Some Limitations of the Sequential Pairwise Associative Memory (SPAM) Model of Rat Serial Pattern Learning

Shannon M. A. Kundey[1], James D. Rowan[2], & Stephen B. Fountain[1]

[1] Kent State University, Kent, OH 44242 and [2] Wesleyan College, Macon, GA 31297

Introduction

The Sequential Pairwise Associative Model (SPAM) is a computational model of serial pattern learning previously used to account successfully for serial pattern learning phenomena in rats learning serial patterns composed of different food reward quantities (Wallace & Fountain 2002, 2003). SPAM is based on pairwise associations between pattern elements and generalization. Wallace and Fountain (2002, 2003) demonstrated that SPAM can successfully simulate putative rule learning (Hulse & Dorsky, 1977) and element discriminability effects (Capaldi & Molina, 1979) in rat serial-pattern learning. Additionally, SPAM was successful in simulating rule generalization (Hulse & Dorsky, 1979; Haggbloom, 1985) and pattern extrapolation (Fountain & Hulse, 1981; Haggbloom & Brooks, 1985).

In the present studies, we examined whether SPAM could simulate rats' pattern learning in two different paradigms: a stimulus anticipation paradigm in a six-light linear array (Fountain, 1991) and a pattern production paradigm in an eight-lever circular array (e.g., Fountain & Rowan, 1995a,b). In both paradigms, patterns were highly structured and contained extensively "branching" sequences of positions in the arrays (i.e., the sequences were characterized by cues that signaled different events at different points in the pattern). Simulations were carried out to determine whether encoding training patterns in terms of sequences of spatial locations in the array or sequences of the turns (left versus right turns of the required distance) could account for rats' performance in these paradigms.

The SPAM Program

The SPAM program was written in C (Turbo C, Borland International, Scotts Valley, CA) for PC-compatible hardware. For a mathematical description of SPAM and more detailed information about the model, see Wallace and Fountain (2002, 2003).

Simulations of Pattern Tracking in a Linear Array

By stimulus location: Fountain (1991, Exp. 1) required rats to track a stimulus pattern in a six-light linear array for hypothalamic brain stimulation reward:

1-2-3-4-6-6-6-6-6-4-3-4-3-5-4-3

In this pattern, each number represents a distinct light location in the linear array. This pattern was modeled using the following pairwise associations:

Start*1, 1*2, 2*3, 3*4, 4*6, 6*6,
6*6, 6*6, 6*6, 6*4, 4*3, 3*4,
4*3, 3*5, 5*4, 4*3, 3*1

Pattern tracking was accomplished by using each item (1, 2, 3, 4, 5, and 6) as a cue to probe the composite trace. As indicated in Figure 1, SPAM was unsuccessful in simulating the performance of rats in Fountain 1991 (Exp. 1) by encoding pairwise associations of location information.

Figure 1: Simulating Pattern Tracking in a Linear Array

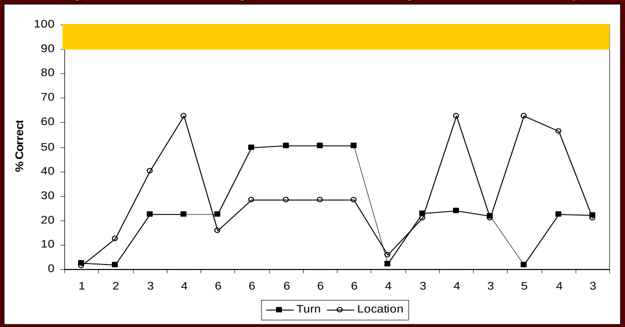

Figure 1 shows simulations from SPAM for Fountain 1991 (Exp. 1) in a linear array. While rats eventually learn this pattern to 90-100% accuracy (as indicated by the yellow zone at the top of the graph), SPAM predicts that rats will never learn to this level using either turn or location information.

