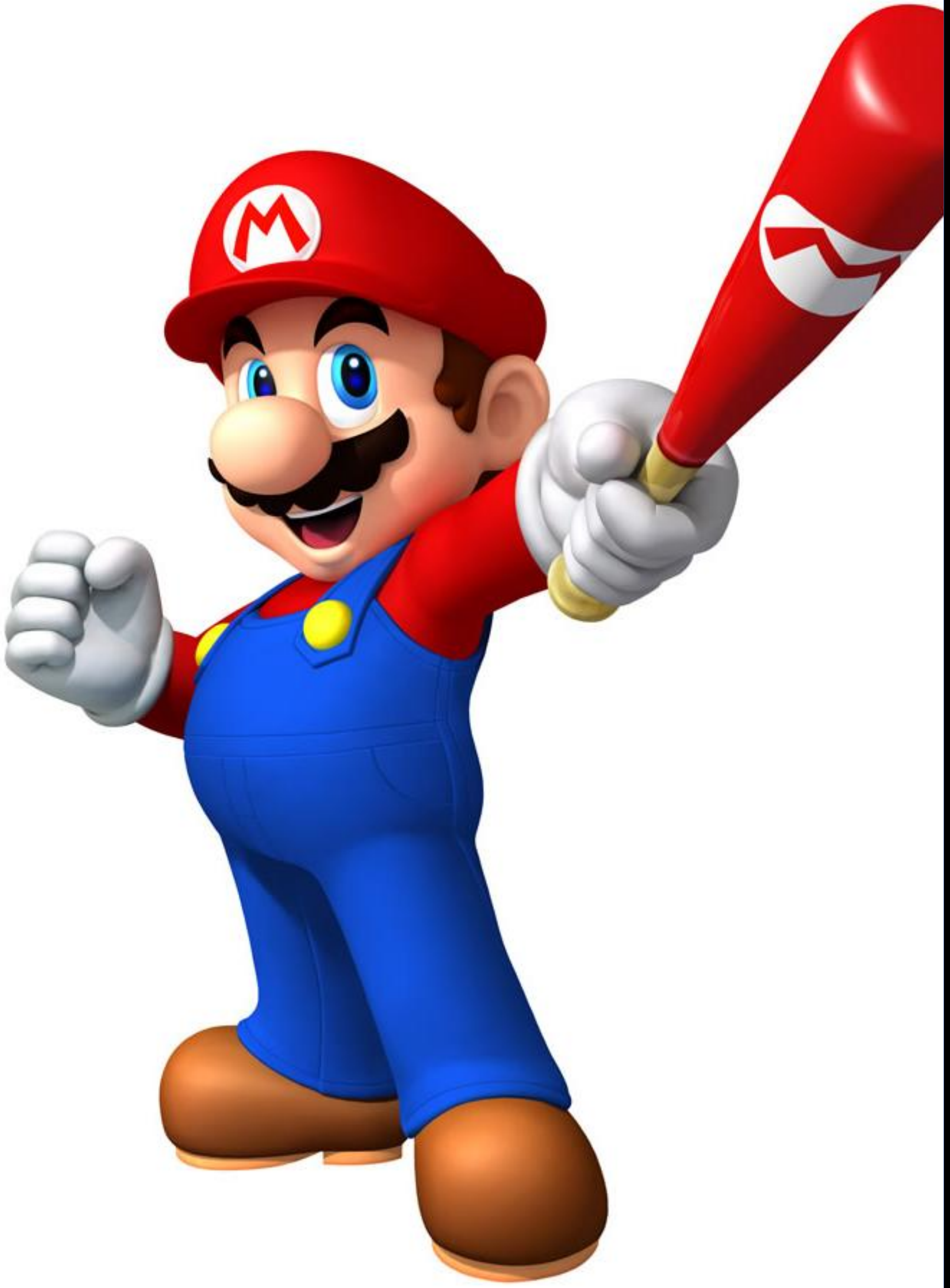
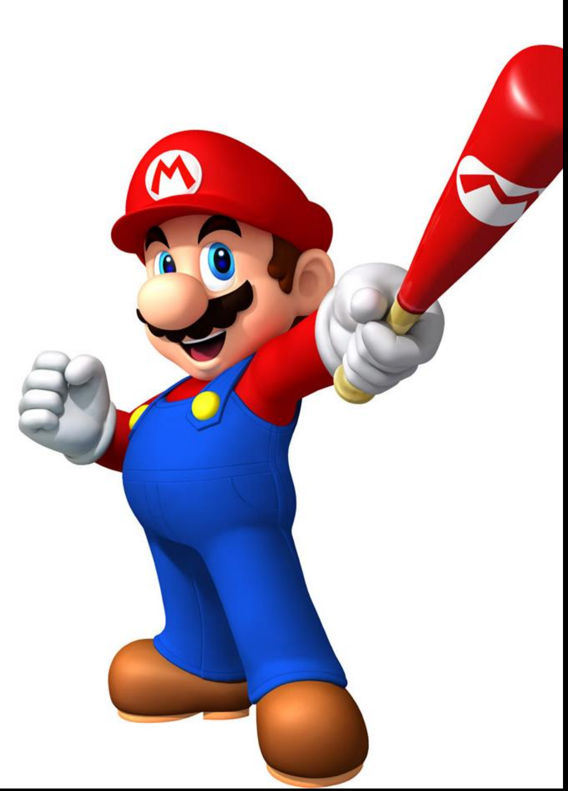


