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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 19(0)

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Publication Date
1997

Peer reviewed

Learning to Comprehend Complex Sentences

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St. John and McClelland (1990) presented a parallel distributed processing model of sentence comprehension. Their Sentence Gestalt (SG) model successfully used syntactic and semantic constraints to perform thematic role assignment, interpret ambiguous words, instantiate vague terms, and infer unspecified roles. In this model, sentences were presented sequentially, and the network was trained to answer queries about the sentences. A limitation of this model, however, was that the query representation was oversimplified. It treated the meaning of the sentence as a set of role-filler pairs. Each query was a role or a filler, which the network was trained to complete with the missing element of the pair. This obviously deviates from natural experience, and excludes the possibility of processing more complex sentences. In particular, there was no mechanism for representing the structural relationships among constituents that occur within a complex sentence.

We aim to develop a model that eliminates the role-filler pairs, relying only on the need to process inputs and respond to queries posed entirely in natural language, with the view that this will lead to the formation of internal representations capturing the structural relations inherent in complex sentences. Among other things, we wish to account for sentence complexity effects seen, for example, in the RSVP paradigm (Miyake, Carpenter and Just, 1994). These authors argue for a capacity theory of comprehension disorders by showing that normal subjects can be induced to exhibit the same qualitative behavior as aphasic patients when processing sentences of differing complexity. We wish to examine whether our model can account for the pattern of relative performance as a function of sentence type, without invoking a capacity pool distinct from the system embodying the language knowledge needed for comprehension.

In pursuit of this ultimate goal, we have considered first a preliminary model, replacing the role-filler pair representation of St. John and McClelland with a canonical proposition representation similar to that used by St. John (1993) in his work on comprehension of script-like stories. The goal was to determine if the SG architecture could in fact learn to process sentences with embedded clauses, using the eleven sentence types described in Miyake, et al, which included several types containing embedded clauses (e.g. "The rat hit the dog that licked the cow."). Fifty training sentences were constructed at random for each sentence type using five animate nouns, five verbs, four datives (where applicable), and the function words 'the', 'to', 'and', 'that', 'was', 'by' and 'it'. Inputs and outputs were localist, and the task was to reproduce the correct agent, object and (where applicable) direct object, in role-specific slots, when probed with the corresponding verb. We were able to obtain convergence during training quite readily with this model. It seems the added complexity of a fuller syntax produces little difficulty for this architecture. Further, the model is able to produce a pattern of performance qualitatively similar to the RSVP data described in Miyake, et al.

The next phase of the research will attempt to go beyond the use of a slot-and-filler probing language, replacing these with modules that process probes consisting of word sequences (natural-language questions) and produce word sequences (natural language declarative sentences) as responses. This model contains two input modules that correspond to the "comprehension" portion of the first model described above; one is used for comprehending the target sentence and the other is used for comprehending questions posed about this sentence. After presenting the target sentence sequentially, as in the model described above, to generate a representation on its Sentence Gestalt layer, we will present a well formed question to the other input. (For the sentence "The rat hit the dog that licked the cow", a question might be "What did the rat do?"). This will generate its own, corresponding SG representation. The output portion of the network will then use these representations to produce the appropriate response sequentially (e.g. "Hit the dog."). So far we have had limited success with a variant of this model.

References

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