# Bayesian Analysis of Gender Bias in Jury Selection


## Abstract

Dr. Spock was charged with conspiracy to violate the military service act in 1967 and was a well-known pediatrician at the time. The jury panel selected by the judge for his trial only contained 9 women. This project uses Bayesian inference to determine if the judge behaved with bias in selecting jurors. We consider two models. The first disregards the information known about the clerk's selection of potential jurors. The second model takes into account the clerk's actions. For both models, we found the judge to have acted with bias.

## I. Background and Significance

Dr. Benjamin Spock worked as a well-known pediatrician beginning in the 1940s. In 1967, he was charged with conspiracy to violate the military service act and was brought to trial before Judge Francis Ford in Boston's Federal court house. The jury was selected by the clerk from a panel of $350$ people, called a venire. The venire included only $102$ women, even though women were more than $50$ percent of eligible jurors in the district. During the next stage, the judge selected $100$ potential jurors of the $350$, of which only $9$ were women (Zeisel 1969).

We are interested in estimating the degree of bias exhibited by the judge. This question is significant because gender bias is a common issue that appears in various situations. There is potential gender bias in the work place, in academic settings, and in jury selection. This project uses Bayesian inference to determine if the judge behaved with bias, first disregarding the clerk's selection of women and then allowing bias from the clerk.

## II. Methods

In order to apply the Bayesian methodology a likelihood for the observed data and prior distributions for the unknown parameters must be specified. From the population of all eligible jurors, the clerk selects $350$ people to form the venire, $m$ of which are women. We model $m$ as a Binomial Random Variable with parameters $350$ and probability of selecting a woman $\theta$. We placed a Uniform prior from $0$ to $1$ on $\theta$. This model ignores the information about the clerk's role in selecting jurors and on average assumes he is unbiased. From the $N = 350$ individuals that make up the venire, $m$ of which are women, the judge selects $n = 100$ potential jurors, $y$ of which are women. Note that we observe $y = 9$ in this particular case. Let each woman in the venire have weight $1$ and each man have weight $\omega$; then $\omega$ is the odds of selecting a man. We assume that the judge selects jurors one at a time such that the probability of selecting an individual is equal to his or her proportion of the total weight of the individuals that remain in the venire. Then, the distribution of $y$ is best described by a Wallenius Noncentral Hypergeometric Distribution, a generalization of the Hypergeometric Distribution where items are sampled with bias (Johnson et al., 1993).

We chose an Inverse Gamma prior for $\omega$ with shape parameter $0.9105$ and scale parameter $0.607$ (Figure A 1 of the Appendix). These parameters were selected so that the probability of the judge being biased towards men was $50\%$ and $E(1/\omega) = 1.5$. This was to give him the benefit of the doubt when selecting the panel of jurors.

## III. Results

Computations were performed using the software R, version 3.1.2 (R Core Team, 2013), with the LaplacesDemon, version 14.06.23 (Statisticat, 2014), and the BiasedUrn packages (Agner, 2013). LaplacesDemon implements Markov Chain Monte Carlo (MCMC) algorithms in R and BiasedUrn contains the Wallenius Noncentral Hypergeometric Distribution. A Metropolis within Gibbs (MWG) algorithm was used and 3 Markov Chains were run with $100{,}000$ iterations each. A burn in period of $50{,}000$ was used.

The three chains converged after the burn in, mixing with each other (Figure A 2 in the Appendix). The posterior density for $\omega$ is shown in Figure 1 below. Overall, we see the posterior is centered at about $15$. This is interpreted as the judge being $15$ times more likely to select a man over a woman. Using the samples from the posterior distribution, the probability of the judge displaying any bias towards men ($\omega > 1$) was estimated to be 1. A $95\%$ Credible Interval was found to be $(7.08, 27.79)$.

