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Keywords: language; narrative; statistical learning; cognitive modeling.

Motivation

The Annual Glushko Dissertation Prize in Cognitive Science was established in 2011 as a way to promote future growth in cognitive science, and encourage students to engage in interdisciplinary efforts to understand minds. The prize is jointly sponsored by the Cognitive Science Society and the Robert J. Glushko and Pamela Samuelson Foundation, and honors young researchers conducting ground breaking research in cognitive science. The immediate goal is to recognize outstanding efforts to bridge between the areas that impinge on cognitive science and create theories of general interest to the multiple fields concerned with scientifically understanding the nature of minds and intelligent systems. Encouraging junior researchers to engage in these enterprises is one of the best ways to assure a robust future for cognitive science. The overarching goal is to promote a unified cognitive science, consistent with the belief that understanding how minds work will require the synthesis of many different empirical methods, formal tools, and analytic theories.

This symposium showcases the PhD research projects of the 2013 winners of the Glushko Dissertation Prizes. 2013 marks the first year that a symposium has been formed to assemble and showcase Glushko Prize winners' research. The prize-winning projects involve research on linguistic compositionality, understanding pictorial narratives, learning object-to-name mappings from complex environments, spatial problem solving, and visual awareness. The recruited research methods include neuroimaging, computational modeling, formal linguistic modeling, corpus analysis, psychological experiments, and theoretical analysis. Taken as a whole, the research projects strongly reinforces the view that contemporary cognitive science research is highly diverse, rigorous, creative, and fertile.

Simple Composition During Language Processing: An MEG Investigation

Douglas Knox Bemis – 2012 PhD from New York University

Keywords: language; minimal phrases; magnetoencephalography.

Abstract: Language derives its expressive power from the ability to combine simple elements into complex ideas. To date, however, the vast majority of neurolinguistic investigations into combinatorial language processing have focused not on this transition from simple to complex, but rather on manipulations of complexity itself or measuring neural activity related to expectation violation. In this talk, I will present a novel neurolinguistic paradigm designed to isolate brain activity related to simple compositional mechanisms by combining the fine spatio-temporal resolution of MEG with the processing of minimal adjective-noun phrases (e.g. “red boat”). First I will demonstrate the ability of this paradigm to identify neural correlates of basic combinatorial processes that underlie the comprehension of such phrases. Then, I will present several experiments that probe the scope of these core processes both within language – comparing comprehension to production – and beyond – investigating combinatorial processing within both the pictorial and mathematical domain.

Structure, Meaning, and Constituency in Visual Narrative Comprehension

Neil Cohn – 2012 PhD from Tufts University

Keywords: narrative; grammar; comics.

Abstract: Narrative has been formally studied for at least two millennia, dating back to the writings of Aristotle. Contemporary research on the structure and comprehension of narratives has examined the discourse of spoken language. However, visual narratives in the form of

sequential images have also been pervasive throughout history, from cave paintings to contemporary comic books and strips. Yet, compared with the study of discourse in verbal language, the study of sequential image comprehension has been relatively impoverished. Just what are the structures motivating visual narratives and how are they processed?

I will explore this question using experiments guided by an overall theory that sequential images at the narrative level are structured and processed analogously to sequences of words at the sentence level. The main idea is that a narrative “grammar” organizes the structure of sequential images in the visual language used in comics, similar to the way that syntax organizes words into coherent sentences. We focus here on two salient parts of this analogy. First, I will explore the idea that visual narrative comprehension involves a system of narrative structure and a system of semantic coherence that contribute to comprehension. This correspondence is akin to the interaction between syntax and semantics at the sentence level. Second, I explore the idea that narrative structure is a hierarchic system that organizes images into constituents, analogous to the phrase structures of syntax in sentences. I will conclude by discussing the overall implications for the analogy between narrative structure in sequential images and syntax in sentence.

More Naturalistic Cross-situational Word Learning

George Kachergis – 2012 PhD from Indiana University
Keywords: statistical learning; cross-situational learning; language acquisition.

Abstract: Language acquisition is a ubiquitous, challenging problem involving fundamental cognitive abilities of attention, learning, and memory. Previous research has found that people can use word-object co-occurrences from ambiguous situations to learn word meanings. A recent associative model can account for a wide variety of word-learning results using competing biases for familiar pairings and for stimuli with uncertain associates (Kachergis, PhD thesis). However, most studies of cross-situational learning present an equal number of words and objects in each learning situation, which is likely unrealistic. Moreover, displaying an equal number of words and objects may encourage learners to use assumptions such as each word going with one object, which may simplify the problem. This paper (Kachergis & Yu, 2013) presents several conditions in which the number of words and objects do not match: either additional objects appear at random, or objects appear sometimes without their intended words. These manipulations do generally hurt learning in comparison to balanced conditions, but people still learn a significant proportion of word-object pairings. The results are explored in terms of statistics of the training trials—including contextual diversity and context familiarity—and with the uncertainty- and familiarity-biased associative model. Parametric differences between conditions hint at hidden cognitive constructs.

Spatial Routines: A Framework for Modeling Visual Problem-Solving

Andrew Lovett – 2012 PhD from Northwestern University
Keywords: cognitive modeling; qualitative representation; visual problem-solving.

Abstract: Visual problem-solving tasks are an effective tool for evaluating cognitive abilities and predicting future performance. For example, Raven’s Progressive Matrices is an intelligence test in which participants compare sequences of images to solve for a missing image. To better understand these tasks and the abilities they evaluate, I developed Spatial Routines, a general computational framework for modeling visual problem-solving. The framework is based on three psychological claims: 1) When possible, people reason about space using qualitative representations (e.g., identifying that one object is right of another), rather than absolute quantitative values. 2) Spatial representations are hierarchical. A given image might be represented as object groups, individual objects, or the parts within each object. 3) Qualitative spatial representations can be compared via structure-mapping: aligning their relational structure to find the corresponding elements.

The models generate symbolic representations from sketched input. They manipulate and compare these representations to determine an answer. They are useful for evaluating theories of perception, comparing problem-solving strategies, and identifying sources of difficulty for test-takers. Because the models must construct their own representations, they can highlight difficulties in representation-building and abstraction not identified by other computational models.

Three task models were constructed: Raven’s Progressive Matrices, geometric analogy, and the visual oddity task. All three models perform as well as human adults, and problems that are difficult for the models are also difficult for people. Furthermore, by ablating a model’s ability to perform certain operations and examining the resulting error pattern, one can generate new hypotheses about human reasoning.

References

Kachergis, G. & Yu, C. (2013). More naturalistic cross-situational word learning (this volume).