1 Bits of philosophy

1.1 Frequentist

"Classical" statistical theory. Definition of probability: long-run limiting frequency of an occurrence in an (infinite) series of repeated trials. Confidence limits are derived by looking at the *tail probabilities*, the probabilities of an event occurring that is as unlikely, or more unlikely than, what actually happened.

- **Pro:** standard approach, well accepted, huge body of methods; "objective".
- **Con:** relies on tail probabilities (which the Bayesians say is worrying about things that didn't happen); requires nonintuitive definition of confidence limits. Decisions about experimental design (e.g., whether you measure a fixed number of events or measure until you've found a fixed number of successes) affect results. Does the definition of probability as the limit of repeated trials make sense for questions (conservation, global change, macroevolution, etc.) where repeated trials are impossible?

1.2 Bayesians

Definition of probability: degree of subjective belief about the outcome, determined by figuring out reasonable betting odds. Confidence limits (or *credible intervals*, as they're called) are based on the range of parameters that incorporates most (e.g. 95%) of the probability density. Bayesians insist that the *prior probabilities*, which are one's *subjective* beliefs before the experiment or observation about the likely outcomes (which in the simplest case are determined by the results of previous observations), affect the *posterior probabilities*, which are what one believes after the experiment.

- **Pro:** intuitive definition of confidence limits as subjective probability distributions. Coherent method for incorporating results of prior experiments. Mimics some of the processes by which we actually make scientific decisions. Brings subjectivity of the process out front. Rather than discarding the conclusions of less successful models, includes them with appropriate weights.
- **Con:** depends on prior *subjective* probabilities. One can try to pretend ignorance, but this is hard to do in a completely consistent way that doesn't somehow affect the results. (But Bayesians would argue that this is the way we do science anyway, we might as well be consistent about it.) Should prior information from (e.g.) hunches or intuition be included on the same footing as information gathered from experiments/observation?

Another way of thinking about this distinction is that

frequentists believe that *parameters are real, while observations represent a sample out of a range of possibilities*

while

Bayesians believe that *observations are real, while parameters represent a sample out of a range of possibilities*

If this distinction doesn't make perfect sense, don't worry about it; we'll come back to it.

The actual operational differences between the way Bayesians and frequentists work, and the conclusions they come to, are not always that great. Both sides tend to look for the pathological cases that their opponents' methods can't deal with.

2 Likelihood and "likelihoodists"

Likelihood is something everybody can agree on.

"Likelihoodists" (for want of a better name) could be counted as a (minor) third party in the debate. They say: forget about probability, just consider the *relative* likelihood of different things happening. Confidence intervals are the sets of all parameters with likelihood (probability of the data happening given the parameters) not too much less than the maximum likelihood.

- **Pro:** middle ground, avoids the worst excesses of frequentism and Bayesianism.
- **Con:** sidesteps important questions; refuses to provide a probability-based rule for making decisions/accepting or rejecting hypotheses.