Bias and the economics of jury selection

William S. Neilson\textsuperscript{a,}\textsuperscript{*}, Harold Winter\textsuperscript{b}

\textsuperscript{a}Department of Economics, Texas A&M University, College Station, TX 77843, USA
\textsuperscript{b}Department of Economics, Ohio University, Athens, OH 45701, USA

Abstract

In considering the expected social loss of the jury process, we investigate the role of peremptory challenges based on observable juror characteristics such as race or gender. The effectiveness of peremptory challenges depends on the relative social costs of incorrect verdicts and hung juries, and on jury pool population demographics. Some of our results are: (a) for a defendant clearly in the majority, awarding peremptory challenges is unlikely to be optimal because of increased wrongful acquittal costs; (b) for a defendant clearly in the minority, asymmetric challenges in favor of the defense may be optimal but only if wrongful conviction costs are “very large” compared to hung jury costs; (c) when optimal, more symmetric challenges should be awarded the less biased the population, but more asymmetric challenges should be awarded the more biased the population; (d) to reduce wrongful acquittal costs, it may be optimal to award asymmetric peremptory challenges in favor of the prosecution; and (e) our results offer no support for the complete elimination of peremptory challenges. © 2000 Elsevier Science Inc.

Keywords: Jury selection; Peremptory challenges; Criminal law

1. Introduction

While not all criminal cases tried before a jury involve questions of juror bias in the jury selection process, there is no doubt that a subset of cases—often highly publicized ones—do raise such questions. Generally, the final stage of the jury selection process involves the lawyers’ use of peremptory challenges to remove prospective jurors. Unlike challenges for...
cause, which are unlimited in number and must be approved by a judge, peremptory challenges are limited in number and, at least historically, require no explanations and are not subject to judicial control. Lawyers obviously use peremptory challenges to remove prospective jurors who are believed to be biased against their side. In this article, we focus on some previously unconsidered economic issues associated with jury selection in criminal trials.

We consider that a criminal trial can result in three different socially costly outcomes: an innocent defendant can be convicted, a guilty defendant can be acquitted, or the jury can be hung, resulting in no decision. Two institutions are in place to reduce the probabilities of socially costly outcomes. First, jurors are instructed to vote guilty only if the defendant is deemed guilty beyond a reasonable doubt. This reasonable doubt standard is designed to reduce the likelihood of wrongful convictions. Second, peremptory challenges allow attorneys to remove some jurors who they think are likely to vote against their sides. We find that the ability of peremptory challenges to reduce expected social loss depends on several factors, including the demographic characteristics of the jury pool population vis-à-vis the characteristics of the defendant, and the relative social costs associated with hung juries and incorrect verdicts. Furthermore, symmetric peremptory challenge regimes, in which both sides get the same number of strikes, have different properties than asymmetric regimes.

The facts in a key Supreme Court case illustrate the setting we are interested in examining. In *Batson v. Kentucky*, Batson, an African-American, was indicted on charges of second-degree burglary and receipt of stolen goods. Once 28 prospective jurors survived the challenge for cause, the prosecution was allowed six peremptory challenges and the defense nine, leaving 12 jurors and 1 alternate to hear the case. With only 4 African-Americans in the group of 28, the prosecution was able to eliminate all 4 from sitting on the final jury. Batson was convicted on both counts.

In *Batson*, the potential juror bias in question was racial, and the prosecution’s actions suggested a belief that a black juror would be biased in favor of a black defendant. In the context of our model, bias refers to some observable characteristic, such as race, that divides the jury into two distinct groups: jurors biased toward acquittal, and jurors biased toward conviction. We recognize that it is not realistic to believe that all members of one racial group are biased against defendants of another racial group, or even biased in favor of defendants of the same racial group. Furthermore, there are obviously more than just two racial groups. For these reasons, our model is restrictive. On the other hand, if jurors can be thought of as being either slightly prodefendant or slightly antidefendant, based on any observable characteristics (such as race, gender, religion, age, occupation, income, marital status, etc.), our model is quite general: defense attorneys will use peremptory challenges to eliminate jurors who are believed to be antidefendant, and prosecuting attorneys will use peremptory challenges to eliminate jurors who are believed to be prodefendant. Whether or not juror bias can be correctly identified is an empirical question, but lawyers certainly behave as if these biases are real and predictable.²

---

While racial bias is only one type of juror bias, it clearly has been the main concern of legal scholars and the courts when considering the effects of peremptory challenges on the jury selection process. In *Batson*, the Supreme Court ruled against the prosecution’s unconstrained use of racial peremptory challenges. The ruling in *Batson* was eventually extended by the court to restrict the removal of jurors not of the same race as the defendant, to restrict the defense’s use of peremptory challenges based on race, and to restrict peremptory challenges based on gender.

Legal scholars have devoted an enormous amount of space to the topic of peremptory challenges. In a nutshell, legal scholars are split into three groups: those who want no constraints on peremptory challenges; those who want to eliminate them; and those who want to reform the system. One of the main arguments in favor of unrestricted peremptory challenges is that they are “a procedure which has been part of the common law for many centuries and part of (the American) jury system for nearly 200 years.” Another argument is that they allow lawyers to eliminate biases that are best not talked about openly. Also, if a juror is unsuccessfully challenged for cause, the peremptory challenge allows a lawyer to strike that juror who may harbor ill-feelings about being challenged. Finally, by eliminating biases that escape the challenge for cause, peremptory challenges can reduce the probability of a hung jury.

The arguments for eliminating peremptory challenges rely on the constitution. Critics of peremptory challenges argue that they violate not only the impartiality guarantee of the Sixth

---

7 Burger (dissenting), 106 S. Ct. 1986 at p. 1731.
8 Babcock, *supra* note 6 at p. 554 argues that a peremptory challenge system “allows the covert expression of what we dare not say but know is true more often than not.”
Amendment, but also the equal protection guarantee of the 14th Amendment for defendants and challenged jurors. If the challenges for cause are conducted properly, it is argued that there are no other biases that need to be eliminated. Thus, those in favor of eliminating peremptory challenges call for an expanded role for challenges for cause.

Finally, the arguments for reforming the peremptory challenge system involve the belief that a defendant should be allowed the widest possible latitude in conducting his defense. In this sense, the unrestricted use of peremptory challenges should be allowed for the defense, but not for the prosecution. Similarly, but with specific focus on minority defendants, a reformed peremptory challenge system can preserve “to the minority culture the ability to make race-based peremptory challenges so long as those challenges foster the inclusion of a cognizable group.”

We depart from the legal literature by specifying an objective function that governs the analysis of jury selection procedures. When a well-defined social goal is identified, this goal allows the debate over the advantages of different legal rules to have specific focus. What, then, is a social goal of jury selection? The goal that we identify is to minimize a social loss function that includes three components: the expected cost of a hung jury; the expected cost of a wrongful conviction; and the expected cost of a wrongful acquittal. Obviously, a hung jury is costly if the case is retried. Not all cases that result in hung juries are retried, though, and sometimes a guilty defendant escapes punishment. Even if the trial results in a unanimous decision, so that a second trial cannot take place, the verdict might be incorrect. One can easily imagine an extremely biased jury that has a high probability of reaching a unanimous decision, but not necessarily the correct decision. Although it can never be guaranteed that juries only convict the guilty and acquit the innocent, the number of peremptory challenges allowed will affect the probability of incorrect decisions being made. Whatever the nature of the costs associated with incorrect decisions, and whatever their magnitude, our social loss function allows for explicit trade-offs between the costs associated with wrongful verdicts and hung juries. The civil rights issues involved in the potential discriminatory use of peremptory challenges is taken as beyond the scope of our analysis.

The article proceeds as follows. In the next section, we review jury selection procedures to establish a basis for our work. We then construct a mathematical model that incorporates a reasonable-doubt standard and many of the features of actual jury selection procedures. To increase tractability, we employ a numerical example that is roughly calibrated to resemble actual hung-jury rates. We then use the mathematical model and the specific numerical

---

11 See Alschuler, supra note 6. Underwood, supra note 6 at p. 728 argues that “the existing law of jury discrimination . . . is (best) understood as chiefly vindicating the right of the excluded jurors, a right in which the defendant has a strong strategic interest but no personal constitutional claim.”

12 Druff, supra note 6 at p. 1596, and Jeffrey Abramson, We, the Jury (1994) at pp. 262–263.

13 Goldwasser, supra note 6.

14 Brand, supra note 6 at p. 627.

15 Daniel L. Rubinfeld and David E.M. Sappington, Efficient awards and standards of proof in judicial proceedings, 18 Rand J Econ 308 (1987) consider the social costs of wrongful acquittal and wrongful conviction in their model, but have a judge, not a jury, as the trier of fact.

