Exercises 01 - Arguments

1 Identifying the parts of an argument

[Copi, Cohen and McMahon, p. 9] Identify the premises and conclusions in the following passages. Some premises do support the conclusion, others do not. Note that premises may support conclusions directly or indirectly and that even simple passages may contain more than one argument.

A) Sir Edmund Hillary is a hero, not because he was the first to climb Mount Everest, but because he never forgot the Sherpas who helped him achieve this impossible feat. He dedicated his life to helping build schools and hospitals for them. — Patre S. Rajashekhar, "Mount Everest," *National Geographic*, September 2003.

(B) Omniscience and omnipotence are mutually incompatible. If God is omniscient, he must already know how he is going to intervene to change the course of history using his omnipotence. But that means he can't change his mind about his intervention, which means he is not omnipotent. — Richard Dawkins, *The God Delusion*. New York: Houghton Mifflin (2006).

2 Reconstructing the form of an argument

[Copi, Cohen and McMahon, p. 55] Each of the following famous passages, taken from classical literature and phi- losophy, comprises a set of arguments whose complicated interrelations are critical for the force of the whole. Construct for each the diagram that you would find most helpful in analyzing the flow of argument in that passage. More than one interpretation will be defensible.

"... You appeared to be surprised when I told you, on our first meeting, that you had come from Afghanistan."
"You were told, no doubt."
"Nothing of the sort. I knew you came from Afghanistan. From long habit the train of thoughts ran so swiftly through my mind that I arrived at the conclusion without being conscious of intermediate steps. There were such steps, however. The train of reasoning ran, 'Here is a gentle-man of medical type, but with the air of a military man. Clearly an army doctor, then. He has just come from the tropics, for his face is dark, and that is not the natural tint of his skin, for his wrists are fair. He has undergone hardship and sickness, as his haggard face says clearly. His left arm has been injured. He holds it in a stiff and unnatural manner. Where in the tropics could an English army doctor have seen much hardship and got his arm wounded? Clearly in Afghanistan.' The whole train of thought did not occupy a second. I then remarked that you came from Afghanistan, and you were astonished."
"It is simple enough as you explain it," I said, smiling.

A. Conan Doyle, *A Study in Scarlet* (1887)

3 Constructing arguments

[Copi, Cohen and McMahon, p. 32] For each of the argument descriptions provided below, construct a deductive argument (on any subject of your choosing) having only two premises.

1. A valid argument with one true premise, one false premise, and a false conclusion
2. An invalid argument with two true premises and a false conclusion
3. A valid argument with two false premises and a true conclusion
4. A valid argument with two true premises and a false conclusions
5. An invalid argument with one true premise, one false premise, and a true conclusion

Exercises 02 - Proofs

A summary of the rules of inference is available in: Lemmon, E.J. *Beginning Logic*, CRC Press (1998[1965]): pp. 39-40. In the proofs, note that the first column contains the assumption on which the line is dependent: only lines that are *assumed* (= A, in the right-hand column) appear here. The center column contains the result of applying a *rule of inference* to one or more of the previous lines, each of these lines is numbered progressively, to mark the *length* of a proof. The right hand column is explicative: it indicates the numbers of those lines on which the *rule of inference* is applied, and which *rule of inference* has been used to obtain that line. *Every* line in a proof is obtained either by assumption (A, marked on the right-hand column) or by application of one of the *rules of inference* from one or more of the previous lines.

1 Translate and prove

[Copi, Cohen and McMahon, p. 340] Translate the following verbal sentence into formal propositional logic, using the notation that is the most familiar to you, and prove the inference using both truth tables and natural deduction: "If Denmark refuses to join the European Community, then, if Estonia remains in the Russian sphere of influence, then Finland will reject a free-trade policy. Estonia will remain in the Russian sphere of influence. So if Denmark refuses to join the European Community, then Finland will reject a free-trade policy."

2 Notable theorems

In the following you shall provide proofs for a number of notable theorems. Prove all of the following theorems using natural deduction.

2.1 Three laws of thought — see Copi-Cohen, pp. 351-352

2.1.1 Principle of identity — *if* P, *then* P

$\vdash P \rightarrow P$

2.1.2 Principle of noncontradiction — *not*-(P *and not*-P)

$\vdash \sim (P \wedge \sim P)$

2.1.3 Principle of excluded middle — P *or not*-P

$\vdash P \vee \sim P$

2.2 De Morgan Theorems

2.2.1 De Morgan 1 — from disjunction negation to negated conjuncts

$\sim (P \vee Q) \vdash \sim P \wedge \sim Q$

2.2.2 De Morgan 2 — from negated conjunction to negated disjuncts

$\sim (P \wedge Q) \vdash \sim P \vee \sim Q$

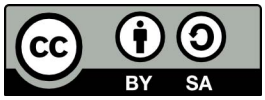
2.3 Implication theorems

2.3.1 Implication 1 — from implicature to conjuncts

$P \rightarrow Q \vdash \sim (P \wedge \sim Q)$

2.3.2 Implication 2 — falsification of hypotheses

$P \rightarrow Q, \sim Q \vdash \sim P$



Exercises 03 - Fallacies

1 Relevance

[Copi, Cohen and McMahon, pp. 125-126] Identify and explain the fallacies of relevance in the following passages:

(A) I was seven years old when the first election campaign which I can remember took place in my district. At that time we still had no political parties, so the announcement of this campaign was received with very little interest. But popular feeling ran high when it was disclosed that one of the candidates was "the Prince." There was no need to add Christian and surname to realize which Prince was meant. He was the owner of the great estate formed by the arbitrary occupation of the vast tracts of land reclaimed in the previous century from the Lake of Fucino. About eight thousand families (that is, the majority of the local population) are still employed today in cultivating the estate's fourteen thousand hectares. The Prince was deigning to solicit "his" families for their vote so that he could become their deputy in parliament. The agents of the estate, who were working for the Prince, talked in impeccably liberal phrases: "Naturally," said they, "naturally, no one will be forced to vote for the Prince, that's understood; in the same way that no one, naturally, can force the Prince to allow people who don't vote for him to work on his land. This is the period of real liberty for everybody; you're free, and so is the Prince." The announcement of these "liberal" principles produced general and understandable consternation among the peasants. For, as may easily be guessed, the Prince was the most hated person in our part of the country.

Ignazio Silone, *The God That Failed* (1949)

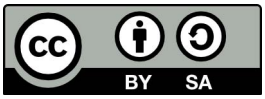
(B) Gender feminism is notoriously impossible to falsify: it chews up and digests all counter-evidence, transmuting it into confirming evidence. The fact that most people, including most women, do not see the pervasive and tenacious system of male power only shows how thoroughly they have been socialized to perpetuate it. The more women who reject the gender feminist perspective, the more this proves them in thrall to the androcentric system. Nothing and no one can refute the hypothesis of the sex-gender system for those who see it so clearly "everywhere."

Christina Sommers, *Proceedings of the American Philosophical Association*, June 1992

2 Defective induction and presumption

[Copi, Cohen and McMahon, pp. 142-144] Identify and explain any fallacies of defective induction or of presumption in the following passages:

(A) My generation was taught about the dangers of social diseases, how they were contracted, and the value of abstinence. Our schools did not teach us about contraception. They did not pass out condoms, as many of today's schools do. And not one of the girls in any of my classes, not even in college, became pregnant out of wedlock. It wasn't until people began teaching the children about contraceptives that our problems with pregnancy began.



Frank Webster, "No Sex Education, No Sex," *Insight* 17 November 1997

(B) There is no surprise in discovering that acupuncture can relieve pain and nausea. It will probably also be found to work on anxiety, insomnia, and itching, because these are all conditions in which placebos work. Acupuncture works by suggestion, a mechanism whose effects on humans are well known. The danger in using such placebo methods is that they will be applied by people inadequately trained in medicine in cases where essential preliminary work has not been done and where a correct diagnosis has not been established.

Fred Levit, M.D., "Acupuncture Is Alchemy, Not Medicine," *The New York Times*, 12 November 1997

(C) "...I've always reckoned that looking at the new moon over your left shoulder is one of the carelessest and foolishest things a body can do. Old Hank Bunker done it once, and bragged about it; and in less than two years he got drunk and fell off of the shot tower, and spread himself out so that he was just a kind of a layer, as you may say; and they slid him edgeways between two barn doors for a coffin, and buried him so, so they say, but I didn't see it. Pap told me. But anyway it all come of looking at the moon that way, like a fool."

Mark Twain, *The Adventures of Huckleberry Finn* (1885)

3 Ambiguity

[Copi, Cohen and McMahon, pp. 152] Identify and explain the fallacies of ambiguity that appear in the following passages:

(A) No man will take counsel, but every man will take money: therefore money is better than counsel. *Jonathan Swift*

4 Identifying and discussing fallacies

[Copi, Cohen and McMahon, chapter 5] Each of the following passages may be plausibly criticized by some who conclude that it contains a fallacy, but each may be defended by some who deny that the argument is fallacious. Discuss the merits of the argument in each passage, and explain why you conclude that it does (or does not) contain a fallacy. Explain why, in the case of some, it may be plausibly argued that what appears at first to be a fallacy is not, when the argument is interpreted correctly.

(A) The only proof capable of being given that an object is visible, is that people actually see it. The only proof that a sound is audible, is that people hear it: and so of the other sources of our experience. In like manner, I apprehend, the sole evidence it is possible to produce that anything is desirable, is that people actually desire it.

