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SITUATION SEMANTICS AND SEMANTIC INTERPRETATION IN CONSTRAINT-BASED GRAMMARS

Per-Kristian Halvorsen

Xerox Palo Alto Research Center
3333 Coyote Hill Road, Palo Alto, CA 94304
and
Center for the Study of Language and Information
Stanford University

ABSTRACT

This paper considers semantic interpretation, particularly in situation semantics, using constraint-based approaches to linguistic analysis (e.g. LFG, FUG, PATR, DCG, HPSG). We show how semantic representations can be arrived at by means of constraints on the relationship between the form of an utterance and its meaning. We examine previous proposals for semantic interpretation in unification grammars, and find that a construal of the semantic constraints as specifying operations in a semantic algebra (as in Montague Grammar), as opposed to constraints on the relationship between syntactic form and meaning representations, has prevented the emergence of simple and powerful methods for deriving semantic analyses in constraint-based frameworks. Using the language for statement of semantic rules in LFG we present examples of an approach to semantics that is systematic without being compositional in the structure of the syntactic tree.

1 The Problem of Semantic Interpretation

The integration of syntactic and semantic processing has prompted a number of different architectures for natural language systems, such as rule-by-rule interpretation (Thompson 1963), semantic grammars (Burton 1976), and cascaded ATNs (Woods 1980). The relationship between syntax and semantics has also been of central concern in theoretical linguistics, particularly following Richard Montague's work, and with the recent rapprochement between theoretical and computational linguistics variations on Montague's interpretation scheme have been adopted and implemented in several syntactic theories with a significant following in computational linguistic circles. The first steps in this direction were taken by Hobbs and Rosenschein (1978). A parser for LFG was augmented with a Montagovian semantics by Halvorsen (1982, 1983). GPSG has been similarly extended by Gawron et al. (1982), and Schubert and Pelletier (1982) followed with a compositional interpretation scheme using a first order logic rather than Montague's computationally intractable higher-order intensional logic.

The introduction of constraint- or unification-based mechanisms[1] for linguistic description has had obvious effects on syntactic theory and syntactic description. The transformational idiom for syntactic description has been eschewed in favor of lexical rules and declarative statements of constraints on the correspondences between different levels of analysis. Semantic analyses have been integrated with several of the unification-based syntactic theories at an early point (Pereira 1983; Halvorsen 1983). But the new possibilities they create for architectures for semantic interpretation or the consequences for the Montagovian view of compositionality have not been widely considered. These possibilities and the impact of situation semantics (Barwise and Perry 1983) is the focus of this paper. We present a view of semantic interpretation based on the notion of structural correspondences and the theory of projections (Halvorsen 1987, Kaplan 1987, Halvorsen and Kaplan 1988). Semantic rules which specify constraints on the correspondence between linguistic form and descriptions of meaning, rather than operations on semantic (e.g. model-theoretic) objects are introduced. Meaning representations can then be determined in a systematic, yet not strictly compositional manner.

2 Unification and Interpretation

We view unification as a technique for combining information given certain facts about how the individual pieces of information relate to each other. The task

[1] All existing constraint-based systems in linguistics rely heavily on unification for finding structural analyses. When the type of constraints considered is extended beyond equational constraints (as in LFG) other solution mechanisms might prove as fruitful as unification. There is a potentially interesting correspondence here with the move from unification-based logic programming towards *constraint logic programming* (Jaffar and Lassez 1987).

of semantic composition is exactly of this nature. It is concerned with the combination of semantic information based on the relationship between the constituents in a phrase-structure tree or some other syntactic representation. The method for combination of information used in Montague grammar (MG) was function application and set formation, or equivalently, the operations of the lambda-calculus. This choice imposes certain restrictions on the manner of combination of information in the interpretation step. Specifically, it requires that the informational substructures to be combined are contiguous in the structure being interpreted. Unification supplemented with the flexible addressing scheme usually associated with it in computational linguistics permits a loosening of this restriction of contiguity.

