Underspecified Semantic Composition

1 Summary So far, Where next?

We've seen that creating a satisfactory semantics for CCG (or variants withing the GCG framework) which closely couples syntactic and semantic operations and uses the typed lambda calculus (LC) is difficult because either the syntax or semantics becomes unnecessarily complex and because beta-reduction is syntactically difficult to work with. We have also seen that it is impossible to solve the issue of quantifier and logical operator scoping ambiguities in any framework that enforces strict syntax-determined translation to LC or FOL, but that underspecified representations of generalized quantifiers and operator scopings are possible, which expand to capture all and only the possible scoped interpretations within FOL or within relatively benign extensions of FOL to handle modal operators such as *possible* and non-FOL quantifiers such as *most*. We have also seen that we can extend out FOL semantics to handle phenomena such as adverbial modification (by PP or AdvP) or tense by reifying events and adopting a (neo-)Davidsonian semantics.

The following sketches how we can integrate these insights about robust computationally-tractable semantics with CCG. However, it assumes you have read or will read the three papers in Reading below in conjunction with the handout as I don't repeat the details from the papers (esp. Copestake, 2007).

2 Wide-coverage Event-based Semantics for CCG: Bos *et al.*

Bos *et al.* (2004) (see Reading) show how to derive FOL neo-Davidsonian representations from CCG derivations using the lambda calculus by assigning lambda functions to complex CCG categories (e.g. (S\ NP)/NP λ P,y,x [P(x y)]) and defining decomposed function application schemes to associate with combinatory and type changing rules. The decomposition operator circumvents some of the problems raised in Handout 2. The paper is the first to show that it is possible to derive a logical semantic representation compositionally from a wide-coverage state-of-the-art parser applied to real data and evaluate the well-formedness of the resulting represenations. However, the resulting semantics doesn't handle scope underspecification or integrate with generalized quantifiers, it introduces argument relations like *agent* and *patient* which lack a coherent semantics (see discussion in Copestake RMRS draft referenced in Handout 2), and it doesn't handle 'construction-specific semantics' (e.g. a noun compound such as *steel warehouse* can mean warehouse *for* steel or warehouse *of* steel, so the N/N + N forward application rule needs to be sensitive to whether it is forming a compound or combining an adjective and noun, because for the compound an adequate semantics will introduce an additional underspecified relation: steel(x) $\wedge$ warehouse(y) $\wedge$ R(x,y)).

3 MRS Composition for CCG

MRS: An Introduction (see Reading below) goes over the motivations for underspecification, describes in detail an approach which is compatible the generalized quantifier approach to natural language quantification, and outlines a preliminary theory of MRS composition. What follows is based on Copestake (2007) (see Reading) which develops the theory of (R)MRS underspecification and composition so that it is applicable to any syntactic framework and degree of syntactic information, in principle. The paper shows how a very underspecified RMRS representation can be extracted from a PoS tagger, whilst a more specified one can be extracted from a parser like RASP which returns syntactic trees but doesn't utilize a lexicon of complex categories / supertags like CCG which encode subcategorisation or predicate valency information.

To extract MRS representations for CCG we start like Bos *et al.* by assuming that (complex) lexical categories are asociated with elementary predications and any arguments encoded in the category (e.g. *kiss* : (S\ NP)/NP : l1,a1,kiss(e1), l2,arg1(a1,x1), l3,arg2(a1,x2) where *lN* is a label and aN is an anchor (see discussion of Fig 6 in Copestake, 2007 for the need for anchors as well as labels). Closed-class vocabulary such as qunatifiers, negation etc is assigned a lexical semantics as in standard (R)MRS, and the combinatory and unary (type-changing) rules must be coupled with semantic operations which handle different types of constructions (e.g. FA must be able to build the appropriate semantics for NP/N + N and for (S\ NP)/NP + NP, in MRS terms scopal combination, op_{spec} and op_{obj} respectively). In other words, we have an even worse construction-specific semantic problem than Bos *et al.* do because we no longer have access to a relatively generic notion of function-argument application within the typed lambda calculus to associate with combinatory rules, and are instead relying on composing our semantics by binding variables in a construction-specific way.

To date, no-one has worked out such a semantics in detail, however, below I sketch one approach which I think combines the best of MRS with the best of CCG syntax without complicating either unnecessarily. it is close to Copestake's (2007) approach to CFG+MRS as exemplified in Fig3 of that paper because it exploits the fact that CCG complex categories encode information about their arguments, and thus represent the same local constructional information as a CFG PS rule. (The approach could also be represented in terms of typed feature structures and unification, see Copestake *et al.*, section 5+, but this would take us too far from frameworks covered in the course so far.)

A semantic derivation for *A person kisssed Kim*

	Hooks	**Slots**	**Rels**	**(Q)Eqs**
a	l1,x1	l2,$x1_{spec}$	l3 a(x1)	h2 $=_q$ l2
			l3 rstr(h2)	
			l3 body(h3)	
person	l4,x2		l4 person(x2)	
NP/N+N	l1,x1			l2=l4
op_{spec}				x1=x2
kissed	l5,$e1_{past}$		l5 kiss(e1)	
		l6,$x3_{arg1}$	l5 arg1(e1,x3)	
		l7,$x4_{arg2}$	l5 arg2(e1,x4)	
Kim	l8,x5		l6 kim(x5)	
(S\NP)/NP+NP	l5,a3,e1			l7=l8
op_{arg2}				x4=x5
(S\NP)+NP	l5,a3,e1			l2=l6
op_{arg1}				x1=x3

Given this approach, the combinatory and unary rules do not need to be associated with a semantics because the semantics is pushed onto the (complex) categories associated with lexical items. By adding features to syntactic categories we can ensure we associate the right construction semantics with subtypes (e.g. for noun compounds $N/N_{nc} \mapsto op_{nc}$ as opposed to adjectives N/N_{adj}, etc).

4 Exercise

Write out the final MRS for the example above.

Work out the semantic derivation for:
Most men probably likes some woman

5 Reading

Wide-Coverage Semantic Representations from a CCG Parser. Johan Bos, Stephen Clark, Mark Steedman, James R. Curran and Julia Hockenmaier. Proceedings of COLING-04, pp.1240-1246, Geneva, Switzerland, 2004. http://www.cl.cam.ac.uk/sc609/pubs.html

Sections 1–4 from Ann Copestake *et al.*, 'Minimal Recursion Semantics: An Introduction' http://www.cl.cam.ac.uk/users/aac10/papers/mrs.pdf

Ann Copestake. Semantic composition with (Robust) Minimal Recursion Semantics. In: Proceedings of the ACL-07 workshop on Deep Linguistic Processing, pages 73-80. Prague, 2007. http://www.aclweb.org/anthology/W/W07/W07-1210.pdf