Journal of Interdisciplinary Science Topics

How many lies could Pinocchio tell before it became lethal?

Steffan Llewellyn
The Centre for Interdisciplinary science, University of Leicester
25/03/2014

Abstract*:*
This paper investigates how many lies Pinocchio could continuously tell before it would become fatal, treating the head and neck forces as a basic lever system with the exponential growth of the nose. This paper concludes that Pinocchio could only sustain 13 lies in a row before the maximum upward force his neck could exert cannot sustain his head and nose. The head's overall centre of mass shifts over 85 metres after 13 lies, and the overall length of the nose is 208 metres.

Pinocchio's Nose

Pinocchio is the fable of a wooden puppet, carved by Geppetto, who dreams of becoming a real boy [1]. Pinocchio was portrayed as a character prone to lying, which is manifested physically through the ability to grow his nose when he tells a lie. One issue of growing his nose would be the shift of Pinocchio's centre of mass within his head, causing strain on his neck, which helps stabilise his head's position with upwards force. If this continued, then his neck could not support his head, potentially decapitating the puppet. Outlined here is the minimum lie count Pinocchio could continuously expel. Where Pinocchio manages to form new is not addressed in this paper.

Maximum Force Pinocchio's Neck Can Exert

The assumption is simplified by allowing the force exerted upwards through the neck to be positioned at the back of the head. The head is treated as a sphere, and the nose as a cylinder, as shown in *Figure 1*.

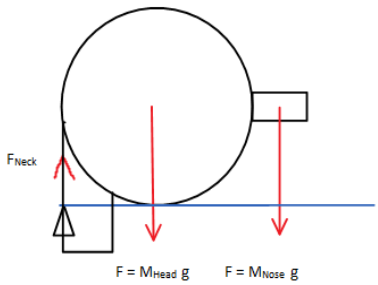

Figure 1: Illustrates the lever system of Pinocchio's head and neck, with opposite forces.

The type of wood Pinocchio is carved from is disputed, but for this paper, it is concluded that Pinocchio is made from Oak, with a density of $\approx 750\ kgm^{-3}$. Pinocchio's neck will brake if its compression strength threshold is overcome by the weight of his head. The compression strength of oak is 1150Psi $\approx 7.9 \times 10^6 N$ [2], and the circumference of the average human neck is 0.4m [3]. The maximum force Pinocchio's neck can sustain is:

$$Circumference = 2\pi r$$
$$r = \frac{0.4}{2\pi} = 0.0637m$$
$$Pressure = \frac{Force}{Area}$$
$$Force = Pressure \times Area$$
$$= (7.9 \times 10^6) \times \pi(0.0637^2)$$
$$Force \approx 1 \times 10^5 N$$

Centre of Mass, and Force Exerted

Neck muscles are required to balance the weight exerted by the skull. Usually, the weight of the nose can be considered negligible. In Pinocchio's case, as the nose increases, it will have a significant impact on the centre of mass and weight of his head. The mass of the head is unchanged:

$$Mass\ of\ Head = Density \times Volume$$
$$= 750 kgm^{-3} \times \frac{4}{3}\pi(0.11^3)\,.$$
$$Mass\ of\ Head = 4.18kg.$$

The nose initially can be considered negligible. However, it becomes more significant as it increases in size. For this model, the nose has an initial length of 1 inch (2.54cm), a diameter of 2cm, and its centre of mass positioned in the middle:

$$Mass\ of\ nose = Density \times Volume$$
$$= 750kgm^{-3} \times \pi(0.01^2)(0.0254)$$
$$Mass\ of\ nose = \ 0.006kg$$

Such a small mass does not affect the Centre of Mass, nor does it apply great force on the neck.

$$Centre\ of\ Mass = \frac{M_H x_H + M_N x_n}{M_H + M_N} = \frac{[(4.18 \times 0.11) + (0.006 \times 0.1227)]}{4.18 + 0.006}$$
$$CoM = 0.11m$$

Since this is a lever system, the weight applied on the neck also depends on the distance from which that force is being applied. The initial force Pinocchio's head exerts is:

$$Total\ Force\ Applied = [(M_H g \times l_h)] + [(M_N g \times l_n)].$$
$$Total\ Force\ Applied = [(4.18 \times 9.81 \times 0.11)] + [(0.006 \times 9.81 \times 0.1227)]$$
$$Total\ force\ Applied = 4.51N$$

This force is miniscule in comparison to the strength of Pinocchio's oak neck, thus, there is no great pressure applied on Pinocchio.