16 This does not take into account the appeals process.
example to analyze the use of peremptory challenges in two settings. We explore a scenario in which the judge must award the same number of strikes to both the defense and prosecution, and then we explore a scenario in which the prosecution is given zero strikes and the judge can award strikes to the defense. This analysis is used to answer a number of questions about optimal peremptory challenge regimes. In particular, we examine when it is optimal to award peremptory challenges, how many challenges to award when it is optimal to award them, and whether there is any scope for asymmetric challenges for the prosecution.

Among our key results are: (a) for a defendant clearly in the majority, awarding peremptory challenges is unlikely to be optimal because of increased wrongful acquittal costs; (b) for a defendant clearly in the minority, asymmetric challenges in favor of the defense may be optimal but only if wrongful conviction costs are “very large” compared to hung jury costs; (c) when optimal, more symmetric challenges should be awarded the less biased the population, but more asymmetric challenges should be awarded the more biased the population; (d) to reduce wrongful acquittal costs, it may be optimal to award asymmetric peremptory challenges in favor of the prosecution; and (e) our results offer no support for the complete elimination of peremptory challenges.

2. Jury selection procedures

There are many variations of jury selection procedures. Specific rules differ not only between federal and state courts, but also from state to state and even from case to case. Despite the differences, there are enough common elements between the different procedures that we can describe one basic selection process that serves our purpose.

For our purposes, the first step involves the questioning of prospective jurors to determine which jurors will eventually sit on the petit jury. This process is known as voir dire examination. How a voir dire examination is precisely conducted depends on the wishes of the judge. Almost anything goes during voir dire, as very personal questions may be asked of the prospective jurors.

Upon completion of the voir dire examination, the first type of challenging is conducted—challenges for cause. There is an extensive set of permissible grounds to challenge for cause, and these grounds vary between jurisdictions. Some grounds are specific in nature. For example, a juror may be challenged for cause if the prospective juror served on a jury formerly sworn to try the defendant on the same charge. Some grounds are more open-ended. For example, a challenge may be made if “the juror has a state of mind...which will prevent him from acting with impartiality.”

Unlike a challenge for cause, which must be approved by a judge, a peremptory challenge (at least historically) requires no judicial approval. As with other jury selection procedures,
there are many different peremptory challenge systems. The American Bar Association Standards describe a system commonly referred to as the Arizona struck system:

Under this practice, jurors are first examined and challenged for cause by both sides. Excused jurors are replaced on the panel, and the examination of replacements continues until a panel of qualified jurors is presented. The size of the panel at this time is the sum of the number of jurors to hear the case plus the number of peremptories to be allowed all parties. The parties then proceed to exercise their peremptories, usually alternating or in some similar way which will result in all parties exhausting their challenges at approximately the same time.20

The number of peremptory challenges given to each side generally depends on the gravity of the crime. For example, in California each side is given 20 strikes in criminal cases where the offense is punishable by death or life imprisonment. In other criminal cases, each side is limited to 10 strikes, except in cases where the offense is punishable by a jail term of 90 days or less. In those cases, only six challenges are allowed per side. While California and many other states give both sides the same number of strikes, some states allot the defense more strikes than the prosecution is allowed. For example, in Georgia the defense is allotted twice as many strikes as the prosecution is allowed. There are no states in which the prosecution is given more strikes than the defense is given.21 Also, individual judges have discretion in awarding peremptory challenges on a case-by-case basis.

3. The model

In this section, we construct a model of the trial process that allows us to analyze the effects of the number of peremptory challenges awarded on the probabilities of a hung jury, wrongful acquittal, and wrongful conviction. To do this, the model must have several features. First, the truth must be objective, not subjective, in that defendants must be either guilty or innocent.22 This is necessary because a defendant must be guilty to be wrongfully acquitted and innocent to be wrongfully convicted. Second, the reasonable-doubt standard is already in place to protect against wrongful convictions, and to assess the impact of jury selection procedures on the social cost of wrongful conviction it is imperative to incorporate some notion of reasonable doubt into the model. Third, jurors must possess some readily observable bias that affects their determination of the defendant’s guilt and that can be used by the attorneys as a basis for peremptory challenges. We assume that jurors are either biased toward acquittal or biased toward conviction, and both the defense and prosecution can identify any given juror’s bias. Finally, we assume that a two-way unanimity rule governs jury verdicts: a unanimous decision is needed to convict or acquit. If there is not a unanimous verdict, the jury is considered hung.

Given the peremptory challenge rules, we can calculate the probabilities that the final jury

---

20 ABA, supra note 17 at pp. 77–78.
22 We only consider criminal cases in this model.
is entirely biased toward acquittal, entirely biased toward conviction, or balanced (i.e., contains jurors biased toward acquittal and jurors biased toward conviction). We then use these probabilities to calculate the probabilities of a hung jury, wrongful acquittal, and wrongful conviction.

To begin with, assume that nature chooses whether or not the defendant is guilty and the strength \( s \) of the evidence against the defendant. Let \( P(G) \) be the probability that nature chooses guilty (so that \( 1 - P(G) \) is the probability that nature chooses innocent), let \( F(s|G) \) be the conditional distribution of the strength of the evidence given that the defendant is guilty, and let \( F(s|I) \) be the conditional distribution of the strength of the evidence given that the defendant is innocent. Let \( f(s|G) \) and \( f(s|I) \) be the corresponding density functions. The evidence is used by jurors in the trial to assess the guilt of the defendant.

To model the reasonable-doubt standard, we assume that some evidence is inconsistent with an innocent defendant, so that if a juror observes that evidence, it could only have been generated by a guilty defendant. More concretely, suppose that an innocent defendant can generate evidence in the interval \([0, s_I]\), and that a guilty defendant can generate evidence in the interval \([s_G, 1]\), with \( 0 \leq s_G < s_I < 1 \) as in Fig. 1. The third inequality means that there is some evidence that is so strong that it could not possibly be consistent with an innocent defendant. This assumption embodies our notion of reasonable doubt: if a juror observes evidence \( s \geq s_I \), that juror can say that the defendant is guilty beyond a reasonable doubt. 23

23 Put another way, we adopt as a reasonable-doubt standard the condition that \( \text{Prob}(G|s) = 1 \). A less stringent reasonable-doubt standard might use, say, the 95%-sure rule of \( \text{Prob}(G|s) \geq 0.95 \). Such a change would raise the probability of wrongful conviction and reduce the probability of wrongful acquittal.
On the other hand, if the juror observes \( s < s_p \), that juror cannot conclude that the defendant is guilty beyond a reasonable doubt. The middle inequality, \( s_G < s_p \), allows for analysis of medium strength cases, that is, cases in which the defendant is neither certainly innocent nor certainly guilty.\(^{24}\)

The third crucial component of the model is juror bias. The strength of the evidence is observed by the jurors as the case is litigated. Jurors do not observe \( s \) directly; rather, they observe \( s \) with bias. Furthermore, the bias is predictable based on an observable binary characteristic, such as race or gender. We assume that all jurors are biased, but that not all of them are biased in the same direction.\(^{25}\) We assume, without loss of generality, that jurors with the characteristic are biased toward conviction and that those without the characteristic are biased toward acquittal. Consistent with the assumption of bias being determined by a binary characteristic, we assume no variation in the magnitude of bias. The bias is operationalized by assuming that jurors do not observe the strength of evidence that nature selects; instead, jurors “observe” the true strength of the case plus some bias parameter. So, for example, when the true strength of the evidence is \( s \), a juror \( j \) biased toward conviction observes evidence of strength \( s_j = s + x \), where \( x \) is a positive number. A juror biased toward acquittal would perceive the same evidence to be of strength \( s_j = s - y \), where \( y \) is a positive number. Since higher values of \( s \) are more likely to have been generated by a guilty defendant, these biased perceptions of the strength of the evidence cause jurors with the binary characteristic to be more likely to find the defendant guilty, and jurors without the characteristic to be more likely to find the defendant not guilty.