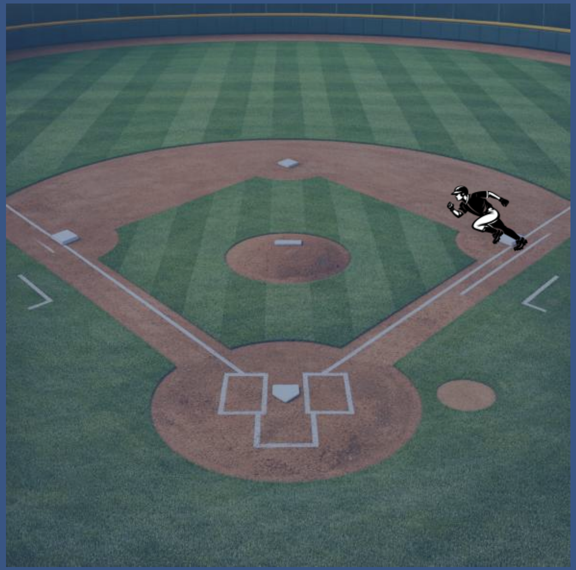
Baseball V

Produced by Dr. Mario | UNC STOR 538

Baseball Decision-Making



- Manager Decisions
  - Situation 1: Man on First and No Outs. Should We Bunt?
  - Situation 2: Man on First and One Out. Should We Steal?
  - Most Decisions in Baseball are Trade-Offs
  - All Decisions Have the Probability of Error



- States of Baseball
  - 24 Unique States in an Inning
  - Represented by 4 Numbers
  - Best State = 0111

