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EDITORIAL

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The next volume of ΦNEWS is scheduled for October 2005. ΦNEWS publishes contributions in terms of expositional papers, announcements of workshops, seminars, conferences, forthcoming publications, new initiatives and other material within the aim and scope of the newsletter. Send your written contribution (preferably in TEX, LATEX, LATEX 2ε) to either one of the ΦNEWS editors. Contact information, and additional information on how to submit material, is available on page 87.

April, 2005
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LOGIC AND THE LAW: CROSSING THE LINES OF DISCIPLINE

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ΦNEWS

Part I: The Possibility of Rapprochment

The present paper is a small part of an effort to expose the logical structure of English criminal law. Results will appear eventually in a monograph of the same name.[1] Our purpose here is to lay to rest some objections that might be raised against the project. A further aim is to show that, in particular cases, legal concepts actually respond well to logical analysis. We demonstrate this as regards the legal concept of proof beyond a reasonable doubt.

1. A Lapsed Alliance

It is said that the first logicians were Greek lawyers. Certainly there were inchoate logicians well before Aristotle's formal systematizations; and it is hardly credible that none was a pleader at the Attic bar. Aristotle (384—322 BC) conceived of his theory

[1] [Gabbay and Woods, 2006].

of the syllogism as the theoretical core of a wholly general account of argument.[2] By these lights, legal argumentation possesses a logical core. It was its preoccupation with argument that bound the logic of the syllogism to the law. It produced an intimate kinship, an alliance enriched by the sharing of further leading ideas, among which we find:

- *Inference*
- *Evidence*
- *Probability*
- *Relevance*
- *Reasonableness*
- *Precedent*
- *Presumption*
- *Plausibility*
- *Explanation*
- *Proof*

For most of their respective histories, lawyers and logicians have found it natural to share this conceptual terrain. Indeed some of history's most visible logicians were also lawyers. Leibniz (1646—1716) was a lawyer, as was Łukasiewicz (1878—1956), Francis Bacon (1561—1626), the spiritual father of inductive logic, was (notoriously) a lawyer, and J.S. Mill (1806—1873) might as well have been. But if one looks at the recent history of these things, the example of Łukasiewicz is anomolous. In the last century, mainstream logic and the law not only went their own respective ways, they showed scant interest in each other's doings.

No one proposing a reconciliation of these two ancient disciplines should be indifferent to the estrangements that came into full force in the century just past. So we shall tarry with them awhile.

2. The Integrity of Disciplines

Enquiry attains the status of a discipline when two factors are in play. One is *subject-matter*. The other is *specialization*. It is a peculiar partnership, in as much as specialization tends to *shrink* subject-matter. So the identity-conferring roles of subject-matter and specialization stand to one another in an interesting kind of "dy-

[2] *Topics* and *On Sophistical Refutations.* See also [Woods, 2001], [Woods and Irvine, 2004].

namic tension". Still, once these factors are catered for, important byproducts are let loose. By and large, these further features fall into one or other of two categories. One is *methodological*. The other is *professional* or *administrative*.[3] Together they conduce to give the disciplines they serve not only their operational and organizational identities, but also their exclusiveness. They endow a discipline with its kitty-bar-the door standoffishness.[4]

Anyone with a nodding familiarity with modern universities will be aware that we have entered an era of interdisciplinarity. Vice-chancellors, deans and granting agencies thrill to the very idea of it, and programmes designed to implement it are approved and funded at the drop of a hat. It has been a remarkable development in light of the inherent resistance that the disciplines display towards foreign trespass. For what *is* interdisciplinarity if not a kind of extraterritorial intrusion? It is therefore hardly surprising that most interdisciplinary initiatives fail outright or are dubiously graced by outcomes that are scorned, or merely ignored, by the home disciplines.[5] The present chapter is an exercise in interdisciplinary enquiry. It seeks, however modestly, to bring together the ancient disciplines of law and logic in ways that overcome their entirely natural territorial antagonisms. Given the modern record, this is an undertaking suffused with risk. Statistically speaking, chances of success are scant. Why would we bother?