John Stuart Mill, *Utilitarianism* (1863)

(B) The Inquisition must have been justified and beneficial, if whole peoples invoked and defended it, if men of the loftiest souls founded and created it severally and impartially, and its very adversaries applied it on their own account, pyre answering to pyre.

Benedetto Croce, *Philosophy of the Practical* (1935)

(C) If science wishes to argue that we cannot know what was going on in [the gorilla] Binti's head when she acted as she did, science must also acknowledge that it cannot prove that nothing was going on. It is because of our irresolvable ignorance, as much as fellow-feeling, that we should give animals the benefit of doubt and treat them with the respect we accord ourselves.

Martin Rowe and Mia Macdonald, "Let's Give Animals Respect They Deserve," *The New York Times*, 26 August 1996

Exercises 04 - Reconstructing and analyzing arguments and fallacies

Reconstruct the argument of the paper by Peter T. Leeson (2012) "Ordeals" *Journal of Law and Economics* Vol. 55.

Like in Exercise 01, try to identify premises and conclusions, as well as the logical form of the argument. Try to be critical about the argument: do the premises support the conclusions? Which premises are doing most of the work and which ones are accessory or just rhetorical? Is the argument convincing? Does it contain fallacies? Would you argue with its premises (they may be false) or with the validity of its conclusions (the argument is invalid)?

Prepare the discussion and share your answers to the above questions in class.

Ordeals

Peter T. Leeson *George Mason University*

Abstract

I argue that medieval judicial ordeals accurately assigned accused criminals' guilt and innocence. They did this by leveraging a medieval superstition called *iudicium Dei* (judgments of God). According to that superstition, God condemned the guilty and exonerated the innocent through clergy-conducted physical tests. Medieval citizens' belief in *iudicium Dei* created a separating equilibrium in which only innocent defendants were willing to undergo ordeals. Conditional on observing a defendant's willingness to do so, the administering priest knew he or she was innocent and manipulated the ordeal to find this. My theory explains the peculiar puzzle of ordeals: trials of fire and water that should have condemned most persons who underwent them did the reverse. They exonerated these persons instead. Boiling water rarely boiled persons who plunged their arms in it. Burning iron rarely burned persons who carried it. Ordeal outcomes were miraculous, but they were miracles of mechanism design.

> It is a fearful thing to fall into the hands of the living God. [Heb. 10:31]

1. Introduction

For 400 years the most sophisticated persons in Europe decided difficult criminal cases by asking the defendant to thrust his arm into a cauldron of boiling water and fish out a ring. If his arm was unharmed, he was exonerated. If not, he was convicted. Alternatively, a priest dunked the defendant in a pool. Sinking proved his innocence. Floating proved his guilt. People called these trials ordeals.[1]

I thank Gary Becker, Omri Ben-Shahar, Peter Boettke, Richard Brooks, Dennis Carlton, Christopher Coyne, Frank Easterbrook, David Friedman, Todd Henderson, Emir Kamenica, Roger Koppl, William Landes, Steven Levitt, Anup Malani, David Myatt, Emily Oster, Alexandre Padilla, Eric Posner, Richard Posner, Jesse Shapiro, Steven Shavell, Andrei Shleifer, and Virgil Storr; seminar participants at Harvard Law School, Stanford Law School, and the University of Chicago; the editors; and an anonymous reviewer for helpful comments. I also thank the Becker Center on Chicago Price Theory at the University of Chicago, where I conducted this research.

[1] Several other ordeals existed, but they were rarely used and generally unimportant. Where they were more important, I discuss them.

[*Journal of Law and Economics*, vol. 55 (August 2012)]

No one alive today believes ordeals were a good way to decide defendants' guilt. But maybe they should. This paper argues that ordeals accurately assigned accused criminals' guilt and innocence. They did this by leveraging a medieval superstition called *iudicium Dei* (judgments of God). According to that superstition, God condemned the guilty and exonerated the innocent through clergy-conducted physical tests.[2]

Medieval citizens' belief in *iudicium Dei* created a separating equilibrium. Guilty defendants expected ordeals to convict them. Innocent defendants expected the reverse. Thus, only innocent defendants were willing to undergo ordeals. Conditional on observing a defendant's willingness to do so, the administering priest knew he or she was innocent and manipulated the ordeal to find this.

My theory explains the peculiar puzzle of ordeals: trials of fire and water that should have condemned most persons who underwent them did the reverse. They exonerated these persons instead. Boiling water rarely boiled persons who plunged their arms in it. Burning iron rarely burned persons who carried it. Ordeal outcomes were miraculous, but they were miracles of mechanism design.

It is easy to dismiss ordeals as the irrational custom of Dark Age ignorance. Much scholarship that addresses ordeals treats them as such (see, for instance, Robertson 1782; Gibson 1848; Plucknett 1956; Baldwin 1961; Caenegem 1988). More recently, several authors have attempted to rescue ordeals from European legal history's museum of the absurd. One account argues that ordeals facilitated community consensus and unity (Colman 1974; Brown 1975; Hyams 1981). Another account suggests that ordeals were criminal punishments (Lea 1973; Hyams 1981).[3] A third argues nearly the opposite: ordeals were a tool of mercy, a way to get criminals off the hook (Kerr, Forsyth, and Plyley 1992).

No one seriously entertains the idea that ordeals actually did what they were supposedly designed to do: determine whether defendants were guilty of the

[2] Unilateral judicial ordeals were not the only medieval judicial procedures grounded in the *iudicium Dei* superstition. Oath swearing and, to a much lesser extent, judicial battle were also connected to this belief.

[3] This view is the most natural one for a rational choice scholar to hold. Efficient criminal punishment imposes a high penalty on criminals with a low probability (Becker 1968). In the context of ordeals, that would mean one of two things. If the ordeal itself was supposed to be the punishment, it would mean using ordeals infrequently and boiling or burning everyone to whom they were applied. But ordeals were used in exactly the opposite way: they were used frequently and boiled or burned only a small percentage of those to whom they were applied. If the boiling or burning was supposed to be the punishment, it would mean boiling or burning only a small percentage of accused persons but not going through the costly process of pretending to boil or burn every accused person, which is what ordeals did. Closely related, if boiling or burning was the desired punishment, ordeals were a highly inefficient way to administer it. Ordeals were multiday undertakings that involved masses, endless rituals, and so on. It is much cheaper to just boil or burn persons instead. A third reason ordeals do not make sense as punishments is that they were applied indiscriminately (that is, without regard to an accused person's guilt or innocence since this had not been determined yet). The theory of efficient punishment says something like "boil every tenth criminal." But ordeals boiled every tenth accused person, which is very different. Finally, while punishments have the same expected cost for guilty and innocent persons, ordeals had different expected costs for them. The features of ordeals are consistent with the idea of ordeals as fact-finding procedures, not punishments.

crimes of which they were accused.[4] My analysis uses rational choice theory to show how ordeals did just that. In doing so, I develop a law and economics of superstition. The law and economics of superstition explores the role that objectively false beliefs play in the legal systems of rational people.

Almost no work uses rational choice theory to investigate superstition's persistence or relationship to the law. Fudenberg and Levine's (2006) model of superstitious beliefs and Posner's (1980) study of the economics of legal systems in primitive societies are two exceptions to this. Fudenberg and Levine consider how certain superstitions can persist even when individuals are patient, rational learners. They show how superstitions can influence rational actors' equilibrium behavior. In my theory of ordeals, superstition also determines individuals' decision making in equilibrium. Further, the superstition-supported equilibrium is self-confirming. This contributes to superstition's persistence, but superstition persists for another reason too: it is socially useful.

This aspect of my analysis is most closely connected to that of Posner (1980). Posner notes superstition's prominence in primitive societies. He suggests that some of these societies' objectively false beliefs may actually promote their well-being. For instance, the belief that wealthy group members are witches helps some primitive societies enforce a norm of group sharing that permits social insurance. My analysis, which finds that medieval judicial ordeals accurately assigned accused criminals' guilt and innocence, complements Posner's suggestion that some superstitions are socially productive.

Most relevant to my argument, Posner (1980, p. 47) points out that certain societies' religious beliefs discourage criminals from concealing their crimes. For instance, if individuals believe it is unlucky to eat with the kin of men they have slain, to avoid this fate they are encouraged to announce their deed when they have killed a stranger. Their religious belief facilitates legal fact finding where conventional fact-finding methods are prohibitively costly.

This insight is directly relevant to ordeals. Ordeals were an institution of self-finding facts where traditional fact-finding methods were not helpful. Their beauty lay in the simple but ingenious way in which they incentivized accused criminals to unwittingly reveal their guilt or innocence.

2. *Iudicium Dei*

The golden age of unilateral European judicial ordeals was the ninth through thirteenth centuries.[5] Two types of ordeals flourished in this age: hot and cold.[6]

[4] Several authors have suggested that the physical aspects of ordeals may have made it physiologically harder for guilty persons to pass them than innocent persons because of guilt-induced bodily stress. For instance, see Plucknett (1956), Roberts (1965), Colman (1974), Hyams (1981), Caenegem (1988), and Pilarczyk (1996).

[5] Reliance on judicial ordeals appears in the earliest of legal codes the world over. On the ubiquity and varieties of ordeals, see Gilchrist (1821), Groitein (1923), and Lea (1866).

