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Coins

“You are to write a program that simulates a number of coin tosses and then prints the number of heads and the number of tails to the computer’s console.” Looking back, I was almost certainly half-asleep as I read over the directions to one of my AP Computer Science assignments. With a uniformly rigorous class schedule, my Computer Science class quickly became sort of a refuge from my other less-interesting classes. AP Computer Science wasn’t an easy class by any means, but I continuously found intrigue in its seemingly endless supply of gotcha moments. This assignment, like many others, sounded easy enough at first. The most direct approach, I figured, would be to designate half of a numerical range to heads and the other half to tails. I could then just have the computer select a number, within that range, at random. The assignment seemed pretty clear-cut, but what it didn’t mention is that computers cannot actually generate random numbers. This was, without a doubt, *the* gotcha moment; instead of being able to just write a few lines of code, I had to do some external research to find the best alternative: using other dynamic numbers as a seed, such as time, to generate pseudo-random numbers. After implementing this alternative, I tested my program by simulating one thousand coin tosses. The results seemed random, but I felt somewhat disappointed knowing that the results were actually deterministic and, on a larger scale, predictable.

Thinking within this perspective leads to a very interesting question: how is a physical coin toss any different than a simulated one? The sheer number of variables affecting a physical toss may seem too overwhelming for reliable predictions, but it

would be naive to dismiss the idea that physical coin tosses are just as deterministic as their simulated counterparts. One of the primary themes in *No Country for Old Men* is determinism versus free will, and that's exemplified by Chigurh's two proposed coin tosses during the film. Instead of directly dismissing free will, however, the coin toss in *No Country for Old Men* embodies a greater philosophical question of whether one truly has control over their actions.

Before diving into that philosophical discussion, however, a look into the background of the coin toss seems pertinent. The earliest records of the coin toss trace all the way back to Roman times, when the game was called "navia aut caput," or "ship or head" (Alleyne, 2009). This name is remarkably similar to the widely adopted modern-day name, "heads or tails," likely because both names intuitively reference each side of a coin as an opposite. *The Telegraph* also notes that "A related game, Cross and Pile, was played in medieval England. The cross was the major design on one side of many coins, and the Pile was the mark created by the hammer used to strike the metal on the other side." Clearly the game has been around in an almost entirely static form for quite some time now, so its ubiquity in the modern-day world doesn't come as much of a surprise.

What is surprising, however, is the extent of that ubiquity. In the United States specifically, the coin flip is incredibly common amongst the general public for settling low-stakes disputes. My personal experience in this regard stretches back to the early years of my childhood, when my parents would consistently use coin tosses to settle disputes between my siblings and myself. The disputes were undoubtedly critical for a child—who got to eat the last piece of pie, who had to do an infrequent chore, or who

got to go to the baseball game. Of course, these disputes are retroactively frivolous, hence making them low-stake and suitable for “random chance” over a logical approach. Eventually, my siblings and I started believing in a bias towards heads, so my parents largely discontinued the coin toss, as, at that point, it merely served to create another argument. The coin toss continued to play a role at later times throughout my late childhood and adolescence, however. At my high school, for example, I recall one of our teachers offering a ten dollar gift card for whoever could correctly guess the highest number of sequential coin tosses. We played this game at each of our monthly award assemblies, as it was a clever form of entertainment as the administrators prepared their presentations. Since my high school was quite small at around 200 students, this game would only go on for a half dozen to a dozen or so tosses, until everyone but one had guessed incorrectly. This made it feel like a much higher-stake game, when, in reality, each of us were all hoping for the very small chance that we would be the one to guess every toss correctly and receive the ten dollar gift card.

Although the coin flip is most often associated with day-to-day low-stakes disputes, there are numerous times throughout history when crucial decisions were placed merely on how a small piece of metal landed. One of the most notable high-stakes flips occurred during the founding of Portland, Oregon, when its two New England native founders “vied for the bragging rights of naming the 640-acre locale after their respective hometowns” (Rheenen, 2014). In order to decide who received the naming rights to the new city, the founders agreed to a two-out-of-three coin toss, in which the founder wishing to name the city “Portland,” of course, won. Another remarkable instance noted by *Mental Floss* is the coin toss between the Wright brothers

that decided who would be the first to attempt a flight. Although Wilbur Wright won the coin flip and attempted the first flight on December 14, 1903, he ended up stalling the flyer and diving it into the sand. After the necessary repairs were made, Wilbur's brother, Orville, attempted and succeeded at flying the aircraft, taking the honor of the first successful flight away from his hopeful brother.

