		

Determining the relative rank of Qualia and Fusion is difficult, because the evaluation of readings and ambiguities of decontextualised sentences is a very artificial task. In fact, the optimal interpretation of such sentences usually is the reading that it has in a prototypical context which we associate with such

sentences when we try to interpret them.

Let us turn now to our issue of the correct definition of the Fusion constraint. Sentence (38) is ambiguous between a simple folding and a creation reading.

(38) *Maria hat die Schachtel gefaltet*
Maria has the box folded
"Maria folded the box"

Under the defintion of Fusion that we assume thus far, Fusion is not violated by the creation reading, because the roles of the foldee and the createe are incompatible: a foldee must exist before the event, whereas the createe must not exist before the event. However, this also means that in the creation reading, the foldee is an implicit argument, the material being used for the box (e.g., paperboard). Thus, a definition of Fusion in terms of faithfulness would make a difference between the two readings, predicting that the simple folding interpretation is optimal (unless some other constraint intervenes).

It is, it seems, a general feature of verb + construction combinations that not all of the verb's arguments are being fused with a construction role and some may remain unrealised. Such interpretations will then regularly compete with simple interpretations where only the case frame of the verb itself is used and all argument slots are filled. Under the assumption that ambiguous cases like (38) regularly occur under such circumstances, I assume that our definition of Fusion as a markedness constraint as in (23) is the better choice.

6 Constructionist OT?

The discussion in this paper raises the question whether Construction Grammar in general is a suitable format for doing OT syntax and semantics.

A crucial difference of such a CxGOT to standard OT syntax lies in the role that is being played by the lexicon and the generator. Whereas most approaches in OT syntax (things are less clear to me in LFG-OT) thus far assume a universal generator function, for a CxG based model this would not make much sense, or, to put it differently, the universal part of Gen would have dramatically less impact than in other models.

Why is this so? OT syntax models based on the minimalist program, the priniciples and parameters framework or government and binding theory attribute universality to syntactic categories, morphosyntactic features and general phrase structure schemata such as X-bar theory. Thus, a substantial part of what is used by the syntactic generator will be invariant between languages.

In CxG, even the constructions within a language may obey contradictory rules. It is the constructions only that determine the range of options in the syntax of the language, and which therefore also determine the candidate set. Thus, there is no way to predict systematic similarities between the candidate sets of two languages.

Odd as this may seem in the first place, it is important to recall that this is the price paid for a conceptual simplification: the Construction notion conflates

morphological and syntactic entities. In morphology, it is much less clear than it is assumed for syntax, whether the generator is doing the same universally. Morphological systems, both inflectional and derivational, can differ in so many ways that an approach, where anything that is possible in one language is a candidate for all languages (leading to a universally uniform candidate set at an abstract level), would look quite artificial.

Therefore, a generator that only generates what the lexicon of the language is able to provide is a reasonable option when dealing with morphology. Consider the following example case. Two languages R and Q differ in that R expresses nominal plural by reduplication whereas Q does so by some other means. The analysis shows that the constraint ranking A $\gg$ B $\gg$ C is sufficient to account for R and it further turns out that the same ranking yields the correct results in Q under the assumption that the reduplication candidate is missing from Q's candidate set. There is no reason to treat such an account as inferior to one where Q does have a reduplication candidate that is banned by a highly ranked *REDUP constraint (which is low ranked in R). The analyses differ, however, in that the first analysis treats the difference as lexical idiosyncrasy whereas the latter one treats it as systematic consequence of constraint ranking. But the stipulation in fact would just be shifted from the lexicon (first scenario) to Eval (second scenario). There might, however, be a diachronic explanation available for the absence of reduplication from Q. In this case, the account using *REDUP would simply be misleading.

The division of labour between Gen and Eval in CxGOT would be one where primarily Eval is responsible for universals and typological generalisations. For OT, this is not a bad result, as constraint interaction is the primary locus of explanation in OT.

Now, let us look a bit more closely on what CxGOT would look like. As we also did in this paper, we have to distinguish two directions of optimisation, one where we go from meaning to form – *form optimisation* –, and one where we go from a phonetic input to an underlying syntactic and semantic parse – meaning optimisation.

I will phrase the following sketch of constructionist OT syntax within a correspondence theoretic approach (McCarthy and Prince, 1995; Vogel, 2004a): three radically distinct levels of representation have to be distinguished, a semantic one, a morphosyntactic one and a phonetic one. Construction grammar provides a theory for morphosyntax on the one hand, and for the lexicon on the other hand. Every lexical item, i.e. every Construction, contains semantic, phonetic and morphosyntactic information (though some of these components may be empty). These enter the three distinct representations, while indices indicate corresponding elements of these representations. OT in such an approach is first of all a theory of the interfaces between morphosyntax and semantics and morphosyntax and PF.

An input to a syntactic derivation not only contains the meaning that is to be expressed but also the set of lexical items to be used. Therefore, the input in form optimisation consists of a semantic representation and a set of constructions. Output candidates are faithful or unfaithful complex constructions

derived by combining primitive constructions.

In meaning optimisation, the input is a phonetic form (PF), and the output candidates are again complex constructions.

A correspondence theoretic OT syntax model has to distinguish *three generators*: for morphosyntax, semantics, PF. *Constructions* like lexical items establish arbitrary correspondences between forms (syntax, PF) and meanings. Constructions are part of the input in form optimisation – as is assumed for lexical items in standard OT syntax –, hence they are subject to faithfulness constraints in an evaluation. Eval may account for the *non-arbitrary* correspondences between syntax, semantics and PF. For instance, OT should account for the range of options for argument fusion.

