Rumelhart Symposium:
Language as a Dynamical System: In Honor of Jeff Elman

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Introduction

Language as a dynamical system, a proposal championed by Jeff Elman (Elman, 1990, 1995; Elman et al., 1996), has had a profound impact on our thinking of the relationship between language and cognition. This perspective distinguishes itself from the view of cognition based on static building blocks in the form of symbols and rules. Recent advances in developmental psychology and cognitive neuroscience provide further support for the dynamical perspective and further evidence on the neural and computational mechanisms underlying the dynamic changes that occur in the language learner and the speaker. In this symposium, several colleagues who have worked with Jeff Elman in the past decade or so will present their data and theory that exemplify the view of language as a dynamical system.

Overview of Presentations

Gerry Altmann

Altmann will begin by describing a variety of data demonstrating how incrementality in language comprehension is intimately tied to dynamically changing predictions in respect of what is likely to be coming next. Data will be drawn from studies in which participants' eye movements are monitored as they hear a sentence describing an event that could unfold within a visual scene that they are either concurrently viewing, or have viewed in the past. Parallels will be drawn with equivalent studies on reading sentences in context, suggesting that the mental representations of the visual world, and of the world experienced through reading, are remarkably similar. Altmann concludes that incrementality in language comprehension is a by-product of the process by which we acquire information about both language and the visual world with which we interact.

Mary Hare

Hare will argue that fundamental issues in the representation and processing of language have to do with the interface among lexical, conceptual, and syntactic structure. Meaning and structure are related, and one view of this relationship is that lexical meaning determines structure. A contrasting view adopted here is that the relevant generalizations are not based on lexical knowledge, but on the language user's interpretation of generalized events in the world. A set of priming studies will demonstrate that nouns denoting salient elements of events prime event participants. In addition, corpus analyses and self-paced reading studies will show that different senses of a verb reflect variations on the types of event that the verb refers to, and that this knowledge leads to expectations about subsequent arguments or structure during sentence comprehension.

Ping Li

Li will present a self-organizing neural network model that simulates developmental changes underlying both monolingual and bilingual language acquisition. The model is based on *DevLex*, a connectionist developmental lexical model (Li et al., 2004, 2006). Of particular relevance to the dynamical perspective is the model's ability to demonstrate how early learning impacts later development, in particular, how early learning leads to dedicated cognitive and neural structures that affect the shape and outcome of later development (positively or adversely). In the case of monolingual acquisition, rapid vocabulary growth observed in early childhood (the so-called "vocabulary spurt") is predated and prepared by the system's building of a structural representation that sets up the basic organization of the lexicon. In the case of bilingual acquisition, the structural consolidation of the first-language lexicon will adversely impact the representation and retrieval of the second-language lexicon, resulting parasitic L2 due to reduced plasticity in the organization and restructuring process (Hernandez & Li, 2007). These findings point to the developmental dynamics in which mechanisms of learning interact with the timing and history of learning to determine developmental trajectories.

Ken McRae

McRae will focus on emergent conceptual hierarchies and the dynamics of similarity. A flat attractor network was trained to map wordforms for basic-level concepts to their semantic features. For superordinate concepts, wordforms were paired equally often with one of its exemplar's representations so that typicality was not built into training, and the network developed superordinate representations based on its experience with exemplars. Previous experiments have shown roughly equal superordinate-exemplar priming (*fruit* priming *cherry*) regardless of typicality. Paradoxically, other experiments and simulations show that basic-level concepts must be highly similar to support priming. The current experiments and simulations examined priming that was virtually identical for high and medium/low typicality items. In the model, unlike features of basic-level concepts, superordinate features are partially activated from a wordform due to a superordinate's one-to-many mapping. Thus, it is easy for a network to move from a superordinate representation to one of its exemplars, resulting in equivalent priming effects regardless of typicality. This research shows that a flat attractor network produces emergent behavior that accounts for human results that have previously been viewed as requiring a hierarchical architecture, and provides insight into temporal aspects of the influences of similarity.

Kim Plunkett

Plunkett will report on a series of experiments that demonstrate that labels can play a causal role in category formation during infancy. Ten-month-old infants were taught to group computer-displayed, novel cartoon drawings into two categories under tightly controlled experimental conditions. Infants were given the opportunity to learn the two categories under four conditions: without any labels, with two labels that correlated with category membership, with two labels assigned randomly to objects, and with one label assigned to all objects. Category formation was assessed identically in all conditions using a novelty preference procedure conducted in the absence of any labels. The labelling condition had a decisive impact on the way infants formed categories: When two labels correlated with the visual category information, infants learned two categories, just as if there had been no labels presented. However, uncorrelated labels completely disrupted the formation of any categories. Finally, consistent use of a single label across objects led infants to learn one broad category that included all the objects. These findings demonstrate that even before infants start to produce their first words, the labels they hear can override the manner in which they categorise objects.

Summary

The wide range of topics and the empirical and modeling data that will be presented at the symposium illustrate clearly the notion of language as a dynamical system, in infant statistical learning (*Plunkett*), bilingual language acquisition and self-organization (*Li*), and the representation of concepts and words in humans and attractor networks (*McRae*). The parallels between language and other domains of cognition are also reflected clearly in the temporal dynamics in sentence comprehension and the representation of event knowledge (*Hare*), and in the representation of information from both language and the visual world during the processing of linguistic and nonlinguistic materials (*Altmann*).

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