More recently, coin tosses have been used in politics, often as a last resort when two candidates receive an equal number of votes. In a city of the Philippines, for example, a mayoral election resulted in two candidates earning 3,236 votes each (Virola, 2013). Following protocol, the election officials flipped a coin five times, and the election went to the candidate who won three of the five flips. It may seem far fetched that coin tosses would ever have an affect on a US election, but that's exactly what happened earlier this year during the Democratic party primaries (Kelly, 2016). In Iowa's Democratic caucus, candidates Hillary Clinton and Bernie Sanders were in a dead heat for the state's delegates, which would ultimately help determine the party's presidential nomination. For every tied precinct, a coin toss was performed in order to declare the winner of that precinct. Amazingly, Hillary Clinton won six out of six coin tosses, helping her expand her lead over Bernie Sanders. While it is generally agreed that these coin tosses did not decide the winner of the Iowa caucus, it's worth noting the surprising significance of the coin toss in this high-stakes scenario. Although arguably not nearly as important as politics, sports is another contentious area where coin tosses are used quite frequently. Most commonly, a coin is tossed at the beginning of the game to decide which team starts, in small events such as middle school soccer games to large events such as the Superbowl. Perhaps the most intriguing toss during a sporting event

occurred at a FIFA football match between Colombia and Paraguay. Instead of landing flat on the ground to reveal a decisive result, it landed perfectly on its side (Univision Deportes, 2016) As expected, both the referee and the players were very surprised that the coin didn't bounce to reveal which team would receive starting possession of the ball. This instance in particular represents the almost pure uncertainty that we have when watching a coin toss, even though the actual uncertainty lies in the thrower.

A study conducted by statistician Persi Diaconis confirms this notion; when using a mechanical coin tosser, built for Diaconis by Harvard University engineering students, a coin will always land with the same result (Kestenbaum, 2004). Diaconis asserted that coin flips merely offer pseudo-random results, as their human throwers introduce a few practically unpredictable variables such as height, speed, and angles at which the coin is thrown and caught. In a more recent study from Diaconis, he concludes that the mathematical chances of a coin toss are not actually 50-50, and that it's instead "closer to 51-49, biased toward whatever side was up when the coin was thrown into the air" (Lewis, 2012). This conclusion is not only quite interesting on its own, but it's also proof of concept that coin tosses are only "random" because of humans, which aren't perfectly "random" to begin with.

Just as a computer requires a seed, such as other dynamic numbers, to generate a pseudo-random number, coin tosses require a separate layer of variability to generate pseudo-random results. This distinction may seem trivial at first, but it becomes a wonderfully helpful simplification when taking a closer look at the actual randomness of a coin toss. Diaconis has proven that humans are the seed to the coin toss by showing that mechanical tosses do not vary. Therefore, it is evident that the only sources of

variability in a coin toss can be attributed to humans and the medium in which the coin is tossed. To clarify, the latter encompasses how the coin physically behaves after a force is acted upon it. To understand how this might vary, consider how a coin flip would differ in three scenarios: indoors, outdoors on a windy day, and in water. The medium is clearly an important factor, perhaps sometimes just as important as the thrower, but it does not change the actual randomness of a coin toss, despite adding additional variables for consideration. That's because of the widely accepted notion that nature is not random. Although certain aspects of nature like weather may *appear* random on the surface, it is common knowledge that everything is ultimately just cause-and-effect. While a considerable portion of nature may not be practically predictable with currently available tools and technology, it would most certainly still be predictable on a larger scale. Science has long and consistently backed this idea of natural determinism, so it is safe to assume that much of the general public understands nature as having no conscious. Where the contention begins, however, is when we consider whether the variables introduced by humans are deterministic. Those variables are deterministic if and only if humans do not have free will. However, if our thoughts and sequential actions are in fact deterministic, the coin toss cannot possibly be random by any measure.

These assertions may sound overly audacious, so it is important to take a step back and consider supporting logical evidence. If free will does exist, it would be impossible to predict the thoughts of an inherently non-deterministic conscious. Although the variables introduced by nature would be deterministic, as discussed earlier, the coin tosser with free will would have the highest level of control, thereby

presenting themselves as a perfectly random seed. The manner in which they throw the coin would be totally unpredictable, as they would freely think of and proceed with their toss without any binding external influence. This would mean that, even if they were taught to throw a coin in a very particular way, they could always just freely change their mind before throwing. Since free will absolutely cannot be predictable, this would suggest that coin tosses are, after all, actually random since their seeds would include fickle free will humans.