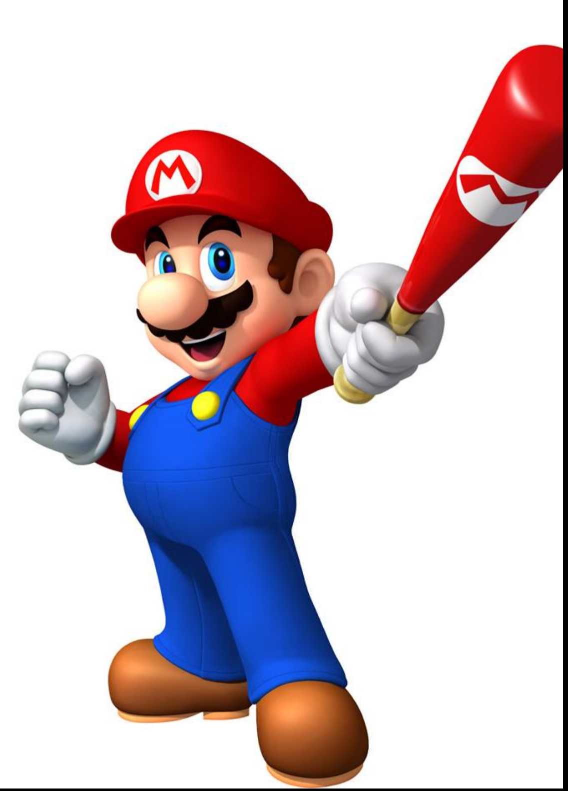
$$E[Runs|0111] = 2.2715$$

  - Worst State = 2000

$$E[Runs|2000] = 0.1028$$

Possible States during an Inning

State	Outs	Runner on First?	Runner on Second?	Runner on Third?
0000	0	No	No	No
1000	1	No	No	No
2000	2	No	No	No
0001	0	No	No	Yes
1001	1	No	No	Yes
2001	2	No	No	Yes

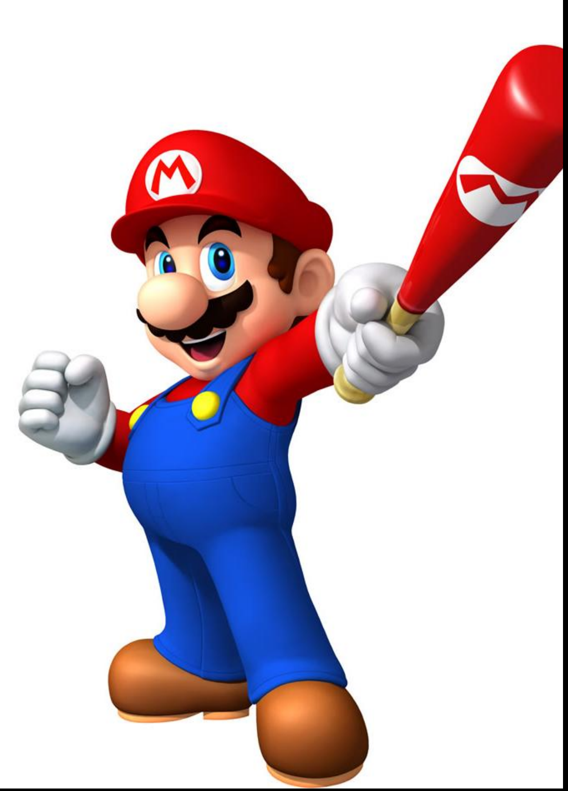


Baseball Decision-Making

- States of Baseball
  - Average Number of Runs for Each State

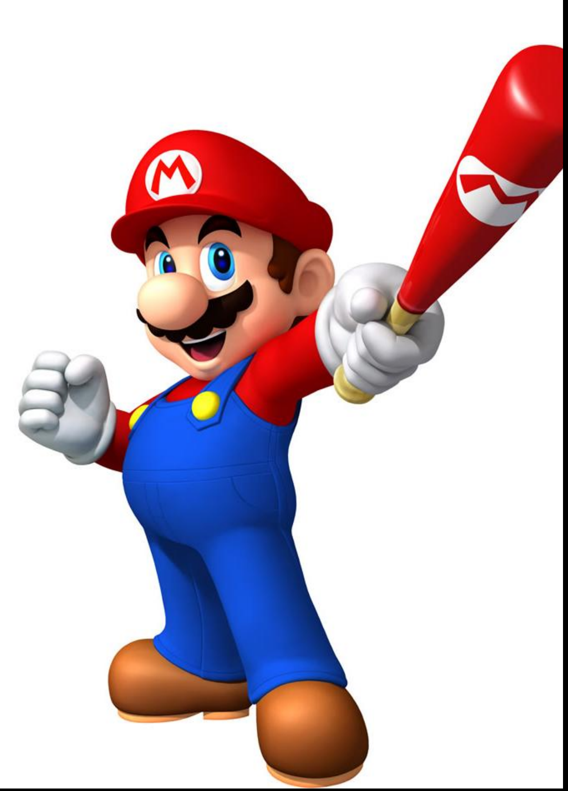
Situation	0 Outs	1 Out	2 Out
000	0.5062	0.2737	0.1028
001	1.3163	0.9225	0.3638
010	1.0932	0.668	0.3174
011	1.9033	1.3168	0.5784
100	0.8744	0.5263	0.2199
101	1.6845	1.1751	0.4809
110	1.4614	0.9206	0.4345
111	2.2715	1.5694	0.695

