The Dissertation Committee for Hugo Marc Mialon
certifies that this is the approved version of the following dissertation:

Three Essays in the Economics of Law and Language

Committee:

Maxwell B. Stinchcombe, Supervisor

R. Preston McAfee, Co-supervisor

Daniel S. Hamermesh

Thomas Wiseman

Stephen J. Trejo

William Spelman

Three Essays in the Economics of Law and Language

by

Hugo Marc Mialon, B.A., M.S.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

May 2004

Three Essays in the Economics of Law and Language

Publication No. ____________________

Hugo Marc Mialon, Ph.D.
The University of Texas at Austin, 2004

Supervisors: Maxwell B. Stinchcombe and R. Preston McAfee

One way to understand freedom is to study the laws that supposedly guarantee it. In nearly all countries, the most important of these laws are written into the Constitution. In the first two chapters of my dissertation, I develop and solve a multi-stage economic model of crime and punishment that is designed to analyze the efficiency of several aspects of the Fourth and Fifth Amendments to the United States Constitution. As a surprising bonus, the model permits analysis of several of the aspects of life that are depicted in Orwell's 1984, which is set in a grim, anti-Utopian future characterized by extreme government control and the complete absence of individual freedom.

THE ECONOMICS OF PRIVACY: BIG BROTHER V. THE FOURTH AMENDMENT. In this paper, the Fourth Amendment is viewed as reducing the conviction probability when the police search a suspect without probable cause. The effect of the Fourth Amendment on social welfare is examined in a strategic model where crime and police search are endogenous. In some parameter ranges, the Fourth Amendment actually increases the police's search intensity, and has an

ambiguous effect on crime and wrongful searches. However, in the other relevant parameter ranges, it reduces the police's search intensity, increases crime, and reduces wrongful searches. Moreover, the Fourth Amendment and a strong form of police accountability are jointly sufficient for ongoing progress in search technology to ultimately lead to a Utopian equilibrium in which the police never search without probable cause and most citizens do not commit crime.

AN ECONOMIC THEORY OF THE FIFTH AMENDMENT. The Fifth Amendment's due process clause requires the prosecution to share evidence with the defense, and its right to silence blocks the jury from drawing an adverse inference from the defendant's silence during trial. I examine the effect of the right to silence and the disclosure requirement on conviction rates and welfare in a model of criminal trials. Mandatory disclosure by the prosecution has an ambiguous effect on the conviction rate without the right to silence, but reduces it with the right to silence. The right to silence always reduces the conviction rate. Its effect on welfare, if welfare is based on the principle that a wrongful conviction is worse than a wrongful acquittal, depends on whether the jury's preferences are biased relative to those of society, the reputations of the police (which is connected to the Fourth Amendment in the long run), and the difficulty of the case. Moreover, mandatory disclosure reduces the efficiency of the right to silence for all parameters.

A jury may infer from a suspect's silence that he is guilty, but may also infer from his statement that he is lying. Silence and lies are two important aspects of spoken language. My study of language continues as I shift focus to lies.

THE ECONOMICS OF ECSTASY. This paper models love-making as a signaling game. In the act of love-making, man and woman send each other possibly deceptive signals about their true state of ecstasy. Each has a prior belief about the other's state of ecstasy. These prior beliefs are associated with the other's sexual response capacity, which varies in different ways for men and women over the life-

cycle. The model predicts that love, formally defined as a mixture of altruism and possessiveness, increases the probability of faking ecstasy, but more so for women than for men, and age has a greater effect on the probability of faking if the partners are in love than if they are not. These predictions are tested with data from the 2000 Orgasm Survey. Besides supporting the predictions, the data also reveal a positive relationship between education and the tendency to fake.

Contents

Chapter 1

The Economics of Privacy

BIG BROTHER IS WATCHING YOU

–George Orwell, *1984*, p.4

1.1 Motivation

The Fourth Amendment to the United States Constitution guarantees that "[The] right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized."[1] The Fourth Amendment protects citizens against the invasion of their privacy by agencies of the United States government. In particular, suspects in a crime have a constitutional right not to be searched by the police unless the evidence against them constitutes probable cause.[2]

[1] See website: http://www.law.cornell.edu/constitution/constitution.billofrights.html.

[2] In practice, probable cause exists when it is more likely than not (more than 50 percent certainty) that the items to be seized are connected to the crime and that they can be found in the

This does not mean that the police never search without probable cause. In practice, most criminal coutcases begin with preliminary hearings with motions by defense counsel to dismiss, exclude, or suppress evidence on the grounds that the search that uncovered it was warrantless, or was conducted without probable cause. Probable cause must often be determined by the police as rapidly as possible because evidence is freshest and most incriminating right after the crime has been committed. The police cannot be directly prevented from searching without probable cause, but if they are found to have done so, then any evidence that they uncovered in this way may be excluded from trial later on. This is the Fourth Amendment's exclusionary rule.[3]

In its war against drugs and terrorism, the United States government has gradually weakened Fourth Amendment protections of this kind against invasions of privacy by the police. One example of new legislation in this direction is the USA Patriot Act, which was passed by Congress shortly after the September 11, 2001, terrorist attacks on the United States. A provision in the Act gives the Federal Bureau of Investigation authority to search library and bookstore circulation records and, where applicable, Internet user records, in an investigation of international terrorism [see McCarthy, 2002, for an analysis of the Patriot Act].

This paper seeks to understand the effects of the Fourth Amendment's exclusionary rule on social welfare as a first step toward determining the optimal extent to which Fourth Amendment rights should be sacrificed for increased security against crime and terrorism. A formal, strategic model is developed to understand the welfare effects of the Fourth Amendment. In the model, crime is endogenous, and the

places to be searched. The legal definition of probable cause was formulated in Brinegar v. US [338 U.S. 839, 1949]: "Probable cause, such as may justify an arrest or a search and seizure without warrant, is a reasonable ground for belief of guilt; and this means less than evidence which would justify condemnation or conviction; probable cause exists where the facts and circumstances within the knowledge of the officer making the arrest or search, and of which he had reasonably trustworthy information, are sufficient in themselves to warrant a man of reasonable caution in the belief that an offense has been or is being committed."

[3]Precendent for the exclusionary rule was set in Mapp v. Ohio [367 U.S. 643, 1961].

police choose whether or not to search suspects when the evidence against them does not constitute probable cause. The model is solved for its equilibrium crime, search, and conviction rates, with stronger and weaker Fourth Amendment protections, which are assumed to reduce the ultimate probability of conviction in cases where the police searched a suspect without probable cause.

Several interesting results emerge. The Fourth Amendment has two conflicting effects on the police's equilibrium search intensity without probable cause. First, it tends to decrease the police's search intensity directly by reducing the probability that search leads to successful conviction. Second, it tends to increase the police's search intensity indirectly by increasing the crime rate. If the direct effect dominates the indirect effect, an increase in Fourth Amendment protections reduces the police's equilibrium search intensity, increases crime, and reduces wrongful searches. But if the indirect effect dominates the direct effect, an increase in Fourth Amendment protections increases the police's equilibrium search intensity, and has an ambiguous effect on crime and wrongful searches. We argue that this explains the absence of conclusive empirical evidence either in favor or against the seemingly intuitive hypothesis that the Fourth Amendment reduces the police's search intensity and increases crime.

We also find that the Fourth Amendment is more likely to reduce the police's search intensity, increase crime, and reduce wrongful searches and wrongful convictions, if the police are held accountable to the people for their mistakes, in the sense that they suffer a loss whenever they invade the privacy of the innocent. Thus, the Fourth Amendment is more likely to reduce wrongful searches and convictions if government officials are democratically elected, citizens have liberties of speech and assembly, and the press is free, each of which tend to make government officials and the police more accountable to the people.

To derive the above results, we focus on the only equilibrium in the model that is both stable, in the sense that it survives small perturbations in the equilibrium strategies, and non-extreme, in the sense that the police do not search with probability 0 or 1 when the evidence does not constitute probable cause. However, the model also has two extreme equilibria that are nonetheless stable, one in which the police always search without probable cause and most citizens commit crime, what we call an anti-Utopian equilibrium, and one in which the police never search without probable cause and most citizens do not commit crime, what we call a Utopian equilibrium. We argue that ongoing progress in search technology will ultimately lead the world from the stable, non-extreme equilibrium to either the Utopian or anti-Utopian equilibrium. We then prove that progress in search technology leads to the anti-Utopian equilibrium if the police is not accountable to the people; but that it leads to the Utopian equilibrium if the police are accountable to the people and strong Fourth Amendment protections are in place.

The next section relates the contribution to the existing economics literature. Section 3 presents the model's notation and assumptions, and formally defines Fourth Amendment protections. Section 4 analyzes the effect of the Fourth Amendment on equilibrium. Section 5 uses the results derived in the previous section to explain the current confusion in the relevant empirical literature. Section 6 analyzes the effect of the Fourth Amendment on the elements of social welfare. Sections 7 compares the predictions of the model under differing degrees of police accountability. Section 8 analyzes the implications of long term progress in search technology. Section 9 summarizes the results and proposes further extensions.

1.2 Related Literature

The economic literature on crime and policing is vast, starting with Becker [1968] and Ehrlick [1973]. For a survey, see Ehrlich [1996]. This literature has rarely considered the strategic interaction between criminals and the police. Persico [2002] develops a model of racial profiling that takes into account the behavior of both criminals and the police. In his model, the objective of the police is to maximize the number of successful searches. Police observe citizens' race, but not their earning opportunities in the legal sector, before deciding whether or not to search them. In equilibrium, the group with lower legal earning opportunities is searched with greater intensity than the group with higher legal earning opportunities. Persico then finds conditions under which forcing the police to equalize its search intensities across the two groups reduces crime.

Persico's focus is on fairness issues that concern the Fourteenth Amendment, which guarantees protection from racial discrimination, rather than the Fourth Amendment, which guarantees protection from unreasonable searches. To our knowledge, Rubin and Atkins [1999] is the only existing manuscript that attempts an analysis of the Fourth Amendment using economic theory. The authors sketch a model in which the Fourth Amendment increases crime. They then perform an empirical analysis on aggregate and city-level US data, the results of which support their prediction only weakly. In their model, the police make their decisions to search suspects without worrying about how their decisions will affect citizens' decisions to commit crime. In our model, citizens' decisions to commit crime influence the police's decisions to search, and vice versa. We explicitly solve for the mixed-strategy Bayesian-Nash equilibria of this interaction.

Our model is also designed to explore the effects of the Fourth Amendment when democracy and First Amendment rights make the police accountable for their mistakes, and in the distant future, when search technologies will have become so advanced that the police could employ them to search every citizen at every moment. Thus, our contribution is also connected, although only in spirit, to the relatively small literatures on the economics of government accountability [see Mashaw, 1978,

	$\varepsilon = I_\varepsilon$	$\varepsilon = G_\varepsilon$
$\neg C$	$P[I_\varepsilon \mid \neg C]$	$P[G_\varepsilon \mid \neg C]$
C	$P[I_\varepsilon \mid C]$	$P[G_\varepsilon \mid C]$

Table 1.1: The likelihood matrix representing the quality of the evidence

Seabright, 1996, and Owen, 1974], and the economics of Utopia and anti-Utopia [see Jonas, 1981, Roback, 1985, Hodgson, 1995, Foss, 2000].

1.3 Model

The model's actors are a unit mass of citizens and a single, perfectly coordinated, police force. In the model, citizens differ according to their benefit or wage from crime, w_C. At time 1, Nature chooses each citizen's w_C according to a cumulative density function $F(w_C)$, which is assumed to be the uniform distribution defined on the $[0, 1]$ interval.[4] This density function is common knowledge, but the police do not learn its realization.

At time 2, citizens choose an action from the set $\{C, \neg C\}$, that is, they each choose whether or not to commit a crime (C). Citizens' choices at time 2 are not observable to the police. At time 3, Nature chooses the preliminary evidence ε. The random variable ε can be in one of two states, I_ε, interpreted as "The evidence against the citizen does not constitute probable cause", or G_ε, interpreted as "The evidence against the citizen constitutes probable cause."

The evidence is noisy, and this noise is represented by the likelihood matrix in Table 1, where $P[I_\varepsilon \mid \neg C]$, for example, is the probability that the evidence does not constitute probable cause given that the citizen did not commit the crime. Given that the truth has two states, the uncertainty associated with the evidence

[4] The results presented in the paper hold for a general class of distributions; we use the uniform distribution to facilitate exposition.

has two dimensions, which are denoted by $q_I := P[I_\varepsilon|\neg C]$ and $q_G := P[G_\varepsilon|C]$. For the moment, let $q := q_I = q_G$, that is, assume that guilty citizens are as likely to generate evidence that constitutes probable cause as innocent citizens are to generate evidence that does not constitute probable cause. Note that q stands for "quality," as this parameter represents the quality of the preliminary evidence.

Assume that the evidence is more often right than wrong for all crimes.

Assumption 1. $q > \frac{1}{2}$.

At time 4, Nature chooses the police's knowledge of the evidence κ. The random variable κ can be in one of two states, P, interpreted as "The evidence against a citizen comes to the police's attention", or $\neg P$, interpreted as "The evidence against the citizen does not come to the police's attention." Assume initially that the police are no more likely to come across the evidence if it constitutes probable cause than if it does not, that is, κ is stochastically independent from ε. Let π denote the unconditional probability that the evidence comes to the police's attention, which may be larger as the size of the police force grows relative to the total population or if higher profile crimes are being considered.

If the evidence does not come to the police's attention, then the game is over. If it comes to their attention, then, at time 5, the police choose an action from the set $\{S, \neg S\}$, that is, they choose whether or not to search (S) the citizen's property. When the police make their decision, they only know whether or not the evidence constitutes probable cause, that is, whether or not $\varepsilon = I_\varepsilon$ or $\varepsilon = G_\varepsilon$. If the police have probable cause, they always choose to search.

Assumption 2. If the police learn G_ε, they always choose S.

The police incur a cost c^S to search a citizen's property. Innocent citizens incur a cost η_I of being searched, which is a measure of the extent to which they value their privacy. But why do people value their privacy? Why are people hurt when their privacy is invaded by the police?

Privacy may be interpreted as the ability to conceal personal information that others might use to one's disadvantage. Concealment, in this sense, serves the important purpose of protecting reputation, which is often a valuable asset in relationships. If citizens are searched by the police in public and the details of the search are subsequently made public, they may suffer a loss of reputation, which might result in them losing their job or their spouse. This is the meaning of privacy underlying the federal Privacy Act [5 U.S.C. Chapter 552 (a), 1976], which limits the retention and dissemination of discrediting personal information in government files. [5]

But invasion of privacy is also damaging because it breaks a social bond of trust. If a father invades his son's privacy, say by searching his room, or asking someone to follow him around school, to ensure that he does not smoke or take drugs, then he is signaling to his son that he does not trust him. And the son might *rebel* against his father and start smoking or taking drugs just to spite him, to assert his independence and prove to himself that he is free to do as he pleases, even if he is the type of son who would not have smoked or taken drugs in the absence of excessive monitoring.

Similarly, if the police inform citizens of the dangers of taking drugs, even warn them that if they are caught taking them, they will be punished, but ultimately leave it up to them to decide what to do by weighing the costs and benefits, then if citizens choose not to take drugs, they are content with their choice, in part simply because it was their own choice. But if the police install surveillance cameras in the house of every citizen and provide strong incentives for citizens to tattle on each other, to ensure that none of them ever take drugs, then citizens may feel that many

[5] Posner [1983] discusses the meaning and value of privacy along these lines.

other aspects of their life are also constrained, and perhaps even worse, they may feel that they have lost the trust of their neighbors. In these circumstances, they may choose to rebel against the police. In the next section, we will see that rebellion of this kind actually occurs in several important regions of the model's parameter space.

For the innocent citizens, the costs of having privacy invaded, loss of reputation, freedom, and others' trust, are exacerbated by feelings that these penalties were not deserved. It is not simply that they have to pay a penalty, but that they have to pay a penalty for something they did not do. For this reason, they may feel that an injustice has been committed against them. Guilty citizens who are searched without probable cause may also suffer penalties even if they are ultimately acquitted, but they will not feel quite as badly that these penalties were not deserved. The injustice can only torment and enrage the truly innocent. Thus, we normalize the cost that guilty citizens incur from having their privacy invaded to zero, and assume that $\eta_I > 0$.

The police incur an additional cost η_P if they search innocent citizens without probable cause. The parameter η_P is a measure of police accountability. The police are accountable to the people for their mistakes if they suffer a loss, for example in reputation, when they search or arrest innocent citizens without probable cause, which is more likely in a democracy with First Amendment freedoms of speech, press, and assembly. With First Amendment rights, if innocent citizens are wrongfully searched or otherwise mistreated by the police, they can assemble outside police headquarters in peaceful protest without fear of repercussions, or publish scathing articles in leading newspapers without censure, which would reduce police reputation. And if government officials face repeated democratic elections, they are forced to mind their reputation in the eyes of the public, and therefore to discipline police departments, in order to be reelected. Thus, in a democracy with First Amendment rights, η_P is an increasing function of η_I, that is, $\eta_P(\eta_I)$, where $\eta_P' > 0$.[6]

For now, we assume that indeed $\eta_P' > 0$; moreover, to simplify notation, we assume a particular functional form, $\eta_P(\eta_I) = \eta_I = \eta$, which corresponds to strict police accountability. In section 7, we relax these assumptions to analyze the interaction between democracy and the First Amendment, on one hand, and the Fourth Amendment, on the other.

If the police learn I_ε and choose not to search, then the game is over. If they choose to search, then, at time 6, Nature chooses the verdict v. The random variable v can be in one of two states, I_v, interpreted as "The not guilty verdict," or G_v, interpreted as "The guilty verdict." If citizens are innocent and the evidence against them does not constitute probable cause, then the verdict is also always I_v.

Assumption 3. $P[I_v|\neg C, I_\varepsilon] = 1$.

Therefore, the space of conviction probabilities has three dimensions, which are denoted by $r_1 := P[I_v|\neg C, G_\varepsilon]$, $r_2 := P[I_v|C, G_\varepsilon]$, and $r_3 := P[I_v|C, I_\varepsilon]$.

Assume that innocent citizens who are searched with probable cause are less likely to be convicted than guilty citizens who are searched with probable cause. Also assume that guilty citizens who are searched without probable cause are less likely to be convicted than guilty citizens who are searched with probably cause.

Assumption 4. $r_1 > r_2$ and $r_2 < r_3$.

The Fourth Amendment upholds the right of citizens not to be searched by the police unless the evidence against them is probable cause. In practice, the Fourth Amendment is an exclusionary rule that indirectly constrains police behavior

[6]Society could also punish police officers directly by fining them or putting them on trial if they are suspected of violating the constitutional rights of citizens. This would make individual police officers directly accountable for their mistakes. Police accountability can be enforced directly, as well as indirectly through protests by the citizens and democratic elections of government officials who control the police.

by making evidence produced by unlawful searches inadmissible at trial, and hence reducing the ultimate conviction probability.

Definition 1 *The Fourth Amendment is a law that reduces the probability of conviction in cases where the police searched a citizen without probable cause. More precisely, the Fourth Amendment increases r_3 strictly above r_2.*

If citizens are searched without probable cause, and the search does not uncover reliably incriminating evidence, then they are acquitted. But if the search uncovers reliably incriminating evidence, then they are acquitted only if their lawyers can appeal to the Fourth Amendment. Therefore, in practice, the Fourth Amendment usually results in the acquittal of known criminals. Of course, protecting criminals is not the ultimate objective of the Fourth Amendment, although it is its proximate result. The Fourth Amendment protects the guilty in the hopes that in equilibrium this will result in fewer innocent citizens being searched by the police. It protects the guilty in order to protect the privacy of the innocent.

The police's utility depends on the probabilities of the two types of court error (in addition to the search cost). The police's attitude toward risk is normalized such that its utility from a rightful conviction or a rightful acquittal is 1, its utility from a wrongful acquittal is 0, and its utility from a wrongful conviction is $U_P := U_P(G_v, \neg C)$:

$$U_P \leq \ U_P(I_v, C) = 0 < U_P(G_v, C) = U_P(I_v, \neg C) = 1 \tag{1.1}$$

A citizen's utility from acquittal is 0 and cost of conviction is s (the sentence length).

An interesting difficulty arises when attempting to define social welfare in a model where decisions to commit crime are endogenous and affected by changes in law. Should social welfare take into account the welfare of criminals, including their benefits from crime and their costs of hiding it from the police? Suppose social welfare does not include the costs and benefits of criminals. Consider those citizens who, before a change in law, chose not to commit crime, but who, after a change in law, choose to commit crime. Before the change in law, their welfare was part of social welfare, but now that the law is changed, their welfare is no longer part of social welfare. Society changed the rules of the game and then neglected those who were affected by the changes. In most of the United States, if citizens are convicted of serious offenses, they lose the right to vote. This is society's way of saying that they are no longer part of the polity, that is, that their welfare is no longer part of social welfare.

On the other hand, anything reflecting the welfare of innocent citizens certainly belongs in the social welfare function, and it is these components of social welfare that are studied in the paper. A first such component is the crime rate. Crime imposes negative externalities on its victims. A second component of social welfare is composed of wrongful convictions. According to an often-cited proverb, it is better to let ten guilty persons go free than to lock up one innocent person. A third component of social welfare is comprised of wrongful searches. The privacy of innocent citizens is an important part of social welfare. As mentioned earlier, privacy is often a necessary input to the creative process. We study the effects of the Fourth Amendment on these three elements of the social welfare function, and we let our readers weigh the relative importance of these elements as they see fair.

1.4 Effect of Fourth Amendment on Equilibrium

Once citizens have learned their benefits from a crime, they each choose whether or not to commit the crime. Suppose the police search when they do not have probable cause with probability σ_I. Then if a citizen is of type w_C, her payoffs from each of the two strategies are

$$\begin{aligned} EU_{\text{Citizen}}(\neg C) &= g(\sigma_I) \\ EU_{\text{Citizen}}(C) &= w_C + h(\sigma_I) \end{aligned} \tag{1.2}$$

where

$$\begin{aligned} g(\sigma_I) &= A_1\sigma_I + A_2 \\ h(\sigma_I) &= A_3(r_3)\sigma_I + A_4 \\ A_1 &= -\eta\pi q,\ A_2 = -\pi(1-q)[\eta + s(1-r_1)] \\ A_3(r_3) &= -s\pi(1-q)(1-r_3),\ A_4 = -s\pi q(1-r_2) \end{aligned} \tag{1.3}$$

$A_1\sigma_I$ is the probability that police wrongfully search an innocent citizen without probable cause, $\pi q\sigma_I$, times the innocent citizen's cost of being wrongfully searched without probable cause, consisting of a loss of privacy, η, but not of a potential wrongful conviction, since by Assumption 3, if innocent citizens are searched without probable cause, they are always acquitted. A_2 is the probability that police wrongfully search an innocent citizen with probable cause, $\pi(1-q)$, times the innocent citizen's cost of being wrongfully searched with probable cause, consisting of a privacy loss, η, and a potential wrongful conviction, $(1-r_1)s$.

On the other hand, w_C is a citizen's benefit of committing crime, while $A_3(r_3)\sigma_I + A_4$ is the citizen's cost of committing crime. $A_3(r_3)\sigma_I$ is the probability that the evidence wrongfully indicates that criminals are innocent but the police search them anyway, $\pi(1-q)\sigma_I$, times the consequent potential cost of conviction, $(1-r_3)s$, which depends crucially on the probability that criminals can be convicted despite having been wrongfully searched by the police, $1-r_3$. A_4 is the probability that the evidence rightfully indicates that criminals are guilty and the police uncover this evidence, πq, times the consequent potential conviction, $(1-r_2)s$.

A citizen of type w_C chooses $\neg C$ if and only if

$$\begin{aligned} g(\sigma_I) &\geq w_C + h(\sigma_I) \\ &\Leftrightarrow w_C \leq g(\sigma_I) - h(\sigma_I) \end{aligned} \tag{1.4}$$

Thus, the fraction of citizens who do not commit crime is

$$\begin{aligned} I(\sigma_I) &= F(g(\sigma_I) - h(\sigma_I)) \\ &= g(\sigma_I) - h(\sigma_I) \\ &= (A_1 - A_3(r_3))\sigma_I + (A_2 - A_4) \end{aligned} \tag{1.5}$$

Since $I(\sigma_I)$ is a probability, it should be between 0 and 1. Since $I(\sigma_I)$ is a monotone function of σ_I, if $I(\sigma_I)$ is between 0 and 1 at its minimum and at its maximum, then $0 \leq I(\sigma_I) \leq 1$ for any $\sigma_I \in [0, 1]$. Therefore, regardless of whether or not $A_1 - A_3 > 0$, $0 \leq I(\sigma_I) \leq 1$ for any $\sigma_I \in [0, 1]$ if $0 \leq (A_2 - A_4) \leq 1$, and $0 \leq A_1 - A_3 + (A_2 - A_4) \leq 1$. This condition is sufficient but not necessary; however, since it simplifies the analysis that follows, we focus on parameter ranges where it is satisfied.

Assumption 5. $0 \leq (A_2 - A_4) \leq 1$ and $0 \leq A_1 - A_3 + (A_2 - A_4) \leq 1$.

Before considering the police's problem, it is worth noting the effect on crime of an exogenous increase in the police's search intensity. Taking the derivative of expression (5) with respect to σ_I yields

$$\frac{\partial I(\sigma_I)}{\partial \sigma_I} = A_1 - A_3(r_3) \tag{1.6}$$

The necessary and sufficient condition for this expression to be positive is presented as the following proposition.