2.1 Compositionality

A clearly desirable trait of any interpretation mechanism is that it be *systematic*. By this we simply mean that the interpretation of the utterance should be mechanically derivable from the information available given the rules of the interpretation scheme. One would also like for the interpretation mechanism to be *complete*. This means that all meaningful utterances in the fragment described should have an interpretation.

Compositionality is an additional requirement often viewed as important (Partee 1983). Under a strict interpretation a *compositional semantics* is one where the interpretation algorithm is recursive on the syntactic tree assigned to the utterance, and the *meaning* of a constituent is required to be a function of the meaning of its immediate constituents. Strict compositionality is not necessarily entailed by systematicity and/or completeness as defined here. However, as long as function application and set formation, or the operations of the lambda-calculus, provide the mechanism for composition of information, strict compositionality does follow from the systematicity requirement. But with new methods for composition of partial information, such as unification or even more general constraint satisfaction techniques, non-compositional alternatives which do not necessarily sacrifice systematicity become available.

The utility of the strict version of the compositionality hypothesis is also brought into question when we turn our attention from *meanings* to *interpretations*, i.e. from the consideration of the semantic potential of sentences or utterance types (meaning), to the impact of an utterance in a specific context (interpretation). Determination of interpretations calls for integration of information from various kinds of sources (e.g. linguistic and non-linguistic context) for which the structured semantic objects of situation semantics and the unification-based constraint-satisfaction techniques we employ are well-suited.

Developments both in grammatical theory and in logic serve as enabling conditions for a shift towards an approach to interpretation reflecting the partiality of the information about meaning made available through discourse, and permitting a systematic, yet not strictly compositional, characterization of meaning. The use of highly typed logics, such as Montague's intensional logic, has been supplemented by investigations of many-sorted logics for natural language semantics (Fenstad et al 1987). The highly typed semantics encouraged a hierarchical view of semantic composition to reflect the type structure. The use of many-sorted logics has promoted a flatter type-structure which eliminates this pull towards compositionality in the structure of the syntactic tree. Along another dimension, the focus on possible-worlds semantics has been expanded to include consideration of semantic systems with partial models, such as situation semantics (Barwise and Perry 1983, 1985). This corresponds well with the tendency in constraint-based systems to provide descriptions which are monotonically increasing in specificity. Situation semantics also provides structured semantic objects as interpretations for utterances (Gawron 1986). It is thus possible to refer to the constituent parts of interpretations, which enables us to explore other avenues to systematic interpretation than composition according to the syntactic phrase-structure.

3 Semantic Interpretation in Montague Grammar

Montague's theory of semantic interpretation is intriguingly elegant (Montague 1970). His model of language involved the construction of two algebras—a syntactic algebra and a semantic algebra.[2] The syntactic algebra provided a set of syntactic objects, i.e. the lexical items, and a set of syntactic operations (e.g. concatenation) defined over the union of the basic and derived syntactic objects. The semantic algebra consisted of a set of semantic objects (e.g. individuals and truth-values) and a set of semantic operations (e.g. function application and set formation) defined over the basic and derived semantic objects.

How, then, did Montague achieve such a successful statement of the relation between syntax and semantics, given the strict separation between the semantic and the syntactic domain, and given that the semantic rules themselves do not relate the syntactic and the semantic level? The answer lies in the structure of the syntactic and the semantic algebras. Montague demanded that there be a homomorphism from the syntactic algebra into the semantic algebra (see Figure 1).

This meant that for each of the syntactic operations there is a corresponding (possibly complex) semantic

[2]See Halvorsen and Ladusaw (1979) for a discussion of the relevant formal properties of Montague's theory of language and semantic interpretation.

