Is the number of Falco lasers ever shot greater than the number of humans alive?

Arya Amami

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Abstract

Approximately two thirds of the *Super Smash Bros. Melee* community believes that there have been more Falco lasers shot than humans are currently alive (c. 8 billion). While his laser is a core part of Falco's kit and a great deal of *Melee* has been played over the past 2.1 decades, *Melee* players (and in fact humans at large) tend to underestimate the size of numbers on the magnitude of the world population. We show that, despite this, it is not unlikely that the comparatively small *Melee* community has been able to overwhelm the human race with lasers. Many calculations of the exact numbers of lasers shot rely on highly uncertain parameters and estimations, often spanning up to a full order of magnitude. When making calculations, taking this uncertainty into account, we find that it is very plausible that more Falco lasers have been shot than there are humans alive today.

1 Introduction

On 13 October 2022, *Melee* commentator Toph posed a novel Fermi Problem on Twitter[1]: "Are there more humans alive on the planet today, or Melee Falco lasers shot across all time?" The question sparked heated discussion, as no single answer appeared to be satisfactory. Many users provided calculated estimates using ad-hoc numbers, some resulting in numbers higher than 8 billion and many resulting in numbers significantly lower than 8 billion. These estimates rely on numbers often produced without justification or make improbable extrapolations of populations (e.g. using the number of copies of *Melee* ever sold without adjusting for the uneven distribution of competitive and non-competitive players). A reliable estimate needs to use empirical statistics wherever possible and must model uncertainty in such a

manner that we may predict the likelihood that we live on a planet with a laser-per-capita value greater than or equal to 1.

1.1 The Lombardi Equation

We have developed an equation for calculating the number of lasers ever shot since *Melee*'s release and we can phrase it as the product of five factors:

$$N = n_l n_g n_p f_f D$$

Where: n_l is the number of lasers shot by a Falco per Falco-player-game, n_g is the number of games played per player per day, n_p is the number of *Melee* players playing per day, f_f is the fraction of *Melee* players who play Falco, and D is the number of days of modern Falco play[1].

While n_l, f_f, and D are very straightforward to calculate, finding accurate values of n_g is nontrivial as a result of the author's highly limited social network and reliable statistics are not available to calculate n_p. Though we will provide heuristic estimates of n_p, it would be wise to allow this value to remain variable and consider on a vibes-basis how plausible having such a number of players playing daily would be.

1.2 Codifying uncertainty in parameters

The novel-ish approach that we present is to embrace the uncertainty of the parameters by using interval arithmetic to define a lower and upper bound for each of the parameters. Furthermore, blindly assuming that our uncertainty is uniform over each interval and uncorrelated with other parameters, Monte Carlo simulation can be utilized to find the approximate likelihood of a laser-dominated world.

1.3 Dataset

We have collected two separate datasets for analysis: one featuring play around the skill level of that of the author[2], containing 1,054 Falco games, and one featuring play from several tournaments since 2019, containing 369 Falco games. This second dataset is filtered for games played onstream, which we assume probably skews the dataset towards high and top-level players, we guess. It is of great utility to have separated datasets between skill brackets as Falco behaviors deviate non-negligibly

[1] "Modern Falco play" is defined as the number of days since Falco players started shooting, on average, n_l lasers per game.

[2] i.e. aggressively middling

between players of various skill brackets, and these can be used as bounds for parameters in the Lombardi equation.

2 Defining parameter values

2.1 n_l: Lasers per Falco per Falco-player-game

Analysis of the low-mid-level dataset yields the result that the average Falco shoots a median of 24.2062 lasers per game. The high-top-level dataset, by comparison, shows that top Falcos shoot an average of 37.0737 lasers per game, over 50% more than their skill-deficient counterparts. This is actually very close to the low-mid-level $\mu + 1\sigma$ value of 37.7273. The true average across all players is probably likely to be between the values for low-mid players and high-top players.

$$n_l = [24.2062, 37.0737]$$

2.2 f_f: Fraction of Falco players

In calculating this value one must consider that the distribution of Falco players across levels of skill is highly uneven. For our estimates, we can ignore the proportion of players who only play casually using a technique known to statisticians as "not how statistics works." This assumes that the amount of lasers shot by casual players is negligible due to both their lack of per-player playtime and the anecdotally low pick rate of Falco in casual play. Public perception of character pick rates is that Falco sees far more use in low and mid-level play than in high-level play, and analysis shows this to be true. Within the dataset of low-mid-level play, players pick Falco on average 23.83% of the time. By contrast, an analysis of 152 players ranked on global top-100 or top-50 lists since 2018 shows that only 17.11% of top-level players play Falco competitively at all. Incorrectly assuming that each player plays their listed characters proportionally (i.e. a player with Fox and Falco listed plays each half the time), top players pick Falco a vanishing 12.83% of the time. The true overall average of Falco pick rate is likely to be between these two values and thus they can serve as upper and lower bounds for f_f.

$$f_f = [0.1283, 0.2383]$$

2.3 D: Number of days of modern Falco play

A naïve estimation of the number of days of modern Falco play is the number of days since the release of *Melee* (as of writing, 7,705 days). However, owing to the utter lack of development of a metagame for probably at least a week or two, it may be best to set a conservative lower bound on this value to account for the time needed for competitive Falco players to achieve full laser potential. As such, we have made the utterly arbitrary decision to set this lower bound as the number of days since Jack Garden Tournament (as of writing, 6,337 days). This tournament was the international breakout performance of Japanese Falco player Bombsoldier, who is often considered to be among the progenitors of modern Falco play.

