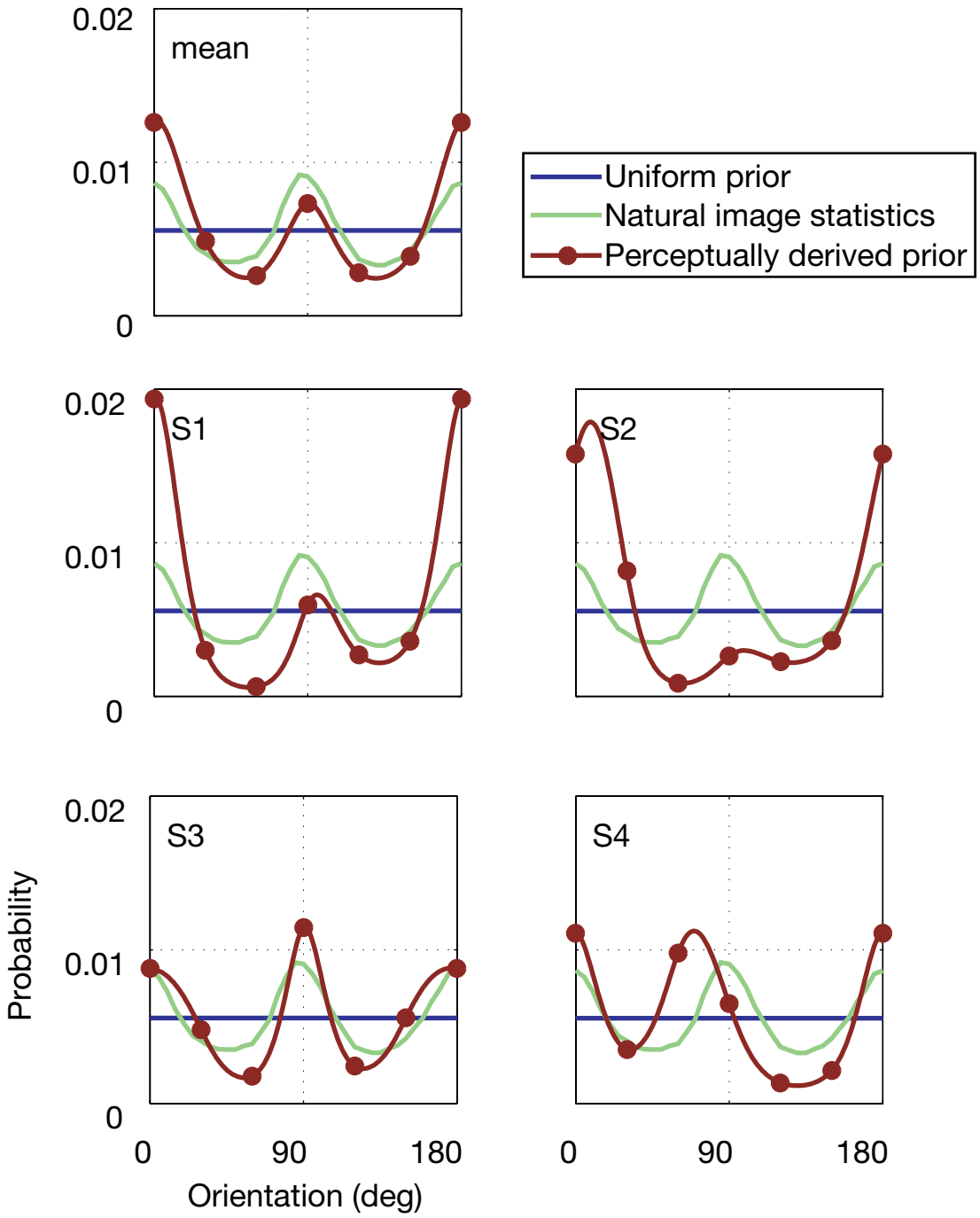

Figure 1: The perceptually derived priors for line orientation for four observers and the mean observer (red lines). We parameterized the prior model using six cubic-spline segments (red dots indicate control points), while constraining it to be positive and integrate to one over the interval from 0 to 180deg. Alternative parameterizations yielded similar results. While there are individual differences, all observers exhibit the use of bimodal priors with peaks near the cardinal directions (horizontal (0deg) and vertical (90deg)). The blue horizontal lines depict uniform (flat) priors. The green lines show the orientation statistics from a publicly-available database of natural scenes (van Hateren & van der Schaaf, 1998), which are also bimodal and peak at the cardinals.

