Bias and Accuracy in Jury Selection

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Abstract

When forming a jury, attorneys consider how its composition will affect the outcome of the case. I propose a framework in which jurors, who vary in the accuracy of their information as well as preferences against wrongful conviction or acquittal, decide over a case according to a unanimous rule. The defense and prosecution observe the differences among jurors and can make peremptory strikes. I find that that under some conditions litigants may prefer to strike better informed jurors; and that whether more information is preferable depends on the bias of the jurors.

1 Introduction

The U.S. Constitution makes provisions for how criminal trials should be conducted, including a guarantee for a right to a trial by jury. Judgement by a panel of one's peers was meant to prevent arbitrary overreaches of the government, and is practiced in various forms across the world. Notably, there is not one clear standard for how juries should be formed, nor what rules should govern how they decide. These features can have marked effects on the outcome of cases, and by extension, the administration of justice.

One area in which this especially manifests is jury selection procedures. Different jurisdictions in the U.S. vary in how they form juries. All states allow litigants to exercise some control in the composition of juries, in the form of challenges for cause or peremptory strikes of potential jurors. Challenges for cause require citing a particular reason the juror cannot be impartial in the case, but peremptory strikes can be levied without justification. The number of peremptory strikes allotted vary considerably by jurisdiction and type of crime. Arizona eliminated the use of peremptory strikes in 2021, while New York state allows up to twenty strikes per side (depending on the type of crime).

The purpose of the peremptory strike system is to add to the legitimacy of the verdict of the case by creating an impartial jury. By allowing both sides to veto potential jurors, the resulting jury should be overall less biased. As such, the decisions reached by the court are less likely to be challenged if the litigants believe the jury was fair. However, whether these strikes do in fact result in more just trials is unclear, and the subject of much debate. How does the ability to remove potential jurors impact the juries that are formed, and the decisions that are made?

Often, the juries that emerge from this process are less diverse and less representative of the jurisdiction. In 1986, the Supreme Court decided in *Batson v. Kentucky* that peremptory challenges cannot be used to remove jurors because of their race. This was followed by decisions extending this protection against being dismissed on the basis of gender or sexual orientation. Nevertheless, these precedents are extremely difficult to enforce. Because peremptory challenges do not require a stated reason, it is hard to prove that such strikes are racially motivated. Justice Thurgood Marshall anticipated these shortcomings in his concurring opinion, arguing that the decision did not go far enough, and that the only way to prevent discrimination in this form was to eliminate peremptory strikes altogether.

Underpinning the importance of these strikes is the fact that in the United States unanimous juries are required to for conviction in criminal cases. This right was established by the Supreme Court in 2020 in *Ramos v. Louisiana*, but had already been in place in the federal courts and the vast majority of states previously. Given this rule, a single juror can greatly affect the outcome of a case. There are two ways this can manifest. The first is if a juror has a particular bias for or against conviction. Inclusion of a juror who has a very strong aversion to conviction makes conviction much less likely. The second is how attentive a juror is, or how likely they are to draw correct inferences from trial. A well informed juror in this sense is not only more likely to vote "correctly" in a case, but their choice is also more influential to how other jurors vote as well.

In this paper, I consider how the composition of juries can affect the verdicts that are reached, and how litigants can employ peremptory strikes in order to influence the verdict. I provide a formal framework in which a jury is deciding the outcome of a case, but does not know whether the defendant is guilty or innocent. Each juror observes a private signal during trial, but the informativeness of that signal varies across jurors. Jurors also differ in their aversion to wrongful conviction or acquittal.

I show the possibility that litigants may prefer to strike more informed jurors, and that the effect of information is contingent on the bias of the jurors. As such, I hope to microfound some of the discussion around how peremptory challenges systematically result in unrepresentative juries, both in terms of bias and accuracy.

2 Related Literature

Analyses of juries are a well charted branch of political economy. There is a rich scholarship on electorates voting as a means of aggregating information, from Condorcet (1785) to Austen-Smith and Banks (1996) and Feddersen and Pesendorfer (1996). A feature particular to to juries in a legal context is that they require unanimity in order to convict. Feddersen and Pesendorfer (1998) show that such voting rules bound the probability of wrongfully convicting an innocent defendant strictly away from 0. Similarly, Duggan and Martinelli (2001) show that in a setting with continuous signals, the probability of making a wrongful conviction is still bounded strictly above 0 absent arbitrarily strong innocent signals. Thus, the desirable properties of majority rule in converging to a correct decision for larger populations does not arise in a setting with a unanimous rule.

More recently, scholars have considered the effects of a range of factors on information aggregation, such as state-dependent turnout implemented by a biased supervisor (Ekmekci and Lauermann, 2020), redistributive policies (Acharya, 2016), and public information (Liu, 2019). Hummel (2012) shows that when jurors vary in their preferences and there is a deliberation stage, the correct decision can be made by a large jury with probability approaching 1. Jurors can also vary on the accuracy of their information. Iaryczower and Shum (2012) consider a model of a court in which judges can vary in two dimensions: their preferences towards incorrect decisions of either type, and the accuracy of their signal. They show that these features can interact in determining how the judges vote in a given case, and estimate the effect of information on the court. I model a similar dynamic in which members of a jury similarly vary in bias and accuracy; however, here I study how a change in the composition of the electorate affects the likelihood of conviction (which requires unanimity).

