A Computational Investigation of Analogical Generalization of Linguistic Constructions

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Abstract

Recent years have seen the growth of usage-based theories of language acquisition centered on pairings of form and meaning called constructions [1-3]. In contrast to a traditional generativist account of language learning [4], these approaches do not assume a dichotomy between syntax and semantics. An iconic example would be the double-object construction (NP-V-NP-NP) which applies a transfer semantics as evidenced by the transfer interpretation of the denominal verbs below [8].

1. a) Joe crutched Marry the apple.
   b) The old man cupped the boy some popcorn.

Constructionist approaches also do not assume a universal grammar and instead propose that language is acquired incrementally using general learning mechanisms. This is consistent with findings that children's production of linguistic constructions is initially conservative and focused on verbs that occur frequently in their linguistic environment [1,5,6]. Analogical generalization has been proposed as a mechanism by which children develop abstract constructions from individual examples [1,7].

We investigate the potential role of analogical generalization in construction learning using a computational model, SAGE, which utilizes SME, an implementation of the structure mapping theory of analogy [9,10]. SAGE operates over hierarchical structured representations, aligning a base and a target pursuant to the constraints of structure mapping. If the alignment score passes a pre-set threshold, they are collapsed into a generalization with a probability distribution governing their differences [9].

Our model operates over sentences annotated with FrameNet [11] frame elements which describe how phrasal constituents fill semantic roles in a conceptual schema. For example, in the first double-object sentence of figure 1, the word *give* evokes the `Giving` frame, and the phrasal arguments fill the roles of `Donor`, `Recipient`, and `Theme`. When a new double-object example comes in (2) the phrase-structure and semantic mappings align. The result is a generalization with consistent syntactic-semantic alignments and a distribution governing individual words in the sentence. A novel phrase structure (3) fails to reach the generalization threshold and becomes a seed for a new construction. This model has been used to simulate denominal verb interpretation [12], but was limited to double-object and transitive constructions. In this work, we produce constructions from a manually annotated set of the CHILDES corpus [13]. We annotated the 13 most common verbs occurring across transcripts of child directed speech [14] resulting in 160 annotations. We manually examine the constructions learned with generalization thresholds from .6 to .8 to simulate more liberal and conservative learners.

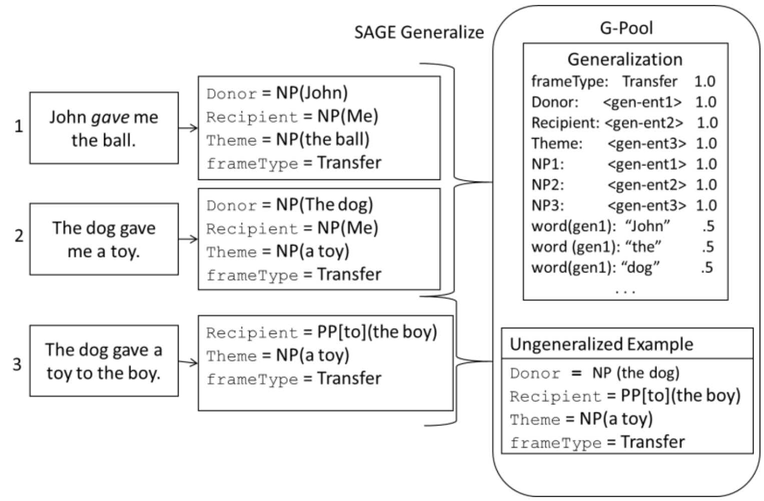

Figure 1: Overview of Analogical Generalization

Table 1 summarizes the generalization landscape across different thresholds. We identify overgeneralizations as those with inconsistent syntactic frames (e.g. combining the intransitive and transitive). A lower threshold means a less conservative learner.

Generalization Threshold	Number of Generalizations	Average Examples per Generalization	Verb Specific Generalizations	Number of Overgeneralizations
.8	24	3.17	22	0
.7	28	4.32	19	4
.6	16	8.69	6	4

Table 1: Generalization Results by Threshold

At .8 we see item-specific learning consistent with early construction acquisition [1]. The exception is an intransitive motion construction for the verbs *come* and *go*. We also see a double object construction and consistent intransitive and transitive constructions separated by verb type. At .7 we begin to get generalizations across phrase-type (go there / go in there), ones with optional oblique arguments, and more cross-word constructions. We also see our first over-generalization errors, specifically generalizing transitive and intransitive constructions for individual verbs. Finally, at .6 we get a very liberal learner with much larger constructions and larger overgeneralizations.

Future work will focus on using the described techniques to improve parsing performance in more traditional parsers [15].

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