Proposition 1 *An exogenous increase in the police's search intensity without probable cause reduces crime if and only if*

$$s > \overline{s}' := \frac{\eta q}{(1-q)(1-r_3)}$$

Paradoxically, an increase in the police's search intensity could actually increase crime. This would happen if, for example, $q = 1$. In this case, if citizens are guilty, then the evidence will always be probable cause against them, and if they are innocent, then the evidence will never be probable cause against them. So if the police search more without probable cause, then they are only searching the innocent more. This, of course, makes it relatively less attractive to be innocent. The same thing happens if η is large enough. If the innocent incur a tremendous cost of being searched without probable cause, and they are searched without probable cause with greater intensity, then becoming a criminal becomes relatively more attractive. If one is going to be treated like a criminal, and the costs of being treated like a criminal are very large, then one might as well also derive the benefit from actually being a criminal. In these cases, an increase in the police's search intensity causes the borderline innocent to *rebel* and turn into criminals.

Now suppose that the population of citizens is distributed according to $(I(\sigma_I), G(\sigma_I))$. If the police observe I_ε, their expected payoffs from searching (S) and not searching ($\neg S$) are, respectively,

$$\begin{aligned} EU_{Police}(S|I_\varepsilon) &= \frac{I(\sigma_I)q}{I(\sigma_I)q + G(\sigma_I)(1-q)}B_1 \\ &\quad + \frac{G(\sigma_I)(1-q)}{I(\sigma_I)q + G(\sigma_I)(1-q)}B_2(r_3) \\ EU_{Police}(\neg S|I_\varepsilon) &= \frac{I(\sigma_I)q}{I(\sigma_I)q + G(\sigma_I)(1-q)} \\ B_1 &= 1-\eta-c^S,\ B_2(r_3) = 1-r_3-c^S \end{aligned} \tag{1.7}$$

If the signal of probable cause is perfectly accurate ($q = 1$), the police's expected utility of not searching when the evidence does not constitute probable cause reaches its maximum of 1. Intuitively, if the police know that evidence that does not constitute probable cause can only come from innocent citizens, then if they observe evidence that does not constitute probable cause, they know for certain that the citizen is innocent, and hence their payoff from not searching the citizen is at the highest possible level.

If the signal of probable cause is perfectly noisy ($q = 1/2$), the police's expected utility of not searching when the evidence does not constitute probable cause is exactly equal to the proportion of citizens who are innocent. Intuitively, if the police know that evidence that does not constitute probable cause is as likely to come from guilty citizens as from innocent citizens, then if the police observe evidence that does not constitute probable cause, they are completely in the dark as to whether the citizen is innocent, and hence their payoff depends only their prior belief that the citizen is innocent.

Now, since citizens and the police are playing an inspection game, we expect them to randomize in equilibrium. Indeed, if all citizens commit crime, the police want to search them even without probable cause. But if the police search them even without probable cause, then they do not all want to commit crime. But if enough of them do not commit crime, then the police do not want to search them without probable cause, and so on. We now locate the parameter ranges where this is the scenario that plays out.

Proposition 2 *Let* $Z(\sigma_I) := EU_{Police}(S|I_\varepsilon) - EU_{Police}(\neg S|I_\varepsilon)$, $\overline{Z}(\sigma_I) := \max\{Z(\sigma_I) : \sigma_I \in [0,1]\}$, $\underline{Z}(\sigma_I) := \min\{Z(\sigma_I) : \sigma_I \in [0,1]\}$, *and*

$$X := \frac{B_2(1-q)}{(1-q)B_2 + q(1-B_1)}$$

(1) If $\overline{Z}(\sigma_I) > 0$, $\underline{Z}(\sigma_I) < 0$, *and* $A_1 - A_3 > 0$, *the game has a unique stable equilibrium*

$$(\sigma_I^* = \frac{X - (A_2 - A_4)}{A_1 - A_3}, I(\sigma_I^*) = X)$$

(2) If $\overline{Z}(\sigma_I) > 0$, $\underline{Z}(\sigma_I) < 0$, *and* $A_1 - A_3 < 0$, *the game has two stable equilibria,* ($\sigma_I^* = 0$, $I(\sigma_I^*) = A_2 - A_4$) *and* ($\sigma_I^* = 1$, $I(\sigma_I^*) = A_1 - A_3 + A_2 - A_4$), *and one unstable equilibrium*

$$(\sigma_I^* = \frac{(A_2 - A_4) - X}{-(A_1 - A_3)}, I(\sigma_I^*) = X).$$

(3) If $\overline{Z}(\sigma_I) < 0$, *the game has a unique stable equilibrium,* ($\sigma_I^* = 0$, $I(\sigma_I^*) = A_2 - A_4$).

(4) If $\underline{Z}(\sigma_I) > 0$, *the game has a unique stable equilibrium,* ($\sigma_I^* = 1$, $I(\sigma_I^*) = A_1 - A_3 + A_2 - A_4$).

Proof. Proofs of all propositions that are not proved in the text are presented in Appendix 1. ■

The game's parameter space can be partitioned into six regions, four of which have different equilibrium sets. The six regions are illustrated in Figure 1. The benefits to the police from searching without probable cause depend on the fraction of citizens who commit crime. In Figure 1, the cases where $\underline{Z}(\sigma_I) > 0$ depict parameter ranges where a large enough fraction of citizens commit crime regardless of the police's search intensity, that the police always find it optimal to increase their search intensity, which eventually leads them to always search without probable cause ($\sigma_I^* = 1$). Similarly, the cases where $\overline{Z}(\sigma_I) < 0$ depict parameter ranges where a small enough fraction of citizens commit crime regardless of the police's search intensity, that the police always find it optimal to decrease their search intensity, which eventually leads them to never search without probable cause ($\sigma_I^* = 0$).

The cases where $\overline{Z}(\sigma_I) > 0$, $\underline{Z}(\sigma_I) < 0$ depict parameter ranges where the police's search intensity affects the fraction of citizens who commit crime to an extent large enough for the police to mind this effect. If $A_1 - A_3 > 0$, an increase in the police's search intensity reduces the fraction of citizens who commit crime. In these parameter ranges, if the police usually search without probable cause, the fraction of citizens who commit crime is small enough that the police want to reduce their search intensity. Similarly, if the police usually do not search without probable cause, the fraction of citizens who commit crime is large enough that the police want to increase their search intensity. Thus, the only stable equilibrium involves the police randomizing between searching and not searching without probable cause.

On the other hand, if $A_1 - A_3 < 0$, an increase in the police's search intensity without probable cause increases the fraction of citizens who commit crime. In these ranges, if the police usually search without probable cause, the fraction of citizens who commit crime is large enough that the police want to increase their search intensity even more. Similarly, if the police usually do not search without probable cause, the fraction of citizens who commit crime is small enough that the police want to reduce their search intensity even further. Thus, the only stable equilibria involve the police either searching always or never.

For now, we focus on the only region of parameter space wherein the equilibrium is both stable, in the sense that a simple dynamic adjustment process in which the police and citizens take turn myopically best responding to each others' current strategies converges to it from any strategy pair in its neighborhood, and non-extreme, in the sense that the police's equilibrium strategy is neither to search with probability 0 nor 1 when the evidence does not constitute probable case (which only happens when sufficiently few or sufficiently many citizens commit crime): $\overline{Z}(\sigma_I) > 0$, $\underline{Z}(\sigma_I) < 0$, and $A_1 - A_3 > 0$. In this region, the equilibrium specifies that the police randomize. For this to be true, it must be that

$$\begin{aligned} EU_{Police}(S|I_\varepsilon) &= EU_{Police}(\neg S|I_\varepsilon) \\ \iff& Z(\sigma_I) = I(\sigma_I)q(B_1 - 1) + (1 - I(\sigma_I))(1 - q)B_2(r_3) = 0 \end{aligned} \tag{1.8}$$

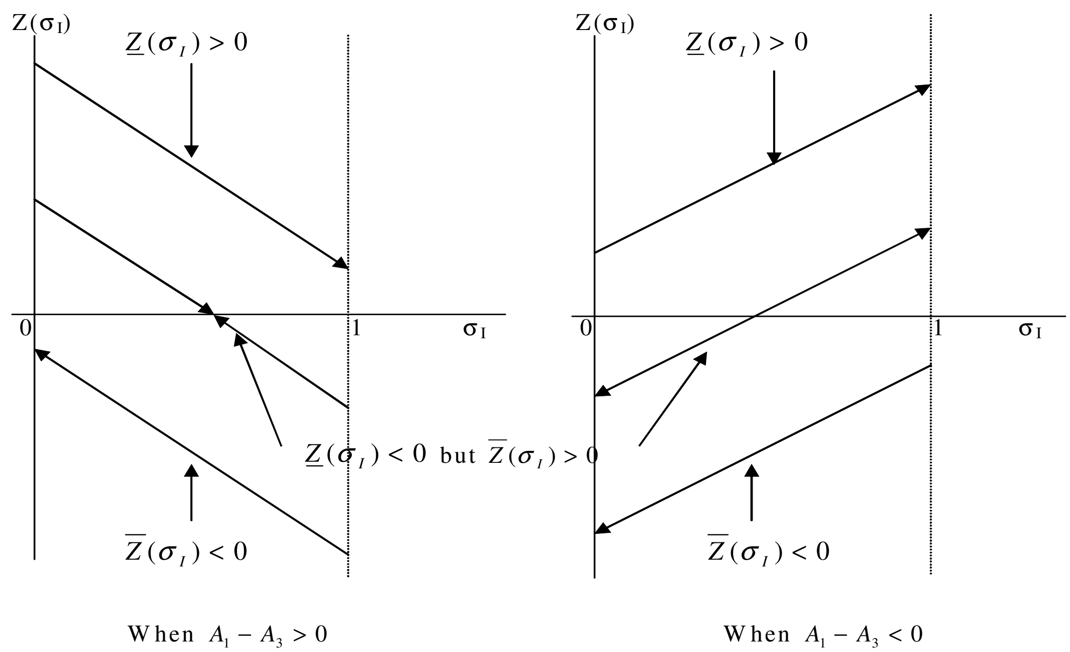

Figure 1.1: The equilibrium set in the six regions of the game's parameter space.

Substituting for $I(\sigma_I)$ yields

$$\begin{aligned} Z(\sigma_I) &= \{\sigma_I(A_1 - A_3(r_3)) + (A_2 - A_4)\}q(B_1 - 1) \\ &\quad +\{1 - \sigma_I(A_1 - A_3(r_3)) - (A_2 - A_4)\}(1 - q)B_2(r_3) = 0 \end{aligned} \tag{1.9}$$

which implicitly defines the police's equilibrium search intensity when the evidence does not constitute probable cause, σ_I^*. Now, in the United States (and most other industrialized countries), some Fourth Amendment rights are already at least partially enforced, and the question before Congress and the Supreme Court is whether to strengthen or weaken them at the margin. The implicit function theorem yields

$$\begin{aligned} \frac{\partial \sigma_I}{\partial r_3} &= -\frac{\frac{\partial Z(\sigma_I)}{\partial r_3}}{\frac{\partial Z(\sigma_I)}{\partial \sigma_I}} \\ &= -\frac{q_I[\frac{\partial I(\sigma_I)}{\partial r_3}(B_1 - 1)] + (1 - q_G)[\frac{\partial G(\sigma_I)}{\partial r_3}B_2(r_3) + G(\sigma_I)\frac{\partial B_2(r_3)}{\partial r_3}]}{q[\frac{\partial I(\sigma_I)}{\partial \sigma_I}(B_1 - 1)] + (1 - q)[\frac{\partial G(\sigma_I)}{\partial \sigma_I}B_2(r_3)]} \\ &= -\frac{\frac{\partial I(\sigma_I)}{\partial r_3}[q_I(B_1 - 1) - (1 - q_G)B_2(r_3)] + \frac{\partial B_2(r_3)}{\partial r_3}[(1 - q_G)G(\sigma_I)]}{\frac{\partial I(\sigma_I)}{\partial \sigma_I}[q(B_1 - 1) - (1 - q)B_2(r_3)]} \end{aligned} \tag{1.10}$$

The term $q(B_1 - 1) - (1 - q)B_2(r_3)$ is equal to $q(-\eta) - (1 - q)(1 - r_3) + c^S(1 - 2q)$, which is negative since $q > 1/2$ by Assumption 1. Also, from (6) and Proposition 1, we know that

$$\frac{\partial I(\sigma_I)}{\partial \sigma_I} > 0 \Leftrightarrow A_1 - A_3(r_3) > 0 \tag{1.11}$$

But in the region of parameter space that we are considering, the only region wherein the equilibrium is both stable and non-extreme, $A_1 - A_3 > 0$. This "stability condition" guarantees that the denominator of (10) is negative.

On the other hand, in the numerator of (10), two opposing effects are at play:

Direct Effect: An increase in Fourth Amendment protections directly discourages searches by reducing the probability that searches lead to rightful convictions.

Indirect Effect: An increase in Fourth Amendment protections indirectly encourages searches by increasing the crime rate and hence increasing the probability that searches lead to rightful convictions.

More precisely, the direct effect of the Fourth Amendment corresponds to the term

$$\frac{\partial B_2(r_3)}{\partial r_3}[(1-q)G(\sigma_I)] < 0 \tag{1.12}$$

whereas the indirect effect corresponds to the term

$$\frac{\partial I(\sigma_I)}{\partial r_3}[q(B_1-1)-(1-q)B_2(r_3)] > 0 \tag{1.13}$$

The direct effect of an increase in Fourth Amendment protections tends to reduce the police's equilibrium search intensity without probable cause, whereas the indirect tends to increase it. If the direct effect dominates the indirect effect, then an increase in Fourth Amendment protections reduces the police's equilibrium search intensity without probable cause. If the indirect effect dominates the direct effect, the marginal increase in Fourth Amendment protections reduces the police's search intensity when the evidence does not constitute probable cause. The necessary and sufficient condition for the direct effect to dominate the indirect effect is presented in the following proposition.

Proposition 3 *An increase in Fourth Amendment protections reduces the police's search intensity without probable cause if and only if*

$$s < \overline{s}'' := \frac{q(\eta + c^S)}{\sigma_I \pi[(1-q)(1-r_3-c^S)+q(\eta+c^S)]^2}$$

Thus, whether or not the direct effect of the Fourth Amendment on the police's search intensity dominates the indirect effect depends on a great many parameters. Let us look at the role played by the probability that the evidence comes to the police's attention, π. From the inequality in the above proposition, it is clear that the direct effect is more likely to be greater than the indirect effect the lower is π. If the probability that the evidence comes to the police's attention is low, say because the size of the police force is small relative to the total population, then the fraction of citizens committing crime is relatively high since criminals can escape capture most of the time. Therefore, the direct effect of the Fourth Amendment on the police's search intensity is large, that is, the Fourth Amendment denies the police a great many possibilities for rightful conviction. Moreover, an increase in Fourth Amendment protections only increases crime by a small measure, since only those citizens who come to the police's attention are protected by the Fourth Amendment, and few citizens come to the police's attention since π is low. Therefore, the indirect effect of the Fourth Amendment on the police's search intensity is small. Hence, if π is low, an increase in Fourth Amendment protections is more likely to have a larger direct effect than indirect effect, and hence more likely to reduce the police's search intensity without probable cause. Thus,

Proposition 4 *An increase in Fourth Amendment protections reduces the police's search intensity without probable cause for a larger range of parameters the smaller is* π.

Indeed, in places swarming with police officers and surveillance cameras, the Fourth Amendment may even have the counter-intuitive effect of increasing the police's search intensity without probable cause.[7]

[7] It is also worth noting the effect of police force size on the equilibrium behavior of citizens and the police, independently of Fourth Amendment considerations. From Proposition 2, we know that in equilibrium $I(\sigma_I^*) = X$, where X does not depend on π. Therefore, π does not affect the crime rate. This suggests, quite surprisingly, that an increase in the size of the police force relative to the total size of the population does not affect the crime rate. Indeed, the crime rate is set to make the police indifferent between searching and not searching without probable cause. But the police's payoffs from searching and not searching without probable cause cannot depend on the probability

1.5 Possible Explanation for Empirical Confusion

Oaks (1970) found that the Fourth Amendment's exclusionary rule had no significant effect on arrests by the police in Cincinnati. Cannon (1974) replicated Oaks's Cincinnati research in thirteen other cities and showed that the effect of the exclusionary rule in Cincinnati was not typical. In several other cities the exclusionary rule significantly reduced the number of arrests. Based on these studies, the Supreme Court reluctantly concluded, in U.S. v. Janis (1976), that "No empirical researcher, proponent or opponent [of the exclusionary rule] has yet been able to establish with any assurance whether the rule has a deterrent effect [on unlawful searches by the police]."

More recently some researchers have used interviews with individual officers (Wasby, 1976, Krantz *et al*, 1979, Orfield, 1987, Canon, 1991), and others have used field observation (Skolnick, 1994, Gould, 2000), as an alternative to official records. The results of these studies are also mixed, with some studies finding a significant effect in some parts of the country and for some types of crime, and other studies finding no significant effect in other parts of the country and for other types of crime. Thus, even today, some researchers (e.g., Orfield, 1987) openly admit that the extant empirical research neither proves nor disproves the inhibitory effect of the exclusionary rule.

Our model suggests that the existing empirical research might both prove and disprove the inhibitory effect of the Fourth Amendment. As Proposition 2 suggests, the Fourth Amendment's exclusionary rule could have completely different effects on the police's search practices if the values of the parameters are sufficiently different. And the parameters in our model may indeed have different values in different parts

π that the evidence comes to their attention. Thus, π does not affect the crime rate. This result may help explain the abundance of empirical evidence that increases in police force size do not reduce crime [see Cameron, 1988, and Levitt, 1999].

of the country, and for different types of crime. For example, Proposition 4 suggests that the Fourth Amendment is more likely to inhibit police search in Houston, where the mean number of sworn officers per 100,000 citizens from 1970 to 1992 was one of the lowest in the nation among big cities at 265, than in Chicago, where mean officers per 100,000 citizens during this period was the second highest in the nation at 475 [these statistics are from Levitt, 1999].

1.6 Effect of Fourth Amendment on Welfare

Let us now analyze the impact of the Fourth Amendment on those elements of social welfare that directly or indirectly concern the innocent: (1) the crime rate, (2) the probability of wrongful search, and (3) the probability of wrongful conviction.

Proposition 5 *A marginal increase in Fourth Amendment protections (1) increases the crime rate, (2) reduces the probability of wrongful search, and (3) reduces the probability of wrongful conviction if* $s \in [\overline{s}', \overline{s}'']$*, but has an ambiguous effect on the crime rate, and therefore also has an ambiguous effect on the probability of wrongful search and wrongful conviction if* $s > \overline{s}''$.

The Fourth Amendment has both a direct and an indirect effect on crime. Indeed, the Fourth Amendment tends to increase crime directly by reducing the total probability that criminals are convicted, but tends to reduce or increase crime indirectly by increasing or reducing the police's search intensity without probable cause.

We know that the Fourth Amendment also has a direct and an indirect effect on the police's search intensity without probable cause, and that the overall effect is negative if and only if the direct effect outweighs the indirect effect. Therefore, if the direct effect of the Fourth Amendment on the police's search intensity without probable cause outweighs the indirect effect, then the direct and indirect effects of the Fourth Amendment on crime both tend to increase crime, so that the overall effect on crime is positive. However, if the indirect effect of the Fourth Amendment on the police's search intensity without probable cause outweighs the direct effect, then the direct and indirect effects of the Fourth Amendment on crime run counter to each other, and the overall effect on crime is ambiguous.

The Fourth Amendment does not have a direct effect, but has two indirect effects, on wrongful searches. The Fourth Amendment tends to increase or decrease wrongful searches indirectly by decreasing or increasing crime, or by increasing or decreasing the police's search intensity without probable cause. Therefore, if the Fourth Amendment reduces the police's search intensity and hence increases crime, then it unambiguously reduces wrongful searches. However, if the Fourth Amendment increases the police's search intensity and hence has an ambiguous effect on crime, then it also has an ambiguous effect on wrongful searches.

Lastly, the Fourth Amendment only has a single indirect effect on wrongful convictions. Indeed, the Fourth Amendment tends to increase or decrease wrongful convictions indirectly only by increasing or decreasing crime. Thus, if the Fourth Amendment increases crime, it reduces wrongful convictions; but if it has an ambiguous effect on crime, then it also has an ambiguous effect on wrongful convictions. The Fourth Amendment does not also affect wrongful convictions through its effect on the police's search intensity without probable cause, because we have assumed that if innocent citizens are searched without probable cause, then they will be acquitted with certainty.

1.7 Police Accountability

In the model, we assumed that $\eta_P(\eta_I) = \eta_I$, that is, the loss in reputation that the police incur from invading the privacy of innocent citizens is directly proportional to the extent to which these innocent citizens value their privacy. This assumption is only valid if politicians face repeated democratic elections, and innocent citizens who feel that they, or others about whom they care, have been mistreated by the police can assemble outside police headquarters in peaceful protest, or publish scathing articles in leading newspapers, which would reduce police reputation and force politicians to discipline police departments.

If the government has control of the press, and uses this control to suppress dissenting opinions, the police can only suffer minor reputation losses by invading the privacy of innocent citizens. In this case, $\eta_P < \eta_I$. How does police accountability interact with the Fourth Amendment's search and seizure law?

Proposition 6 *An increase in Fourth Amendment protections reduces the police's search intensity without probable cause for a smaller range of parameters the smaller is η_P relative to η_I.*

An increase in Fourth Amendment protections reduces the police's search intensity without probable cause by reducing the probability that such searches lead to successful convictions (the direct effect), but it also increases crime. The police would respond to the increase in crime by increasing their search intensity without probable cause (the indirect effect), especially if they did not care too much about harassing the innocent in the process. But if the police are wary of wrongfully searching innocent citizens because that would too severely tarnish their reputation, then the indirect effect of the Fourth Amendment on the police's search intensity without probable cause is much smaller. Thus, an increase in Fourth Amendment protections is more likely to decrease the police's search intensity without probable cause, and hence decrease wrongful searches and wrongful convictions, the more accountable the police are for their mistakes.

If society's objective is to reduce wrongful searches and wrongful convictions by increasing Fourth Amendment protections, or to reduce crime by reducing Fourth Amendment protections, then it is more likely to achieve its objectives if it has made the police publicly accountable to the people. To the extent that the First Amendment translates into increased police accountability, the First Amendment enhances the effect of the Fourth Amendment on social welfare.

Finally, it is worth noting the effect of police accountability on the equilibrium behavior of citizens and the police, independently of Fourth Amendment considerations.

Proposition 7 *An increase in* η_P *relative to* η_I *reduces the police's search intensity without probable cause and increases crime.*

Though a marginal increase in police accountability may increase crime, it also reduces the police's search intensity without probable cause, and hence reduces wrongful searches and wrongful convictions. Moreover, as we shall see in the next section, the absence of police accountability combined with progress in search technology may lead society toward an anti-Utopia equilibrium in which the police always search without probable cause and crime is at its highest. The discounted present value of police accountability may therefore be much larger than one might think.

1.8 2084

Thus far, we have only analyzed the region of the model's parameter space wherein the equilibrium is stable and non-extreme, in the sense that the police do not search with probability 0 or 1 when the evidence does not constitute probable cause. Let us call this region R_{2003}, because it is the only region that gives rise to an equilibrium that resembles the state of social interaction between citizens and the police in today's world. But how will citizens and the police interact in the future, when technological advances permit the police to monitor every citizen at every moment?

This future is not light-years away. After September 11, 2001, the Bush administration, through the Defense Advanced Research Projects Agency, began funding a program called Total Information Awareness. In an article titled "You Are a Suspect," New York Time's columnist William Safire describes the system:

> Every purchase you make with a credit card, every magazine subscription you buy and medical prescription you fill, every Web site you visit and e-mail you send or receive, every academic grade you receive, every bank deposit you make, every trip you book and every event you attend – all these transactions and communications will go into what the Defense Department describes as "a virtual, centralized grand database."
>
> To this computerized dossier on your private life from commercial sources, add every piece of information that government has about you – passport application, driver's license and bridge toll records, judicial and divorce records, complaints from nosy neighbors to the F.B.I., your lifetime paper trail plus the latest hidden camera surveillance – and you have the supersnoop's dream: a "Total Information Awareness" about every U.S. citizen. [Safire, 2001]

The United States Transportation Security Administration already uses voice stress analysis and biometric technologies to prevent a person who might pose a danger to air safety from boarding an airplane. Characteristics such as fingerprints, hand geometry, facial appearance, and retina and iris scans are all considered biometric measures. However, biometrics have the potential to reveal much more about a person than simply their identity. For instance, retina scans can reveal medical conditions such as pregnancy, high blood pressure, and AIDS [see Star, 2002].

In the future, biometric measures, wiretaps, X-rays, and DNA testing will become increasingly accurate, omniscient, and invasive.[8] In terms of our model, r_1 will increase and r_2 will decrease because search technologies will become increasingly accurate, and π will increase because they will become increasingly omniscient. But because they will also become increasingly invasive, they will increase the individual's cost of privacy invasion, η_I. If the government had technology that were capable of constantly monitoring every citizen's actions, medical conditions, genetic predispositions, and perhaps even thoughts, and if they used these technologies to search citizens even in the absence of probable cause, then citizens would incur a tremendous loss of privacy, η_I.

In the model, if η_I will increase enough, then, all else constant, $A_1 - A_3$ will become negative. Thus, advances in search technologies will propel the world from R_{2003} where $A_1 - A_3 > 0$, to another region of parameter space where $A_1 - A_3 < 0$.