[6] When this paper refers to "ordeals," it is referring to hot and cold ordeals. Some legal systems gave the plaintiff the right to choose the kind of ordeal the defendant would undergo. Other systems gave the defendant the right to choose, but ordinarily the court chose. See Lea (1973, pp. 45–46).

Hot ordeals included hot-water and hot-iron ordeals (*iudicium aquae fervantis* and *iudicium ferri*).[7] Cold ordeals included cold-water ordeals (*probatio per aquam frigidam*).[8]

In the hot-water ordeal, a priest boiled a cauldron of water into which he threw a stone or ring.[9] As Bishop Eberhard of Bamburg's late-twelfth-century breviary instructed, the proband "shall plunge his hand into the boiling water" and recover the object. "[A]fterwards let [his hand] be immediately sealed up."[10] If he is innocent, the proband will succeed in "bring[ing] forth his hand safe and unharmed from this water. But if he be guilty and presume to plunge in his hand," it will show harm from burning on inspection 3 days later (Howland 1901, pp. 7–9). The hot-iron ordeal worked similarly, but instead of plunging his arm into a cauldron of water, the proband carried a piece of burning iron nine paces.[11]

Ninth-century theologian Hincmar of Rheims described the cold-water ordeal as follows: "[H]e who is to be examined by this judgment is cast into the water bound, and is drawn forth again bound." If he is guilty and "seeks to hide the truth by a lie, [he] cannot be submerged": he will float (Howland 1901, p. 11). If he is innocent, he can be submerged: he will sink.

The law reserved ordeals for certain cases. England used them only in criminal cases—accusations of homicide, robbery, arson, and so on.[12] Punishments for failing ordeals ranged from fines, to mutilation, to death.[13] The rest of Europe used ordeals mostly in criminal cases but sometimes in civil cases too.[14]

The law also reserved ordeals for cases in which judges could not confidently conclude defendants' guilt or innocence without them (Bartlett 1986; Bloomfield

[7] The hot-water and hot-iron ordeals sometimes came in "strengths" corresponding to the severity of the alleged crime or extent of the defendant's disrepute. The single hot-water ordeal involved the proband putting his arm into boiling water only up to his wrist. The single hot-iron ordeal involved carrying a piece of hot iron that weighed only 1 pound. The triple hot-water ordeal involved the proband putting his arm in boiling water up to the elbow. The triple hot-iron ordeal involved carrying a piece of iron that weighed 3 pounds.

[8] Hot-water ordeals are older. They first appear in the *Lex Salica* circa 507–11. Cold-water ordeals are a ninth-century invention.

[9] The particulars of ordeals varied by time and place, but their basics were similar. Throughout the existence of ordeals, individuals invoked them for a variety of purposes ranging from political (Who is the rightful heir to this office?) to religious (Is this relic genuine?). I exclusively consider ordeals invoked for judicial purposes.

[10] The proband was the person who underwent the ordeal. Usually this was the defendant, although occasionally plaintiffs were probands as well.

[11] On the continent, justice systems sometimes used another variety of hot ordeal—the hot-plowshares ordeal. The idea was the same as in the other hot ordeals, but the proband walked across hot plowshares instead of thrusting his arm into boiling water or carrying burning iron.

[12] There are a few post–Norman conquest cases of English ordeals in civil cases, but they are rare.

[13] For example, in pre-eleventh-century England, criminal punishment was financial (Klerman 2001, p. 5). Under the Assize of Clarendon, criminal punishment was mutilation. Under the Assize of Northampton, it was death. The Assizes of Clarendon and Northampton required defendants who passed the ordeal but whose community members considered them of "very bad repute" and "evilly defamed by the testimony of many legal men" to "abjure the realm" (Howland 1901, p. 16).

[14] It is likely that part of the reason ordeals were more commonly used in criminal cases than in civil ones is that evidence was typically harder to get in the former.

1969; Davies and Fouracre 1986; Groitein 1923; Lea 1866; McAuley 2006; Miller 1988; Thayer 1898).[15] As thirteenth-century German law put it, "It is not right to use the ordeal in any case, unless the truth may be known in no other way" (Bartlett 1986, p. 26).

If a defendant confessed or reliable witnesses testified against him, the court would convict him without an ordeal.[16] Where the court considered the accusation plausible but such evidence was lacking, it often permitted the defendant to exonerate himself by swearing off the accusation with an oath. The court could order defendants to take oaths alone or with a specified number of oath helpers to assist them.

Oath swearing had limited usefulness. Certain defendants' oaths were unacceptable, such as those of unfree persons, who composed much of the medieval population. Foreigners, persons who perjured themselves, those who had failed in a legal contest, and those with tarnished reputations also had unacceptable oaths. In cases in which oath helping was used, defendants' inability to produce the requisite number of compurgators created a similar problem. Justice systems unwilling to convict or exonerate accused persons indiscriminately when regular evidence was silent needed another way to determine their guilt or innocence.[17] That way was ordeals.[18]

The ostensible power of ordeals to determine defendants' guilt or innocence rested on the idea that they were *iudicia Dei*. Where man could not correctly assign criminal status, he recruited the Lord. As a Carolingian capitulary put it, "Let doubtful cases be determined by the judgment of God. The judges may decide that which they clearly know, but that which they cannot know shall be reserved for Divine judgment" (Lea 1866, p. 176). According to medieval Christian belief, if priests performed the appropriate rituals, God would reveal individuals' guilt by letting boiling water or burning iron harm them (or making holy water reject their guilty bodies) and reveal their innocence by miraculously saving their limbs from harm (or accepting their guiltless bodies into his blessed pool).

[15] Before the thirteenth century, a panel of judges or court presidents usually heard criminal cases. Depending on the court, judges included royal justices, clerics, counts, and local landowners. Judges decided whether an ordeal was required and, if so, which one. As I discuss, clerics administered and officiated ordeals.

[16] The Assizes of Clarendon and Northampton required ordeals for all major crimes. However, in practice, courts did not order accused persons to undergo ordeals if there was clear evidence of their guilt (Groot 1982). For a summary of some basic features of Anglo-Saxon law, see Pollock (1898) and Pollock and Maitland (1959).

[17] Since evidence was absent for crimes involving unobservable acts or states of mind, ordeals were often used to try accusations of magic, idolatry, and heresy. Other crimes unlikely to produce evidence that often used ordeals include incest and adultery.

[18] A court might also order an ordeal if the law prescribed judicial combat but one of the would-be combatants could not fight (for instance, if she were a woman) and could not find a champion to replace her or if the defendant had no specific accuser to combat (because he had been accused on public suspicion).

3. Law, Economics, and Superstition

3.1. A Theory of Medieval Judicial Ordeals

There are two obvious alternatives to asking God to find facts in doubtful cases. Judges could ask accused persons whether they are guilty. Alternatively, they could threaten to torture accused persons to encourage them to tell the truth. The trouble with these approaches is that they produce significant mistakes. Every accused person asked about his guilt proclaims his innocence. Torture has the opposite problem: if its threat is ominous enough to prompt guilty persons to confess, it is ominous enough to prompt innocent persons to confess too.

In contrast, ordeals could correctly identify defendants' guilt or innocence because they imposed different expected costs on the guilty and innocent. Consider how a medieval citizen's belief that ordeals were *iudicia Dei* influenced his incentive to undergo or decline an ordeal.

Suppose a medieval farmer accuses his neighbor, Frithogar, of stealing his beast. Frithogar denies it. The farmer has no witnesses but is well respected. Frithogar is not. The court does not believe the farmer would accuse Frithogar for no reason. It orders Frithogar to undergo the hot-water ordeal.

Frithogar believes in *iudicium Dei*. He believes that by performing the appropriate rituals, priests can ask God to reveal his guilt or innocence through the hot-water ordeal and that God will do so. To evidence his innocence, God will perform a miracle that prevents the boiling water from harming his arm. To evidence his guilt, God will let the boiling water harm him.

Below I consider what happens when Frithogar is a skeptic—when he believes the foregoing might be true but his belief is incomplete. For now, assume his belief that ordeals are *iudicia Dei* is complete. What will Frithogar do?

Suppose Frithogar stole the farmer's beast. He knows this, but nobody else knows. In this case, if Frithogar undergoes the ordeal, he expects to burn his arm. Moreover, by doing so, he expects to reveal his guilt and thus to suffer the legal punishment for stealing beasts: a large fine. Frithogar's other option is to decline the ordeal. He can avoid the ordeal by confessing his crime or settling with the farmer. Both alternatives punish him,[19] but neither is as punishing as the fine for stealing beasts. By declining the ordeal, Frithogar suffers less punishment than if he undergoes it.[20] He also saves his arm. Thus, if he is guilty, Frithogar chooses to decline the ordeal.

Now suppose Frithogar is innocent. The farmer's beast wandered off. Frithogar knows he did not steal it, but nobody else knows. In this case, if Frithogar

[19] He can also avoid the ordeal by fleeing his town. But for this example I suppose that fleeing is more costly to Frithogar than confessing or settling, so Frithogar never considers this option.