Some recent political economy work has also focused on who gets selected to serve on juries. Van der Linden (2018) argues that litigants can be constrained by their level of rationality, and shows that when they vary in their ability to strategize, jury selection becomes more complex. Most relevant for the present analysis, Flanagan (2015) shows that when jurors are distinguished by their probability of convicting, the defense drops the jurors with the highest probability of conviction and the prosecution drops the jurors with the lowest probability of conviction. This results in a higher likelihood of impanelling a jury that is entirely contained in the extremes of either end of the distribution of types. He briefly considers a setting with strategic voting by the jurors and shows robustness of his findings. This paper contributes to this literature by establishing that in a setting in which jurors are distinguished by both their threshold for conviction as well as the quality of their information under some conditions better informed jurors may be struck from the jury more often than less informed jurors.

A stream of literature also studies how the racial and gender diversity of a jury can impact the decisions that are reached. Many scholars have argued that diversity on a jury decreases the likelihood of conviction (i.e. Bradbury and Williams (2013)). Further, Anwar, Bayer and Hjalmarsson (2012) and Flanagan (2018) show that more diverse jury pools also are associated with a lower probability of conviction, especially for black men. Part of the aim of this paper is to understand why these patterns emerge, and how jury composition can impact the decisions that are made. The forthcoming analysis also explicitly models an adversarial relationship between defense and prosecution. This is in line with theories that regardless of the true state, prosecutors prioritize conviction. However, there is reason to believe this relationship can vary, particularly with the institutional features of a jurisdiction (see Gordon and Huber (2009) for a review of the scholarship on prosecutors).

3 Model Setup

Suppose there is a jury consisting of J members who are deciding a case according to a unanimous rule. Jurors each vote whether to acquit, A, or convict, C. If all jurors choose to convict, the trial results in a conviction, else, it ends in acquittal. There are two possible states of the world, one in which the defendant is guilty, which occurs with probability π, and the other in which the defendant is innocent, which occurs with the remaining probability $1 - \pi$. The possible states are thus $\Omega = \{G, I\}$. Each juror j has utility as follows, for a given profile of actions a and state ω:

$$u_j(a, \omega) = \begin{cases} 0 & a = (C, ..., C) \text{ and } \omega = G \\ 0 & a \neq (C, ..., C) \text{ and } \omega = I \\ -z_j & a = (C, ..., C) \text{ and } \omega = I \\ -(1 - z_j) & a \neq (C, ..., C) \text{ and } \omega = G. \end{cases}$$

Where $z_j \in [0, 1]$ captures juror j's aversion to wrongful conviction relative to incorrect acquittal. A higher value of z_j corresponds to a higher standard for conviction and is described by Feddersen and Pesendorfer (1998) as a "threshold of reasonable doubt."

The jurors do not know the true state, but receive private signals over the guilt or innocence of the defendant, $s_j \in \{g, i\}$. The accuracy of these signals vary by juror and is correct for juror j with probability p_j. That is, $Pr(g|G) = Pr(i|I) = p_j$. We will assume these signals are informative, $p_j > 1/2$.

Each player devises a strategy defined by probability of conviction contingent on their signal. So call the probability of player j voting to convict if the defendant is guilty

$$\gamma_j{}^G = p_j\sigma_j(g) + (1 - p_j)\sigma_j(i)$$

and the probability of voting to convict if the defendant is innocent

$$\gamma_j{}^I = (1 - p_j)\sigma_j(g) + p_j\sigma_j(i).$$

Consider two parties in a case, the prosecution and the defense. Assume both also do not know the true state. The prosecution wants to maximize the total probability of conviction, and the defense aims to minimize the overall probability of conviction.

3.1 Comments on the Model

This setup closely follows Feddersen and Pesendorfer (1998) except it allows two forms of heterogeneity among jurors. First, jurors vary in their preferences over type of error. We assume that all jurors prefer to match the state (i.e. acquit when the defendant is innocent and convict when they are guilty), but that they differ in their relative assessment of incorrectly rendering a guilty verdict to an innocent one. I further relax the requirement that all jurors' signals have the same accuracy. Here, some jurors' signals are correct more often than others. Both of these additions account for some of the characteristics of potential jurors that attorneys consider when choosing whom to strike.

Flanagan (2015) shows how peremptory strikes can influence jury composition and make panels more extreme. However, he primarily considers sincere jurors who vary only in their likelihood of conviction. Here, the jurors' differences in preferences as well as in the accuracy of their information complicate the strategic dynamics within the jury, and consequently, who gets struck from the jury.

4 Analysis

The analysis of the game will proceed as follows. First, I will consider how the impaneled jurors vote during a trial. Next, I will consider how this behavior impacts the litigants' preferences over who serves on a jury. Finally, I will provide a numerical example with two jurors to illustrate the possibility that an attorney may prefer to strike better informed jurors.