Assumption 6. As search technologies become more advanced, r_1 will tend to 1, r_2 will tend to 0, π will tend to 1, and η_I will increase enough to ensure that $A_1 - A_3 < 0$.

In the model, there are three regions of parameter space where $A_1 - A_3 < 0$, each with a different equilibrium set. In the first region, call it R^1_{2084}, there is a

[8] For a summary of the current state of development of several of these search technologies, see Appendix 2.

unique, stable, pure-strategy equilibrium in which the police always search without probable cause, and a great many citizens commit crime. This is an anti-Utopian outcome. The police constantly monitor citizens to ensure that they do not commit crime, frustrated citizens desperately retaliate to the invasion of privacy and loss of freedom by committing more crime, which fuels more police oversight, and so on until police oversight is absolute.

Definition 2 *An anti-Utopian equilibrium is one in which the police always search without probable cause and most citizens commit crime.*

In the second region, call it R^2_{2084}, there is a unique, stable, pure-strategy equilibrium in which the police never search without probable cause, and very few citizens commit crime. This is a Utopian outcome. The police show trust toward citizens by respecting their freedom and subordinating itself to their general will, and citizens thrive on their freedom to such an extent that they do not feel the need to abuse of it.[9]

Definition 3 *A Utopian equilibrium is one in which the police never search without probable cause and most citizens do not commit crime.*

In the third region, call it R^3_{2084}, there are two stable, pure-strategy equilibria, the anti-Utopian equilibrium that arises in R^1_{2084} and the Utopian equilibrium in R^2_{2084}, and a single, unstable, mixed-strategy equilibrium.

By increasing citizens' cost of privacy invasion, advances in search technologies could therefore alter the way citizens and the police interact in several different

[9]From Proposition 1, we know that in the anti-Utopian equilibrium, the crime rate is $A_1 - A_3 + A_2 - A_4$, while in the Utopian equilibrium, the crime rate is $A_2 - A_4$. But we are considering parameter ranges for which $A_1 - A_3 << 0$. Therefore, the crime rate is much higher in the anti-Utopian equilibrium than in the Utopian equilibrium.

ways, depending on parameters. The task of predicting which way it will alter this interaction has traditionally been reserved for science fiction writers. Orwell's *1984* is the most famous and influential anti-Utopian work of the twentieth century. In *1984*, Orwell depicts a dark future in which the police employ technology capable of monitoring every citizen's actions, for the sole purpose of furthering the government's objectives, which are totalitarian and ruthless.

One of the most important search technologies employed by the Party to monitor the population of Oceania is known as the telescreen, a large rectangular mirror-like plaque that is attached to a wall in almost every apartment in Oceania. The ubiquitous telescreen not only transmits but also receives information from within its range.[10] Big Brother's government is also conducting intensive research on the problem of finding out what people are thinking against their will, because the Party cannot stand that even one individual, such as Winston Smith, can have a heterodox thought. Indeed, in 1984, all crimes are comprehended in one crime: Thoughtcrime. And this ultimately involves, not forbidden acts, but forbidden thoughts.

Through the telescreen and the Thought Police, Big Brother's government is relentlessly searching all citizens, and so most of the time, it is searching them without probable cause. But are many citizens rebelling and committing crime,

[10] In this passage, Orwell decribes the workings of the telescreen, and how one might feel living in its presence:

> Any sound that Winston made, above the level of a very low whisper, would be picked up by it; moreover, so long as he remained in the field of vision which the metal plaque commanded, he could be seen as well as heard. There was of course no way of knowing whether you were being watched at any given moment. How often, or on what system, the Thought Police plugged in on any individual wire was guesswork. It was even conceivable that they watched everybody all the time. But at any rate they could plug in your wire whenever they wanted to. You had to live–did live, from habit that became instinct–in the assumption that every sound you made was overheard, and, except in darkness, every moment scrutinized. [Orwell, 1949, p. 4-5]

as our model would predict? Although Winston knows that writing in a diary is strictly forbidden, he eventually ends up doing it, and although Winston and Julia know that making love in the country-side is strictly forbidden, they eventually end up doing it, because when privacy is so scarce, even an ephemeral moment of it is priceless. In Orwell's anti-Utopia, the police search without probable cause relentlessly, and all, even mildly, dissenting citizens eventually rebel and commit crime, only inevitably to be caught and punished. This approximates the outcome in region R^1_{2084} in the model.

In Orwell's 1984, technological change has ultimately lead to anti-Utopia. But technological change could also have lead to Utopia. Is there a key factor that might guarantee that technological progress leads to anti-Utopia? A factor that guarantees anti-Utopia may well be present in Orwell's vision of 1984. In his vision, Orwell describes a government that has complete control over the press and the media. The telescreen only shouts out Party slogans all day. Citizens can turn the volume of the telescreen down, but never off. Books are written by the Ministry of Truth, a branch of government. Revolutionary books, such the infamous book by Emmanuel Goldstein, are banned. Even history itself is rewritten to conform with the ideologies of the Party. Big Brother's government is no longer accountable, in any way, to the people of Oceania.

Returning to our simple model, we now demonstrate that absence of police accountability leads to the anti-Utopian equilibrium.

Proposition 8 *(The Big Brother Theorem, Part I). If the police are not accountable to the people, progress in search technology will lead to the anti-Utopian equilibrium.*

Absence of police accountability is sufficient for anti-Utopia. If the police are not accountable, they will suffer few losses from searching the innocent without probable cause. So they will search with greater intensity without probable cause.

But progress in search technology will make these searches more invasive, so that the world will be in a rebellious (mutual trust) region of the model's parameter space, where high (low) search rates are associated with high (low) crime rates. If innocent citizens have to suffer the costs of being treated like criminals, and these costs are large, then they might as well also derive the benefits from actually being criminals. For this reason, more innocent citizens will rebel and commit crime. But this increase in crime will push the police to increase their search intensity even further, and so on until the police will always search without probable cause and a great many citizens will commit crime–the anti-Utopian equilibrium.[11]

On the other hand, absence of Fourth Amendment protections is neither necessary nor sufficient for progress in search technology to lead to anti-Utopia. To understand the role of the Fourth Amendment in an Orwellian future, we first prove a lemma.

Lemma 1 *In R^3_{2084}, the Utopian equilibrium Pareto dominates, and risk dominates, the anti-Utopian equilibrium if relatively strong Fourth Amendment protections are in place.*

In R^3_{2084}, both the Utopian and anti-Utopian equilibria are strict, and hence stable. The problem of choosing between strict equilibria, what are called conventions, has been analyzed by Young [2001], in the context of the evolution of institutions. To choose between conventions, Young introduces the concept of stochastic

[11] An implicit assumption in Part I of the Big Brother Theorem (like in Orwell's novel) seems to be that the police always have better control of emerging technology than the population. Indeed, otherwise organized criminals might develop new hiding technology to counter the police's new search technology. However, absence of accountability itself may limit diffusion of new technologies, especially those produced through government research and development. Moreover, Part I of the Big Brother Theorem continues to hold even if criminals also have new hiding technology, as long as the innocent do not. If the innocent also have new hiding technology to counter the police's new search technology, and thereby protect their privacy, then technological progress would not increase η_I enough to propel the world from R_{2003} where $A_1 - A_3 > 0$, to R^1_{2084}, R^1_{2084}, or R^1_{2084}, where $A_1 - A_3 < 0$. In this case, the world would remain in R_{2003}, where the equilibrium is the one that we analyzed in Section 4.

stability. Loosely speaking, an equilibrium is stochastically stable if it is more likely to be the convention at any given time. Young proves that in 2x2 games, stochastic stability and risk dominance are equivalent. By Lemma 1, the Utopian equilibrium risk dominates the anti-Utopian one. Therefore, in our model, only the Utopian equilibrium is stochastically stable in R^3_{2084}. Henceforth, we assume that in R^3_{2084}, the stochastically stable and risk dominant equilibrium will emerge as the dominant convention.[12] With this assumption, the following result can be proved.

Proposition 9 *(The Big Brother Theorem, Part II). If the police are accountable to the people and strong Fourth Amendment protections are enforced by the courts, progress in search technology will lead to the Utopian equilibrium.*

Strong Fourth Amendment protections and strict police accountability are jointly sufficient for Utopia. Police accountability combined with Fourth Amendment protections will ensure that the police's search intensity without probable cause is lower. But search technology will become increasingly invasive, so that the world will be in a mutual trust (rebellious) region of the model's parameter space, where low (high) search rates are associated with low (high) crime rates. If the police show trust toward citizens by respecting their privacy and freedom, then citizens will thrive on their freedom to such an extent that they will not want to abuse of it. Thus, with police accountability and Fourth Amendment protections lowering the search intensity, the crime rate will be lower. Because the crime rate is lower, the police will reduce their search intensity even further, and so on until the police never

[12] Another strong argument in favor of the risk dominant equilibrium is set forth in Carlsson and van Damme [1993], who analyze equilibrium selection in what they call a "global game," which is a game where Nature selects the payoff structure from a given class of games and each player only receives a noisy signal of the game selected. They show that in 2 x 2 games, when the noise vanishes, iterated elimination of dominated strategies in the global game forces players to coordinate on the risk dominant equilibrium.

search without probable cause and most citizens do not commit crime–the Utopian equilibrium.

Both police accountability and Fourth Amendment protections are needed to make this argument work. In particular, Fourth Amendment protections alone need not reduce the police search intensity. Recall that the Fourth Amendment directly tends to reduce the police's search intensity without probable cause by reducing the probability that these searches lead to successful convictions; but it also indirectly tends to increase the police search intensity by increasing crime. However, with strict police accountability, the indirect effect of the Fourth amendment on search intensity is small. Indeed the police would only respond strongly to an increase in crime by increasing their search intensity if they did not care so much about invading the privacy, and constraining the freedom, of the innocent in the process. Thus, only a combination of police accountability and Fourth Amendment protections lead to Utopia in our simple model of crime and punishment.

1.9 Conclusion

The paper's principal findings may be summarized as follows:

1. A decrease in Fourth Amendment protections tends to increase the police's search intensity directly by increasing the probability that search leads to successful conviction, and tends to decrease the police's search intensity indirectly by decreasing crime.

2. If the indirect effect dominates the direct effect, a decrease in Fourth Amendment protections decreases the police's search intensity, and has an ambiguous effect on crime and wrongful searches.

3. If the direct effect dominates the indirect effect, a decrease in Fourth Amendment protections increases the police's search intensity, decreases crime, and increases wrongful searches.

4. A decrease in Fourth Amendment protections is more likely to increase the police's search intensity, decrease crime, and increase wrongful searches the more accountable is the police to the people.

5. If the police is not accountable to the people today, then in 2084 the police will always search without probable cause and a great many people will commit crime.

6. If the police is strictly accountable to the people and Fourth Amendment protections are strictly enforced today, then in 2084 the police will never search without probable cause and most people will not commit crime.

The model could be fruitfully extended in several directions; for example, to analyze the implications of discrimination and organized crime.

Discrimination. Because of labor-market discrimination, minorities earn lower wages in the legal sector, and hence have lower opportunity costs of working in the illegal sector, relative to whites. To capture labor-market discrimination in the model, we could assume that criminal benefits, w_C, are uniformly distributed on the interval $[0, d]$, where d might be larger for minorities than for whites. However, access to better jobs may also imply access to more lucrative criminal opportunities. Thus, the net return from crime is not necessarily higher for individuals who suffer labor-market discrimination. Moreover, access to better jobs also implies access to better legal counsel, which could be captured in the model by considering lower q_G and higher r_3.

Organized Crime. To evade the police, organized criminals can use technologies that may be as sophisticated as those employed by the police to search criminals. Professional killers can put silencers on their guns to avoid detection. Heads of crime organizations can order the murder of members suspected of snitching, to ensure that they cannot provide further evidence to the police that might lead to the organization's downfall. In these examples, hiding destroys evidence, or prevents it from existing in the first place, thereby ensuring not only that the police do not have evidence that warrants a search, but also that the police would not have evidence that might lead to a conviction if they searched despite the absence of a warrant. In the model, this might correspond to a lower q_G and higher r_3 for organized crimes than for crimes by individuals. On the other hand, police and prosecutors probably receive different payoffs from successfully convicting organized criminals. Also, organized criminals generally commit crimes of a different nature and magnitude than individual criminals.

It would certainly be very interesting to analyze the implications of discrimination and organized crime for the strategic interaction between citizens and the police, as well as for the efficiency of the Fourth Amendment.

1.10 Appendix 1: Proofs

Proof of Proposition 2. Since

$$\begin{aligned} Z(\sigma_I) &= EU_{Police}(S|I_\varepsilon) - EU_{Police}(\neg S|I_\varepsilon) \\ &= I(\sigma_I)[q(B_1 - 1) - (1-q)B_2(r_3)] + (1-q)B_2(r_3) \end{aligned}$$

when $Z(\sigma_I) > 0$, $EU_{Police}(S|I_\varepsilon) > EU_{Police}(\neg S|I_\varepsilon)$, and vice versa.

Case 1: $\overline{Z}(\sigma_I) > 0$, $\underline{Z}(\sigma_I) < 0$, and $A_1 - A_3 > 0$

If $A_1 - A_3 > 0$, $I(\sigma_I)$ increases as σ_I increases. Since $[q(B_1 - 1) - (1-q)B_2] < 0$, $Z(\sigma_I)$ is a decreasing function of σ_I.That is, $Z(\sigma_I)$ is at its maximum when $\sigma_I = 0$, and at its minimum when $\sigma_I = 1$. Thus, the conditions that $\overline{Z}(\sigma_I) > 0$ and $\underline{Z}(\sigma_I) < 0$

mean that $Z(\sigma_I) > 0$ at $\sigma_I = 0$ and $Z(\sigma_I) < 0$ at $\sigma_I = 1$. Since $EU_{Police}(S|I_\varepsilon) > EU_{Police}(\neg S|I_\varepsilon)$ when $\sigma_I = 0$, but $EU_{Police}(S|I_\varepsilon) < EU_{Police}(\neg S|I_\varepsilon)$ when $\sigma_I = 1$, no pure-strategy equilibrium exists. The unique mixed-strategy equilibrium is defined by $Z(\sigma_I) := I(\sigma_I)q(B_1 - 1) + G(\sigma_I)(1-q)B_2 = 0$. Thus,

$$I(\sigma_I^*) = \frac{(1-q)B_2}{(1-q)B_2 + q(1-B_1)} = X$$

Therefore, the police's equilibrium search intensity without probable cause is

$$\sigma_I^* = \frac{X - (A_2 - A_4)}{(A_1 - A_3)}$$

This mixed-strategy equilibrium is stable. Suppose police perturb their strategy by $\varepsilon > 0$. At $\sigma_I^* + \varepsilon$, $Z(\sigma_I = 0) < 0 \Leftrightarrow EU_{Police}(S|I_\varepsilon) < EU_{Police}(\neg S|I_\varepsilon)$ since $Z(\sigma_I)$ is a decreasing function of σ_I. That is, police would want to decrease its search intensity as a result. Any small perturbation from the equilibrium would eventually lead back to the original equilibrium.

The condition that $Z(\sigma_I)|_{\sigma_I=0} > 0, Z(\sigma_I)|_{\sigma_I=1} < 0$ is equivalent to

$$(A_2 - A_4) < X < A_1 - A_3 + (A_2 - A_4)$$

Case 2: $\overline{Z}(\sigma_I) > 0$, $\underline{Z}(\sigma_I) < 0$, and $A_1 - A_3 < 0$

If $A_1 - A_3 < 0, I(\sigma_I)$ decreases as σ_I increases. Given that $[q(B_1 - 1) - (1-q)B_2] < 0$, $Z(\sigma_I)$ is an increasing function of σ_I.That is, $Z(\sigma_I)$ is at its minimum when $\sigma_I = 0$, and at its maximum when $\sigma_I = 1$. Hence, the conditions that $\overline{Z}(\sigma_I) > 0$, and $\underline{Z}(\sigma_I) < 0$ mean that $Z(\sigma_I) > 0$ at $\sigma_I = 1$, and $Z(\sigma_I) < 0$ at $\sigma_I = 0$. Since $EU_{Police}(S|I_\varepsilon) > EU_{Police}(\neg S|I_\varepsilon)$ when $\sigma_I = 1$, but $EU_{Police}(S|I_\varepsilon) < EU_{Police}(\neg S|I_\varepsilon)$ when $\sigma_I = 0$, the two pure-strategy equilibria are: ($\sigma_I^* = 0, I(\sigma_I^* = 0)$) and $(\sigma_I^* = 1, I(\sigma_I^* = 1))$. The unique mixed-strategy equilibrium is defined by $Z(\sigma_I) := I(\sigma_I)q(B_1 - 1) + G(\sigma_I)(1-q)B_2 = 0$. Thus

$$I(\sigma_I^*) = \frac{(1-q)B_2}{(1-q)B_2 + q(1-B_1)} = X$$

Therefore, the police's equilibrium search intensity without probable cause is

$$\sigma_I^* = \frac{(A_2 - A_4) - X}{-(A_1 - A_3)}$$

This mixed-strategy equilibrium is not stable. Suppose police increases its search intensity by ε.For $\sigma_I^* + \varepsilon$, $EU_{Police}(S|I_\varepsilon) > EU_{Police}(\neg S|I_\varepsilon)$ since $Z(\sigma_I)$ is an increasing function of σ_I.In this case, police would want to increase search intensity even more, and vice versa.

The condition that $Z(\sigma_I)|_{\sigma_I=0} < 0, Z(\sigma_I)|_{\sigma_I=1} > 0$ is equivalent to

$$0 < A_1 - A_3 + (A_2 - A_4) < X < (A_2 - A_4)$$

Case 3: $\overline{Z}(\sigma_I) < 0$

Regardless of $A_1 - A_3 > 0$, the condition that $\overline{Z}(\sigma_I) < 0$ implies $EU_{Police}(S|I_\varepsilon) < EU_{Police}(\neg S|I_\varepsilon)$ for all $\sigma_I \in [0,1]$. Therefore, the unique pure-strategy equilibrium is $\sigma_I^* = 0$.

Case 4: $\underline{Z}(\sigma_I) > 0$

Regardless of $A_1 - A_3 > 0$, the condition that $\underline{Z}(\sigma_I) > 0$ implies $EU_{Police}(S|I_\varepsilon) > EU_{Police}(\neg S|I_\varepsilon)$ for all $\sigma_I \in [0,1]$. Therefore, the unique pure-strategy equilibrium is $\sigma_I^* = 1$.

Proof of Proposition 3. Comparing (12) and (13) in the text, we find that

$$\begin{aligned}
\frac{\partial B_2(r_3)}{\partial r_3}[(1-q)G(\sigma_I)] &< -\frac{\partial I(\sigma_I)}{\partial r_3}[q(B_1 - 1) - (1-q)B_2(r_3)] \\
&\Leftrightarrow G(\sigma_I) > \sigma_I s\pi[(1-q)B_2(r_3) + q(1-B_1)] \\
&\Leftrightarrow 1 - X > \sigma_I s\pi[(1-q)B_2(r_3) + q(1-B_1)] \\
&\Leftrightarrow s < \overline{s}'' := \frac{q(\eta + c^S)}{\sigma_I \pi[(1-q)(1-r_3-c^S) + q(\eta + c^S)]^2}
\end{aligned}$$

Proof of Proposition 5. The equilibrium crime rate is $1 - I(\sigma_I)$, where

$$I(\sigma_I) = (A_1 - A_3(r_3))\sigma_I + (A_2 - A_4)$$

Differentiating with respect to r_3 and using the chain rule yields

$$\frac{\partial I(\sigma_I)}{\partial r_3} = \frac{\partial \sigma_I}{\partial r_3}(A_1 - A_3(r_3)) - \frac{\partial A_3(r_3)}{\partial r_3}$$

By the stability condition, $A_1 - A_3(r_3) > 0$. Moreover, $\frac{\partial A_3(r_3)}{\partial r_3} = s\pi(1-q) > 0$. Now if $s \in [\overline{s}', \overline{s}'']$, then $\frac{\partial \sigma_I}{\partial r_3} < 0$, so that $\frac{\partial I(\sigma_I)}{\partial r_3} < 0$, and hence $\frac{\partial G(\sigma_I)}{\partial r_3} > 0$. However, if $s > \overline{s}''$, then $\frac{\partial \sigma_I}{\partial r_3} > 0$, so that $\frac{\partial G(\sigma_I)}{\partial r_3} \gtrless 0$. The probability of a wrongful search is

$$P[S, \neg C] = I(\sigma_I)q\pi\sigma_I + I(\sigma_I)(1-q)\pi$$

Differentiating with respect to r_3 and using the chain rule twice yields

$$\frac{\partial P[S, \neg C]}{\partial r_3} = q\pi[\frac{\partial I(\sigma_I)}{\partial r_3}\sigma_I + \frac{\partial \sigma_I}{\partial r_3}I(\sigma_I)] + (1-q)\pi\frac{\partial I(\sigma_I)}{\partial r_3}$$

If $s \in [\overline{s}', \overline{s}'']$, then $\frac{\partial \sigma_I}{\partial r_3} < 0$ and $\frac{\partial I(\sigma_I)}{\partial r_3} < 0$, so that $\frac{\partial P[S,\neg C]}{\partial r_3} < 0$. However, if $s > \overline{s}''$, then $\frac{\partial I(\sigma_I)}{\partial r_3} \gtrless 0$, so that $\frac{\partial P[S,\neg C]}{\partial r_3} \gtrless 0$. The probability of a wrongful conviction is

$$P[G_v, \neg C] = I(\sigma_I)(1-q)\pi(1-r_1)$$

Differentiating with respect to r_3 and using the chain rule yields

$$\frac{\partial P[G_v, \neg C]}{\partial r_3} = \frac{\partial I(\sigma_I)}{\partial r_3}(1-q)\pi(1-r_1)$$

If $s \in [\overline{s}', \overline{s}'']$, then $\frac{\partial I(\sigma_I)}{\partial r_3} < 0$, so that $\frac{\partial P[G_v,\neg C]}{\partial r_3} < 0$. However, if $s > \overline{s}''$, then $\frac{\partial I(\sigma_I)}{\partial r_3} \gtrless 0$, so that $\frac{\partial P[G_v,\neg C]}{\partial r_3} \gtrless 0$.

Proof of Proposition 6. A_3, A_4, B_2 do not depend on η_P or η_I. In terms of η_P and η_I,

$$A_1 = -\eta_I\pi q,\ A_2 = -\pi(1-q)[\eta_I + s(1-r_1)],\ B_1 = 1 - \eta_P - c^S$$

Since a change in police accountability only affects η_P, the only difference between a world without police accountability and one with it, is in the term $B_1 = 1-\eta_P-c^S$. In particular, a reduction in police accountability increases B_1. Notice that the term B_1 appears only once in expression (10). In fact, B_1 only affects what we called the indirect effect of the Fourth Amendment on the police's search intensity without probable cause. In particular, as B_1 increases, this indirect effect decreases. Moreover, as η_P decreases, B_1 increases. Therefore, the indirect effect is smaller the more accountable is the police to the public.

Proof of Proposition 7. From Proposition 2, we know that in equilibrium

$$\begin{aligned}\sigma_I^* &= \frac{X-(A_2-A_4)}{A_1-A_3} \\ I(\sigma_I^*) &= X = \frac{B_2(1-q)}{(1-q)B_2+q(1-B_1(\eta_P))}\end{aligned}$$

But

$$\frac{\partial X}{\partial \eta_P} < 0$$

Therefore, the crime rate is higher, and the police's search intensity without probable cause is lower if the police are accountable to the public for their errors than if they are not.

