ERGODICITY

HOW IRREVERSIBLE OUTCOMES AFFECT LONG-TERM PERFORMANCE IN WORK, INVESTING, RELATIONSHIPS, SPORT, AND BEYOND

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ADVANCE PRAISE

"This is one of the most important books I've read, period. It's short, articulate, and expansive on a singular subject matter — ergodicity, which is really the key ingredient to success in life, marriage, business, family, happiness, health, etc. It's mathematical in origin but ubiquitous in application. High performance only matters if you survive."

— BLAKE JANOVER, JANOVER INC. CEO

"A fascinating book [...] Once I started, I couldn't put it down [...] the math is minimal, and Luca treats the subject well. I wish I had read it two years earlier."

— ROBERT MATTHEWS, VP OF ENGINEERING, EQUIFAX

"One of the most important books for everyone to read. Ergodicity should be taught in school, and it should be a common metric in businesses that leaders pay attention to and are deliberate about."

— MATT CANNON

"Practical, easy-to-understand explanation of a complex issue. The examples the author uses make the definitions come to life."

— SCOTT MILLER

INTRODUCTION

In July 2021, I was diagnosed with malignant eye cancer. Thankfully, it was an early stage, and it appears the medical therapy worked well.

The cliché is that this brief encounter with death would have led me to live every day as if it were the last. It didn't. It never does.

People who are reminded of their mortality are often shaken up from their routine, yes, but never really live their day as if it were the last one:[1] doing so would be suboptimal if there's more than one day left.

In fact, **all our decisions are underpinned by an implicit assumption of a time horizon for which to optimize.** Whether to do unpaid work is influenced by how long we think a work relationship will last. Whether to marry our romantic partner is influenced by how long we believe our love will last.[2]

Time horizons are the basis of our decisions – and of our regrets. Live as if you would die tomorrow, and you will regret not having pursued long-term engagements (such as fulfilling professional ambitions, building a family, and so on). But live as if you couldn't die, and you will regret not having done what you cannot do anymore.

Getting the time horizon right is fundamental for a life with few regrets. Sadly, there's too much variance and too many unknowns for us to get it reliably right. However, **we can improve our outcomes by understanding the effect of time and variance on our choices**, and making choices that do not require our guess to be exact to work out.

Ergodicity is the field of study that concerns itself with precisely that. And reading this book will help you make better decisions – decisions that don't ignore time but leverage it, decisions that minimize regret and yet maximize long-term potential.

A NOTE ABOUT THIS BOOK

I wrote this book to explain the relevance of ergodicity to readers interested in its practical applications but not in its mathematical foundations.

In the inevitable tradeoff between formal precision and accessibility, I favored the latter. Therefore, this book contains sentences that are correct in their practical meaning but technically imprecise. **I use footnotes to reference justifications and more precise formulations.**

Sometimes, I edited quotes for punctuation. Emphasis is always mine.

Enjoy this book!

ANY QUESTIONS?

Feel free to email me at **Luca@Luca-Dellanna.com**

PART I

LOSSES ABSORB FUTURE GAINS

Ever since a young age, we are taught that a cost-benefit analysis determines whether it is a good idea to do something. If the gains are larger than the losses, then go ahead.

The real world begs to differ. There are cases in which it is a terrible idea to do something whose gains are larger than its losses.[1] The next chapter tells the story of how my cousin learned this lesson during his short-lived career as a professional skier.

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1. This applies to "Russian Roulette situations" – a concept explained in the chapter after the next.

1

IT IS NOT THE FASTEST SKIER THAT WINS RACES

My cousin was born in a mountain village in the French Alps. Like many there, he learned to ski before reading. I am a good skier, but I remember the humiliation when I was 14 and he was 6, seeing him surpass me, swift as a bullet. At a young age, he made it into the World Championships for his age bracket. Boy, he was fast!

His career ended abruptly a decade later, one leg injury at a time, until he had to retire before his twenties. From him, I learned that the skiers that you see on TV, the fastest racers in the world, didn't get there because they were the fastest.

They got there because they were the fastest of those who didn't get injured and forced into retirement.

In skiing, and life in general, **it is not the best who succeed. It is the best of those who survive.**

2

PERFORMANCE VS. SURVIVAL

In theory, performance determines success. The fastest skier wins the race, and the most performing employee becomes the most successful one.

In practice, **performance is subordinate to survival.** It is the fastest racer of those who survive that wins races, it is the highest performing employee who doesn't burn out that becomes the most successful, and so on.

I'm not just making the banal point that survival matters. I'm saying it matters *more than performance*.[1]

On the next page, let's run the numbers.