$$D = [6\,337, 7\,705]$$

2.4 n_g: Number of games played per player per day

Finding values for this parameter of sufficient statistical signficance is very difficult as we have a sample size of two (2) players, for whom the average number of games per day is 15.3151. This includes days of zero games played but arbitrarily excludes days during gaps of greater than or equal to six days. Despite literally no evidence to back this claim, we believe this to be a somewhat above-average amount of games played per player (vibes). That being said, this value also only accounts for Slippi play and does not include LAN play on non-Slippi media. For this reason, we believe that this absurdly-low statistical power result will suffice as an average from which to derive the lower and upper bounds of this parameter. Cancels out, or whatever. Assuming that less-active players play 50% less than average and more-active players play 50% more than average, this yields a lower bound of 7.6576 and an upper bound of 22.9727. We are sure the true average is within this range, probably.

$$n_g = [7.6576, 22.9727]$$

2.5 n_p: Number of *Melee* players playing per day

This is the most difficult parameter to find a value of as there is no single centralized place to play *Melee*. The next closest thing is Slippi, but this is far from centralizing as a great deal of *Melee* happens in LAN settings and many players, especially those with robust social circles or easy access to other players, play on Slippi rarely, if ever. In any case, *Melee* magnate Fizzi36 has yet to release active-player statistics.

While not defined by usership, another somewhat-centralizing pillar of the *Melee* community is its major tournament livestreams. Using this as an estimate for *Melee*'s playerbase is highly imperfect, as viewership numbers include both a great number of non-player spectators and exclude a great number of non-spectator players (largely Europeans). Despite this uncertainty, it remains the best basis for estimates of this parameter.

If we model the playerbase of *Melee* as increasing linearly for the last D days and the current playerbase as the global maximum, then it suffices to define the average active playerbase as one half of the current active playerbase. For the purposes of defining a lower and upper bound on the number of players, we select two tournaments whose viewership numbers will be the basis for calculations. For the lower bound, we select The Big House 10, a multi-game tournament whose *Melee* viewership is high but not record-breaking, at 76,070 peak viewers. For the upper bound, we select Smash Summit 11, an invitational tournament whose peak viewership is higher than any other *Melee*-only tournament, at 116,972 peak viewers. Using a conservative estimate of 25% being the proportion of tournament viewers who actively play *Melee*, we find the bounds of active players to be $[19\,018, 29\,243]$, which can be halved to yield the average active playerbase.

It is worth noting that these numbers are significantly lower than the current number of unique players whose replays are registered on Chart.slp[2] (currently 85,630), suggesting these numbers may be varyingly conservative depending on how strongly factors like account decay[3], registration proportion[4], and non-Slippi players are weighed.

$$n_p = [9\,509, 14\,622]$$

3 Calculation of N

Evaluation of the Lombardi equation with the parameters we have defined yields the following interval:

$$L = [1\,433\,221\,092, 22\,867\,523\,353]$$

[3]It is highly unlikely that every account registered on the website continues to play actively indefinitely.

[4]Although the proportion of active players who have registered their replays onto the site is likely to be low, each player having played with a large number of unique opponents means that every player brings many others with them onto the site, much like how a virus can infect those within physical proximity of an infected person.

The world population is contained within this range, and in fact, the geometric mean of the upper and lower bounds is less than 30% lower than the world population. However, this should not be taken as conclusive evidence that Falco players have failed to best the human race's capacity to reproduce (and to be sure, this entire study should not be taken as conclusive of anything at all, really). Using the Monte Carlo method shows that 35.951% of parameter configurations result in a value of L greater than 8 billion. However, this is using the speculative estimate of n_p, the most uncertain parameter.

We can fix L at 8 billion and treat n_p as an unknown to find the lower and upper bounds for at least how high n_p would need to be for L to surpass the world population. Doing so, we find the bounds to be $[53\,084, 5\,116]$. While the lower bound implies a number of currently active *Melee* players greater than the figure of 85,630 suggested by Chart.slp, the upper bound is a mere tenth of that figure.

4 Limitations

By far the most salient limitation of this study is that we are not a statistician and are likely to be perversely wielding hallowed tools of mathematics in a manner most profane.

Furthermore, several of the parameters of the Lombardi equation have either high levels of uncertainty as discussed in each section, bias in sampling, or both. Data greatly underrepresents players who have achieved the incredible feat of having a level of skill lower than that of the author and depending on how numerous this population is this could greatly lower values for the parameter n_l. Additionally, not at all accounted for in this study is the incidence of games including more than two players, which is likely to both increase n_g and decrease n_l.

Finally, a critical semantic ambiguity exists in Toph's question: In referring to lasers, does one mean precisely the projectile produced by Falco's neutral special attack, or does one refer to any laser projectile produced by Falco's blaster? This study assumes the former but if the latter is to be considered then figures for n_l may be significantly higher. Falco's back-throw and up-throw cause him to shoot three lasers and his down-throw causes him to shoot four lasers. While not nearly as ubiquitous as Falco's neutral special, his throws are indeed still an important part of his kit and see a good deal of use.

5 Conclusion

To answer Toph's seminal tweet plainly: Probably more lasers, I guess. While the results do not categorically demonstrate if there have been more lasers shot or if there are more humans alive, we demonstrate that reasonable bounds for the problem lie well within the order of magnitude of the world population, and as such it is not unreasonable to think that there may have been more lasers shot.

Competing Interests: We declare no conflict of interest as we are precisely down neutral, ergo free of material desire.

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References

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