**Why you can trust this info**

**I've done the actual mathematical design of slot machines, professionally, for hire.**  I know how they work.  If that's not enough for you, see my general [slot machine page](http://vegasclick.com/games/slots/) for more reasons why my articles are credible.

**Slot machines are random**

**Slot machines work like every other casino game:**

1. **In every round there's a random result** (from dice being thrown, cards being dealt, or reels being spun).
2. **When you win, the payout is less than the odds of winning.**

In other words, the casino has a built-in mathematical edge on the games.  The casino doesn't have to screw with the dice to beat players at craps, they don't have to screw with the cards to beat players at blackjack, and they don't have to screw with the machines to beat the players at slots.  The payline symbols are  chosen at random, and it's the math that ensures that you're a long-term loser.

**As humans we try to look for patterns.**  We "sense" that the machines run in hot or cold cycles, that they pay better (or worse) at different times of day, or that other various things influence the results—but they don't.  We look for patterns because we're not comfortable with cold, hard, non-patterned randomness.  But whether you like it or not, random results is what you get.

**That means, for example, that it doesn't matter how long it's been since a jackpot hit.**  The odds are the same on every spin.  You've got the same chance of scoring a jackpot on a machine that just hit one, as a machine that last hit one three months ago.  A machine is never "due" to hit.  Every spin is random.  The random nature of slots also means that it's impossible to predict when the payouts will be good.  Any streaks you see are pure chance, nothing more.

**That makes sense, because the whole foundation of casino gaming is randomness.**  Every other game in the casino, from craps to roulette, works the same way.  The outcome is random, and the odds are simply tilted in the casino's favor.  There's no mystery about slots, just like there's no mystery about craps.  Why would there be?

**Even if the casinos wanted the machines to operate otherwise, they don't have a choice.**  Gaming regulations demand that the machines are completely random.  For example, this is from [Nevada Gaming Regulation 14](http://gaming.nv.gov/stats_regs/reg14.pdf) (PDF):

"[A gaming device] must use a random selection process to determine the game outcome of each play of a game...Each possible permutation or combination of game elements which produce winning or losing game outcomes must be available for random selection at the initiation of each play....The selection process must not produce detectable patterns of game elements or detectable dependency upon any previous game outcome, the amount wagered, or upon the style or method of play."

**There you have it.**  Slots aren't affected by the presence (or absence) of a player's card, how long it's been since the last jackpot hit, or anything else.  Slots don't have periods where they pay out more to "make up" for earlier periods where they paid out less.  They're random, period.  Anyone who says otherwise is simply pulling B.S. out of thin air and declaring it to be fact, with no evidence to support their delusions.

**The Simplest Slot Machine**

**To prep us for understanding the odds on slots, let's start with something simple:  a coin-flip game.**  You bet $1 on the flip of a coin.  For every heads you win $1, and for every tails you lose $1.

**It's pretty easy to see that this is an even-sum game.**  You would expect to be dead-even in the long term.  Which is why the casino would never offer such a game—there's no profit in it for them.  So now let's modify the game, to give the casino an edge.  In the casino version, you still lose your dollar when you get tails, but when you get heads, the dealer pays you only 90¢.

**You don't have to be a rocket scientist to see that the casino has an edge on this game.**  It's a long-term loser to the player.  The average loss is 5¢ per bet:  for every dollar bet on average, the player will get back 95¢, and the casino will keep 5¢ as its profit.  (If you thought the average loss was 10¢, remember that the penalty kicks in only when you lose, which is only 50% of the time.)

**By the way, if you think it would be crazy to play such a losing game, then ask yourself why people gamble in the first place,** because casino games are the same kind of sure losers as our coin-flip game.  In fact, many casino games are even worse:  the house edge in roulette is 5.3%, and on most slots it's even higher.

**Anyway, back to the coin-flip game.**  Okay, so now let's say that the casino wants to turn the game into a machine version so they don't have to pay a dealer to stand there all day and flip a coin.  The design of the machine  game is pretty easy:  We program the machine to choose a 0 or 1 randomly, to show a spinning coin, to stop on heads when it picked 0 and to show a tails when it picked 1, and to pay you 90¢ when you got a heads.

**We can even make it work even more like a slot machine:**  Instead of a spinning coin, it's a slot machine with a *single reel*, with 11 heads symbols and 11 tails symbols.