We make the assumption that jurors are oblivious to their own bias and do not compensate for it in any way when making judgments. Justice Scalia, in his dissenting opinion in *J.E.B. v. Alabama*, argues that:

The biases that go along with group characteristics tend to be biases that the juror himself does not perceive, so that it is no use asking about them. It is fruitless to inquire of a male juror whether he harbors any subliminal prejudice in favor of unwed fathers.\(^{26}\)

\(^{24}\) Joel Schrag and Suzanne Scotchmer, Crime and prejudice: the use of character evidence in criminal trials, *J. Law Econ Org* 319 (1994) use a similar strength of evidence model. In their model, however, the reasonable-doubt standard is determined by a jury made up of identical jurors, whose objective is to minimize the sum of expected wrongful acquittal and wrongful conviction costs. The jurors’ estimates of these costs are a function of the evidence presented. Schrag and Scotchmer’s jury process is a means to the ultimate social goal of crime deterrence. The social goal we consider is to minimize the expected social loss of the jury process itself.\(^{25}\) These are strong simplifying assumptions. First, we have assumed that all jurors are biased, ruling out the possibility of unbiased jurors. Second, there is only one source of bias: the observable characteristic being discussed. Weakening either of these assumptions would make the model more realistic, but at the expense of ease of exposition. With different sources of bias, or, equivalently, different magnitudes of bias, it would be necessary to keep track of the order in which jurors should be struck, greatly complicating the mathematical analysis. The model developed here provides a thorough analysis of the simplest setting that has all of the necessary components. A brief analysis of how weakening these assumptions affects the probabilities of hung juries, wrongful acquittals, and wrongful convictions is contained in the Appendix.

\(^{26}\) 114 S. Ct. 1419 (1994) at pp. 1438-1439.
Explicitly, jurors act as if the evidence $s_j$ is generated by the distributions $F(s|G)$ and $F(s|I)$. The bias we are considering involves an honest different interpretation of the strength of the evidence between different recognizable groups.\(^{27}\) No juror in our model is biased in such a way as to want to convict a person believed to be innocent. Thus, a very strong case will be beyond the reasonable-doubt standard for all jurors, regardless of their bias.\(^{28}\)

Using the Arizona struck system, the attorneys for both sides (and the presiding judge) see all members of the jury pool before making their selections. Let $N$ be the size of the pool after all the challenges for cause are exhausted, let $n_d$ be the allotted number of peremptory challenges for the defense, let $n_p$ be the allotted number of peremptory challenges for the prosecution, and let $n_0$ denote the number of individuals in the pool possessing the characteristic. Also, $n_d + n_p = N - 12$ (because 12 jurors are required for a sitting jury, and we are assuming there are no alternate jurors), and $n_d \geq n_p$ (because the institutional rules do not allow for the prosecution to be given more challenges than the defense is allowed).

The defense will use its peremptory challenges to strike jurors possessing the characteristic, since everyone with the characteristic is biased toward conviction, and the prosecution will use its challenges to strike jurors who do not possess the characteristic.\(^{29}\) There are three cases:

1. $n_0 < n_d$. In this case, the defense has more strikes than there are jurors biased toward conviction and the prosecution has fewer strikes than it wishes to use. The defense strikes all $n_0$ pool members possessing the characteristic (and uses the rest of its strikes indifferently), the prosecution strikes $n_p$ members who do not have the characteristic, and the final sitting jury consists of 12 members, all of whom are biased toward acquittal. Everyone who is biased toward conviction is eliminated from the jury.
2. $N - n_0 < n_p$. In this case, the prosecution has more strikes than there are jurors biased toward acquittal and the defense has fewer strikes than it wishes to use. The prosecution strikes everyone without the characteristic (and uses the rest of its strikes indifferently), and the final sitting jury consists of 12 members, all of whom are biased toward acquittal.

\(^{27}\) Sheri Lynn Johnson, Black innocence and the white jury, 83 Michigan L Rev 1611 (1985) and Nancy J. King, Postconviction review of jury discrimination: measuring the effects of juror race on jury decisions, 92 Michigan L Rev 63 (1993) present a thorough discussion of the evidence pertaining to the effect of racial composition on jury decisions.

\(^{28}\) For example, in *J.E.B.*, a paternity case, Justice Scalia notes that the scientific evidence presented at the trial established the defendant’s paternity with 99.92% accuracy. Even an all male jury in this case would have likely found paternity. 114 S. Ct. 1419 (1994) at p. 1437.

\(^{29}\) An alternative to the Arizona struck system is the sequential jury system in which lawyers only observe 12 jurors at a time and any struck juror is replaced by a juror drawn randomly from an unobserved pool. Since our model assumes that all jurors biased in one direction are identical, behavior is identical in the two systems because the lawyers wish to strike everyone biased against their sides. If jurors were allowed to have different magnitudes of bias, though, implementing the sequential system would require the use of a search model, which raises several interesting issues of its own beyond the scope of this article.
toward conviction. Everyone who is biased toward acquittal is eliminated from the jury.

3. $n_d < n_0 < N - n_p$. In this case, the defense strikes $n_d$ members with the characteristic and the prosecution strikes $n_p$ members without the characteristic. Those who are left comprise the sitting jury, of whom $n_0 - n_d < 12$ are biased toward conviction and the rest are biased toward acquittal. In this case, the jury is said to be "balanced."

In a criminal case, the reasonable-doubt standard institution is in place, so the correct comparison for jurors to make is $s_j$ against the threshold $s_t$. In Case 1 above, everyone on the jury is biased toward acquittal, so every member of the jury observes evidence of strength $s_j = s - y$. The verdict is guilty if $s \geq s_j + y$, and the verdict is not guilty if $s < s_j + y$, as shown in Fig. 2. In Case 2, everyone on the jury is biased toward conviction and observes evidence of strength $s + x$, so the verdict is guilty if $s \geq s_j - x$, and the verdict is not guilty if $s < s_j - x$. As one would expect, if the jury is biased toward acquittal, a guilty verdict is more difficult to obtain; and if the jury is biased toward conviction, a guilty verdict is less difficult to obtain. Finally, in Case 3, some members of the jury are biased toward conviction and some are biased toward acquittal.
The verdict is guilty if $s \geq s_I + y$ so that both types believe the defendant is guilty beyond a reasonable doubt. The verdict is not guilty if $s \leq s_I - x$, so that neither type believes the defendant is guilty beyond a reasonable doubt. The jury is hung if $s_I - x \leq s < s_I + y$, so that the jurors who are biased toward conviction judge the defendant to be guilty beyond a reasonable doubt, while those who are biased toward acquittal do not.\(^{30}\) Note that the only way to get a hung jury in this framework is if the final jury contains members with both types of biases and if the evidence is sufficiently close to the reasonable-doubt standard threshold $s_I$.\(^{31}\)

One more parameter is needed in order to compute the probabilities of a wrongful acquittal, wrongful conviction, and hung jury: the proportion of the population exhibiting the identifiable characteristic. Let $\pi$ denote the probability that an individual drawn randomly from the population exhibits the characteristic associated with bias toward conviction. It is now straightforward to compute the probabilities of a wrongful acquittal ($P_{WA}$), a wrongful conviction ($P_{WC}$), and a hung jury ($P_{HJ}$). Formal constructions are contained in the Appendix. All three probabilities of interest can be affected by a judge’s actions. A judge has discretion over the size of the jury pool, $N$, by choosing how many peremptory challenges each side is allowed. In a symmetric strikes case, the judge sets $n_d = n_p$. In an asymmetric strikes case, the judge sets $n_d > n_p$.

To summarize, the model takes as primitives the biases of the population and the conditional distributions of the strength of the evidence against the defendant. Jurors are biased in their perceptions of the strength of the evidence, so that jurors who are biased toward conviction vote to convict a defendant on weaker evidence than jurors who are biased toward acquittal. The initial jury is drawn randomly from the population at large, and the parameter $\pi$ measures the fraction of the population that is biased toward conviction. Lawyers use peremptory challenges to remove jurors biased against their case, making it possible to calculate the three probabilities of interest: $P_{WA}$, the probability of wrongful acquittal; $P_{WC}$, the probability of wrongful conviction; and $P_{HJ}$, the probability of a hung jury.\(^{32}\)

\(^{30}\) In the Appendix, we briefly examine a more general setting in which there are more than two juror types.

\(^{31}\) One referee correctly points out that a key reason for there being a relatively small number of hung juries is because of a subtle process of accommodation among jurors. Accommodation in our model only occurs in a trivial sense when the evidence is strong enough for both types of jurors to convict, or when the evidence is weak enough for both types of jurors to acquit. We have no mechanism that allows for one type of juror to change the bias of another type of juror.