Proof of Proposition 8. The current state of interaction between citizens and the police is given by the unique stable mixed-strategy equilibrium, which only arises in R_{2003}, defined by

$$(A_2-A_4) < X < (A_1-A_3)+(A_2-A_4)$$

where $A_1-A_3>0$. By Assumption 6, in the future, η_I will increase sufficiently to propel the world to a region in which $A_1-A_3<0$. In this region, $(A_2-A_4) > (A_1-A_3)+(A_2-A_4) \geq 0$, where the last inequality holds by Assumption 5. Now, assume that the police is not accountable in a dynamic sense: η_P does not increase as η_I increases. Note that as η_I increases, X is unaffected; indeed, X depends, not η_I, but on η_P, which does not change by assumption. We know that

$$A_2-A_4 = -\eta_I\pi(1-q) - s\pi(1-q)(1-r_1) + s\pi q(1-r_2) \geq 0$$

Therefore, as η_I increases, $A_2 - A_4$ decreases, and $(A_1 - A_3) + (A_2 - A_4)$ decreases, which necessarily propels the world to R^1_{2084}, defined by

$$(A_1 - A_3) + (A_2 - A_4) < (A_2 - A_4) < X$$

In this region, the unique, stable equilibrium is the anti-Utopian one. Note that the world cannot end up in either R^2_{2084} or R^3_{2084}, since R^2_{2084} corresponds to the parameter range that satisfies

$$X < (A_1 - A_3) + (A_2 - A_4) < (A_2 - A_4)$$

and R^3_{2084} corresponds to the parameter range

$$(A_1 - A_3) + (A_2 - A_4) < X < (A_2 - A_4)$$

Proof of Lemma 1. First, we prove Pareto dominance. The citizen's expected payoff in the Utopian equilibrium is

$$\begin{aligned} EU_{\mathrm{Ci}\,tizens,Utopia} &= \int_0^{(A_2-A_4)} A_2 dw_C + \int_{(A_2-A_4)}^1 (w_C + A_4) dw_C \\ &= A_2(A_2 - A_4) + \left\{ (1 - (A_2 - A_4)) \left[\frac{1}{2}(1 + (A_2 + A_4)) \right] \right\} \end{aligned}$$

The citizen's expected payoff in the anti-Utopian equilibrium is

$$\begin{aligned} EU_{\mathrm{Ci}\,tizens,Anti-Utopia} &= \int_0^{A_1-A_3+A_2-A_4} (A_1 + A_2) dw_C \\ &\quad + \int_{A_1-A_3+A_2-A_4}^1 (w_C + A_3 + A_4) dw_C \\ &= (A_1 + A_2)(A_1 - A_3 + A_2 - A_4) \\ &\quad + \left\{ (1 - (A_1 - A_3 + A_2 - A_4)) \left[\frac{1}{2}(1 + (A_1 + A_3 + A_2 + A_4)) \right] \right\} \end{aligned}$$

Therefore,

$$\begin{aligned} & EU_{\mathrm{Ci}\,tizens,Utopia} - EU_{\mathrm{Ci}\,tizens,Anti-Utopia} \\ = \; & -(2A_3)[1 - (A_2 - A_4)] - 2A_1(A_1 - A_3 + A_2 - A_4) \\ & +(A_1 - A_3)(A_1 + A_3) > 0 \end{aligned}$$

On the other hand, the police's expected payoff in the Utopian equilibrium is

$$\begin{aligned} EU_{Police,Utopia} &= \frac{I(\sigma_I^*)q}{I(\sigma_I^*)q + [1 - I(\sigma_I^*)](1-q)} \\ &= \frac{(A_2 - A_4)q}{(A_2 - A_4)q + (1 - (A_2 - A_4))(1-q)} \end{aligned}$$

The police's expected payoff in the anti-Utopian equilibrium is

$$\begin{aligned} EU_{Police,Anti-Utopia} &= \frac{I(\sigma_I^*)qB_1 + (1 - I(\sigma_I^*))(1-q)B_2}{I(\sigma_I^*)q + [1 - I(\sigma_I^*)](1-q)} \\ &= \frac{[A_1 - A_3 + A_2 - A_4]qB_1 + [1 - (A_1 - A_3) - (A_2 - A_4)](1-q)B_2}{[A_1 - A_3 + A_2 - A_4]q + [1 - (A_1 - A_3) - (A_2 - A_4)](1-q)} \end{aligned}$$

As $r_3 \to 1$, $B_2 \to 0$, so that $EU_{Police,Anti-Utopia} < 0$. But $EU_{Police,Utopia} > 0$ for all parameters. Therefore, the Utopian equilibrium Pareto dominates the anti-Utopian equilibrium. We now prove risk dominance. Let I denote the probability that the representative citizen will not commit crime. Then the police's expected payoff of searching with or without probable cause is

$$EU_{Police}(S|I) = (1 - I)(B_2 + \gamma) + I(B_1 + \delta)$$

where γ and δ are some function of parameters. Similarly, the police's expected utility of not searching without probable cause and searching with probable cause is

$$EU_{Police}(\neg S|I) = (1 - I)(\gamma) + I(1 + \delta)$$

Therefore,

$$EU_{Police}(S|I) < EU_{Police}(\neg S|I) \iff (1 - I)B_2 < I(1 - B_1)$$

Now, $B_2 \to 0$ as $r_3 \to 1$, and $1 - B_1$ is an increasingly large positive number as η increases, so for almost all I, $EU_{Police}(S|I) < EU_{Police}(\neg S|I)$. In other words, the strategy $\sigma_I^* = 0$ risk dominates the strategy $\sigma_I^* = 1$ for the police. Similarly, one can show that the strategy $I(\sigma_I^*) = A_2 - A_4$ risk dominates the strategy $I(\sigma_I^*) = A_1 - A_3 + A_2 - A_4$ for a representative citizen with type w_C distributed on the $[0, 1]$ interval.

Proof of Proposition 9. Suppose the police is accountable, so that η_P increases with η_I, For notational simplicity, consider the case where $\eta_P = \eta_I = \eta$. In this case, as η increases, X also decreases. Let $\widehat{\eta}$ denote the value of η satisfying $A_1(\eta) - A_3 = 0$. For any $\eta > \widehat{\eta}$, $(A_1(\eta) - A_3) + (A_2(\eta) - A_4) < (A_2(\eta) - A_4)$. As $\eta \to \widehat{\eta}$ (from the left), $(A_1(\eta) - A_3) + (A_2(\eta) - A_4) \longrightarrow (A_2(\eta) - A_4)$. If $X(\eta) > (A_2(\eta) - A_4)$ as $\eta \longrightarrow \widehat{\eta}$, then the only region that can be reached is R^1_{2084}. If $X(\eta) < (A_2(\eta) - A_4)$ as $\eta \longrightarrow \widehat{\eta}$, then R^2_{2084} or R^3_{2084} may be reached. By Assumption 6, $r_1 \longrightarrow 1$, $r_2 \longrightarrow 0$, and $\pi \longrightarrow 1$. Therefore, as $\eta \longrightarrow \widehat{\eta}$,

$$\begin{aligned} X|_{\eta \to \widehat{\eta}} &= \frac{(1-q)(1-r_3-c^S)}{(1-q)(1-r_3-c^S) + s(1-q)(1-r_3) + c^S q} \\ (A_2 - A_4)|_{\eta \to \widehat{\eta}} &= s(q - (1-q)(1-r_3)) \end{aligned}$$

If Fourth Amendment protections are strong, that is $r_3 \longrightarrow 1$, then

$$\begin{aligned} X|_{\eta \to \widehat{\eta}} &< (A_2 - A_4)|_{\eta \to \widehat{\eta}} \\ &\iff \frac{(1-q)(-c^S)}{(1-q)(-c^S) + c^S q} < sq \end{aligned}$$

The expression on the right hand side of the inequality is negative, since $q > 1/2$ by Assumption 1, while the expression on the right hand side is positive. Therefore, the inequality is always satisfied. This means that either R^2_{2084} or R^3_{2084} is reached as η increases. Moreover, by Lemma 1, the stochastically stable equilibrium in both these regions is Utopian. Therefore, police accountability and strong Fourth Amendment protections are jointly sufficient for Utopia.

1.11 Appendix 2: Search Technology

The government employs the following search technologies to fight crime.

Wiretaps

From 1982 to 1992, more than 22,000 convictions have resulted from court-authorized surveillances (e.g., wiretaps, pen registers and trap and traces). According to several statistics, wiretaps are one of the strongest weapons in the war against crime [Yung, 1996]. Law enforcement agencies have also adapted their techniques to the recent developments in internet and communication technology. In 2001, the FBI acknowledged that it used an Internet electronic surveillance system called Carnivore to investigate and prosecute criminal suspects in more than two dozen cases. Carnivore is a software program developed by the FBI that can be installed on the network of an Internet Service Provider, such as America Online, to monitor, intercept and collect e-mail messages and other Internet activity [see Barrett, 2002].

Cameras

The government has several types of electronic visual surveillance technology at its disposal. Miniature video cameras available on the retail market weigh less than two pounds and can fit in the palm of one's hand. These cameras can be concealed in a briefcase, lamp, plant, lunch box, television, or teddy bear. Miniature still cameras can be disguised as cigarette lighters or watches. A camera fitted with a "pinhole lens" is virtually undetectable because the aperture of its conical lens has a diameter of less than 1/8 of an inch. Cameras equipped with such lenses can be hidden in sprinkler heads, heating vents, or clocks.

Furthermore, computer imaging systems can create images without having to "see" at all. Technicians can use sound waves or microwave technology to gather huge data sets, which computers can then transform into visual images. For example, the United States government uses microwave technology for its more sophisticated surveillance satellites. From space, the satellites can "see" objects as small as three feet across through clouds and in darkness. This technology creates the real possibility that the government will soon be able to gain detailed visual images of private dwellings without even installing a camera or entering the premises. [Greenfield, 1991]

X-Rays

Superman is the greatest fictional crime fighter in the history of American popular culture. To catch evil doers, he can fly, he can use his super-human strength, and he can see through anything with his x-ray vision. Now, research and development efforts have begun that would give police officers something much like Superman's x-ray vision. At least two private companies and one government laboratory (Millitech Corporation, Raytheon, and the Idaho National Engineering Laboratory), each with its own design, are currently developing technology that allows police officers to see through clothing to detect whether a person is carrying a concealed weapon. The idea is to produce a commercially and technologically viable device that could do an "electronic frisk" of a suspect from a distance of up to twenty feet. [see Harris, 1996].

Another private company, American Science and Engineering, has manufactured a device called the BodySearch, which is being used by U.S. Customs inspectors at airports in New York and five other cities to detect contraband [see Vina, 2002]. The low-power X-ray penetrates only a few millimeters below the skin, seeing through clothing and eliminating the need for strip or pat-down searches. BodySearch scans are so sharp that the shape of a person's navel is visible, along with the shapes of other, more private parts.

DNA Samples

DNA forensic technology has become the most effective method of identifying criminals. DNA matches are far superior to eyewitness accounts, where the odds for correct identification are about 50:50. An important question currently before the Supreme Court is whether to require probable cause before sampling the DNA of suspects prior to their arrest by piercing their skin or scraping the inside of their mouth [see Jewkes, 2001]. Technological advances have also made it possible to collect DNA evidence for future use. Many law enforcement agencies currently maintain databanks containing the genetic information of convicted felons.

Chapter 2

The Economics of Silence

"Though silence is not necessarily an admission, it is not a denial, either."

–Marcus Tullius Cicero

"Silence is as full of potential wisdom and wit as the unhewn marble of great sculpture. The silent bear no witness against themselves."

–Aldous Huxley [1928, ch. 1]

2.1 Motivation

The Fifth Amendment to the Constitution of the United States guarantees that

> No person (...) shall be compelled in any Criminal Case to be a witness against himself, nor be deprived of life, liberty, or property, without due process of law.[1]

[1] See, for example, Gunther and Sullivan (1997, Appendix A). For a Pulitzer prize-winning account of the history of the Fifth Amendment, from its origins in the Israel of biblical times, see Leonard Levy (1968).

This paper studies several aspects of the Fifth Amendment's right to silence and right to due process of law.

The right to silence. The clause against self-incrimination implies that a criminal defendant has a right to remain silent at his own trial. But if the defendant's silence were to lead the jury to draw an inference against the defendant, the right to silence would be a limited one. In 1965, in Griffin v. California [380 U.S. 609], the Supreme Court held that a comment by the prosecution on the defendant's failure to testify violated the Fifth Amendment. In 1981, in Carter v. Kentucky [450 U.S. 288], the Court held that the Fifth Amendment required an instruction to the jury that no inference be drawn from the defendant's silence:

> No judge can prevent jurors from speculating about why a defendant stands mute in the face of a criminal accusation, but a judge can, and must, if requested to do so, use the unique power of the jury instruction to reduce that speculation to a minimum. [450 U.S. at 303]

Northern Ireland abolished the right to silence in 1988, and England followed in 1994, mainly to facilitate the conviction of suspected terrorists. England's Criminal Justice and Public Order Act [1994] specifies that "it will be permissible for the court or jury to draw such inferences as appear proper from [the defendant's] failure to give evidence or his refusal, without good cause, to answer any question" [Part 3, Section 35.2].[2]

What is the effect of the right to silence on social welfare? To answer this question, a model of criminal trials is developed, and the right to silence is given formal expression in terms of the parameters. In the model, before the defense

[2] See website http://www.hmso.gov.uk/acts/acts1994.htm. See Bucke *et al* (2000) and Jackson *et al* (2000) for a report on the new legislation against the right to silence in England and Northern Ireland, respectively.

makes its case, the jury has a posterior over the defendant's innocence, given all information available to date. The right to silence is the requirement that this posterior continue to govern the jury's decision-making upon observing silence from the defendant.

One might speculate that in reality juries draw adverse inferences from silence despite the judge's instruction to the contrary. But the judge's principal role in a criminal trial is to instruct the jury in matters of law. The law explicitly requires jurors to abandon rationality with respect to the defendant's silence. To the extent that jurors are committed to obey the law, they are committed to obey the judge's instruction. Moreover, judges may "audit" jury deliberations, and occasionally set aside verdicts if they believe that the verdicts were unjustified given the evidence and their instructions to the jury.[3]

In the model, the instruction that no inference be drawn from silence is assumed to be successful, and is shown to distort the jury's decisions in a way that reduces the conviction rate. It helps the guilty by increasing wrongful acquittals, and also helps the innocent by reducing wrongful convictions.[4] If social preferences are measured in terms of the two types of court error, the right to silence cannot

[3]Unfortunately, there is no reliable and conclusive empirical evidence on the effects of the abolition of the right to silence in England in 1994, partly because other changes to criminal procedure were implemented at the same time, and the effects are difficult to disentangle. But there is evidence that that the right to silence has reduced conviction rates in the US. Cassell and Fowles [1998] regressed the FBI's clearance rate (the rate at which the police declare crimes solved) on a dummy variable, equal to zero before 1966 and one thereafter, capturing the effect of Miranda v. Arizona [384 U.S. 436], in which the Court held that the Fifth Amendment required the police to warn arrested citizens of their right to silence before interrogating them. They found the estimated coefficient on the dummy to be negative and statistically significant: Miranda had significantly reduced the clearance rate. Although a distinction exists between the right to silence at trial and the Miranda warning, Miranda is simply reminding arrested citizens of their right to remain silent at every stage of the legal process.

[4]This result seems to contradict a claim by Jeremy Bentham: "Not only are the guilty served but it is they alone that are served [by the right to silence]... without any mixture of the innocent" [Bentham, 1825, p. 161]. But Bentham was writing at a time when the accused was prohibited from testifying at trial. In the mid-1800s, the rule was changed to give defendants the right to testify if they wished. Bentham was referring to the more restrictive rule of the time, not to the modern rule by which defendants are allowed to testify, and if they do not testify, the jury is prohibited from drawing an adverse inference.

improve social welfare unless the jury's preferences are biased relative to those of society; if jury preferences coincide with social preferences, the first best outcome is achieved without the right to silence. The preferences of juries may be biased relative to those of society in cases where juries discriminate against defendants based on race or gender, or in cases where defendants cannot afford the lawyers who are best able to select the juries to minimize the biases against their clients.

In cases where juries are biased, the welfare effect of the right to silence depends on several of the model's parameters. The prior probability that the defendant is truly guilty in the model is linked to the reputations of the police and the judiciary. The prior probabilities that correlate the evidence with the truth are linked to the strength of the case. If the reputations of the police and the judiciary are good, the right to silence is shown to reduce welfare in cases for which evidence is strong. If the reputations of the police and the judiciary are bad, no inference from silence increases welfare in cases for which evidence is weak. With the possibility of plea bargaining, the cases that reach trial may be a biased sample of the set of cases, and biased toward difficulty. Since plea bargaining is prevalent in the US, the Fifth Amendment's right to silence may increase welfare in cases where juries are biased if the reputations of the police and the judiciary are bad. The prevalence of jury discrimination, police discrimination, and judiciary corruption would thus be arguments to preserve the right to silence in the US.

Due process of law. The second Fifth Amendment right analyzed in the paper is the right to due process of law. Among other things, the due process clause requires prosecutors to share evidence with the defense. In most of the US, discovery power is much broader for the defense than for the prosecution. And all states require the prosecution to share exculpatory evidence. Mandatory disclosure by the prosecution ensures that the defense is no less informed, and in most cases, better informed than the prosecution.

In the model without the right to silence, the disclosure requirement has an ambiguous effect on the conviction rate. It increases the likelihood that the defense has exculpatory evidence, which can decrease the conviction rate; but it also makes the jury's adverse inference from the defendant's silence more adverse, which increases the conviction rate. However, with the right to silence, mandatory disclosure cannot make the adverse inference from silence more adverse since the right to silence blocks the adverse inference in the first place. Also, if efficiency is measured in terms of the two types of court error, mandatory disclosure reduces the efficiency of the right to silence, regardless of the reputations of the police and the judiciary or the average difficulty of cases that reach trial. Society always feels worse about reversing the jury's verdict given silence from "guilty" to "innocent" if it can rule out the possibility that the defendant was silent simply for lack of being informed, which it can with mandatory disclosure.

The rest of the paper is organized as follows. Section 2 relates the contribution to existing literature. Sections 3 and 4 develop the model and derive equilibrium. Sections 5 and 6 define the disclosure requirement and the right to silence, respectively, and analyze their effects on equilibrium. Section 7 analyzes the interaction between mandatory disclosure and the right to silence. Section 8 summarizes the results and proposes avenues for further research.

2.2 Relation to Existing Literature

A large economics literature exists on pre-trial bargaining [see, for example, P'ng, 1983, Reinganum, 1988, and Spier, 1992]. In this literature, the trial process is usually modeled with a single parameter, the exogenous probability that the defendant is ultimately convicted. Relatively fewer papers model the trial process more explicitly. Gay *et al* [1989] develop an inquisitorial model of trials, in which defendants choose whether to be tried by a judge or jury. The right to a jury trial is a Sixth Amendment right, whereas due process and the right to silence are Fifth Amendment rights. Also, the model that is developed here to analyze the efficiency of Fifth Amendment rights is adversarial rather than inquisitorial.

Shin [1998] compares the adversarial and inquisitorial systems in terms of social efficiency, concluding that the adversarial model is superior because it allows an effective allocation of the burden of proof. In Shin's models, social utility coincides with the jury's utility, and weighs wrongful acquittals and wrongful convictions equally. The principle that a wrongful conviction is worse than a wrongful acquittal, is a central feature of criminal cases. Therefore, Shin's conclusions apply to civil, not criminal, cases. In contrast, the model developed here allows the jury's utility to differ from society's utility, and allows each of them to weigh wrongful convictions more heavily than wrongful acquittals. As such, the conclusions derived from the model apply to criminal cases as well.

Cooter and Rubinfield [1994] analyze legal discovery. They note that discovery, which compels the sharing of information, can affect the probability of settlement and the accuracy of trials. They focus their analysis more on the former effect, mentioning only briefly that mandatory disclosure can improve the accuracy of trials by increasing the information available to the jury. The present paper focuses only on the effect of mandatory disclosure on trial outcomes, and demonstrates that this effect is potentially ambiguous. Moreover, Cooter and Rubinfeld do not consider the interaction between mandatory disclosure and the right to silence. An analysis of this interaction is a contribution of the present paper.

Seidmann and Stein [2000] analyze the right to silence, but do not consider its interaction with mandatory disclosure. They argue that the right to silence helps the innocent, that is, reduces wrongful convictions, only because it allows criminals to avoid conviction without lying, so that statements by innocent defendants are more credible. In the model developed here, the right to silence reduces wrongful convictions without the possibility of perjury, by tending to block unraveling, the phenomenon that "no news is bad news," which was first described by Milgrom [1981]. Baird *et al* [1998, p. 91] mention that the right to silence at trial may prevent unraveling, but do not pursue this line of inquiry formally.

2.3 Model of Criminal Trials

The set of players is $\{P, D, J\}$, where P is the prosecution, D is the defense, and J is the jury. D and the defendant are treated as the same person, so there are no agency problems. J comprises several jurors, whose individual verdicts are inputs into a group decision-rule, usually unanimity, which outputs a unified and final verdict. In this sense, J is treated as a single player with a single voice.[5]

Let Ω denote the state space. The model's intrinsic uncertainty is summarized by the vector $(\tau, \varepsilon, \kappa) \in \Omega$, where $\Omega = \{I_\tau, G_\tau\} \times \{I_\varepsilon, G_\varepsilon\} \times 2^{\{P,D\}}$. The random variable τ, called the "truth," can be in one of two states, I_τ, interpreted as "The truth is that D is innocent", or G_τ, interpreted as "The truth is that D is guilty." The random variable ε, called the "evidence," can be in one of two states, I_ε, interpreted as "The evidence is in favor of D's innocence", or G_ε, interpreted as "The evidence is in favor of D's guilt."

The random variable κ, called the "knowledge," can be in one of four states, DP, interpreted as "Both P and D know the evidence", $D\neg P$, interpreted as "D and only D knows the evidence", $\neg DP$, interpreted as "P and only P knows the evidence", or $\neg D\neg P$, interpreted as "Neither D nor P know the evidence."

Assumption 1. J does not know ε nor τ.

[5] Several papers have investigated the welfare implications of different group decision rules, for example, Fedderson and Pesendorfer [1998] and Duggan and Martinelli [2001].

		I_ε	G_ε
$P[I_\tau]$	I_τ	$P[I_\varepsilon \mid I_\tau]$	$P[G_\varepsilon \mid I_\tau]$
$P[G_\tau]$	G_τ	$P[I_\varepsilon \mid G_\tau]$	$P[G_\varepsilon \mid G_\tau]$

Table 2.1: The likelihood matrix representing the quality of the evidence

P, D, and J have a common prior over the realization of the truth, denoted by $P[G_\tau]$, which may be associated with the reputations of the police and the judiciary. $P[G_\tau]$ is exogenous and embodies everything that leads up to the trial. Typically leading up to a criminal trial are police investigations, and preliminary hearings, with motions by defense counsel to suppress evidence. If it is perceived that the police and judges are fair, in the sense that they usually conduct their investigations, and render their decisions, with strict regard for the constitutional rights of suspects, $P[G_\tau]$ will tend to be higher. If it is perceived that the police and judges are corrupt or biased, in the sense that they usually investigate, and render decisions, without regard for constitutional rights, $P[G_\tau]$ will tend to be lower. If one wanted jury members to be perfectly unbiased, one would have to reduce their rationally formed assessment that the defendant is likely to be guilty of what is charged given that they have already made it so far into the system.

The quality of the evidence is represented by the likelihood matrix given in Table 1, where $P[G_\varepsilon|I_\tau]$, for example, is the probability that the evidence indicates that D is guilty given that D is innocent. The evidence is more often right than wrong:

Assumption 2. $P[I_\varepsilon|\ I_\tau] > P[G_\varepsilon|I_\tau]$ and $P[I_\varepsilon|G_\tau] < P[G_\varepsilon|G_\tau]$.

These conditional probabilities may be associated with the difficulty of the case. Sexual assault is a crime that usually takes place in private, without witnesses, and usually leaves behind little reliable evidence, unless the victim immediately goes to the hospital. The sum total of the evidence in a trial for sexual assault, were it known, might well constitute a relatively inconclusive case, either in favor or against

	I_ε	G_ε
I_τ	$P[I_\varepsilon \mid I_\tau] = 0.6$	$P[G_\varepsilon \mid I_\tau] = 0.4$
G_τ	$P[I_\varepsilon \mid G_\tau] = 0.41$	$P[G_\varepsilon \mid G_\tau] = 0.59$

Table 2.2: A Difficult Case

	I_ε	G_ε
I_τ	$P[I_\varepsilon \mid I_\tau] = 0.9$	$P[G_\varepsilon \mid I_\tau] = 0.1$
G_τ	$P[I_\varepsilon \mid G_\tau] = 0.09$	$P[G_\varepsilon \mid G_\tau] = 0.91$

Table 2.3: A Not Too Difficult Case

the accused. Thus, we might say that sexual assault cases tend to be relatively "difficult". See Tables 2 and 3. The possibility of plea bargaining may also affect the average difficulty of the cases that go to trial. The cases that do not settle are the ones where there is asymmetric information, and this is more common in the difficult cases. Therefore, with the possibility of plea bargaining, the cases that reach trial may be a biased sample of the set of cases, and biased toward difficulty.

Assume lawyers are no more likely to know the evidence if it is in their favor than if it is not, and no more likely to know it if the defendant is guilty than if he is not.

Assumption 3. κ is stochastically independent from (τ, ε).

Denote the unconditional probability that D knows the evidence by δ, and the unconditional probability that P knows the evidence by π. Assume initially that the event that D is informed and the event that P is informed of the evidence are independent. Then Table 4 represents the lawyers' information structures. The independence of D and P's information structures will be relaxed when the Fifth

	P knows ε	P does not know ε
D knows ε	$P[DP] = \delta\pi$	$P[D\neg P] = \delta(1-\pi)$
D does not know ε	$P[\neg DP] = (1-\delta)\pi$	$P[\neg D\neg P] = (1-\delta)(1-\pi)$

Table 2.4: Information Structures Without Mandatory Disclosure

Amendment's disclosure requirement on prosecutors is introduced in Section 5.

At time 0, the truth, τ, the evidence, ε, and the lawyers' knowledge of the evidence, κ, are realized; D learns the truth. At time 1, P makes its case. At time 2, D makes its case, having heard the arguments presented by P. At time 3, J renders its verdict having heard the arguments presented by D and P.

Assumption 4. D and P cannot lie, that is, they cannot say what they know to be false, and they cannot say that for which they lack evidence.

In the US, lawyers are disbarred if they are found to have presented false evidence or to have knowingly allowed their clients to commit perjury. Given Assumption 4, if D or P know the evidence ε, their action set is {"ε", "s"}, where the quotation marks indicate vocalization of the evidence, and s stands for silence. If they do not know the evidence, they must take action "s". J's action set is $\{I_v, G_v\}$, where I_v is the not guilty verdict, and G_v is the guilty verdict. The outcome space is $\{G_v \& G_\tau,\ G_v \& I_\tau,\ I_v \& G_\tau,\ I_v \& I_\tau\}$. The second outcome is a wrongful conviction, the third is a wrongful acquittal. Assume D wants the verdict to be I_v, and P wants the verdict to be G_v, regardless of the state. The utilities of the lawyers are, after normalization:

$$\begin{aligned} U_P(G_v, G_\tau) &= 1, U_P(G_v, I_\tau) = 1, U_P(I_v, G_\tau) = 0, U_P(I_v, I_\tau) = 0 \\ U_D &= 1 - U_P \end{aligned} \tag{2.1}$$

One might object that even in the US, trials are not strictly adversarial. In principle, perhaps, state and federal prosecutors are supposed to maximize social welfare. If this were the case, it would be more realistic to assume that P wants the verdict to be G_v if and only if the state is G_τ. In practice, however, prosecutors may not simply maximize social welfare. Either to climb the ranks in US Attorney offices or to have better outside options, prosecutors need trial experience and a reputation for winning cases.[6] Moreover, even if reputation and human capital incentives would lead prosecutors to withhold evidence when it is in the defendant's favor, the Fifth Amendment's disclosure requirement on prosecutors would not allow them to do so. Section 5 formulates this requirement in terms of the parameters, and analyzes its effect on equilibrium when prosecutors only care to win.

