# Project 1: Martingale

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## 1 QUESTION SETS

### QUESTION SET 6:

**1.1 In Experiment 2, do the upper standard deviation line (mean + stdev) and lower standard deviation line (mean – stdev) reach a maximum (or minimum) value and then stabilize?**

**1.2 Do the standard deviation lines converge with one another as the number of sequential bets increases? Thoroughly explain why it does or does not.**

### QUESTION 7:

**1.3 What are some of the benefits of using expected values when conducting experiments instead of simply using the result of one specific random episode?**

### 1.4 Question Set 1

Based on the experimental results of Experiment 1, the estimated probability of winning $80 within 1000 sequential bets is close to 100%. All episodes reached $80 well within 1000 sequential bets. The mean spins to reach 80 is 168.895 with a standard deviation of 13.62 spins while the median spins is 168 spins.

### 1.5 Question 2

The estimated expected value of the Experiment 1 winnings after 1000 sequential bets is $80. The mean of the winnings at 1000 spins is 80 with a standard deviation of 0.0 so there is no variance.

### 1.6 Question Set 3

In Experiment 1, the upper standard deviation line (mean + stdev) and lower standard deviation line (mean – stdev) do not reach a maximum (or minimum) value due to the large variance from the increasing bets, but then stabilize and converge at a value of 80 once the end condition has been reached. The upper and lower bands converge as all the episodes reach 80 and are filled forward, when the standard deviation reaches 0. No matter the loss streak, a win will only $1 more than the previous peak winnings. Thus, the sim only needs to win 80 times, no matter the losses.

### 1.7 Question 4

To win the player must win 80 bets before losing 9 bets in a row within 1000 bets. The chance of losing 9 bets in a row is $\mathbf{(10/19)^9}$, while it is expected at least one loss will occur within $\mathbf{1000/(10/19)^9}$ or about 322.68 spins. Using Experiment 2 results, the estimated probability of winning 80 within 1000 bets is about 62.9% based on the 629 wins within 1000 episodes.

### 1.8 Question 5

The estimated expected value of the winning after 1000 sequential bets using the Experiment 2 results: 0.629*80 – 0.371*256 = 50.32 – 94.976 = -$44.656 while the mean of the winnings was -44.66.

### 1.9 Question Set 6

In Experiment 2, the upper standard deviation line (mean + stdev) and lower standard deviation line (mean – stdev) do not reach a maximum (or minimum) but then stabilize as standard deviation trends towards 162 and the mean trends towards -45. The upper band trends towards 120 and the lower band trends towards -210.

The bands do not converge and stay apart as standard deviation only trends higher.

### 1.10 Question 7

The benefits of using expected values is that with the law of large numbers the average of the results from random samples tend to converge to the actually

probability value while a single random episode will skew in favor of the result of that one episode.