Baseball Decision-Making



- States of Baseball
  - Example: Pitching States of Plate Appearances
    - 1 = Strike & 0 = Ball
    - Situation: Strike, Ball, Ball, Ball, Strike, Strike = 100011

States For Strikeouts	States For Walks	States For Hits
111	0000	1
1011	10000	0
1101	01000	10
0111	00010	01
11001	110000	00
Etc.	Etc.	Etc.



Baseball Decision-Making

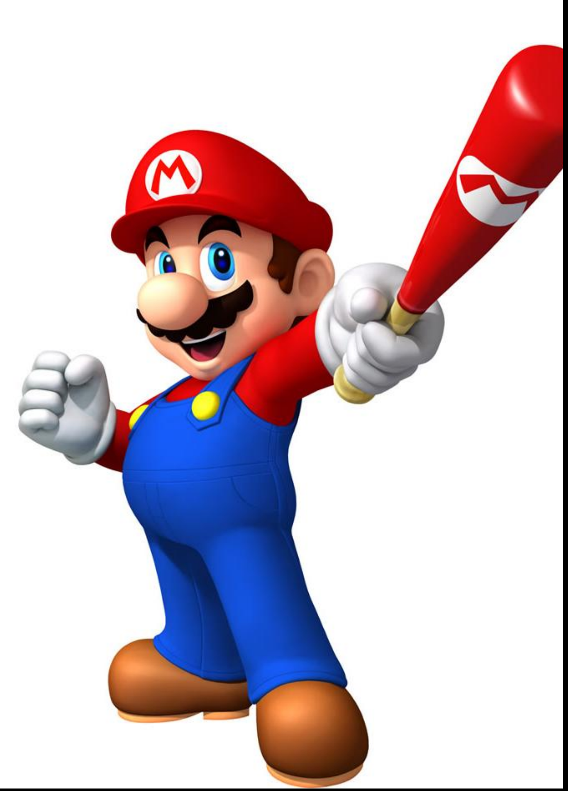
- Experiment
  - Any Situation where Outcome is Uncertain
  - Typically, Set of Outcomes (O) is Finite and Can Be Listed
  - Example: Pitcher Throws a Pitch

$$O = \{Strike, Ball, Hits\ Batter, Hit\ in\ Play\}$$

- Random Variable
  - Associated with Experiments
  - Typically Involves Numeric Outcome Based on Observation
  - Usually Notated with Capital Letter (X)
  - Sample Space (S) Represents Possible Values Involving Subsets of Set of Outcomes (O)
  - Example: X = Number of Balls in a Plate Appearance

$$S = \{0, 1, 2, 3, 4\}$$

Baseball Decision-Making



- Expected Value
  - Average Value of a Random Variable if Experiment Repeated Infinite Number of Times
  - Formula for Expected Value