How could this work in detail? Constructions are smaller or larger pieces of structure that may or may not be specified (partially or fully) at different levels of representations (phonetically, semantically etc.). We will represent them as ordered triples.

primitive Constructions $cx_i = \langle m_i, s_i, p_i \rangle$, where any of m_i, s_i, p_i may be empty. ('m' for meaning, 's' for morphosyntactic structure, 'p' for PF)

Everything, from morphemes via syntactic patterns to meaningful intonational contours is a Construction. In sentences, several Constructions are concatenated with each other to yield complex Constructions. We will use capital letters to distinguish complex Constructions from primitive Constructions, and their complex semantic, syntactic and phonetic representations from those of primitive constructions.

complex Constructions $CX_i = \langle M_i, S_i, P_i \rangle$

Every candidate is such a complex Construction. The input of form optimisation is an ordered pair that contains a semantic specification M_{input} and a numeration, a set of (unconcatenated) primitive constructions CxS_{input}. The input of meaning optimisation is a PF, P_{input}.

Input (form optimisation) $= \langle M_{input}, CxS_{input} \rangle$

CxS$_{input}$ $= \{cx_1, \ldots, cx_n\}$

Input (meaning optimisation) $= P_{input}$

The generator generates complex constructions out of the constructions in CxS_{input}. Additionally, constructions not included in CxS_{input} may be added, or constructions from CxS_{input} may be left out in generating a candidate, thereby yielding faithfulness violations. As we already discussed in the case of argument linking, there may not be only one way to derive a semantic representation from a given set of constructions. The same surely holds of the PF component, so Gen generates a whole set of candidates from a given set of primitive constructions.

Constructions are concatenated by Gen to yield complex constructions. Let us assume a concatenation operation $\oplus$ for each of the three generator functions.[3]

candidate $\mathrm{CX}_k = cx_1 \oplus cx_2 \oplus \ldots \oplus cx_n$

Generator $GEN = \langle$*M-GEN, S-GEN, P-GEN*$\rangle$

M-Gen *M-Gen*$(\{cx_1, \ldots, cx_n\})$
$= \{M_i | M_i = m_1 \oplus\ m_2 \oplus\ \ldots \oplus\ m_n\}$

S-Gen *S-Gen*$(\{cx_1, \ldots, cx_n\})$
$= \{S_i | S_i = s_1 \oplus\ s_2 \oplus\ \ldots \oplus\ s_n\}$

P-Gen *P-Gen*$(\{cx_1, \ldots, cx_n\})$
$= \{P_i | P_i = p_1 \oplus\ p_2 \oplus\ \ldots \oplus\ p_n\}$

The set of candidates that we get from applying GEN on a particular set of primitive constructions X is the set of triples that we get by combining each element of M-GEN(X) with each element of S-GEN(X) and P-GEN(X).

GEN(X) $GEN(X) =$ *M-GEN*$(X) \times$ *S-GEN*$(X) \times$ *P-GEN*(X)

The infinite set of all derivable expressions of a language, DEL, is derived by applying GEN on any set of Constructions X in the language.

We get the actual candidate set CAND for a given input by selecting from DEL those candidates that match an additional selection criterion.[4] In form optimisation, this criterion is that for any candidate CX_k, M_k is identical to M_{input}, whereas for meaning optimisation, P_k is fixed by the input.

candidate set (form optimisation) For a given Input IN $= \langle M_i, CxS_i\}$, $\mathrm{CAND}_i = \{CX_k | M_k = M_i\rangle$

candidate set (meaning optimisation) For a given Input IN $= P_i$, CAND_i $= \{CX_k | P_k = P_i\}$

Candidates may still vary with respect to the features that interest us like argument fusion, scope, lexical ambiguity resolution a.o. at M, construction set, constituency a.o. at S, linear order, prosodic structure a.o. at P.

Besides markedness constraints on S, M, and P, Eval contains constraints on the correspondences between M, S and P, as well as input and output. For each candidate CX_k, it needs to be fixed which elements of M_k, S_k and P_k correspond to each other, in order to evaluate correspondence constraints (like, e.g., "if m_1 has scope over m_2, then p_1 precedes p_2").[5]

[3] $\oplus$ needs to be defined differently for each generator, of course. We do not go into this here.

[4]

[5] See Vogel (2004a,b, 2006, 2009) for applications of correspondence based OT syntax and Vogel (2013) for a more recent discussion of the syntactic generator and using faithfulness in OT syntax.

7 Conclusion

The discussion in this paper focused on a core problem in the syntax-semantics interface, argument linking. Nearly all theories in generative grammar, including construction grammar, assume argument linking to be more or less hard wired in the lexical entries of lexemes, in particular verbs and Constructions. Our discussion of variable argument linking showed to the contrary that syntax in fact underspecifies semantics and that there is a gap to be filled in order to account for particular linking patterns.

We saw, as a result of this underdetermination, that the integration of verb and construction can still vary in many respects. Optimality theory offers the tools to model the interplay of violable semantic constraints like Fusion and world knowledge and other factors that we observed in our analysis of the phenomena discussed in this paper.

Our results are, thus, (i) that the indirect and non-deterministic character of argument linking invites an optimality theoretic view of the syntax-semantics interface, (ii) that constructions and lexical entries underspecify argument linking, rendering "classical" accounts incomplete, and (iii) that construction grammar is a reasonable format for OT syntax.

Construction grammar adds to OT syntax a theory of the lexicon. It changes the picture to the extent that morphosyntactic representations are largely language particular. This leads to a proposal about universal grammar that is specific for CxG-OT: with respect to syntax, it is mainly the *interfaces* – syntax-semantics,syntax-phonology – which have universal properties. This can be expressed in the model by interface-related correspondence constraints within Eval, whereas the Gen component of the OT model has little, if any explanatory value. This reasonable, though perhaps unorthodox hypothesis is worth further exploration.

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