Many biological systems perform collective computation. When presented with a set of moving dots, the brain, made up of billions of neurons, can decide whether the dots are moving left or right, even if the difference in the sizes of the groups moving either direction is not very large. A group of quorum sensing bacteria can sense its cell density and start to produce toxic molecules only when the density is sufficiently high. Flocks of birds and schools of fish can stay together and navigate with beautiful coordinated motion. In social groups of primates, the distribution of the degree of consensus about each monkey’s ability to use force is informative about the animals’ abilities and the animals use estimates of this emergent property to decide how to behave. In each example, the individual members of the group make decisions based on noisy environmental information and a function of or algorithm acting on those individual decisions determines the group’s output. This two-step process allows the group to produce a successful output or behavior, even though the individuals could not perform that computation and there may be conflicts of interest between them. There are thus three factors affecting the collective computation: the statistical properties of the environment, the strategies individuals use to make decisions, and the algorithm that produces a group output from individual decisions. This leads use to ask the following questions. What strategies should individuals in a group with conflicting interests use to make decisions? How do the individuals’ strategies affect the collective computation? What function of the individuals’ decisions produces the most accurate collective computation?

The sequential probability ratio test (SPRT) is the optimal way to decide between two alternatives in a noisy environment in the sense that for a given amount of time the SPRT is the most accurate algorithm and for a given error rate the SPRT reaches a decision most quickly. The algorithm works by keeping track of the amount of evidence supporting one alternative and deciding in favor of that alternative once that amount is sufficiently high or deciding against it once that amount is sufficiently low. While this algorithm assumes the decider has perfect memory, in reality this is rarely the case and a simple way to model memory loss is to assume that the amount of evidence decays back toward 0 at teach point in time. This forgetful model of decision-making can be transformed into a leaky integrator model, a set of SDEs describing how the variables accumulating evidence for each alternative change over time. This model has been successfully applied to neural decision-making. In this application, each of two neural populations responds to evidence for either left or right motion. The SDEs describe how the firing rates of the two populations change over time and a decision is made once one the difference in firing rates is sufficiently high. The visual stimulus driving this decision process is made up of dots moving in a particular direction and a correct decision is one in favor of that direction. While the SPRT has been applied to animal conflicts, to our knowledge the leaky integrator model has not been. In this application, each of two animals has a belief about its dominance with respect to the other which increases or decreases as the animal wins or loses fights against its opponent. The SDEs describe how these opinions change over time and one animal agrees to be subordinate if its opinion goes below its threshold. A correct decision is one in which the weaker individual agrees to be subordinate to the stronger. Both individuals involved in the decision value making a correct and fast decision and a there is a tradeoff between accuracy and speed. Additionally, each would prefer that the other agree to be subordinate. This introduces a conflict of interest. The individuals’ thresholds are the strategies they use to negotiate accuracy, speed, and their personal preferences.