Math 153 Final Project Proposal

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Introduction

For our final project, we have decided to study evolutionary game theory and the development of white sclera in the context of being able to demonstrate that the player will follow through with what they they said they will do. Sclera are what most people call the "whites" of someone's eyes. Humans are unique in that the entire sclera of most humans' eyes are, in fact, white. Meanwhile, in other mammals, including other primates, the visible part of the sclera matches the color of the iris. To help us understand the problem and question we are trying to understand better, the potential role identifying liars by their eyes and gazes [1] and the cost of "honest smiles" in interactions [2].

There are two hypotheses for the development of white sclera that we plan on exploring through the lens of evolutionary game theory:

1. White sclera aid cooperation
2. White sclera convey honesty

We discuss the reasoning behind these hypotheses and the games we will use to explore these hypotheses below.

White sclera aid cooperation

The **cooperation hypothesis** arises from the observation that the presence of white sclera can aid in cooperation by helping animals tell which direction another animal is looking [3]. If two animals with white sclera want to cooperate with each other to achieve some goal, the presence of white sclera can make this easier. On the other hand, the presence of white sclera can also betray intentions and make it easier for another animal to defect; for example, if one animal looks at food, another animal can follow the first animal's gaze to get to the food first.

These dynamics suggest that a **prisoner's dilemma** is a natural way to start exploring how white sclera may evolve in a population. We will modify the prisoner's dilemma by introducing a binary phenotype for visible white sclera. If an individual has this phenotype, it is easier to cooperate with, but also easier to defect against; it is also harder for the individual to defect. As a result, when an individual has white sclera, their opponent's payoffs should increase. Furthermore, if the individual tries to defect, their payoff will be lower.

We also want to capture the dynamic that two individuals with white sclera should find it much easier to cooperate with each other, and much harder to defect against each other. Thus, when two individuals with white sclera cooperate with each other, their payoff is much higher than standard, and the payoff from defecting is much lower than standard.

We plan to study this hypothesis by evolving a population of players with mutations changing both the strategy and the presence of the white sclera phenotype.

White sclera convey honesty

The **honesty hypothesis** arises from the observation that the presence of white sclera can give away lies; "shifty eyes" are a classical giveaway that someone is lying. At first blush, this would suggest that white sclera should be selected against, since the presence of the white sclera phenotype would make it difficult for an individual to lie convincingly. However, this effect might be counteracted if white sclera can convey honesty. For example, if an individual has white sclera, and their eyes are not shifty, then there may be good cause to believe them. If, on the other hand, the individual does not have white sclera, it is impossible to tell whether they are lying are not, so we may as well treat them as if they are lying. In this way, cooperative societies will devolve into deceptive societies, with potentially worse fitness for the society in the long run [4].

To test out this hypothesis, we propose studying a bluffing game. Each round, two players contribute one unit to the pot. Then, each player receives a hand with value uniformly chosen from the interval $[0, 1]$. In each round, one player goes first (play alternates between rounds) by choosing whether to bet some value $B > 0$. The other player then chooses whether to call or to fold. If player two folds, then player one receives one unit of payoff. Otherwise, the two hands are compared, and the player with the higher hand wins a payoff of $B + 1$.

It is known that player 2's optimal strategy is to call if their hand has value greater than $c = \frac{B}{B+2}$. Thus, if player 1 plays optimally, they know that they will lose any bet when their hand has value less than c. Such bets are called **bluffs**. The optimal strategy is for player 1 to bluff with probability $c - c^2$ [5].

We will change the dynamics of this game by introducing a white sclera phenotype. Now, instead of just having the value of the bet for information, player 2 will also have knowledge of player 1's phenotype. If player 1 has the white sclera phenotype, then player 2 will know whether player 1 is bluffing; otherwise, player 2 will not have any other information. We plan to evolve a population of players with mutations changing both their strategies and the presence of the white sclera phenotype. We will start off all individuals playing the optimal strategy and evolve individuals from there.

References

[1] Richard Wiseman, Caroline Watt, Leanne ten Brinke, Stephen Porter, Sara-Louise Couper, and Calum Rankin. The eyes don't have it: Lie detection and neuro-linguistic programming. *PLOS ONE*, 7(7):1–5, 07 2012.

[2] Samuele Centorrino, Elodie Djemai, Astrid Hopfensitz, Manfred Milinski, and Paul Seabright. Honest smiles as a costly signal in social exchange. *Behavioral and Brain Sciences*, 33(6):439–439, 2010.

[3] Hiromi Kobayashi and Shiro Kohshima. Unique morphology of the human eye and its adaptive meaning: comparative studies on external morphology of the primate eye. *Journal of Human Evolution*, 40(5):419 – 435, 2001.

[4] Luke McNally and Andrew L. Jackson. Cooperation creates selection for tactical deception. *Proceedings of the Royal Society of London B: Biological Sciences*, 280(1762), 2013.

[5] Chris Ferguson and Thomas S Ferguson. On the borel and von neumann poker models. *Game theory and applications*, 9:17–32, 2003.