Estimating processing time of online semantic interpretation components

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ABSTRACT
The objective of this work is to model human performance on natural language comprehension tasks. The current approach is based on the assumption that parsing and reference identification are independent processes that contribute to the semantic interpretation of sentences in texts (Greene, McKoon, and Ratcliff, 1992). An important problem related to the study of natural language comprehension is the methodological difficulties related to the design of tasks isolating the temporal dimension of component processes such as parsing, and reference identification. Although, computational models offer the possibility to decompose latency data into the temporal contributions of independent processes The application of this approach is currently under investigation. Some results have already been obtained in the area of pronoun interpretation (Emond, in progress; Garrod, Freudenthal, & Boyle, 1993).

Keywords
Natural language, semantic interpretation, categorical grammars, parsing, reference identification, computer simulation.

CATEGORICAL GRAMMARS AND COGNITIVE ARCHITECTURES

The development of computational cognitive models of natural language processing requires both a strong linguistic foundation and a sound cognitive theory. This paper is an example of this methodological commitment by presenting some elements supporting the development of cognitive models of natural language processing using categorical grammars into unified theories of cognition (Anderson, & Lebiere 1998; Lehman, Lewis, & Newell 1998; Newell, 1990). In spite of their strong linguistic foundations (Desclés 1990; Shaumyan 1987; Steedman 1998), categorical grammars have not been used to their full potential as a framework for developing cognitive models of natural language representation and processing (Altmann, & Steedman 1988; Briscoe 1987; Pickering 1993; Steedman 1996). The moderate interest in categorical grammar is surprising given that categorical grammars provide both simple and powerful mechanisms for describing on-line semantic interpretation. Although, one would also like to avoid implementing models with computational resources that are beyond the power of human cognition. One obvious advantage of modelling natural language processing in a cognitive architecture is that many constraints on modelling parsing and semantic interpretation such as modularity, working memory limitation, and graceful degradation of performance (Briscoe 1987) are already taken care of by the cognitive architecture. The present approach uses the ACT-R cognitive architecture which has a strong empirical validation in many cognitive domains (Anderson 1993; Anderson, & Lebiere 1998).

PARSING AND REFERENCE IDENTIFICATION

Two features of categorical grammars seem important for modelling on-line semantic interpretation are: 1) the monostratal (Steedman 1998) or minimalist position on the number of representational levels between a written or phonological realization and semantic interpretation, and 2) the dual characteristic of categories representing both the combinatory properties of word types and predicate structure valence. From a cognitive perspective, the restricted number of knowledge representation levels is essential because any level of representation requires processing cycles to traverse its structure which can rapidly accumulate and impede on the adequacy of the model for latency data. In addition to the construction of predicate structures associated to the parsing process, semantic interpretation must also be supplemented by reference identification processes. The reference identification processes are especially important for comprehension when words with poor descriptive content are present (such as pronouns).

The current approach is based on the assumption that parsing and reference identification are independent processes that contribute to the semantic interpretation of sentences in texts (Greene, McKoon, and Ratcliff, 1992). The proposed organization of procedural knowledge is divided into two classes of productions. The first class of productions generate semantic structures that are used by the second class which implements a version of the anaphora resolution process presented in Greene, McKoon, and Ratcliff (1992). According to their proposal, the resolution process is a parallel retrieval process of potential discourse entities in memory. This retrieval process tries to identify a unique discourse entity that best matches the constraints provided by a pronoun with its surrounding context. If a single entity cannot be found then the pronoun is left without an interpretation. The current ACT-R model implements the parallelism as a partial pattern matching process. Following the retrieval of discourse entities, a test is performed on the

exact matching of retrieval constraints with the retrieved values to determine if a pronoun can receive an interpretation.

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