Sub-compositionality

ABSTRACT. It is commonly held in most accounts of sentence semantics that semantic composition is homomorphous to syntactic composition. Consequently, rules of semantic composition are defined in terms of syntactic categories of expressions. The paper argues that this assumption is not a necessary consequence of the Principle of Compositionality, and in fact in need of revision. There appear to be types of syntactic constructions where semantic sub-rules of composition apply to mere semantic sub-types of the construction. Such constructions are called sub-compositional. Accounts in the tradition of Montague's were able to avoid sub-compositionality, and thereby adhere to homomorphy, only at the expense of 'generalizing to the worst case'. It is argued that this method is not in accordance with the aims of an appropriate theory of composition. Rather such a theory should properly acknowledge differences in compositional properties among semantic types of expressions. Using the example of German verb gradation with *sehr* 'very', it is argued that the compositional analysis of certain sub-compositional constructions may require deep decomposition of lexical meanings. Although the general assumption of homomorphy is therefore no longer rigidly tenable, this does not mean that the Principle of Compositionality is to be abandoned or modified.

1 Rules in compositional semantics

1.1 The Principle of Compositionality

This article will be based on the following version of the Principle of Compositionality (PC):

> **Principle of Compositionality**
>
> The meaning of a complex expression is a function of the lexical meanings of its components and the syntactic structure of the whole.

I will use the term 'construction' for morphosyntactically complex expressions, much as the term is used in Construction Grammar, but to the exclusion of lexical expressions, and without committing to any particular assumptions on grammar and language made in this approach. For the sake of convenience, the formation of morphologically or syntactically complex expressions will just be called 'syntactic composition', while the term 'semantic composition' will refer to the composition of meaning.

1.2 Regularity of composition

PC is usually considered necessary for explaining the apparent ability of human language users to interpret arbitrary regular complex expressions efficiently and uniformly. The explanation tacitly presupposes the assumption that the semantic operations involved in composition follow rules.

> **Regularity of semantic composition**
>
> The meaning of a syntactically regular expression derives from the meanings of its components in a regular way.

What does it mean for semantic composition to be regular? There must be rules that define syntactically regular expressions; and there must be rules that describe the way in which the meanings of regular complex expressions are derived from the meanings of their respective component expressions. The ways of derivation must apply uniformly to different individual cases and they must apply generally. Therefore the rules must apply to types of cases, in this context: types of expressions. Types of expressions subsume different individual cases, and they represent general categories. If a rule applies, for example, for a specified type of construction, the number of concrete instances is in principle open. In this sense, rules of syntactic or semantic composition capture general patterns. This is how PC is implicitly understood: We assume that compositionality rests on the availability of a limited number of patters of syntactic and semantic composition. Thus, the condition of regularity of composition roughly means the following:

(1) For all complex expressions of a given *type*, the *same* semantic operation yields its meaning out of the meanings of their components.[1, 2]

This condition does not entail that different semantic operations apply to different types of cases. Indeed in all actual accounts of composition like those of model-theoretic semantics (MTS) in the tradition of Montague a small number of semantic operations are assumed to apply to a considerably larger set of types of constructions.

1.3 Types of expressions

Any given lexical expression is not just of a certain type, but belongs to hierarchies of types in the sense of Carpenter (1992). The possible types form a semi-lattice ordered by the partial ordering relation of subsumption; some types are sub-types of others, i.e. more specific.[3] The most specific, or minimal, type consists just of an individual lexical expression. The most general type comprises all lexical expressions indiscriminately. Let us consider some types to which the German intransitive verb *bluten* "bleed" belongs (names of non-minimal types are written in small capitals in order to distinguish types from instances of the type):

(2)
type	other expressions of the same type
LEXICAL EXPRESSION	*für* 'for', *bald* 'soon'
PREDICATE TERM	*Ausdruck* 'expression', *geben* 'give'
1-PLACE PREDICATE TERM	*Buch* 'book', *grün* 'green'
1-PLACE VERB	*schlafen* 'sleep', *sitzen* 'sit', *arbeiten* 'work'
GRADABLE 1-PLACE VERB	*schmerzen* 'ache', *lachen* 'laugh'
VERB OF EMISSION	*strahlen* 'radiate', *stauben* 'give off dust'
VERB OF SECRETION	*schwitzen* 'transpire', *fetten* 'give off grease'
bluten	(none)

The types in (2) are ordered decreasingly by subsumption. They include traditional syntactic categories such as 1-PLACE VERB. The more specific types are based on semantic characteristics which are usually not considered significant for syntax.

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[1] An aspect which will be ignored here is the fact that one complex expression may belong to different types and thereby receive different compositional meanings.

[2] The types mentioned here, of course must not be minimal types that consist of just one individual case.

[3] An ordering is partial iff some, but not necessarily all, pairs of cases can be compared with respect to the ordering. For example, of the types 1-PLACE VERB and 2-PLACE VERB neither subsumes the other.

For the unlimited set of lexical or complex expressions of a given language, systems of types can be set up under various aspects. Any such aspect, for example syntactic behaviour, defines a type hierarchy of its own. We will say that two types (out of arbitrary systems) coincide iff they represent the same class of expressions.

1.4   Syntax and semantics

For the question of compositionality two systems of types are relevant. In order to define syntactically regular expressions, a system of morphosyntactic rules is to be assumed. These rules define morphosyntactic types of expressions: t is a morphosyntactic type iff there is a morphosyntactic rule that has t as its (maximum) range of application. For example, VERB in English constitutes a morphosyntactic type since verbs constitute the range of application for the rules of verb inflection. In general, the morphosyntactic types correspond to the constituent categories of the morphosyntactic system of the language.

Analogously, the system of rules of semantic composition gives rise to another type system: t is a semantic type iff there is a semantic composition rule that has t as its (maximum) range of application. For example, 1-PLACE PREDICATE TERM has been considered a candidate semantic type, being the range of application of the rule which combines a predicate with its argument.[4]

In view of these considerations, one fundamental question for any theory of composition is this: Do the respective systems of syntactic types and of semantic types match? Are the same categories relevant for both syntactic and semantic composition? Or are the two systems, at least to some degree, incongruous? Traditional wisdom assumes that the two systems match. All formal work on compositionality is based on this assumption. Some authors even consider it part of the very notion of compositionality. Janssen (1997:426f) goes as far as stating, in a list of assumptions "implicit in it [i.e. the principle of compositionality, S.L.]", "For each syntactic rule there is a semantic rule that describes its effect. In order to obtain this correspondence, the syntactic rules should be designed appropriately. For instance, semantic considerations may influence the design of syntactic rules."