Let's imagine that every time my cousin participates in a skiing race, he has a two-in-ten chance of winning it, and a two-in-ten chance of breaking his knee.[2] How many races will he have won, on average, at the end of a championship consisting of ten races?

The naïve answer is two races. That is the product of the number of races, ten, times the probability of winning each, two-in-ten. This would be correct if the race outcomes were independent of each other. However, if he breaks his knee during a race, he misses the following ones.

So, he can participate in the second race only if he didn't injure his legs during the first one. He can participate in the third race only if he didn't injure his legs in the previous two races, and so on. His chances of completing all ten races are pretty slim – only 11%.[3] If we take the time to compute his chances to participate in each race, we discover that his expected number of wins is less than one.[4] This is fewer than the two wins we would expect if injuries didn't prevent him from participating in subsequent races.

The point is, **in a single instant of time, pure performance is all that matters. Instead, over a prolonged period of time, survival dwarfs performance.**

Race #	Probs of participating	Probs of finishing	Expected wins
1	100%	80%	16%
2	80%	64%	13%
3	64%	51%	10%
4	51%	41%	8%
5	41%	33%	7%
6	33%	26%	5%
7	26%	21%	4%
8	21%	17%	3%
9	17%	13%	3%
10	13%	**11%**	2%
TOTAL			**0.71**

WE CAN ONLY OBSERVE THE LONG-TERM OUTSIDE OF THE SHORT-TERM

There is a difference between what matters when we consider narrow intervals and what does when we consider broader ones. **Over the short term, consequences that apply beyond the short term do not matter. Over the long term, they do.**

In my cousin's case, the broken leg preventing him from competing in future races is a "phantom consequence" that is not observable in the short term but affects the long term. If we make decisions based on what happens over narrow intervals and forget about these "phantom consequences," we will make bad decisions.[5]

Ergodicity is the study of these phantom consequences.[6]

IRREVERSIBILITY ABSORBS FUTURE GAINS

The explanation for the skier paradox is that, whereas my cousin had a chance to win each race, he is not guaranteed to race all of them. Any major injury prevents him from participating, causing him to forego expected future gains.[7]

In general, we can say that in any repeated activity, **irreversibility absorbs future gains.**

This means that you cannot extrapolate future outcomes from solely the expected outcomes of the activity performed once. You also need to consider the impact of irreversible consequences.

For children, falls, fights, and mistakes in general tend to have more reversible consequences than for adults. Sometimes I wonder if part of the nostalgy for childhood is nostalgy for reversibility.

SUSTAINED PERFORMANCE

Of course, what I mentioned so far is about long-term performance, not short-term performance. However, in many venues of life, the two are more similar than apparent.

For example, winning a single race is an instance of short-term performance. However, to become a good enough racer to get admitted to the race and have a chance at winning it, long-term performance is necessary, too.

Too often, we observe a snapshot of someone's life and believe that we have witnessed a piece of short-term performance. But if practice is required to get to a place where one can attempt that, then what we are really observing is long-term performance. A professional skier successfully managed risk in the previous decades – no matter what he seems to be doing in this one race we're observing.

PRACTICAL APPLICATIONS

If you practice yoga, do not attempt to reach the maximum amount of stretch per session.[8] Instead, maximize the amount you can achieve without risking any major injury.[9] A single trauma is enough to prevent you from practicing effectively for months or even years.

If you are a salesperson, do not attempt to make the most sales this quarter. Instead, aim to sell as much as possible without risking your reputation and your brand's.

If you have a job, do not attempt to work as hard as possible. Instead, work as hard as you can without risking your health, marriage, or mental sanity. These three are damn hard to recover once lost.[10]

More in general, in any endeavor in which success depends on you accumulating some kind of resource (money, skill, connections, trust[11], etc.), **do not maximize growth regardless of survival. Instead, maximize growth that conserves survival.**

THE SWEET SPOT

The above is not an invitation to excessive prudence. Yes, until you experience pain, you do not know where the boundary is. And yes, going too slowly comes with problems, too.

Rather, the above is an invitation to **distinguish between calculated risks whose consequences you can recover from and recklessness whose consequences might permanently debilitate you.**

There is a sweet spot where you expose yourself to the former but not the latter[12], and that's a good place to aim.

Of course, easier said than done. Moreover, some people feel such a strong desire to achieve a risky goal that they might feel that not doing it would permanently debilitate them. That's fine. This book wants to be informative, not prescriptive. It aims to give you the tools to make informed decisions, not to make decisions for you.