Figure 1: Translation and interpretation through homomorphisms in Montague Grammar (after Halvorsen and Ladusaw 1979)

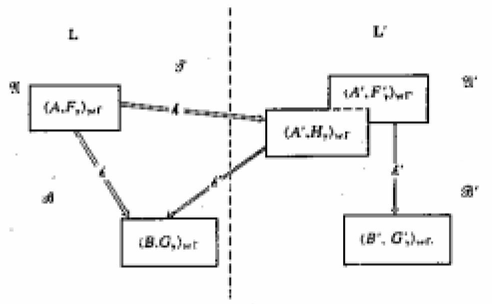


Fig. 1. The Translation Process.

k the translation function from L into L'
k' the meaning assignment determined for L' by $\mathcal{B}'$ (also guaranteed to be a meaning assignment for the derived syntactic algebra $\langle A', H_\gamma \rangle_{\gamma \in \Gamma}$ by Remark 1.)
h the meaning assignment determined for L by $\mathcal{B}$ the interpretation induced by the translation base into L'.

operation. The definition of the homomorphism determines directly what semantic rule can serve to interpret constructions derived by a given syntactic rule. It also provides an automatic "completeness"-proof for the interpretation system in that every well-formed syntactic object is guaranteed to have a corresponding well-formed semantic object (see Section 2.1). The result is the so-called "rule-to-rule" approach to semantic interpretation: An analysis for a sentence consists of two analysis trees, one for the syntax and one for the semantics. The application of a rule in the syntax is always mirrored by the application of the same semantic rule.

In Montague's approach to compositional semantics, the number and complexity of the operations in the semantic algebra are reflected directly in the operations in the syntactic algebra and the syntactic rules. Montague's semantic rules involve the the full range of semantic operations admissible in the semantic algebra, and they each correspond to distinct syntactic rules. In unification-based grammars there is, basically, only one compositional operation: unification. This creates problems for Montague's method for coordinating syntax and semantics through homomorphisms. The establishment of a homomorphism between the syntax and the semantics becomes difficult since the operational vocabulary employed in the syntax of unification grammars has been greatly simplified relative to Montague's system, while no similar simplification of the underlying semantic algebra has been proposed. In this new type of grammar one can not rely on homomorphisms to correlate syntax and semantics. We propose that the syntax/semantics interactions instead be related by rules which explicitly constrain the cooccurrence possibilities for structures on the different levels.

4 Semantic Interpretation in Constraint-based Grammars

It is important for the success of unification-based approaches to natural language processing that a semantic analysis can be provided using a restricted rule language, like the one employed for syntactic description, without loss of precision. In demonstrating this one can not rely on the accomplishments of Montague grammar, since, as was shown in Section 3, Montague's coordination of syntax and semantics based on homomorphisms does not carry over to constraint-based frameworks. In this section we present a model for semantic composition and semantic interpretation which is better suited for constraint-based theories of linguistic processing. In the process, our constraint-based system is contrasted with the most prominent distinguishing features of Montague grammar.

Our model of semantic interpretation (Figure 2) is based on the view that there are several information sources which are of semantic relevance (e.g. constituent-structure and functional structure).[3] We formalize the informational dependencies in terms of constraints on the *structural correspondences* (Kaplan 1987) between representations of the different formal aspects of the utterance and the interpretation. The theory of *projections* sets out the details of how information flows between the different levels of representation (Halvorsen 1987; Halvorsen and Kaplan 1988). Syntactic phrase-structure rules annotated with functional and semantic descriptions are used to express the connection between syntax and semantics (Figure 3). We are operating with a level of semantic representation intermediate between syntactic structure and interpretations, but these representations are different from phrase-structural and functional representations in that they are model-theoretically interpreted or have associated proof-theories.[4]

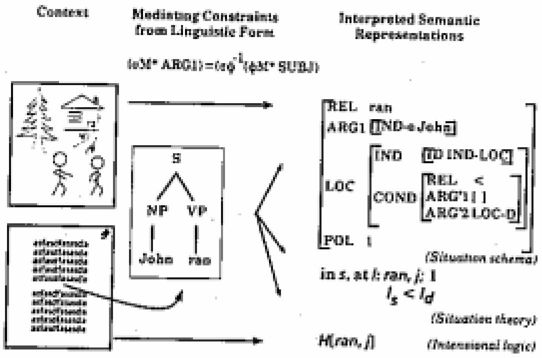
4.1 Semantic Rules vs. Semantic Constraints

The *semantic constraints* (or *semantic equations*) which appear as annotations on the phrase-structure rule in Figure 3 are the constructs corresponding most closely to *semantic rules* in Montague grammars. But Montague's semantic rules operate exclusively in the semantic domain: They specify semantic operations (e.g. function application or abstraction) on semantic objects (e.g.