From this point of view, PC has the status of a methodological principle: Try to construct a formal description of natural language with a 'syntax' and a 'semantics' that match in this sense. However, whether such a description actually constitutes an implementation of PC, would depend on the question whether the 'syntax' and 'semantics' components really constitute a syntax and a semantics, respectively.[5] Consequently, this kind of approach does not help to decide whether or not human language actually is compositional. This, however, is a very important question for any theory of language - and it is not settled. The argument based on the fact that regular complex human language sentences can be interpreted effectively and uniformly provides strong evidence in favour of PC, but it does not prove it.

The only way, it appears, of providing an empirical proof of PC would consist in a successful description of syntactic and semantic composition in accordance with PC. The description of syntactic composition would have to be in accordance with syntactic theory and methodology, i.e. adequately 'autonomous'. Certainly, the notion of designing syntax as to meet the requirements of semantics is not necessarily compatible with this requirement. Likewise, a theory of semantic composition would have to take into account syntactic structure but may have 'autonomous' perspectives, too. Only when both accounts of compos-

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4   It will be argued below that 1-PLACE VERB does not constitute a uniform semantic type, whence 1-PLACE PREDICATE TERM doesn't either.

5   See Kracht (2007) for an in-depth discussion of this point. Kracht argues convincingly that the question of compositionality for a given description, and therefore the observation of PC in general, crucially depends on a proper separation of syntactic and semantic aspects of grammar.

ition, syntactic and semantic, are sufficiently elaborated, it will be possible to settle the question as to whether or not the two type systems match.

1.5 Sub-compositionality

What kind of mismatch could possible arise between the type systems of syntactic and semantic composition? Given what we know about language, the major syntactic and semantic constituent categories seem to match at least partially. Syntactic types such as PROPER NAME, PROPER NOUN, 1-PLACE VERB, 2-PLACE VERB appear to exhibit homogeneous compositional behaviour – for the prototypical cases, ignoring relational nouns, intensional verbs, non-intersecting adjectives and similar exceptions. According to theories of language acquisition that assume either semantic or syntactic bootstrapping[6], it is the match of the central instances of syntactic and semantic types that crucially helps acquiring syntactic rules and lexical knowledge.

Yet there is still room for mismatch. The same syntactic construction might have developed to host different patterns of semantic composition: such as intersecting adjectives alongside with non-intersecting ones, extensional verbs along with intensional verbs, definite NPs as well as indefinites and genuinely quantifying NPs. While all the examples just quoted may turn out to in fact involve different *syntactic* types, in principle a situation might arise where a syntactic type is semantically heterogeneous. Assume a syntactic construction that consists of two expressions, of syntactic type Y1 and Y2, respectively. Let one of the types, say Y2, be syntactically minimal in the sense that there are no syntactic subtypes of Y2 that could be justified by merely morphosyntactic regularities. The expressions of Type Y2 might nevertheless exhibit differing compositional behaviour, forcing a distinction between semantic subtypes E1, E2 … within the class of expressions of Type Y2. I want to call such a construction **sub-compositional**. In general, a syntactic construction is sub-compositional if there is no uniform rule of semantic composition for it. Thus, there would be distinct semantic types with uniform syntactic behaviour.

A stronger mismatch would result if certain semantic categorizations cut across several syntactic types. For example, gradability of adjectives is a property that would probably not be considered relevant for syntax, as there is nothing syntactically wrong with graded ungradables, such as in *he is more married than his wife*. Gradability, however, clearly matters for semantic composition, and it cuts across syntactic distinctions of adjective types such as 1-PLACE vs. 2-PLACE ADJECTIVE. Below in §3 it will be argued that gradation of German verbs with *sehr* ('very, a lot') constitutes this type of phenomenon: across syntactic types of verbs, semantic patterns of gradation divide syntactic types of verbs into several semantic sub-types with their own sub-rules of composition.

In Section 2 the classical Montagovian approach to compositionality will be briefly reviewed w.r.t. its attitude towards the matching of syntax and semantics. It will be argued that the analyses proposed for the central NP_VP construction fail to appropriately deal with the actual varieties of compositional patterns, the failure being due to the attempt of matching syntactic and semantic composition for this construction in general. In Section 3 data will presented that strongly suggest that gradation of verbs in German represents a phenomenon which is irreducibly sub-compositional. Section 4 will reflect on the consequences of sub-compositionality for a general theory of composition.

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[6] For example Pinker (1984, and later work) on semantic bootstrapping, Gleitman (1990) on syntactic bootstrapping.

2 Semantic regularity in classical implementations of compositionality

2.1 The classical scheme

The classical model of composition was developed in model-theoretic semantics (MTS for short), such as Montague Grammar (Montague 1970, 1973) and its later developments and derivatives. In a nutshell, its basic design is as follows. A lexicon provides a set of basic expressions. These are assigned a lexical meaning, one or more syntactic types (categories) that figure in the syntactic composition rules, and a logical type. The logical type, such as FIRST-ORDER 1-PLACE PREDICATE, is the same for all instances of a syntactic type. This is the first constraint that makes sure that syntactic and semantic types match. Rules of syntactic composition define the ways in which regular complex expressions can be formed. According to a syntactic rule, expressions of specified syntactic types can be combined by means of some syntactic operation such as concatenation to form a complex expression of specified type. The meaning of a complex expression is determined by rules of semantic composition. According to these rules the meaning of a regular complex expression is defined as the value that some semantic operation such as functional application yields for the meanings of the component expressions. For each syntactic rule there is a rule of semantic composition. This is the second constraint that makes syntactic and semantic composition match: the rules of semantic composition apply to the meanings of syntactic types of input expressions.