THE PATH FORWARD

So far, I've talked about irreversibility in a rather abstract way. The next chapter presents a quantifiable example: Russian Roulette.

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1. I'm not saying that speed or performance doesn't matter. It does. It just matters less than survival, given a long enough time frame.
2. Of course, these odds are greatly exaggerated, to show the point more clearly.
3. That would be 80% (the chances of safely completing a race) to the power of 10 (the number of races).
4. The expected number of wins is $\sum(0.8^i \cdot 0.2)$, with i ranging from 1 to 10, where 0.8 is the chance of ending the race without an injury, and 0.2 is the chance of winning it. The result is 0.71 expected wins.
5. Good ideas make for some of the worst mistakes.
6. Between others.

7. You can only expect average returns if you can play the game a large number of times – that's what the law of large numbers is about. Therefore, if you want to get average returns, you should use a strategy that enables you to play the game a large number of times. This point will be further explored later.

8. Yes, I know, yoga is much more than stretching. Still, the example holds for the stretching part.

9. Or, better and wiser, focus on getting the input right rather than on maximizing the output. Practitioners will know what I mean.

10. This doesn't mean that hard work is bad. It's not. Small stretches of extremely hard work are good and, in some professions, necessary. The problem is when there is no time for recovery, and damage accumulates until the inevitable breakdown.

11. Trust takes years to create and seconds to destroy, they say. True. And on top of that, **trust takes personal closeness to create – if you break the trust someone put in you, you might be denied that closeness and thus the chances to rebuild trust.**

12. Depending on the domain, in absolute terms, or relatively to the minimum reasonably possible to conduct the activity.

3

RUSSIAN ROULETTE

If you are reading this book, you probably never played Russian Roulette. It is a gambler's game of the riskiest kind. The player takes a gun, empties the cylinder, and puts back a single bullet. Then, he spins the cylinder to randomize the position of the bullet. Finally, he takes the gun to his head. After staring at death for a few seconds, he pulls the trigger. If he survives, he collects a prize, usually in the tens of thousands of dollars. (Obviously, do not try this at home, or anywhere else.)

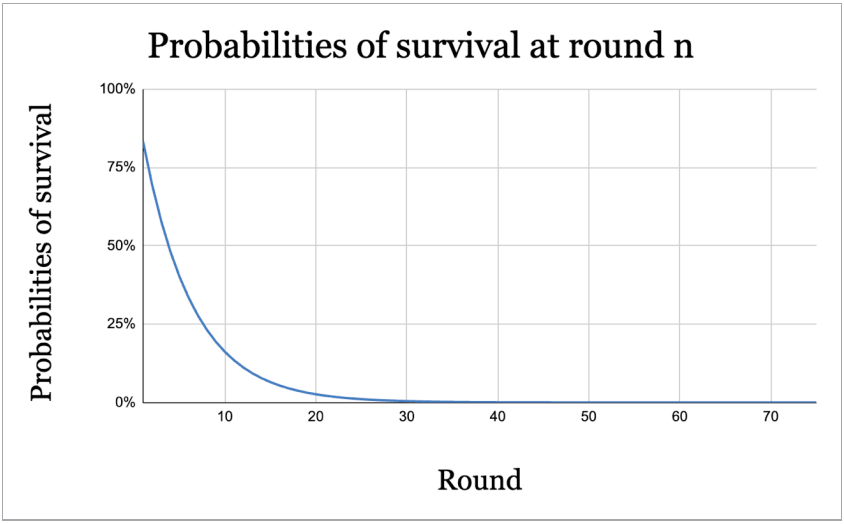
I'm telling you about Russian Roulette because some people are terrible at judging its odds. They then apply the same mistake to other areas of their lives, such as their relationships or careers, with disastrous consequences. Let's see if you can guess better than them.

Usually, the game is played with a six-hole cylinder. This means that when the player pulls the trigger, he has a one-in-six chance of dying and a five-in-six chance of winning. Let's imagine that the prize for a win is $6,000. How much money are you expected to win if you play Russian Roulette once?

The right answer is $5,000. That is the prize, $6,000, multiplied by the chances of winning, five in six. Now, a harder question. **How much are you expected to win if you play Russian Roulette a hundred times?**

A back-of-the-napkin calculation would yield $500,000. That would be $5,000 (the expected winnings for a single play) multiplied by 100 (the number of plays). However, this answer is wrong.