For all the sheer rubbish that interdisciplinary initiatives sometimes give rise to, there have been of late some highly instructive successes. Biochemistry is now a mature science, having achieved its independence from the parent disciplines. Cognitive science is a newer hybrid, brought about by the merger of computer science and psychology. Cognitive science is not yet as mature a science as biochemistry, but its boosters are legion and its prospects glowing.[6] Biochemistry is an attractive example of the *offspring model* of interdisciplinary enquiry. Neither chemistry nor biology, it numbers among its principal results insights that chemistry alone and biology alone are powerless to sustain, or even formulate, and yet its existence as a *bona fide* discipline has not damaged the integrity of either parent. Cognitive science also seems headed toward the status of a fully independent offspring discipline, but with some

[3] A discipline's identity is shaed by those methods of operation that are characteristic of it. Professional or administrative traits influence conditions of entry, issuance of qualifications and general management of the discipline's infrastructure, including ways and means of the dissemination of results.

[4] The idea of disciplinary integrity is an ancient one. Aristotle refused admittance to "inappropriate" premisses, even if true. A statement is inappropriate in an argument when it belongs to a discipline different from the one represented by the argument's conclusion. See *On Sophistical Refutations* 172^a8 and *Physics* $223^a\ 21^7$—15, 263^a4 – 264^a6.

[5] To mention just one example, informal logic has produced a vigorous research-programme in the past thirty-five years or so, but one could count on the fingers of one hand (with room left over) leading representatives of the mathematical mainstream who have paid it the slightest heed.

[6] A notable dissident is Jerry Fodor, for whom the name of cognitive science is an oxymoron. ([Fodor, 2000])

interesting differences. One is that one of the partners, computer science, is itself an interdisciplinary enterprise, and psychology, the other partner, has recently opened itself to instruction from neurobiology (which in turn is a union of medicine and biology).

Not all interdisciplinary successes fall into the offspring camp. A notable example is the *take-over* model, typified by Descartes' greatest achievement, the algebraicization of geometry. What Descartes (1596—1650) showed was that algebra is a *minimum vocabulary* for geometry. His founding of analytic geometry is a paradigm of reductive interdisciplinarity, in which one of the partner disciplines, if not driven into outright retirement, is nevertheless revealed to be expressively redundant. Take-over interdisciplinarities bear some likeness to zero-sum games. They are mergers that often produce winners and losers, in which losers are, in some way or other, junior partners of the others. In extreme cases, the losing partner *does* go into permanent retirement.[7] Offspring interdisciplinarities, on the other hand, produce multiple winners. The parent disciplines are left intact, and neither they nor the new discipline need be considered junior to the others.

The establishment of a discipline's expressive redundancy is rarely an end in itself. Someone in John Le Carré's novel, *A Perfect Spy*, remarks that anyone coining unnecessary and confusing terms is little more than a piss artist. There is useful instruction in this pungent observation. If the take-over by discipline D' of discipline D establishes the expressive redundancy of D, that might be of interest to those interested in expressibility as such. More commonly, there is s deeper interest. For example, if D were met with (apparent) ontological or epistemological difficulties of which D' is free, then D's expressibility in D' would suggest that it is in fact free of those difficulties. This is a useful reminder that take-overs needn't wholly disfavour the over-taken. What an over-taken discipline may lose in foundational independence might free it from conceptual or epistemological complexity. Still, the character in Le Carré's book makes an important point. There is little to recommend the tarting up of one discipline in the notation of another if nothing else follows from it.

Both the take-over and offspring models admit of *partial* instantiation. Not every take-over is as comprehensive as that of geometry by algebra. As logicians will know, Heyting's intuitionistic calculus is a part of logic representable in the modal system S4, a different part of logic. Similarly, biochemistry is not the offspring of all of chemistry[8] and all of biology, but rather of respective parts most congenial to one another. It is a congeniality born, for the most part, of a cross-over of interests and an intersection of subject matter. Here, too, the equivocal role of subject matter is on view. If its primary function is to protect disciplinary integrity, its further function is to weaken disciplinary monopolies. Not only is the territorial protection afforded by subject matter degraded by the integral constraints of specialization, but

[7] As witness the displacement of astrology by astronomy and of alchemy by chemistry.

[8] Notwithstanding the widely held belief that all of biology is reducible to chemistry.

considerations of subject matter open a discipline to foreign incursion (provided it is not *too* "foreign").

