

# Anatomy of a Scholarly Article

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## A Cognitive Model for the Representation and Acquisition of Verb Selectional Preferences

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### Abstract

We present a cognitive model of inferring verb selectional preferences from individual verb usage. The selectional preferences for each verb argument are represented as a probability distribution over the set of semantic properties that the argument can possess—a semantic profile. The semantic profiles yield verb-specific conceptualizations of the arguments associated with a syntactic position. The proposed model can learn appropriate verb profiles from a small set of noisy training data, and can use them to simulate human plausibility judgments and analyzing implicit object alternation.

over all the classes that can occur in that position. Ruvink's model was proposed as a model of human learning of selectional preferences that made minimal representational assumptions; it showed how such preferences could be acquired from usage data and an existing conceptual hierarchy. However, his and later computational models (see Section 2) have properties that do not match with certain cognitive plausibility criteria for a child language acquisition model. All these models use the training data to "teach models", and most of them use information theoretic measures that rely on total counts from a corpus. Therefore, it is not clear how the representation of selectional preferences could be updated incrementally in these models as the person receives more data. Moreover, the assumption that children have access to a full hierarchical representation of semantic classes may be too strict. We propose an alternative view in this paper which is more plausible in the context of child language acquisition.

In previous work (Alshabli and Niswanjan, 2007), we have proposed a usage-based computational model of early verb learning that uses Bayesian clustering and prediction to model language acquisition and use. Individual verb usages are incrementally grouped to form emergent classes of linguistic constructions that share semantic and syntactic properties. We have shown that our Bayesian model can incrementally acquire a general conception of the semantic roles of predicates based only on exposure to individual verb usages (Alshabli and Niswanjan, 2007). The model forms probabilistic associations between the semantic properties of arguments, their syntactic positions, and the semantic properties

|             | Alternating verbs | Non-alternating verbs |
|-------------|-------------------|-----------------------|
| Agent       | 0.75              | 0.50                  |
| Instrument  | 0.50              | 0.50                  |
| Location    | 0.50              | 0.50                  |
| Time        | 0.50              | 0.50                  |
| Quantity    | 0.50              | 0.50                  |
| Quality     | 0.50              | 0.50                  |
| Material    | 0.50              | 0.50                  |
| Direction   | 0.50              | 0.50                  |
| Force       | 0.50              | 0.50                  |
| State       | 0.50              | 0.50                  |
| Color       | 0.50              | 0.50                  |
| Temperature | 0.50              | 0.50                  |
| Weight      | 0.50              | 0.50                  |
| Length      | 0.50              | 0.50                  |
| Width       | 0.50              | 0.50                  |
| Height      | 0.50              | 0.50                  |
| Area        | 0.50              | 0.50                  |
| Volume      | 0.50              | 0.50                  |
| Mean        | 0.75              | 0.50                  |

Figure 6: Similarity with the base profile for Alternating and Non-alternating verbs.

then verbs with stronger preferences. We use the cosine measure to estimate the similarity between two profiles  $p$  and  $q$ :

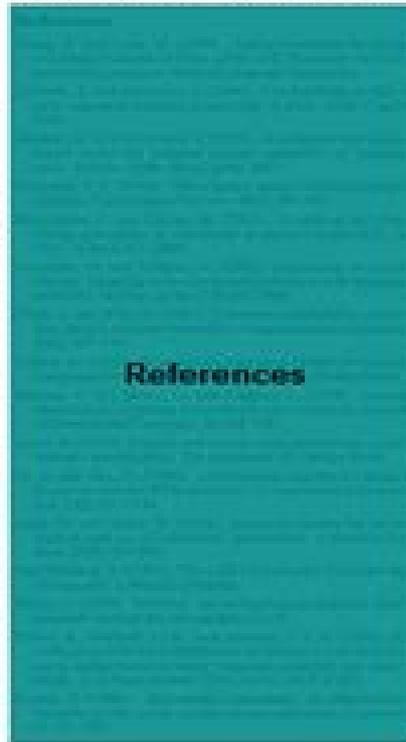
$$\text{similarity}(p, q) = \frac{p \cdot q}{\|p\| \|q\|} \quad (9)$$

The similarity values for the Alternating and Non-alternating verbs are shown in Figure 6. The larger values represent more similarity with the base profile, which means a weaker selectional preference. The means for the Alternating and Non-alternating verbs were respectively 0.75 and 0.50, which confirm the hypothesis that verbs participating in implicit object alternations select more strongly for the direct objects than verbs that do not. However, like Ruvink (1996), we find that it is not possible to set a threshold that will distinguish the two sets of verbs.

### 5. Conclusions

We have proposed a cognitively plausible model for learning selectional preferences from instances of verb usage. The model represents verb selectional preferences as a semantic profile, which is a probability distribution over the semantic properties that an argument can take. One of the strengths of our model is the incremental nature of its learning mechanism, in contrast to other approaches which learn selectional preferences in batch mode. Here we have only reported the results for the final stage of learning, but the model allows us to monitor the semantic

profile during the course of learning, and compare it with child data for different age groups, as we do with semantic roles (Alshabli and Niswanjan, 2007). We have shown that the model can produce appropriate semantic profiles for a variety of verbs, and use these profiles to simulate human judgments of verb-argument plausibility, using a small and highly noisy set of training data. The model can also use the profiles to measure verb-argument compatibility, which was used in analyzing the implicit object alternation.



### 1. Introduction

Verbs have preferences for the semantic properties of the arguments filling a particular role. For example, the verb eat expects that the object receiving its theme role will have the property of being edible, among others. Learning verb selectional preferences is an important aspect of human language acquisition, and the acquired preferences have been shown to guide children's expectations about meaning in upcoming arguments in language comprehension (Crain et al., 2002).

Ruvink (1996) introduced a statistical approach to learning and use of verb selectional preferences. In this framework, a semantic class hierarchy for words is used, together with statistical tools, to infer from a verb's selectional preferences for a particular argument position in the form of a distribution.



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