Rotational Possibilities Frontier (RPF)

Calculation

Freestyle Trampoline Association

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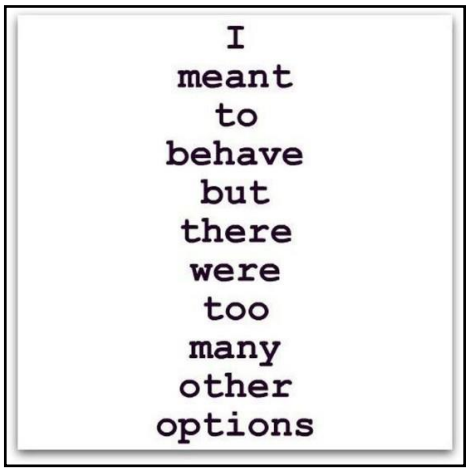
Rotational Possibilities Frontier ~ RPF

Now that we have demonstrated all skills are just arbitrary marker boys long the path of acrobatics, how many marker boys are there? We have shown how there are literally infinite numbers of rotational possibilities, when you look at the path described above, on all three axes. You should also realize that all minor body movements contribute to the overall possibilities. I have created an equation with the kind help of Mr. Ben Senderling *(MS, MBA)* that I call the ***"Rotational Possibilities Frontier"*** or **RPF**.

This is a mathematical equation that provides an actual number of rotational possibilities across all axes, based on what human beings can do with different body positions, along with the possible rotations around any axis in terms of degrees. Ben has been an amazing advisor on this concept and has made sure that my subpar mathematical abilities did not get in the way of the underlying concept I wish to demonstrate through this equation.



Each degree of each flip can be calculated by this equation and each degree of each body segment movement can also be calculated. By formulating an equation we can actually determine how many 'different' degrees of movement and rotation are possible. These degrees are important to know because then we know how many different Mazes can be created.

Mathematically there are infinite possibilities because you can subdivide each degree along the axis path indefinitely; however, by providing an actual numerical value to the possibilities, in terms of degrees, provides coaches and athletes with a baseline of their options when training. This is a theoretical equation to demonstrate the vastness of the possibilities, so please don't get to wrapped up in the specific numbers. Just realize that this equation gives backing to a *real* quantification of the possibilities.

The **RPF** mathematical function stands to act as a *Possibility Frontier* much like a "*Production Possibilities Frontier*" used in economics, which is also fundamentally theoretical. By determining what the actual possibilities are, we can derive an actual ***Spacial Awareness Quotient (SAQ)*** and categorize an athletes understanding of how to build skills based on their SAQ score. As mentioned, routines are only one aspect of great acrobatics. It does not in any way determine how much control the athlete has between different skills and learning new skills, only how well they performed the series of skills they already knew. This series of skills is repeated over and over again and does not actually determine how 'skilled' that athlete is in the grand scheme of acrobatics. It only shows how well they can repeat previously constructed routines.

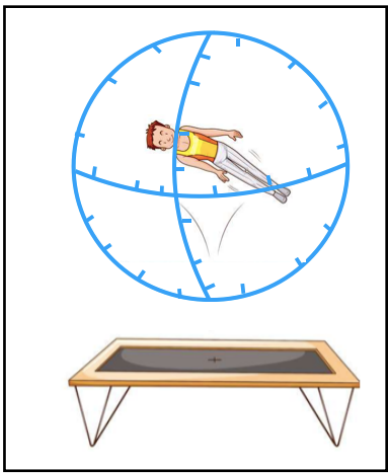
It also does not tell you *how* they will be able to build new skills in the future without the coach telling them the answers. Routines are impressive at one level, but they do not encompass the true understanding of the underlying path to success for all the possibilities of skills. The RPF tells coaches how many 'marker boys' there are in the acrobatic landscape as they navigate their ship. Each 'step' is a degree of rotation around some kind of axis. I am a trampolinist at heart so the RPF is strictly created for trampoline based athletes, however you can see how the theory can be applied to all disciplines.