The alternative argument that humans do not have free will is admittedly much more nihilistic as it presents some tough moral questions. Within scope, however, if humans are deterministic, meaning that our thoughts and actions are merely an unchangeable result of the cumulation of external stimuli, the coin toss is, by extension, deterministic. This would indicate that someone's thoughts and actions are predictable; it is important to emphasize, however, that it is not currently practical to do so. With that said, being impractical by current technology standards does not equate to being impossible. By definition, determinism would still be predictable, despite requiring a larger scale. Therefore, the variables in which a human presents in a coin toss would also be absolutely predictable. Both the amount and breadth of those variables would certainly be overwhelming, but, again, their yes-or-no ability to be predicted would remain unchanged. Therefore, a deterministic human seed would be of definite pseudo-randomness, as the only "randomness" involved would merely be a result of a kind of deterministic chaos. That is to say, the results would seem random, but would not actually be random, much like how a computer behaves.

Some people very passionately support either free will or determinism, while some others claim there is a middle ground between the two. In a survey conducted by *Scientific American*, 58.9% of respondents said that “we have free will,” while the remaining 41.1% said that “we do not have free will.” A compilation of respondent comments reveals the primary arguments for each side. While free will is difficult to support with evidence, the main argument claims that we essentially have free will...because we do. Some believe that we are in total control over our conscious thoughts and actions, because it quite frankly feels like we are. This is an understandable argument for free will, but determinism offers a somewhat stronger argument by applying everything we know about everything else in nature to humans. The main argument for determinism states that we are merely highly sophisticated zombies that *feel* as if we have control. The entire premise of this argument is that the influence of external stimuli will only affect an individual’s brain in a single way and that that individual cannot freely change how they think and what they do. Unlike free will, there is a small amount of scientific evidence for determinism; a fairly recent study conducted by a number of neuroscientists at the Institute for Human Cognitive and Brain Sciences in Leipzig, Germany revealed that brain activity can be analyzed to “predict decisions before they are consciously made” (Smith, 2008). One of the lead researchers commented that if decisions are being made up to ten seconds in advance as the data shows, then “there’s not much space for free will to operate.”

The relationship between the free will vs determinism debate and the coin toss, especially as it is presented in *No Country for Old Men*, is remarkable. In *No Country for Old Men* specifically, free will vs determinism is one of the primary themes and,

although the idea of free will is not directly dismissed in the film, it is most definitely called into question. The film suggests that Anton doesn't feel responsible for his murders, that Llewelyn can't prevent himself from returning to the crime scene and running away in the manner in which he does, and that Sheriff Bell can't help but feel apathetic because of everything he has been exposed to throughout his career. At the same time, the film hints at some amount of free will; in one of the very final scenes, for example, Carla Jean rejects an alternative fate offered to her by Anton via a coin toss. While it's difficult to objectively determine what exactly the film is suggesting, my perception of the film is that it's leaning towards determinism while simultaneously asking the audience to draw their own conclusions.

The iconic coin toss at the Texaco gas station is an almost perfect embodiment of the greater philosophical question of whether one truly has control over their actions. The scene is beautifully constructed, has a somewhat awkward feel, and, most importantly, demonstrates how we place so much on such a small object, expecting a random result, when, in reality, it is very possible that the outcome is pseudo-random and entirely destined. Anton appears to recognize some level of determinism; he exits the scene by stating that the older gentleman shouldn't place the coin in his pocket, since it's his lucky coin and that if he does, it will just become another coin, which he later concludes with "which it is." This dialogue suggests that Anton is aware of the irony in placing such a major decision in the hands of what appears to be just a bunch of deterministic chaos.

Not every question has an answer and the question of whether a coin toss is actually random is no exception. What many consider to be a trivial way to solve a

dispute is actually an encompassment of a much larger philosophical discussion, one that requires you to consider if we are any different from a pseudo-random seed used by computers. Regardless of where you stand on the amount of free will humans have, it's difficult to avoid questioning why we toss small pieces of metal to remove ourselves from the decision-making process, only to leave it in the hands of a perceived level of "randomness."

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