This design straightforwardly implements PC: the meaning of a complex expression is a function of the meanings of its component expressions, where the choice of that function is determined by the syntactic rule used to form the expression. According to this model, the meaning assignment is what is called a homomorphism. The syntactic structure of complex expressions is mirrored by the way in which their meanings are calculated.

> **Homomorphy of syntactic and semantic composition (HSS)**
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> For every complex expression of a particular syntactic composition, the same rule of semantic composition applies.[7]

HSS rules out sub-compositionality a priori. However, central linguistic constructions such as subject+predicate had been considered semantically heterogeneous ever since. Therefore their apparent sub-compositionality was one of the main challenges to a formal theory of composition from the very beginning. Montague's (1973) approaches in "The proper treatment of quantification in ordinary English" (PTQ) and his earlier work can be seen as attempts at overcoming the intuitive sub-compositionality of the NP_VP construction (among other problems). The NP_VP construction is intuitively heterogeneous w.r.t. the NP position in that it harbours NPs of apparently different logical nature, such as proper names, pronouns, definites and indefinites along with genuinely quantifying NPs. A second point of sub-compositionality concerns the VP position; it allows for verbs with an intensional subject argument (*the temperature rises*) as well as for the ordinary verb with extensional subject argument (*the sun rises*). The meanings of these two semantic sub-types of verbs combine differently with the meanings of their subject NP. In the following we will have a closer look at the ways in which the classical theory dealt with issues of potential sub-compositionality.

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[7] Janssen (1997) puts it this way: "The meaning of an expression is determined by the way in which it is formed from its parts. The syntactic production process, therefore, is the only input to the process determining its meaning." (p.427)

2.2 General strategies of evading sub-compositionality

Never aiming at a complete coverage of composition, MTS approaches use the method of "fragments". The fragmentariness of these accounts is two-fold. First, only a limited set of construction types is dealt with. Second, the lexical elements within the syntactic categories included are always just very small sets of representative items. This offers the opportunity, heavily made use of, to exclude cases from the syntactic categories to which the proposed analysis would not apply. As a result, sub-compositional constructions are reduced to semantically homogeneous sub-constructions.

Another strategy, legal in MTS, would consist in artificially distinguishing in syntax between sub-types with equal syntactic, but different compositional behaviour (cf. the quote from Janssen 1997 above). According to the definition of syntactic and semantic types given above, this would mean to actually define syntactic rules in terms of semantic types. Proceeding in such a way undermines HSS at its very root; there is no sense in talking of a match of syntax and semantics if the two systems of composition are not defined independently.

The most problematic strategy, however, is what was dubbed "generalization to the worst case": a method of subsuming less complex cases under cases of higher complexity by exploiting logical equivalences. The discussion to follow will focus on this strategy.

2.3 The "uniform analysis" of NPs

In PTQ, Montague presented a uniform analysis of singular quantificational, indefinite and definite NPs, including proper names and third person personal pronouns. The treatment was taken over by MTS in general and considerably elaborated in Generalized Quantifier Theory (GQT) initiated by Barwise & Cooper (1981). GQT extended the uniform treatment to non-logical quantifiers such as *many* or numerals. NPs are considered as composed of an expression of type DET– *a, the, some, every, each, all, no, both, neither, many, few, most, a few, one, two, …*[8] – and an expression of type NOUN; proper names and singular third person personal pronouns are considered lexical NPs. Leaving aside technical and notational details and ignoring tense and mood, the uniform treatment in this approach is essentially this: a sentence of the form 'NP_VP' is analyzed as "the property expressed by the VP is one of the properties of "NP" ". For example,

(3) a. *every boy is hungry*   **every(boy) (hungry)**[9]
      = **hungry** $\in \{p \mid \forall x(x \in \textbf{boy} \rightarrow x \in p)\}$

  b. *Paul is hungry*   **Paul(hungry)**
      = **hungry** $\in \{p \mid \textbf{paul} \in p\}$

In (3a), **hungry** and **boy** denote one-place first-order predicates, or sets,[10] the lexical meanings of *hungry* and *boy*, respectively. **every** is an operator which takes two first-order one-place predicates, first a noun meaning and then a VP meaning; thus **every** itself is second-order. The result of combining the determiner meaning with the noun meaning, in this case **every(boy)**, is a second-order one-place predicate, i.e. a quantifier in the technical sense. It predicates of the VP meaning that it is true of every boy. **Paul** in (3b), with a capital P, also denotes a second-order predicate, namely the predicate that is true of all properties of Paul. It predicates of the VP meaning that it is true of Paul. Thus, the meanings of both types of NPs are uniformly treated as second-order predicates that apply to the predicate denoted by the

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8   List from Barwise & Cooper (1981: 171)
9   We are using the notation of Barwise & Cooper (1981: 171) rather than Montague's original notation which would be in need of more explanation.
10 The difference between properties, predicates and sets is of no relevance here.

VP. Both sentences in (3) are treated as instances of second-order predication.

A simple set-theoretical transformation shows that (3b) is equivalent to (3c), where **paul** with a lower case **p** is a simple individual term that denotes Paul.

(3) c. *Paul is hungry* $\Leftrightarrow$ **paul** $\in$ **hungry**   or   **hungry(paul)**

Unlike the formula in (3b) this is a simple first-order predication; the formula says that Paul belongs to the set of the hungry, or equivalently, that the predicate of being hungry applies to Paul. Note the crucial fact that the simple formula in (3c) is equivalent to the meaning of the sentence *Paul is hungry*, but is *not* the meaning proper that PTQ and GQT assign. The meaning proper is a second-order predication about the property of being hungry.

