## Title
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# A Sparse Distributed Memory Model of Overregularization

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## Introduction

Overregularization (OR) errors and U-shaped learning during past tense acquisition have been used to support the model of a symbolic, two process system of learning requiring both rule use and memorization. Beginning with the work of Rumelhart and McClelland (1986), connectionist networks have attempted to model these phenomena with varying degrees of success. We examine the ability of Kanerva's (1988) sparse distributed memory (SDM) to simulate Palermo and Howe's (1970; hereafter P&H) experimental analogy to past tense acquisition. SDM, like the connectionist networks, does not explicitly encode rules, therefore, if it is able to simulate P&H's behavioral data, the plausibility of a sub-symbolic, one process account will be strengthened.

## Sparse Distributed Memory

SDM (Kanerva, 1988) is a content-addressable associative memory system in which only a small, random subset of all possible addresses is realized as "hard" locations. During storage, the probability is small that an exact match will be found for a target address among the hard locations, so the data is stored at hard locations which are "near" the target using a kind of superposition. A similar process occurs during retrieval when the data from the target address's neighboring hard locations are summed. The use of superposition and summation allows SDM to maintain a high level of fidelity despite the many-to-many mappings between addresses and hard locations. For the same reasons SDM is able to exhibit graceful degradation, prototype extraction and noise suppression.

Our implementation of SDM incorporates noise during storage and retrieval, and as such, is a modification of Kanerva's model. Our belief that noise is a critical factor in learning , whose effects diminish as learning proceeds, led to a strategy of decreasing noise during our simulations.

## SDM Simulations of Palermo & Howe (1970)

SDM was used to simulate P&H's paired associates learning task in which adult subjects were presented with both regular (rule governed) stimulus-response pairs and more frequent irregular pairs which were exceptions to the rule. Notably, the composition of the training and testing materials did not change through the course of the experiment, i.e., there were no shifts in frequency of presentation over trials. SDM was able to mimic P&H's behavioral data in a number of critical areas: (1) Both P&H's subjects and SDM learned the irregulars much sooner and better than the regular pairs. (2) SDM was able to match the OR rates found among P&H's subjects. (3) SDM replicated the frequency effects exhibited by P&H's subjects: as frequency of presentation increased, both acquisition rates and OR rates decreased. (4) There was no evidence of U-shaped learning either in P&H's subjects or the SDM simulations.

## Discussion

OR errors have received much attention in the debate between symbolic and connectionist approaches to cognition. The work presented here does not resolve the debate, but SDM's success at modeling P&H's behavioral data does suggest that a sub-symbolic approach is plausible. We are currently working to determine how well this one process system is able to model other memory phenomena including interference and recognition.

An interesting behavioral question is also raised by this study. While it seems clear that OR errors are not confined to language acquisition, P&H's study provides no evidence that U-shaped learning exists outside this domain. In addition, the child language acquisition data suggest that while U-shaped learning is evident in some children, it may be an exceptional occurrence. So, the question of whether U-shaped learning is a general cognitive phenomenon, or even characteristic of language acquisition, remains to be answered.

## References

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