The *partial offspring* model seems clearly best for the interactions of logic and law. No one we know sees in such a rapprochment even the slightest prospect of take-over; nor is there particular reason to anticipate the emergence of a wholly realized offspring discipline. The more realistic expectation is that

Proposition 1 (Elucidation of common concepts) *In those respects in which logic and the law share basic concepts, interdisciplinary success requires that the one discipline achieve conceptual elucidations that the other doesn't (or can't) provide.*

Corollary 1a: *Since the present authors are logicians, it is appropriate that they attempt to satisfy Proposition (1) by providing elucidations of legal concepts that flow from logic's treatment of them. Needless to say, it may also be hoped that legal scholars would produce elucidations that flow conversely.*

3. Interdisciplinary Skepticism

How reasonable is it to expect that we might achieve some degree of success in the manner of Proposition (1)? The natural state of a discipline is to resist foreign incursion. A discipline's default position is that extraterritorialities are unhelpful. We might say, then, that

Proposition 2 (Inertia) *Disciplines are intertial with regard to extra-disciplinary incursions.*

That is one strike against our project. Another is occasioned by the modern structure of logic itself. The American logician W.V. Quine (1908—2000) famously quipped that logic is an old discipline, but since 1879 it has been a great one. The reference to 1879 is to the year of publication of Gottlob Frege's *Begriffsschift* ([Frege, 1879], which marks (somewhat honorifically) the subordination of logic to mathematics, itself a kind of take-over. The mathematization of logic had been underway in fits and starts since the seventeenth century ([Leibniz, 1966]) and had achieved considerable momentum by the middle of the nineteenth century, especially in England ([Boole, 1847, 1958], [De Morgan, 1966, 1847]).

In Frege's hands, the mathematicization of logic is decidely ironic. It instantiates the take-over model of interdisciplinarity. Its driving idea was *logicism,* the doctrine that all of arithmetic reduces without relevant loss to pure quantification theory and set theory (themselves united by a common purpose). Frege (1848—1925) saw logicism as a corrective to Kant's doctrine of the synthetic apriority of arithmetic. Frege's purpose was to show against Kant (1724—1804), that arithmetic was an analytic discipline.[9] This he would do by finding an uncontestedly analytic discipline to which

[9] An analytic discipline was thought to be one all of whose truths are so solely in virtue of the

arithmetic would reduce. No one at the time seriously doubted that logic was indeed analytic. The problem was that by the time of the logicist programme, arithmetic had gone transfinite, a momentous turn to which the logic of the day could not begin to offer satisfactory accommodation.[10] Thus was occasioned a remarkable transformation within logic itself, in which the old syllogistic logic was jettisoned in favour of innovations purpose-built to achieve the take-over of arithmetic. Let there be no mistake, modern logic was a take-over of the old logic, but it was motivated largely by the transfinite character of the new arithmetic, together with the desire to have a logic that would take arithmetic over. Frege, along with Charles Peirce (1839—1914) independently, would succeed in the one respect only to fail in the other.[11] The new logic would flourish, but the attempt to reduce arithmetic to it would fail.[12] This, too, is ironic. Much of the impulse to mathematicize logic was to facilitate logic's appropriation of mathematics. With the failure of logicism, there was ample motivation to re-think the desirability of mathematizing logic. But, as things turned out, it was a transformation that stuck, and it set the stage for a century and more of rich attainment in that logic's four main precincts: *set theory, proof theory, model theory* and *recursion theory.*[13]

Therewith a problem. We may call it the *apples-and-oranges problem.* Having taken the mathematical turn, logic detached itself from its historic mission of producing the theoretical core of a wholly general theory of argument and reasoning. In so doing, it substantially fractured the enduring kinship between the ancient disciplines of law and logic. It was a transformation that engineered a radical alienation between the two former friends. For while legal argument and legal reasoning remain to this day *context-sensitive, agent-oriented, concretely realized, non-demonstrative, highly nuanced* and strikingly *tacit*, mathematical logic was *symbolic*, *formal, abstract, deductive, context-free, agent-insensitive, explicit* and, most of all, *mathematical.* Apples and oranges. Worse, phosphorous and water.