$$E[X] = \sum_{x \in S} xP(X = x)$$

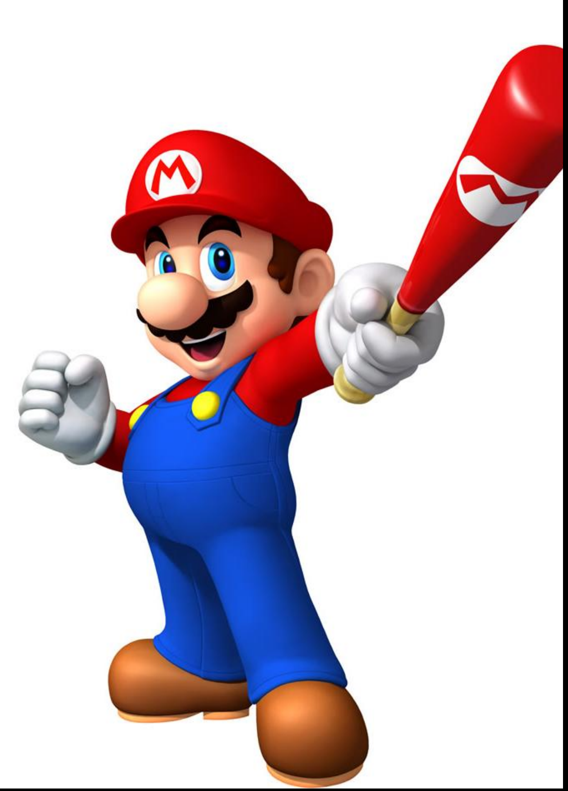
  - Example: X = Number of Balls in Plate Appearance

$$E[X] = 0 \times 0.2 + 1 \times 0.4 + 2 \times 0.3 + 3 \times 0.05 + 4 \times 0.05 = 1.35$$

x	P(X=x)
0	0.2
1	0.4
2	0.3
3	0.05
4	0.05

  - Formula Based on Law of Conditional Expectations

$$E[X] = \sum_{y \in S} E[X|Y = y]P(Y = y)$$



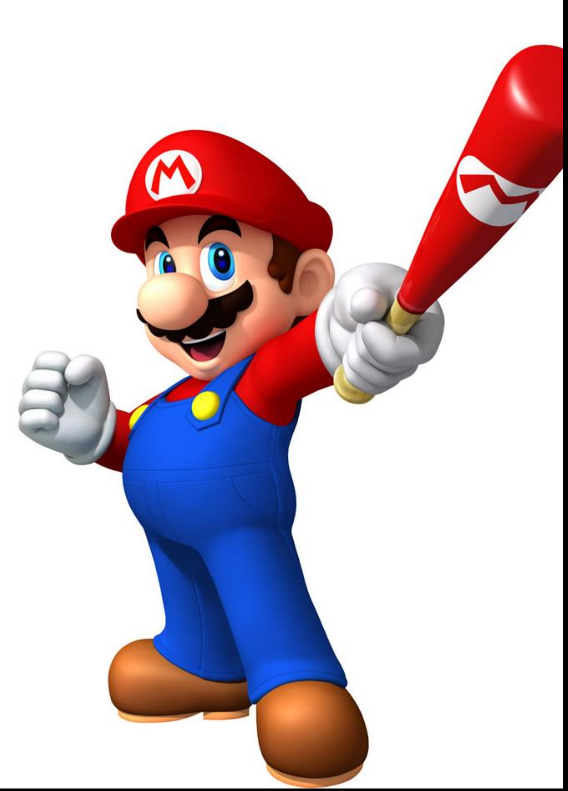
Baseball Decision-Making

- Expected Value
  - Example:
    - X = Number of Balls in a Plate Appearance
    - Y = First Pitch is a Strike (Yes = 1 & No = 0)
    - Average of 0.99 Balls When First Pitch is a Strike
    - Average of 1.83 Balls When First Pitch is a Ball