\(^{32}\) Schwartz and Schwartz, supra note 6 also formally model the peremptory challenge process. Although there are several similarities between our model and theirs, including the use of a variable to measure population bias and a concern with hung juries, the models have several important differences. Specifically, they do not consider wrongful acquittals or wrongful convictions; they do not explicitly consider the guilt or innocence of the defendant, but instead focus on how jurors differ in their view of how the defendant should be punished; they do not use the size of the jury pool as a choice variable in their model; and, they consider only one composition of the population from which the jury pool is drawn. Their main focus is on the ability of peremptory challenges to reduce the probability of a hung jury, and they conclude that this probability can best be minimized by moving to a system of majority (as opposed to unanimous) verdicts.
4. A numerical example

To facilitate the analysis, we employ a numerical example to see how the probabilities of a hung jury, wrongful acquittal, and wrongful conviction respond to changes in the number of strikes and the biases of the population. In the numerical analysis, we assume that $s_G = 0.4$ and $s_I = 0.6$, and that the probability density functions $f(s|I)$ and $f(s|G)$ are triangular. We also assume that $P(G) = 0.8$, so that nature selects a guilty defendant 80% of the time. As for the biases, we assume that $x = y = 0.05$, so that the bias toward conviction and the bias toward acquittal are of equal magnitude.\(^{33}\) Note that the supports of the two conditional density functions overlap on an interval of length 0.2 and that the biases combine to form a spread of 0.1, so that the biases are large relative to the domain of contested cases.

The threshold probabilities for the three outcomes of concern (wrongful acquittal, wrongful conviction, and hung jury) are achieved when the jury is either completely biased toward acquittal with probability one, completely biased toward conviction with probability one, or balanced with probability one. Table 1 gives the threshold probabilities.

Our starting values for the example were calibrated around the probability of a hung jury being no more than 10%, which is consistent with the stylized facts.\(^{34}\) Obviously, there are no stylized facts with respect to the probabilities of wrongful acquittal or wrongful conviction. Our intention was to make wrongful conviction a relatively unlikely event, which appears to be a well-stated goal of the legal system. We achieve this goal by a combination of the following: the probability that a defendant is innocent is 20%; the reasonable-doubt standard of $s \geq s_f$ is severe; and only a jury all biased toward conviction can wrongfully convict an innocent person. Part of the cost of a legal system that is concerned with keeping the probability of wrongful conviction small, however, is that the probability of wrongful acquittal may be relatively large. In our example, $P_{WA}$ reaches a maximum threshold of 14%.

How important these probability thresholds are depends on the social cost values assigned to a hung jury, wrongful acquittal, and wrongful conviction. In discussing social loss issues, we express the social loss function as

\[ L(N) = P_{HJ}(N)C_{HJ} + P_{WA}(N)C_{WA} + P_{WC}(N)C_{WC} \]  

\(^{33}\) The robustness of the results to this parameterization is explored in the Appendix.

\(^{34}\) Abramson, supra note 12 at p. 198. Our maximum value of 9% overstates the evidence that Abramson cites, but his evidence is drawn from a world in which peremptory challenges are frequently used. Our maximum value takes into account the possibility of using no peremptory challenges.
where \( C_{HJ} \), \( C_{WA} \), and \( C_{WC} \) are the monetary social cost values for a hung jury, wrongful acquittal, and wrongful conviction, respectively.\(^{35}\) The effect of symmetric and asymmetric peremptory challenges on the social loss function through changes in \( P_{HJ} \), \( P_{WA} \), and \( P_{WC} \), are examined with the aid of Figs. 3 and 4.

4.1. Symmetric challenges

One way for a judge to allocate peremptory challenges is to provide the prosecution and the defense with the same number of strikes. The judge’s only decision in this case is to determine the size of the jury pool, \( N \). The number of strikes each side gets, then, is \((N - 12)/2\). The effect of \( N \) on the three probabilities of interest, \( P_{HJ} \), \( P_{WA} \), and \( P_{WC} \), are shown in Fig. 3.

The first graph in Fig. 3 depicts the hung jury probability distribution over \( \pi \) for different values of \( N \). The (thin) top curve represents no peremptory strikes \((N = 12)\); the (thicker) middle curve represents 6 strikes each \((N = 24)\); and, the (thickest) bottom curve represents 30 strikes each \((N = 72)\).\(^{36}\) With no peremptory challenges, for central values of \( \pi \), \( P_{HJ} \) remains flat at its threshold value of 9%. This is because it is nearly impossible in this range of \( \pi \) to draw 12 jurors from the population who have identical biases. As \( \pi \) becomes more extreme at either end, however, \( P_{HJ} \) begins to fall as the probability of drawing a balanced jury begins to fall.

As the number of peremptory challenges increases, the \( P_{HJ} \) distribution shifts down and begins to tighten about \( \pi = 0.5 \). For any given value of \( \pi \), as \( N \) increases, the probability of having a jury that is balanced begins to fall. For large values of \( \pi \), symmetrically increasing the number of strikes increases the probability of having a jury completely biased toward conviction. For example, with \( \pi = 0.75 \), if the defense and prosecution are given four extra strikes each, the size of the jury pool must increase by eight persons. Of these eight, on average six will be biased toward conviction and two will be biased toward acquittal. The prosecution’s four extra strikes can eliminate the two members of the pool biased toward acquittal and two other jurors biased toward acquittal from the original group of \( N \) before the increase. With similar reasoning for small values of \( \pi \), symmetrically increasing the number of strikes increases the probability of having a jury completely biased toward acquittal. As the probability of having a completely biased jury increases, \( P_{HJ} \) falls because a completely biased jury cannot be hung. It also can be seen that the probability of a hung jury drops quickly as the number of strikes increases, especially for more extreme values of \( \pi \). For example, at \( \pi = 0.7 \), \( P_{HJ} \) falls from 9% to 5.5% to 0.1% as the number of strikes each side gets increases from 0 to 6 to 30, respectively. Beyond 30 strikes, \( P_{HJ} \) becomes negligible.

\(^{35}\) Another component of the social loss function can be the administrative costs of increasing \( N \). The more peremptory challenges there are, the greater the costs of voir dire and the greater the opportunity costs of the prospective jurors. We consider these costs lexicographically so that, all else being equal, it is socially preferable to use as small a jury pool as possible.

\(^{36}\) We consider 30 strikes each side as a maximum because only in unusual cases does a court ever award that many challenges.
The second graph in Fig. 3 depicts the wrongful acquittal probability distribution over $\pi$ for different values of $N$. For values of $\pi < 0.6$, $P_{WA}$ increases with the number of strikes (from the thin curve to the thickest curve). This is because the probability of having a jury
Fig. 4. Trial outcome probabilities with asymmetric strikes.
completely biased toward acquittal increases with the number of strikes for \( \pi < 0.6 \).\(^{37}\) For smaller values of \( \pi \), fewer strikes are needed to reach the \( P_{WA} \) maximum threshold value of 14\%. For values of \( \pi > 0.6 \), \( P_{WA} \) is constant at its minimum threshold of 5\% as the number of strikes increases. This is because the probability of having a jury completely biased toward acquittal is very close to zero in this range of \( \pi \).

The third graph in Fig. 3 depicts the wrongful conviction probability distribution over \( \pi \) for different values of \( N \). For values of \( \pi < 0.4 \), \( P_{WC} \) is negligible. A necessary condition for a wrongful conviction is that the jury be completely biased toward conviction. When \( \pi < 0.4 \), this type of jury is very unlikely to occur.\(^{38}\) For values of \( \pi > 0.4 \), however, \( P_{WC} \) increases with the number of strikes (from the thin curve to the thickest curve). This is simply because the probability of having a jury completely biased toward conviction increases with \( N \) for \( \pi > 0.4 \). The larger the value of \( \pi \), the fewer strikes are needed to reach the \( P_{WC} \) maximum threshold value of 0.14\%.

### 4.2. Asymmetric challenges in favor of the defense

Another way for a judge to allocate peremptory challenges is to allow the defense more strikes than the prosecution is allowed. In this case, the judge not only must determine the size of the jury pool \( N \), he also must assign specific values to the number of prosecution strikes, \( n_p \), and the number of defense strikes, \( n_d \), with \( n_p + n_d = N - 12 \), and \( n_d > n_p \).\(^{39}\) Fig. 4 presents the probability distributions over \( \pi \) for increases in \( N \), assuming that both sides are initially allowed 0 strikes and \( N \) is increased by holding \( n_p \) constant and increasing \( n_d \). The 0 strikes curves in Fig. 4 are identical to the 0 strikes curves in Fig. 3.

