Dice Rolls are Not Completely Random

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By: Ben P. Stein

A six-sided die. Credit: Steve A Johnson via flickr.

Dungeons and Dragons, Yahtzee, and a huge number of other games all rely on throwing dice--from the 4-sided pyramid shape to the familiar 6-sided cube and the monster 20-sided variety. The dice are meant to introduce an element of chance to these games; we expect that the outcomes of the rolls will be truly random.

However, new theoretical models and high-speed movies of dice rolls of numerous shapes and sizes confirm this is not strictly

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the case. They show that dice thrown with a 1 on the top are slightly more likely to land as a 1 than as the other values for every type of the various kinds of dice they studied. But at the same time, it's usually too hard for someone to predict the outcome of the throw of a single die--you'd have to know the starting conditions of the throw and its environment so precisely that for all practical purposes, the result could be considered random.

Exploring a question that was debated in the 17th century by scientists and mathematicians Blaise Pascal and Pierre de Fermat, and many others before and since, doctoral student Marcin Kapitaniak at the University of Aberdeen, Scotland and his co-authors created a sophisticated theoretical model of the die throw in three dimensions. They considered how the effects of gravity, air resistance, friction of the table, and other factors influence the outcome of the roll. In addition, they observed the fall of the die with a high-speed camera that could capture the die's trajectory at a rate of 1500 frames per second. What did they find to be the most important factor?

"The initial position of the die," Tomasz Kapitaniak,of the University of Lodz in Poland, wrote to me in an email. Small changes in the position can significantly affect the outcome. Other factors are less significant. "The air resistance can be neglected," he said.

However, he quickly added, "friction is important."

With a high-friction table, in which the dice can't slide across very easily, the dice tend to bounce around more times, tumbling and twirling, and making the results harder to predict. With a smooth, low-friction, or soft table, the dice tend to bounce fewer times.

Even bouncing doesn't always mix things up. The high-speed video showed that dice frequently did not change their face even after a bounce.

Could gamblers use the knowledge from this paper to their advantage, by placing the desired value of their roll as the

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highest-lying face of their die?

"I don't know how to use it practically in casino," Kapitaniak wrote. Players would have to know everything so precisely--most importantly, the exact position of the die--to be able to predict the results with certainty.

On the other hand, casino operators won't ever be able to achieve 100% random rolls with dice. They often drill the pips--the little dots in dice--and fill it with uniformly weighted material in efforts to make all sides of the dice equally probable to come up in a roll.

"Drilling the pips...gives the symmetry in the die but symmetry is not enough" to make it random, he said. "[The] top face will always be more probable."

If not random, is the die roll chaotic--the popular concept that originated in the second half of the 20th century, in which small differences in starting conditions can lead to large differences in end results? The most common example is the hypothetical picture of a butterfly flapping its wings in South America changing air circulation patterns to influence the weather halfway around the globe. The end result is knowable only if you have precise knowledge of the starting conditions of the world's weather.

A die roll is chaotic only if it bounces on the table an infinite number of times, according to Kapitaniak. But this is far from attainable, due to the fact that the die loses energy with each bounce due to friction.

With the high-speed camera images and the new theoretical treatment, this paper provides a new contribution to the question of the true randomness of dice throws and coin tosses. It contributes to an increasingly sophisticated understanding of what can be considered fully random in everyday life.

And in a more practical vein, if you're playing Dungeons and Dragons tonight, it probably wouldn't hurt to start your roll with the coveted 20 on top--it may occasionally give you the desired

results, while Dungeon Masters could insist on playing on the roughest, highest-friction table they can find.

The work will appear in an upcoming issue of the journal Chaos.

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Kal • 6 days ago

Interesting to read that the dice are not truly random.
You sometimes also have this complaint on websites too for the same kind of games, such as http://www.freethedice.com, where it seems that some times players go on good runs or bad runs, although I have researched computer algorithms for throwing dice and they also are nearly random but not 100%.

I wonder if it would be possible to perfect a dice throwing technique to be able to roll exactly the same dice most of the time using the same throw? It must be possible but just exceptionally difficult.

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I am wondering your thoughts about the potentially random roll based on a new dice design called Polydi. The Polydi dice can be rolled like a tradditional die or they can be "spun". If the user spins the dice, would that create a truly random roll. You mention, "They show that dice thrown with a 1 on the top are slightly more likely to land as a 1". When spinning a Polydi, it starts on the semi round section (no numbers), it will ultimately fall on one the triangular sections (not the semi round). You can see the Polydi spin at http://youtu.be/-3fZQHhneeA Please let me know your thoughts about the new dice design at the Polydi page on G+ https://plus.google.com/111005...
We hope you like our new dice design. More importantly, we hope you agree that it creates a random roll (or at least as random as other dice).
The Polydi is patent pending.

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