

# Quantification and Scope in Categorical Compositional Distributional Semantics

Jules Hedges and Mehrnoosh Sadrzadeh

Department of Computer Science, University of Oxford,  
School of Electronic Engineering and Computer Science, Queen Mary University of London

**Abstract.** Categorical compositional distributional semantics is a model of natural language; it combines the statistical vector space models of words with the compositional models of grammar. We formalise in this model the generalised quantifier theory of natural language, due to Barwise and Cooper. The underlying setting is a compact closed category with bialgebras. We start from a generative grammar formalisation and develop an abstract categorical compositional semantics for it, then instantiate the abstract setting to sets and relations and to finite dimensional vector spaces and linear maps. We prove the equivalence of the relational instantiation to the truth theoretic semantics of generalized quantifiers. The vector space instantiation formalises the statistical usages of words and enables us to, for the first time, reason about quantified phrases, sentences compositionally, and quantifier scope in distributional semantics.