A Self-Organizing Connectionist Model of Bilingual Lexical Development

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How do bilingual learners acquire a structured representation for the two lexicons at early stages of lexical acquisition? In this study, we attempt to address this question with Devlex-II, a self-organizing connectionist model. Previous connectionist simulations suggest that bilingual lexical representations may be functionally separate, but architecturally homogeneous (Li & Farkas, 2002). Here, we expand this single-mechanism-variable-representation view from a dynamical developmental perspective. Results from our study will provide insights into the long-standing debate on distinct versus shared structure of bilingual lexical representation.

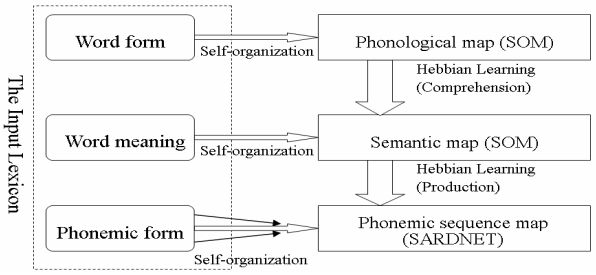

Figure 1: The DevLex-II model of lexical development.

The DevLex-II model is a cognitively and neurally plausible connectionist model based on principle of self-organization and Hebbian learning rules (Zhao & Li, 2005). It consists of three self-organizing feature maps that are connected via associative links trained by Hebbian learning. Upon training, the meaning, phonology, and phonemic sequence of a word are processed by the network.

The acquisition of Chinese and English is the bilingual context that the current model simulates. Here, each lexicon included 500 words, and was derived from CDI, the MacArthur-Bates Communicative Development Inventories. In the current study, we manipulated (1) the size of the input lexicon over different developmental stages, and (2) the onset time of L2 lexical learning – simultaneous: onset times of the two languages are identical; sequential: onset time of L2 (Chinese) is delayed relative to that of L1 (English). The sequential learning can be further divided into two situations, one as early L2 learning and the other late L2 learning. Our results show that: (1) distinct representations for the two lexicons can gradually develop in our network under simultaneous learning; (2) the representational structure is highly dependent on the onset time of L2 learning (Figure 2): when the learning of L2 was early relative to that of L1, distinct representations of the L2 lexicon may be established (Fig. 2a); when the learning of L2 was delayed relative to that of L1, the consolidation of L1 would significantly (sometimes dramatically) impact the representation of L2 (e.g., resulting in parasitic L2 lexicon; Fig. 2b). As seen in Fig. 2b, compared with L1 words, the L2 words occupied only small and fragmented regions on the semantic map (the shaded areas), and the small chunks isolated from the main part of the L2 words tended to be interspersed in L1 regions and close to those L1 words with similar meaning.

Our results suggest a dynamic developmental picture for bilingual lexical acquisition: the acquisition of two languages entails strong competition in a highly interactive context and limited plasticity as a function of timing of learning; whether bilingual representations are distinct or shared will depend on important developmental factors such as the history of learning. Our study illustrates computational mechanisms underlying L1-L2 competition, learning entrenchment, and plasticity of learning (see also Hernandez, Li, & MacWhinney, 2005).

(a) (b)

Figure 2: Semantic organization of the bilingual lexicon acquired by DevLex-II. Shaded areas indicate L2 (Chinese) representations. (a) Early L2 learning. (b) Late L2 learning.

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