PHSX815_Project1

Going Bald: is it Natural or is it Gnomes?

Berg Dodson

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1 Introduction

Losing your hair can be a harrowing experience. Hair serves as an expression of self, as an icon of youth, as insulation against the cold of winter. However, hair is wasted on the young and and desperately missed by the elderly. This implies that there is some process that happens between being young and being old that causes balding to happen. In order to prevent balding from happening the cause must be determined and addressed. Taking a reductionist view of the causes of hair loss, it must be caused by either natural causes or supernatural causes since this constitutes all possible causes that could possibly exist.

This paper seeks to determine if the cause of hair loss can be considered natural or supernatural. This paper is organized as follows: Sec. 2 explains the two hypotheses: that hair loss is natural or supernatural. It also explains the statistical analyses that will be applied to make our conclusion. A description of the computer simulation developed to simulate these possibilities is provided in Sec. 3. This will also include any necessary acknowledgements for inspiration for the code. Analysis of the outputs of the code are included in Sec. 4. Finally, conclusions are presented in Sec. 5 and we should be able to answer confidently what causes hair loss.

2 Hypotheses to Explain hair loss

One explanation for hair disappearing is that this is just part of getting old. Hormones change, genes dictate that you look better with a shiny head than a hairy head. Hair loss doesn't happen overnight but is a gradual process, and the accepted wisdom is that you will lose, on average, one hair every two days [1].

However, it is obvious to anyone who has watched a friend go bald that process of going bald occurs in tandem with a loss of child-like wonder and innocence. Of course child-like wonder and innocence is what protects us from supernatural and fantastical creature, like gnomes. When someone has lost this innocence gnomes are free to pursue all kinds of mischief, like stealing hairs off your head to insulate their homes. It is known that gnomes will snatch five hairs a day if given a chance [2].

These two rates allow us to simulate two possible distributions for the each of these hypotheses. This will be done by making two distributions. The natural hair loss hypothesis will be a normal distribution with an event corresponding to the time between individual hairs falling out, $\lambda_{natural} = 5$. The Gnome assisted hair loss hypothesis will also be a normal distribution but using the rate corresponding to gnomes yanking out hairs, $\lambda_{gnome} = 7$.

3 Code Explanation

Simulations of each distribution were created to show how each hypothesis would appear if they were the true hypothesis. `Proj1_Gen+Write.py` was used to create these simulation. It begins by taking the parameters for the experiment – random number seed, rate, number of measurements per experiment, number of experiments – and passing these parameters to an instance of the random class from `Random.py`. The random class then creates a random Poisson distribution based on these parameters and returns that distribution. Once `Proj1_Gen+Write.py` receives the distribution, it records these distributions into a .txt file. For this project, `Proj1_Gen+Write.py` was run two times to create the data for each H_0 and H_1.

Plots and simulation analysis were preformed by the `Proj1_Read+Plot_v2.py` script. `Proj1_Read+Plot_v2.py` imports the simulated data for both H0 and H1 previously generated by `Proj1_Gen+Write.py`; sorts the data; calculates the mean, median and first three confidence intervals (1-3 σ); calculates the log-likelihood ratio; calculates the power of the test; and plots the results. Specifically the plots distributions along with the calculated statistical quantities as well as plotting the log-likelihood distribution. Each of these tasks has a designated function or portion of the text dedicated to performing it. The confidence intervals were calculated by sorting the data then finding where 65, 95, and 99 percent of the data was relative to the median of the data. Additionally the power of the test was calculated. The meaning and interpretation of everything mentioned here will be discussed in the 4 section.

4 Analysis

To rehash breifly, both the H_0 and H_1 theories, the natural and gnome assisted hair loss, were simulated as Poisson distributions.

$$f(x) = \frac{\lambda^x}{x!} e^{-\lambda} \tag{1}$$

From this information we expect that both distributions should have peaks at λ. From 1 we can see that these distributions both have a mean of 5.0022 and 6.997128 for H_0 and H_1, respectively. With the means being so close together though it will be difficult to differentiate between the two different theories.

To quantify this we can look at the power of the test and defining α and β. For the type one error, where we mistakenly choose H_1 over H_0, we can say we are comfortable if this happens 5% of the time, i.e. if the data point we end up measuring is in the 95th percentile, above the 3 σ confidence interval, we will decide that the H_1 hypothesis was responsible for our measured data. However if our measured data is below this the 3 σ confidence interval, then we will decide that H_0 is responsible for the data that we measure. Based on this and the two distributions that we have, the power of the test, the percent of the time we correctly pick H_1 over H_0, is 5.2%. This is not very often and means we will only correctly choose that gnomes are responsible for hair loss 1 our of about 20 times. This is reaffirmed in figure 2 that show the plots of the log-likelihood ratio tests. For the given distributions of the two theories we are barely able to distinguish between the two of them.