This treatment of NPs is problematic, for syntactic, semantic and superordinate reasons (s. 2.5 for the latter). As to syntax, it can be argued that the elements treated as determiners do not form a uniform syntactic type; for example *many*, *few*, and the numerals can be preceded by the definite article and possessive pronouns, but not by the other elements of the set; they would more adequately be analysed as a sub-type of adjectives. Furthermore, it can be shown that definite NPs, including personal pronouns and proper names do not possess scope, whence their syntax is different from genuinely quantifying NPs containing e.g. *every* or *all*. Due to the scopelessness of definites the distinction of external (sentence) negation and internal (VP) negation does not apply in their case; sentence negation coincides with VP negation, the only negation available: *Paul is not hungry*. By contrast, the distinction matters for genuinely quantifying NPs such as *every boy*: cf. *not every boy is hungry* vs. *every boy is not hungry*.[11] Similarly, indefinite "determiners" such as *no*, *some*, *many*, *a few* and the numerals have scope only under marked contextual conditions (i.e. in partitive or generic readings).[12]

More severely, the analysis is inadequate from a semantic point view. The uniform treatment of definite NPs such as proper names and genuinely quantifying NPs disregards the semantic differences between the two types of nouns. Treating first-order predications such as in (3b) as second-order predications cannot be justified in an adequate account of compositionality[13]. Since proper name meanings combine with the VP meaning in one way - the VP meaning constitutes a predicate over the NP referent - and the meanings of quantifying NPs in another way - the NP meaning constitutes a predicate over the VP denotation - the two subtypes of NPs require different composition rules.

2.4   The "uniform analysis" of verb arguments

The technique of GWC, illustrated for the NP position, has also been applied for coping with semantic sub-regularities concerning the VP position. For example, the verb *rise* is used in (4a) for predicating about the extension of its subject NP (extensional use), while the predication in (4b) is about the intension of the subject (intensional use).

(4) a. *the sun is rising*

    b. *the temperature is rising*

Montague in PTQ presents an analysis that treats both, intensional and extensional verbs, as predications over the intension of the subject argument, i.e. over the temperature function that assigns a temperature value to indices of world and time. While this is adequate for intensional verbs, it is problematic for the extensional cases. It can be considered somehow logically

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[11] See Löbner (2000: §1-3) for an extensive discussion of this point), also Krifka (1992).

[12] See Krifka (1999) and Löbner (1987, 1990:§3) on indefinites. For general non-quantificational theories of indefinites and definites see Heim's (1982) File Change Semantic and Kamp's Discourse Representation Theory DRT (Kamp & Reyle 1993).

[13] Even third-order treatments of ordinary NP-VP sentences have been proposed, see Keenan & Faltz (1985:87ff).

admissible as a border-line case: a predication over an extension can be considered a trivial case of predicating over the intension, namely over the one value the intension takes for the given world and time. This treatment does, however, not capture the logical property of extensional predication that an argument term can be replaced *salva veritate* by a term with the same extension. In Montague's treatment, this shortcoming is remedied by additional meaning postulates for individual verbs that permit the logical reduction of the intensional interpretation to an equivalent extensional predication.

The remedy, however, leads into a dilemma. If the primary output of the compositional system, the intensional interpretation, is considered the meaning proper, the account fails to capture the logical behaviour of extensional verbs and is hence semantically inadequate. If alternatively the meaning proper is the result of a two-step procedure which first produces the intensional interpretation and then reduces it to its extensional variant by applying the individual meaning postulate for the verb involved, the result will be properly extensional. But the total process of meaning assignment for extensional instances of NP_VP now violates the requirement of regularity since the result of composition depends on the presence or absence of a meaning postulate for the verb which declares it an individual exception.

2.5   Constraints on a theory of composition, and the principal inappropriateness of generalizing to the worst case

As can be seen from the two cases discussed, GWC is highly problematic. The very idea of GWC contradicts the objective of an adequate theoretical account of semantic differences since the notion obviously presupposes that there are *different* cases to be subsumed under one 'uniform' treatment. These cases may differ w.r.t. syntactic and/or in semantic composition. What makes the method even more problematic is the fact that the 'worst cases' are given the status of paradigm cases although, as a rule, they are rather marginal due to their unusual semantic complexity.[14]

From a logical point of view, GWC generally fails to accurately account for the properties of the less than worst cases. As a central feature of its conception, predicate logic distinguishes orders of predication. Consequently, if a case of predication logically behaves like first-order rather than second-order predication, then the semantic analysis ought to reproduce this property of the construction. A similar distinction applies to extensional vs. intensional verbs: intensions are entities of higher logical order than their respective extensions.

In addition to these objections, GWC violates reasonable external constraints on a theory of semantic composition. One such constraint derives from the concern that a theory of semantic composition should be plausible from the point of view of cognitive processing. This would be the case if the semantic operations could be considered corresponding to cognitive processes that are actually carried out during semantic processing. Even if not yet really understood, these processes are constrained by requirements of economy, executability and learnability. Processing definite NPs such as personal pronouns and proper names as second-order predicates would be obviously uneconomic when a simple first-order treatment is functionally equivalent.

A second objection derives from the perspective of language acquisition. It appears plausible that the acquisition of semantic composition is to a considerable extent monotone: central rules of semantic composition are unlikely to be replaced once they have received sufficient and persistent confirmation. Children acquire definite NPs, such as personal pronouns, proper names and definite descriptions, much earlier than genuine quantifiers like "every". Con-

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14 As for the NP_VP construction, only a very small percentage of NPs in actual language use is genuinely quantificational. Intensional subject constructions such as *the temperature is rising* appear to be even more infrequent. See Löbner (1979) for a lexical exploration of intensional verb constructions in German.

sequently, they build up a composition rule for verbs with definite NP subjects which has the referents of the NP as instances of simple first-order predication. It is extremely implausible that this composition rule should later be replaced by a quantifier interpretation of definite NP arguments. In Löbner (2000: 253-276) it is shown how quantification proper can be conceived of as a modification of an underlying first-order predication. This kind of account is more in accordance with the course of language acquisition than GQT.

Similar considerations apply to the case of extensional verbs. From the point of view of processing it appears implausible that for extensional verbs first an intensional interpretation should be generated only to be reduced to the simpler extensional variant in a second step. The type of construction represented by *the temperature is rising* involves some sort of abstraction, the formation of a functional concept that assigns varying temperature values to different times. This is not involved in the case of extensional predication. As for acquisition, extensional verbs are, of course, acquired much earlier than intensional verbs like *rise* In fact there seem to be languages where this type of construction is not available at all.[15]

As a result, generalization to the worst case should be dismissed altogether as an admissible method in a theory of semantic composition since it conceals, rather than reveals the actual mechanisms of semantic composition. A theory aiming at a proper understanding of the interplay of syntactic and semantic composition should distinguish what is actually different.