The first graph in Fig. 4 depicts the hung jury probability distribution over \( \pi \) for different defense strike values: \( n_d = 0 \) (the thin curve); \( n_d = 6 \) (the thicker curve); and, \( n_d = 30 \) (the thickest curve). As \( n_d \) increases, holding \( n_p = 0 \) constant, the hung jury probability distribution shifts right and narrows. For all values of \( \pi < 0.5 \), \( P_{HJ} \) decreases with increases in \( n_d \). With the jury pool already favorable to the defense, the asymmetric increase in strikes increases the probability of having a jury that will be completely biased toward acquittal, thus lowering the probability of having a hung jury. For example, with \( \pi = 0.33 \), increasing \( n_d \) by 6 increases \( N \) by 6. On average, only two of those six jurors will be biased toward conviction, and the defense can use its six extra strikes to eliminate those two jurors and four others from the original \( N \).

For values of \( \pi > 0.5 \), the effect on \( P_{HJ} \) of asymmetric increases in \( n_d \) is ambiguous.

---

\(^{37}\) For values of \( \pi \) between 0.4 and 0.6, increasing the number of strikes reduces the probability of having a balanced jury and slightly increases both the probabilities of having a jury completely biased toward acquittal and a jury completely biased toward conviction. This accounts for the increase in both \( P_{WA} \) and \( P_{WC} \) in Fig. 3 when 0.4 < \( \pi < 0.6 \).

\(^{38}\) While only a jury completely biased toward conviction can wrongfully convict, any type of jury composition can wrongfully acquit. This accounts for the difference in the minimum thresholds for \( P_{WC} \) and \( P_{WA} \).

\(^{39}\) For example, in the 1972 Harrisburg Seven trial, 46 jurors survived the challenge for cause. The prosecution was given 6 challenges and the defense was given 28 challenges. Van Dyke, \textit{supra} note 22 at p. 147.
Increasing \( n_d \) from 0 to 6 reduces \( P_{HJ} \) until \( \pi = 0.65 \), and then \( P_{HJ} \) increases.\(^{40}\) For example, consider \( \pi = 0.8 \). With 0 strikes each (the thin curve), \( P_{HJ} = 8.4\% \). As \( n_d \) is increased to 6 (the thicker curve), \( P_{HJ} \) increases to 8.9\%. Further increases in \( n_d \), however, begin to reduce \( P_{HJ} \). As \( n_d \) is increased to 30 (the thickest curve), \( P_{HJ} \) decreases to 8.0\%. With \( \pi = 0.8 \), the jury pool is unfavorable to the defense. As \( n_d \) is initially raised above \( n_p \), the defense begins to counter the unfavorable jury pool by increasing the probability of having a balanced jury (from 93\% with no strikes to 98\% with six strikes), and \( P_{HJ} \) increases. But as \( n_d \) is further increased, the defense begins to gain an advantage by lowering the probability of having a balanced jury (to 88\% with 30 strikes) and increasing the probability of having a jury completely biased toward acquittal. For more extreme values of \( \pi > 0.5 \), it takes many more defense strikes to eventually reduce \( P_{HJ} \).

The second graph in Fig. 4 depicts the wrongful acquittal probability distribution over \( \pi \) for different values of \( n_d \). For all values of \( \pi \), increasing \( n_d \) over \( n_p \) increases \( P_{WA} \). At very extreme values of \( \pi \), the increase in \( P_{WA} \) is negligible. At \( \pi = 0.9 \), for example, \( P_{WA} \) is constant at its minimum value of 5\% for \( n_d \) equal to 0, 6, or 30. This is because both a jury all biased toward conviction and a balanced jury have the same probability of wrongfully acquitting a defendant. At \( \pi = 0.9 \), it takes more than 30 strikes for the defense to increase the probability of a jury that is all biased toward acquittal above zero. But for a wide range of values of \( \pi \), even slight increases in \( n_d \) over \( n_p \) enhance the defense’s advantage over the prosecution. As \( n_d \) is further increased, \( P_{WA} \) eventually reaches its maximum value of 14\%.

The third graph in Fig. 4 depicts the wrongful conviction probability distribution over \( \pi \) for different values of \( n_d \). Even with zero strikes each, \( P_{WC} \) is negligible for values of \( \pi \) less than approximately 0.65. Giving the defense an advantage over the prosecution has no significant effect in this range. For values of \( \pi > 0.65 \), increasing \( n_d \) over \( n_p \) reduces the probability of wrongful conviction (from the thin curve to the thickest curve), as the probability of having a jury completely biased toward conviction continually decreases.

5. Implications of the results

The results depicted in Figs. 3 and 4 allow us to address some specific issues regarding the use of peremptory challenges in the jury selection process. The first issue we examine concerns the conditions under which it is optimal to use peremptory challenges. The second issue concerns the optimal number of peremptory challenges to award when it is efficient to use challenges. Finally, we address the issue of the effects of awarding asymmetric peremptory challenges in favor of the prosecution. All of these issues, however, are being considered only within the context of our stylized model. A more general discussion of the role of peremptory challenges in the legal system can be found in our concluding comments.

\(^{40}\) The threshold value of \( \pi \) for which \( P_{HJ} \) begins to increase depends on the number of strikes the defense is given over the prosecution. If the defense is given one strike to the prosecution’s zero strikes, for example, the additional strikes causes \( P_{HJ} \) to fall until \( \pi = 0.55 \), and then it causes \( P_{HJ} \) to increase.
5.1. When is it optimal to award peremptory challenges?

To determine when it is optimal to use peremptory challenges, we must determine the effect of these challenges on the probabilities of hung juries and wrongful verdicts that are included in the social loss function. Although peremptory challenges can affect these probabilities, these challenges do not work in a vacuum—the reasonable-doubt standard plays a large role in determining the effectiveness of peremptory challenges. Because of the reasonable-doubt standard, the strength of the evidence must be high for a conviction to occur. In our model, conviction requires the evidence to be strong enough to prove guilt with certainty. If the strength of the evidence is not strong enough for conviction but is strong enough to be in the hung jury range (see Fig. 2), it is still much more likely to have been generated by a guilty defendant than by an innocent defendant. In our numerical example, it is 64 times more likely that evidence in the hung jury range is generated by a guilty defendant when compared to an innocent defendant. This implies that if peremptory challenges reduce the number of hung juries, the existence of the reasonable-doubt standard creates a situation in which the additional verdicts are often wrongful acquittals, but rarely wrongful convictions.

The most straightforward tradeoff we can consider is the one between an increase in the probability of a wrongful acquittal and a decrease in the probability of a hung jury when the probability of a wrongful conviction is not affected by the number of peremptory challenges. For a defendant clearly in the majority \( p < 0.4 \), the jury population is favorable to the defense and the probability of a wrongful conviction is already at its minimum threshold of zero even without peremptory challenges. Awarding the same number of challenges to both sides, or asymmetric challenges to the defense, simply enhances the defense’s favorable position and does not affect the probability of a wrongful conviction. Whether or not it is optimal to award peremptory challenges depends on how the probabilities of a hung jury and a wrongful acquittal change, and how their social costs compare. For this range of \( p \), awarding peremptory challenges increases the number of verdicts reached, but these additional verdicts are all acquittals. However, most of these additional acquittals (64 of every 65 acquittals) are incorrect decisions. Thus, peremptory challenges are very costly in terms of wrongful acquittals. Specifically, if the social cost of a wrongful acquittal is more than slightly above the social cost of a hung jury (i.e., \( C_{WA}/C_{HJ} > 65/64 = 1.02 \)), it is not optimal to award any peremptory challenges.

\[ C_{WA}/C_{HJ} \approx 2.0 \]

In Fig. 2, and using our parameterization, the area under the curve \( f(s|G) \) and in the hung jury range is 16 times the area under the curve \( f(s|I) \) and in the hung jury range. Also, the prior probability that the defendant is guilty is four times the prior probability that the defendant is innocent. Bayes’ rule then establishes that the posterior probability of guilt, given that the evidence is in the hung jury range, is 64 times larger than the posterior probability of innocence. The range of \( p \) for which the probability of a wrongful conviction is not affected by peremptory challenges is larger for asymmetric defense strikes than it is for symmetric strikes. See Figs. 3 and 4.

