

The math behind happiness

Shubham [[website](#), [twitter](#)]

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1 Background

This weekend, I went on a ski trip with a group of friends. Organizing and figuring out the right trade-offs to make for a new group of friends is a time-consuming process: east coast or west coast? 2 days or 4? valentine's weekend, or the weekend after? Will everyone feed off each other's energy etc, etc - keeping everyone satisfied with the decisions made is a hard problem!

1.1 Day 1

As the days leading up to it flew by, I found myself suddenly on the base of this hill we were supposed to conquer. It being my first time skiing, I confidently strutted over to the bunny hill to race against some 5 year olds, ready to crush this new skill and catch up... except for the fact that I could barely stand still without falling. Whelp.

After countless hours of intense coaching, training, and tremendous willpower, I managed to descend down the bunny hill without inflicting fatal bodily harm unto myself - which meant I was ready to graduate and try out the greens! And so everyone watched, as I triumphantly plopped on the ski lift, only to find out - to my very horror - that you're supposed to ski off the lift itself. Yep, I ate snow. Those were a painful few first lifts.

Rolling down a few greens quickly brought us to the end of the first day of skiing. Nursing my bruises, we managed to make it to our spacious Airbnb [Fig 1] - and glorious it was! With 3 floors, 4 rooms, a hot tub, kitchen and games - we were ready to make the most of our evenings! Things started off with trying to find a place to eat, which was incredibly hard. After multiple trips to various restaurants and scurrying to make reservations, we scarfed down some pizza and headed home for some much needed rest and recuperation.

Just kidding - after some fair allocation algorithms were run for room allotment, the games were on! I kicked things off with a black grape v/s green grape blind taste test [Fig 2b]¹, after which we decided to play exploding kittens [Fig 2d] as we were getting comfortable with each other as a group; post which, we decided to play the game "We're not really strangers".

This game sparked discussions about knowing each other: what do we think about each other? What is something we're healing from, or holding onto? What's a fear you have? After some lighthearted ribbing and fun, we took a quick dip in the hottub and decided to call it a night, in order to wake up at 7am for Plattekill (a tall order!).

1.2 Day 2

And so ended day one at Bellyayre mountain, and off to sleep I went. We rose early on day 2, intending to get a full day of exercise in (having arrived after 11 am on day 1). My lessons from day 1 proved useful as I tried to navigate the decidedly harder routes at Plattekill.

As the saying goes, there's two kinds of skiers: those who speed with grace, and those who redefine gravity. I was firmly in the latter camp. While falling down at sharp bends was quickly proving to be a pattern, I was nothing if not a speed demon. You could find me hurtling down at 30 miles per hour, shouting "ON YOUR LEFT!" to the bewildered

¹The author would like to say that black grapes won with 100% of the vote, even though everyone on this trip save said author sided with green grapes a-priori. The author would additionally like to add that a completely unbiased instagram poll lead to a 19-18 win for black grapes, after removing 6 of the people on this trip who voted in the wrong direction.



(a) *Upstairs bedroom*



(c) *Upstairs living room*



(b) *Main bedroom*



(d) *Downstairs living room*

Figure 1: The beautiful apartment

beginners in front of me, as I found myself - an atheist - soul searching for the existence of god on this wretched planet.

And slowly but surely, as I started to go through greens with only minor speeding infractions, my friends thought it appropriate to level me up - and try a blue. "A promotion - how exciting!" were certainly not the words in my head as I hurtled down a mountain, riding off a mogul like a Costco version of E.T, and crashed into a fence instead of falling down safely.

The lack of correct decision making prompted me to take the rest of the day slower and put myself in timeout for a few minutes; I think physical injuries are unavoidable, but reviewing incorrect calls to your own safety and well-being can be critical. I continued pizzaing my way through greens for the rest of the day - I was nothing if not persistent!

Post day-1, we were better prepared for dinner decisions to be made, and decided to set our own spread. As people worked to get ingredients, make pasta, blend pina coladas, cut fruits and set up the table, I realized this was what society was all about. Everyone pulled their weight, trying to do things they were best positioned to do; for me, it reinforced the idea that successes of trips almost entirely depend on the people going!

After a good hearty meal, the next obvious thing to do was - play more games! Starting off with many hilarious moments in taboo, we resumed our game of "We're not really strangers" from the previous night. As we went through the game, we discussed many questions in depth, such as: What loving thing have you done for yourself lately? What do



Figure 2: Day 1 shenanigans

you feel underappreciated for? And as I always do, I derailed the game to go on a tangent to ask everyone questions: what is the most important quality in a person to you? What do you absolutely need in a best friend? What does friendship mean to you?