[3]Prosodic structure, discourse context, as well as physical and pragmatic constraints in the situation being described are crucial for interpretation, but not considered here.

[4]In our descriptive work we have utilized representations in Montague's higher order intensional logic (Halvorsen 1982, 1983), situation schemata (Fenstad et al. 1985, 1987), and PROSIT, a language for reasoning with situation theory (Nakashima et al. 1988).

Figure 2: Integration of semantic information



sets). The semantic constraints in unification grammars, on the other hand relate several levels of linguistic description.

Figure 3: Phrase-structure rules annotated with semantic and functional descriptions:

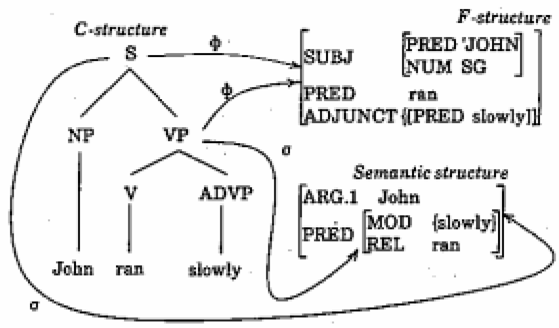
$$S \longrightarrow \underset{(\phi\mathcal{M} * \texttt{SUJB}) = \phi *}{NP} \quad \underset{\substack{\phi\mathcal{M}* = \phi* \\ (\sigma\mathcal{M} * \texttt{PRED}) = (\sigma *)}}{VP}$$

$$VP \longrightarrow V \quad \underset{\substack{\phi* \in (\phi\mathcal{M} * \texttt{ADJUNCTS}) \\ \sigma* \in (\sigma\mathcal{M} * \texttt{MOD})}}{ADVP}$$

Consequently, the S-rule in Figure 3 performs several functions. First, it admits a certain phrase-structure configuration: S dominating an NP and a VP. Second, the association of elements of the rule with annotations express constraints on the correspondence between phrase-structure configurations and other levels of analysis (*projections*). The annotations fall into two categories: The function ϕ maps from phrase-structure nodes to functional structures. Semantic structures are related to phrase-structure nodes by means of the function σ.[5] Finally, the σ-equations themselves indicate how to combine partially specified semantic structures in order to successively approximate an interpretation for the entire sentence. The ϕ-equations do the same for the functional projection. In particular, the annotation on the NP states that this node (denoted by $*$) has a mother ($\mathcal{M}*$, i.e. the S-node), which again has a functional structure ($\phi\mathcal{M}*$), and the statement ($\phi\mathcal{M} * $ SUBJ) asserts that this functional structure has a SUBJ attribute. The value of this attribute is then asserted to be equal to the value of the functional structure of the NP, ($\phi*$). The σ-equations on the VP node ensure that the content of the VP is accessible under the semantic PRED attribute as a subpart of the content of the S node. Together the rules in Figure 3 serve to relate the three structures in Figure 4 to give a syntactic and semantic analysis for the sentence *John ran slowly.*

[5]See Halvorsen and Kaplan (1988) for details.

Figure 4: C-structure, semantic structure, and functional structure related by constraints



Notice that in Figure 4 the functional structure attribute, ADJUNCT and the semantic structure attribute MODifier are introduced in the same rule and associated with the same phrase, but the ADJUNCT is located at the sentence level, while the semantic MODifier is on the VP level. This illustrates that the semantic structure is not a simple image of the functional structure.

4.2 Description vs. Construction

The perspective prevalent in constraint-based systems draws a distinction between *description* of structures and the *construction* of structures. Montague's semantic rules specify how to *construct* the semantic objects which are the interpretations of sentences by telling us what semantic operations to apply to what semantic objects. In particular, the MG rule in Figure 5 states that the semantic object which is the meaning of the VP is constructed by applying the function which is the interpretation of the ADVP constituent to the meaning of the V constituent.