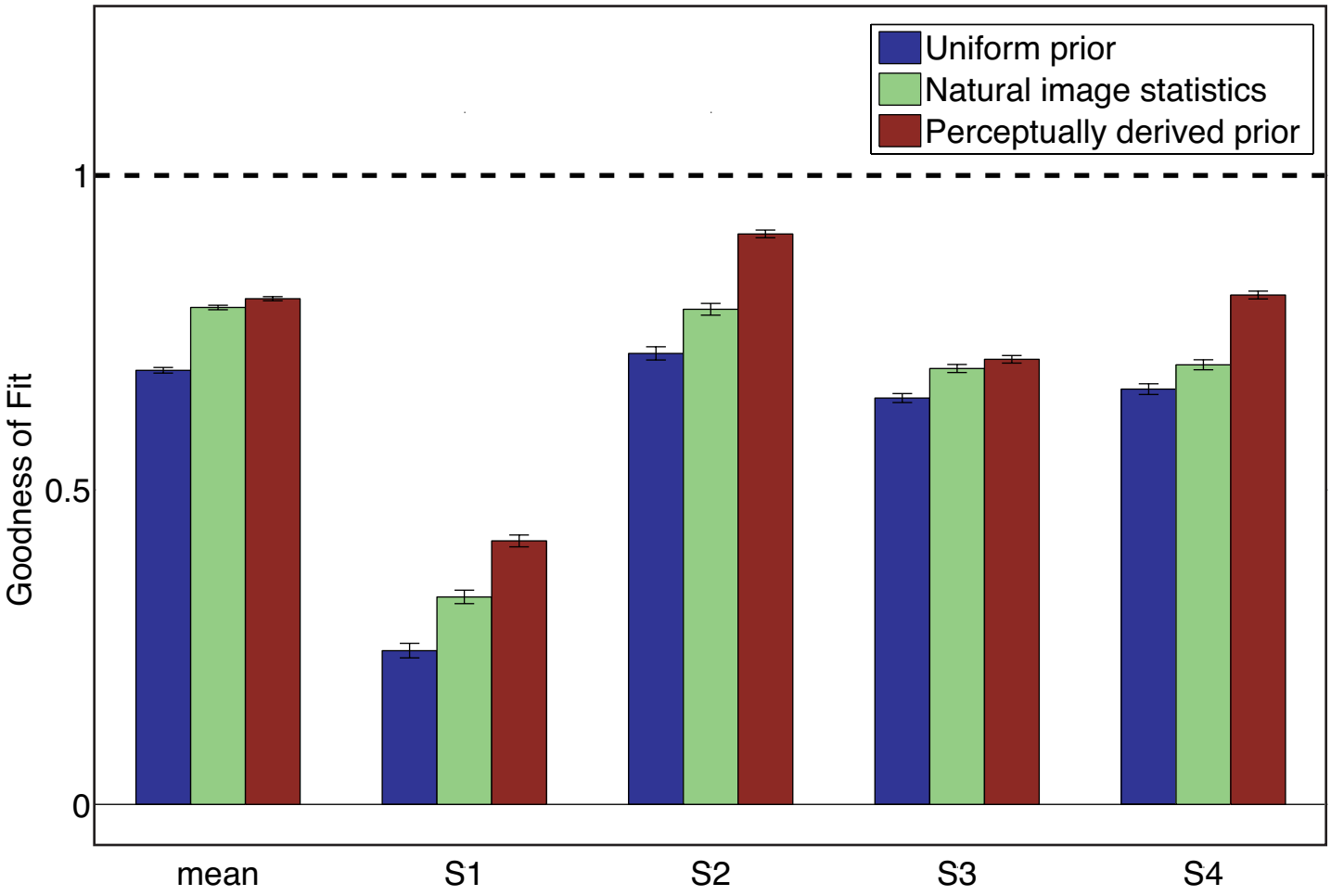

Figure 2: Goodness of fit for four observers and the mean observer for the three models shown in Figure 1. The uniform prior and natural-image statistics have no free parameters whereas the perceptually derived prior has six free parameters. Goodness of fit was calculated as the log likelihood of each model given the behavioral data, re-normalized such that 0 and 1 correspond to performance of two natural extreme models: a coin-flipping model, which responds randomly on each trial, independent of the stimulus (0 free parameters) and a model that draws responses from a binary distribution with mean corresponding to the average subject response for that stimulus (24 free parameters). We cross-validated the estimates by bootstrapping the data 300 times, each time fitting 90% of the data and only showing the fit for the remaining unfit data. This approach naturally penalizes overfitting, and thus prevents systematic bias toward models with more free parameters. All models, including the uniform prior model, incorporated the likelihood models derived separately for each observer from the LvL and HvH datasets. The error bars are two standard errors from the bootstrapped errors. In all cases, the non-uniform priors provided a better description of behavior than the uniform prior.