J's attitude toward risk is normalized such that its utility from a rightful conviction or a rightful acquittal is 1, its utility from a wrongful acquittal is 0, and its utility from a wrongful conviction is $U_J = U_J(G_v, I_\tau)$, which is smaller or equal to 0:

$$U_J \leq \; U_J(I_v, G_\tau) = 0 < U_J(G_v, G_\tau) = U_J(I_v, I_\tau) = 1 \tag{2.2}$$

In a parallel fashion, society's attitude toward risk is normalized such that its utility from a rightful conviction or a rightful acquittal is 1, its utility from a wrongful acquittal is 0, and its utility from a rightful conviction is $U_S = U_S(G_v, I_\tau)$, which is smaller or equal to 0:

$$U_S \leq U_S(I_v, G_\tau) = 0 < U_S(G_v, G_\tau) = U_S(I_v, I_\tau) = 1 \tag{2.3}$$

J's utility may differ from society's utility in two broad ways: (1) $0 \geq U_J > U_S$, or (2) $0 \geq U_S > U_J$. Case (1) corresponds to a jury that discriminates against the defendant for no valid reason. For example, if the jury is predominantly white and the defendant is a black man with a history of convictions, the jury may not attach a large enough relative disutility to the outcome in which the defendant is convicted even though he is innocent of the particular crime with which he is charged. Case (2) corresponds to a jury that discriminates in favor of the defendant for no valid

[6] Glaeser, Kessler, and Piehl [2000] examine data on prisoners incarcerated for drug crimes. Their empirical analysis reveals that Assistant U.S. Attorneys tend to prosecute wealthier and more educated individuals, perhaps in part because these cases increase their reputation, and therefore their salary in the private sector. Boylan and Long [2000] analyze federal drug trafficking cases from 1993 to 1996 and find that the plea rate is smaller in U.S. Attorney districts where private salaries are higher. Moreover the plea rate is smaller in districts where there are either few or many, but not an average number of, prosecutors. The authors' explanation is that prosecutors take cases to trial to acquire human capital, unless they are closely monitored.

reason. For example, if the defendant is a young, beautiful woman, the jury may not attach a large enough relative disutility to the outcome in which she is acquitted even though she is guilty.[7]

During the jury selection stage, experienced lawyers can detect and eliminate candidate jurors who are unfavorably biased. Wealthy defendants can afford experienced lawyers, whereas indigent defendants are randomly appointed a lawyer by the State; thus, indigent defendants probably face more "hostile" juries.

2.4 Equilibrium

If the reputation of the police is so poor that the common prior that D is innocent is equal to 1, no amount of evidence could lead J to infer that D is guilty. If J is so biased that it attaches a utility level of $-\infty$ to a wrongful conviction, no amount of evidence could lead the jury to convict. In either case, the evidence is not pivotal to J's verdict.

Definition 4 *Evidence is pivotal if J's optimal action is to convict if it knows G_ε and to acquit if it knows I_ε.*

Lemma 2 *J's optimal action is to convict if it knows G_ε and to acquit if it knows I_ε if and only if*

$$U_J \in PIV = [1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[G_\varepsilon|G_\tau]}{P[G_\varepsilon|I_\tau]}, 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau]}]$$

[7] King [1993] reviews the empirical evidence concerning the effect of jury discrimination on jury decisions. The evidence confirms that juror race affects jury decisions in some cases. For example, a 1984 study of the relationship between verdicts and the racial composition of juries in Dade County, Florida found that juries with at least one black juror were less likely than all-white juries to convict black defendants.

Proof. See Mathematical Appendix. ■

Assumption 5. $U_J \in PIV$, that is, evidence is pivotal.

The first proposition identifies the unique equilibrium for the above adversarial game.

Proposition 10 *In the game with Assumption 1 through 5, the following strategy vector is a perfect Bayesian equilibrium and the unique equilibrium surviving iterative deletion of weakly dominated strategies: P and D reveal the evidence if and only if it is in their favor (otherwise they remain silent), J acquits if it hears evidence in favor of D, convicts if it hears evidence against D, and if it hears nothing but silence, it acquits if and only if* $U_J \leq \eta$, *where*

$$\eta = 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau](1-\delta) + P[G_\varepsilon|G_\tau](1-\pi)}{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau](1-\pi)}$$

Proof. See Mathematical Appendix. ■

The parameter η is the cutoff below which D is acquitted given silence and above which D is convicted given silence. If $\delta = 1$, the cutoff reduces to

$$1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[G_\varepsilon|G_\tau]}{P[G_\varepsilon|I_\tau]} \tag{2.4}$$

which is the lower bound of the set of juries PIV, for whom evidence is pivotal. Thus, if D is completely informed, J always convicts given silence. If J knows that D is perfectly informed and D has remained silent, J knows that the evidence is against D, and since evidence is pivotal, J convicts. If $\pi = 1$, the cutoff reduces to

$$1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau]} \tag{2.5}$$

which is the upper bound of PIV. If P is perfectly informed, J always acquits given silence. If J knows that P is perfectly informed and P has remained silent, J knows the evidence is against P, and since evidence is pivotal, J acquits.

	P knows ε	P does not know ε
D knows ε	$P[DP] = \pi$	$P[D\neg P] = \delta(1-\pi)$
D does not know ε	0	$P[\neg D \neg P] = (1-\delta)(1-\pi)$

Table 2.5: Information Structures With Mandatory Disclosure

2.5 Mandatory Disclosure of Exculpatory Evidence

Let MD denote mandatory disclosure by the prosecution. Without MD, the event that D is informed and the event that P is informed of the evidence are independent. Then Table 2 represents the correct information structures. With MD, if D is not informed, P cannot be informed of the evidence. Then Table 5 represents the correct information structures. Without MD, the probability that D is informed is δ, but with MD, the probability that D is informed is $\delta + \pi(1-\delta) > \delta$.

MD alters the time structure of the model: between time 0 and time 1 (that is, right before P presents its case), D learns any evidence that P knows. This increases the probability that D has exculpatory evidence to present, which tends to decrease the conviction rate (the direct effect). But this also makes J's adverse inference from D's silence more adverse, which tends to increase the conviction rate (the strategic effect).

MD's strategic effect is to change the cutoff, above which J convicts and below which J acquits given silence, from $\eta_{\neg MD}^{\neg RTS}$ to $\eta_{MD}^{\neg RTS}$, where

$$\begin{aligned} \eta_{MD}^{\neg RTS} &= 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau](1-\delta) + P[G_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau]} \\ &< \eta_{\neg MD}^{\neg RTS} = 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau](1-\delta) + P[G_\varepsilon|G_\tau](1-\pi)}{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau](1-\pi)} \end{aligned} \tag{2.6}$$

since $P[G_\varepsilon|G_\tau] > P[G_\varepsilon|I_\tau]$ by Assumption 2. Define three sets:

$$\begin{aligned} PIV_{I_v I_v}^{MD} &= [1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[G_\varepsilon|G_\tau]}{P[G_\varepsilon|I_\tau]}, \eta_{MD}^{\neg RTS}) \\ PIV_{I_v G_v}^{MD} &= [\eta_{MD}^{\neg RTS}, \eta_{\neg MD}^{\neg RTS}] \\ PIV_{G_v G_v}^{MD} &= [\eta_{\neg MD}^{\neg RTS}, 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau]}] \end{aligned} \tag{2.7}$$

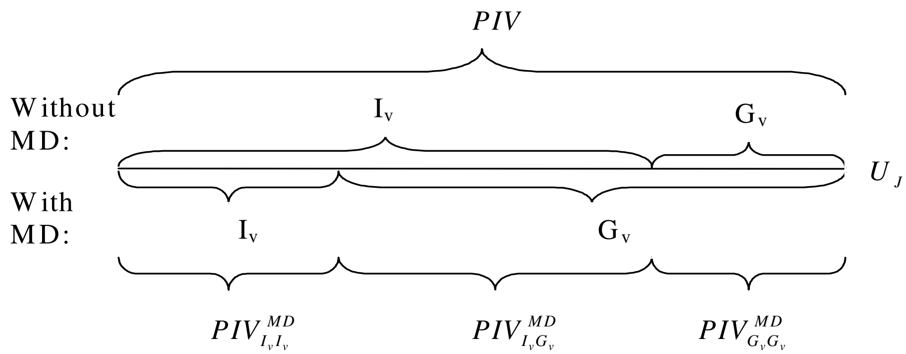

Figure 2.1: Effect of MD on J's equilibrium verdict given silence.

Note $PIV = PIV^{MD}_{I_vI_v} \cup PIV^{MD}_{I_vG_v} \cup PIV^{MD}_{G_vG_v}$. These sets are illustrated in Figure 1.

From Proposition 10, we know J's equilibrium strategy is to acquit given silence if and only if $U_J \leq \eta$. Thus, MD reverses J's verdict given silence from I_v to G_v for all $U_J \in PIV^{MD}_{I_vG_v}$, and leaves it unchanged for all $U_J \in PIV^{MD}_{I_vI_v} \cup PIV^{MD}_{G_vG_v}$.

A J drawn from $PIV^{MD}_{I_vI_v}$ so despises a wrongful conviction that its equilibrium action given silence is to acquit with or without MD (no strategic effect), and although MD increases the probability that D has exculpatory evidence to present, this cannot reduce the conviction rate either, because J is already acquitting given silence (no direct effect). With such a J, MD does not affect the conviction rate.

A J drawn from $PIV^{MD}_{G_vG_v}$ so little dislikes a wrongful conviction that its equilibrium action given silence is to convict with or without MD (no strategic effect), but MD nevertheless reduces the conviction rate because it increases the probability that D has exculpatory evidence to present (direct effect). More formally, without MD, D is convicted if and only if the evidence is against D or the evidence is in D's favor but D does not know it:

$$P[G_v] = (1 - \delta)P[I_\varepsilon] + P[G_\varepsilon] \tag{2.8}$$

With MD, D is also convicted if and only if the evidence is against D or the evidence is in D's favor but D (and hence P) does not know it, but now the probability that D knows the evidence is greater:

$$P[G_v] = (1 - \pi)(1 - \delta)P[I_\varepsilon] + P[G_\varepsilon] \tag{2.9}$$

Therefore, MD reduces the conviction rate by

$$\pi(1 - \delta)P[I_\varepsilon] > 0 \tag{2.10}$$

Only if J is drawn from $PIV^{MD}_{I_vG_v}$ does MD affect J's verdict given silence. This type of J would acquit without MD, but convict with MD (strategic effect). Intuitively, without MD, if J hears only silence, it might infer that the evidence is in D's favor but only P knows it. With MD, if J hears only silence, it is less likely to draw such an inference: now J knows that D is better informed, and hence J's adverse inference in the face of silence becomes more adverse. And although MD also tends to reduce the conviction rate because it increases the probability that D has exculpatory evidence to present (direct effect), the strategic effect dominates, so that MD results in a higher conviction rate. More formally, without MD, D is convicted if and only if the evidence is against D and P knows it:

$$P[G_v] = \pi P[G_\varepsilon] \tag{2.11}$$

But with MD, D is convicted if and only if the evidence is against D or the evidence is in favor of D but D does not know the evidence:

$$P[G_v] = (1 - \pi)(1 - \delta)P[I_\varepsilon] + P[G_\varepsilon] \tag{2.12}$$

Therefore, MD increases the conviction rate by

$$(1 - \delta)(1 - \pi)P[I_\varepsilon] + (1 - \pi)P[G_\varepsilon] > 0 \tag{2.13}$$

Proposition 11 *For all* $U_J \in PIV^{MD}_{I_v I_v}$*, MD does not affect the conviction rate. For all* $U_J \in PIV^{MD}_{I_v G_v}$*, MD increases the conviction rate. For all* $U_J \in PIV^{MD}_{G_v G_v}$*, MD reduces the conviction rate.*

MD's effect on the conviction rate is therefore ambiguous. But as is shown later, this effect is less likely to be ambiguous with the right to silence, which is now introduced.

2.6 Right to Silence

Let RTS denote the right to silence. RTS alters the time structure of the model: if D remained silent at time 2, the judge instructs J of D's RTS between time 2 and time 3 (that is, right before J renders its verdict). At the start of time 2, just before D makes its case, J has a posterior over D's innocence, given all information available to date. RTS means that this posterior should continue to govern J's decision-making upon observing silence from D, that is, no updating should occur upon observing D's silence.

In the equilibrium of the model with MD,

$$
\begin{aligned}
& P[I_\tau | P \text{ and } D \text{ chose ``s''}] \\
= \; & \frac{P[I_\tau]\{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau]\}}{P[I_\tau]\{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau]\} + P[G_\tau]\{P[I_\varepsilon|G_\tau](1-\delta) + P[G_\varepsilon|G_\tau]\}}
\end{aligned}
\tag{2.14}
$$

and

$$
\begin{aligned}
& P[I_\tau | P \text{ chose ``s''}] \\
= \; & \frac{P[I_\tau]\{1-\pi + P[I_\varepsilon|I_\tau]\pi\}}{P[I_\tau]\{1-\pi + P[I_\varepsilon|I_\tau]\pi\} + P[G_\tau]\{1-\pi + P[I_\varepsilon|G_\tau]\pi\}}
\end{aligned}
\tag{2.15}
$$

Without RTS, J's decision-making is governed by $P[I_\tau | P$ and D chose "s"], but with RTS, it should be governed by $P[I_\tau | P$ chose "s"].

Thus, without RTS, J renders verdict I_v given silence if and only if

$$\begin{aligned} U_J &\leq 1 - \frac{P[G_\tau | P \text{ and } D \text{ chose "s"}]}{P[I_\tau | P \text{ and } D \text{ chose "s"}]} \\ &= 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon | G_\tau](1-\delta) + P[G_\varepsilon | G_\tau]}{P[I_\varepsilon | I_\tau](1-\delta) + P[G_\varepsilon | I_\tau]} = \eta_{MD}^{\neg RTS} \end{aligned} \tag{2.16}$$

but with RTS, if the judge's instruction is successful, J renders verdict I_v if and only if

$$\begin{aligned} U_J &\leq 1 - \frac{P[G_\tau | P \text{ and } D \text{ chose "s"}]}{P[I_\tau | P \text{ and } D \text{ chose "s"}]} \\ &= 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{1 - \pi + P[I_\varepsilon | G_\tau]\pi}{1 - \pi + P[I_\varepsilon | I_\tau]\pi} = \eta_{MD}^{RTS} \end{aligned} \tag{2.17}$$

where $\eta_{MD}^{\neg RTS} < \eta_{MD}^{RTS}$ by Assumption 2. RTS increases the cutoff above which J convicts, and below which J acquits given silence. Define three sets:

$$\begin{aligned} PIV_{I_v I_v}^{RTS} &= [1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[G_\varepsilon | G_\tau]}{P[G_\varepsilon | I_\tau]}, \eta_{MD}^{\neg RTS}) \\ PIV_{G_v I_v}^{RTS} &= [\eta_{MD}^{\neg RTS}, \eta_{MD}^{RTS}] \\ PIV_{G_v G_v}^{RTS} &= (\eta_{MD}^{RTS}, 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon | G_\tau]}{P[I_\varepsilon | I_\tau]}] \end{aligned} \tag{2.18}$$

Note $PIV = PIV_{I_v I_v}^{RTS} \cup PIV_{G_v I_v}^{RTS} \cup PIV_{G_v G_v}^{RTS}$. These sets are illustrated in Figure 2. From Proposition 10, we know J's equilibrium strategy is to acquit given silence if and only if $U_J \leq \eta$. Therefore, for all $U_J \in PIV_{I_v I_v}^{RTS} \cup PIV_{G_v G_v}^{RTS}$, RTS has no effect on the verdict given silence. However, for all $U_J \in PIV_{G_v I_v}^{RTS}$, RTS changes the verdict given silence from G_v to I_v. Henceforth the analysis focuses on the juries $U_J \in PIV_{G_v I_v}^{RTS}$ who are not so extreme in their preferences that the judge's instruction produces no effect on their equilibrium behavior.

For these juries, without RTS, D is convicted if and only if the evidence is against D, or the evidence is in D's favor but D and P do not know it:

$$P[G_v] = (1-\pi)(1-\delta)P[I_\varepsilon] + P[G_\varepsilon] \tag{2.19}$$

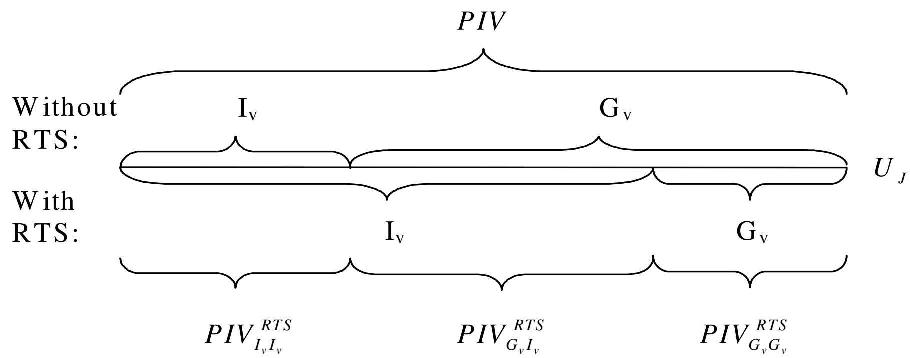

Figure 2.2: Effect of RTS on J's equilibrium verdict given silence.

But with RTS, D is convicted if and only if the evidence is against D, and P knows it:

$$P[G_v] = \pi P[G_\varepsilon] \tag{2.20}$$

Therefore, for all $U_J \in PIV^{RTS}_{G_v I_v}$, RTS reduces the conviction rate by

$$(1-\pi)\{(1-\delta)P[I_\varepsilon] + P[G_\varepsilon]\} > 0 \tag{2.21}$$

RTS reduces the conviction rate because it shifts the burden of proof onto P.

RTS protects D if D (and hence P) does not know the evidence, or if D knows the evidence, it is not in D's favor, but P does not know it. In the former case, D must remain silent; in the latter case, D chooses to remain silent. In either case, if D is guilty, D is rightfully convicted without RTS, but wrongfully acquitted with RTS. If D is innocent, D is wrongfully convicted without RTS, but rightfully acquitted with RTS. Thus, RTS protects the innocent by reducing the probability of wrongful conviction, but at the expense of protecting the guilty by increasing the probability of wrongful acquittal.

To study the effect of RTS on social welfare, society's preferences are now measured in terms of the two types of court error, and society is assumed to favor a wrongful acquittal over a wrongful conviction:

Proposition 12 *For all* $U_J \in PIV_{G_v I_v}^{RTS}$, *RTS improves welfare if and only if*

$$U_S \leq 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau](1-\delta) + P[G_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau]} = \eta_{MD}^{\neg RTS}$$

Since the lower bound of $PIV_{G_v I_v}^{RTS}$ is $\eta_{MD}^{\neg RTS}$, a necessary condition for RTS to improve welfare is that $U_S < U_J$. That is, RTS can only improve welfare if J's preferences are biased against D relative to social preferences. If $U_J = U_S$, society's problem (whether or not to implement RTS) and J's problem (whether or not to convict given silence) exactly coincide, so the first best outcome is achieved without RTS. If $U_S > U_J$, J incurs more disutility from a wrongful conviction than society does. In this case, RTS cannot improve welfare either since RTS reduces the probability of wrongful conviction.

If J's preferences are biased against D relative to social preferences, the welfare effect of RTS varies depending on the other parameters. All else equal, if the reputations of the police and the judiciary are bad and the case is difficult, RTS increases welfare. Intuitively, since the case is difficult, the evidence might well be in favor of D's guilt even if D is innocent, and might well be in favor of D's innocence even if D is guilty. Moreover, D is more likely to be innocent since the reputations of the police and the judiciary are bad. Thus many innocent defendants and few guilty defendants stand to benefit from RTS. Therefore, RTS improves welfare, especially since society favors a wrongful acquittal over a wrongful conviction.

If the reputations of the police and the judiciary are good and the case is not too difficult, RTS reduces welfare. Since the case is not too difficult, the evidence is probably in favor of D's innocence if D is innocent, and in favor of D's guilt if D is guilty. Moreover, D is more likely to be guilty since the reputations of the police and the judiciary are good. Thus many guilty defendants and few innocent defendants stand to benefit from RTS. Thus, RTS reduces welfare, even though society favors a wrongful acquittal over a wrongful conviction.

The American system of criminal justice encourages plea bargaining (partly to reduce state court costs), which may mean that the set of cases that go to trial are a selected sample of cases that are more difficult than average. Therefore, in the US, the right to silence may increase welfare in cases where the jury's preferences are biased if the reputations of the police and the judiciary are bad. The prevalence of jury discrimination, police discrimination, and judiciary corruption would thus be arguments to preserve the right to silence in the US.

2.7 Interaction of Mandatory Disclosure and Right to Silence

In the previous section, RTS was defined in the model with MD. RTS is now defined in the model without MD. In this model,

$$\begin{aligned} & P[I_\tau | P \text{ and } D \text{ chose "s"}] \\ = & \frac{P[I_\tau]\{P[I_\varepsilon|I_\tau](1-\delta)+P[G_\varepsilon|I_\tau](1-\pi)\}}{P[I_\tau]\{P[I_\varepsilon|I_\tau](1-\delta)+P[G_\varepsilon|I_\tau](1-\pi)\}+P[G_\tau]\{P[I_\varepsilon|G_\tau](1-\delta)+P[G_\varepsilon|G_\tau](1-\pi)\}} \end{aligned} \tag{2.22}$$

and

$$\begin{aligned} & P[I_\tau | P \text{ chose "s"}] \\ = & \frac{P[I_\tau]\{1-\pi+P[I_\varepsilon|I_\tau]\pi\}}{P[I_\tau]\{1-\pi+P[I_\varepsilon|I_\tau]\pi\}+P[G_\tau]\{1-\pi+P[I_\varepsilon|G_\tau]\pi\}} \end{aligned} \tag{2.23}$$

Thus, without RTS, J renders verdict I_v if and only if

$$U_J \leq 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau](1-\delta)+P[G_\varepsilon|G_\tau](1-\pi)}{P[I_\varepsilon|I_\tau](1-\delta)+P[G_\varepsilon|I_\tau](1-\pi)} = \eta_{\neg MD}^{\neg RTS} \tag{2.24}$$

With RTS, J renders verdict I_v if and only if

$$U_J \leq 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{1-\pi+P[I_\varepsilon|G_\tau]\pi}{1-\pi+P[I_\varepsilon|I_\tau]\pi} = \eta_{\neg MD}^{RTS} = \eta_{MD}^{RTS} = \eta^{RTS} \tag{2.25}$$

With RTS, J's cutoff, above which it convicts and below which it acquits given silence, is the same with or without MD. Intuitively, MD cannot make J's adverse inference from silence more adverse if RTS does not allow an adverse inference from silence in the first place. Thus, with RTS, MD only increases the probability that D has exculpatory evidence to present, and hence unambiguously reduces the conviction rate.

Now, $\eta_{\neg MD}^{\neg RTS} < \eta^{RTS}$ since

$$\frac{1-\pi+P[I_\varepsilon|G_\tau]\pi}{1-\pi+P[I_\varepsilon|I_\tau]\pi} < \frac{P[I_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau]} < \frac{P[I_\varepsilon|G_\tau](1-\delta)+P[G_\varepsilon|G_\tau](1-\pi)}{P[I_\varepsilon|I_\tau](1-\delta)+P[G_\varepsilon|I_\tau](1-\pi)} \tag{2.26}$$

where the last inequality follows from Assumption 2. Define the set $PIV_{G_vI_vG_vI_v}^{RTS}$ $= [\eta_{\neg MD}^{\neg RTS}, \eta^{RTS}]$. These are the only juries for whom evidence is pivotal and RTS changes the verdict given silence from G$_v$ to I$_v$ both with and without MD.

From Proposition 12, we know that with MD, for all $U_J \in PIV_{G_vI_vG_vI_v}^{RTS}$, RTS improves welfare if and only if $U_S \leq \eta_{MD}^{\neg RTS}$. Similarly, without MD, RTS improves welfare if and only if $U_S \leq \eta_{\neg MD}^{\neg RTS}$. But $\eta_{MD}^{\neg RTS} < \eta_{\neg MD}^{\neg RTS}$ since MD makes J's adverse inference from D's silence more adverse without RTS (see section 5). This leaves three regions of parameter space:

$$U_S < \eta_{MD}^{\neg RTS} < \eta_{\neg MD}^{\neg RTS} \tag{Region 1}$$

$$\eta_{MD}^{\neg RTS} < U_S < \eta_{\neg MD}^{\neg RTS} \tag{Region 2}$$

$$\eta_{MD}^{\neg RTS} < \eta_{\neg MD}^{\neg RTS} < U_S \tag{Region 3}$$

The extent to which U_S is smaller (greater) than $\eta_{MD}^{\neg RTS}$ $[\eta_{\neg MD}^{\neg RTS}]$, determines the extent to which RTS increases (decreases) welfare in the game with MD [without MD]. Thus, in Region 1, RTS increases welfare, but less with MD than without it. RTS changes J's verdict given silence from G_v to I_v for all juries in $PIV_{G_vI_vG_vI_v}^{RTS}$, and this change is beneficial to society with or without MD in Region 1, because in this region society's disutility from wrongful conviction is relatively large. Without

MD, if D remains silent, society cannot rule out the possibility that D does not know the evidence, nor the possibility that the evidence misleadingly indicates that D is guilty. But with MD, if D remains silent, society can rule out the former possibility, leaving only the latter. Thus, society benefits more (in expected terms) from the verdict change given silence from G_v to I_v without MD than with it.