2.6   Summary on the classical account of the English NP_VP construction

The discussion shows that *if* the English NP_VP construction is considered a syntactically uniform type *then* it must be considered severely sub-compositional, both w.r.t. the subject position and the VP position. In the classical account, the sub-compositionality is not adequately dealt with. The "uniform treatment" of the construction is achieved only at the expense of violating vital constraints on any appropriate linguistic theory of composition. These include

- independent syntactic foundation of the rules of morphosyntactic composition
- independent semantic foundation of the rules of semantic composition
- plausibility of the rules of composition from the perspective of cognitive processing
- plausibility of the rules of composition from the perspective of language acquisition

The discussion of the classical accounts of the NP_VP construction does not necessarily mean that a treatment in accordance with these constraints would invalidate HSS. Still, properly determined sub-types of NPs and VPs might turn out to coincide with the semantic types that are to be distinguished. Nevertheless, the discussion was worthwhile in this context, as it helped to make clear what would make up an adequate account of composition.

We will now turn to a semantic phenomenon which seems to represent a genuine, irreducible case of sub-compositionality, gradation of verbs in German[16]. The construction GRADADV_VERB, with an unspecific grading adverb GRADADV combined directly with a verb, hosts quite a few different patterns of semantic composition, depending on the semantic sub-type of verb. Unlike the semantic sub-types in the English NP_VP construction, the respective semantic verb-types do not seem to coincide with syntactic sub-types.

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[15] This seems to be the case, for example, in Lakhota which apparently lacks functional nouns such as "temperature" altogether (Robert Van Valin, p.c.).
[16] There is nothing particular about German; other languages will be quite similar.

	adjective intensification (positive form)	verbs: degree intensification	verbs: extent intensification
German	***sehr** groß*	*wächst **sehr***	*arbeitet **viel***
Russian	***očen** bolšoy*	***očen** rastët*	***mnogo** rabotaet*
Hungarian	***nagyon** nagy*	***nagyon** nő*	***sokat** dolgozik*
Japanese	***totemo** ôkii*	***totemo** hueru*	***takusan** hataraku*
Italian	***molto** grande*	*cresce **molto***	*lavora **molto***
Spanish	***muy** grande*	*crece **mucho***	*trabaja **mucho***
French	***très** grand*	*grandit **beaucoup***	*travaille **beaucoup***
English	***very** big*	*grows **a lot**[19]*	*works **a lot***

Table 1: standard adjective and verb intensifiers

3   A case study in sub-compositionality: gradation of verbs in German[17]

3.1   Gradation of verbs in general

Verb gradation as such is a phenomenon not much investigated, but gaining momentum in the last years. Bolinger (1972) presented a descriptive account of verb gradation in English in terms of types of grading; but he did not attempt a semantic analysis.[18] Usually considered a phenomenon associated with adjectives, gradation in the case of verbs is in fact quite common, although usually not by morphological means. Bolinger distinguishes two types of gradation, extent intensification and inherent intensification. Extent intensification contributes a quantity specification of the event, or events, referred to. The quantity specification concerns the temporal dimension: frequency, duration or temporal proportion. With agentive verbs it can be roughly paraphrased as 'spend [X] time with V-ing':

(5)   *I use my cell phone <u>a lot</u>*

This type of modification requires an atelic verb phrase, i.e. an activity or state term in Vendler's (1967) classification. Since the gradation concerns the time argument common to all verbs, the construction receives a fairly uniform compositional interpretation across atelic verbs; its compositional interpretation does not require a deep analysis of verb meaning.

The phenomenon of interest here is Bolinger's 'inherent' intensification, for which the term 'degree intensification' will be preferred here. The adverb specifies some degree, or gradable aspect, of the situation referred to.

(6)   German
         e*r hat sehr gelitten*
         he has very suffered
         'he suffered/was suffering/has suffered a lot'

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[18]   Tsujimura (2001) offers a first, but incomplete account of degree gradation in Japanese. Recent work by Kennedy et al. investigates a closed-scale gradation in depth, but the type is complementary to open-scale gradation considered here (Hay, Kennedy & Levin 1999, Kennedy & McNally 2005).
[19]   According to Bolinger (1972: 221), *to like* is the only English verb that takes *very* as intensifier.

It is not the temporal extent that is specified in (6), but the intensity of suffering. We follow Bolinger in calling verbs that permit degree intensification 'degree verbs'. Degree verbs can be telic or atelic, static or dynamic; they occur in all Vendler classes and with any arity. This does not mean, of course, that all verbs are degree verbs; which verbs are, is an open question. Examples of non-degree verbs are *sit*, *sleep*, *eat, die, mean, constitute*.

For upgrading, the standard case of intensification, German has separate adverbs for extent intensification and degree intensification, *viel* ('much') and *sehr* ('very'), respectively. An analogous distinction exists, e.g., in Russian, Hungarian and Japanese. By contrast, English, French and Spanish use the same intensifier for extent and degree intensification, but a different one for adjective intensification. Italian uses *molto* in all three cases. (see Table 1)

The following discussion is confined to German *sehr*. It should be added that this type of intensifier is confined to adjectives, adverbs and verbs that are related to open scales, i.e. scales without an absolute maximum. For closed scales, other intensifiers such as *ganz* ('wholly', 'completely') are used.[20]

3.2 The German degree intensifier *sehr* with adjectives

The German adverb *sehr* (a cognate of English *sore*) is the standard adverb for up-grading adjectives; it expresses a degree higher, or more marked, than what is required for using the bare adjective. The intensifier can be used with all gradable adjectives and adverbs in the positive.[21]

(7) a. *das Buch ist sehr schön/ dick/ teuer/   unterhaltsam*
     the book is very nice/ thick/ expensive/ entertaining

   b. re-interpretation necessary
     das Buch ist (!) *sehr englisch*
     the book is   very English

The basic logical properties of *sehr* with adjectives can be captured by the following meaning postulates (for ADJ the respective adjective is to be inserted):

(8) a. if x is "sehr ADJ", then x is ADJ

   b. x may be ADJ but not "sehr ADJ"

   c. if x is ADJ but not "sehr ADJ" and y is "sehr ADJ", then y is more ADJ than x

Given that all gradable adjectives relate to a scale and denote some interval of marked degree on that scale, the combination of *sehr* with an adjective would denote an extra marked part of the scale within the marked part denoted by the bare adjective.[22] The function of *sehr* ADJ can be illustrated as in Fig. 2.