A formal social loss comparison can be made using Eq. (1). Setting \( P_{WC} = 0 \), the change in social loss generated by the use of peremptory challenges is given by \( \Delta L = \Delta P_{HJ} \times C_{HJ} + \Delta P_{WA} \times C_{WA} \). So, peremptory challenges reduce social loss if \( C_{W}/C_{HJ} \leq -\Delta P_{HJ}/\Delta P_{WA} \). In this case (with \( P_{WC} = 0 \)), all verdicts in trials that
The tradeoff between a wrongful conviction and a hung jury, when the probability of a wrongful acquittal is not affected by peremptory challenges, depends on whether symmetric challenges or asymmetric challenges for the defense are being used. In the case of symmetric challenges, for a defendant clearly in the minority ($\pi > 0.6$), the only tradeoff to consider when awarding peremptory challenges is that between a decrease in the probability of a hung jury and an increase in the probability of a wrongful conviction. For this range of $\pi$, peremptory challenges increase the number of verdicts reached, but now all the additional verdicts are convictions. However, very few of these additional convictions (1 of every 65) are incorrect decisions. Thus, the social cost of a wrongful conviction must be “large” relative to the social cost of a hung jury (i.e., $C_{WC}/C_{HJ} > 65$) for it to not be optimal for a judge to award any symmetric peremptory challenges.44

In the case of asymmetric challenges for the defense, for a defendant in a small minority ($\pi > 0.9$), the only tradeoff to consider when awarding peremptory challenges is that between an increase in the probability of a hung jury and a decrease in the probability of a wrongful conviction.45 For this range of $\pi$, awarding peremptory challenges in favor of the defense reduces the number of verdicts reached. Of every 65 fewer verdicts reached, only one of them is for an innocent defendant. Thus, asymmetric challenges are only warranted if the social cost of a wrongful conviction is deemed to be 65 times higher than the social cost of a hung jury. Recall that this is the exact opposite of the requirement for the use of symmetric peremptory challenges for a defendant clearly in the minority. In other words, our model yields the result that there is always some scope for peremptory challenges when $\pi$ is sufficiently large. If the social cost of a wrongful conviction is relatively high (i.e., $C_{WC}/C_{HJ} > 65$), it is optimal to award asymmetric defense challenges. If not (i.e., $C_{WC}/C_{HJ} < 65$), it is optimal to award symmetric peremptory challenges. Thus, if the objective is to minimize the social loss of jury selection, our results offer no support for the complete elimination of peremptory challenges.

Finally, there are ranges of $\pi$ in which all three probabilities of interest are affected by peremptory challenges. In the case of symmetric challenges, the relevant range is $0.4 < \pi < 0.6$: when awarding challenges in this range, a judge must consider the tradeoff between reducing the probability of a hung jury and increasing the probabilities of both types of incorrect decisions. In the case of asymmetric challenges in favor of the defense, the relevant range is $0.65 < \pi < 0.9$: when awarding challenges in this range, a judge must consider the tradeoff between reducing the probability of a wrongful conviction, increasing the probability of a wrongful acquittal, and reducing or increasing the probability of a hung jury (see

---

44 More formally, set $P_{WA} = 0$. Peremptory challenges reduce social loss if $C_{WC}/C_{HJ} \leq -\Delta P_{HJ}/\Delta P_{WC}$. Here, all verdicts in trials that would have hung without peremptory challenges are convictions, and the threshold for considering symmetric strikes when the defendant is in the majority is $1/P(GiHJ)$.

45 For $\pi < 0.9$, the probability of a wrongful acquittal increases with the number of asymmetric defense challenges. See Fig. 4.
Fig. 4). Unfortunately, these tradeoffs are not easily depicted with social cost ratios because now all three social costs are involved. Even in these ranges of $\pi$, however, our model still offers some very specific results. Symmetric peremptory challenges have absolutely no ability to reduce the probability of a wrongful verdict, be it a wrongful conviction or a wrongful acquittal. The sole advantage of symmetric challenges, then, is that they reduce the probability of a hung jury when the social cost of a hung jury is relatively high. As for asymmetric challenges in favor of the defense, their main advantage is that they reduce the probability of a wrongful conviction when the social cost of a wrongful conviction is relatively high.\footnote{For a defendant in the majority, asymmetric defense strikes can also be used to reduce the probability of a hung jury in the unlikely case that the social cost of a hung jury exceeds the social cost of a wrongful acquittal.}

In conclusion, for sufficiently strong evidence, the reasonable-doubt standard leads to many wrongful acquittals but very few wrongful convictions. In this setting, if the social cost of a wrongful acquittal just slightly outweighs the social cost of a hung jury, which is likely to be the case, our model yields no scope for peremptory challenges when the defendant is clearly in the majority. When the defendant is in a small minority, asymmetric defense strikes are optimal if the social cost of a wrongful conviction is 65 times that of the social cost of a hung jury. But if this is not the case, it is optimal to award symmetric peremptory challenges to lower the probability of a hung jury.\footnote{These results are robust to changes in the parameters used in the numerical example. The Appendix contains details.} In other words, the fact that a defendant is a member of a small minority does not imply that it is optimal to use asymmetric defense strikes — their use depends on relative social costs. There is no doubt that the legal system considers a wrongful conviction extremely costly, but its cost relative to a hung jury cost is the key issue, and this may be difficult to determine. Those who argue in favor of peremptory challenges, however, never raise the issue of these relative social costs.

5.2. When justified, what is the optimal number of peremptory challenges?

Under the Rules of Criminal Procedure for the United States District Courts, Rule 24b pertains to the number of peremptory challenges allowed:

- If the offense charged is punishable by death, each side is entitled to 20 peremptory challenges.
- If the offense charged is punishable by imprisonment for more than one year, the government is entitled to 6 peremptory challenges and the defendant or defendants jointly to 10 peremptory challenges.
- If the offense charged is punishable by imprisonment for not more than one year or by fine or both, each side is entitled to 3 peremptory challenges.\footnote{USCS Fed. Rules Crim. Proc. R 24 (1997).}

This federal statutory rule, and the rules of many state jurisdictions, allow for more challenges, the more serious is the crime the defendant is accused of. No defense of this position, however, is ever clearly offered. While the literature on peremptory challenges has much to say about maintaining or eliminating the peremptory challenge system, the issue of
how many challenges to award (other than zero) is almost completely overlooked. In our model, whether or not to use peremptory challenges depends on the jury pool demographics and also on the relative social costs of a hung jury, a wrongful acquittal, and a wrongful conviction, but not obviously on the gravity of the crime. It is possible that different crimes involve different social cost ratios, but even if this is true it tells us nothing about how many peremptory challenges to efficiently award.\textsuperscript{49}

Our model allows us to clearly address the issue of the number of challenges to award. If it is optimal to award symmetric peremptory challenges, the social cost of a hung jury must be relatively high. In this case, peremptory challenges should be awarded to reduce the probability of a hung jury.\textsuperscript{50} For extreme values of $\pi$ (either high or low), it takes very few challenges to effectively reduce the probability of a hung jury.\textsuperscript{51} The more central the value of $\pi$, the (possibly many) more challenges are required. Thus, if required, more symmetric peremptory challenges should be awarded the less biased the population.

If it is optimal to award asymmetric challenges in favor of the defense, the social cost of a wrongful conviction must be relatively high. In this case, peremptory challenges should be awarded to the defense to reduce the probability of a wrongful conviction.\textsuperscript{52} The larger the value of $\pi$, the more defense challenges are required to effectively reduce the probability of a wrongful conviction. Thus, if required, more asymmetric challenges in favor of the defense should be awarded the more biased the population against the defendant.

In conclusion, the role of peremptory challenges in our model is to reduce the probability of a bad outcome, as defined by relative social cost ratios. Of course, from a practical standpoint, administrative costs can impose a limit on the number of peremptory challenges that are feasible. But whether or not there is a role for limiting the number of peremptory challenges still depends on the demographics of the jury pool population. For some values of $\pi$, administrative costs may not be constraining because very few challenges may be needed to achieve a desired goal.

\textsuperscript{49} It is reasonable to assume that the more serious the crime, the more costly is a wrongful verdict and a hung jury. This makes it ambiguous as to how a more serious crime affects the social cost ratios of interest in determining the optimal number of peremptory challenges.

\textsuperscript{50} Again, this statement assumes that administrative costs enter the social loss function lexicographically and are less important than the costs of a hung jury, a wrongful acquittal, or a wrongful conviction.

\textsuperscript{51} Furthermore, for extreme values of $\pi$ enough peremptory challenges should be used to drive the probability of a hung jury to zero. Consider, for example, a situation in which $\pi < 0.4$, so that the probability of a wrongful conviction is zero. As argued in Footnote 43, peremptory challenges reduce social cost if $C_{WA}/C_{HJ} \leq \Delta P_{HJ}/\Delta P_{WA} = 1/(G(HJ))$. Neither the cost ratio nor the ratio of probability differences changes with the number of strikes until one of the probabilities is driven to its threshold value. So, if it is optimal to use symmetric strikes to reduce the probability of a hung jury, it is optimal to use enough strikes to drive the probability down to its threshold value of zero.