RPF =

Take-off Possibilities *(TOP)* x Flip Possibilities *(FP)* x Landing Possibilities *(LP)*

When described in ordinary language the equation is quite simple. It basically says that by multiplying up all of the ways you can take-off, move in the air, and land we can determine how many possibilities an athlete will have every time they jump. For a multi skill routine we simply multiply those possibilities by the number of skills that athlete wishes to do to account for each possible combination. The RPF is calculated assuming that each axis an athlete rotates on will be divided into one degree increments. For these axes *"α"* represents rotation around the mediolateral axis *(flips)*, *"β"* represents rotation around the anterposterior axis *(cartwheel)* and *"γ"* represents rotation around the vertical axis *(spinning)*.

Like any equation there are certain assumptions we have to make to identify what situation the equation will describe. We will also make the assumption that for a trampoline athlete you can only do a maximum of 5 twists on the anteroposterior axis (cartwheel) and 5 rotations on the mediolateral axis *(flips)*. We will also assume that athletes will only maintain one position once within each complete flip and that they can choose to flip or twist in both directions. While it may be possible to rotate in all three directions this is a very advanced subset of skills. You will see that with these assumptions, based on the current capabilities of a trampolinist, we can make an estimation about the total number of different possibilities an athlete has in the air. Let's look at each section of this equation in more detail.



Take-Off Possibilities *(TOP)*:

$$\text{TOP}=(TOP_{\alpha})(TOP_{\beta})(TOP_{\gamma})(ROM_{TOP})$$

Simplified: TOP = (360 * 360 * 360) (1.09633 x 10^{39})

TOP= **5.11503 x 10^{46}**

Think of the body in a bubble with 360° surrounding it on all 3 axes. We are simply accounting for all the possibilities of these three degrees of rotation and multiplying it by the possible body positions *(each degree being a different position).* The result is the total number of possible take-off positions.

Taking off from your head may be dangerous in certain circumstances; however, some performers in circus acts have shown it is possible to flip from their head and neck. It can be done by those who have

properly learned how to do it. This equation is meant to provide a numerical value to *all* the possibilities and in no way determines what each athlete *should* or *can* do. The SAQ equation that follows this RPF function will go into more detail about practical applications.

The above section of the equation describes all of the positions an athlete can jump from on a trampoline. This includes standard take-off positions from the feet, stomach or back, to obscure take-off positions such as bouncing off one pointed toe like a ballerina with the other leg over the head, to one arm at 68° elbow flexion and 64° shoulder flexion and the other arm at 3° elbow flexion and 31° shoulder abduction and 54° shoulder flexion with the head tilted the right at 29°.

The ROM_{TOP} was simply calculated by taking all the joints of the major body such as elbows, knees, neck, arms etc and multiplying their range of motions together to find the total number of possible positions. The calculation is based on current anthropometric data from different sources and is sufficient to provide an estimate of the total number of body positions for the purposes of this theoretical equation. Every study has slightly different values for each range of motion but an average was taken and gives us the number:

ROM_{TOP} = **1.09633 x 10^{39}**

As you can see when really adding up the potential possibilities, the options are so vast it is hard to keep track. This is why a 'Code of Points' was created. It is important to have a RPF as a baseline to remind ourselves of all the options we tend to forget about on a regular basis in the face of constant routines.

Flip Possibilities *(FP)*:

$$FP = (RP_{GBA} * RP_{\gamma}) * ROM_1^{FP^N}$$

$$FP = (5*360*360) * (ROM_1^{FP} * ROM_2^{FP} * ROM_3^{FP} * ROM_4^{FP} * ROM_5^{FP})$$

RP_{GBA} is the degree of flips about the body's *"Gravity Based Axis."* This may seem to go against what is typically taught in biomechanics where the body can rotate in three directions, but I believe is a much more applicable formulation to help us achieve the desired possible flips numerical value. If you are doing a flip by being asymmetrical during the take-off, then you will either do a flip forwards, backwards or sideways *(left or right).* This means that gravity will pull you towards the Earth on one side of the body or another creating a rotational trajectory that will not stop until you hit the ground. We are not concerned with whether it is a forward or backwards flip on the mediolateral axis or the anteriorposterior axis creating a side flip. No matter what, you are doing a *"flip"* so we have condensed the traditional three-axis label and simplified it into two axes for the practical application of this formula.