[20] Judges considered a person's refusal to undergo an ordeal evidence of guilt. For example, when Walicherius of Brion claimed a vineyard as his own against several monks and, failing to receive warranty from a man he alleged could warrant his claim, the court ordered him to undergo an ordeal, Walicherius refused. When he later revived his claim in Angers and the court learned of his refusal to undergo the ordeal in Brion, it found against him (White 1995, pp. 115–16).

undergoes the ordeal, he expects to deliver his arm from the boiling water unharmed. Moreover, by doing so, he expects to reveal his innocence and thus to avoid legal punishment. If Frithogar declines the ordeal and confesses or settles instead, he suffers a punishment for a crime he did not commit. Thus, if he is innocent, Frithogar chooses to undergo the ordeal.

The ordeal creates a separating equilibrium that sorts Frithogar by his guilt or innocence. It does this by satisfying the single-crossing condition: if he is innocent, Frithogar finds it cheaper to undergo the ordeal than if he is guilty. The ordeal leverages Frithogar's superstition—his objectively false belief that ordeals are *iudicia Dei*—to incentivize him to reveal his criminal status to the legal system.

3.2. Iudicia Cleri

In the equilibrium just described, guilty persons never undergo ordeals. Innocent ones always do. But what happens to them when they do?

Ordeals work only if they do not injure the people who undergo them. They exonerate only probands they do not harm. Short of genuine *iudicia Dei,* how can boiling water be made innocuous to human flesh?

By *iudicia cleri.* Because of the sorting effect of ordeals, priests who administer them learn of defendants' guilt or innocence. Conditional on observing a defendant's willingness to undergo an ordeal, the administering priest knows the defendant is innocent. Knowing this, the priest can fix the ordeal to find the correct result. For example, if Frithogar chooses to undergo his ordeal, the ordeal-administering priest can lower the water's temperature so it does not boil him. Frithogar plunges his arm into the cauldron expecting to be unharmed. His expectation is fulfilled—not by God but by the newly informed priest.

To accomplish such manipulation, priests required latitude in their administration of ordeals. Liturgical *ordines* and royal dooms prescribed ordeal instructions for clerical administrators. A striking feature of these instructions is the scope they created for priestly ordeal fixing. Consider the clerical instructions for the hot-iron ordeal prescribed by a tenth-century English doom (Howland 1901, pp. 12–13):

> Concerning the ordeal we enjoin in the name of God and by the command of the archbishop and of all our bishops that no one enter the church after the fire has been brought in with which the ordeal is to be heated except the priest and him who is to undergo judgment. . . . Then let an equal number from both sides enter and stand on either side of the judgment place along the church. . . . And no one shall mend the fire any longer than the beginning of the hallowing, but let the iron lie on the coals until the last collect. . . . And let the accused drink of the holy water and then let the hand with which he is about to carry the iron be sprinkled, and so let him go [to the ordeal].[21]

Several features of these instructions stand out (Henry 1789, p. 273). First,

[21] Hot-water ordeal instructions were similar. See Howland (1901, pp. 7–9).

only the priest and proband were initially allowed in the church after the priest made the ordeal fire. This gave the priest opportunity to manipulate the fire and thus the iron's temperature. The doom indicates that before the proband begins the ordeal, "two men from each side go in and certify that [the iron] is as hot as we have directed it to be" (Howland 1901, p. 12). But the priest's isolation until this point allowed him to defraud the certifiers, for example, by providing them with a different iron for inspection than he provided the proband.

Second, the ordeal ceremony forbade mending the fire after the communion consecration. It required the iron to remain on dying coals until the priest made his final prayer. If the priest failed to manipulate the fire's temperature or switch the iron, he could let the iron cool before the proband handled it by delaying and drawing out the final prayer.

Third, the ordeal ceremony required observers to align along the church's walls for the ordeal's duration. In a reasonable-sized church, this put them a considerable distance from the ordeal stage. By diminishing observers' ability to observe, that distance facilitated priestly chicanery.

Finally, the ordeal instructions directed the priest to sprinkle the proband's hand with holy water immediately before he carried the iron. It is easy to imagine how sprinkling could become dousing under a manipulative priest's control. The water helped offset any injurious heat remaining on the iron that fire fixing or iron tampering failed to address.

Hot-ordeal formulae also granted clerics discretion in deciding the outcomes of ordeals (see, for instance, Colman 1974; Brown 1975; Ho 2003–4). They instructed the proband's "hand [to] be sealed up, and on the third day" for the priest to examine "whether it is clean or foul within the wrapper" (Howland 1901, pp. 12–13). But they were silent about what it meant for a hand to be "clean or foul." The hand's state depended largely on the priest's judgment.[22]

Cold-water ordeals permitted outcome fixing too but in a different way (see also Radding 1979). Men have less body fat than women. Because of this, while the average lean male has an 80 percent chance of sinking in water, the average lean woman has only a 40 percent chance (Kerr, Forsyth, and Plyley 1992, p. 586). This difference enabled manipulation of cold-water ordeals through the selection of who was sent to them. If cold-water ordeals were used only for men, priests could reliably exonerate persons who underwent them.[23]

Because of priestly manipulation, the separating equilibrium that ordeals create

[22] However, in West Frisian Synod Law, in certain cases it was possible to appeal to the community to decide ordeals' outcomes (Colman 1974, p. 590).

[23] Whether priests believed that ordeals were *iudicia Dei* or instead understood that they were really *iudicia cleri* is an interesting historical question but unimportant for my theory. As long as priests manipulate ordeals to reflect the information they receive about defendants' guilt or innocence after defendants decide to decline or undergo them, ordeals are effective. The evidence is unclear about what priests truly believed. However, it is important to point out that priestly manipulation of ordeals is not incompatible with priestly faith in ordeals as genuine *iudicia Dei*. According to the developing doctrine of *in persona Christi*, priests may have believed that they were acting in the person of Christ—that is, that God was guiding them—when they manipulated ordeals.

is self-confirming when individuals start with the certainty that ordeals are *iudicia Dei*. Guilty persons always expect ordeals to harm them and find them guilty in the process. They always decline ordeals. So guilty persons' belief is never challenged. Innocent persons always expect ordeals to not harm them and exonerate them in the process. They always undergo ordeals. Having observed their willingness to do so, ordeal-administering priests infer these persons' innocence. Priests fix ordeals to exonerate them.[24] So innocent persons' expectation is always fulfilled. In equilibrium, the only evidence that ordeals generate confirms the belief that they are *iudicia Dei*. Ordeals reinforce the superstition that makes them effective.

3.3. Skeptics

The equilibrium described above illustrates how ordeals work when individuals have complete faith in them, but it breaks down if we allow that faith to be incomplete. If instead of assuming that defendants never question the outcomes of ordeals, we allow defendants to update their beliefs about the legitimacy of ordeals after observing the history of these outcomes just as we allow priests to update their beliefs about defendants' guilt or innocence after observing defendants' decisions to decline or undergo ordeals, this equilibrium might implode.

Here, everyone who undergoes an ordeal is exonerated. But a 100 percent acquittal rate may seem suspicious to persons whose belief that ordeals are *iudicia Dei* is incomplete.[25] Individuals may be skeptical about ordeals for other reasons too. The presence of observers at ordeals suggests that medieval citizens at least entertained the idea that ordeals' outcomes could reflect worldly influences in addition to otherworldly ones.

Skeptics pose a potential problem for ordeals. Innocent skeptics may decide they do not want to hazard ordeals because they fear the possibility that boiling water will boil them, burning iron will burn them, and so on. If everyone passes ordeals, innocent skeptics' fear disappears. But then the problem raised above emerges: guilty skeptics may decide they want to hazard ordeals. In both cases pooling occurs, destroying the ability of ordeals to distinguish guilty persons from innocent ones. How did ordeal-administering priests overcome this problem?

They condemned a positive proportion of probands. To see how this worked, consider a defendant, *j*, ordered to an ordeal: $j \in \{j_g, j_i\}$. When j is guilty of the crime he has been accused of, $j = j_g$. When j is innocent of the crime he has

[24] Although bribing the priest was of course possible, there was a check on this: priests worked for privately owned bishoprics whose owners' revenues depended on local producers' productivity and thus lower rates of crime, which in turn necessitated judicially honest priests. These owners therefore had an incentive to limit priestly corruption of ordeals, for example, by firing corrupt priests, where they could.

[25] Persons with complete belief totally discount the possibility that observed outcomes of ordeals are anything other than God's work. They interpret a 100 percent acquittal rate as evidence that 100 percent of probands were innocent and thus saved by God.

been accused of, $j = j_i$.[26] Defendant j can undergo the ordeal or decline it. If j undergoes the ordeal and is found guilty, he earns β. If j undergoes the ordeal and is found innocent, he earns 0. If j declines the ordeal, he earns θ. As in Frithogar's case, $0 > \theta > \beta$.[27]

But j is a skeptic. He believes ordeals may be *iudicia Dei,* but he also believes they may be a sham perpetrated by crafty priests. Thus, $\rho \in (0, 1)$ measures the strength of j's belief that ordeals are *iudicia Dei,* [28] where ρ is the probability j assigns to God's revealing his guilt through the ordeal if $j = j_g$ or the probability he assigns to God's revealing his innocence through the ordeal if $j = j_i$. Further, j's priest condemns a proportion of defendants who undergo ordeals equal to $\gamma \in (0, 1)$, and j knows probands' historical success rate.