4.1 Trial

At trial, each juror's choice over whether to acquit or convict depends on the prior probability of guilt, the signal the juror received through the trial, and the probability that the juror is pivotal. In a setting in which conviction requires a unanimous vote, a juror is pivotal only if all other jurors also vote to convict. After observing their signal, a juror compares their expected utility of conviction or acquittal, conditioning on pivotality. Their choice of whether to convict or acquit (or mix) hinges on their threshold for reasonable doubt. In an equilibrium σ, juror j convicts after a guilty signal with probability $\sigma_j(g)$ and convicts after an innocent signal with probability

$\sigma_j(i)$. In particular, a juror convicts after observing signal s_j if

$$Pr(G|s_j, Piv_j(\sigma)) > z_j.$$

Juror j votes to convict if their belief that the defendant is guilty given her signal and pivotality is higher than her threshold for conviction.

I follow Fedderson and Pesendorfer by restricting my analysis to "responsive profiles." Such profiles involve all players behaving differently upon observing guilty or innocent signals. That is, the probability of voting to convict after a guilty signal is not equal to the probability of voting to convict after receiving an innocent signal. In such profiles we have ${\gamma^G}_j \neq {\gamma^I}_j$. This eliminates the possibility of equilibria in which jurors always convict or always acquit regardless of signal.

We can further rule out that jurors vote against their signal, meaning that they ever acquit after a guilty signal and convict after an innocent signal.

Lemma 1. *There is no equilibrium in which any juror j votes to convict with positive probability after an innocent signal and acquit with positive probability after a guilty signal.*

Because of the informativeness of the signals, they are always weakly better off following their signals. So each player is weakly more likely to convict if they receive a guilty signal than an innocent one.

This leaves three remaining strategy profiles available to jurors. The first is informative voting, in which jurors acquit if they receive an innocent signal and convict if they receive a guilty signal. Second, jurors may acquit upon receiving an innocent signal and mix between convict and acquit after receiving a guilty signal. Finally, jurors can convict after receiving guilty signal, and mix after an innocent signal. An equilibrium exists in which each of the J impanelled jurors plays one of the above strategies.

Proposition 1. *In any responsive equilibrium, there are L, M, and N mutually exclusive (possibly empty) sets of jurors such that:*

1. *all $l \in L$ play $\sigma_l(g) = 1$ and $\sigma_l(i) = 0$,*
2. *all $m \in M$ play $\sigma_l(g) > 0$ and $\sigma_l(i) = 0$, and*
3. *all $n \in N$ play $\sigma_l(g) = 1$ and $\sigma_l(i) > 0$.*

When pivotal, a juror knows that all jurors in groups L and M received guilty signals. However, jurors in group N obfuscate their signal with this strategy. A juror votes to convict after a guilty signal if their expected utility of conviction is strictly greater than their expected utility of acquittal, conditional on pivotality. Given the profile above, the probability of conviction if the state is guilty is

$$\Gamma^G = \prod_l^L p_l \prod_m^M p_m \sigma_m(g) \prod_n^N \big(p_n + (1 - p_n)\sigma_m(i)\big).$$

While the probability of conviction if the state is innocent is

$$\Gamma^I = \prod_l^L (1 - p_l) \prod_m^M (1 - p_m)\sigma_m(g) \prod_n^N \big((1 - p_n) + p_n \sigma_m(i)\big).$$

Therefore, the probability of a player j being pivotal if the state is guilty is $Pr(piv_j(\sigma)|G) = \frac{\Gamma^G}{\gamma^G{}_j}$ and the probability of being pivotal if the state is innocent is $Pr(piv_j(\sigma)|I) = \frac{\Gamma^I}{\gamma^I{}_j}$.

4.2 Jury Composition

Consider an equilibrium where all jurors convict after a guilty signal and mix after an innocent signal. This implies for all jurors j the following conditions must hold:

$$\frac{p_j \pi Pr(piv_j(\sigma)|G)}{p_j \pi Pr(piv_j(\sigma)|G) + (1-p_j)(1-\pi)Pr(piv_j(\sigma)|I)} > z_j$$

and

$$\frac{(1-p_j)\pi Pr(piv_j(\sigma)|G)}{(1-p_j)\pi Pr(piv_j(\sigma)|G) + p_j(1-\pi)Pr(piv_j(\sigma)|I)} = z_j. \quad (1)$$

Rearranging equation (1), we have

$$\frac{Pr(piv_j(\sigma)|G)}{Pr(piv_j(\sigma)|I)} = \frac{z_j p_j (1-\pi)}{(1-z_j)(1-p_j)\pi}.$$

If all jurors are in the set N, then $Pr(piv_j(\sigma)|G) = \prod_{n \neq j}^{N} \big(p_n + (1-p_n)\sigma_n(i)\big)$ and $Pr(piv_j|I) = \prod_{n \neq j}^{N} \big(1 - p_n + p_n \sigma_n(i)\big)$. So, the mixed strategies in equilibrium must satisfy

$$\frac{\prod_{n \neq j}^{N} \big(p_n + (1-p_n)\sigma_n(i)\big)}{\prod_{n \neq j}^{N} \big(1 - p_n + p_n \sigma_n(i)\big)} = \frac{z_j p_j (1-\pi)}{(1-z_j)(1-p_j)\pi}. \quad (2)$$

Note that for all n, $\sigma_n(i) < 1$ and $p_n > 1/2$. Therefore, an increase in any $\sigma_n(i)$ constitutes a decrease in the left-hand side of (2) (i.e. the probability of being pivotal if the defendant is guilty or innocent are closer). So in equilibrium, as z_j increases, there must be some $\sigma_n(i)$ that decrease. As such, the equilibrium probability of conviction decreases.