And in the warmth of the living room in front of the fireplace, with dinner table music playing in the background, I talked about some concepts I'd been thinking about for over a year now: the math behind happiness. It received a better reception than I'd hoped for, so I'm finally putting things down in a blogpost.

Most of these thoughts aren't fully formed, and I've prioritized writing something over writing something perfect; I apologize for that (and appreciate comments, ideas, inferences and extensions).

2 Setup

Suppose there are n humans in the world; define the happiness of human i as H_i . Let's define the k factors affecting happiness as f_1, f_2, \dots, f_k .

We can now define the input parameters: $H_i(f_1, \dots, f_k, H_{-i})$, where H_{-i} is the happiness vector of everyone except the i^{th} person².

²In a previous version of this draft, I had H be a time series, but I think this introduces complexity without adding any interesting analysis, so elided for ease

2.1 Factors of happiness

The f_i s are non-directly-societal factors such as income, food/water, stability, safety, self-esteem, physical and mental health, morality, creativity, self-actualization. Additionally, they include feelings of community and togetherness, consumption and vacations, donations and altruism. The factors feel almost [Maslow-y](#) in nature.

2.2 The dependence on H_{-i}

For a human, it's easier to think about and model the dependence on f_1, \dots, f_k - but clearly, the emotions of other humans around us affects us in a "real" manner. If a close friend is sad, it seems to directly translate into you being sadder as well - the idea here is to capture that dependence.

2.3 But Shubham, what about emotions?

One of the reasons that made me hesitant to post this was the answer to this question. It feels wrong and counter-intuitive to try to "math" out relationships, or emotions, or happiness, to think in utility function space.

A thing that I want to say about this is: I consider myself a +1.5 standard deviation emotional person (and I think people close to me would agree); the reason I believe having this framework is useful is to understand and communicate your emotions and feelings. Being able to relay my ideas precisely and having another human get it is truly a rush; and I would claim understanding your own happiness function is a means of self-discovery, really. Math can be beautiful, if used carefully and results taken with a boatload of salt.

3 Inferences

3.1 Personal happiness functions

If you marginalize out the H_{-i} factor, you come up with what I'd like to call a personal happiness function, also abbreviated as PH function.

$$PH_i(f_1, \dots, f_k) = H_{i,t}(f_1, \dots, f_k, H_{-i})$$

Why PH? Obviously because the higher your PH, the more [based](#) you are.

Increasing your PH is a journey of self-love. Getting a good amount of sleep, eating well, exercising and playing sports, meditating and emotional regulation are all ways to increase your PH. Things I've found helpful to increase my PH recently have been exercise, higher agency, a larger set of hobbies and interests, travel.

3.2 Defining $\beta_{x,y}$ and $\gamma_{x,y}$

We define

$$\beta_{x,y} = \frac{dH_x}{dH_y}$$

roughly, my beta to someone is how much happier I become when their happiness increases by a unit. This is my way of formalizing how "close" I feel to a person; I have higher beta to them!

You might imagine this as: Suppose I have a cookie; I'd rather have half a cookie so my

friend could have a cookie too (I'd lose 0.5 cookies for them to gain 1); that'd be a friend with a $\beta = 0.5$. You could imagine the same idea in other situations, such as winning the lottery for a million dollars.

You might think "Well, obviously a person would give up more cookie than lottery money!"; note that the difference in happiness in both cases would also be proportionally large, but that makes it pretty unintuitive to come up with betas. In my head, it's better to average across a bunch of large and small change-of-happiness examples for intuition.

Additionally, let's define

$$\gamma_{x,y} = \frac{\beta_{x,y}}{\beta_{y,x}}$$

Gamma is an interesting parameter here; it's trying to measure how much you'd give up for someone, compared to how much they'd give up for you. If friendships are symmetric, $\gamma = 1$.

3.3 The case of friendship symmetry ($\gamma = 1$)

Suppose all the betas in the world happened to be symmetric; that is, $\beta_{x,y} = \beta_{y,x}$. In that case, I think we'd have to enforce that $\beta \leq 1$; the idea being that if both betas were more than 1, we'd run into a sort-of-circular issue.

If both x and y want something the same amount (let's say, a 10y life-extending serum), and $\beta_{x,y} = \beta_{y,x} > 1$, then we'd have that x would be willing to give up > 10 years of life for an extra 10 years of y 's life; and y would do the same for x , meaning they end up in this infinite game, both end up losing a few years of life - because giving it up for the other would make them happier!³

3.4 Personality types

I think you could now start analyzing various social dynamics in terms of β s and γ s.

