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Authors

Perfors, Amy
Kemp, Charles
Tenenbaum, Josh
[et al.](#)

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Learning Inductive Constraints: The Acquisition of Verb Argument Constructions

Amy Perfors (perfors@mit.edu)

Charles Kemp (ckemp@mit.edu)

Josh Tenenbaum (jbt@mit.edu)

Elizabeth Wonnacott (liz@ewonnacott.co.uk)

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Introduction

Children seeking to learn about the world are faced with the need for inductive constraints: without them, every datum may have an infinite number of possible interpretations. We suggest that hierarchical Bayesian models (HBMs) can help to explain the computational principles that might allow these constraints to be learned, and demonstrate this by exploring how a simple HBM – a Dirichlet-multinomial model – can explain important aspects of the acquisition of verb argument constructions. HBMs learn on multiple levels simultaneously, inferring which hypothesis best accounts for some data as well as which is the best higher-level hypothesis (overhypothesis) about the nature of the lower-level hypotheses.

For instance, if the data is a set of sentences, the hypotheses might pertain to which verbs are grammatical in which sentence constructions (verb “sub-categorization”), and the overhypotheses might be information about what those hypotheses could look like: do verbs tend to occur in multiple constructions, or in just one? Which constructions are most common in the language as a whole? Our model has been previously shown to capture overhypotheses about feature variability and the learning of the shape bias (Kemp, Perfors, & Tenenbaum, 2007). The acquisition of verb argument constructions is additionally interesting for several reasons.

Learning verb argument constructions

One issue in learning verb argument constructions is whether the child can identify grammatical combinations of verbs and constructions simply from distributional information abstracted from exposure to the input (Pinker, 1989; Braine & Brooks, 1995). Another issue is how to capture the role of verb-specific and more abstract biases in sentence processing (Juliano & Tanenhaus, 1994). A recent Artificial Language Learning demonstrated that (adult) learners do acquire verb-specific statistics, although the usage of these statistics depends upon the overall distributional properties of the language, which suggests the necessity of over-hypotheses. Our model accounts for performance in these tasks. It can acquire both specific and general knowledge about the distribution of verb argument constructions on the basis of realistic child-directed syntactic input alone (from CHILDES) and it qualitatively matches the pattern of acquisition in children, in which there is little generalization in the early stages, but later, generalization occurs, particularly with low-frequency verbs (Theakston, 2004). It can also explain why in some

circumstances novel constructions are easier to learn when anchored by a highly frequent verb (Goldberg, Casenhiser, & Sethuraman, 2006).

Other computational models of verb construction learning perform inference on multiple levels: for instance, the models of both Alishahi and Stevenson (2005) and Dowman (2000) can learn information about both verb constructions and specific verbs. However, neither model learns about variability on both levels, which is necessary to explain the “anchoring” effect of highly frequent verbs (Goldberg et al., 2006) as well as people’s performance in the artificial language learning tasks of Wonnacott, Newport, and Tanenhaus (in press). Furthermore, the fact that our model can also apply to non-linguistic phenomena like the shape bias suggests that it may be valuable to view aspects of domain-specific verb construction knowledge as a solution to the deeper, domain-general problem of learning inductive constraints.

In sum, we present a simple domain-general model of learning overhypotheses that can address a number of issues surrounding the acquisition of verb argument constructions. By learning about variability on multiple levels simultaneously, the model captures a range of phenomena, and also suggests the utility of viewing the learning verb argument constructions as a specific application of the broader problem of learning inductive constraints in general.

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