## 2 FIGURES

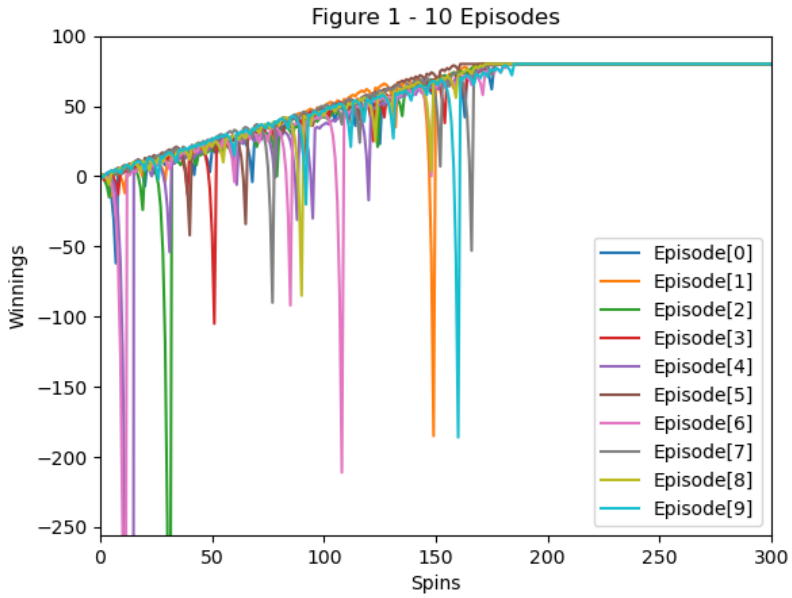


***Figure 1*** — 10 Episodes using Sim 1.

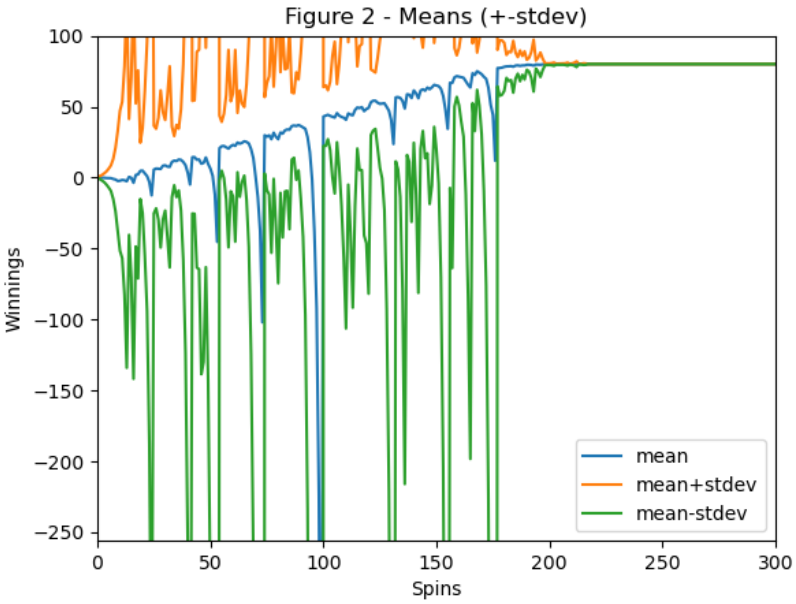


***Figure 2*** — Means (+- std) of 1000 Episodes using Sim 1.

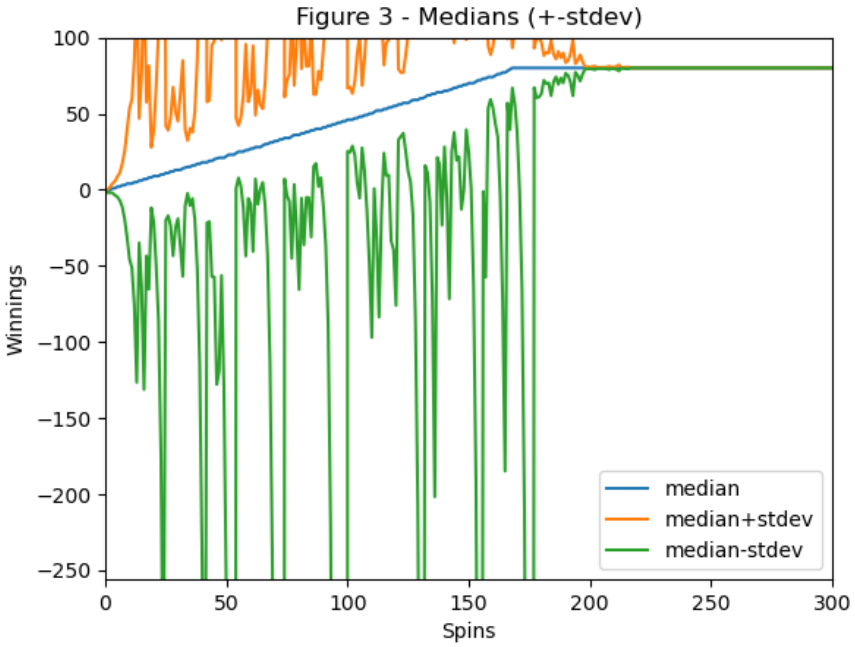


*Figure 3* — Medians (+- std) of 1000 Episodes using Sim 1.

