Pattern Structure and Scopolamine Effects in a Serial Reaction Time Task for Rats

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INTRODUCTION

The serial reaction time (SRT) task is a popular paradigm used for studying implicit sequence learning in animals and humans, where subjects track a repeating unstructured sequence of lights in an array and reaction time and error rates are recorded and analyzed. Previous studies in humans have shown that muscarinic cholinergic antagonists (such as scopolamine) do not produce learning impairments in the SRT task.

Our research on serial pattern learning (SPL) uses an octagonal chamber apparatus with a circular array of levers and, in a manner similar to the SRT procedure, requires rats to choose levers in sequence. Our SPL studies have shown that muscarinic cholinergic antagonists (in this case, atropine) cause impairments in acquisition and retention of patterns in the SPL paradigm.

We examined why muscarinic cholinergic antagonists produce impairments in SPL but not in SRT tasks. We developed a patterned SRT task for rats that combined aspects of both the SRT and SPL paradigms by using a structured pattern in an SRT procedure. Scopolamine was administered during acquisition. Our hypothesis was that differential effects of muscarinic cholinergic antagonists result not from the paradigm used, but from what rats are required to learn in typical SPL and SRT tasks, namely, structured versus unstructured sequences.

METHOD

Subjects. 12 male hooded rats implanted with bipolar electrodes for hypothalamic brain-stimulation reward (BSR).

Pre-training. Rats were trained to track a light presented randomly above 8 levers in an SRT chamber for BSR. If a rat made an incorrect response, a 3 second time-out was given in which all lights went off and the rat could not receive BSR. Following the time out, a light would illuminate above the correct lever, and the rat could respond again. Pre-training continued until all rats reached a criterion of 10% errors or fewer for the session.

Testing. The day after pre-training criterion, rats were randomly divided into 2 groups.
- Scopolamine (N=6), 0.6 mg/kg i.p. 30 min prior to testing.
- Control (N=6), saline injection 30 min prior to testing.

The testing session consisted of 960 trials (i.e., 960 responses on the appropriate lever in the chamber) comprised of three phases:
- Warm-up: First 80 trials, equivalent to pre-training.
- Pattern: 800 trials made of 50 presentations of the 16 element pattern,
  2345-4567-7654-5432
  where digits represent the left-to-right position of the correct lever for each trial.
- Transfer: Last 80 trials, returning to random across all eight levers again with no time-out for incorrect responses.
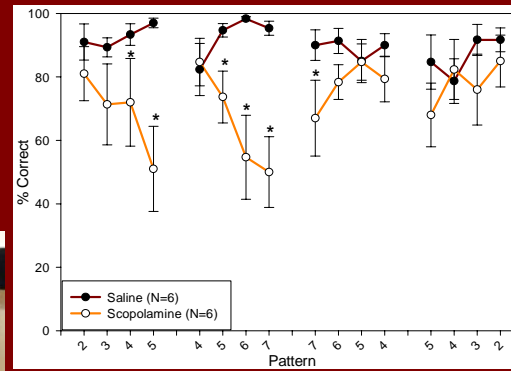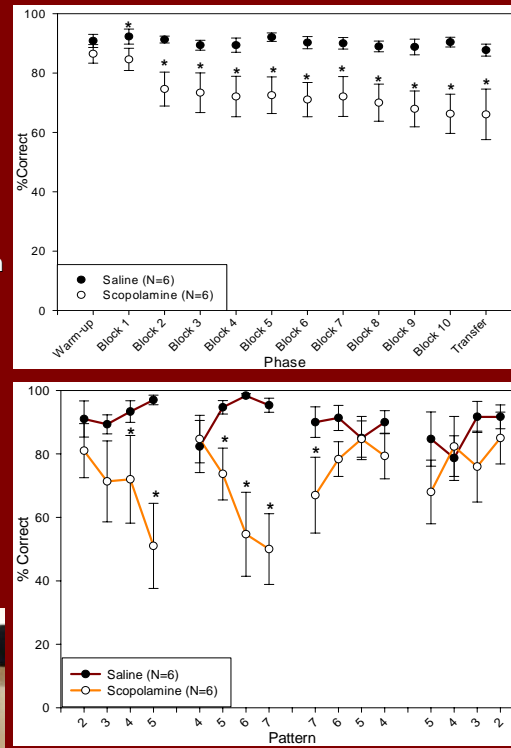
RESULTS

Figure 1: Percent Correct by Acquisition Block
Rats injected with scopolamine made significantly more errors during the pattern and transfer compared to controls. When presented with a random sequence during the warm-up phase, rats performed equally in the two groups. When the pattern was introduced, however, those rats injected with scopolamine showed statistically significant impairments (asterisks) in the percent of correct responses for the remainder of the test session.

Figure 2: Percent Correct by Pattern Element
Across elements of the pattern, rats injected with scopolamine showed significant impairments (asterisks) in the first half of the pattern at within chunk elements, and also in the second half of the pattern at chunk boundaries. Two types of errors were seen at the within chunk elements in the first half of the pattern:
- Perseveration errors - selecting the lever for which the rat was last reinforced rather than the next lever in the pattern.
- Back-1-lever error - selecting the lever to the left, or back one, rather than to the right for the next correct response.

At chunk boundary elements of each half of the pattern there were primarily overextension errors, which occur when the rat overextends the rule of a previous chunk.

Figure 1. %Correct by Phase. Saline (N=6) ● ; Scopolamine (N=6) ○

Figure 2. % Correct by Pattern. Saline (N=6) ; Scopolamine (N=6)

DISCUSSION

Scopolamine did not cause any impairments in performance during warm-up when the sequence was random, but did in later blocks when the sequence became a structured pattern. These findings support the previously described differences observed in our lab between the SRT and SPL paradigms. Work previously conducted in the SRT procedure used random sequences, whereas the work from the SPL procedure used structured patterns. We suggest that the differential effects of scopolamine on performance observed in our lab are not due to the difference in paradigms per se, but result from what rats are required to learn in each of the tasks: either a pattern that is highly structured or a randomly generated unstructured sequence. Thus, acquisition in SRT tasks is not inherently resistant to anticholinergic challenge but appears to depend on the nature of the sequential information to be learned.

Additionally, we were able to create an SRT task that could test the effects of scopolamine on learning in a single test session. Most tests examining the effect of scopolamine (and many other drugs) on performance require many days of testing and repeated exposure to the drug. Our test was given in one session and required only one drug injection. This technique is novel and innovative and could prove valuable for future research assessing the effects of other pharmacological agents on learning ability.