\textsuperscript{52} When it is optimal to award peremptory challenges to the defense, it is also optimal to award zero strikes to the prosecution. To see why, suppose instead that the prosecution strikes $n_p$ jurors who are biased toward acquittal. The optimality of asymmetric challenges suggests that the goal is to seat a jury that is entirely biased toward acquittal. To do this, the defense would need, on average, an additional $n_p/(1-\pi)$ strikes to counteract the prosecution’s strikes. In general, if there is any cost to calling extra jurors, when asymmetric challenges are optimal they should be awarded to either one side or the other.
5.3. Is there a role for awarding asymmetric peremptory challenges in favor of the prosecution?

Up until this point, we have allowed for peremptory challenges to be awarded within the institutional boundaries that currently exist—the defense can never have fewer challenges than the prosecution has. Once we allow for the possibility that asymmetric challenges can be awarded in the prosecution’s favor, our model yields two very strong results: it is optimal to have some type of peremptory challenge regime for all values of \(\pi\); and, it is never optimal to award both sides a positive number of challenges.

Consider a situation in which it is not optimal to award peremptory challenges under the current institutional rules. When a defendant is clearly in the majority and the social cost of a wrongful acquittal just slightly outweighs the social cost of a hung jury, it is not optimal to award symmetric peremptory challenges or asymmetric challenges in favor of the defense. In either of these cases, peremptory challenges increase the probability of a wrongful acquittal when it is not optimal to do so. But if the social cost ratio between a wrongful acquittal and a hung jury is relatively large, it would be optimal to reduce the probability of a wrongful acquittal. Awarding asymmetric challenges in favor of the prosecution would accomplish this goal. Now consider a defendant who is in a small minority. If the social cost of a wrongful conviction is less than 65 times the social cost of a hung jury, we argued above that it is optimal to award symmetric peremptory challenges to reduce the probability of a hung jury. But in this case, awarding asymmetric peremptory challenges in favor of the prosecution would reduce the probability of a hung jury at a faster rate than awarding symmetric challenges. Thus, fewer challenges can be used if the defense has none.\(^{53}\)

To summarize, the optimal peremptory challenge regime to use depends on the value of \(\pi\) and relative social costs. Whenever it is optimal to use peremptory challenges to reduce the probability of a wrongful acquittal, asymmetric challenges to the prosecution can achieve that goal. Whenever it is optimal to use peremptory challenges to reduce the probability of a wrongful conviction, asymmetric challenges to the defense can achieve that goal. Whenever it is optimal to use peremptory challenges to reduce the probability of a hung jury, symmetric challenges can achieve that goal, but asymmetric challenges (to the defense for a majority defendant and to the prosecution for a minority defendant) can achieve that goal with fewer challenges. Over the whole range of \(\pi\), it will always be optimal to achieve at least one of these goals. Thus, in every jurisdiction there is always scope for peremptory challenges when we allow for the prosecution to have asymmetric challenges.

\(^{53}\) Allowing for the defense to have no peremptory challenges for a defendant in a small minority may violate the defendant’s and/or the jurors’ civil rights. The purpose of asymmetric challenges to the prosecution in our setting is to reduce the probability of a hung jury. Civil rights issues, however, may have a higher priority when considering an expanded social loss function.
6. Concluding comments

The current state of the role of peremptory challenges in the legal system is largely tied to the Supreme Court’s decision in Batson.54 Beginning with that decision, the court has both reformed the system and fostered the debate by making it more difficult to base peremptory challenges on race or gender. Briefly, the court’s reform involves what is referred to as a Batson challenge. A peremptory challenge used against a racial or gender bias may be questioned by the opposing counsel. Unless a neutral explanation is accepted by the court, the peremptory challenge will be denied. If the court’s objective is to restrict certain types of peremptory challenges, the Batson challenge has several shortcomings.55 First, a Batson challenge is not an effective way to restrict peremptory challenges because it is easily circumvented with a neutral explanation.56 Second, they are costly to administer in that each challenge can create its own mini-trial. Third, many costly appeals by convicted defendants are based on the outcomes of these mini-trials. Finally, many costly appeals are based on the role of a Batson challenge in trials in which the potential bias is not racial or gender. The precise scope of Batson is often at issue when other potential biases, such as age or religion, are involved.

The Batson decision has led to much debate in the legal literature about the efficacy of peremptory challenges. While much of the literature is concerned with civil rights issues, the literature is almost exclusively focused on potential biases that attract Batson scrutiny—i.e., biases that often involve binary characteristics. Our model, in which jurors are explicitly distinguished by a binary characteristic, lends itself well to a examination of efficiency issues that have been overlooked by this vast literature. Our goal has been to draw attention to factors that have important implications for the efficient use of peremptory challenges. Specifically, peremptory challenges affect the probabilities of three types of social costs associated with jury trials—wrongful acquittals, wrongful convictions, and hung juries. What type of peremptory challenge regime is optimal (symmetric or asymmetric), and how many challenges to award, depends on the relative social costs of bad outcomes and the demographics of the jury pool population.

The results of our model do not provide universal support for many of the current reforms that are discussed in the literature, initiated by the courts, or proposed by state legislatures. For example, in theory the Batson challenge is supposed to eliminate certain types of peremptory challenges. But many of the challenges that come under Batson scrutiny can yield potential benefits in our model. Also, most statutory rules allow for a precise number of peremptory challenges to be awarded, and these rules are applied across large (federal or state) jurisdictions. These consistent rules across jurisdictions ignore the demographics of local jury pool populations. We argue that these demographics are important in determining the efficiency of peremptory challenges.

54 106 S. Ct. 1712 (1986).
55 Alshuler, supra note 6, provides an excellent discussion of the shortcomings of the Batson challenge.
56 Brand, supra note 6 at pp. 584–589, provides evidence that “the federal courts would probably find Batson violations in only 6.7% of the hundreds of cases which have considered the question.”
Our results are derived assuming that it is possible to perform a case-by-case examination of the role of peremptory challenges. This is impractical. Each jurisdiction would need to determine its local jury pool demographics, collecting data not only on such things as race and gender but also marital status, employment status, educational attainment, and any other factor that might affect a juror’s bias. It would also be necessary to determine the social cost ratios for each crime, and while society has already revealed through the reasonable-doubt standard that wrongful convictions are regarded as more costly than wrongful acquittals or hung juries, social cost ratios are still relevant. Nevertheless, this article demonstrates the best that a peremptory challenge system can do under the constraints imposed by the reasonable-doubt standard and the unanimity rule. Clearly, an implementable policy must be derived as a second-best solution from a setting with additional constraints, such as a requirement that peremptory challenge systems remain fixed for a particular offense within a particular jurisdiction.

In all, peremptory challenges do not work in a vacuum: there is a vast institutional system in place that leads to an ultimate verdict in a jury trial. Any practical discussion of judicial reform must consider all of the appropriate tradeoffs. Our intention has not been to resolve the issue of whether or not peremptory challenges have benefits that exceed all their costs, but to identify potential tradeoffs that have been previously ignored.

Acknowledgments

We are grateful to Warren Schwartz, Federico Trionfetti, and two anonymous referees for helpful comments. Neilson thanks the Private Enterprise Research Center at Texas A&M for financial support.

Appendix

The model

In this Appendix we formally construct the probabilities of a wrongful conviction, a wrongful acquittal, and a hung jury. Recall that $P(G)$ is the probability that the defendant is guilty, $F(s|G)$ is the conditional distribution of the strength of the evidence given that the defendant is guilty, and $F(s|I)$ is the conditional distribution given that the defendant is innocent. Evidence stronger than $s_I$ is inconsistent with an innocent defendant, and therefore $s_I$ is the reasonable-doubt standard threshold. The jury pool consists of $N$ members drawn independently from a population of whom a fraction, $\pi$, exhibit an observable characteristic that corresponds to bias toward conviction. Finally, the defense is given $n_d$ peremptory challenges, and the prosecution is given $n_p$ peremptory challenges.

Let $B(n,N,\pi)$ denote the binomial probability distribution for drawing no more than $n$ “successes” in a sample of size $N$ when the probability of an individual “success” is $\pi$. The final sitting jury is completely biased toward acquittal if no more than $n_d$ of the original $N$ potential jurors exhibit the characteristic. Letting $P_a$ denote the probability that the final jury
is completely biased toward acquittal, we have $P_a = B(n_p, N, \pi)$. Similarly, letting $P_c$ denote the probability that the final jury is completely biased toward conviction, $P_c = B(n_p, N, 1-\pi)$. Finally, the probability of a balanced jury containing members of both types is $P_b = 1 - P_a - P_c$. Note that this construction implicitly assumes that jurors are selected at random from a representative cross-section of the population.