When in the air rotating with the GBA you will also be able to twist along the Vertical axis after gravity has decided what *"flip"* you will do, be it sideways or forwards/backwards. Since twisting rotations are also determined primarily by your take-off position we assume for the purposes of this equation that once you take-off you will continue the path that was created by the take-off position based on where the mass of the body is distributed. The GBA which is determined by the take-off position follows a constant trajectory meaning you do not really have another option. You also do not really have another

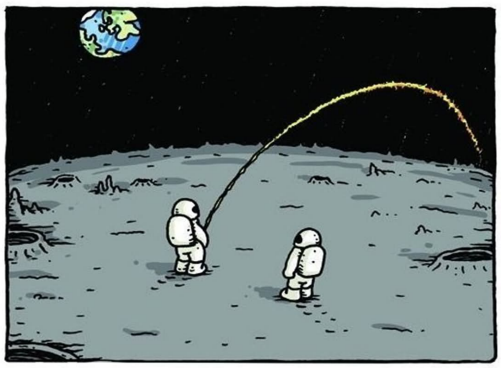
option in terms of twisting. Few athletes have the ability to twist in both direction once already in the air so that would be considered negligible and those few options are not included in the RPF.

Remember how humans have inherent rotation and velocity woven into their existence? This equation only focuses on two of the three axes: The gravity axis *(GBA)* is both the front flip/backflip axis and the side flip axis. The second axis in consideration with this equation is the spin axis *(twisting).* Rotating on all three axis at one time is not as simple as some think. You can tend to rotate on two axes at a time and rearrange the combination of the two axes *(out of three)* but maintaining a rotation on all three axes stably over time is not easy to do. If you would like to get involved with the research we are doing with Ben please let us know. Further research needs to be done on this topic for acrobatics. *For a full mathematical overview please see references.*

To see a video demonstrating this stability issue please check out this video:

Astronaut Richard Garriot demonstrates a great visual in space of how unstable rotating on three axes can be with a pack of cards:

https://www.youtube.com/watch?v=fPI-rSwAQNg&feature=youtu.be&t=10s



Due to the above issue we will simply assume only two axes can be rotated on stably at one time until more research is done; the rotational axis based on gravity and the twisting axis. Another important assumption is that athletes can flip to a precision of one degree. If a skill is assumed to have five flips we can start to enter some numbers based on degrees.

The ROM_1^{FP}, ROM_2^{FP},ROM_3^{FP}, ROM_4^{FP} and ROM_5^{FP} represent the Range Of Motion for each flip *(1.09633 x 10^{39})*. We assume that the athlete can maintain a new position during each flip for the purposes of this equation. If the athlete chooses to change position in the air then it is assumed each flip could be a new position in the air and means that each rotation is multiplied by the ROM^{FP} constant seen earlier. ROM^{FP} is always a whole number and is the total number of possible body positions. Any shape change in the body can create slightly new flips so each time an athlete hits a new position they would also be doing a new flip by definition even if the position is not recognized by the code of points.

If a coach wanted to calculate a real number of possible number of flips an athlete *can* do they simply have to decide the maximum number of flips the athlete *would* do. It is important to realize no more than 5 flips have been done consistently, so we use that as a maximum. However, as athletes learn and the equipment becomes more powerful there is no telling what people will be able to do in the future.