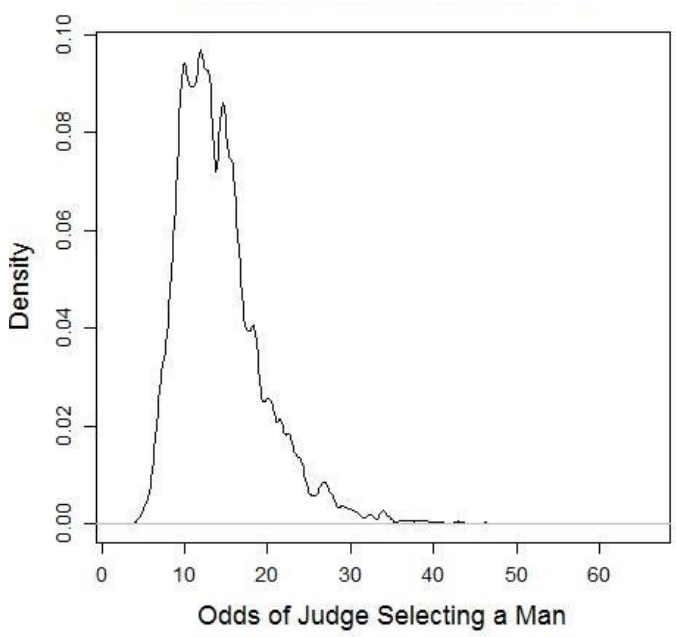


*Figure 1: Posterior density for odds of selecting a man under model 1*

The second model was considered because knowing the clerk's choice of women gave a better understanding of how to evaluate the judge's bias. In the second model, we allow the clerk's bias to play a role in the analysis. We again have the priors for $\theta$ to be Uniform on $0$ to $1$ and for $\omega$ to have an Inverse Gamma prior with shape parameter $0.9105$ and scale parameter $0.607$. The parameter $m$ no longer has a Binomial Distribution. We will assume it to be fixed at $102$. Recall this was the number of women in the clerk's selection of $350$ people. We again ran three MCMC chains of $100{,}000$ iterations each, with a burn in period of $50{,}000$. The three chains converged after the burn in, mixing with each other (Figure A 3 in the Appendix). The posterior density for $\omega$ is shown in Figure 2 on the next page. We see a drastic drop in the center of the posterior. Now, the odds of the judge selecting a man is centered around $5$. Calculating the probability that the judge was biased even slightly towards men, we again find it to be $1$. A $95\%$ Credible Interval for the odds of selecting a man is given to be $(2.50, 9.87)$.

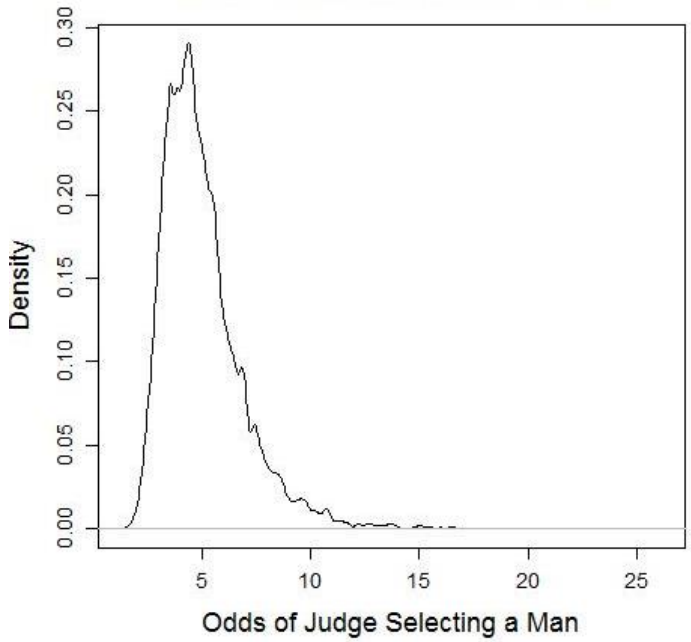


*Figure 2: Posterior density for odds of selecting a man under model 2*

## IV. Conclusion

In the first model, we neglected the clerk's bias in estimating the judge's bias. For the first analysis, we assumed no knowledge about the clerk's behavior. Overall, using our prior, the clerk was on average unbiased. It was not until the second model where we included the information about the clerk's selection. This removed some of the fault from the judge. However, he was still biased in favor of men, on average selecting a man 5 times more often than a woman. The major limitation to this project is that we do not know if the judge had reason to be biased. The pool of women applicants selected by the clerk may not have been ideal for the judge to choose from. Our model allowed us to isolate the judge's bias from that of the clerk. Overall, we found the judge to have acted with bias.

## V. References


Agner Fog (2013). BiasedUrn: Biased Urn model distributions. R package version 1.06.1. http://CRAN.R-project.org/package=BiasedUrn.

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Parry, Manon. "Benjamin Spock: Pediatrician and Anti-War Activist." *American Journal of Public Health* 101.5 (2011): 802–803. *PMC*. Web. 10 May 2015.

R Core Team (2013). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/.

Statisticat, LLC. (2014). LaplacesDemon: Complete Environment for Bayesian Inference. Bayesian-Inference.com. R package version 14.06.23. [http://www.bayesian-inference.com/software].

Zeisel, H. "Doctor Spock and the Case of the Vanishing Women Jurors." *University of Chicago Law Review* 37.1 (1969): 1-18. Web. 10 May 2015.