In region 2, RTS reduces welfare with MD, but increases welfare without it. In this region, society's disutility from wrongful conviction is sufficiently high that, if it cannot rule out the possibility that D does not know the evidence, it benefits from the verdict change from G_v to I_v, but it's disutility from wrongful conviction is also sufficiently low that, if it can rule out this possibility, it is harmed by the change in verdict occasioned by RTS.

In region 3, RTS reduces welfare, but more with MD than without it. The verdict change due to RTS is beneficial to society with or without MD in region 3, because in this region society's disutility is relatively small. But the verdict change is more beneficial to society without MD, because with MD, society can eliminate the possibility that D does not know the evidence if D remained silent, leaving only the possibility that the evidence wrongfully indicates that D is guilty. Thus RTS either increases welfare less or reduces welfare more with MD than without it:

Proposition 13 *For all $U_J \in PIV^{RTS}_{G_vI_vG_vI_v}$, MD reduces the welfare efficiency of RTS for all parameters.*

This result may have implications for the design of constitutions. Implementing a right to silence is more likely to improve social welfare in a system of criminal justice in which disclosure requirements on prosecutors are relatively weak than in one in which they are relatively strong, regardless of the average difficulty of the cases that go to trial or the reputations of the police and the judiciary.

2.8 Conclusion

The paper's principal findings may be summarized as follows:

1. Mandatory disclosure by prosecutors has an ambiguous effect on conviction rates without the right to silence, but reduces conviction rates with the right to silence.

2. The right to silence reduces the conviction rate, thereby increasing wrongful acquittals and reducing wrongful convictions.

3. If social welfare is measured only in terms of two types of court error, and the jury's preferences are biased against the defendant relative to social preferences, then

   (a) If the reputations of the police and the judiciary are good, the right to silence reduces social welfare in cases for which evidence is strong,

   (b) If the reputations of the police and the judiciary are bad, the right to silence improves social welfare in cases for which evidence is weak,

   (c) Mandatory disclosure reduces the welfare-efficiency of the right to silence for all parameters.

It would be interesting to study the interaction between Fifth Amendment rights and other rights guaranteed by the United States Constitution. For example, the Fourth Amendment's restrictions on unreasonable searches and seizures may be positively correlated with police reputation. If jury members have come to trust that most police officers follow the cumbersome procedures set forth by the Fourth Amendment, painstakingly establish probable cause, and obtain a proper warrant before searching a suspect's property, then they may be more likely to believe ex ante that the defendant who stands before them in court is guilty, which means that their prior belief that the defendant is guilty may be higher.

I have begun work on modeling the Fourth Amendment more explicitly. In this work, I view the Fourth Amendment as reducing the conviction probability in cases where the police searched a suspect without probable cause, and examine the effect of the Fourth Amendment on the equilibrium elements of social welfare in a model where crime and police search are endogenous. Preliminary results indicate that the Fourth Amendment reduces the police's equilibrium search intensity, increases crime, and reduces wrongful searches and wrongful arrests. The last result provides a rationale for assuming that the Fourth Amendment increases the jury's prior belief that the defendant is guilty. Given result 3.a above, this suggests that the Fourth Amendment may reduce the positive welfare effects of the Fifth Amendment's right to silence.

However, this conflict may be relatively small. The Fourth Amendment is not the only determinant of police reputation. Police reputation is also a function of the types of laws that the police choose to enforce, and the methods by which they choose to enforce them. If the police spend a great deal of resources going after "victimless" crimes (e.g., drug use and prostitution) or using unethical methods (e.g., lying in court), then their reputation suffers, with the Fourth Amendment perhaps having only a small offsetting effect.

2.9 Mathematical Appendix

Proof of Lemma 2. After learning I_ε, if J chooses G_v then J's expected utility is

$$P[I_\tau|I_\varepsilon]U_J(G_v, I_\tau) + P[G_\tau|I_\varepsilon]U_J(G_v, G_\tau) \tag{A.1}$$

$$= P[I_\tau|I_\varepsilon]U_J + P[G_\tau|I_\varepsilon]$$

If J chooses I_v then J's expected utility is

$$P[I_\tau|I_\varepsilon]U_J(I_v, I_\tau) + P[G_\tau|I_\varepsilon]U_J(I_v, G_\tau) \tag{A.2}$$
$$= P[I_\tau|I_\varepsilon]$$

Therefore, J renders the verdict I_v (that is, the evidence is pivotal) if and only if

$$U_J \leq 1 - \frac{P[G_\tau|I_\varepsilon]}{P[I_\tau|I_\varepsilon]} = 1 - \frac{P[G_\tau]}{P[I_\tau]}\frac{P[I_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau]}$$

After learning G_ε, if J chooses G_v then J's expected utility is

$$P[I_\tau|G_\varepsilon]U_J(G_v, I_\tau) + P[G_\tau|G_\varepsilon]U_J(G_v, G_\tau)$$
$$= P[I_\tau|G_\varepsilon]U_J + P[G_\tau|G_\varepsilon]$$

If J chooses I_v then J's expected utility is

$$P[I_\tau|G_\varepsilon]U_J(I_v, I_\tau) + P[G_\tau|G_\varepsilon]U_J(I_v, G_\tau)$$
$$= P[I_\tau|G_\varepsilon]$$

Therefore, J renders the verdict G_v (that is the evidence is pivotal) if and only if

$$U_J \geq 1 - \frac{P[G_\tau|G_\varepsilon]}{P[I_\tau|G_\varepsilon]} = 1 - \frac{P[G_\tau]}{P[I_\tau]}\frac{P[G_\varepsilon|G_\tau]}{P[G_\varepsilon|I_\tau]}$$

In general, the evidence is pivotal if U_J lies in the set

$$PIV = [1 - \frac{P[G_\tau]}{P[I_\tau]}\frac{P[G_\varepsilon|G_\tau]}{P[G_\varepsilon|I_\tau]}, 1 - \frac{P[G_\tau]}{P[I_\tau]}\frac{P[I_\varepsilon|G_\tau]}{P[I_\varepsilon|I_\tau]}]$$

Proof of Proposition 10. Given the candidate strategies for P and D, three of J's information sets are reached with positive probability: "I_ε", "G_ε", "s". Since evidence is pivotal (Assumption 5), J renders the verdict G_v if it hears "G_ε" and the verdict I_v if it hears "I_ε". Upon hearing nothing, J's posterior is

$$P[G_\tau|\text{“}s\text{”}] \tag{A.1}$$
$$= \frac{P[G_\tau]\{P[I_\varepsilon|G_\tau](1-\delta)+P[G_\varepsilon|G_\tau](1-\pi)\}}{P[G_\tau]\{P[I_\varepsilon|G_\tau](1-\delta)+P[G_\varepsilon|G_\tau](1-\pi)\}+P[I_\tau]\{P[I_\varepsilon|I_\tau](1-\delta)+P[G_\varepsilon|I_\tau](1-\pi)\}}$$

J renders the verdict I_v if and only if

$$P[G_\tau|\text{“}s\text{”}]U_J(I_v|G_\tau) + P[I_\tau|\text{“}s\text{”}]U_J(I_v|I_\tau) \tag{A.2}$$
$$\geq P[G_\tau|\text{“}s\text{”}]U_J(G_v|G_\tau) + P[I_\tau|\text{“}s\text{”}]U_J(G_v|I_\tau)$$

Substituting (A.1) and the values of J's utility function into (A.2), we get that J renders the verdict I_v when it hears "s" if and only if

$$U_J(G_v|I_\tau) \leq 1 - \frac{P[G_\tau]}{P[I_\tau]} \frac{P[I_\varepsilon|G_\tau](1-\delta) + P[G_\varepsilon|G_\tau](1-\pi)}{P[I_\varepsilon|I_\tau](1-\delta) + P[G_\varepsilon|I_\tau](1-\pi)}$$

Whether or not (A.6) is satisfied, P and D at least weakly prefer to present the evidence if and only if they know that it is in their favor. Thus, the candidate strategies for D and P are best responses to J's persuasion rule. It is straightforward but tedious to show that iterative deletion of weakly dominated strategies eliminates all Nash equilibria other than this one.

Chapter 3

The Economics of Ecstasy

This is the very ecstasy of love. –William Shakespeare in Hamlet, act 2, sc. 1.

3.1 Motivation

In this paper, love-making is modeled as a signaling game. In the act of love-making, the man and the woman send each other (possibly deceptive) signals about their true state of ecstasy. For example, if the woman is not in ecstasy, then she may decide to fake it. The man and the woman each have a prior belief about the other's state of ecstasy. These prior beliefs are directly associated with the other's sexual response capacity, which varies in different ways for men and women over the life-cycle:

> The discrepancy between sexual drive and sexual gratification differs for men and women in our society throughout the life cycle. Men are most potent and virile in their late teens and early twenties.... Women seldom achieve maximum sexual response capacity until their mid-thirties.... (Mahoney,1983, pp. 45-46)

> The early development of sexual responsiveness in the human male and its later development in the female, the location of the period of maximum responsiveness for the male in the late teens and early twenties and for the female in the late twenties, the subsequent decline of the male's sexual capacities from that peak into old age... (Kinsey *et al.*, 1968, p. 759)

Male sexual response capacity is highest during the early twenties and declines steadily into old age. Female sexual response capacity is low during the teens, increases during the twenties, reaches a maximum during the late twenties, then declines into old age. One explanation is hormones. Levels of the 17-ketosteroids rise sharply in females during the late teens, peak somewhere in the mid twenties, drop sharply until the mid thirties, stay constant until the late fifties, then drop further (Kinsey *et al.*, 1968, p. 756-757).

Therefore, when a woman is middle-aged, her partner's prior belief that she is in ecstasy during love-making is generally higher than when she is younger or older. In the model, the equilibrium probability of faking changes when the prior belief about the woman's state of ecstasy changes. In this way, the model yields different predictions about faking behavior for women of different ages.

On the other hand, the male sex hormone testosterone is at its highest during the late teens and early twenties, then gradually falls over a man's lifetime. Therefore, when a man is young, his partner's prior belief that he is in ecstasy during love-making is generally higher than when he is either middle-aged or older. Since the model's equilibrium is also sensitive to the prior belief that the man is in ecstasy, the model also yields different predictions about faking behavior for men of different ages.

Although men may not be able to fake ejaculation, they may nevertheless be able to fake orgasm. Ejaculation is the propulsion of seminal fluid, while orgasm is the peak feeling in sex. In *Love and Orgasm*, psychiatrist Alexander Lowen, based on his clinical observations, concludes that "...in terms of full satisfaction, the male suffers from orgasmic impotence as much as the female does" (1975, p.56). If male ejaculation and orgasm were completely distinct, then men would have the same capacity to fake orgasm as women do. However, to the extent that they are related, the cost of faking and the probability of being caught faking are greater for men than for women. In the model, this difference in signaling costs between the sexes generates differences in equilibrium strategies between the sexes.

One more factor is crucial in determining the amount of deception between a man and woman–love. "It was the men I deceived the most that I loved the most," wrote the French author Marguerite Duras (1990, p. 203). But what is love? In this paper, love is formally defined as a mixture of altruism and possessiveness. Love is shown to alter the man and the woman's payoff functions in way that increases the equilibrium probability of faking, but more so for the woman than for the man. The model also predicts that age should have a greater effect on the probability of faking if the partners are in love than if they are not.

The model's predictions are tested on data gathered from the 2000 *Orgasm Survey*. The predictions of signaling models have rarely been tested with field data. Spence (1974) develops the theory of signaling for the job market, where a less productive worker finds it costly to mimic a more productive worker in acquiring more education. Acharya (1988) notes that the two major predictions of signaling models, such as the one developed by Spence, are that (1) the equilibrium price function is monotonic in the signal, and (2) the signal in monotonic in the true type.

To test (1), in the case of job market signaling, the wage paid in response to education must be estimated conditional on the equilibrium signaling rule that defines a worker's level of education. Testing (2) requires data on the workers' types before they acquire education. These are usually unobservable. Data can be obtained on the workers' types after they have acquired education, but their ex post types may have been affected by education. Thus, Acharya concludes that the main testable implication of a signaling model is (1). The 2000 *Orgasm Survey* is interesting because it contains observations on the partners' types in the signaling model developed in this paper. People were directly asked whether or not they had faked an orgasm. With such data, the predictions of the model that relate the true type (in ecstasy or not in ecstasy) to the signal (moan or remain silent) are testable.

The remainder of the paper is organized in six sections. In section one, the model's uncertainty spaces, strategy spaces, and payoff functions with and without love are specified and interpreted. In the second section, the model is solved for the cases of no love, weak mutual love, weak unrequited love, and strong mutual love, and the resulting testable predictions are highlighted. The third section contains a description of the data and variables that are used to test the predictions of the theory. The fourth section contains the empirical model. In section five, the empirical results are compared with the theory. Section six summarizes the key findings and proposes extensions.

3.2 A Theoretical Model of Love-Making

A man and a woman are making love. Call the man, Adam, and the woman, Eve. Each is wondering about the extent to which the other is enjoying the love-making. Adam's uncertainty, which is represented by the random variable ω_{Eve}, is about whether or not Eve is in ecstasy. Eve's uncertainty, which is represented by the random variable ω_{Adam}, is about whether or not Adam is in ecstasy.

In the first stage of the game, Adam and Eve simultaneously decide whether to moan or to remain silent. In the second stage, they simultaneously decide whether to act as though the other is in ecstasy (this could involve staying with or embracing the other), or to act as though the other is not in ecstasy (this could involve leaving or getting angry at the other).

The common prior that Eve is in ecstasy, denoted by $a_{Eve}(Age_{Eve})$, is assumed to depend critically on Eve's biological age, and the common prior that Adam is in ecstasy, denoted by $\alpha_{Adam}(Age_{Adam})$, is assumed to depend critically on Adam's biological age. As argued in the introduction, the sexual response capacities of men and women vary in different ways over the life-cycle. It is taken as stylized facts that the lifetime evolutions of Adam and Eve's sexual response capacities resemble those drawn in Figure 1, where Adam and Eve are assumed to be of the same age.[1]

The priors are assumed to be common knowledge. In the present context, this assumption may be defended on the grounds that sex education is widespread. Sex education courses in high schools contain references to differences in sexual capacities between the sexes and changes in sexual capacities for each of the sexes over the life-cycle. Moreover, most Americans receive informal sex education from men and women's magazines, which contain numerous references to the lifetime evolutions of male and female sex drive. Therefore, Figure 1 may conceivably be common knowledge for a given couple in North America.

3.2.1 Mating Strategies

Denote the game for which the uncertainty and action spaces have just been described by $\Gamma(\omega_{Eve}, \omega_{Adam})$. Given that Adam is not certain whether Eve is in ecstasy,

[1] Allen and Brinig (1998) analyze the implications of these stylized facts for divorce. They argue that the spouse having the lowest demand for sex at any time in the marriage has a property right over the occurence of sex. For this reason, the wife may have more bargaining power at the margin in young couples, while the husband may have more barginaing power at the margin in middle-aged couples.

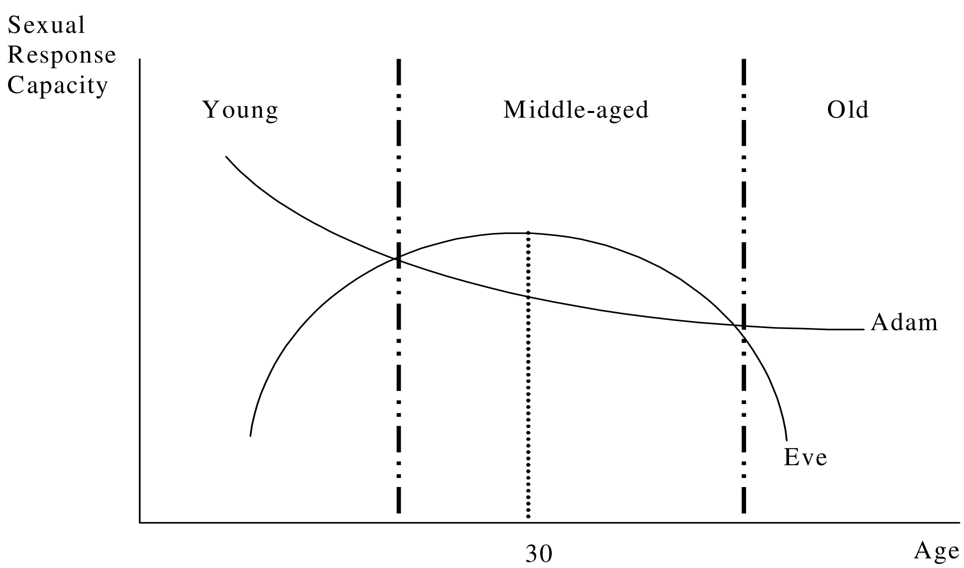

Figure 3.1: The lifetime evolutions of Adam and Eve's sexual response capacities, assuming that Adam and Eve are the same age.

and vice versa, Adam and Eve each have ten information sets in $\Gamma(\omega_{Eve}, \omega_{Adam})$. At each of these information sets, they each have two possible courses of action. Therefore, they each have $2^{10} = 1024$ possible strategies to pick from.

To make the analysis more tractable, $\Gamma(\omega_{Eve}, \omega_{Adam})$ is broken into two independent games, $\Gamma(\omega_{Eve})$ and $\Gamma(\omega_{Adam})$, one for each component of the uncertainty in the original game. In $\Gamma(\omega_{Eve})$, Adam is wondering whether Eve's moaning is genuine or fake. In the rhetoric of signaling games, Eve is the sender and Adam is the receiver. In $\Gamma(\omega_{Adam})$, Eve is wondering whether or not Adam's moaning is fake. Here, Adam is the sender and Eve is the receiver.

Each of these two games is further simplified by assuming that Adam and Eve never remain silent (always moan) when they are in ecstasy and always act as though the other is not in ecstasy if the other remains silent (in other words, there are no quiet orgasms). Let us now describe the strategies sets in $\Gamma(\omega_{Eve})$. In this game, the state of nature is whether or not Eve is in ecstasy. Eve is privy to Nature's choice, while Adam is not. The first component of Eve's strategy designates the action taken when she is in ecstasy, the second component, the action taken when she is not. By assumption, Eve always moans when she is in ecstasy, so her choice set only consists of two strategies.

The first strategy is for her to moan when she is not in ecstasy. This is the strategy of a devoted girlfriend or a courtesan, depending on whether the intent is to spare feelings or gain favors. This strategy is referred to as the *Faking* strategy. The second strategy is for Eve to remain silent when she is not in ecstasy. This is the strategy of a noble maiden or a jaded wife, depending on whether the honesty is motivated by higher principle or frustration. This is referred to as the *Honest* strategy.

On the other hand, the first component of Adam's strategy designates the action taken when Eve has vocalized an orgasm, the second component, the action taken when Eve has remained silent. By assumption, Adam always acts as though Eve is not in ecstasy when she remains silent, so his choice also only consists of two strategies.

The first strategy is for him to act as though he believes that Eve is in ecstasy when Eve is moaning. This is the strategy of a gentleman or a chauvinist, depending on whether the trust is motivated by respect or narcissism. This is referred to as the *Confident* strategy. The second strategy is for Adam to act as though he believes that Eve is not in ecstasy despite her moaning. This is the strategy of a pessimist or a wimp, depending on whether the distrust is motivated by misogyny or inferiority. This is the *Insecure* strategy.

Strategies in $\Gamma(\omega_{Adam})$ are identical to those in $\Gamma(\omega_{Eve})$, only the roles are reversed. Adam chooses between *Faking* and *Honest*, while Eve chooses between *Confident* and *Insecure*.

3.2.2 Faking without Love

To complete the description of the two signaling games, $\Gamma(\omega_{Adam})$ and $\Gamma(\omega_{Eve})$, utilities must be assigned to the various consequences. What do Adam and Eve want? In what follows, $s \neq r$ and $s, r \in \{Adam, Eve\}$, where s refers to senders and r refers to receivers in the signaling games. Let $\overline{o}_s > 0$ denote senders' utility from their own ecstasy. Let $\overline{c}_s > 0$ denote senders' cost of faking ecstasy.

The strategic situation between sender and receiver has been modeled as a one period game. In reality, relationships are repeated games. Accordingly, the cost of faking $\overline{c}_s$ should be interpreted as the sum of the physical and moral cost of faking, which the sender experiences immediately, and the cost of faking associated with the (unmodeled) continuation game which follows the sender's decision to fake. Implicit in this continuation game is a probability that the receiver will discover that the sender is faking and a consequent punishment, which the sender might discount at a rate smaller than unity. For parsimony, all four parameters, the physical and moral cost, the probability of being caught, the punishment, and the rate of time preference, are rolled up into a single parameter, $\overline{c}_s$.

Let $\overline{e}_r^1 > 0$ denote receivers' disutility from acting as though they are not the source of senders' ecstasy when in fact they are the source of senders' ecstasy, and $\overline{e}_r^2 > 0$ denote receivers' disutility from acting as though they are the source of senders' ecstasy when in fact they are not the source of senders' ecstasy. In other words, $\overline{e}_r^1$ is the receivers' disutility from their own unfounded insecurity (type 1 error), while $\overline{e}_r^2$ is the receivers' disutility from their own unfounded confidence (type 2 error).

The disutility $\overline{e}_r^1$ should be interpreted as the receiver's distuility from his type 1 error associated with the continuation game which follows the sender's decision to moan and the receiver's mistaken decision to act insecure when the sender is in ecstasy. Implicit in this continuation game is a probability that the receiver discovers the mistake, and a feeling of remorse that is felt only after the mistake is discovered, and which the receiver might discount at a rate smaller than unity.

Let $\overline{e}_s^1 > 0$ denote senders' disutility from the receivers' unfounded insecurity (type 1 error), and $\overline{e}_s^2 > 0$ denote senders' disutility from the receivers' unfounded confidence (type 2 error). Eve may strongly dislike Adam's misplaced machismo.

The egotistical payoffs in the model should have at least one more dimension. Adam, for example, may strongly prefer that Eve vocalize ecstasy insofar as it excites him and helps him to reach orgasm, especially if orgasm is important to him. In this case, the probability that Adam is in ecstasy, α_{Adam}, is a function of Eve's decision to fake.

However, the game with uncertainty about Eve's state of ecstasy, wherein the Eve decides whether to fake, is being considered separately from the game with uncertainty about Adam's state of ecstasy, wherein Adam derives pleasure from his own ecstasy. Therefore, the aforementioned effect cannot explicitly be taken into account in the model. However, this effect is implicitly taken into account by increasing receivers' utility if senders' vocalize ecstasy. Let $\overline{v}_r > 0$ denote receivers' utility from senders' vocalization of ecstasy.

The variable $\overline{v}_r$ may be construed as "the effect of language on experience." Experience shapes language, but language also shapes experience. An effect can become a cause, reinforcing the original cause and producing the same effect in an intensified form, and so on indefinitely. In this way, ecstasy produces cries of ecstasy, and the cries of ecstasy themselves multiply the ecstasy, which produces greater cries of ecstasy, and so on, with increasing returns to scale, to the point of bliss.

This would complete the specification of Adam and Eve's payoff functions if they did not love each other.

3.2.3 Faking with Love

What does love have to do with it? Adam and Eve's preferences surely depend on whether or not they are in love. Love reduces, although it does not eliminate, conflicts of interest. If Adam loves Eve, her happiness is one of the main things determining Adam's happiness; Adam and Eve therefore have a common interest in making Eve happy. If Eve also loves Adam, then Adam and Eve also have a common interest in making Adam happy. Unless their love is so precisely calculated that their objectives are identical, there is still room for conflict, in either direction; if Adam and Eve love each other too much, Adam's attempts to benefit Eve at his expense will clash with Eve's attempts to benefit Adam at her expense.

Love has just been described as altruism or caring. Becker (1974) defines love between parent and child as altruism to derive his famous Rotten Kid Theorem.

Bergstrom (1989) defines love between man and woman as altruism to pose a puzzle about the allocation of spaghetti between lovers.

In reality, love describes a mix of emotions, some of them far from altruistic. All love's mixed emotions other than altruism will be referred to as possessiveness. Possessiveness, in its more benign incarnation, is a demand for togetherness, but in its darker incarnation, is a feeling of jealousy. If Adam is possessive of Eve, then Adam does not want Eve to leave him (or grow angry at him). If she leaves him for another man, then Adam will be jealous of this other man. Eve may selfishly enjoy a little jealousy on Adam's part, but certainly not too much of it. Love may make Adam too jealous of Eve, which Eve detests, and at the same time make Adam care for Eve so that Eve's disutility from Adam's own jealousy gives Adam disutility. Adam's heart is then torn between two opposite forces, both the product of love.

The notion of possessiveness can be captured in the model. Consider the following outcome: Eve is in ecstasy but Adam acts on a belief that she is not in ecstasy. One way for Adam to act, if he believes that he is not pleasing Eve, is to storm off, shy away, or grow angry. And one of these actions may well be an optimal one for him if he fears being made a fool of by Eve. If Eve is not possessive of Adam, then this outcome, though perhaps mildly unpleasant, is certainly not dire. If, however, Eve is possessive of Adam, then this outcome is dire indeed: Eve runs the risk of loosing the man she loves.[2] Here, possessiveness affects Eve's utility in the same direction as caring would affect her utility. Possessiveness induces Eve to despise this particular outcome, and Adam despises this particular outcome himself since the last thing he wants is to misread Eve's feelings, especially if he too is in love.