Further discouragements lie in wait. One flows from a particular aspect of the apples-and-oranges differences between law and logic. The law – especially the common law – is deeply responsive to an *epistemology of tacitness.* With respect to some of its leading concepts – proof beyond a reasonable doubt and determination by the balance of probabilities are two – there is an attitude of Don't Ask – Don't Tell. It is

meanings of their contained terms. On the other hand, a synthetic B *priori* discipline was taken to be one whose truths while not analytic (hence synthetic) are nevertheless knowable independently of sensory experience. Kant's logic is examined in [Tiles, 2004].

10 Transfinite arithmetic studies actual, rather than potential, infinities, conceived of as quite definite cardinal or ordinal numbers.

11 [Frege, 1964, 1978], [Peirce, 1931—1958, 3. 328—358, 3. 456—552 and 4. 12—20].

12 The principle reason that one of the host disciplines – set theory – was shown to be inconsistent, and subsequent attempts to produce a consistent rehabilitation of sets were not credibly analytic.

13 A more detailed treatment of the mathematicization of logic may be found in [Gabbay and Woods, 2004a].

typified by a well-known observation of *McCormick on Evidence*:

> Reasonable doubt is a term in common use as familiar to jurors as to lawyers. As one judge has said it needs a skillful definer to make it plainer by the multiplication of words. ([Strong, 1999, p. 517])

Here is an attitude embodied in an epistemological maxim which we might call the Tacitness Principle:

Proposition 3 (Tacitness) *Articulation risks conceptual distortion.*[14]

One need hardly say that the common law discloses many exceptions to the Tacitness Principle. What matters for present purposes is that, where the law does endorse it, a logician would be strongly minded to demur from it. Accordingly, since logic greatly prizes explicitization and precision, there are fundamental issues on which, to a degree at least, logic and the law have opposing epistemological inclinations.

If the law and mainstream logic disagree on the extent to which precision and articulation are attainable virtues (if virtues at all), they also disagree, or appear to disagree, on a further equally fundamental epistemological issue. The law embodies a *fallibilist epistemology.* But logic has long since championed the high road of certainty. Fallibilism is a philosophical thesis about the relationship of error to knowledge.[15] Its central idea is that

Proposition 4 (Fallibilism) It *can be reasonable to execute knowledge-acquiring procedures that one knows will, on occasion, produce error.*

Proposition (4) is itself contextualized by three related claims.

- Given their constitutions and the circumstances in which they operate, error is in principle unavoidable by beings like us.
- Errors, when committed, are in principle recognizable as such.
- Errors, once revealed, are in principle open to correction.

These are considerations that mitigate the "crap-shoot" aspect of unadulterated fallibilism, and much welcome on that account. Even so, Proposition (4) states the dominant fact, since each of these mitigations is open, in turn, to erroneous application. So, the correction of an error might produce a further error.

Fallibilism, then, is not merely the view that it can be rational to employ methods which one knows to be imperfect, but also that, for certain ranges of cases,[16] the best

[14] Hart and Honoré's *Causation in the Law* also imported into legal studies, via the concepts of "family resemblance" and "open texture", a rejection of essential definitions, occasioned by developments in ordinary language philosophy ([Hart and Honoré, 1959]). See also the entry on "indeterminacy" in [Bix, 2004, pp. 97—98].

[15] Its present-day form derives from Peirce. ([Peirce, 1955]).

[16] All, in some versions.

procedures possible will harbour these imperfections. If this is right, an interesting implication presents itself.

Proposition 5 (Error-persistence) *For beings like us, fallibility persists even under the maximization of error-avoidance.*

Corollary 5(a) *If fallibilism is true, maximal error-avoidance does not guarantee error-elimination.*

Epistemic procedures aim at knowledge. Imperfect epistemic procedures aim at knowledge imperfectly. If fallibilism is correct, imperfect epistemic procedures are the best that we humans can command. Where, then, does this leave the project of knowledge? A traditional skeptic might answer that this must leave the project of knowledge in tatters. The fallibilist is not so-minded. His further view is that

Proposition 6 (Taking for knowledge) *Although such knowledge as can be got is got by imperfect procedures, knowledge is nevertheless a realizable attainment for beings like us.*