By turns: We next attempted to simulate the results of Fountain (1991, Exp. 1) by restating the pattern in terms of the turns the subject would need to make in the chamber from one stimulus location to another. For example, to move from 1 to 2, the rat would need to move to the right by one stimulus location (i.e., +1). Similarly, to move from 5 to 3, the rat would move to the left by two stimulus locations (i.e., -2). The pattern, restated in terms of the turns the subject would need to make in the linear array, is:

-2, +1, +1, +1, +2, 0, 0, 0, 0, -2, -1, +1, -1, +2, -1, -1

Modeling based on pairwise associations was accomplished in a manner similar to that described above. As indicated in Figure 1, SPAM was unsuccessful in simulating the performance of rats in Fountain (1991, Exp. 1) when the pattern was assumed to be encoded as a series of turns.

Simulations of Pattern Production in a Circular Array

By stimulus location: While SPAM has addressed some early work in serial pattern learning successfully, whether SPAM can simulate data from more recent research utilizing spatial locations in an octagonal operant chamber has not been considered formally. Here, we investigated whether SPAM could simulate learning of a commonly-used pattern in a circular array:

123 234 345 456 567 678 781 812

In this pattern, each number represents a distinct spatial location in a circular array. Importantly, 1 and 8 represent adjacent locations. Convolution and pattern tracking were accomplished in a manner similar to that for the linear array. As indicated in Figure 2, SPAM was unsuccessful in simulating the performance of rats learning a commonly used pattern in a circular array by encoding pairwise associations of location information.

Figure 2: Simulating Pattern Tracking in a Circular Array

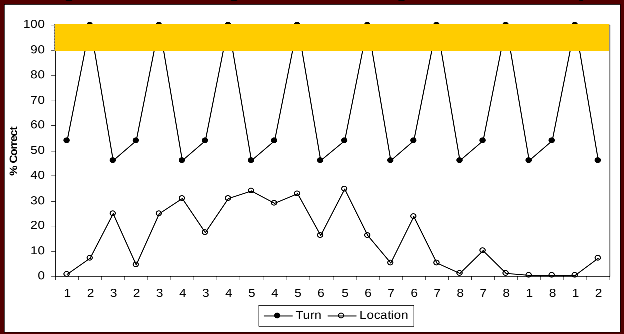

Figure 2 shows simulations from SPAM of pattern tracking of a commonly used pattern in a circular array. While rats eventually learn this pattern to 90-100% accuracy (as indicated by the yellow zone at the top of the graph), SPAM predicts that rats will never learn to this level using either turn or location information.

By turns: Next, we attempted to simulate learning of this pattern in a circular array by restating it in terms of the turns the subject would make in the circular array. As in the linear array, for a subject to move from 1 to 2, it would need to move to the right by one stimulus location (i.e., +1) in the circular array. The pattern restated in terms of the turns the subject would need to make in the circular array is:

-1, +1, +1 -1, +1, +1 -1, +1, +1 -1, +1, +1
-1, +1, +1 -1, +1, +1 -1, +1, +1 -1, +1, +1

Modeling based on pairwise associations was accomplished in a manner similar to that for the linear array. As indicated in Figure 2, SPAM was unsuccessful in simulating the performance of rats learning a commonly used pattern in a circular when the pattern was assumed to be encoded as a series of turns.

Discussion

While SPAM has been used to simulate reward magnitude serial pattern learning phenomena successfully, it does not appear to simulate data from other paradigms commonly used in serial pattern learning accurately. One potential pitfall of SPAM is that it is currently unable to handle multiple cues (e.g., from both location and turns) concurrently on any given trial. Evidence from our lab indicates that in the octagonal (circular array) paradigm, serial pattern learning recruits multiple learning systems including a rule induction system and an item association system (e.g., Fountain & Rowan, 2000). For SPAM to simulate serial pattern phenomena accurately, it will likely need to code information from various cues concurrently.