Similarly, as p_j increases, some $\sigma_n(i)$ decrease. However, how this affects the probability of conviction is complicated by the fact that a change in p_j also affects j's probability of conviction, because it affects the likelihood she receives either type of signal. The overall probability of conviction is

$$PC(\sigma, p_j) = \pi(p_j + (1-p_j)\sigma_j(i))Pr(piv_j(\sigma)|G) + (1-\pi)(1-p_j+p_j\sigma_j(i))Pr(piv_j(\sigma)|I).$$

Therefore, while increases in both z_j and p_j may increase the probability that other players vote to convict, how p_j affects the overall conviction probability is dependent on the values of the other parameters.

4.3 Numerical Example

The effect of a particular juror's accuracy impacts the overall probability of conviction by affecting the strategy of that juror, the strategy of the other jurors, and the likelihood of receiving either signal. In this section, I provide a numerical example showing that the probability of conviction can decrease with higher signal accuracy of a juror. So under some conditions, the prosecution may prefer to strike jurors with more accurate signals in order to increase the overall probability of conviction. I also show that for other values of the parameters, particularly when the jurors are less biased towards conviction, increases accuracy can increase the probability of conviction. Therefore, the prosecution's preferences depends on the interaction between their accuracy and bias.

Suppose a jury consists of two jurors, 1 and 2, who must both agree to convict in order to render a conviction. Consider an equilibrium in which both jurors mix after receiving an innocent signal, and convict after receiving an guilty signal. This implies that each juror j is indifferent between convicting and acquitting after an innocent signal, which requires:

$$z_j(1-\pi)p_j(1-p_{-j}+p_{-j}\sigma_{-j}(i)) - (1-z_j)\pi(1-p_j)(p_{-j}+(1-p_{-j})\sigma_{-j}(i)) = 0.$$

Given the mixed strategies of each juror, the overall probability of conviction is:

$$PC(\sigma, p_j) = \pi(p_1+(1-p_1)\sigma_1(i))(p_2+(1-p_2)\sigma_2(i))+(1-\pi)(1-p_1+p_1\sigma_1(i))(1-p_2+p_2\sigma_2(i)).$$

How the probability of conviction changes with an increase in p_j varies with the values of the other parameters. In particular, the conviction probability may increase or decrease with a higher accuracy of a juror, depending on the prior probability of guilt as well as the biases of the jurors.

For example, suppose $\pi = 1/2$, $z_1 = z_2 = 1/3$ and $p_1 = p_2 = 3/4$. Under these parameters, there is a unique equilibrium in which both jurors always convict after a guilty signal, $\sigma_1(g) = \sigma_2(g) = 1$, and mix after an innocent signal $\sigma_1(i) = \sigma_2(i) = 3/7$. Juror 1's signal accuracy affects both $\sigma_1(i)$ and $\sigma_2(i)$ in the following ways:

$$\frac{\partial \sigma_1(i)}{\partial p_1} = 80/49, \qquad \frac{\partial \sigma_2(i)}{\partial p_1} = -(256/49).$$

Evaluating the effect of a change in p_1 on the the overall probability of conviction at the given values, we have $\frac{dPC}{dp_1} = -(368/343)$. So the probability of conviction is decreasing with juror 1's accuracy at this equilibrium. The more accurate a given juror's signal is, the less likely the jury is to render a conviction.

When selecting among jurors, attorneys consider how their inclusion can affect the outcome of the case. Suppose we have jurors 1 and 2 as above, as well as an additional juror j' with $z_{j'} = z_1$ and $p_{j'} = p_1 - \epsilon$. By the above argument, a jury consisting of jurors 1 and 2 will result in a lower probability of conviction than a jury consisting of j' and 2 (or j' and 1). Therefore, the prosecutor will choose to strike either judge 1 or 2, and keep the less informed j' on the jury.

Suppose instead that $z_1 = z_2 = 7/16$. With this increased aversion to wrongful conviction, in equilibrium the overall probability of conviction increases with more precise signals. Each player now plays convict after receiving an innocent signal with probability $\sigma_1(i) = \sigma_2(i) = 1/9$. Both players mixing probabilities respond to a change in p_1 in the following ways:

$$\frac{\partial \sigma_1(i)}{\partial p_1} = 160/81, \qquad \frac{\partial \sigma_2(i)}{\partial p_1} = -(224/81).$$

These values are both greater than with the previous values of z_1 and z_2. Consequently, the aggregate probability of conviction is increasing with greater accuracy for these higher thresholds of reasonable doubt. Specifically, here $\frac{dPC}{dp_1} = 16/189$. So if the prosecution is choosing whom to strike from a pool consisting of jurors 1, 2, and j', as above, they prefer to keep jurors 1 and 2, striking the juror with less accurate information, j'.