$$E[X] = 1.83 \times 0.43 + 0.99 \times 0.57 = 1.35$$

y	E[X|Y=y]	P(Y=y)
0	1.83	0.43
1	0.99	0.57

Baseball Decision-Making



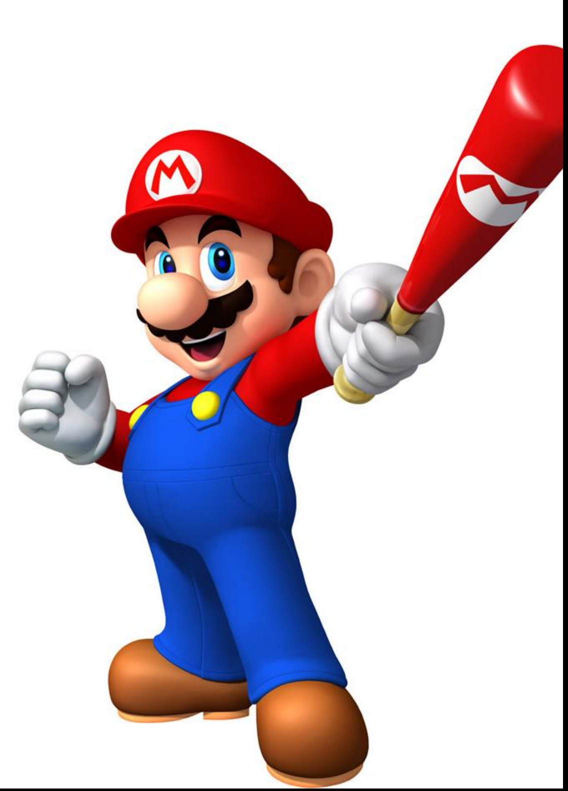
- Should We Bunt with Man on First and No Outs?
  - Expect 0.87 Runs Under Current State = 0100
  - List of Possible Resulting States With Probabilities

Result	Resulting State	Probability	Expected Runs (from Figure 6-2)
Batter is safe and runner advances to second base	0111	0.1	1.46
Runner advances to second base and batter is out	1010	0.7	0.67
Both runners are out	2000	0.02	0.1
Runner is out at second base and batter reaches first base	1100	0.08	0.53
Batter is out and runner remains on first base	1100	0.1	0.53

Based on Previous Table

Based on Known Relative Frequencies

Baseball Decision-Making



- Should We Bunt with Man on First and No Outs?
  - Expected Number of Runs Scored After Bunt (X)

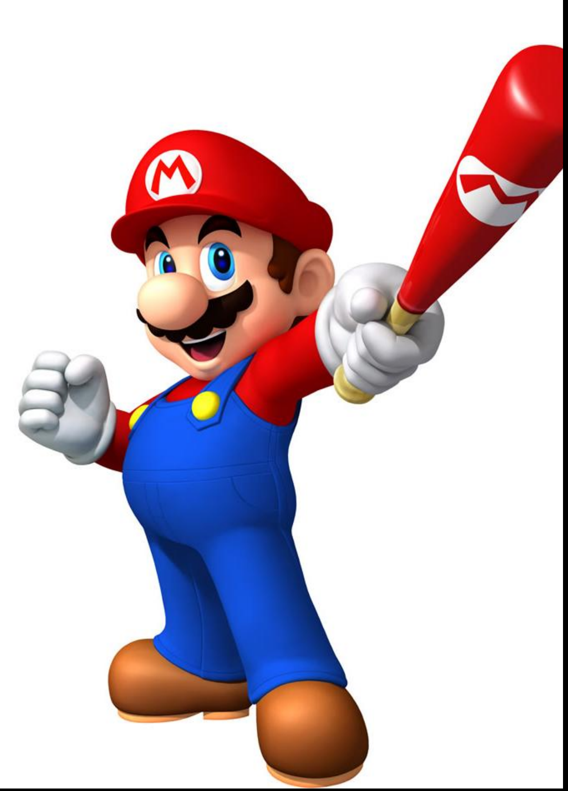
$$E[X] = 0.1 \times 1.46 + 0.7 \times 0.67 + 0.02 \times 0.1 + 0.08 \times 0.53 + 0.1 \times 0.53 = 0.71$$

  - Comparing Expected Runs Without Bunt Versus After Bunt
    - Under Current State = 0.87 Runs
    - After Bunt = 0.71 Runs (Clearly Worse)
  - All of This is Based on the Average Hitter

- What if I am Batting? Should I Bunt?
  - Strike Out 85% of the Time
  - Single 10% of the Time
  - Walk 5% of the Time
  - Suppose Stupid Manager Lets Me Swing for the Fence

$$E[X] = 0.85 \times E[X|1100] + 0.1 \times E[X|0101] + 0.05 \times E[X|0110] = 0.69$$