**Anyway, from this example you can see that all the casino needs to do to win is to provide a random game.**  There's no need to program in streaks or cycles or anything else.  As long as the game is random, the player will be a long-term loser.

**Slot machines work exactly same way:**  The payouts are simply less than the odds of hitting them.  You can't beat a coin-flip game when you're paid only 90¢ on your wins.  By the same token, you can't beat a slot machine since it underpays you on your wins.

**Picking the symbols**

**Enough coin-flipping, let's move on to slots.** On a slot machine, a random number generator (RNG) picks a random number for each reel, which each number picked corresponding to a stop on its reel.  Then the machine directs the reels to stop on the spots selected by the RNG.

**Note that by the time the reels are spinning, the game is already over.**  The RNG has already selected the stops, and the reels spin sort of as a courtesy to the player.   Slot machines don't even need visible reels—you could just put your money in and the machine could tell you whether you how much (if any) you won.  Wrap your head around that one for a minute.  The presence of the visible reels makes no difference in the game—they're just there to show you what the computer picked.

**How the stops are selected**

**A typical non-progressive *video* slot has 35 to 50 stops per reel.**  An *electro-mechanical* slot uses an (invisible) "virtual reel" of 64 to 256 stops, which are mapped to the 22 stops on the physical reel.  The physical reel isn't big enough to hold all the stops that are needed, so it's the big one that's used in the computer program.  ([source](http://www.nh.gov/gsc/calendar/documents/20091117_harrigan_dixon.pdf))

**If you saw a worker open up an electro-mechanical slot machine you might see a reel like the one on the right**, if it were unfolded.  There are various symbols spread across 22 stops.  Yes, the blanks count as stops.  You might think that since there are 11 blanks you have a 50% chance of hitting one, and since there's only one jackpot symbol you have a 1-in-22 chance of getting it.  But it doesn't work that way, because we're not really working with a 22-stop reel.  We're really working with an invisible reel of like 128 or so stops, controlled by the computer.  The computer will pick a number from 1-128, each of which is mapped to a specific symbol.  Here's a **hypothetical** map for the reel shown at right:

|  |  |  |
| --- | --- | --- |
| **Selected Number** | **Symbol Picked** | **Total no.of symbols** |
| 1-73 | Blank | 73 |
| 74-78 | Cherry | 5 |
| 79-94 | Bar | 16 |
| 95-107 | Double Bar | 13 |
| 108-118 | Triple Bar | 11 |
| 119-126 | Red 7 | 8 |
| 127-128 | Jackpot | 2 |

**Say the computer picks #53.**  That's a blank, and it tells the reel to stop on a blank.  If it picks #75, then it tells the reel to stop on a cherry.  If it picks #127, then the reel tops on the jackpot symbol.

Most of the numbers are for the lower-paying symbols, so that's what's more likely to get chosen. That's what we mean when we say the reel is *weighted.* Some symbols are more likely to be chosen than others, even if they appear the same number of times on the physical reel.

So you don't really have a 1 in 22 chance of hitting the jackpot symbol on this reel. Your odds are actually 2 in 128, or 1 in 64.

And of course, the most likely symbol is a blank. On our sample machine, you have a 73 in 128 chance (57%) of drawing one of those.

Speaking of blanks, when the computer picks a blank, it actually picks a *specific* blank. Same for the other symbols that appear on the reel multiple times, like cherries and certain bars. The table above was simplified to make things easier to understand, but now that we've come this far, let's now look at how every single position on the reel might be weighted.

|  |  |  |  |
| --- | --- | --- | --- |
| **Stop** | **Symbol** | **SelectedNumber** | **Numberof Chances** |
| 1 | cherry | 1-2 | 2 |
| 2 |  | 3-7 | 5 |
| 3 | — | 8-12 | 5 |
| 4 |  | 13-17 | 5 |
| 5 | 7 | 18-25 | 8 |
| 6 |  | 26-30 | 5 |
| 7 | — | 31-35 | 5 |
| 8 |  | 36-41 | 6 |
| 9 | cherry | 42-43 | 2 |
| 10 |  | 44-49 | 6 |
| 11 | == | 50-56 | 7 |
| 12 |  | 57-62 | 6 |
| 13 | cherry | 63 | 1 |
| 14 |  | 64-69 | 6 |
| 15 | = | 70-75 | 6 |
| 16 |  | 76-81 | 6 |
| 17 | — | 82-87 | 6 |
| 18 |  | 88-93 | 6 |
| 19 | ΞΞ | 94-104 | 11 |
| 20 |  | 105-115 | 11 |
| 21 | jackpot | 116-117 | 2 |
| 22 |  | 118-128 | 11 |