From j_g's perspective, if ordeals are *iudicia Dei,* γ reflects guilty persons who underwent ordeals and were condemned by God, which would happen to him if he underwent the ordeal since he is guilty. If ordeals are a sham, γ reflects priestly condemnations of defendants who underwent ordeals and thus the probability that he would be condemned if he underwent the ordeal. Therefore, j_g declines the ordeal if $\rho\beta + (1 - \rho)\beta\gamma < \theta$. This is true for any $\gamma > (\theta - \rho\beta)/(\beta - \rho\beta)$.

From j_i's perspective, if ordeals are *iudicia Dei,* γ reflects guilty persons who underwent ordeals and were condemned by God, which would not happen to him if he underwent the ordeal since he is innocent. If ordeals are a sham, γ reflects priestly condemnations of defendants who underwent ordeals and thus the probability that he would be condemned if he underwent the ordeal. Therefore, j_i undergoes the ordeal if $\rho 0 + (1 - \rho)\beta\gamma > \theta$. This is true for any $\gamma < \theta/(\beta - \rho\beta)$.

To ensure a separating equilibrium, the priest must condemn enough probands to deter guilty skeptics from wanting to undergo ordeals (which would create a pooling equilibrium that involved all defendants choosing to undergo ordeals) but not so many probands as to also deter innocent skeptics from wanting to do so (which would create a pooling equilibrium that involved all defendants declining ordeals). The priest must condemn $\theta/(\beta - \rho\beta) > \gamma > (\theta - \rho\beta)/(\beta - \rho\beta)$.

Since where $\rho \in (0, 1)$ and $0 > \theta > \beta$, $\forall\rho : \theta/(\beta - \rho\beta) > (\theta - \rho\beta)/(\beta - \rho\beta) \Rightarrow \exists\gamma : \theta/(\beta - \rho\beta) > \gamma > (\theta - \rho\beta)/(\beta - \rho\beta)$. By adjusting the proportion of

[26] I assume that, although the legal system does not initially know whether j is guilty or innocent, j knows whether he is guilty or innocent. This is a reasonable assumption in most cases, although it may not always hold. Suppose that j's legal system does not distinguish between justifiable homicide and ordinary murder. In this case, although j may know that he killed the person he is accused of killing, he may be uncertain about his guilt from God's, and thus the ordeal's, perspective.

[27] In practice, different ordeal alternatives will have different prices. But for my purpose, which is to examine the decision to decline or undergo an ordeal, this is unimportant. I therefore treat all ordeal alternatives as requiring the defendant to pay the same price, θ.

[28] I assume that j and the priest know j's level of belief. Medieval priests knew how often their community members went to church, received Communion, confessed, and practiced other religious rituals. So this assumption is reasonable. Others observe j's level of belief imperfectly.

probands he condemns, the priest can use ordeals to support a separating equilibrium for any positive level of belief that ordeals are *iudicia Dei*.

The priest prefers not to condemn any innocent persons. Therefore he sets $\gamma = \gamma^{\star} \equiv (\theta - \rho\beta)/(\beta - \rho\beta) + \varepsilon$. This minimizes the number of innocent probands he must condemn to ensure separation given the strength of individuals' belief that ordeals are *iudicia Dei*.

The optimal proportion of probands the priest condemns decreases as individuals' belief that ordeals are *iudicia Dei* increases.[29] As ρ approaches θ/β, which is the lowest level of belief that prevents a pooling equilibrium in which both guilty and innocent persons choose to undergo ordeals without the priest condemning any innocent probands, $\gamma^{\star}$ approaches zero. As ρ approaches zero, $\gamma^{\star}$ approaches θ/β, which is the highest proportion of innocent probands the priest can condemn without driving all defendants into a pooling equilibrium in which both guilty and innocent persons decline ordeals.

It is useful to consider how, starting in disequilibrium, potential probands' and priests' behavior could converge on equilibrium. Disequilibrium prevails when the proportion of probands a priest condemns is outside the range required to secure separation—that is, $\gamma > \theta/(\beta - \rho\beta)$ or $\gamma < (\theta - \rho\beta)/(\beta - \rho\beta)$.

The priest can learn that he has set γ too high or too low from two sources. First, he learns that γ is too high when he observes that every accused person confronted with an ordeal chooses to decline it. Unless every person accused of a crime is in fact guilty, at least some defendants will choose to undergo ordeals when $\gamma < \theta/(\beta - \rho\beta)$. Thus, if the priest observes all of them choosing the opposite, he knows that $\gamma > \theta/(\beta - \rho\beta)$. In this case the priest knows he needs to condemn fewer probands. He lowers γ until some accused persons begin to choose to undergo ordeals. This occurs when γ drops below $\theta/(\beta - \rho\beta)$.

Similarly, the priest learns that γ is too low when he observes that every accused person confronted with an ordeal chooses to undergo it. Unless every person accused of a crime is in fact innocent, at least some defendants will choose to decline ordeals when $\gamma > (\theta - \rho\beta)/(\beta - \rho\beta)$. Thus, if the priest observes all of them choosing the opposite, he knows that $\gamma < (\theta - \rho\beta)/(\beta - \rho\beta)$. In this case the priest knows he needs to condemn more probands. He raises γ until some accused persons begin to decline ordeals. This occurs when γ rises above $(\theta - \rho\beta)/(\beta - \rho\beta)$.

The priest can also learn that he has set γ too low (although not if he has set it too high) if he observes rising rates of crime or repeat probands. When $\gamma < (\theta - \rho\beta)/(\beta - \rho\beta)$, guilty persons are willing to risk undergoing ordeals.

[29] The use of champions in unilateral ordeals—persons who underwent ordeals by proxy—was infrequent and does not affect my argument. Even when champions were used, undergoing an ordeal remained more expensive for guilty persons than for innocent ones because the former expected to be convicted with a higher probability. Thus, in situations in which belief was imperfect, the use of champions could influence the optimal rate of proband condemnations (γ), but sorting was unaffected.

When they do, some of them are exonerated. These persons learn that ordeals are a sham.

Such persons are unlikely to tell others as much. To do so would be to inform them of their guilt. Much more likely, such persons will proclaim the legitimacy of ordeals. After all, others will consider these persons' exonerations only as legitimate as the ordeals that produced them. Still, with firsthand knowledge that ordeals are a sham, guilty persons who passed their ordeals are willing to commit more crime than before.

If the priest observes rising crime rates, or simply the same probands appearing before him repeatedly, he knows that $\gamma < (\theta - \rho\beta)/(\beta - \rho\beta)$ and thus that he needs to condemn more probands. To do this, he condemns probands whose repeated appearance suggests that they know ordeals are a sham. He continues to raise γ if necessary until some accused persons begin to decline ordeals. This occurs when γ rises above $(\theta - \rho\beta)/(\beta - \rho\beta)$.

For the convergence processes described above to occur, the only information potential defendants require is γ: the proportion of probands condemned in their community. They do not require information about the priest's methods or objectives. For a given level of belief and given payoffs of declining an ordeal, passing one, and failing one, γ alone determines defendants' expected payoff of hazarding the ordeal. Thus, as long as defendants know this, their behavior will comport with what the priest desires once he has lowered or raised γ sufficiently to place it within the range derived above.

It is reasonable to think that medieval citizens would have often had a good idea about the frequency with which others in their communities who hazarded ordeals failed or succeeded. The fate of probands was not private, and medieval communities were usually small. Similarly, it is reasonable to think that medieval priests knew how probands decided when confronted with ordeals and knew those probands' identities. Priests were the persons administering their ordeals.

It is also useful to consider how robust the ordeal-created equilibrium is when citizens' belief in ordeals as *iudicia Dei* is incomplete. As demonstrated above, when individuals' belief that ordeals are *iudicia Dei* is complete ($\rho = 1$), priests condemn no probands. The resulting separating equilibrium is self-confirming: every person who has experience with an ordeal has experience that confirms his belief that ordeals are *iudicia Dei*. This is also true when individuals are skeptics if their belief that ordeals are *iudicia Dei* is strong enough to produce a separating equilibrium without priests condemning any innocent probands. This is when $\rho \geq \theta/\beta$.

When individuals are skeptics and their belief falls below this threshold, things are different. Priests must condemn $\gamma^* > 0$ of probands. The separating equilibrium that emerges is semi-, but not completely, self-confirming. As when individuals' belief that ordeals are *iudicia Dei* is complete, in this case too, only innocent probands undergo ordeals. But now priests condemn some of them. These individuals have experiences that contradict their belief that ordeals are *iudicia Dei* rather than confirm it.

The trouble these individuals pose for ordeals is small. Consider the kinds of problems an innocent person whom an ordeal condemns can create. He can proclaim his innocence and tell everyone that ordeals are a sham, but this is the same thing a truly guilty person would do, so no one's belief is affected. Alternatively, he can exploit his knowledge that ordeals are a sham by committing crimes and hoping to be ordered to undergo ordeals. But similar to the case in disequilibrium considered above, if he does this, he confronts the priest repeatedly. Suspicious of the repeat proband, the priest condemns him, foiling his plan.[30]

The real danger to ordeals when priests had to condemn innocent probands was not that condemned probands would tell others that ordeals were a sham or that they would exploit the system. It was that publicly observed events would contradict the ordeal's results, evidencing the illegitimacy of ordeals. For example, one medieval defendant accused of murder underwent an ordeal, failed, and was hanged. A few weeks later, the man he murdered came home (Bartlett 1986, p. 160).