Taken together, these examples suggest that an attorneys preferences over the accuracy of a juror hinge critically on the bias of the jurors. With jurors with lower thresholds for convictions (i.e. they were biased more towards conviction), the prosecution could increase the probability of conviction by removing a more informed juror. However, when the jurors less disposed towards conviction, in the sense that z_j is higher, the prosecutor prefers to strike the less informed juror. This example illustrates that when the jurors' bias is favorable to an attorney, they may prefer to keep an uninformed juror, but as this bias diminishes they may instead prefer more informed jurors.

5 Discussion & Conclusion

This project demonstrates the possibility that when determining who should serve on a jury, lawyers balance the effect of a potential juror's bias against how well informed they are. In some cases, lawyers may choose to eliminate jurors who are better informed in order to affect the outcome of the case. Whether they prefer more or less informed jurors depends on the juror's preferences for conviction. This dynamic has yet to be explored in the literature on juries, though is present in voir dire practice. In jury questioning processes, it is common to ascertain potential jurors' education and knowledge of the criminal justice system. This raises normative questions about the desirability of these selection procedures in achieving the most accurate decisions.

This setting provides an empirical implication that when two venirmen display similar biases towards a litigant, we might expect that party to strike the one who is better informed. Or conversely, if they are similarly biased away from the litigant, that party seeks to strike the one who is less informed. Bringing this implication to data poses a challenge, however, as voir dire practices are often opaque. While many states collect information on the demographics, education levels, and attitudes towards law enforcement, these data are presently inaccessible. Future work might also consider testing this implication in an experimental setting, by providing subjects with descriptions of potential jurors and facts of the case, assigning them a defense or prosecution role, and observing whom they strike from the pool.

References

Acharya, Avidit. 2016. "Information aggregation failure in a model of social mobility." *Games and Economic Behavior* 100:257–272.

Anwar, Shamena, Patrick Bayer and Randi Hjalmarsson. 2012. "THE IMPACT OF JURY RACE IN CRIMINAL TRIALS." *The Quarterly Journal of Economics* 127(2):1017–1055.
URL: *http://www.jstor.org/stable/23252002*

Austen-Smith, David and Jeffrey S Banks. 1996. "Information aggregation, rationality, and the Condorcet jury theorem." *American political science review* 90(1):34–45.

Bradbury, Mark D and Marian R Williams. 2013. "Diversity and citizen participation: The effect of race on juror decision making." *Administration & Society* 45(5):563–582.

Duggan, John and César Martinelli. 2001. "A Bayesian model of voting in juries." *Games and Economic Behavior* 37(2):259–294.

Ekmekci, Mehmet and Stephan Lauermann. 2020. "Manipulated electorates and information aggregation." *The Review of Economic Studies* 87(2):997–1033.

Feddersen, Timothy J and Wolfgang Pesendorfer. 1996. "The swing voter's curse." *The American economic review* pp. 408–424.

Feddersen, Timothy and Wolfgang Pesendorfer. 1998. "Convicting the innocent: The inferiority of unanimous jury verdicts under strategic voting." *American Political science review* 92(1):23–35.

Flanagan, Francis X. 2015. "Peremptory challenges and jury selection." *The Journal of Law and Economics* 58(2):385–416.

Flanagan, Francis X. 2018. "Race, gender, and juries: Evidence from North Carolina." *The Journal of Law and Economics* 61(2):189–214.

Gordon, Sanford C and Gregory A Huber. 2009. "The political economy of prosecution." *Annual Review of Law and Social Science* 5:135–156.

Hummel, Patrick. 2012. "Deliberation in large juries with diverse preferences." *Public Choice* pp. 595–608.

Iaryczower, Matias and Matthew Shum. 2012. "The value of information in the court: Get it right, keep it tight." *American Economic Review* 102(1):202–237.

Liu, Shuo. 2019. "Voting with public information." *Games and Economic Behavior* 113:694–719.

Van der Linden, Martin. 2018. "Bounded rationality and the choice of jury selection procedures." *The Journal of Law and Economics* 61(4):711–738.

6 Appendix

6.1 Proofs

Lemma 1. *There is no equilibrium in which any juror j votes to convict with positive probability after an innocent signal and acquit after a guilty signal with positive probability.*

Proof. Suppose towards a contradiction that j votes to convict with positive probability if $s_j = i$ and acquit with positive probability if $s_j = g$. This implies

$$U_j(C|g, piv_j) \leq U_j(A|g, piv_j) and U_j(C|i, piv_j) \geq U_j(A|i, piv_j).$$

Or,

$$Pr(G|g, piv_j) \leq z_j and Pr(G|i, piv_j) \geq z_j.$$

Which implies

$$\begin{aligned} Pr(G|g, piv_j) &\leq Pr(G|i, piv_j) \\ \frac{Pr(g|G)Pr(piv_j|G)Pr(G)}{Pr(g|G)Pr(piv_j|G)Pr(G) + Pr(g|I)Pr(piv_j|I)Pr(I)} &\leq \\ \frac{Pr(i|G)Pr(piv_j|G)Pr(G)}{Pr(i|G)Pr(piv_j|G)Pr(G) + Pr(i|I)Pr(piv_j|I)Pr(I)} \end{aligned}$$