Growth of the nose

During Disney's Pinocchio, the puppet's lies cause extreme growth of his nose [4]. Thus, it is not absurd to model one lie causing an increase in the length of the nose by a factor of two (i.e. the nose doubles in length for every lie). Assuming the nose also remains the same density, as mass is in proportion with the volume, the length of the nose will eventually exert significant force to the head-neck lever system. The nose is determined unbreakable, as it built upon the foundation of lies. *Figure 2* demonstrates the force exerted by the head on the neck. Once Pinocchio's nose grows to the point at which it exceeds just over 140 metres, the force exerted downwards would cause the supporting neck to snap. Due to the exponential nature of his nose growth, Pinocchio cannot tell 13 consecutive lies, as, at this point, his nose would reach a length of 208m, and his centre of mass would have shifted by roughly 85m. *Table 1* outlined in *Supplementary material* demonstrates calculations made for this approximation.

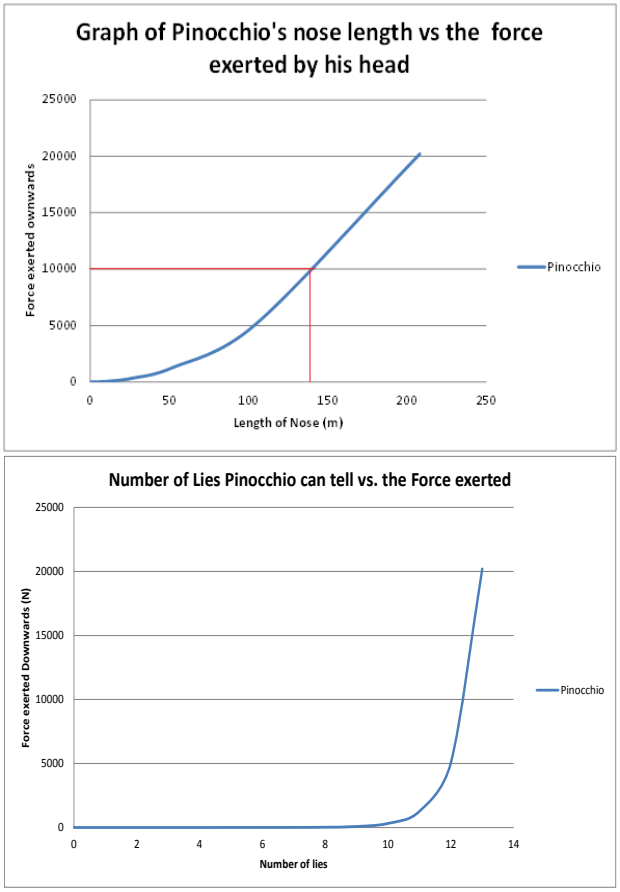

Figure 2a: Graph demonstrating how the growth of Pinocchio's nose would alter the mass to such an extent, it would overcome the forces of his neck. Figure 2b: Graph demonstrating the number of lies Pinocchio could tell vs the total downward force exerted. It demonstrated an exponential relationship.

Conclusion

Pinocchio's anatomy has extraordinary properties. It is outstanding that his nose seemingly deposits mass from nowhere. Nevertheless, this unique ability can be of great concern for the puppet, and lengthy, extensive lies are advised against, for the health and well-being of Pinocchio.

References

[1] DisneyWiki, “Pinocchio,” 2013. [Online]. Available: http://disney.wikia.com/wiki/Pinocchio. [Accessed March 2014].
[2] Engineering Toolbox, “Wood Beams Strength,” 2014. [Online]. Available: http://www.engineeringtoolbox.com/wood-beams-strength-d_1480.html. [Accessed March 2014].
[3] Anonymous, “What is the average circumference of the human neck?,” December 2013. [Online]. Available: http://www.chacha.com/question/what-is-the-average-circumference-of-a-human-neck. [Accessed March 2014].
[4] W. Disney, “Pinocchio 70th Anniversary Platinum Edition - Pinocchios Lies,” Disney, 2009. [Online]. Available: https://www.youtube.com/watch?v=hJ3lxzuI_sc. [Accessed March 2014].