The correct answer is about $0. After 100 rounds of Russian Roulette, you're almost certainly dead and unable to collect any winnings.[1]

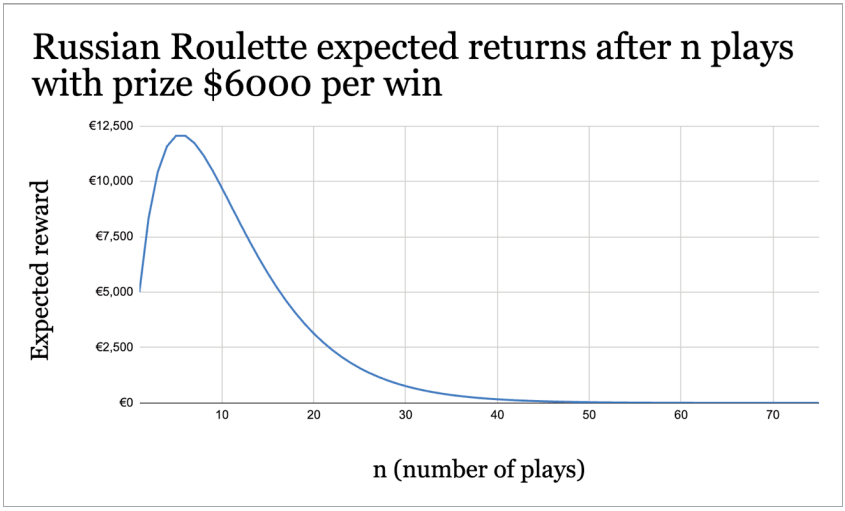


This applies not only to Russian Roulette but also to risky investments or risky tactics such as lying. The likely outcome of you doing it once is getting ahead. But the likely outcome of you making it your strategy is likely to leave you seriously damaged.

One of the lessons of ergodicity is that, if a tactic has great chances of succeeding, it doesn't imply it would make for a great strategy. Risk accumulates.

But let's go back to the Russian Roulette.

The chart below shows you the expected returns after playing Russian Roulette multiple times. As you can see, returns quickly plummet. [2]



This is because, in the beginning, winning a round increases your small winnings by a lot, but towards the end, you are already rich, and further wins add a small percentage to your wealth. Conversely, the chances of losing it all are constant at one-in-six and get harder and harder to avoid.

The previous thought experiment comes from Nassim Nicholas Taleb's "Skin In The Game" and clearly shows the link between ergodicity and irreversibility.

People who replied "$500,000" to the previous question assumed that death in one round just means that no winnings are collected during that round, but future rounds are still winnable. In Russian Roulette, however, one loss means that you also forego all future gains. Losses are irreversible and extend into the future.

Sadly, relationships, careers, investments, and sports often share this undesirable property. For example, relationships are like Russian

Roulette – in the sense that they grow stronger over time, but only if you get to spend time with your partner. If, one day, you break their trust, they might decide not to see you again. You will lose all chances to rebuild the relationship.

Similarly, in investing, losing your capital means that you have lost both your capital *and* all future returns that it could have generated.

THE PATH FORWARD

If you feel slightly confused, don't worry. It's normal. Irreversibility is counterintuitive and goes against what we usually learn in school, that averages matter equally in the short- and in the long-term. This is seldom true. The next chapter explains why.

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1. You only have a 12-in-a-billion chance of surviving 100 rounds of Russian Roulette.

   For comparison, you have a 16% chance of surviving 10 rounds and a 1% chance of surviving 25 rounds.

   In general, your chances of survival are $(5/6) \wedge n$, where 5/6 is your chances of surviving one round, and n is the number of rounds played. Death over time is certain, that is, $(5/6)^n$ tends to zero for $n \rightarrow \infty$.

2. In the first part of the curve, returns increase. This is because by playing an extra round, your total winnings increase by more than the probabilities of survival decrease. For example, by playing a second round, you can double your win but only decrease your chances of survival by one-sixth compared to playing once.

   However, after a bit, the returns stall, as in each round, you get to add a smaller and smaller percentage of your wealth, while your probabilities of losing it all are still 1/6. For example, by playing a sixth time, you only increase your winnings by 6/5, but your chances of survival decrease by one-in-six, a 5/6 multiplier. The two multipliers are reciprocal, so they cancel each other. Your rate of growth plateaus at 1.

   After that, the returns decrease. For example, by playing a seventh time, your winnings in case of survival become 7x instead of 6x, a 7/6 multiplier. However, your chances of survival still decrease by one-in-six, a 5/6 multiplier. 7/6 multiplied by 5/6 makes 35/36, which is lower than one, so returns decrease. Afterward, it's all downhill. Your rate of growth keeps decreasing: 40/42, 45/48, 50/54, ...