For this example let's look at a 5 flip example:

$$FP = (5*360*360) * (1.09633x10^{39})^5$$

$$FP= 648,000 \times 1.583822 \times 10^{195}$$

$$\mathbf{FP = 1.026317 \times 10^{201}}$$

Number Of Different "Flips" Possible=

102,631,700,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,

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Landing Possibilities *(LP)*:

$$LP=(LP_{\alpha})(LP_{\beta})(LP_{\gamma}) \times ROM_{LP}$$

Fundamentally the TOP and LP portions of the equation are the same. They are simply mathematical expressions of the total possible landing positions that an athlete can land in after they do their flips. Without limitations or assumptions they can land in as many ways as they can take-off so the function is actually the same. The reason for keeping them separate terms is because in practice there could be different possibilities for the take-off and landing positions. And for these cases the two terms should be separate.

$$LP=(LP_{\alpha})(LP_{\beta})(LP_{\gamma})(ROM_{LP})$$

Simplified: $LP = (360 * 360 * 360) (1.09633 \times 10^{39})$

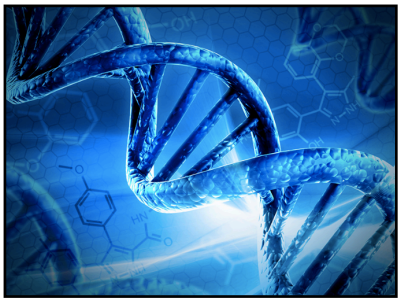
$$LP= \mathbf{5.11503 \times 10^{46}}$$

In total you could look at the complete RPF for 5 flips as follows in a simplified manner:

$$\mathbf{RPF\ for\ 5\ flips = (5.11503 \times 10^{46}) * (1.026317 \times 10^{201}) * (5.11503 \times 10^{46})}$$

$$\mathbf{RPF\ For\ 5\ Flips = 2.685208 \times 10^{294}}$$

What the above theoretical equation demonstrates is that all the possible rotations that athletes *can* do along the rotational landscape is astronomically high. This is the total amount of 'marker boys' on the path of acrobatics including all the degrees on all axes; as well, if you did all of those pathways up to 5 flips in every possible human body position. We now know how many 'marker boys' there are on the path so to speak and simply need to now narrow in on the specific Mazes that the athletes need to do to be able to go through the different marker boys that they choose. They will not want to go through all of them but now that we have outlined how many possibilities there are, we can now decide which options we want to take and how well we have be trained to take those options safely.



You can think of the RPF as a DNA strand. We will discuss evolutionary learning in later chapters but for now think of the RPF as DNA for acrobatics. The pathway for each athlete consists of **648,000** steps/marker boys *(D)*. In this fun analogy, there are 648,000 'basepairs' in the *Acrobatic Genome*. Each basepair has **1.09633 x 10^{39}** possible combinations ($ROM_1{}^{FP}$). The human genome only has four *(A,T,G,C).* Athletes have many body positions that they can create along this DNA strand to create behaviours. In a fun sort of way, you can summarize the RPF equation into a simple form:

$$\mathbf{D} * ROM_1{}^{FP}$$

$$\mathbf{648{,}000 * 1.09633 \times 10^{39}}$$

$$\mathbf{= 7.1042184 \times 10^{44}}$$

Ben mentioned to me that this fun abstraction would not include the elimination of the third axis or the differences in take-off and landing positions which make that number much higher. I agree with Ben but I love analogies so I couldn't help but create a fun equation that would map out the **DNA of Acrobatics.**

Not all of the ‘basepairs’ are activated all the time but this is essentially the number of ‘base pairs’ for an acrobatic career if you were foolish enough to try and quantify it.

Ben had another great analogy: Understanding the distance of the ‘ultimate’ rotational pathway is similar to taking two different pathways when on a family vacation. You can go from Omaha straight to California and get there after a few days of driving or you can take the scenic route for your entire life enjoying every step of the way and never actually get to California.Your path is yours to choose, but make sure you look at all the options before making a choice.

Now we will look at the ***Spatial Awareness Quotient*** *(SAQ)* to determine how well your athlete can navigate themselves through the 2.685208×10^{294} marker boys.

Contact the FTA to get more information about this calculation as well as get on board and help with the research:

Contact Email: info@FreestyleTrampolineAssociation.com