Supporting Online Material for

Defusing the Childhood Vocabulary Explosion

Bob McMurray

E-mail: bob-mcmurray@uiowa.edu

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Bob McMurray
Dept. of Psychology
University of Iowa
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S1) Figure 1A. Inset reports developmental norms for word production in English-learning infants from the MacArthur-Bates Communicative Development Inventory [S6].

S2) Deceleration. Deceleration late in acquisition is observed because a Gaussian distribution of time-to-acquisition has more moderate words than difficult ones.

S3) Benefits/Costs of Learning a Word. Simulations in which each word accelerated learning used the following algorithm. On each time-step, the number of newly acquired words was determined. The threshold of each unlearned word was then reduced by a constant (0.1 time-steps) for each new word. This benefit was small (average threshold was 4000), but higher benefits caused unreasonably fast learning. Costs were modeled identically to benefits, but with a negative constant.

S4) Generality. Additional simulations used Poisson and Power distributions of time-to-acquisition and demonstrated acceleration. F, χ² and Gamma were also tested. These distributions approximate an exponential function with small-valued parameters (e.g. χ² with 2 d.f.), and a Gaussian at higher values (>2 d.f.). The exponential is one of the few distributions which do not show acceleration, since difficulty is inversely related to number of items. However, for parameters, all three distributions resemble a Gaussian and show acceleration. Finally, a bimodal Gaussian distribution was tested and showed two spurts.
**S5) Word Frequency Simulations.** Word frequencies for the 2000 most frequent words of English were taken from [S7] for adult-directed-speech and [S8] for child-directed-speech. Frequencies were first transformed by their natural logarithm. Time-to-acquisition thresholds were then linearly scaled from this log frequency. Each frequency was subtracted from the maximum frequency (so that most frequent words would have the smallest threshold), multiplied by 800 and added to 3000.

The fixed-threshold frequency model reframes the problem, assuming that each word is equally difficult to learn and that how often a word is heard determines when it is acquired. Thus, frequency of occurrence may be sufficient to drive acceleration (although other factors are likely involved). This is supported empirically by a relationship between the children’s early productions and the frequency of isolated words in their caregiver’s speech [S9]. For this model, the log-frequency of each word was divided by the sum of the log-frequencies to compute each word’s probability of occurrence. On every trial, one word was chosen from that distribution to receive a point, and learning was achieved when each word crossed its threshold.

Finally, the broad class of distributions for which the spurt was seen suggests that these results will replicate for any language in which there are very few high frequency words and more medium/low frequency words. Zipf’s law suggests that all languages show this property.

**References**