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[20] See Kirschbaum (2002: §2.2, §3) for an elaborate account of types of adjective intensification in German. It would carry over, mutatis mutandis, to the gradation of verbs.

[21] Note that closed-scale adjectives such as *complete*, which cannot be modified with *very*, are basically not gradable. If used graded or modified with *sehr*, they undergo re-interpretation by way of coercion.

[22] For an analysis of *sehr*_ADJ implementing the postulates in (8) see Bierwisch (1989: 166, 177); an analysis of gradable adjectives in terms of markedness on a scale is proposed in Löbner (1990: §8).

$\leftarrow \neg$ *sehr* ADJ   *sehr* ADJ $\rightarrow$

$\leftarrow$ $\leftarrow$ $\neg$ADJ   ADJ $\rightarrow$ $\rightarrow$ $\rightarrow$

Fig. 2: scale diagram for *sehr* ADJ

3.3 *sehr* with degree verbs: examples

The meaning postulates for *sehr* with adjectives carry over, mutatis mutandis, to degree verbs. For example, if something grows a lot, it grows; it may grow, but not a lot; and if it grows a lot, it grows more than what just grows, but not a lot. Let me give a few representative examples with different semantic types of verbs. The collection of types is not exhaustive.

(9) a. *sie* *fror* *sehr*   verb of sensation
     she was-cold very   *frieren*

     b. *ihre Pupille* *hat* *sich* *sehr* *geweitet*   degree achievement verb on a
     her pupil has REFL very widened   specific scale *sich weiten*

     c. *die Erfahrung hat ihn* *sehr* *verändert*   degree achievement verb on an
     the experience has him very changed   unspecific scale *sich verändern*

     d. *er fürchtet* *ihn* *sehr*   verb of emotional attitude
     he is afraid of him very   *fürchten*

     e. *das* *schockierte* *ihn* *sehr*   verb of emotional effect
     that shocked him very   *schockieren*

     f. *er* *blutete* *sehr*   verb of substance emission
     he bled very   *bluten*

     g. *er hat sich* *sehr* *verfahren*   verb of wrong action
     he has REFL very lost his way   *sich verfahren*

     h. *sie* *hebt* *sich* *sehr* *von den andern ab*   verb of comparison
     she stands REFL very from the others out   *sich abheben von*

     i. *er stottert* *sehr*   verb of marked behaviour
     he stutters very   *stottern*

     j. *sie schlugen* *ihn* *sehr*   gradable verb of action
     they beat him very   *schlagen*

3.4 Syntax

Although these examples trivially represent different constructions, due to the respective argument structures of the verbs, the grading adverb invariably modifies the verb itself prior to its combination with any arguments. Aspect does influence the interpretation of the gradation for certain types of verbs (see the next subsection) while tense obviously does not. Consequently the gradation applies between aspect and tense. What matters for the semantic composition is the syntactic combination of the adverb with the verb (plus aspect) itself. Syn-

tactically, the hosting construction does not select degree adverbs; rather degree adverbs share the position with manner adverbs. Nor does the verb position select gradable verbs. Thus the GRADADV_VERB construction is a semantic type that does not match with any syntactic type. Consequently, the semantic type of degree verb cross-cuts with various syntactic types of verbs.[23]

In addition, many degree verbs exhibit systematic alternation. For example the verb *ärgern* "annoy, irritate, tease" of emotional effect occurs in the following constructions:

(10) a. *sie*   *ärgert* *ihre* *Schwester* *sehr*   causative agent
          she   annoys   her   sister   very

      b. *das*   *ärgert* *ihre* *Schwester* *sehr*   causative source
          that   annoys   her   sister   very

      c. *ihre*   *Schwester* *ärgert sich* *sehr* *(darüber)*   reflexive
          her   sister   is angry   very   about that

The gradation invariably relates to the degree of anger of the experiencer argument. In general, gradation affects the same aspect of the situation, independent of the way in which the varying argument structure of the verb is mapped into syntax.

3.5   Determining the scale of grading

With adjectives as well as with verbs, the intensification expressed by *sehr* relates to a certain scale. In the case of graded adjectives, the scale is provided by the adjective.[24] Notably, *sehr* itself does not provide a scale[25] although it is itself gradable (its suppletiver comparative form is *mehr* 'more', its superlative *am meisten* 'most'). In this respect it resembles English *very* or French *très*. Therefore, in the case of combining *sehr* with a verb, the scale *sehr* is to be related to has to be provided by the lexical meaning of the verb. Unlike gradable adjectives, however, most types of degree verbs do not semantically specify a particular prominent scale. Hence the question arises as to how the scale of intensification is compositionally determined. The following will not offer a formal account – which is not yet available – but just illustrate the type of problem a compositional account is facing.

a. Verbs of sensation. Stative intransitive verbs of sensation or emotion like *frieren* 'be cold', *schwitzen* 'be warm, hot' (one meaning variant, besides 'sweat, transpire'), *sich freuen* 'be glad', *sich ärgern* 'be angry' are semantically close to adjectives; in fact the respective state predications are lexicalized as adjectives in many languages (cf. the English equivalents, but also corresponding adjectives in Korean or Japanese.) The state expressed is subjectively perceived in varying degrees and hence takes values on a scale. The individual verb determines a condition of the experiencer, e.g. felt temperature or joy, and predicates of the subject argument that it exhibits this condition to a certain degree. The addition of *sehr* specifies this degree as high. In a Davidsonian account of verb meaning, the verb would refer to a situation e of a certain type, which is characterized by the fact that there is an experiencer

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[23] One would not even want to syntactically distinguish gradable verbs from non-gradable ones. Even non-gradable verbs can be syntactically combined with *sehr* or other intensifiers; the verb meaning is then coerced into a gradable reading.

[24] The scale of grading to which *sehr* relates is not just the scale the adjective in its positive form relates to, but the derived scale of the extent to which the minimum value for "being ADJ" is exceeded (as illustrated in Fig.2); for a formal account see Bierwisch (1989: 166, 177).