Consider the opposite outcome: Eve is not in ecstasy, but Adam acts on a belief that she is in ecstasy. One way for Adam to act, if he believes that he

[2] Perhaps Eve might employ a peculiar tactic, known as "playing hard to get," in order not to lose the man she likes. Our model does not allow for this type of strategy.

is pleasing Eve, is to stick around. And this may well be an optimal action for him to take if he is possessive of Eve. If Eve is not possessive of Adam, then this outcome is dreadful: Eve may well despise the excessive attention of a man she does not love. If Eve is possessive of Adam, then this outcome, though still unpleasant, is certainly not dreadful: Eve does not mind so much the attention, though completely misguided, of a man she loves. Here, possessiveness affects Eve's utility in the opposite direction that caring would affect her utility. Possessiveness induces Eve to despise this particular outcome a lot less, and perhaps even enjoy it, even though Adam despises this outcome since it involves him being duped.

But how much does Adam despise the outcome where he learns that he has been duped? If Adam does not love Eve, then this outcome is quite unpleasant: Eve has made a fool of him. To prevent such a wound to his ego, Adam could instead get angry at Eve (or otherwise grow distant from her), and this would not displease him much provided he does not love her much. If Adam is possessive of Eve, then this outcome is not altogether unpleasant: Adam does not mind so much being duped, for love makes the ego melt away. The alternative is to get angry at Eve (or otherwise distance himself from her), and this would displease him more provided he loves her much.

In this paper, love is defined a mixture of caring and possessiveness. In the following notation, $s \neq r$ and $s, r \in \{Adam, \, Eve\}$. Define three love functions that vary with the individual-specific parameters for caring, $\kappa_s, \; \kappa_r \in [0, 1]$. Let $o_r(\kappa_r)$ denote the indirect utility that receivers derive from the direct utility that senders derive from their own ecstasy. Let $c_r(\kappa_r)$ denote the indirect cost that receivers incur from the direct cost that senders incur for faking ecstasy. Let $v_s(\kappa_s)$ denote the indirect utility that senders derive from the direct utility that receivers derive from senders' vocalization of ecstasy.

Define four love functions that also vary with individual-specific parameters for possessiveness, π_r, $\pi_s \in [0,1]$. Let $e_r^1(\kappa_r,\pi_r)$ denote the disutility that receivers derive directly from, and indirectly from the disutility that senders derive from, their own unfounded insecurity. Let $e_r^2(\kappa_r,\pi_r)$ denote the disutility that receivers derive directly from, and indirectly from the disutility that senders derive from, their own unfounded confidence.

Let $e_s^1(\kappa_s,\pi_s)$ denote the disutility that senders derive directly from, and indirectly from the disutility that receivers derive from, receivers' unfounded insecurity. Let $e_s^2(\kappa_s,\pi_s)$ denote the disutility that senders derive directly from, and indirectly from the disutility that receivers derive from, receivers' unfounded confidence.

The following parametric assumptions are made:

$$\begin{aligned}
o_r(\kappa_r) &= \kappa_r\overline{o}_s \ , \ c_r(\kappa_r) = \kappa_r\overline{c}_s \ , \ v_s(\kappa_s) = \kappa_s\overline{v}_r \\
e_r^1(\kappa_r,\pi_r) &= (1-\kappa_r)\pi_r\overline{e}_r^1 + \kappa_r e_s^1 \ , \ e_r^2(\kappa_r,\pi_r) = (1-\kappa_r)(1-\pi_r)\overline{e}_r^2 + \kappa_r e_s^2 \\
e_s^1(\kappa_s,\pi_s) &= (1-\kappa_s)\pi_s\overline{e}_s^1 + \kappa_s e_r^1 \ , \ e_s^2(\kappa_s,\pi_s) = (1-\kappa_s)(1-\pi_s)\overline{e}_s^2 + \kappa_s e_r^2
\end{aligned} \tag{3.1}$$

In these functions, our definition of love has a precise expression. For example, if $\kappa_r = 0$, then the receiver does not care for the sender, only for the receiver; if $\kappa_r = 1$, then the receiver does not care for the receiver, only for sender. On the other hand, if $\pi_r = 0$, then the receiver is not possessive of the sender, in the sense that the receiver experiences no disutility from mistakenly distrusting the sender, only disutility from mistakenly trusting the sender. If $\pi_r = 1$, then the receiver is so possessive of the sender that the receiver gets no disutility from mistakenly trusting the sender, only disutility from mistakenly distrusting the sender. The interpretation of κ_s and π_s is analogous. Notice that possessiveness operates on the relative disutilities experienced by senders and receivers from receivers' type 1 versus type 2 errors.

Iterating the above recursive equations until convergence for all $\kappa_s, \kappa_r, \pi_s, \pi_r \in (0,1)$ yields:

$$e_r^1(\kappa_r, \pi_r) = \begin{cases} 0 \text{ if } \kappa_r = 0,\ \pi_r = 0 \\ \overline{e}_r^1 \text{ if } \kappa_r = 0,\ \pi_r = 1 \\ (1-\kappa_r)[\frac{\pi_r \overline{e}_r^1 + \kappa_r \pi_s \overline{e}_s^1}{1-\kappa_r \kappa_s}] \text{ if } \kappa_r, \pi_r \in (0,1) \\ \overline{e}_s^1 \text{ if } \kappa_r = 1 \end{cases} \tag{3.2}$$

$$e_r^2(\kappa_r, \pi_r) = \begin{cases} \overline{e}_r^2 \text{ if } \kappa_r = 0,\ \pi_r = 0 \\ 0 \text{ if } \kappa_r = 0,\ \pi_r = 1 \\ (1-\kappa_r)[\frac{(1-\pi_r)\overline{e}_r^2 + \kappa_r (1-\pi_s) \overline{e}_s^2}{1-\kappa_r \kappa_s}] \text{ if } \kappa_r, \pi_r \in (0,1) \\ \overline{e}_s^2 \text{ if } \kappa_r = 1 \end{cases} \tag{3.3}$$

$$e_s^1(\kappa_s, \pi_s) = \begin{cases} 0 \text{ if } \kappa_s = 0,\ \pi_s = 0 \\ \overline{e}_s^1 \text{ if } \kappa_s = 0,\ \pi_s = 1 \\ (1-\kappa_s)[\frac{\pi_s \overline{e}_s^1 + \kappa_s \pi_r \overline{e}_r^1}{1-\kappa_s \kappa_r}] \text{ if } \kappa_s, \pi_s \in (0,1) \\ \overline{e}_r^1 \text{ if } \kappa_s = 1 \end{cases} \tag{3.4}$$

$$e_s^2(\kappa_s, \pi_s) = \begin{cases} \overline{e}_s^2 \text{ if } \kappa_s = 0,\ \pi_s = 0 \\ 0 \text{ if } \kappa_s = 0,\ \pi_s = 1 \\ (1-\kappa_s)[\frac{(1-\pi_s)\overline{e}_s^2 + \kappa_s (1-\pi_r) \overline{e}_r^2}{1-\kappa_s \kappa_r}] \text{ if } \kappa_s, \pi_s \in (0,1) \\ \overline{e}_r^2 \text{ if } \kappa_s = 1 \end{cases} \tag{3.5}$$

These love functions formalize the notion that the sender's possessiveness and care for the receiver may conflict when the sender is not in ecstasy and the receiver acts as if the sender is in ecstasy. Indeed, e_s^2 is increasing in the caring parameter, κ_s, provided that $\overline{e}_s^2$ is smaller than $\overline{e}_r^2$; but e_s^2 is unambiguously decreasing in the possessiveness parameter, π_s.

This completes the specification of the utility functions of Adam and Eve in the event that they love each other, and even in the event that one loves the other but not vice-versa. The normal form of the faking games, denoted $\Gamma(\omega_s)$ for all $s \in \{Adam, Eve\}$, is given in Table 1. The sender is the row player and the receiver is the column player.

Table 1: Normal Form of the Faking Game $\Gamma(\omega_s)$

	Confident	Insecure
Faking	$\alpha_s[\overline{o}_s+v_s]+(1-\alpha_s)[v_s-e_s^2-\overline{c}_s]$, $\alpha_s[o_r+\overline{v}_r]+(1-\alpha_s)[\overline{v}_r-e_r^2-c_r]$	$\alpha_s[\overline{o}_s+v_s-e_s^1]+(1-\alpha_s)[v_s-\overline{c}_s]$, $\alpha_s[o_r+\overline{v}_r-e_r^1]+(1-\alpha_s)[\overline{v}_r-c_r]$
Honest	$\alpha_s[\overline{o}_s+v_s]$, $\alpha_s[o_r+\overline{v}_r]$	$\alpha_s[\overline{o}_s+v_s-e_s^1]$, $\alpha_s[o_r+\overline{v}_r-e_r^1]$

Whether the sender experiences the utility $\overline{o}_s$ does not depend on the sender's choice of strategy, only on Nature's choice of strategy. Adding a term to the sender's utility function that depends only the strategy choices of another player does not affect the pattern of best responses and therefore does not affect the set of Nash equilibrium probabilities of faking. This yields a first testable prediction.

TP0 The level of satisfaction that men and women derive from their own orgasm does not affect their own probability of faking.

3.3 Lovely Equilibria

The parameters of $\Gamma(\omega_s)$ are $\overline{o}_s$, $\overline{c}_s$, $\overline{e}_r^1$, $\overline{e}_r^2$, $\overline{e}_s^1$, $\overline{e}_s^2$, $\overline{v}_r$, α_s, κ_s, κ_r, π_s and π_r for all $s \neq r$, $s, r \in \{Adam, Eve\}$. To focus on the effect of age, love, and gender differences in the cost of faking on the equilibrium probability of faking, all parameters other than $\overline{c}_s$, α_s, κ_s, κ_r, π_s and π_r are set equal to 1. The cost of faking is assumed to be greater for Adam than for Eve. In particular, let $\overline{c}_{Eve} = 0$ and $\overline{c}_{Adam} = 1$. Finally, love is assumed to be an equal mixture of caring and possessiveness, that is $\lambda_{Adam} := \kappa_{Adam} = \pi_{Adam}$ and $\lambda_{Eve} := \kappa_{Eve} = \pi_{Eve}$. The cases of no love, weak mutual love, weak unrequited love, and strong mutual love are analyzed in turn. In what follows, ϕ denotes the sender's probability of choosing *Faking* and ψ denotes the receiver's probability of choosing *Confident*.

Case 1. No Love ($\lambda_{Eve} = 0$, $\lambda_{Adam} = 0$).

In this case, $\Gamma(\omega_{Eve})$ reduces to

	Confident	Insecure
Faking	$2\alpha_{Eve} - 1$, α_{Eve}	0, $1 - \alpha_{Eve}$
Honest	α_{Eve}, α_{Eve}	0, 0

For all $\alpha_{Eve} \in (0, \frac{1}{2}]$, the set of Nash equilibria is $\{(\phi, \psi) : (\phi = 0, \psi = 1) \vee (\phi = 1, \psi = 0)\}$. For all $\alpha_{Eve} \in (\frac{1}{2}, 1)$, the unique equilibrium is $(\phi = 0, \psi = 1)$. On the other hand, $\Gamma(\omega_{Adam})$ reduces to

	Confident	Insecure
Faking	$3\alpha_{Adam} - 2$, α_{Adam}	$\alpha_{Adam} - 1$, $1 - \alpha_{Adam}$
Honest	α_{Adam}, α_{Adam}	0, 0

For all $\alpha_{Adam} \in (0, 1)$, the unique equilibrium is $(\phi = 0, \psi = 1)$.

To facilitate comparative statics, every Nash equilibrium is assumed to occur with some positive probability. Then, for example, Eve fakes with positive probability if α_{Eve} is no greater than $\frac{1}{2}$, that is, if Eve is young or old, while Eve fakes with zero probability if α_{Eve} is greater than $\frac{1}{2}$, that is, if Eve is middle-aged. With this assumption, the above analysis generates two testable predictions.

TP1 Younger and older women who are not in love are more likely to fake than middle-aged women who are not in love.

TP2 Age has a greater effect on the probability of faking for women who are not in love than for men who are not in love.

Case 2. Weak Mutual Love ($\lambda_{Eve} = \frac{1}{2}$, $\lambda_{Adam} = \frac{1}{2}$).

In this case, $\Gamma(\omega_{Eve})$ reduces to

	Confident	Insecure
Faking	$\frac{3}{2}\alpha_{Eve}$, $\alpha_{Eve}+\frac{1}{2}$	$\frac{1}{2}\alpha_{Eve}+\frac{1}{2}$, 1
Honest	$\frac{3}{2}\alpha_{Eve}$, $\frac{3}{2}\alpha_{Eve}$	α_{Eve}, α_{Eve}

For all $\alpha_{Eve} \in (0, \frac{1}{2})$, the equilibrium set $\{(\phi,\psi) : (\phi = 1, \psi = 0) \vee (\phi \in [0, \frac{\alpha_{Eve}}{1-\alpha_{Eve}}], \psi = 1)\}$. If $\alpha_{Eve} = \frac{1}{2}$, then the equilibrium set is $\{(\phi,\psi) : (\phi \in [0,1], \psi = 1) \vee (\phi = 1, \psi \in [0,1])\}$. For all $\alpha_{Eve} \in (\frac{1}{2}, 1)$, the equilibrium set is $\{(\phi,\psi) : \phi \in [0,1], \psi = 1\}$. On the other hand, $\Gamma(\omega_{Adam})$ reduces to

	Confident	Insecure
Faking	$\frac{5}{2}\alpha_{Adam}-1$, $\frac{3}{2}\alpha_{Adam}$	$\frac{3}{2}\alpha_{Adam}-\frac{1}{2}$, $\frac{1}{2}\alpha_{Adam}+\frac{1}{2}$
Honest	$\frac{3}{2}\alpha_{Adam}$, $\frac{3}{2}\alpha_{Adam}$	α_{Adam}, α_{Adam}

$\Gamma(\omega_{Adam})$ has the same equilibrium with weak mutual love as with no love.

A comparison of cases 1 and 2 yields two additional testable predictions.

TP3 Women are more likely to fake if they are in love than if they are not in love.

TP4 Younger and older women are even more likely to fake than middle-aged women if they are in love than if they are not in love.

It has often been claimed that women are more altruistic than men.[3] There is a growing literature in experimental game theory that attempts to measure gender differentials in altruism in a variety of strategic situations. For example, in a double-anonymous dictator experiment, Eckle and Grossman (1998) show that women, on average, donate twice as much as men to their anonymous partners. In response to these considerations, the case of unrequited female love is also analyzed.

[3]For example, Charles Darwin (1874) writes that "Woman seems to differ from Man in mental disposition, chiefly in her greater tenderness and less selfishness..." (p. 586).

Case 3. Weak Unrequited Love ($\lambda_{Eve} = 1/2$, $\lambda_{Adam} = 0$).

In this case, $\Gamma(\omega_{Eve})$ reduces to

	Confident	Insecure
Faking	$\frac{3}{2}\alpha_{Eve}$, α_{Eve}	$\frac{1}{2}\alpha_{Eve} + \frac{1}{2}$, 1
Honest	$\frac{3}{2}\alpha_{Eve}$, α_{Eve}	α_{Eve}, α_{Eve}

For all $\alpha_{Eve} \in (0, 1)$, the equilibrium set is $\{(\phi, \psi) : (\phi = 1, \psi = 0) \vee (\phi = 0, \psi = 1)\}$. On the other hand, $\Gamma(\omega_{Adam})$ reduces to

	Confident	Insecure
Faking	$3\alpha_{Adam} - 2$, $\frac{3}{2}\alpha_{Adam}$	$2\alpha_{Adam} - 1$, $\frac{1}{2}\alpha_{Adam} + \frac{1}{2}$
Honest	α_{Adam}, $\frac{3}{2}\alpha_{Adam}$	α_{Adam}, α_{Adam}

$\Gamma(\omega_{Adam})$ has the same equilibrium with weak unrequited love as with weak mutual love or no love.

This analysis predicts that if a woman's love is unrequited, then she is less likely to fake than if her love is mutual.

In some cases, a love may blossom between a man and a woman that is so strong that each would readily die to save the other's life, if the occasion presented itself.

Case 4. Strong Mutual Love ($\lambda_{Eve} = 1$, $\lambda_{Adam} = 1$).

In this case, $\Gamma(\omega_{Eve})$ reduces to

	Confident	Insecure
Faking	$2\alpha_{Eve}$,$2\alpha_{Eve}$	1, 1
Honest	$2\alpha_{Eve}$, $2\alpha_{Eve}$	α_{Eve}, α_{Eve}

$\Gamma(\omega_{Eve})$ has the same equilibrium set for each of the same age categories with strong mutual love as with weak mutual love. However, $\Gamma(\omega_{Adam})$ does not. Indeed, $\Gamma(\omega_{Adam})$ reduces to

	Confident	Insecure
Faking	$3\alpha_{Adam}-1$, $3\alpha_{Adam}-1$	α_{Adam}, α_{Adam}
Honest	$2\alpha_{Adam}$, $2\alpha_{Adam}$	α_{Adam}, α_{Adam}

For all $\alpha_{Adam} \in (0, \frac{1}{2})$, the equilibrium set $\{(\phi, \psi) : (\phi = 0, \psi = 1) \vee (\phi \in [\frac{\alpha_{Eve}}{1-\alpha_{Eve}}, 1], \psi = 0)\}$. If $\alpha_{Eve} = \frac{1}{2}$, then the equilibrium set is $\{(\phi, \psi) : (\phi = 0, \psi = 1) \vee (\phi = 1, \psi = 0)\}$. For all $\alpha_{Eve} \in (\frac{1}{2}, 1)$, the unique equilibrium is $(\phi = 0, \psi = 1)$.

A comparison of cases 1 and 4 yields the following testable prediction:

TP5 Middle-aged and older men are more likely to fake than younger men if they are in love than if they are not in love.

However, since strong mutual love is rarer than weak mutual love, we have one final testable prediction:

TP6 Love has a greater positive effect on women's probability of faking than on men's probability of faking.

3.4 Data

From the 2000 *Orgasm Survey*, data were gathered that can be used to test several of the predictions of the model. The survey was devised by the professional psychologists and statisticians of PsychTests, a firm specialized in online testing for academic and business purposes.[4] The online survey was answered voluntarily and anonymously by 16,000 women and men, aged 14 to 74. People were asked a variety of questions concerning their sexual experiences in their current or most recent relationship. Several of the questions addressed the subject of faking orgasm.

Those people who were drawn to fill out the survey might have been those who have a greater tendency to fake or who are more suspicious that their partner is faking. Thus, the following results may contain a selection bias due to the sampling procedure.

Table 2 contains a description of the key variables that were constructed from the *Orgasm Survey*. The variable *Faking* will be the main dependent variable. Notice that respondents were not asked how many times they had faked an orgasm, only whether or not they had faked an orgasm at one time or another in their current relationship.

The variable *BelieveConfident* is a good proxy for the probability of being caught faking insofar as women guess accurately whether their partners can tell if they are faking. Since part of a woman's cost of faking is experienced only if she is caught faking, *BelieveConfident* is also a possible measure of a woman's cost of faking.

The variable *Altruism* is a possible measure of altruism. If a woman expresses an extreme preference for her partner's sexual pleasure, then this might suggest that she cares for her partner. However, a woman might express an extreme preference for her partner's sexual pleasure for selfish reasons too: perhaps her partner is impotent, and she would prefer that he not be. On the other hand, if a man expresses an extreme preference for his partner's sexual pleasure, then this might mean that he cares for his partner's sexual pleasure, or that he wants to demonstrate his own

[4] See website: http://www.psychtests.com.

Table 2: Description of Key Variables

Notation for Variable	Description of Variable	Value of Variable
Faking	Have you faked an orgasm?	1 = Yes, 0 = No
Confident	Can you tell if	
	your partner is faking?	1 = Yes, 0 = No
BelieveConfident	Can your partner tell	
	if you are faking?	1 = Yes, 0 = No
Age	Age	$14 \leq Age \leq 74$
Altruism	How important is it to	1 = Extremely, 0 = o/w (Altruism 1)
	you that your partner	1 = Very, 0 = o/w (Altruism 2)
	reach orgasm?	1 = Somewhat, 0 = o/w (Altruism 3)
Egoism	How important is it to	1 = Extremely, 0 = o/w (Egoism 1)
	you that you reach	1 = Very, 0 = o/w (Egoism 2)
	orgasm?	1 = Somewhat, 0 = o/w (Egoism 3)
Possessiveness	How would you feel	1 = Embarrassed, Guilty,
	about your partner	Bad for my partner,
	faking an orgasm?	Indifferent, Flattered, Happy
		0 = Angry, Deceived,
		Ridiculed, Inadequate,
		Betrayed, Appalled
DisutilityDuped	Would you want your partner	1 = Yes
	to fake it if s/he had not	0 = No
	spontaneously reached orgasm?	
AgeLostVirginity	How old where you when	$14 \leq Age \leq 74$
	you lost your virginity?	
Education	Formal education	9 = less than sec 3, 11 = sec 3 or 4
		12 = high school, 13 = 1-3 post-sec
		14 = some undergrad, 16 = bachelor
		17 = some grad, 18 = masters
		20 = doctorate, 21 = post-doc

Table 3: Summary Statistics

Variable	Women	(N=4084)	Men	(N=2232)
	Mean	Std. Dev.	Mean	Std. Dev.
Faking	0.72	0.45	0.26	0.44
Confident	0.74	0.44	0.55	0.49
BelieveConfident	0.24	0.43	0.66	0.47
Age	26.74	8.21	28.67	9.48
DisutilityDuped	0.04	0.19	0.06	0.23
AgeLostVirginity	16.54	2.45	17.23	3.09
Education	13.91	1.91	14.20	2.26

sexual prowess. With these caveats in mind, *Altruism* will serve as the empirical analogue of the parameter κ in our model.

A measure of possessiveness is also available. Recall the two effects of possessiveness in our model. First, it reduces the woman's disutility from her partner's miscalculated confidence. Second, it reduces her disutility from her own miscalculated confidence.

This second effect is captured by the variable *Possessiveness* in Table 2. Respondents were asked how they would feel about their partner faking an orgasm. If they expressed negative feelings toward their partner (Angry, Deceived, Ridiculed, Inadequate, Betrayed, Appalled) at the prospect of their partner faking, then this suggests that they are not possessive of their partner, in the sense in which we defined possessiveness in our model. If they expressed negative feelings toward themselves (Embarrassed, Guilty, Bad for my partner), neutral feelings (Indifferent), or positive feelings toward their partner (Flattered, Happy), then this suggests that they are more possessive of their partner. Therefore, *Possessiveness* will serve as the empirical analogue of the parameter π in our model.

Table 3 contains summary statistics for each of the variables in Table 2 except those relating to love. The average age of respondents is significantly lower than the US adult population average, and the average educational attainment is approximately one year above the US population average for both men and women.

Since the survey was administered online, the sample was limited to respondents who have access to computers and who are familiar with the Internet. People with higher educational attainment tend to earn a higher income, and people who earn a higher income tend to have easier access to computers. Therefore, people who have access to computers may be a selected sample of people with above average educational attainment. Moreover, since the Internet has been commercialized for use in daily computer communications only since the mid 1980's (see Segaller, 1998), younger people tend to be more familiar with it than older people. Therefore, people who are familiar with the Internet may be a selected sample of people who are younger than average.

The mean age at first intercourse is slightly higher for men than for women. This seems surprising. Michael *et al* (1994), based on a representative survey of 3,500 American adults, report that the mean age at first intercourse was 17.5 for white women born from 1963 to 1972, and 16.8 for black women in the same age category. On the other hand, the mean age at first intercourse was 17.4 for white men born from 1963 to 1972, and 15.3 for black men in the same age category. However, Michael *et al* also calculate that for the successive ten-year birth cohorts, 1933 to 1942, 1943 to 1952, 1953 to 1962, and 1963 to 1972, the percentages of men who had not lost their virginity by age twenty rose steadily from 1.0 to 1.7 to 6.0 to 8.3 percent, whereas those of women oscillated from 4.6 to 4.7 to 3.6 to 5.8 percent.

Table 3 also reveals that 72 percent of women have faked an orgasm in their current or most recent relationship and 55 percent of men believe they could tell if their current or most recent partner had faked an orgasm. At least two stories would be consistent with these facts: (a) women are faking even though their partners can tell that they are faking, in which case women are under the illusion that their faking is more credible than it is in reality, or (b) men believe they can tell that their partners are not faking even though their partners are faking, in which case

Table 4: Percent Distributions of Altruism, Egoism and Possessiveness

How important is it to you that your partner reaches orgasm? (Altruism)	Women	Men
Extremely	41.0	47.5
Very	41.6	38.3
Somewhat	14.4	12.1
Not at all	3.0	2.1
How important is it to you that you reach orgasm? (Egoism)	Women	Men
Extremely	10.2	26.8
Very	30.4	38.7
Somewhat	47.4	28.7
Not at all	12.0	5.8
How would you feel about your partner faking? (Possessiveness)	Women	Men
Positive feelings toward partner	4.1	5.1
Neutral feelings	20.3	13.1
Negative feelings toward self	34.1	32.8
Negative feelings toward partner	41.5	50.0

men are under the illusion that their sexual prowess is greater than it is in reality.

