Logic, Lambdas, Vectors, and Concepts

Reinhard Muskens

Tilburg University
r.a.muskens@gmail.com
http://freevariable.nl

In this talk I will consider a range of approaches to modelling natural language meaning and explore possibilities to combine them. One approach I will consider is the one that I am most familiar with. It stems from Richard Montague's [4] observation that natural languages and logical languages can be treated on a par. Let's call this the *logical* approach. Another approach will be the *distributional* one, characterised by Firth's dictum that "you shall know a word by the company it keeps". A third category of approaches can be called *conceptual*. It includes forms of semantics that build on Peter Gärdenfors's [2] theory of "Conceptual Spaces", but also theories such as the one in Löbner [3], which is based on Barsalou's [1] frames.

Can these theories be combined? In particular, can work in the logical tradition be combined with any of the other theories? This would possibly be advantageous, as the virtues of the logical approach and any of the other approaches tend to be complementary. If a combined theory could be made to work, we could potentially profit from the best of two worlds.

One virtue that the logical tradition can bring to other approaches is *ease of composition*. In the talk I will emphasise that logical semantics in fact consists of two components. The first is the use of the (simply) typed lambda calculus as a composition engine. The second is logic in a more narrow sense, some theory of operators such as $\neg$. $\vee$, $\wedge$, $\forall$, $\exists$, $\Box$, $\Diamond$, and friends. It is entirely possible to have the first component without having the second and in fact in joint work with Mehrnoosh Sadrzadeh (e.g. [5]) we have used the lambda calculus to provide phrases with vector-based meanings on the basis of vector-based word meanings. The typed lambda calculus is a general theory of typed functions and in itself it is quite neutral with respect to the kind of functions it is applied to. It is also the case that many theories of syntax have a simple interface with semantics via lambdas. This means that once a semantic theory has been provided with a compositional mechanism via the lambda calculus, it will also connect with those syntactic formalisms.

I will explore to what extent this mechanism could also be put to use in the approaches to semantics I have dubbed "conceptual" and what may be good ways to combine the resulting compositional conceptual semantics with a logical semantics based on truth-conditions.

References

1. Barsalou, L.: Perceptual Symbol Systems. Behavioral and Brain Sciences **22**, 577–660 (1999)

2. Gärdenfors, P.: Conceptual Spaces: The Geometry of Thought. MIT Press (2004)
3. Löbner, S.: Functional Concepts and Frames. In: Gamerschlag, T., Gerland, D., Osswald, R., Petersen, W. (eds.) Meaning, Frames, and Conceptual Representation, pp. 15–42. Düsseldorf University Press, Düsseldorf (2015)
4. Montague, R.: The Proper Treatment of Quantification in Ordinary English. In: Hintikka, J., Moravcsik, J., Suppes, P. (eds.) Approaches to Natural Language, pp. 221–242. Reidel, Dordrecht (1973), reprinted in [6]
5. Sadrzadeh, M., Muskens, R.: Static and Dynamic Vector Semantics for Lambda Calculus Models of Natural Language. Journal of Language Modelling **6**(2), 319–351 (2019)
6. Thomason, R. (ed.): Formal Philosophy, Selected Papers of Richard Montague. Yale University Press (1974)