## Appendix

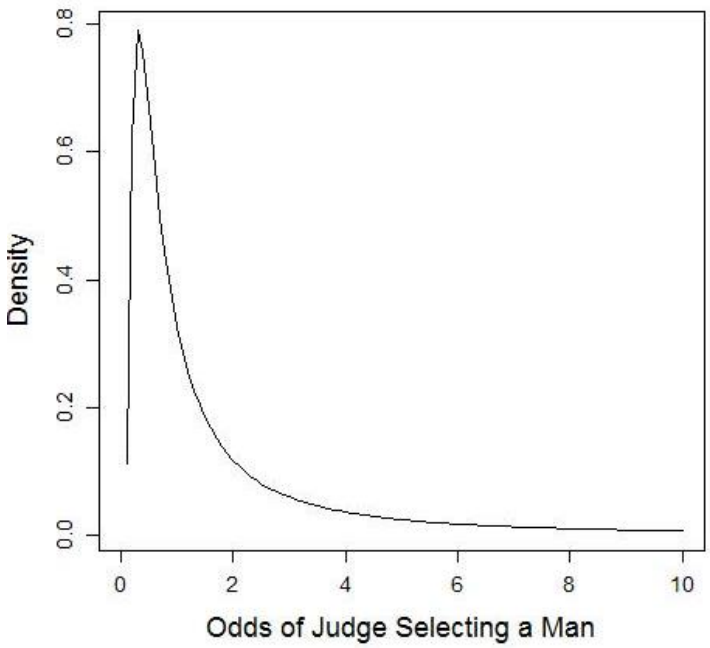


*Figure A 1: Density plot for Inverse Gamma (shape = 0.9105, scale = 0.607)*

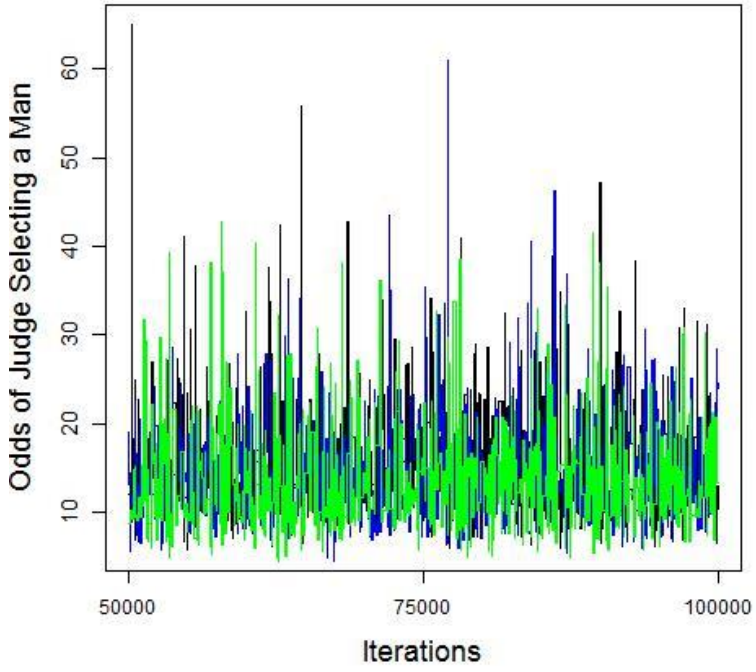


*Figure A 2*: *Mixing of MCMC chains for model 1*

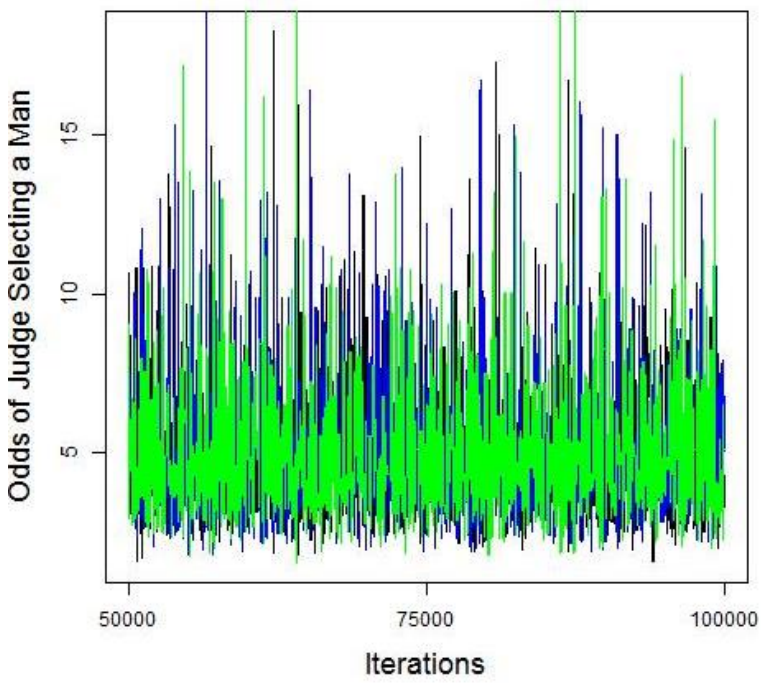


*Figure A 3*: *Mixing of MCMC chains for model 2*