Such incidents threatened to initiate a process that could destroy the operation of ordeals. An occasional contradictory incident could be explained away, but if they happened frequently, individuals' belief that ordeals were *iudicia Dei* could weaken considerably. To ensure separation with weaker belief, priests would have to condemn a higher proportion of innocent probands. This would increase the chance of additional ordeal-contradicting incidents, weakening belief further, requiring priests to condemn more probands, and so on. Eventually ρ would reach zero. The use of ordeals would break down.

Fortunately for ordeals, instances like the murdered man returning home were rare (Bartlett 1986, p. 160). They were rare for two reasons. First, the cases in which judges used ordeals militated against such situations. Judges used ordeals when normal evidence was lacking. The prospect that evidence would come back later to contradict the results of an ordeal was therefore slim. Second, for reasons I discuss below, medieval citizens' belief that ordeals were *iudicia Dei* was strong. So $\gamma^\star$ was positive but low: priests did not have to condemn a high proportion of probands to produce separation. There were therefore few cases in which contradictory evidence was possible.

Examining the possibility of growing skepticism that ordeal-contradicting incidents can create when belief in ordeals is incomplete sheds light on the robustness of the ordeal-created equilibrium in the face of a gradual leak of in-

[30] Before their ordeals, probands spent several days with the priests who officiated ordeals, partaking in Mass, prayer, and so on. This may have permitted priests to glean additional information about probands' guilt or innocence (Pilarczyk 1996, p. 98; Henry 1789, p. 273). Such information supplemented that which priests received from observing defendants' willingness to undergo ordeals, facilitating their ability to identify (and thus condemn) a guilty defendant who took his chances with the ordeal because γ had been set too low, because he had figured out that ordeals were a sham, or because some other imperfection prevented flawless separation.

formation about priestly manipulation. Consider the case in which someone tells others that he saw the priest rig an ordeal.

We can think about such an information leak in terms of the unraveling logic described above. When there is a leak, ρ falls, requiring a higher $\gamma^{\star}$. Starting from an equilibrium with a relatively high ρ and thus a relatively low $\gamma^{\star}$, the additional ordeal-contradicting incidents the leak indirectly generates are few. Strong believers largely discount leaks as rumor, which leads to a small effect on belief. A small fall in belief requires only a small increase in the proportion of probands the priest must condemn, contributing minimally to ordeal-contradicting incidents that, when numerous, can set in motion the unraveling process described above. In this case, the ordeal-created equilibrium exhibits local robustness—robustness to the unraveling scenario in the neighborhood of relatively strong belief.

In contrast, starting from an equilibrium with a relatively low ρ and thus a relatively high $\gamma^{\star}$, the additional ordeal-contradicting incidents that the same information leak indirectly generates are numerous. Weak believers discount leaks little, which leads to a large effect on belief. A large fall in belief requires a large increase in the proportion of probands the priest must condemn, which contributes significantly to ordeal-contradicting incidents and, in doing so, sets in motion the unraveling process described. In this case, the ordeal-created equilibrium exhibits local fragility—fragility tending toward the unraveling scenario in the neighborhood of relatively weak belief.

3.4. Accessing and Strengthening Belief

Ordeals are robust to skepticism but not infinitely so. The stronger the belief that ordeals are *iudicia Dei,* the better ordeals work in terms of robustness to information leakages and condemnations of innocent persons. Ordeal ceremonies were therefore arranged to access and strengthen potential probands' belief in the legitimacy of ordeals. They accomplished this in several ways.

First, "the Church . . . followed the policy of surrounding [ordeals] with all the solemnity which her most venerated rites could impart" (Lea 1973, p. 33). Priests administered ordeals, in churches, as part of ordeal masses. Besides the standard sacred Mass rituals, such as Communion, these masses involved sacred rituals specific to ordeals, such as christening the ordeal stage and implements.

Second, ordeal ceremonies reinforced guilty and innocent defendants' expectations about ordeals' outcomes by reminding each of their fate in undergoing the ordeal. Consider the prayer the priest made before the proband over the cauldron of ordeal water (Lea 1973, p. 34): "O holy water . . . I adjure thee by the living God that thou shalt show thyself pure . . . to make manifest and reveal and bring to naught all falsehood, and to make manifest and bring light to all truth; so that he who shall place his hand in thee, if his cause be just and true, shall receive no hurt; but if he be perjured, let his hand be burned with fire."

Third, ordeal ceremonies highlighted the religious foundations of ordeals, reminding probands of their divine precedent and successful track record. Consider the following hot-water ordeal prayer (Howland 1901, p. 8): "O Lord . . . make known Thy righteous judgment. . . . [S]anctify . . . this water being heated by fire. Thou that didst save the three youths, Sidrac, Misac, and Abednego, cast into the fiery furnace at the command of Nebuchadnezzar, and didst lead them forth unharmed by the hand of Thy angel . . . and, as Thou didst liberate the three youths from the fiery furnace and didst free Susanna from the false charge . . . so, O Lord, bring forth his hand safe and unharmed from this water [if he is innocent]."[31]

Finally, ordeal ceremonies reminded probands of God's omniscience, omnipotence, and infallible power to exculpate the innocent and condemn the guilty through trials of fire and water. Consider the priest's benediction of the water in the hot-water ordeal (Howland 1901, p. 8): "I bless thee, O creature of water, boiling above the fire . . . I adjure thee by Him who ordered thee to water the whole earth from the four rivers, and who summoned thee forth from the rock, and who changed thee into wine. . . . [P]unish the vile and wicked, and purify the innocent. Through Him whom hidden things do not escape and who sent thee in the flood over the whole earth to destroy the wicked and who will yet come to judge the quick and the dead and the world by fire. Amen."

These features of ordeal ceremonies tapped into and bolstered the belief that the success of ordeals required (Lea 1866, p. 257; see also Hyams 1981, p. 111): "In those ages of faith, the professing Christian, conscious of guilt, must indeed have been hardened who could undergo the most awful rites of his religion, pledging his salvation on his innocence, and knowing under such circumstances that the direct intervention of Heaven could alone save him from having his hand boiled to rags, after which he was to meet the full punishment of his crime, and perhaps in addition lose a member for the perjury committed."

4. Predictions and Evidence

My theory of medieval judicial ordeals generates several predictions. The evidence supports them.

4.1. Most Probands Are Exonerated

If my theory is correct, the evidence on ordeal outcomes should point to plenty of priestly ordeal fixing. Most probands should be exonerated. The surviving records of ordeal outcomes support this prediction.

These records are from the early thirteenth century. They have two sources.

[31] The three youths referenced here are the righteous boys God saves from the fiery death King Nebuchadnezzar orders in the Book of Daniel. Susanna is the woman sentenced to death in the same book. The prophet Daniel exonerates her in the last hour. His name means "judgment of God" in Hebrew.

The first source is the *Regestrum Varadinense*, an ordeal register from Varad, Hungary (modern-day Oradea, Romania), under the reign of King Andrew II, which Zajtay (1954, pp. 541–52) and van Caenegem (1991, p. 76) analyzed. The *Regestrum* records hot-iron ordeals that Hungarian clerics administered in the basilica of Nagyvárad between 1208 and 1235.

These records include outcomes for 308 cases involving ordeals. In 100 of these cases, the ordeal was aborted before it produced a final result, typically because the parties settled.[32] My theory suggests that defendants in these cases were guilty, but of course there is no way to know whether this was so.

Examining the outcomes of the 208 cases in which defendants underwent ordeals is more instructive. The data are telling: probands failed their ordeals in only 78 cases, or 37.5 percent of the time. Probands passed their ordeals in 130 cases, or 62.5 percent of the time.[33] Unless nearly two-thirds of ordeal-officiating priests did not understand how to heat iron, these data suggest priestly rigging intended to exculpate probands. Ordeals exonerated the overwhelming majority of probands tried in the basilica of Nagyvárad.

Like the data relating to ordeal outcomes described below, these data must be interpreted with caution. It is impossible to say whether the percentage of probands who failed (or passed) their ordeals is large or small in the context the data consider. The data do not tell us that the persons who were exonerated were in fact innocent. And since we have no counterfactual, they do not tell us whether a still larger proportion of defendants might have been exonerated in a world without ordeals. What the data do tell us is that most persons who underwent ordeals in the basilica of Nagyvárad were exonerated and thus that ordeals could not have been used exclusively to extract guilty pleas.

The second source of records for outcomes of ordeals finds this result more strongly still but is based on fewer cases. This source is the plea rolls that English royal courts kept between 1194, the year of the first surviving roll, and 1219, when English courts stopped ordering ordeals. Kerr, Forsyth, and Plyley (1992, pp. 580–81) uncovered 19 probands in these records for whom the rolls report ordeals' outcomes.[34] Sixteen probands underwent cold-water ordeals. Three un-

[32] Seventy-five cases were settled. The plaintiff withdrew his complaint in the other 25. Some of the withdrawals came after the defendant had already carried the hot iron but before his arm was unwrapped. It is very likely that these defendants were innocent. At the very least, we can conclude that their accusers thought the ordeal would find them so. This is the only reason they would have withdrawn their accusation: to avoid a possible perjury charge, which could result if the ordeal exonerated the defendant.

[33] This estimate, 62.5 percent, is a conservative estimate of the proportion of probands who were unharmed by red-hot iron in Varad. As indicated in note 32, some plaintiff withdrawals came after the proband had carried the iron. It is probable that these probands, who are not included in my calculation, were also unharmed. If their plaintiffs thought otherwise, they would not have withdrawn their complaints.