Notice also that 66 percent of men believe that their partners can tell whether or not they are faking, versus only 24 percent of women. These data suggest that the probability of being caught faking is much greater for men than for women, and hence, (at least part of) the cost of faking is greater for men than for women. This was a crucial assumption in the theoretical model.

Table 4 contains summary statistics for each of the variables in Table 2 relating to love. Notice that 48 percent of men, versus only 41 percent of women, say that it is extremely important that their partner reaches orgasm. However, the chi-square test does not reject the hypothesis that *Gender* and *Altruism* are independent. Nevertheless, only 40 percent of women, versus an overwhelming 66 percent of men, say that it is either very or extremely important for them to reach orgasm. The chi-square test easily rejects the hypothesis that *Gender* and *Egoism* are independent. On sexual pleasure, men seem to be as altruistic as women, but significantly more egotistical than women.

Moreover, only 42 percent of women, versus 50 percent of men, expressed negative feelings toward their partner at the prospect of their partner faking. Therefore, the data suggest that women are more possessive than men, in the sense that they would be less devastated than men if they were to discover that their confidence was misplaced.

3.5 An Empirical Model of Love-Making

The sample is restricted to heterosexuals 18 years of age and over.[5] The game theoretic model suggests that a woman's decision to fake is a function of her partner's decision to be confident, and vice versa. Ideally, therefore, the variable $Faking$ (for the set of women) would be regressed on the variable $Confident$ (for the corresponding set of men), and the variable $Confident$ on the variable $Faking$, and the system would be solved simultaneously.

However, this would require us to have data on couples (and to resolve the identification problem). Only individual data are available. For any given woman, the man with whom she is having intercourse cannot be identified. Most likely, this man is not even in the sample.

The data do, however, contain clues about the man with whom a woman is having intercourse. Recall that the variable $BelieveConfident$ equals 1 if the woman believes that her partner can tell if she is faking, and 0 otherwise. Therefore, the variable $BelieveConfident$ is a good proxy for the variable $Confident$ (and for the probability of being caught faking) insofar as women guess accurately whether their partners can tell if they are faking. If a woman has been with her partner for a long time, then her guess is more likely to be accurate. Therefore, the sample is further

[5] The theoretical model can be modified to address faking behavior in lesbian couples. However, only 2.3 percent of women who responded to the Orgasm Survey are lesbian. Moreover, too few of these women answered the questions concerning faking orgasm to reliably test any theoretical predictions.

restricted to respondents involved in steady sexual relationships.

This subsample is divided into two groups: W, the set of women, and M, the set of men. First, several variations of the following basic empirical model, corresponding to the game with uncertainty about the woman's state of ecstasy, are estimated:

$$\begin{aligned}\Pr(Faking_w = 1) = \Phi(&\beta_0^w + \beta_1^w BelieveConfident_w + \beta_2^w Y_w + \beta_3^w Egoism_w \\ &+ \beta_4^w Love_w + \beta_5^w D_1 * (a_w^* - Age_w) + \beta_6^w D_2 * (Age_w - a_w^*) \\ &+ \beta_7^w D_1 * (a_w^* - Age_w) * Love_w + \beta_8^w D_2 * (Age_w - a_w^*) * Love_w)\end{aligned} \quad (3.6)$$

Φ is the cumulative normal distribution, and equation (6) is a probit model. The variables *Possessiveness* and *Altruism* will serve as proxies for *Love*. The variables D_1 and D_2 are dummies, where $D_1 = 1$ if $a_w^* \geq Age$, and $D_2 = 1$ if $Age \geq a_w^*$. The function $D_1 * (a_w^* - Age_w)$ has higher values for women who are much younger than a_w^*, smaller values for women who are only slightly younger than a_w^*, and zero values for women who are older than a_w^*. The function $D_2 * (Age_w - a_w^*)$ is analogous.

The parameter a_w^* is the woman's lifetime peak of sexual response capacity. The sex literature discussed in the introduction suggests that women reach their lifetime peak of sexual response capacity around the age of thirty. Therefore, we let $a_w^* = 30$.

The vector Y_w is a vector of controls which includes (a) the age when the respondent lost her virginity, (b) the respondent's level of education, (c) dummy variables for the frequency with which the respondent has sex (several times a day, once a day, once a week, two or three times a month, once a month, six times a year, three to five times a year, two to three times a year, with fewer than two times a year the excluded category), and (d) dummy variables for the percent of the time that the respondent achieves orgasm during sex (100 percent, 85-99 percent, 61-84 percent, 40-60 percent, 20-39 percent, 10-19 percent, with 0-9 percent the excluded category).

Table 5: Correlation Matrices for the Controls

Women ($N = 3012$)	Education	AgeLostVirginity	OrgasmRate	FrequencySex
Education	1	.246	-.021	-.024
AgeLostVirginity		1	-.055	-.055
OrgasmRate			1	.165
FrequencySex				1
Men ($N = 1950$)	Education	AgeLostVirginity	OrgasmRate	FrequencySex
Education	1	.239	-.047	-.026
AgeLostVirginity		1	-.104	-.146
OrgasmRate			1	.061
FrequencySex				1

The upper half of Table 5 presents Pearson correlation coefficients for these controls. For women, education is strongly positively correlated with age of virginity loss, and slightly negatively correlated with orgasm rate and frequency of sex. Age of virginity loss is slightly negatively correlated with orgasm rate and frequency of sex, and orgasm rate is highly positively correlated with frequency of sex.

Several variations of the following basic empirical model, corresponding to the game with uncertainty about the man's state of ecstasy, are also estimated:

$$\Pr(Faking_m = 1) = \Phi(\beta_0^m + \beta_1^m BelieveConfident_m + \beta_2^m Y_m + \beta_3^m Egoism_m \tag{3.7}$$

$$+ \beta_4^m Love_m + \beta_5^m (AGE_m - a_m^*) + \beta_6^m (AGE_m - a_m^*) * Love_m)$$

The parameter a_m^* is the man's lifetime peak of sexual response capacity. The sex literature discussed in the introduction suggests that men reach their lifetime peak of sexual response capacity in their late teens. Therefore, we let $a_m^* = 18$.

The vector Y_m contains the same controls as in Y_w. The bottom half of Table 5 contains correlation coefficients for these controls. For men, as for women, education is strongly positively correlated with age of virginity loss, and slightly negatively correlated with orgasm rate and the frequency of sex. For men, unlike for women, age of virginity loss is strongly negatively correlated with orgasm rate and frequency of sex, and orgasm rate is slightly positively correlated with frequency of sex.

3.6 Estimation Results

Table 6 presents the marginal effects for equations (6) and (7). None of the vectors of coefficients on the egoism variables is significantly nonzero. The level of satisfaction that men and women derive from their own orgasm does not affect their observed probability of faking. These findings confirm TP0.

Among women who do not care for their partner's sexual pleasure and who are younger than 30 (their peak of sexual response capacity), those who are much younger than 30 are more likely to fake than those who are closer to 30. This finding tends to support TP1. However, among women who do not care for their partner's sexual pleasure and who are older than 30, the effect of age relative to 30 on the probability of faking is not statistically significant. Therefore, the results are mixed regarding TP1.[6]

Among men who do not care for their partner's sexual pleasure, men who are closer to 18 (their peak of sexual response capacity) are less likely to fake than men who are much older than 18. An F-test shows that the effect of age relative to the peak of sexual response capacity is greater for men than for women. Therefore, the data do not confirm TP2.

Possessiveness and altruism each have a significantly positive effect on women's probability of faking. Women who are possessive of their partners are 10 percent more likely to fake than women who are not possessive of their partners. Women

[6] The effect of age relative to 30 may be statistically significant only for women who are younger than 30 because relatively fewer women are older than 30 in the sample.

Table 6: Marginal Effects of the Determinants of the Probability of Faking

	Women ($N = 3012$)		Men ($N = 1950$)	
	(1)	(2)	(3)	(4)
BelieveConfident	-.2941	-.2938	-.2270	-.2274
	(.0204)	(.0204)	(.0228)	(.0229)
DisutilityDuped	.1657	.1653	.1343	.1323
	(.0272)	(.0272)	(.0521)	(.0522)
$D_1{*}(30 - Age)$	.0081	.0132		
	(.0022)	(.0028)		
$D_2{*}(Age - 30)$	.0021	-.0015		
	(.0022)	(.0027)		
$(Age - 18)$			.0137	.0124
			(.0033)	(.0042)
Possessiveness	.1054	.1053	.0607	.0597
	(.0167)	(.0167)	(.0209)	(.0209)
Egoism 1	-.0409	-.0334	.0275	.0290
	(.0388)	(.0384)	(.0556)	(.0557)
Egoism 2	.0279	.0287	.0507	.0524
	(.0269)	(.0268)	(.0525)	(.0526)
Egoism 3	.0469	.0472	.0375)	.0403
	(.0256)	(.0256)	(.0540)	.0402
Altruism 1	.1967	.1090	-.0056	-.0136
	(.0576)	(.0674)	(.0871)	(.0936)
Altruism 2	.1476	.1450	-.0399	-.0413
	(.0590)	(.0592)	(.0863)	(.0863)
Altruism 3	.1026	.1016	-.0733	-.0751
	(.0513)	(.0515)	(.0783)	(.0781)
$D_1{*}(30 - Age){*}$Altruism 1		.0127		
		(.0043)		
$D_2{*}(Age - 30){*}$Altruism 1		.0098		
		(.0046)		
$(Age - 18){*}$Altruism 1				.0049
				(.0066)
AgeLostVirginity	-.0193	-.0189	-.0203	-.0202
	(.0033)	(.0033)	(.0036)	(.0036)
Education	.0081	.0076	.0111	.0108
	(.0044)	(.0044)	(.0046)	(.0047)
LR chi2(32)	406.58	415.64	272.01	274.23
Pseudo R^2	0.1181	0.1208	0.1186	0.1196

Standard errors are in parenthesis. All regressions control for sex frequency and orgasm rate.

who care extremely for their partner's sexual pleasure are 11 percent more likely to fake than women who care very much for their partner's sexual pleasure. The data support the hypothesis that love and faking are positively correlated for women, and hence support TP3.

Men who are possessive of their partners are also significantly more likely to fake than men who are not possessive of their partners. However, men are not significantly more likely to fake if they care for their partners' sexual pleasure than if they do not. This is in stark contrast to women. Therefore, the data support the conclusion that love and faking are less positively correlated for men than for women, and hence confirm TP6.

The impact of age relative to 30 is greater for women who care for their partner's sexual pleasure than for women who do not care for their partner's sexual pleasure (see the interactions between age and altruism in column 2). Altruistic love enhances the effect of age on women's probability of faking. These results support TP4. However, the interaction between altruism and age relative to the peak of sexual response capacity is not significant for men (see column 4). Therefore, the data do not support TP5.

Men and women who believe that their partners can tell if they are faking are significantly less likely to fake than men and women who believe that their partners cannot tell if they are faking (see the *BelieveConfident* variable in columns 1 through 4). This finding is consistent with the basic theoretical prediction that an increase in the cost of faking tends to reduce the equilibrium probability of faking.

Men and women who would hate to find out that their partners are faking are significantly less likely to fake themselves than men and women who would be indifferent to finding out that their partners are faking (see the *DisutilityDuped* variable in columns 1 through 4). Therefore, the data provide gender-neutral support for the behavioral theory of "Do unto others as you would have done unto you."

Men and women who lost their virginity at a younger age are more likely to fake than men and women who lost their virginity at a later age. Lastly, more educated men and women are more likely to fake than less educated men and women. People with more education may be a selected sample of people with above-average intelligence. Intelligence may reduce the costs of faking, since the production, and successful perpetuation, of lies requires a considerable degree of imagination. A basic prediction of the theoretical model is that a decrease in the cost of faking tends to increase the equilibrium probability of faking, which explains the empirical finding that education and faking are positively correlated for both men and women.

3.7 Conclusion

This paper attempted to apply the rational choice paradigm of economics to the study of human sexuality, particularly sexual deception. Love-making was modeled as a signaling game, and it was shown that the equilibrium probability of faking is decreasing in the cost of faking and increasing in the strength of love, formally defined as a mixture of caring and possessiveness. These predictions were tested with available field data. In accordance with the rational theory, measures of love are strongly positively correlated, while measures of faking costs are strongly negatively correlated, with faking behavior.

A surprising finding is that education and faking are positively correlated for both men and women. This finding naturally elicits the question of whether there exists a positive relationship between education and the tendency to lie in general. Existing research on this issue is surprisingly scant. Sacerdote and Glaezer (2001) find that, in the United States, church attendance and education are positively correlated across individuals but negatively correlated across religious groups. Individuals with less education (e.g., high school dropouts) are a selected sample of individuals with lesser social skills, and church attendance is a social event. However, individuals with more education may acquire scientific knowledge that may conflict with religious beliefs. Therefore, education may cause individuals to sort into less fervent religious groups.

One would expect church attendance and honesty (especially in affairs relating to sex) to be positively correlated. Of Moses's Ten Commandments, two relate directly to honesty: "Thou shall not commit adultery" (the Sixth Commandment), and "Thou shall not bear false witness against thy neighbor" (the Ninth Commandment). If education is positively correlated with church attendance, and church attendance is positively correlated with honesty, education should be positively correlated with honesty. But that would be at variance with the finding that education and the tendency to fake ecstasy are positively correlated.

Bibliography

[1] Acharya, Sankarshan (1988): "A Generalized Econometric Model and Tests of a Signaling Hypothesis with Two Discrete Signals," *The Journal of Finance*, Vol XLIII, No. 2, 413-429

[2] Allen, Douglas W., and Brinig, Margaret (1998): "Sex, Property Rights, and Divorce," *European Journal of Law and Economics*, 5, 211-33

[3] Baird, Douglas G.; Gertner, Robert H. and Picker, Randal C. (1998): *Game Theory and the Law*, Harvard University Press

[4] Barrett, Catherine M. (2002): "FBI Internet Surveillance: The Need for a Natural Rights Application of the Fourth Amendment to Insure Internet Privacy," 8 *Rich J.L. & Tech.* 16

[5] Baumgardner, J. (2001): "Burden of Proof," *Harper's Magazine*, October

[6] Becker, Gary S. (1974): "A Theory of Social Interactions," *Journal of Political Economy*, vol. 82, no. 6, p.1063-1093

[7] Becker, Gary S. (1968): "Crime and Punishment: An Economic Approach," *Journal of Political Economy*, Volume 76, Number 2, 169-217

[8] Bentham, Jeremy (1825): *A Treatise on Judicial Evidence*, Quality Court, Chancery Lane

[9] Bergstrom, Ted (1989): "Love and Spaghetti, The Opportunity Cost of Virtue," *Journal of Economic Perspectives*, Vol. 3, No. 2, 165-173

[10] Boylan, Richard T. and Long, Cheryl X. (2000): "Size, Monitoring, and Plea Rate: An Examination of United States Attorneys," *Political Economy Working Paper*, Washington University in St. Louis

[11] Bucke, Tom, Street, Robert and Brown, David (2000): "The right to silence: the impact of the Criminal Justice and Public Order Act 1994," *A Research , Development and Statistics Directorate Report*, Home Office Research Study 199, London: Home Office

[12] Cameron, Samuel (1998): "The Economics of Crime Deterrence: A Survey of Theory and Evidence," *Kyklos*, Vol. 41, No. 2, 301-323

[13] Cannon, Bradley C. (1973-74): "Is the Exclusionary Rule in Failing Health? Some New Data and a Plea Against a Precipitous Conclusion," 62 *Ky. L.J.* 681

[14] Cannon, Bradley C. (1991): "Courts and Policy: Compliance, Implementation and Impact," in John B. Gates and Charles A. Johnson, eds., *The American Courts: A Critical Assessment*, Washington, D.C.: CQ Press

[15] Carlsson, H. and van Damme, E. (1993): "Global Games and Equilibrium Selection," *Econometrica*, Vol. 61, 989-1018

[16] Crocker, L. (1993): "Can the exclusionary Rule be Saved?" 84 *The J. of Crim. L. & Criminology* 310

[17] Davies, T.Y. (1983): "A Hard Look At What We Know (and still need to know) About the "Costs" of the Exclusionary Rule: The NIJ Study And Other Studies of "Lost" Arrests," 3 *American Bar Foundation Research Journal* 611

[18] Darwin, Charles (1874): *The Descent of Man, and Selection in Relation to Sex*, New York: Hurst & Company

[19] Duggan, John and Martinelli, Cesar (2001): "A Bayesian Model of Voting in Juries, " *Games and Economic Behavior*, Vol 37, No. 2, 259-94

[20] Duras, Marguerite (1990): *Practicalities*, London: Penguin Books

[21] Eckel, Catherine C., and Grossman, Philip J. (1998): "Are women less selfish than men?: Evidence from Dictator Experiments," *The Economic Journal*, 108, 726-735

[22] Ehrlick, Isaac (1973): "Participation in Illegitimate Activities: A Theoretical and Empirical Investigation," *Journal of Political Economy*, Volume 81, Number 3, 521-65

[23] Ehrlick, Isaac (1996): "Crime, Punishment, and the Market for Offenses," *Journal of Economic Perspectives*, Volume 10, Number 1, 43-67

[24] Feddersen, Timothy and Pesendorfer, Wolfgang (1998): "Convicting the Innocent: The Inferiority of Unanimous Jury Verdicts under Strategic Voting, " *American Political Science Review*, Vol. 92, No. 1, 23-35

[25] Foss, Nicolai J. (2000): "Economics and utopia: Why the learning economy is not the end of history (book review)," *Journal of Economic Literature*, Vol. 38, No. 4, 985-86

[26] Gay, Gerald D.; Grace, Martin F.; Kale, Jayant R.; Noe, Thomas H. (1989): "Noisy Juries and the Choice of Trial Mode in a Sequential Signalling Game: Theory and Evidence," *RAND Journal of Economics*, Vol. 20, No. 2, 196-213.

[27] Glaeser, Edward L., Kessler, Daniel P. and Piehl, Anne Morrison (2000):

"What Do Prosecutors Maximize? An Analysis of the Federalization of Drug Crimes," *American Law and Economics Review*, v.2, n.2, 259-290

[28] Greenfield, Kent (1991): "Cameras in Teddy Bears: Electronic Visual Surveillance and the Fourth Amendment," 58 *U. Chi. L. Rev.* 1045

[29] Harris, David A. (1996): "Superman's X-Ray Vision and the Fourth Amendment: The New Gun Detection Technology," 69 *Temple L. Rev.* 1

[30] Hodgson, Geoffrey M. (1995): "The Political Economy of Utopia," *Review of Social Economy*, Vol. 53, No. 2, 195-213

[31] Huxley, Aldous (1928): *Point Counter Point*, Garden City: Doubleday, Doran and Company

[32] Jackson, J., Wolfe, M. and Quinn, Katie (2000): "Legislating Against Silence: The Northern Ireland Experience," *NIO Research and Statistical Series*, No. 1

[33] Jewkes, Michael P. (2001): "Just Scratching the Surface: DNA Sampling Prior to Arrest and the Fourth Amendment, " 35 *Suffolk U. L. Rev.* 125

[34] Jonas, Hans (1981): "Reflections on Technology, Progress, and Utopia," *Social Research*, Vol. 48, No. 3, 411-55

[35] King, Nancy J. (1993): "Postconviction Review of Jury Discrimination: Measuring the Effects of Juror Race on Jury Decisions," *Michigan Law Review*, Vol 92, No. 1, 63-130

[36] Kinsey, A., et al. (1968): *Sexual Behavior in the Human Female*, Philadelphia: W.B. Saunders Co.

[37] Krantz, Sheldon, Gilman, Bernard, Benda, Charles G., Hallstron, Carol Rogoff, and Nadworny, Eric J. (1979): *Police Policymaking*, Lexington, MA: Lexington Books

[38] Levitt, Steven D. (1997): "Using Electoral Cycles in Police Hiring to Estimate the Effect of Police on Crime," *American Economic Review*, Vol. 87, No. 3, 270-290

[39] Levy, Leonard (1968): *Origins of the Fifth Amendment*, Oxford University Press

[40] Lowen, A. (1975): *Love and Orgasm: A Revolutionary Guide to Sexual Fulfillment*, Collier Books

[41] Mahoney, E.R. (1983): *Human Sexuality*, New York: McGraw-Hill

[42] Mashaw, Jerry L. (1978): "Civil Liability of Government Officers: Property Rights and Official Accountability," *Law and Contemporary Problems*, Vol. 42, No. 1, 8-34

[43] McCarthy, Michael T. (2002): "USA Patriot Act," 39 *Harv. J. on Legis.* 435

[44] Michael, Robert T., Gagnon, John H., Laumann, Edward O., Kolata, Gina (1994): *Sex in America: A Definitive Survey*, Toronto: Little, Brown and Company

[45] Milgrom, Paul R. (1981): "Good News and Bad News: Representation Theorems and Applications," *Bell Journal of Economics*, 12, 380-391

[46] Oaks, Dallin H. (1970): "Studying the Exclusionary Rule in Search and Seizure," 37 *U. Chi. L. Rev.* 665

[47] Orfield Jr., Myron W (1987): "The Exclusionary Rule and Deterrence: An Empirical Study of Chicago Narcotics Officers," 54 *U. Chi. L. Rev.* 1016

[48] Orwell, George (1949): *Nineteen Eighty-Four*, Martin Secker & Warburg Ltd

[49] Owen, Bruce D. (1974): "The Economics of the First Amendment: Discussion," *American Economic Review*, Vol. 64, No. 2, 400-02

[50] Persico, Nicola (2002): "Racial Profiling, Fairness, and Effectiveness of Policing," *American Economic Review*, Vol. 92, No. 5, 1472-1497

[51] Posner, Richard A. (1983): *The Economics of Justice*, Harvard University Press: Cambridge, Massachusetts

[52] Posner, Richard A. (1998): *Economic Analysis of Law*, Aspen Law and Business

[53] P'ng, I. P. L. (1983): "Strategic Behavior in Suit, Settlement, and Trial," *Bell Journal of Economics*, Vol. 14, No. 2, 539-550

[54] Rasmussen, Eric (2000): "An Economic Approach to Adultery Law," in Anthony Dnes and Robert Rowthorn (eds.) *Marriage and Divorce: An Economic Perspective*, Cambridge University Press

[55] Reinganum, Jennifer F. (1988): "Plea Bargaining and Prosecutorial Discretion," *American Economic Review*, Vol. 78, No. 4, 713-728.

[56] Roback, Jennifer (1985): "The Economic Thought of George Orwell," *American Economic Review*, Vol. 75, No. 2, 127-32

[57] Rubin, Paul and Atkins, Raymond A. (1999): "Effects of Criminal Procedure on Crime Rates: Mapping Out the Consequences of The Exclusionary Rule," *The Independent Institute*, Working Paper

[58] Sacerdote, Bruce, and Glaezer, Edward L. (2001): "Education and Religion," NBER Working Paper 8080

[59] Safire, William (2002): "You Are a Suspect," *The New York Times*, November 14

[60] Seabright, Paul (1996): "Accountability and decentralization in Government: An Incomplete Contracts Model," *European Economic Review*, Vol. 40, No. 1, 61-89

[61] Segaller, Stephen (1998): *Nerds 2.0.1: A Brief History of the Internet*, TV Books Inc

[62] Seidmann, Daniel. J. and Stein, Alex (2000): "The Right to Silence Helps the Innocent: A Game-Theoretic Analysis of the Fifth Amendment Privilege," *Harvard Law Review*, 114, 431-510

[63] Shifrin, Orrin S. (1991): "Alabama v. White," 81 *J. Crim. L. & Criminology* 760

[64] Shin, Hyun Song (1998): "Adversarial and inquisitorial procedures in arbitration," *RAND Journal of Economics*, 29, 378-405

[65] Skolnick, Jerome H. (1994): *Justice Without Trial: Law Enforcement in a Democratic Society*, 3rd ed., New York: Macmillan

[66] Spence, A. M. (1973): "Job Market Signaling," *Quarterly Journal of Economics*, 87, 355-374

[67] Spier, Kathryn E. (1992): "The Dynamics of Pretrial Negotiation," *Review of Economic Studies*, Vol. 59, No. 1, 93-108.

[68] Star, Greg (2002): "Airport Security Technology: Is the use of Biometric Identification Technology Valid Under the Fourth Amendment?" 20 *Temp. Envtl. L. & Tech. J.* 251

[69] Vina, Stephen (2002): "Virtual Strip Searches at Airports: Are Border Searches Seeing Through the Fourth Amendment?" 8 *Tex. Wesleyan L. Rev.* 417

[70] Wasby, Stephen L. (1976): *Small-Town Police and the Supreme Court*, Lexington, MA: Lexington Books

[71] Young, Peyton H. (2001): *Individual Strategy and Social Structure: An Evolutionary Theory of Institutions*, Princeton and Oxford: Princeton University Press

[72] Yung, Andrew W. (1996): "Regulating the Genie: Effective Wiretaps in the Information Age," 101 *Dick. L. Rev.* 95

Vita

Hugo Marc Mialon was born in Montreal, Canada on 25 April 1977, the son of Yves Mialon and Elly Gellens. He received the Bachelor of Arts degree in Economics from McGill University. He started the doctoral degree program at the University of Texas at Austin in August 1999.

Permanent Address: 4505 Duval Apt. 109, Austin, TX, 78751, USA

This dissertation was typeset with LaTeX 2_ε[7] by the author.

[7] LaTeX 2_ε is an extension of LaTeX. LaTeX is a collection of macros for TeX. TeX is a trademark of the American Mathematical Society. The macros used in formatting this dissertation were written by Dinesh Das, Department of Computer Sciences, The University of Texas at Austin, and extended by Bert Kay and James A. Bednar.