**The fourth column (Number of Chances) shows the weighting.** We've got a 2 in 128 chance of landing on the first stop (a cherry), and an 8 in 127 chance of hitting stop #5, the Red 7. Notice how the blanks surrounding the Jackpot symbol, #20 and #22, are heavily weighted. They're more likely to be selected, resulting in the "near-miss" effect. You think you just almost got the jackpot symbol, but it's really an illusion. You weren't close at all. It's like the blanks above and below the jackpot have little magnets on them.

**So far we've talked about only one reel, though most slots have three or five, and each reel is actually weighted differently.** As you go from reel to reel the weighting gets heavier, so you're more likely to hit higher paying symbols elastarly on. By the  reel the higher-paying symbols are even less likely. This results in another kind of near-miss effect: How many times have you gotten JACKPOT, then another JACKPOT, and then... a blank? After the first two hits you're holding your breath for the third reel, but in reality your odds are poorer for getting that third jackpot symbol than they were for getting either of the first two symbols. However, for the rest of this discussion, we're going to assume that each reel is in fact identical in order to make the math easier.

**A Par sheet details the probabilities for a particular machine.**  Slot makers guard them religiously, but a few have made their way into the public's hands.  From them we can see that the principles are exactly as I described.  Here are the publicly-available Par sheets I know about.  (I'll also publish my own when I get a chance.)

* Academic report by Canadian researchers, based on various Par sheets they obtained ([PDF](http://www.nh.gov/gsc/calendar/documents/20091117_harrigan_dixon.pdf))
* Blazing 7's slot by Bally, obtained by a slot machine collector ([PDF](http://rwatts.cdyn.com/download/8200%20bally.pdf))
* Red White & Blue, obtained by mathematician Michael Shackleford ([web page](http://wizardofodds.com/slots))

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Jackpot Amount** | **Odds** | **Source** |
| **Double Diamond** | 2500 coins | 1 in 46,656 | Par sheets obtained by Canadian researchers ([PDF](http://www.nh.gov/gsc/calendar/documents/20091117_harrigan_dixon.pdf)) |
| **Blazing 7's** | 5000 coins | 1 in 93, 312 | Bally's par sheet ([PDF](http://rwatts.cdyn.com/download/8200%20bally.pdf)) |
| **Phantom of the Opera** | 5000 coins | 1 in 114,131to1 in 155,345 | Par sheets obtained by Canadian researchers ([PDF](http://www.nh.gov/gsc/calendar/documents/20091117_harrigan_dixon.pdf)) |
| **Red White & Blue** | 2400 coins | 1 in 262,144 | [Wizard of Odds](http://wizardofodds.com/slots)  |
| **Double Strike** | 5000 coins | 1 in 500,000 | [Wizard of Odds](http://wizardofodds.com/slots/slotapx1.html) (estimate) |
| **Money Storm** | 10,000 to 50,000 | 1 in 2,188,411 | Par sheets obtained by Canadian researchers ([PDF](http://www.nh.gov/gsc/calendar/documents/20091117_harrigan_dixon.pdf))  |
| **Lucky Larry's Lobstermania** | 10,000 to 50,000 | 1 in 8,107,500 |
| **Megabucks** | $8 to $33 million(progressive) | 1 in 49,836,032 | [John Robison](http://robison.casinocitytimes.com/article/the-odds-of-winning-megabucks-47597) in Casino City Times |
| Note that there are often different versions of machines with the same name, so the numbers above might not applyto every flavor of the named machine.  What you should take from this is that as the jackpot goes up,so does the difficulty in actually hitting it. |

**Hitting the jackpot**

**So now that we know the weighting of the reels, we can answer that elusive question: What are the odds of hitting the jackpot?** Here's the answer. Assuming we have three identical reels as listed above, then the odds of getting the jackpot symbol on any reel is 2/128. The probability of hitting the jackpot on all three reels is 2/128 x 2/128 x 2/128 = 1 in 262,144. (If you played fast at 800 spins for 8 hours a day, you'd hit the jackpot on average once every 41 days.)  This in fact is the odds of hitting the jackpot on Red White & Blue.  (See the [main slot article](http://vegasclick.com/games/slots/) for more on jackpot odds.)