[25] In this regard *sehr* crucially differs from the large set of scale-specific gradable manner adverbs such as "slowly", "skilfully" etc.

EXP(e),[26] syntactically specified by the subject of the construction; a certain bodily or emotional condition COND of the experiencer, i.e. COND(EXP(e)) is lexically specified and said to take some value other than normal. Intensification by *sehr* relates to the scale of possible degrees of COND(EXP(e)).

b. Verbs of degree achievement on a specific scale. The numerous verbs of this type usually come in an intransitive variant and a causative variant, like *sich verbessern* 'become better' and *verbessern* 'make better'. In German, most of them are deadjectival, deriving either from the positive or the comparative form, but invariably meaning 'become/make more ADJ', where ADJ is the source of derivation. The adjective is gradable, related to an open scale. The pattern is near-productive, seemingly only constrained by morphological conditions such as the exclusion of past participle forms as a source. Usually the intransitive version is the reflexive form of the causative one: (*sich*) *ver-eng-en* ('to narrow', > *eng* 'narrow'), (*sich*) *ver-kleiner-n* ('to become/make smaller', > *klein-er*, comparative of *klein* 'small') etc. Some verbs of this type are not derived from adjectives: *wachsen* 'grow', *steigen* 'rise', *spreizen* 'spread out, force apart' or *dehnen* 'stretch'. Verbs of this semantic type refer to events which consist in (the causation of) a change in time of a specific attribute of the theme argument such as its *size, length* etc. The addition of *sehr* to the predication specifies that change as big. Thus, the scale to which the intensification relates is the extent of VCHG(THEME(e)), where VCHG represents the change of the theme w.r.t. the dimension of change specified by the verb, i.e. the difference between the value the theme argument occupies on the scale before the event and the value it takes afterwards; this holds both for the intransitive and the causative verb variants.

c. Verbs of degree achievement on an unspecific scale. This type of verb is maybe less productive, but still not rare. Prototypical members are reflexive or causative (*sich*) *ändern*, (*sich*) *verändern* 'change, become different', *umformen* 'reshape', *überarbeiten* 'rework', *umstrukturieren* 'restructure', *modifizieren* 'modify', *mutieren* 'mutate' and many others. The pattern of *um-* prefixation is productive with verbs of producing, shaping etc. The meaning of the verbs is similar to the previous type: they express a change of the theme argument in some respect, and intensification by *sehr* relates to the extent of the change. But the verbs of this type do not specify lexically the dimension of change. The scale relevant for the intensification is the extent of some unspecific change the theme argument undergoes, CHG(THEME(e)).

d. Verbs of emotional attitude such as *fürchten* 'be afraid of' are similar to the verbs of bodily or emotional attitudes. They denote a specific emotional attitude of the experiencer specified by the subject of the construction towards a specified source argument: ATT(EXP(e),SRC(e)). Intensification relates to the intensity of that attitude.

e. Verbs of emotional effect. This group is large and exhibits manifold alternation (cf. (10)): Thy express events that involve the coming about of a specific emotional effect on the part of the experiencer. Intensification by means of *sehr* specifies this effect as strong. The dimension involved is thus the intensity of EMO(EXP(e)), with EMO the emotional effect on the experiencer.

f. Verbs of substance emission are mostly erived from nouns denoting some kind of substance; the verbs are intransitive and roughly mean 'emit/give out N', where N denotes that substance: *bluten* ('bleed', > *Blut* 'blood'), *schwitzen* ('sweat', > *Schweiß* 'sweat'), *stauben* ('send out dust', > *Staub* 'dust'), *haaren* ('lose hair', > *Haar* 'hair'), *dampfen* ('steam', > *Dampf* 'steam'), *nässen* ('wet', > *nass* (adj.) 'wet') and many more. These verbs have an implicit argument, which normally does not surface, but may occasionally, such as in *Blut und Wasser schwitzen*, 'to sweat blood and water'; let us call it EMI, for emitted substance. The

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[26] In the following, roles of verbs that are part of the argument structure of the verb are underlined. Roles and attributes that do not surface grammatically are not underlined.

intensification relates to the quantity of the substance emitted, i.e. QUANT(EMI(e)).

g. Verbs of wrong action. The pattern *sich ver*-V, meaning roughly 'to V with a wrong outcome', is very productive in German; almost any action verb, transitive or intransitive, can enter the pattern. It means to do what the source verb expresses with a result that erroneously differs from the intended result: taking the wrong way (*sich verlaufen > laufen* 'run, go'), misspelling what one writes (*sich verschreiben > schreiben* 'write'), dialling the wrong number, or the number wrong, *sich verwählen* (*> wählen* 'dial'), making a mistake *sich vertun* (*> tun* 'do'). Intensification relates to the extent of the difference between the intended result INTRES and the actual result RES of the action e, something like DIFF(INTRES(e), RES(e)).

h. Verbs of comparison include *sich abheben* 'stand out', *sich unterscheiden* 'differ' or *sich ähneln* 'be similar'. They are usually non-transitive two-place verbs with an oblique object, some of them with reciprocal uses; they express some sort of general comparison stating an unspecific difference or similarity. The scale relevant for *sehr* intensification is DIFF(C1(e), C2(e)), where C1 and C2 are the two roles surfacing in the construction, and DIFF the degree in which they differ in some respect not specified. The difference is expressed to be great if *sehr* is added. There do not seem to be many verbs that relate to a difference in some specific dimension such as the verbs of the productive English type represented by *outnumber, outweigh, outage, outrank* etc.; one German example would be *überwiegen* 'outweigh, outbalance, prevail'.

i. Verbs of marked behaviour denote actions, or conditions, that differ from the unmarked way of performance in a specific respect, e.g. volume of speech, speed of motion, evenness of walking etc. *sehr* with this type of verbs marks that difference as great. The type includes cases such as *schreien* 'shout, cry', *flüstern* 'whisper', *stottern* 'stutter', *hinken* 'limp', *rennen* 'run', *schielen* 'squint' and many others. Intensification concerns the extent of deviation from the unmarked.

j. Gradable verbs of action. Finally, there is a big residue type of verbs of action which do not seem so far to fit into a clear pattern. For example *schlagen* 'beat' can be intensified with *sehr*, with the result of at least two readings. Intensification may apply to the effort the agent invests into the beating, resulting in markedly many and/or heavy strokes; it may as well relate to the effect it has on the victim, in terms of pain or harm. It is not clear which transitive action verbs qualify for intensification with *sehr*. One sub-type consists of verbs that denote an action that leaves some effect on the patient; this type includes beneficiary verbs such as *helfen* 'help' or *schaden* 'damage, harm'; here *sehr* concerns the extent of the effect of action. Other verbs just denote some sort of action with intensification relating to some attribute of the agent, e.g. *sich anstrengen* 'exert o.s.'.