[34] The plea rolls contain references to a similar number of outcomes, but since these rolls recorded only failures (this being the only instance in which outcomes had implications for the royal exchequer), I cannot use data from these rolls to illuminate the proportion of probands who passed ordeals (Kerr, Forsyth, and Plyley 1992, p. 579).

derwent hot-iron ordeals. Fourteen of the 16 probands who underwent cold-water ordeals passed. All three probands who underwent hot-iron ordeals passed. On the basis of these data, ordeals exonerated English probands 89 percent of the time (see also Klerman 2001, p. 12).[35]

Focusing on the probands who underwent hot-iron ordeals, it again appears that priests did not understand how to heat iron or that they chose not to so as to exculpate probands. The sample is tiny, but, suspiciously, red-hot iron is never harmful to those carrying it. This is the opposite of what the evidence should show if the iron that probands carried was actually red hot. As historians of medieval English law Pollock and Maitland (1959, p. 599) put it, the "evidence . . . we have seems to show that the ordeal of hot iron was so arranged as to give the accused a considerable chance of escape."[36]

Turning to the cold-water ordeal, we see a related pattern. Recall that because of differences in body fat, men are likely to sink in water and thus to be exonerated at cold-water ordeals, while women are likely to float and thus to be convicted.[37] If, then, as my theory suggests, medieval justice systems sought to exonerate persons who were willing to undergo ordeals, they should have sent only men to cold ordeals and sent women only to hot ones.

The data support this prediction. Ninety-one ordeals appear in England's eyre rolls between 1194 and 1208. Eighty-four of the probands are male, and seven are female. Judges ordered 79 of the men to cold-water ordeals, one to the hot-iron ordeal, and four to unspecified ordeals. They ordered all seven women to hot-iron ordeals (Kerr, Forsyth, and Plyley 1992, 581). Thus, while judges ordered men to cold-water ordeals between 94 and 98.8 percent of the time, they never ordered women to cold-water ordeals.

Two cases that involve a man and woman jointly accused of the same crime are particularly instructive. In one case, the defendants were accused of burglary. In the other, they were accused of murder. In both cases judges ordered the men to cold-water ordeals and the women to hot-iron ordeals (Maitland 1887 I, nos. 12 and 119). In a third case, a woman was accused of murder, ordered to the

[35] As Maitland (1887 I:xxiv) put it, "[S]uccess at the ordeal" was "far commoner than failure."

[36] The hypothesis that priests were selling justice has difficulty explaining the notable feature of the data on ordeals: most defendants underwent ordeals. If priests routinely sold justice, most defendants facing ordeals would settle with their accusers. Accusers could extort no more from defendants than could priests. And by bribing their accusers to drop their complaints, defendants could avoid undergoing ordeals. Faced with the prospect of having to bribe priests to secure their innocence, defendants would settle instead. If priests colluded with accusers to extort defendants, we would also expect settlements. By settling with their accusers, defendants could avoid ordeals, priests and accusers could divide the settlement price, and priests could avoid the labor of administering ordeals. Thus, if priests were selling justice, we should observe settlements, not defendants choosing to undergo ordeals and being exonerated. But the data show the opposite: most defendants underwent ordeals and were exonerated. Only a minority settled.

[37] This assumes that the average medieval male was lean. That seems reasonable given the paltry diet of most medieval citizens.

hot-iron ordeal, and passed. A man was then accused of the same murder but ordered to the cold-water ordeal instead (Maitland 1887 I, no. 101).[38]

4.2. Ordeals Are Not Used for Defendants Who Are Known Nonbelievers

According to my theory, ordeals inform priests about defendants' guilt or innocence only if defendants' belief that ordeals are *iudicia Dei* is at least positive. If that theory is correct, medieval legal systems should have exempted nonbelievers (that is, those for whom $\rho = 0$ or $0 < \rho < \rho^*$, the critical threshold required to ensure separation for a given γ^*) from ordeals. The evidence supports this prediction.

There was one major group of obvious nonbelievers in medieval Europe: Jews. Medieval judicial ordeals were intimately connected to and strongly dependent on Christian belief. Priests administered ordeals, in churches, as part of Catholic Mass, with all the attendant Catholic ritual. The Christian trappings of ordeals were designed to access and strengthen individuals' belief that ordeals were *iudicia Dei*. But they were intended for, and only capable of having the desired effect on, Christians.

As Bartlett (1986, p. 54) puts it, "[S]uch a sacral proof" as ordeals, "so deeply hedged about with Christian liturgy and ritual, a proof which normally required a vigil in a church and prior communion, was so indelibly Christian that it would be . . . in Christian eyes, virtually meaningless to apply it to non-Christians." More important, it would be meaningless in non-Christian eyes to apply it to non-Christians. In contrast to Christians, for Jews, "[t]rials by ordeal . . . were totally alien to their nature and tradition" and belief (Eidelberg 1979–80, p. 111).

Because of Jews' nonbelief in Christian ritual, we find a bifurcated medieval trial policy in doubtful cases involving Jews and Christians. If the defendant was Christian, he was tried by ordeal. If he was Jewish, he was tried by compurgation.[39] As Charlemagne's capitularies instructed (in 814 and 809, respectively), "If a Jew accuses a Gentile, the accused if need be, can prove his rightness by valid witnesses and an oath upon relics or by trial by ordeal involving glowing iron. . . . [B]ut if a Gentile accuses a Jew, it suffices to bring two witnesses, Jew or Gentiles, and bear an oath" (Eidelberg 1979–80, p. 112).[40]

[38] Twelfth-century Icelandic law required men to go to cold-water ordeals and women to hot-water ordeals. In twelfth- and thirteenth-century England, the time period of the data considered above, the law did not make any provision for the differential treatment of men and women in terms of hot or cold ordeals. See Lea (1973, p. 46) and Kerr, Forsyth, and Plyley (1992, p. 581).

[39] However, Jews were sometimes subjected to trial by combat (Lea 1866, p. 103). I discuss this medieval judicial institution below.

[40] Some burgesses also received exemptions from ordeals, although this seems to have been the result of a political bargain with government authorities. In the twelfth century, some clerics began seeking exemption from hot and cold ordeals, but they already used these to a very limited extent, relying heavily on compurgation instead. Clerical exemptions were based on the growing ecclesiastic concern that ordeals were uncanonical, which came to a head in 1215. See Bartlett (1986).

4.3. Ordeals Are Abandoned When Clerics Stop Administering Them

Medieval persons' belief that ordeals were *iudicia Dei* ($\rho > 0$), and thus ordeals' ability to work, depended on their religious status—a status dependent on priests' central role in their administration. Only clerics could perform the religious rituals, such as Mass, that invoked godly intervention in judicial matters. My theory therefore predicts that when priestly involvement in ordeals ceased, so must have ordeals.

The history of the demise of ordeals supports this prediction. High-ranking ecclesiastics began seriously questioning the relationship of ordeals to their religion in the twelfth century.[41] "[T]he twelfth century was the great age of [canonical] sifting, and the credentials of the ordeal were among the things sifted" (Bartlett 1986, p. 83).

According to the ecclesiastic critics of ordeals, ordeals had no scriptural sanction. Despite ordeal rituals' allusions to Daniel, Susanna, and the fiery furnace, the Bible contains but one instance of what might be construed as an actual judicial ordeal. In the Book of Numbers (Num. 5:11–31), an accused adulteress undergoes an ordeal of bitter waters (poison ingestion) to prove her fidelity. Besides the fact that this is the lone potential case of scriptural sanction for judicial ordeals, medieval judicial ordeals were not ordeals of bitter waters.[42] They were ordeals of boiling water, burning iron, and dunking in pools, which had no scriptural support.

The detractors of ordeals argued that ordeals had an even more severe problem that cast doubt on their canonical credentials. They violated an important Christian proscription with lots of scriptural support: "[T]hou shalt not tempt the Lord thy God" (Deut. 6:16; Matt. 4:7). Judicial ordeals required priests to command God to perform miracles at their whim, which the Bible forbids.

Together with the fact that there existed more papal decretals questioning the religious status of ordeals than supporting it, these factors led the Fourth Lateran Council to reject the religious legitimacy of judicial ordeals and to ban priests from participating in them in 1215. As the council's decree read, "[L]et no ecclesiastic . . . pronounce over the ordeal of hot or cold water or glowing iron any benediction or rite of consecration, regard being also paid to the prohibitions formerly promulgated respecting the single combat or duel" (Howland 1901, p. 16).[43]

[41] Some high-ranking ecclesiastics questioned ordeals from their inception in Christendom, but these criticisms did not gain ground until the twelfth century. When they did, ordeals began to disappear in some places toward the end of the twelfth century (Caenegem 1991, pp. 85–86). However, the widespread disappearance of ordeals did not occur until the thirteenth century, after Pope Innocent III's edict.

[42] The next closest thing to a judicial ordeal in the Bible is the casting of lots that a crew of sailors undertakes to decide who offended God and caused a storm in the Book of Jonah (Jon. 1:7).

[43] There were other objections to ordeals, but those discussed were the most important. The most significant objection not discussed here was the argument that clerics should not participate in activities that potentially involved the shedding of blood. For a detailed discussion of the theological issues driving the Fourth Lateran Council's ordeal prohibition, see Baldwin (1961) and McAuley (2006).