To corroborate this

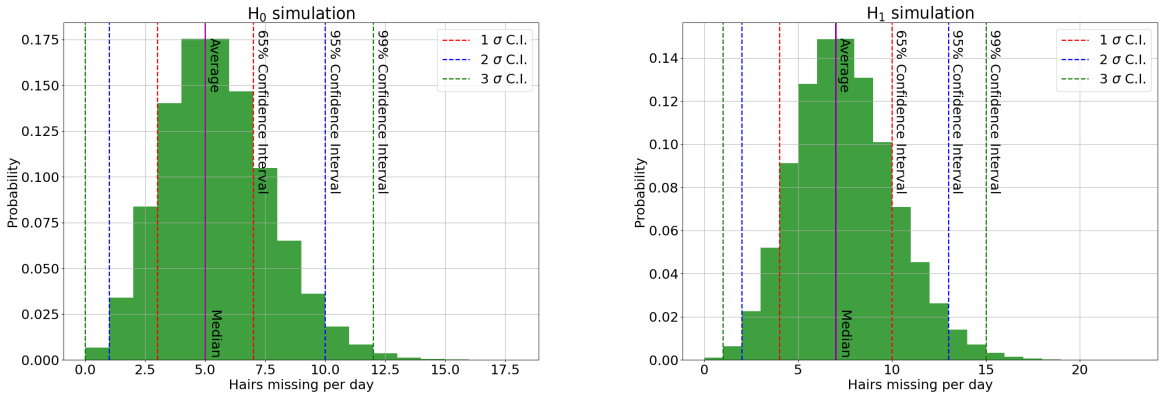

Figure 1: Simulations of the average number of hairs lost each day naturally (rate parameter λ = 5 hairs/day). (Left) Average number of hairs plucked by gnomes each day (rate parameter λ = 7 hairs/day). This data is simulated over 100,000 measurements. Shown in the figures are the median expected average time, along with the 1, 2, and 3 σ confidence intervals (symmetric around the median)

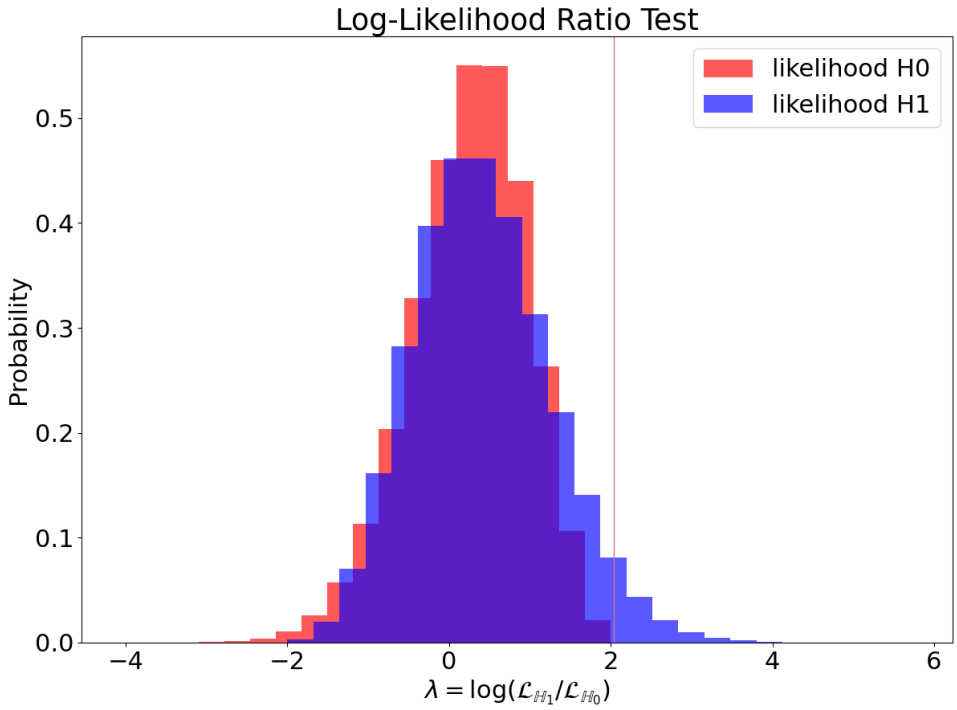

Figure 2: Log-likelihood ratio test performed for the data simulated in figure 1. The vertical pink line refers to the critical $\lambda - value values howing the values above which we would correctly distinguish between H_1$ and H_0.

5 Conclusion

According to our results, it is very difficult to distinguish between the two theories that we have. In order to meaningfully distinguish between the two theories you will have to make an unseemly number of measurements. Thus it will take too many measurements to easily distinguish between whether hair loss is due to gnomes or natural causes.

Here are the references

[1] D. Williamson, M. Gonzalez, and A. Finlay, *The effect of hair loss on quality of life*, *Journal of the European Academy of Dermatology and Venereology* **15** no. 2, (2001) 137–139, `https://onlinelibrary.wiley.com/doi/pdf/10.1046/j.1468-3083.2001.00229.x`.

[2] B. D. Dodson, *First Gnome Dream* Revealed in a dream, February, 2023.