Assume Runner Gets to Third



Baseball Decision-Making

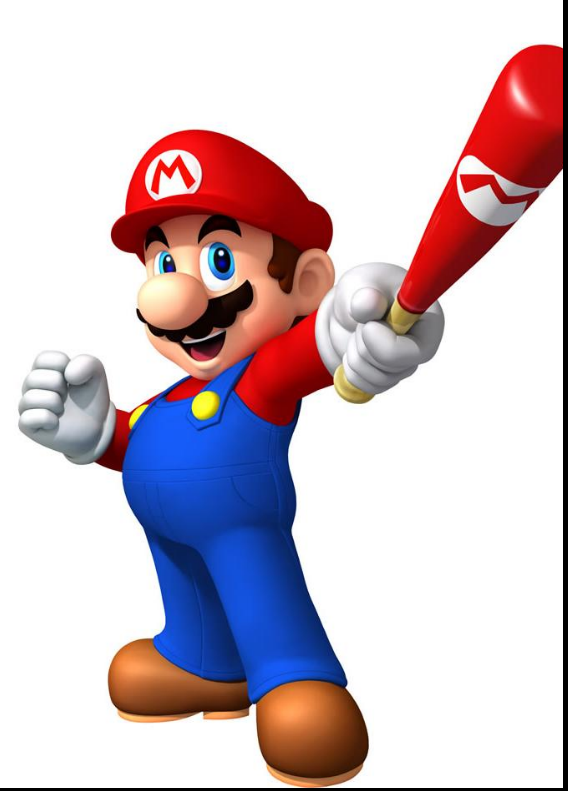
- Should We Steal if Man on First and No Outs?
  - Suppose I am on First Base…No
  - Suppose Usain Bolt is on First Base…Yes
  - Short Answer: Depends on How Fast the Runner Is?
  - Let p = Probability of a Successful Steal
  - Expect 0.87 Runs Under Current State = 0100
  - Success: State = 0010 with 1.09 Expected Runs
  - Failure: State = 1000 with 0.27 Expected Runs
  - Based on Law of Conditional Expectations for Expected Runs After Steal

$$E[X] = p \times 1.09 + (1 - p) \times 0.27$$

  - When do We Want to Steal?

$$p \times 1.09 + (1 - p) \times 0.27 > 0.87$$
$$1.09p + 0.27 - 0.27p > 0.87$$
$$0.82p + 0.27 > 0.87$$

$$\longrightarrow \quad p > \frac{0.87 - 0.27}{0.82} = 73.2\%$$



Baseball Decision-Making

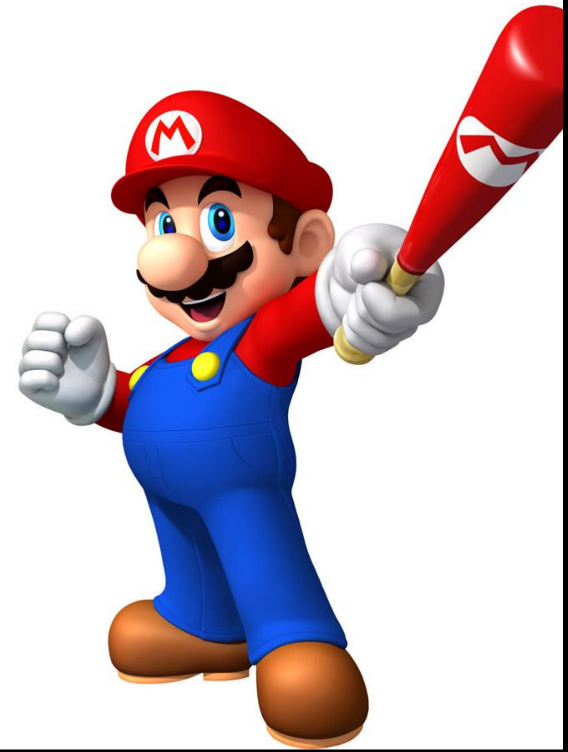
- Should We Steal if Man on First and No Outs?
  - In 2016, 71% Chance of Success on Steals
  - Implies Bad Idea Based on Average Rate
  - Suppose Super Mario is on 1st Base with 95% Chance of Stealing