Which is for juror j,

$$\begin{aligned}
\frac{p_j Pr(piv_j|G)\pi}{p_j Pr(piv_j|G)\pi + (1-p_j)Pr(piv_j|I)(1-\pi)} &\leq \frac{(1-p_j)Pr(piv_j|G)\pi}{(1-p_j)Pr(piv_j|G)\pi + p_j Pr(piv_j|I)(1-\pi)} \\
\frac{p_j}{p_j Pr(piv_j|G)\pi + (1-p_j)Pr(piv_j|I)(1-\pi)} &\leq \frac{(1-p_j)}{(1-p_j)Pr(piv_j|G)\pi + p_j Pr(piv_j|I)(1-\pi)} \\
p_j((1-p_j)Pr(piv_j|G)\pi + p_j Pr(piv_j|I)(1-\pi)) &\leq (1-p_j)(p_j Pr(piv_j|G)\pi + (1-p_j)Pr(piv_j|I)(1-\pi)) \\
p_j(Pr(piv_j|G)\pi + Pr(piv_j|I)(1-\pi)) &\leq p_j Pr(piv_j|G)\pi + (1-p_j)Pr(piv_j|I)(1-\pi) \\
p_j Pr(piv_j|I)(1-\pi) &\leq (1-p_j)Pr(piv_j|I)(1-\pi) \\
p_j &\leq (1-p_j)
\end{aligned}$$

Contradiction, $p_j \in (1/2, 1]$. ■

Proposition 1. *In any responsive equilibrium, there are L, M, and N mutually exclusive (possibly empty) sets of jurors such that:*

1. *all $l \in L$ play $\sigma_l(g) = 1$ and $\sigma_l(i) = 0$,*
2. *all $m \in M$ play $\sigma_l(g) > 0$ and $\sigma_l(i) = 0$, and*
3. *all $n \in N$ play $\sigma_l(g) = 1$ and $\sigma_l(i) > 0$.*

Proof. By Lemma 1, we can rule out strategies in equilibrium in which $\sigma_j(i) > 0$ and $\sigma_j(g) < 1$. Therefore, in equilibrium any juror j can play one of the following:

1. $\sigma_j(i) = 0$ and $\sigma_j(g) > 0$, or
2. $\sigma_j(i) > 0$ and $\sigma(g) = 1$.

This permits one pure strategy, $\sigma_j(i) = 0$ and $\sigma_j(g) = 1$, when

$$U_j(C|g, piv_j) > U_j(A|g, piv_j) \text{ and } U_j(C|i, piv_j) < U_j(A|i, piv_j).$$

Which amounts to

$$Pr(G|g, piv_j) > z_j \text{ and } Pr(G|i, piv_j) < z_j. \quad (3)$$

There are also two mixed strategies. One where a juror convicts after a guilty signal and mixed after an innocent signal, which requires

$$Pr(G|g, piv_j) > z_j \text{ and } Pr(G|i, piv_j) = z_j. \quad (4)$$

And another in which a juror acquits after an innocent signal and mixes after a guilty signal,

$$Pr(G|g, piv_j) = z_j \text{ and } Pr(G|i, piv_j) > z_j. \quad (5)$$

For any player j the probability the defendant is guilty given j is pivotal and received the guilty signal is

$$Pr(G|g, piv_j) = \frac{p_j \pi Pr(piv_j|G)}{p_j \pi Pr(piv_j|G) + (1 - p_j)(1 - \pi)Pr(piv_j|I)}$$

and the probability the defendant is guilty given j is pivotal and received the innocent signal is

$$Pr(G|i, piv_j) = \frac{(1 - p_j)\pi Pr(piv_j|G)}{(1 - p_j)\pi Pr(piv_j|G) + p_j(1 - \pi)Pr(piv_j|I)}.$$

Jurors with (p_j, z_j) satisfying equation (1) are in set L, satisfying (2) are in M, and (3) in N. ■

6.2 Numerical Example

Assume there are two jurors, and consider an equilibrium in mixed strategies in which both jurors always convict when $s_j = g$ and mix according to to σ_j when $s_j = i$. Suppose $s_j = i$. To find j's mixed strategy, she must be indifferent between playing C and Q, conditioning on pivotality (i.e. $a_{-j} = C$). The probability of the other player choosing C if the state is G is

$$Pr(a_{-j} = C|G) = p_{-j} + \sigma_{-j}(i)(1 - p_{-j}).$$

And the probability of the other player choosing C if the state is I is

$$Pr(a_{-j} = C|I) = (1 - p_{-j}) + \sigma_{-j}(i)p_{-j}.$$

Given these probabilities, j mixes when her expected utility of playing C is equal to her expected utility of playing Q,

$$\begin{aligned} Eu_j(C|C,i) &= Eu_j(Q|C,i) \\ 0 * Pr(G|C,i) - z_j * Pr(I|C,i) &= 0 * Pr(I|C,i) - (1 - z_j) * Pr(G|C,i) \\ z_j * Pr(I|C,i) &= (1 - z_j) * Pr(G|C,i) \\ z_j &= \frac{Pr(G|C,i)}{Pr(G|C,i) + Pr(I|C,i)} \\ z_j &= Pr(G|C,i). \end{aligned}$$