For some but not all types of gradable verbs, the scale of grading interacts with aspect. For the verbs of substance emission, more substance is emitted the longer the event is continued. If the aspect of the verb is imperfective (in the sense of Comrie 1976), gradation relates to the rate of emission. If verbal aspect is perfective, perfect or prospective, i.e. if reference is to the total event, the quantity grading may also refer to the total amount of substance emitted. Analogous conditions hold for degree achievements on specific or unspecific scales.

3.6 Rules of composition and logical entailments

The observed variety of compositional patterns corresponds with varying types of logical entailments and equivalences ($\Leftrightarrow$), for example:

(11) a. *sie fror <u>sehr</u>* $\Leftrightarrow$ *ihr war <u>sehr</u> kalt* (adj.)
                                                        'she (lit. to her) was very cold'

b. *sich <u>sehr</u> weiten*	⟺	<u>viel</u> *weiter* (adj. comp.) *werden* 'become much wider'
d. *sich <u>sehr</u> fürchten vor*	⟺	<u>große</u> *Furcht* (noun) *haben vor* 'have great fear of'
f. *<u>sehr</u> bluten*	⟺	<u>viel</u> *Blut* (noun) *verlieren* 'lose much blood'
g. *sich <u>sehr</u> verwählen*	⟺	<u>sehr falsch</u> *wählen* 'dial very wrong'
h. *sich <u>sehr</u> abheben*	⟺	<u>sehr</u> *anders* (adj.) *sein* 'be very different'
i. *<u>sehr</u> stottern*	⟺	<u>sehr</u> *stockend* (adv.) *sprechen* 'speak very haltingly'

Logical equivalences like these constitute semantic evidence and explananda. The fact that they differ in form and cannot be unified to one general pattern provides strong evidence for the sub-compositionality of verbal degree intensification. If a uniform rule of interpretation were assumed, it seems impossible to derive all these different types of equivalences from it.

3.7   Summary on verb gradation

These data may suffice to show that there are considerable differences in compositional behaviour across various semantic types of verbs. It appears that an account of verb gradation can only be satisfactory if it is able to uncover the varying ways in which intensification finds its scale in the complex lexical meaning of the verb. Some cases concern implicit dimensions of overt arguments, others dimensions of implicit arguments; in yet other cases, the crucial scale is a scale of differences between varying components of the verb meaning. Although the resulting picture of semantic composition is diverse and complex, there appear to be sub-rules that apply homogeneously for each type of gradable verb. These rules are, apparently, grounded in the type of lexical meaning of the verb – and therefore general rules.

A promising framework for decomposition appears to be a frame semantics for verbs, or equivalent means such as the attribute-value structures used in formal linguistics. Frames[27] can be used to represent the attributes of events (which include explicit and implicit arguments) and, recursively, their respective attributes and hence the possible dimensions of intensification. Different instances of the same semantic type of verb would share the same general frame structure, but differ in individual specifications of certain frame components. Instances of the same type of verb frame would interact with a grading adverb in a uniform way.

A frame analysis into verb meanings appropriate for a systematic compositional account of verb gradation would lead beyond those parts of verb frames that were elaborated in earlier theories such as Fillmore's. These accounts were essentially restricted to the representation of explicit (and sometimes implicit) verb arguments, i.e. those attributes of events which directly surface in syntax. Gradation of degree verbs, by contrast, concerns attributes of arguments rather than attributes of the event itself. Thus, the determination of the relevant scale of gradation reveals deeper elements of verb meaning.

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[27] For an appropriately elaborate frame conception see Barsalou (1992); Petersen (2007) offers a formalization of Barsalou's notions.

4 Conclusion

If the existence of sub-compositional constructions is to be acknowledged – what does that mean for a theoretical account of compositionality? First of all, it does not mean to abandon the Principle of Compositionality. As long as semantic composition follows rules and does not draw on extra-linguistic information, it is in accordance with PC. Sub-compositionality, however, requires a revision of HSS, the notion that semantic composition is a homomorphous picture of syntactic composition. While the classical approach assumes that the function that yields the meaning of the whole is determined by syntactic structure alone, we are now faced with cases where, in addition, the finer semantic types of the component expressions may matter. Note that this possibility, too, is covered by the phrasing of PC in its classical version. If the theory of compositional semantics is extended to more and more data, it might well turn out that sub-compositionality and the need of deep lexical decomposition is the rule rather than the exception. Other basic constructions that host a variety of sub-compositional sub-types may display a similar picture, for example the A_N construction. In fact, such constructions have led to similar considerations about the role of the lexicon in the determination of compositional regularities, e.g. Pustejovsky's conception of co-composition (this volume).

For the actual practice of doing analysis of semantic composition this means that it is no longer possible to more or less neglect lexical meanings, as has been common practice in MTS. Rather the analysis of composition has to be based, at least for some constructions, on a systematic decomposition of lexical meanings. This decompositional analysis would have to establish types of lexical meanings, and representations thereof, that allow an explanation of their compositional behaviour.

Such an approach is well in accordance with a cognitive perspective on composition. In actual semantic processing, lexical meanings are, of course, not only available as some idiosyncratic units of knowledge, but rather as instances of more general patterns of concepts. Thus, the information available for processing is not confined to individual lexical meaning plus some level of syntactic type. Rather it includes qua the structure of the lexical meaning the whole hierarchy of semantic types the lexical entry belongs to – and this information can naturally be fed into the semantic processing.

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