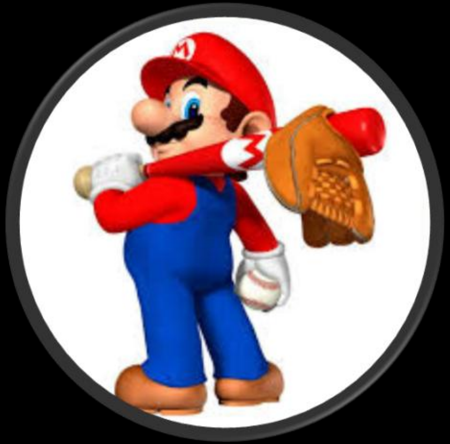
$$E[X] = 0.95 \times 1.09 + (1 - 0.95) \times 0.27 = 1.049$$

  - Marginal Increase:

$$1.049 - 0.87 = +0.179\ Runs$$

- Conservative Versus Liberal Base Running
  - Expected 0.87 Runs in State = 0100
  - Single Gets Hit and Runner Is Faced With Two Choices
    - Scenario 1: Attempt to Get to 3rd Base
    - Scenario 2: Stop at 2nd Base





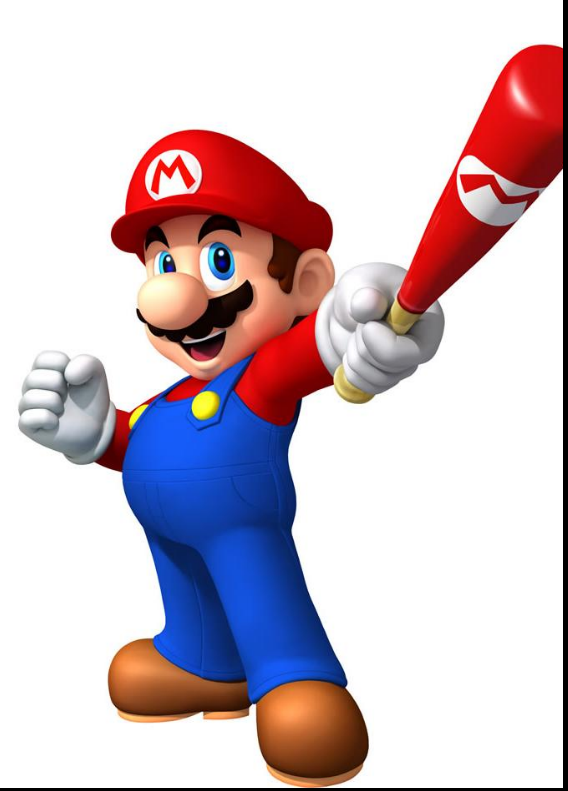
Baseball Decision-Making

- Conservative Versus Liberal Base Running
  - Under Scenario 1: Expect 1.68 Runs in State = 0101
  - Under Scenario 2: Expect 1.46 Runs in State = 0110
  - If Runner is Out: Expect 0.53 Runs in State = 1100
  - Let p = Probability Base Runner Gets to 3rd Base
  - If p = 0.81, then…

$$p \times 1.68 + (1 - p) \times 0.53 = 1.46$$

  - Interpretation: If Base Runner has a 81% Chance of Getting to 3rd Base, the Expected Number of Runs Under the Attempt "Breaks Even" with the Expected Number of Runs of Being a Coward
  - Data from 2005: 97% of the Time Base Runner Succeeded
  - Only Thing That's on My Mind, is Who's Gonna Run This Town Tonight

Baseball Decision-Making



- Conservative Versus Liberal Base Running

Situation	Breakeven Probability
first 0 outs	0.81
first 1 out	0.73
first 2 outs	0.90
second 0 outs	0.86
second 1 out	0.73
second 2 outs	0.39

Final Inspiration

If you are scared of a new situation, then lean in; you may just get hit by a pitch.

-Mahatma Mario