Figure 5: Montague grammar rule for VP adverbs

$$\text{VP} \rightarrow \text{V ADVP} \triangleq [\![\text{ADVP}]\!]([\![V]\!])$$

In contrast, the semantic descriptions of the annotated phrase-structure rules specify *properties* of the semantic objects which can serve as interpretations for the syntactic configurations they are associated with, but they do not constitute a step-by-step algorithm for construction of the interpretations. Unification is not an operation on the objects in an underlying semantic algebra. Unification is simply used to combine *descriptions* of semantic objects. The annotated phrase structure rules in Figure 3 expresse that the $[V\ ADVP]_{VP}$ configuration in the domain of phrase-structures is *correlated* with the occurrence of a semantic structure which has a PRED attribute associated with the semantic structure of the VP and where the interpretation of the adverb is the value of the MODifier attribute which is encapsulated in the PREDicate together with the semantic structures of other elements of the VP, e.g. the verb *run* (cf. Figure 4). Any semantic representation, however constructed, which satisfies this description (and possibly other more specific descriptions), satisfies the semantic constraints of the annotated rules in Figure 3.

4.3 Partiality and Non-compositionality

Semantic interpretation in unification grammar typically has the property that the information that is associated with a constituent at any one point in the analysis only provides a partial description of the interpretation of the constituent. Moreover, information relating to the the interpretation of a phrase can originate not only from its immediate constituents, but from noncontiguous phrases, as well as from context and other levels of analysis. This entails a divergence from a strictly compositional approach to semantic interpretation, but not an abandoning of a systematic algorithm for interpretation.

5 Other Views of Semantic Interpretation in Unification Grammars

Cooper has taken another approach to interpretation in unification grammars (Cooper 1985; 1986). Cooper views what we are calling semantic constraints as specifying semantic operations on semantic objects. Since unification is the only operation available in the constraint language in the grammatical theory he is using, it follows that unification takes on the role as the single most important semantic operation. This contrasts with our view where unification only functions to combine *descriptions* of semantic objects. According to Cooper's theory, the semantic equations of the PATR-style rule below, imply an instruction to unify the interpretation of the S node with the interpretation of the VP node, and to unify the interpretation of the (subject) NP with the second argument role of the VP, which is an unsaturated state of affairs.[6]

```
(S NP  VP
       (((0 syntax) (2 syntax))
       ((2 syntax form) finite)
       ((0 semantics) (2 semantics))
       ((1 semantics) (2 semantics arg1))))
```

If one restricts one's attention to a small fragment of English, it is possible to maintain that the only semantic operation needed is akin to unification. This is the case if the semantic operations involved only have the effect of (a) introducing (possibly unsaturated) states of affairs; or (b) filling argument positions in states of affairs. But if one wants to utilize the full range of semantic operations available in situation theory, this parallel between the operations available in the language of semantic descriptions and the operations in the semantic algebra breaks down. Specifically, situation theory allows the formation of conditions from collections of parameterized states of affairs and the formation of types from collections of conditions. The standard treatment of VPs in situation semantics provides them with types as interpretations. Thus, the interpretation of the phrase *kiss Mary* in Cooper (1985) is the following type:

$$[\mathrm{s}| < l, kiss, \mathrm{s}, Mary, 1 >] \quad (1)$$

While the semantic operations involved in filling argument positions can be viewed as a natural extension to the notion of unification as used in the propagation of information in the syntactic derivation, the operation of type formation does not fit into this mold equally well. Some flexibility can be achieved by defining the unification operation to give different results when applied to different types of semantic objects, but this flexibility is not enough to allow us to hold forth unification as the only semantic operation in the semantic algebra.

We maintain that the constraints on the syntactic rules licensing the phrase VP *kiss Mary* should be understood as characterizing properties of the type which can serve as the interpretation for the VP by reference to the different parts of the description of the type (i.e.

[6] A state of affairs contains a relation, its arguments, and a polarity: $< walk, John; 1 >$. An unsaturated state of affairs is a state of affairs with one or more of its arguments (or the polarity) left unspecified.

its parameter, s, its body, $< l, kiss, s, Mary, 1 >$, and the identical labelling of the parameter and the kisser-role of the relation). Unification does play an important role in semantic interpretation in constraint-based grammars, but not because unification necessarily is an operation in the semantic algebra. Rather, unification serves to combine the constraints on the relationship between syntactic structure and meaning representations provided by the annotated phrase-structure rules.