It is now straightforward to calculate the probabilities of a wrongful conviction, a wrongful acquittal, and a hung jury. For a wrongful conviction to occur, the defendant must be innocent, which occurs with probability $1 - P(G)$; the jury must be entirely biased toward conviction, which occurs with probability $P_c = B(n_p, N, 1-\pi)$; and the case must be sufficiently strong that jurors biased toward conviction choose to convict, that is, $s \geq s_I - x$. Putting this all together, we get that the probability of a wrongful conviction is

$$P_{WC} = [1 - P(G)] \cdot B(n_p, N, 1 - \pi) \cdot [1 - F(s_I - x)]$$

(A1)

A hung jury occurs if the jury is balanced and if $s_I - x \leq s < s_I + y$, so that jurors biased toward conviction vote to convict and jurors biased toward acquittal vote to acquit. This yields

$$P_{HJ} = [1 - P(G)] \cdot [1 - B(n_p, N, \pi) - B(n_p, N, 1 - \pi)] \cdot [1 - F(s_I - x)]$$

$$+ P(G) \cdot [1 - B(n_p, N, \pi) - B(n_p, N, 1 - \pi)] \cdot [F(s_I + y|G) - F(s_I - x|G)].$$

(A2)

The first term is the probability of a hung jury when the defendant is innocent, and the second term is the probability of a hung jury when the defendant is guilty.

To find the probability of wrongful acquittal, first note that, even in the absence of bias, the reasonable-doubt standard dictates an acquittal if the case is insufficiently strong, that is, if $s < s_I$. Biases affect how the jury actually acts, though. If the jury is entirely biased toward conviction, or if it is balanced, it acquits a guilty defendant when $s < s_I - x$. If the jury is entirely biased toward acquittal, it acquits a guilty defendant when $s < s_I + y$. The probability of a wrongful acquittal is therefore

$$P_{WA} = P(G) \cdot [(1 - B(n_p, N, \pi)) \cdot F(s_I - x|G) + B(n_p, N, \pi) \cdot F(s_I + y|G)].$$

(A3)

The first term in brackets is the probability that either a balanced jury or one biased toward conviction is presented with evidence that is not strong enough to convict, and the second term in brackets is the probability that a jury biased toward acquittal is presented with evidence that is not strong enough to convict.

**Differentiated jurors**

In the baseline model presented in the text, all jurors are biased and can be classified into two types: those biased toward conviction with magnitude $x$, and those biased toward acquittal with magnitude $y$. Suppose instead that there are four types of jurors, two types biased toward conviction with magnitudes $x_H$ and $x_L < x_H$, and two types biased toward acquittal with magnitudes $y_H$ and $y_L < y_H$. The case in which $x_L = y_L = 0$ can be interpreted as having some unbiased jurors. We wish to compare outcomes in the four-type setting to outcomes in the two-type setting in which all jurors biased toward conviction have the same magnitude $x_H$ and all jurors biased toward acquittal have the same magnitude $y_H$. 


Fig. 5 shows how the various types of jurors vote based on the strength of the evidence. A wrongful conviction occurs if the defendant is innocent and all jurors vote for conviction. If all jurors have bias $x_H$, then a wrongful conviction occurs if $s \geq s_t - x_H$. If, instead, some jurors have strong bias $x_H$ and some have weak bias $x_L$, a wrongful conviction occurs if $s \geq s_t - x_L$, and the jury is hung if $s_t - x_H \leq s \leq s_t - x_L$. Consequently, when jurors have differentiated degrees of bias, some wrongful convictions are replaced with hung juries.

A wrongful acquittal occurs if the defendant is guilty and all jurors vote for acquittal. If all jurors have bias $y_H$, then a wrongful acquittal occurs if $s \leq s_t + y_H$. If some jurors have strong bias $y_H$, and some have weak bias $y_L$, a wrongful acquittal occurs if $s \leq s_t + y_L$, and the jury is hung if $s_t + y_L \leq s \leq s_t + y_H$. Consequently, when jurors have differentiated degrees of bias some wrongful acquittals are replaced with hung juries.

In summary, allowing jurors to have differing magnitudes of bias leads to higher probabilities of a hung jury, lower probabilities of wrongful conviction, and lower probabilities of wrongful acquittal than when all jurors have maximal bias. Setting $x_L = y_L = 0$ shows that the same effects hold when some jurors are allowed to be unbiased.
The results presented in the article are based on a specific numerical example. Those results are robust to changes in the parameters. As we change the size of the bias or the probability of being guilty, the threshold values for $P_{HJ}$, $P_{WA}$, and $P_{WC}$ change, as do the threshold cost ratios for using strikes when the defendant is in either a strong majority or a strong minority. Some examples of these changes in the minimum and maximum thresholds are provided in Table A1.

The table shows that changing either the magnitude of bias or the prior probability of guilt changes the range of values that the probabilities of a hung jury, a wrongful acquittal, and a wrongful conviction can take. An increase in the magnitude of the bias expands the range of probabilities for hung juries, wrongful acquittals, and wrongful convictions, as one would expect from Fig. 2. An increase in the prior probability of guilt expands the range of probabilities for hung juries, contracts it for wrongful convictions, and shifts it rightward for wrongful acquittals. All of these changes are rather small.

The column labeled $C_{WA}/C_{HJ}$ shows the threshold value below which it is optimal to use symmetric strikes when $\pi < 0.4$. This threshold increases with the magnitude of the bias, and decreases with the prior probability of guilt. The column labeled $C_{WC}/C_{HJ}$ is the threshold below which it is optimal to use asymmetric strikes for the defense when the value of $\pi$ is sufficiently high. It is decreasing in the magnitude of the bias and increasing in the prior probability of guilt.

The directions of the movements in the threshold cost ratios can be explained. As discussed in the text, the threshold values are related to the posterior probabilities of guilt and innocence. The threshold value of $C_{WA}/C_{HJ}$ is $1/P(G|HJ)$, and the threshold value of $C_{WC}/C_{HJ}$ is $1/P(I|HJ)$, where $P(G|HJ)$ and $P(I|HJ)$ are the posterior probabilities of guilt and innocence, respectively, conditional on the evidence being in the hung jury range (i.e., $s \in [s_l - x, s_r + y]$). When the prior probability of guilt, $P(G)$, rises, the posterior probability of guilt also rises. Consequently, the threshold for wrongful acquittal vs. hung jury falls, and the threshold for wrongful conviction vs. hung jury rises.

When the magnitude of bias, $x$, rises, the size of the interval consistent with hung juries increases (see Fig. 2). This increases the probability that the evidence is in the hung jury

<table>
<thead>
<tr>
<th>$x$</th>
<th>$P(G)$</th>
<th>Probability ranges $P_{HJ}$, $P_{WA}$, $P_{WC}$</th>
<th>Threshold cost ratios $C_{WA}/C_{HJ}$, $C_{WC}/C_{HJ}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05</td>
<td>0.8</td>
<td>[0, 0.090], [0.050, 0.139], [0, 0.0014]</td>
<td>1.016, 65</td>
</tr>
<tr>
<td>0.04</td>
<td>0.8</td>
<td>[0, 0.072], [0.057, 0.128], [0, 0.0009]</td>
<td>1.008, 241</td>
</tr>
<tr>
<td>0.06</td>
<td>0.8</td>
<td>[0, 0.109], [0.044, 0.150], [0, 0.0020]</td>
<td>1.019, 54.3</td>
</tr>
<tr>
<td>0.05</td>
<td>0.9</td>
<td>[0, 0.101], [0.056, 0.156], [0, 0.0007]</td>
<td>1.007, 145</td>
</tr>
<tr>
<td>0.05</td>
<td>0.7</td>
<td>[0, 0.080], [0.044, 0.112], [0, 0.0021]</td>
<td>1.027, 38.3</td>
</tr>
</tbody>
</table>
range for both types of defendants. However, the proportional increase in the probability that the evidence is in the hung jury range is larger for an innocent defendant than for a guilty defendant. Consequently, the posterior probability of an innocent defendant rises with the magnitude of the bias and the posterior probability of a guilty defendant falls. Therefore, the threshold for wrongful acquittal vs. hung jury rises, and the threshold for wrongful conviction vs. hung jury falls.