Juror j's belief that the state is G after observing $s_j = i$ and $a_{-j} = C$ is

$$\begin{aligned} Pr(G|C,i) =& \frac{Pr(a_{-j}=C|G)Pr(i|G)Pr(G)}{Pr(a_{-j}=C|G)Pr(i|G)Pr(G)+Pr(a_{-j}=C|I)Pr(i|I)Pr(I)} \\ =& \frac{(p_{-j}+\sigma_{-j}(C)(1-p_{-j}))(1-p_j)\pi}{(p_{-j}+\sigma_{-j}(C)(1-p_{-j}))(1-p_j)\pi+((1-p_{-j})+\sigma_{-j}(C)p_{-j})p_j(1-\pi)}. \end{aligned}$$

So we have in equilibrium,

$$\begin{aligned} z_j =& \frac{(p_{-j}+\sigma_{-j}(i)(1-p_{-j}))(1-p_j)\pi}{(p_{-j}+\sigma_{-j}(i)(1-p_{-j}))(1-p_j)\pi+(1-p_{-j})+\sigma_{-j}(i)p_{-j})p_j(1-\pi)} \\ \sigma_{-j}(i) =& \frac{p_jp_{-j}\pi - p_jp_{-j}z_j - p_j\pi z_j + p_jz_j + p_{-j}\pi z_j - p_{-j}\pi}{p_jp_{-j}\pi - p_jp_{-j}z_j + p_j\pi z_j - p_j\pi + p_{-j}\pi z_j - p_{-j}\pi - \pi z_j + \pi}. \end{aligned}$$

Juror $-j$'s mixing probability varies with both p_j and p_{-j}, therefore a change in p_j affects both $\sigma_j(i)$ and $\sigma_{-j}(i)$.

$$\begin{aligned} \frac{\partial\sigma_{-j}(i)}{\partial p_j} =& \frac{p_{-j}\pi - p_{-j}z_j - \pi z_j + z_j}{p_jp_{-j}\pi - p_jp_{-j}z_j + p_j\pi z_j - p_j\pi + p_{-j}\pi z_j - p_{-j}\pi - \pi z_j + \pi} \\ &- \frac{(p_{-j}\pi - p_{-j}z_j + \pi z_j - \pi)(p_jp_{-j}\pi - p_jp_{-j}z_j - p_j\pi z_j + p_jz_j + p_{-j}\pi z_j - p_{-j}\pi)}{(p_jp_{-j}\pi - p_jp_{-j}z_j + p_j\pi z_j - p_j\pi + p_{-j}\pi z_j - p_{-j}\pi - \pi z_j + \pi)^2} \end{aligned}$$

$$\begin{aligned} \frac{\partial\sigma_{j}(i)}{\partial p_j} =& \frac{p_{-j}\pi - p_{-j}z_{-j} + \pi z_{-j} - \pi}{p_{-j}p_j\pi - p_{-j}p_jz_{-j} + p_{-j}\pi z_{-j} - p_{-j}\pi + p_j\pi z_{-j} - p_j\pi - \pi z_{-j} + \pi} \\ &- \frac{(p_{-j}\pi - p_{-j}z_{-j} + \pi z_{-j} - \pi)(p_{-j}p_j\pi - p_{-j}p_jz_{-j} - p_{-j}\pi z_{-j} + p_{-j}z_{-j} + p_j\pi z_{-j} - p_j\pi)}{(p_{-j}p_j\pi - p_{-j}p_jz_{-j} + p_{-j}\pi z_{-j} - p_{-j}\pi + p_j\pi z_{-j} - p_j\pi - \pi z_{-j} + \pi)^2} \end{aligned}$$

Note that for any values of the parameters, $\frac{\partial\sigma_{-j}(i)}{\partial p_j} < 0$. If $\pi < \frac{p_{-j}z_{-j}}{2p_{-j}z_{-j}-p_{-j}-z_{-j}+1}$, then $\frac{\partial\sigma_j(i)}{\partial p_j} > 0$.

The overall probability of convictions is:

$$
\begin{aligned}
PC(\sigma(p_j), p_j) =& \pi(p_j + (1 - p_j)\sigma_j(i))(p_{-j} + (1 - p_{-j})\sigma_{-j}(i)) \\
&+(1 - \pi)(1 - p_j + p_j\sigma_j(i))(1 - p_{-j} + p_{-j}\sigma_{-j}(i)).
\end{aligned}
$$