6 Grammatical Relations and Interpretation

If the coordination between syntax and semantics is not automatically achieved by virtue of a general correspondence (e.g. homomorphism in Montague grammar), we have to introduce some additional mechanism for correlating predicates and arguments with verbs and phrases in the syntactic tree. Simple heuristics based on order of occurrence in the surface string are not reliable. Other proposals for semantic interpretation in situation semantics make reference in the semantic objects themselves to grammatical relations. The objective is to attain the correct predicate-argument relations in the face of relation-changing linguistic rules such as passivization (*John kicked Pluto* vs. *Pluto was kicked by John*). These rules complicate the relationship between surface order of phrases and their argument roles. In an active sentence with the verb *kick* the first NP denotes the kicker (agent), but in the corresponding passive sentence the first NP denotes the thing which was kicked. Cooper (1985; 1986) suggests the use of different indeterminates for the various grammatical functions (e.g. s, a subject indeterminate; o an object indeterminate). In (1) this device is used to express the restriction that the meaning which is to be unified with the s indeterminate in the meaning for *kiss Mary* has to derive from a phrase carrying the grammatical relation of *subject* in an utterance. Similarly, Gawron (1986) makes use of semantic objects, so called labelled indeterminates, where grammatical relations label argument roles (Figure 6).[7]

The argument roles of a verb like *hand* can be filled in different ways. The role of the recipient can either be filled by the object as in *The boy handed the girl the toy*, or by a prepositional phrase (a so called TO-OBJ) as in *The boy handed the toy to the girl*. These two possibilities correspond to the differently labelled indeterminates, $\$y$ and $\$z$, in Figure 6. Gawron proposes a set of semantic rules operating on the labelled objects. One of these rules, the QI (Quantifying In) Rule (see (2)) is used in the composition of NP meanings (which are parametric indeterminates) with the situation types (i.e. labelled indeterminates) associated with verbs, verb-phrases and sentences.

[7]Here and in the following we will identify the argument roles of *hand* with argument positions: The hander-role is associated with the first argument position the recipient-role is associated with the second argument position; and the object-transferred role is associated with the third argument position.

Figure 6: Labelled indeterminates: *hand* (Gawron 1986)

$y={<	LOC	$LOC0
	REL	hand
	SUBJECT	$IND0
	OBJECT	$IND1
	OBJ2	$IND2
	POL	$POL0>}
$z={<	LOC	$LOC0
	REL	hand
	SUBJECT	$IND0
	TO-OBJECT	$IND1
	OBJECT	$IND2
	POL	$POL0>}

$$QI([\![XP]\!]\ FUN\ [\![HEAD]\!]) = \cup([\![XP]\!]\ B([\![XP]\!] : ARG\ FUN[\![HEAD]\!])) \quad (2)$$

The QI rule takes an indeterminate ⟦XP⟧, a label FUN, and a second indeterminate ⟦HEAD⟧. It produces another labelled indeterminate which consists of the union of the indeterminate ⟦XP⟧ and a new labelled indeterminate which results from substituting the ARG value of ⟦XP⟧ for the value of FUN in ⟦HEAD⟧. Gawron points out that the effect of applying QI to labelled indeterminates expressing the same content, but labelled differently, produces semantic objects with clearly different contents. His examples are (3) and (4), where $\$y$ and $\$z$ are the labelled indeterminates in Figure 6. $\$y$ and $\$z$ are labelled indeterminates both expressing the same content and differing only in their labelling.

$$QI([\![the\ girl]\!]\ OBJECT\ [\![\$y]\!]) \quad (3)$$

$$QI([\![the\ girl]\!]\ OBJECT\ [\![\$z]\!]) \quad (4)$$

In (3) *the girl* will be associated with the recipient role of *hand*, whereas in (4) *the girl* becomes the transferred object. This means that the meaning (here content) of a constituent is no longer a *function* of the meanings (contents) of its parts. The meaning function also depends on the labelling of the contents. Based on this Gawron concludes that direct interpretation in Montague's sense is not possible in his theory: The labelled semantic objects are a crucial intermediate stage in the interpretation process.

