Learning word meaning by inferring speakers' intended referents:

An incremental approach to socially-guided statistical learning

Michael C. Frank

Department of Psychology, Stanford University

Molly L. Lewis

Department of Psychology, Stanford University

Noah D. Goodman

Department of Psychology, Stanford University

Many thanks to ...

Please address correspondence to Michael C. Frank, Department of Psychology, Stanford University, 450 Serra Mall (Jordan Hall), Stanford, CA, 94305, tel: (650) 724-4003, email: mcfrank@stanford.edu.

Abstract

How do children learn word meanings?

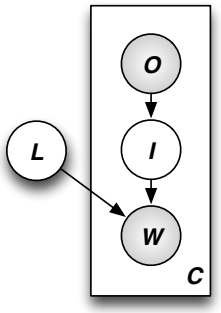

Figure 1. Caption.

Introduction

Model

Model Specification

By Bayes' rule:

$$P(I,L|C) \propto P(C|I,L)P(I,L). \tag{1}$$

$$P(I,L|W,O) \propto P(W,O|I,L)P(I,L). \tag{2}$$

But the objects O are observed in the context. In addition, for simplicity, we assume that there is a uniform prior over possible intentions (though we return to this issue in the Discussion). By the generative model in Figure 1, the remaining expression can be factored as follows:

$$P(I,L|W,O) \propto P(W|I,L)P(I|O)P(I)P(L). \tag{3}$$

But now we integrate over all possible L:

$$P(I|W,O) \propto \int_L P(W|I,L)P(I|O)P(I)P(L) \tag{4}$$

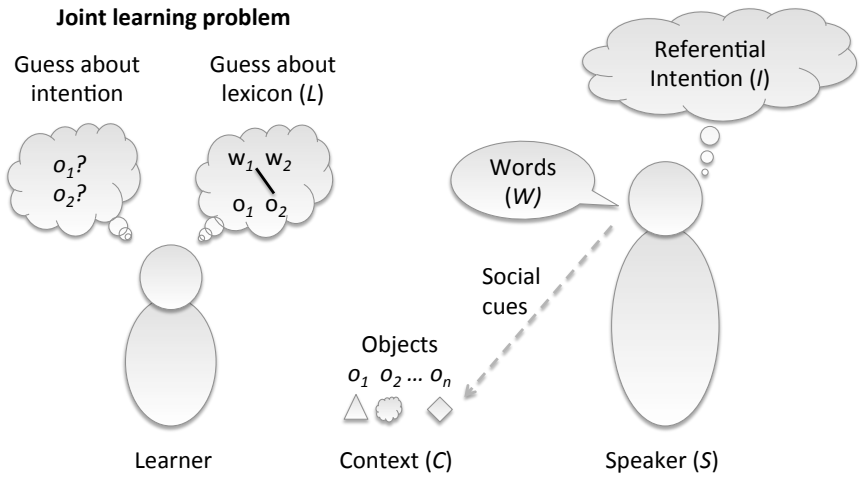

Figure 2. Caption. From Frank (in press).

In this model, the lexicon L consists of two separate parts. The referential lexicon L_R is a set of integrated Dirichlet-Multinomial distributions, one for each object in the world. This distribution represents the posterior probability of a particular word, relative to that object.

$$P(L) = \prod_{o \in W} P(L_{R_o}) + P(L_{NR}). \tag{5}$$

$$P(W|I,L) = \gamma \tag{6}$$

$$p(w|I,R,L_R,L_{NR}) = p(w|O_i) * prod_{s \in S-S_r} P(W_s|L_{NR})$$

Inference

Batch inference using a gibbs sampler.

Incremental inference using a particle filter.

$$P_t(L|W_{1\ldots t}, O_{1\ldots t}) = P_{t-1}(L|\ldots)P(I_t|W_t, O_t) \tag{7}$$

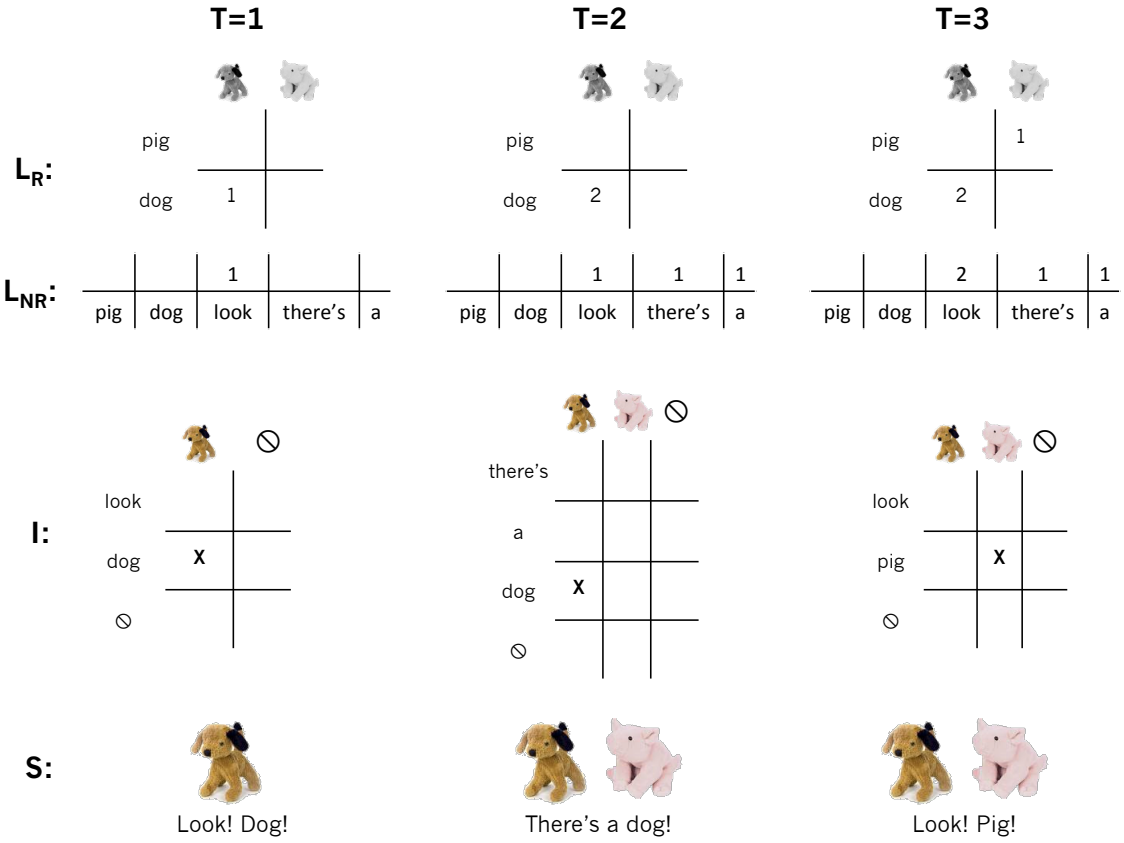

Figure 3. Caption.

Simulations

Cross-situational word learning with adults

Yu & Smith (2007).

Experiments with children

Disambiguation.

Dewar & Xu (2007).

Corpus simulations

Rollins subset (Frank, Goodman, & Tenenbaum, 2009)

Fernald & Morikawa (Johnson, Demuth, & Frank, 2012)

Discussion