Which can increase or decrease in p_j, depending on the values of the other parameters:

$$
\begin{aligned}
\frac{dPC}{dp_j} =& \pi(p_j + (1 - p_j)\sigma_j(i))((1 - p_{-j})\frac{\partial \sigma_{-j}(i)}{\partial p_j}) \\
&+(1 - \pi)(1 - p_j + p_j\sigma_j(i))(p_{-j}\frac{\partial \sigma_{-j}(i)}{\partial p_j}) \\
&+\pi(1 - \sigma_j(i) + (1 - p_j)\sigma_j(i)\frac{\partial \sigma_j(i)}{\partial p_j})(p_{-j} + (1 - p_{-j})\sigma_{-j}(i)) \\
&+(1 - \pi)(-1 + \sigma_j(i) + p_j\frac{\partial \sigma_j(i)}{\partial p_j})(1 - p_{-j} + p_{-j}\sigma_{-j}(i)).
\end{aligned}
$$

Further, how the conviction probability changes with the accuracy of a particular juror depends on the bias of the juror:

$$
\begin{aligned}
\frac{\partial^2 PC}{\partial p_j \partial z_j} =& \pi(p_j + (1 - p_j)\sigma_j(i))((1 - p_{-j})\frac{\partial^2 \sigma_{-j}(i)}{\partial p_j \partial z_j}) \\
&+(1 - \pi)(1 - p_j + p_j\sigma_j(i))(p_{-j}\frac{\partial^2 \sigma_{-j}(i)}{\partial p_j \partial z_j}) \\
&+\pi(1 - \sigma_j(i) + (1 - p_j)\sigma_j(i)\frac{\partial \sigma_j(i)}{\partial p_j})(1 - p_{-j})\frac{\partial \sigma_{-j}(i)}{\partial z_j} \\
&+(1 - \pi)(-1 + \sigma_j(i) + p_j\frac{\partial \sigma_j(i)}{\partial p_j})p_{-j}\frac{\partial \sigma_{-j}(i)}{\partial z_j}.
\end{aligned}
$$

Numerical Example

Suppose $\pi = 1/2$ and $p_1 = p_2 = 3/4$. A responsive equilibrium requires that each juror weakly prefers to acquit than convict after an innocent signal:

$$(1-z_j)(1/2)(1/4)(\sigma_{-j}(g)(3/4)+\sigma_{-j}(i)(1/4))-z_j(1/2)(3/4)(\sigma_{-j}(g)(1/4)+\sigma_{-j}(i)(3/4)) \leq 0.$$

Which can be rewritten,

$$(1-z_j)(3\sigma_{-j}(g)+\sigma_{-j}(i))-z_j(3\sigma_{-j}(g)+9\sigma_{-j}(i)) \leq 0.$$

Lower z_j

Further suppose $z_1 = z_2 = 1/3$. We can now solve directly for an equilibrium:

$$\begin{aligned}(2/3)(3\sigma_{-j}(g)+\sigma_{-j}(i))-1/3(3\sigma_{-j}(g)+9\sigma_{-j}(i)) &\leq 0\\ 6\sigma_{-j}(g)+2\sigma_{-j}(i))-3\sigma_{-j}(g)-9\sigma_{-j}(i)) &\leq 0\\ 3\sigma_{-j}(g)-7\sigma_{-j}(i)) &\leq 0.\end{aligned}$$

Note that this precludes the possibility of any responsive equilibrium in which a juror always acquits after an innocent signal. If $\sigma_{-j}(i) = 0$, then the only value of $\sigma_{-j}(g)$ that satisfies the above condition is $\sigma_{-j}(g) = 0$, which is inconsistent with the definition of a responsive profile. Therefore, the only possible strategy profiles in this case are ones in which $\sigma_j(i) > 1$. Under these parameters, the unique equilibrium is one in which for both jurors $\sigma_j(g) = 1$ and $\sigma_j(i) = 3/7$.

From this equilibrium, we can see how changes in one juror's accuracy, p_j, affects

$\sigma_j(i)$ and $\sigma_{-j}(i)$,

$$\frac{\partial \sigma_j(i)}{\partial p_j} = 80/49, \qquad \frac{\partial \sigma_{-j}(i)}{\partial p_j} = -(256/49).$$

Consequently, a change in p_j affects the overall conviction probability locally, $\frac{dPC}{dp_j} = -(368/343)$.

Higher z_j

Suppose instead $z_1 = z_2 = 7/16$. An responsive equilibrium now requires

$$\begin{aligned}(9/16)(3\sigma_{-j}(g) + \sigma_{-j}(i)) - 7/16(3\sigma_{-j}(g) + 9\sigma_{-j}(i)) &\leq 0 \\ 27\sigma_{-j}(g) + 9\sigma_{-j}(i)) - 21\sigma_{-j}(g) - 63\sigma_{-j}(i)) &\leq 0 \\ 6\sigma_{-j}(g) - 54\sigma_{-j}(i)) &\leq 0.\end{aligned}$$

Again, an equilibrium is not possible when $\sigma_{-j}(i) = 0$. So we have a unique equilibrium in which both jurors play $\sigma_j(g) = 1$ and $\sigma_j(i) = 1/9$. Plugging in these values of the parameters, we have:

$$\frac{\partial \sigma_1(i)}{\partial p_1} = 160/81, \qquad \frac{\partial \sigma_2(i)}{\partial p_1} = -(224/81), \qquad \frac{dPC}{dp_1} = 16/189.$$