The approach which is advocated here makes it unnecessary to allow reference to grammatical relations in the semantic objects. By limiting the use of grammatical relations to the constraints expressing conditions on the correspondence *between* the phrasal, functional and semantic structures, we avoid the problems pointed out by Gawron (1986). In our approach, the correlation of grammatical relations and semantic argument roles are accomplished in the annotations on the lexical items, and these annotations express constraints on the relationship between functional structures and semantic structures. We do not need to import concepts from the analysis of grammatical relations into the semantic analysis. Consider the lexical item for *hand* as it occurs in the sentence *The boy handed the toy to the girl*:

hand V $(\phi\mathcal{M}*\ \mathtt{PRED})=\text{'hand'}$
$(\sigma\mathcal{M}*\ \mathtt{REL})=\text{hand}$
$(\sigma\mathcal{M}*\ \mathtt{ARG1})=\sigma(\phi^{-1}(\phi\mathcal{M}*\ \mathtt{SUBJ}))$
$(\sigma\mathcal{M}*\ \mathtt{ARG2})=\sigma(\phi^{-1}(\phi\mathcal{M}*\ \mathtt{TO\text{-}OBJ}))$
$(\sigma\mathcal{M}*\ \mathtt{ARG3})=\sigma(\phi^{-1}(\phi\mathcal{M}*\ \mathtt{OBJECT}))$

We use the theory of projections to relate information about grammatical relations and semantic roles (Halvorsen and Kaplan 1988). Recall that the ϕ-projection maps c-structure into f-structure and the σ-projection maps c-structure into semantic structure. We can use the composition of the σ-projection with the inverse of the ϕ-projection, $\sigma \circ \phi^{-1}$, to express the fact that the subject of *hand* fills the first argument (giver) role. Thus $(\sigma\mathcal{M}*\ \text{ARG1})=\sigma(\phi^{-1}(\phi\mathcal{M}*\ \text{SUBJ}))$ states that the semantic structure of the first argument of the verb *hand*, $(\sigma\mathcal{M}*\ \text{ARG1})$, is the semantic structure corresponding to the node, or set of nodes, associated with he functional subject of the verb $\sigma(\phi^{-1}(\phi\mathcal{M}*\ \text{SUBJ}))$. Similarly, the last two lines of equations in the lexical entry for *hand* relate the recipient role in the semantic structure to the TO-OBJ and the transferred object to the OBJECT. The relation changing rules of LFG, such as Dative Alternation, can apply without modification to the entry above and give the correct predicate argument associations for sentences like *The boy handed the girl the toy*.

Reference to grammatical features, such as grammatical relations, belong in the *inter-module* constraints which characterize the relationship between the phrase-structure, the functional structure and the semantic representation of a sentence. On the other hand, semantic operations, such as quantification (cf. the QI rule), may properly be a part of the semantic algebra, but they need not figure in the statement of the semantic constraints.

7 Conclusions

Adoption of a constraint-based approach to semantic composition invites a perspective on interpretation where partial information about the interpretation of phrases originate in the lexical items, in the constituent structure and in the functional structure, as well as in other modules of linguistic analysis. Descriptions of the interpretation of phrases are accumulated incrementally and the interpretation associated with a constituent can be affected by non-local context. This contrasts with the derivational (or constructive) and strictly compositional approach to interpretation advocated in Montague grammar.

The rule language of unification grammars is strongly limiting in the operations it makes available. Most theories of natural language semantics, on the other hand, make use of a rich arsenal of semantic operations. This difference is a source of problems for Montague's homomorphism-based strategy for interpretation if one takes semantic constraints in unification grammars to specify semantic operations. We have sketched a different view of semantic interpretation in unification grammars where unification of descriptions of semantic representations are used to characterize the class of objects that can serve as interpretations for an utterance. Through a simple extension to the rule language used for syntactic analysis in LFG, we are able to express semantic constraints that are sensitive to a combination of phrasal, functional and, potentially, other properties of the utterance.

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