**Calculating the payback**

**Now that we know the weighting of the reels, we can calculate the payback for this machine**, which the percentage of money the machine would pay back over an infinite number of spins.  Of course you can't play for an infinite amount of time, but the point is, the longer you play, the closer your return will come to what the payback suggests.

**Our slot has the following paytable.**

|  |
| --- |
| **Bluejay Bonanza Slot Machine paytable** |
| **Symbols** | **Payout** |
| Jackpot (3 JP symbols) | 1666 |
| 7 7 7 | 300 |
| Ξ Ξ Ξ | 100 |
| = = = | 50 |
| — — — | 25 |
| 3 of any bar | 12 |
| 3 cherries | 12 |
| 2 cherries | 6 |
| 1 cherry | 3 |

**To find the payback of the machine, we multiply the probability of each winning hit times the payout for that hit, then add them all up, as shown in the following table.**  I included a "How Calculated" column if you're interested in seeing how I derived the probabilities. The numbers I use there came from the first table, above ("Total no. of symbols" column).

|  |
| --- |
| **Bluejay Bonanza Slot Machine** |
| **Symbols** | **Probability** | **How calculated** | **Payout** | **Prob. x Payout** |
| Jackpot (3 JP symbols) | 0.000004 | 2/128 x 2/128 x 2/128 | 1666 | 0.7% |
| 7 7 7 | 0.000244 | 8/128 x 8/128 x 8/128 | 300 | 7.3% |
| Ξ Ξ Ξ | 0.000635 | 11/128 x 11/128 x 11/128 | 100 | 6.4% |
| = = = | 0.001048 | 13/128 x 13/128 x 13/128 | 50 | 5.2% |
| — — — | 0.001953 | 16/128 x 16/128 x 16/128 | 25 | 4.9% |
| 3 of any bar | 0.030518 | (16+13+11)/128 x (16+13+11)/128 x (16+13+11)/128 | 12 | 36.6% |
| 3 cherries | 0.000060 | 5/128 x 5/128 x 5/128 | 12 | 0.1% |
| 2 cherries | 0.004399 | ((5/128)x(5/128)x(128-5)/128)x3(prob. 1st reel x prob. 2nd reel x prob. NOT 3rd reel; then multiply all by 3, to account for the 2 cherries appearing in any of 3 different positions -- 1,2 or 2,3 or 1,3) | 6 | 2.6% |
| 1 cherry | 0.108211 | (5/128x(128-5)/128x(128-5)/128)\*3prob. 1st reel x prob. NOT 2nd reel x prob. NOT 3rd reel; then multiply all by 3, to account for our single cherry appearing on any one of the three reels | 3 | 32.5% |
| **Total** | **96.3%** |

**So this is a 96.3% machine, meaning that if you played it forever, you'd get back 96.3¢ for every $1 you put into it.**  Of course you can't play it forever, and in the short-term anything can happen, but the longer you player, closer your return will come to 96.3%—meaning you will have lost 3.7% of all the money you bet.

**Of interest is that the small payouts account for most of the payback.**  The single cherry alone provides nearly a third of all the money you get back from the machine.  Same for "any bar / any bar / any bar".  The jackpot itself comprises less than 1% of the total payback.

Note that some figures are not exact due to rounding.

**The RNG is constantly picking numbers**

**The RNG is always working, even when you're not playing, picking thousands of 3-number combinations per second.**  The moment you press the button or pull the lever, the RNG picks its 3 numbers for your play.  So if someone hits a jackpot on a machine you were just playing, relax, you wouldn't have gotten it had you kept playing, because you would have hit SPIN at a slightly different time than they did.  Every millisecond you delay in hitting the SPIN button results in a different combination.

The reason the machine constantly picks numbers is so that no one can discern any pattern in the number-picking process and therefore predict a winner. It's extremely unlikely that anyone could do so even if the RNG *didn't* keep picking random numbers all the time, because the number of random numbers in a complete cycle is astronomical, but having the RNG pick numbers all the time removes any remote possibility that anyone could predict the outcome.