Learning Computational Construction Grammars through Situation-Based Intention Reading and Semantico-Syntactic Pattern Finding

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Empirical studies on usage-based language acquisition extensively document how children acquire language through general cognitive capacities by actively participating in communicative interactions (Bybee, 2013). Tomasello identifies two of these capacities that play a crucial role, namely intention reading and pattern finding (Tomasello, 2003). Through intention reading, children try to reconstruct the intended meaning of the utterances they observe. Through pattern finding, children gradually abstract away from concrete utterances and meaning representations and acquire productive schemata that generalise over form and meaning. Complementing the abundance of theoretical and empirical evidence for both intention reading (Bruner, 1983; Nelson, 1998) and pattern finding (Goldberg, 1995; Croft, 2000), we have recently introduced a computational model of these capacities (Nevens et al., 2022).

In this work, we provide a computational operationalisation of the intention reading and pattern finding capacities. Concretely, we present an agent-based simulation in which an artificial agent is endowed with these capacities and uses them to bootstrap a construction grammar through communicative interactions. The constructions are computationally represented and processed using Fluid Construction Grammar (FCG – Steels, 2011; van Trijp et al., 2022). The interactions involve asking and answering questions about scenes of geometrical objects with various shapes, colours, sizes, and materials (Johnson et al., 2017). The learning task involved is twofold: (i) the reconstruction of queries (i.e. meaning representations) that correspond to observed questions based on the provided answer and the observed scene, and (ii) the generalisation of linguistic schemata (i.e. constructions) based on the reconstructed question-query pairs. The latter involves learning semantico-syntactic patterns by abstracting over differences and similarities in the form and meaning of observed utterances. The outcome is a productive grammar consisting of modular form-meaning mappings of varying degree of abstraction, together with a network of grammatical categories that models how the constructions can combine. This grammar consists of 149 constructions that cover more than 10,000 unique utterances and supports both language comprehension, i.e. mapping a question onto a query, and language production, i.e. expressing a query in the form of a question.

In sum, we present a computational model of how construction grammars can be learned in communicative interactions through the cognitive capacities of intention reading and pattern finding. We thereby provide computational evidence for the cognitive plausibility of theories from usage-based language acquisition (Tomasello, 2003), as the learning operators lead to dynamics that are similar to those observed in the psycholinguistics literature (i.a. Pine and Lieven (1997); Tomasello (2003); Ambridge and Lieven (2015)). Specifically, starting out with holistic mappings between form and meaning, the agent gradually learns an inventory of increasingly abstract and modular constructions. These constructions give insight into the compositional and non-compositional aspects of the observed utterances. Moreover, this work corroborates theoretical findings of the field of construction grammar, e.g. as the agent's constructions become conventionalised through an entrenchment process that corresponds to statistical pre-emption (Goldberg, 2011). The agent simultaneously constructs a network of grammatical categories that are construction-specific and functionally motivated, resonating with Croft (2001)'s "Radical Construction Grammar".

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