Anxious attachment styles, or people you might call "clingy" seem to have $\beta > 1$ in their relationships frequently, though this doesn't turn out great for their mental health.

Avoidant attachment styles are interesting, and the categorization seems less clear than anxious styles. Their β seems to depend strongly on the sign of change in happiness, and is discontinuous at 0; ie, they might seem much further away when there's conflict, and they tend to prioritize not hurting themselves at those times.

Having a high β and negative γ seems to occur in bullying / person-trying-to-break-into-clique style relationships, which are often toxic (I'd characterize most relationships with a negative beta as toxic).

Suppose you define $B_x = \sum_{y \neq x} \beta_{x,y}$; B_x is something like "the love person x has to give to the world". People who feel strongly about making society better, or giving back seem to have distributions that have smaller fraction of B_x distributed among their closest friends, and a long tail of trying to help humanity. Taken to the extreme, these people care about making as many people happy as possible.

³This implicitly is thinking about decision-making as an individual prospect, and betas as unknowable I believe; otherwise I think this could plausibly be a stable equilibrium, since x knows that y wants to give the serum to x to be happy. I'd still prefer to truncate things at $\beta = 1$ to keep things simple.

3.5 Streams of thought

1. Someone asked me if β s are transitive. Interesting thought - I didn't think so, but maybe the claim

$$\text{sign}(\beta_{x,z}) = \text{sign}(\beta_{x,y}) \cdot \text{sign}(\beta_{y,z})$$

has some truth if you believe "The enemy of my enemy is my friend"?

2. Following up on some of the examples above, I do think if someone has a higher fraction of their happiness vested in closer relationships, their eventual beta to their own happiness goes up (since the close relationship's happiness is closely linked to theirs!). This might explain often why extremely ambitious people trying to do a lot for the world seem less "happy"...
3. I think there are people who are consistently "high gamma" and vice-versa. People who are "high gamma" tend to form friendships and relationships easily, give out a lot of love and are social butterflies. Sometimes, this means they have a lower beta allocation for close friends, so it might be harder to feel like you "know" these people well; they're distributing their beta really wide! Though I do think these people tend to have higher B 's on average as well (beta sums, which could be termed empathy).
4. In a nutshell, I think you care about γ when making new friends, and β when making close friends!
5. "Anonymous Penguin" pointed out there could be cases where an extra unit of happiness for person x could cause an infinite blowup in happiness (self-exciting process). I think this isn't exactly right, but the counterargument relies on the time-series:
 - (a) It takes time for happiness to propagate among people,
 - (b) There's happiness decay with time tThose arguments save the framework from being broken, but it's an interesting thought! Maybe this leads to the famous quote "Happiness shared is doubled"?
6. Another argument pointed out by "Anonymous Penguin": non-transitivity is interesting because then you have things like
 - (a) Suppose $1 > \beta_{x,y}, \beta_{y,x} > \beta_{x,z} = 0$, all $\gamma = 1$ (symmetric)
 - (b) There are cases where x will give something up for y , and y will give that up to z and the total sum of happiness will increase, but this won't happen if x gives things directly to z
7. Someone asked me what α was in this document. Clearly the true alpha is the friends we made along the way...

I believe there's a lot more analysis we can draw out of this framework; I'm excited to see what people come up with!

4 Conclusion

After a good night's sleep and a hearty breakfast thanks to the cooking prowess of the many amazing people on this trip, I finally felt comfortable on the greens and the blues on day 3; being able to do them without lethally injuring someone seemed like a huge win, and I was (well, mostly) in control too! And of course, that (with some egging on) inevitably led to me foolishly believing I was well positioned to take on (drum roll)... a *black*.

Turns out, most of that belief was a pretty big lie. As I zoomed down the lanes with my limbs at angles they shouldn't have been at, I cursed my bravery and felt the shame brought unto my ancestors as I took the tumbles that hath been signed up for. Either way, all my joking and trolling upto the trip turned out to be true - I *did* end up doing a green on day 1, blue on day 2 and black on day 3 - who would've thought!

And as we were driving home, cracking various jokes and karaoke-ing at the top of our voices to the songs on the radio, something a friend told me stuck in my head; he said about his partner, "for me, I have a beta of one to her".

And someday, I hope I - and you too, dear reader - can find a connection that deserves $\beta = \gamma = 1$; or, in other words, "the one".



(a) Homecooked meal!



(c) Who did it better?



(b) On the mountain - ski ya later!



(d) Sneak pic of me being happy in that moment

Figure 3: More trip pics