Statement of Research Interests

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Research Objective. My research is in the area of cognitive science, at the intersection of computer science and cognitive psychology. The main question that I address with my research is the nature of language. Language processing in humans is reliable, flexible, and fast. I would like to understand what cognitive processes make these features possible. Answering such questions, besides advancing the field of cognitive science, would also have important practical implications. First, it would enable us to write better texts that can be easily understood. Second, it can help design tutors for reading and comprehension. Last, but not least, executable computational models of language processing can facilitate the automation of language understanding and the design of language-based human-computer interfaces. For instance, INP, the language-comprehension model that I have developed, represents a fast and simple algorithm for language processing that has the potential of being used as a basis for building an interface with a computer.

Research approach. I believe that an excellent starting point in answering the question about the nature of language is to look at those phenomena of language that “stretch” and “stress” it: figurative language, semantic illusions, language comprehension under time pressure. In such extreme instances, fundamental language mechanisms are exposed. Understanding such phenomena makes possible the understanding of the more basic processes that underlie “normal”, literal processing. In my research, I started with investigating how people comprehend metaphors; later, I noticed that many of the mechanisms involved in metaphor comprehension were also part of a language phenomenon called “semantic” (or Moses) illusion\(^1\). I developed a theory of language that could account for these phenomena and also could explain intrusion patterns encountered in sentence memory experiments, priming of a word by a preceding context, and, ultimately, “normal” literal language processing. This theory is expressed as a computational model — essentially, an on-line algorithm for language processing that runs in constant time per word. One deep conclusion that resulted from these studies is that literality is a continuum: the boundary between metaphor and literal is often hard to trace and a single processing mechanism can account for the comprehension of both metaphor and literal.

Methodology. My training as a computer scientist makes me strive for formalism in describing my theories. I use computational modeling (understood as a running program that performs the task being modeled) to describe my theories. I believe that this approach is advantageous for several reasons. First, computational modeling helps to frame a theory in precise and minute detail, forcing one to pay attention to all the assumptions made. Second, a computational model

\(^1\)The semantic illusions refer to people not noticing the distortion in questions such as \textit{How many animals of each kind did Moses take on the ark?} This phenomenon was noted first by Erickson and Mattson (1981). For the Moses question they reported that about 80\% of the interrogated participants answered “two”, without noticing that Noah rather than Moses was the character in the ark story, in spite of actually knowing the correct facts.
is a powerful engine for generating predictions. Third, a computational model produces numbers that can be directly compared with the data being modeled; and, fourth, a computational model is a program that performs the task and, although sometimes it may rely on simplifying assumptions, can often serve as a starting point for a real-world application.

I have used this methodology in producing INP, a computational model for sentence comprehension. INP is a computational model that performs both parsing and semantic processing of the sentence in real time. It is incremental (it processes the sentence as it “reads” words, one by one, before reaching the end of the input). INP can successfully account for many experimental data from the psycholinguistic literature. INP is a pioneer in the domain of computational models of language: it is the first computational model to perform both syntactic and semantic processing in real time and to account for the comprehension of all kinds of metaphors and literals. Moreover, INP proposes (and implements in detail) a unification of multiple psycholinguistic phenomena (e.g., metaphor, semantic illusion, sentence memory) under one mechanism. My research results have been presented in several venues, including the *Cognitive Science* journal\(^2\), the *Journal of Memory and Language*\(^3\), and two International Conferences on Cognitive Modeling\(^4,5\).

Whereas I use computational modeling to formulate my theories, I also apply the traditional methods of experimental psychology (such as data collecting through experimentation with human subjects) to constrain my theories. In my research I often design and run experiments to test predictions of my models (some of these experiments were published in the *Memory and Cognition* journal\(^6\)).

**Future plans.** In the future I would like to continue my theoretical research in cognitive science and also pursue its applications in computer science. On the more theoretical side, I am interested in several questions that further throw light on the basic mechanisms of language. One such question refers to the processing of negative sentences: can negation be explained by those mechanisms occurring in normal, literal comprehension or there must be additional, negation-specific processes involved? I am also interested in investigating language comprehension under time pressure. What errors do people make under pressure? Which are those processes so essential to language comprehension that they are still performed under pressure and which processes are short-circuited? Another research project involves the comprehension of instructions: how do people comprehend directions and how do they go from language comprehension to task execution? What new knowledge structures are created in the process of executing a task based on instructions? An issue that poses particular interest for a model such as INP is how knowledge is organized in long-term memory and how more general facts (e.g., *People have food for dinner*) are inferred from specific propositions such as *Tom has steak for dinner*.

I also intend to pursue a number of more applied research directions. I would like to investigate how INP (whose strength is in processing at the semantic rather than syntactic level) can be


combined with a more powerful parser, that would make the task of arbitrary text comprehension more robust and that, ultimately, would lead to a powerful language-based human-computer interface. Another practical issue that I plan to explore is scalability: how well would INP behave when the knowledge base is comparable with that of humans? I am also interested in using INP as a tool for evaluating text comprehensibility and for pertinently advising writers. In a world where text (e.g., technical manuals) is generated automatically, such a program would be very useful.

In the future I hope to build fruitful collaborations with other researchers, from domains as diverse as computer science, psychology, or human-computer interaction. My own background in computer science and psychology taught me that interdisciplinarity can often bring fresh perspectives into a field. I believe that interdisciplinarity is a fruitful approach to the problem of language understanding and I am looking forward to develop further my expertise in cognitive science and computer science.