If ordeals did not depend on medieval citizens' religious beliefs, the Church's condemnation and clerics' withdrawal should not have affected medieval judicial systems' reliance on them. Although the religious trappings that formerly framed ordeals would no longer be involved, secular judicial systems could have continued to use boiling water, burning iron, and dunking in pools to decide defendants' guilt and innocence in doubtful cases. If citizens' superstition was not important to the functionality of ordeals, these religious trappings would not have been missed. Ordeals would have continued as successfully as they did before.

But they did not. Instead, secular judicial systems abandoned ordeals where their traditional religious trappings evaporated. Denmark prohibited ordeals in 1216, England in 1219, and Scotland in 1230. Italy ended ordeals in 1231, although some Italian towns had already abandoned them by then. And Flanders's criminal justice system dispensed with ordeals between 1208 and 1233 (Caenegem 1991, p. 87). Shortly thereafter Norway, Iceland, Sweden, and others followed suit. France never formally abolished ordeals, but the last mention of them that historians can find is in 1218, just after the Church's ban (Caenegem 1991, p. 87).

Where priests defied the Council's prohibition and continued to participate in ordeals, places such as Germany, Greece, Hungary, Poland, and Croatia, ordeals lingered longer. But "[w]ith trifling exceptions, the ordeal could not continue without priests" (Bartlett 1986, p. 101; see also Lea 1866, p. 267). So ordeals went extinct where clerics refused to officiate them.[44] By denouncing the canonical status of ordeals and banning clerical participation in them, the Fourth Lateran Council's decision "robbed the ordeal of all religious sanction" (Plucknett 1956, p. 118). Without the religious sanction on which the belief that ordeals were *iudicia Dei* rested, trial by fire and water became impotent—useless as tools to separate the guilty from the innocent.

Ordeals' post-Church condemnation collapse stands in stark contrast to another popular medieval judicial process that the Fourth Lateran Council also condemned and prohibited priests from administering: judicial combat. Judicial combat was used for deciding property disputes and criminal cases.[45] It provides a useful contrast to ordeals because, although "the moral influence of the ordeal depended entirely upon its religious associations," that of judicial combat did not (Lea 1866, p. 272). For example, "while a duel may be fought without the aid of a priest[,] the efficacy of an ordeal depended wholly upon the religious rites which gave it the sanction of a direct invocation of the Almighty" (Lea

[44] Secular authorities understood the importance of priestly participation to the operation of ordeals. A decade before the Church's ban, some clerics decided for themselves that ordeals were at odds with their religion, so they stopped administering them. But secular authorities would have none of it. As Pope Innocent III complained, "Although canon law does not admit ordeal by hot iron, cold water and the like, unhappy priests are being compelled to pronounce the blessing and become involved in such proofs and are being fined by the secular officials if they refuse" (Bartlett 1986, p. 98).

[45] On the law and economics of judicial combat, see Leeson (2011).

1973, pp. 162–63; see also Bloomfield 1969, p. 555; Bartlett 1986, pp. 120–21; Rollason 1988, p. 15; Palmer 1989, p. 1553).

This crucial difference between ordeals and judicial combat explains why, although the Church condemned and prohibited priestly participation in them both in 1215, judicial combat "survived for centuries the ordeal proper" (Thayer 1898, p. 39). In Spain, judicial combat continued until the late thirteenth century. In Italy, Flanders, and Germany it continued until the fourteenth century. In Portugal, France, and Hungary, it lasted until the fifteenth century. Even England did not see its last judicial combat until 1456 (Russell 1980, p. 154).

5. Concluding Remarks

After the Church withdrew its support from ordeals in the thirteenth century, the use of ordeals ended. Trial by jury replaced them in England. Trial by inquisition replaced them on the continent.[46] No one longs for the return of ordeals, but as I explain, if the appropriate belief structure existed to support them, perhaps they should.

My analysis of the law and economics of medieval judicial ordeals leads to several conclusions. First, although rooted in superstition, judicial ordeals were not irrational. Fact finding in the Middle Ages was costly. Given technological limitations, it was often impossible. In an environment in which people assigned a high probability to the idea that priests could call on God to reveal judicial truth, ordeals were an effective way of accessing defendants' private information about their criminal status. Ordeals achieved what they sought: they accurately assigned guilt and innocence where traditional means could not.

Second, my analysis suggests that optimal legal institutions depend partly on the beliefs of the people they encompass. For example, the legal regime that is efficient in a society in which people believe firmly that God curses cheaters is different from the legal regime that is efficient in a society in which people do not believe this. In the former society, superstition does part of the work that we normally ask state-made law and punishment to do. Ceteris paribus, the efficient legal regime in the latter society involves more state-made law and punishment than it does in the former. Similarly, in a society in which citizens believe strongly that trials of fire and water are *iudicia Dei,* such as medieval society until the thirteenth century, it is cheaper to use such trials to establish accused persons' guilt or innocence in certain cases than it is to use other methods for this purpose that do not leverage citizens' beliefs, such as trial by jury or inquisition.

The reason it does not make sense for modern developed societies to use medieval judicial ordeals is not that postordeal trial methods are inevitably su-

[46] On the evolution of trial by jury and inquisition in England and on the European continent after the ordeal's demise, see, for instance, Pollock and Maitland (1959). On the economics of these traditions, see Hayek (1960) and Glaeser and Shleifer (2002).

perior. It does not make sense for them to use medieval judicial ordeals because (1) technological advance has made fact finding in the cases in which medieval legal systems used ordeals infinitely cheaper than it once was and (2) citizens in modern developed societies do not believe that trials of fire and water are *iudicia Dei,* which medieval judicial ordeals require to work.[47] In a dramatically less technologically advanced state, such as that which prevailed in the Middle Ages, or even in a technologically advanced state where individuals believe strongly that trials of fire and water are *iudicia Dei,* medieval-style judicial ordeals could again be the efficient option.[48]

Finally, my examination of ordeals suggests that objectively true beliefs do not necessarily supplant objectively false ones. More important, it suggests that, in some cases at least, society is better off because of this. If institutions based on objectively false beliefs, such as the belief that God intervenes in man's judicial proceedings to ensure that the righteous party prevails, produce social outcomes that are as good as, or better than, the social outcomes that institutions based on objectively true beliefs produce, there is no pressure for the former beliefs to give way to the latter. Ordeals are an example of this. This logic explains how a judicial institution based on objectively false beliefs could last for nearly half a millennium: superstition can be socially productive.

Perhaps surprisingly, this means that societies composed of individuals who lack certain objectively false beliefs can be worse off than societies composed of individuals who believe deeply in objectively false propositions. To return to the example from above, holding other features and beliefs constant, a society in which no one believes in an invisible, omnipotent, and omniscient being who interferes with human affairs to ensure cosmic justice will have to devote more resources to addressing crime than a society in which every person believes firmly in such a being. The superstitious society outperforms the scientific one.

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[47] However, many citizens in modern developed societies do believe in other superstitions that their countries' legal systems can, and in some cases do, leverage to improve criminal justice in much the same way that medieval legal systems leveraged the *iudicium Dei* superstition for that purpose. Consider, for example, the common belief that polygraph tests are capable of measuring physiologically whether persons are lying or telling the truth.

[48] Where these conditions are satisfied in some modern developing countries, medieval-style ordeals are still used to decide accused criminals' guilt or innocence. For example, although its government has criminalized the practice, ordeals called "sassywood" remain popular in Liberia. See Leeson and Coyne (2012).

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Probability and probabilistic fallacies

1 Bayes theorem, theory and applications

1.1 Bayes Theorem

Prove Bayes Theorem starting from the fundamental probability axioms and the definition of conditional probability as discussed in class.

1.2 Application

Consider the following problem:

You have been called to jury duty in a town where there are two taxi companies, Green Cabs Ltd. and Blue Taxi Inc. Blue Taxi uses cars painted blue; Green Cabs uses green cars. Green Cabs dominates the market, with 85% of the taxis on the road. On a misty winter night a taxi sideswiped another car and drove off. A witness says it was a blue cab.

The witness is tested under conditions like those on the night of the accident, and 80% of the time she correctly reports the color of the cab that is seen. That is, regardless of whether she is shown a blue or a green cab in misty evening light, she gets the color right 80% of the time.

You conclude, on the basis of this information:

(a) The probability that the sideswiper was blue is 0.8.

(b) It is more likely that the sideswiper was blue, but the probability is less than 0.8.

(c) It is just as probable that the sideswiper was green as that it was blue.

(d) It is more likely than not that the sideswiper was green.

2 Fallacies

2.1 Linda the bank teller

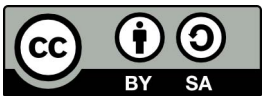
Consider the following problem:

Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.

Which is more probable? Explain why.

(a) Linda is a bank teller

(b) Linda is a bank teller and is active in the feminist movement



2.2 Medical diagnoses

Consider the following problem:

"One in a thousand people has a prevalence for a particular heart disease. There is a test to detect this disease. The test is 100% accurate for people who have the disease and is 95% accurate for those who don't (this means that 5% of people who do not have the disease will be wrongly diagnosed as having it). If a randomly selected person tests positive what is the probability that the person actually has the disease?"

This question was put to 60 students and staff at Harvard Medical School. Almost half gave the response 95%. The 'average' answer was 56%. In fact, the correct answer is very different and was given by just 11 participants.

What is the correct answer? Why?