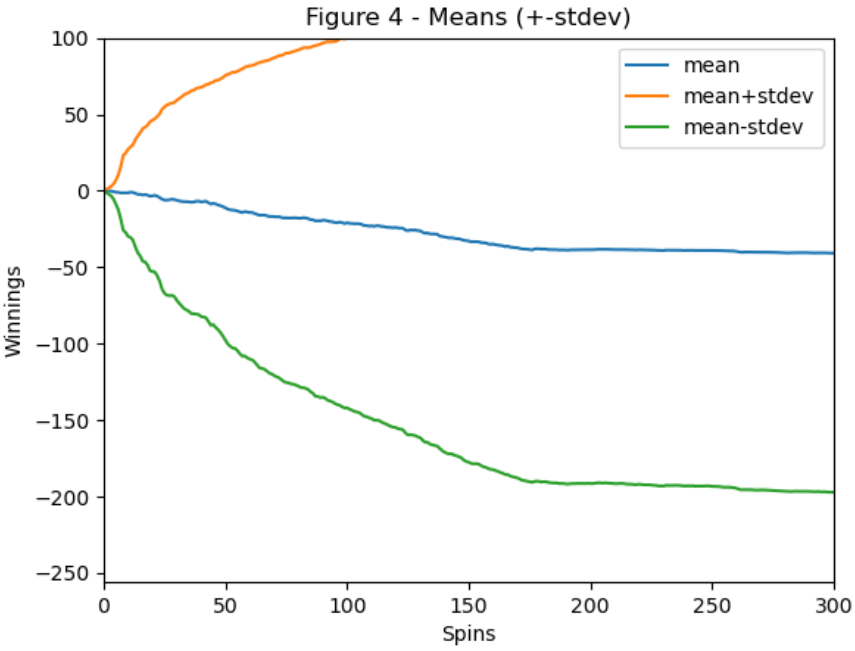


*Figure 4* — Means (+-std) of 1000 Episodes using Sim 2.

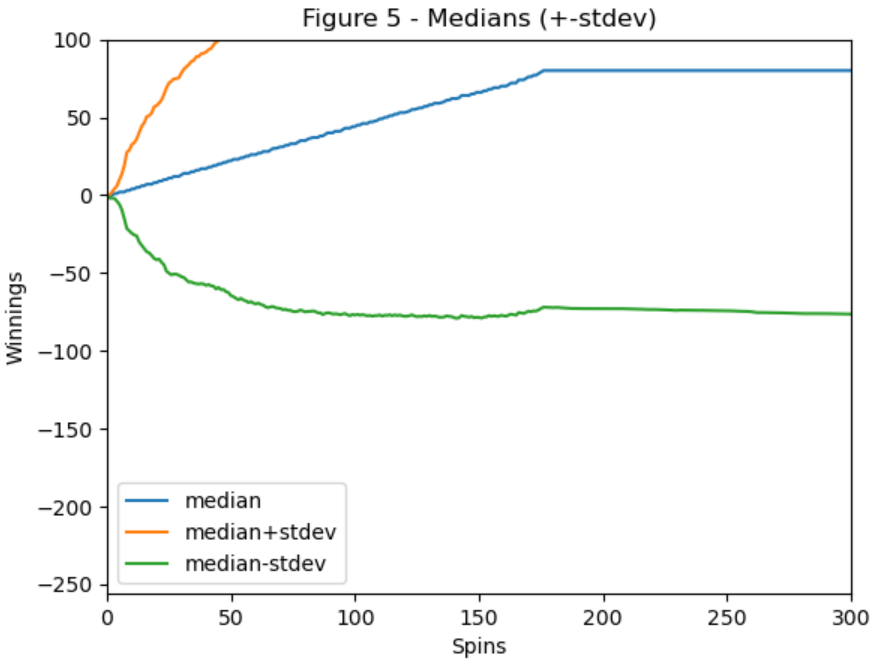


***Figure 5*** — Medians (+-std) of 1000 Episodes using Sim 2.