Probability and Eye Color

Sarah White

Practical Applications of Advanced Math

Amy Goodrum

July 9, 2010

Abstract

While there has traditionally been a strict brown-vs.-blue model for eye color, scientists now know that this is both overly simplistic and inaccurate. In reality, there are at least eight different genes that affect human eye color. A survey was administered that asked participants the eye color of themselves, their parents, and their grandparents. The results showed that brown-eyed parents were more likely to have brown-eyed children, just like blue-eyed parents were more likely to have blue-eyed children. However, there were some cases in which blue-eyed parents had a brown-eyed child, which demonstrates how more than one gene influences eye color.

Background

Traditionally, eye color has been attributed to a single gene, with brown eyes always being dominant over blue eyes. This means that even if someone had an allele for both eye colors, that person would have brown eyes. Additionally, it would mean that blue-eyed parents could not have a brown-eyed child, which, though rare, does actually occur (Carlson, 2000). But how does this happen?

Each individual has two copies of each of their genes, though they can be the same or different versions. These versions, called alleles, determine how, or if, the genes produce the proteins necessary for life. A gene may have an allele that produces a protein that works, and an allele that makes a protein that does not work. Either way, as long as at least one of the alleles produces a working protein, the gene will be fully functional. This is how alleles are dubbed 'dominant' and 'recessive.' The dominant allele is the one that makes the working protein, so it is the one that is expressed (Morris, 2007).

Scientists have discovered at least eight genes that affect the color of our eyes. These genes control the amount of melanin, a pigment, inside the iris. Melanin is produced by cells called melanocytes and then stored inside melanosomes. The amount of influence certain genes have on melanin production and storage varies; some play a large part, and others do not. For instance, *OCA2* has the most influence on the amount of melanin in our eyes—approximately seventy-five percent of the necessary information for melanin production comes from that single gene. The most common form of *OCA2* produces a protein called P-protein that helps with the formation and processing of melanin, which generally results in brown eyes. However, there is another *OCA2* allele that actually reduces the concentration of P-protein and is commonly

associated with blue eyes. This allele makes eyes blue by switching off the ability to produce melanin in the front of the iris (Quill, 2008). This sounds similar to the traditional brown-blue model, but *OCA2* is not the only gene that influences eye color. If a person has the blue *OCA2* allele, but the brown alleles for all the other genes, then that person could very well have green or brown eyes (Lamb, 2009).

Method

I conducted an online survey of 100 of my peers that asked what color their eyes were, as well as the color of their parents' and grandparents' eyes. There were seven questions, one for each person involved, and there were five answers to each of the questions that participants could choose from: blue, green, brown, hazel, and other. A copy of the survey can be found in Appendix A. I had a time frame of about four days in which to gather and analyze the required responses. Additionally, the survey could not be taken more than once on the same computer, and participants could choose not to answer a question (in retrospect, I should have made it so that participants were required to provide an answer to every question; it would have saved me the trouble of going back and deleting every incomplete, and therefore useless, response).

Results

The results were that the majority of people surveyed, exactly 53%, had brown eyes, though I was surprised by how large the number of blue-eyed participants was. Because blue is supposed to be recessive, I expected there to be just a few people with that eye color, but more than 26% had blue eyes. Very few people had green, hazel, or other eye colors, about 21% altogether. *See Appendices B and C.* I also noticed that certain eye colors tended to be found with greater frequency in certain families, with blue-eyed children coming from blue-eyed parents and so on. Based on the results of my survey, I concluded that the probability of having the same eye

color as your parents is around 45%, especially if your grandparents had that same eye color as well. However, having looked through the individual responses, I saw twice where a brown-eyed child had come from two parents with recessive eye colors. This demonstrates how there is more than one gene that influences eye color. If an individual has a blue *OCA2* allele, but has the brown allele for every other gene, that person is likely to have green or brown eyes. In the end, a person never really knows what color his/her eyes will be based solely on the color of the parents' eyes. Even if one's parents both have brown eyes, depending on their genes, their child could have any eye color. Of course, that is only if we look at just the parents. If the entire family up to that generation have all had brown eyes, then it is fairly safe to say that the child will have brown eyes as well.

Conclusion

In short, based on the results of my survey, a child has approximately a 45% chance of having the same eye color as his or her parents. If time were not an issue, I could have surveyed more people and therefore gotten a broader idea of how genetics affect eye color. If I had surveyed more people, then there would have been more chances to find different eye color combinations, which would represent the entire population more accurately. Two things my research and survey did not take into consideration were changes in eye color and heterochromia, nor did they answer why and how these happen. However, they did properly demonstrate the probability of a person having a certain eye color based on their family history.

References

Carlson, C. (2000. *Re: how do two blue-eyed parents produce a brown eyed child?.* Retrieved July 14, 2010 from http://www.madsci.org/posts/archives/2000-06/961696074.Ge.r.html

Lamb, N. (2009). *The Genetics of eye color*. Retrieved July 9, 2010 from http://www.hudsonalpha.org/education/outreach/basics/eye-color

Morris, P.J. (2007). *Heritability, human eye color [athro limited: evolution]*. Retrieved July 13, 2010 from http://www.athro.com/evo/gen/inherit1.html

Quill, E. (2008). *Don't it make your brown eyes blue? - sciencenow*. Retrieved from http://news.sciencemag.org/sciencenow/2008/02/01-01.html

Appendices

Appendix A (from http://www.surveymonkey.com/XF6KYDK).

Family Eye Colors

1. What is your eye color?

- blue
- green
- brown
- hazel
- other

2. What is your mother's eye color?

- blue
- green
- brown
- hazel
- other

3. What is your father's eye color?

- blue
- green
- brown
- hazel
- other

4. What is your maternal grandmother's eye color?

- blue
- green
- brown
- hazel
- other

5. What is your maternal grandfather's eye color?

- blue
- green
- brown
- hazel
- other

6. What is your paternal grandmother's eye color?

- blue
- green
- brown
- hazel
- other

7. What is your paternal grandfather's eye color?

- blue
- green
- brown
- hazel
- other

Done

Appendix B.

Family Eye Colors

	Family Member						
Eye Color	self	mother	father	m. grandmother	m. grandfather	p. grandmother	p. grandfather
blue	25	29	25	25	29	27	23
green	4	10	8	9	9	10	10
brown	58	49	56	50	49	55	54
hazel	11	10	9	10	5	5	8
other	2	2	2	6	8	3	5

Appendix C.