Proposition 7 (Defeasibility) *Under the requisite procedures,* taking something as known *advances the project of knowledge defeasibly, and nothing advances it non-defeasibly.*[17]

Although fallibilism has had some good innings in the past decades, it is greatly at odds with a longer-lived and more deeply dug-in epistemological rival. It is a rival admitting of variations – some with celebrated names, and not always pairwise compatible. At the appropriate level of generality we can call it simply *infallibilism*, and characterize it as the view that

Proposition 8 (Infallibilism) *Fulfillment of the project of knowledge turns on epistemic procedures that* eliminate *(rather than minimize) error.*

How do these reflections bear on the matter presently under review? They bear as follows. The law incorporates a fallibilist orientation. Mainstream mathematics has an infallibilist signature.

4. Answering the Skeptics

We have four challenges that require a response.

(a)A partnership between logic and the law is made improbable by their respective inertial resistances.

[17] Defeasibility is a notion introduced to the philosophy of law by H.L.A. Hart (1907—1992) in his lectures on Moral and Legal Reasoning in New College, Oxford in the academic year 1951—2.

(b)The differences between logic and the law are so great as to create an apples-and-oranges problem for any prospect of interdisciplinary rapprochment.

(c)On some central issues logic and the law are riven by a fundamental disagreement over the Tacitness Principle.

(d)The law and logic split along fallibilist and infallibilist lines.

We shall briefly consider these objections, beginning with apples-and-oranges.

4.1 Apples-and-Oranges

It would be wrong to leave the impression that the mathematicization of logic has generated an uncontested monolith. Even as Frege's and Russell's logicistic projects were unfolding,[18] alternative approaches were being developed. Intuitionism, many-valued and modal systems emerged as early alternatives of classical logic.[19] Some of the beneficiaries of this advance were epistemological concepts, such as *knowledge* and *belief* ([Hintikka, 1962]), and moral/legal concepts, such as *obligation* and *permission*, all of which were conceived of as modal operators by analogy with the alethic modalities, *necessity* and *possibility*. Of particular relevance to legal studies is the modal logic of obligation and permission, *deontic logic* so-called (Mally, 1926], [von Wright, 1951]); see also ([Bix, 2004, p. 50])

Most of these non-classical developments reflect an interest in how reasoning is actually done. In the case of modal logic, there is a recognition that reasoning often pivots on what is taken as *necessary* or is assumed to be *possible*. Epistemic logic takes notice of the role that reasoning plays in the attainment of *knowledge*. Deontic logic examines the logical relations that connect the concepts of *obligation* and *permission*. Much of the motivation of many-valued logic arises from the *vagueness* of human languages. Even intuitionist logic was designed better to capture the structure of mathematical reasoning on the ground. None of these developments required, or aspired to, the abandonment of an abstractly mathematical methodology. This suggests that this kind of formal treatment is not intrinsically hostile to an interest in reasoning as it actually occurs. Even so, it could not be denied that a significant gap remained between the methodology and the subject matter, a gap which theorists attempted to bridge with the device of *ideal models*. (For reservations, see [Gabbay and Woods, 2003c]).

The gap considerably narrowed with the emergence of "user-friendly" logics in the second half of the past century. These developments arose from three principal sources, and largely independently of one another. From logic itself there flowed

[18] Bertrand Russell (1872—1970) was also a notable proponent of logicism. As it happens, however, Russell had a different understanding of this doctrine from Frege's. While interesting, and important for the philosophy of mathematics, this is a point that need not occupy us here.

[19] L.E.J. Brouwer pioneered intuitionist logic in the teens of the last century. A standard formulation is [Heyting, 1966]. Many-valued logic appeared in [Łukasiewicz, 1920]. C.I. Lewis' work on modal logic dates from 1912, and is accessibly reported in [Lewis, 1918].

a rich pluralism of reinvigorated modal logics ([Kripke, 1963], [Gabbay, 1976]), logics of relevance ([Anderson and Belnap, 1975]), time and action logics ([Gabbay *et al.*, 1994]) and other forms of dynamic logics ([van Benthem, 1996] [Gochet, 2002]), situational logics ([Barwise and Perry, 1983]), game-theoretic logics ([Hintikka and Sandu, 1997])[20], and systems of belief dynamics ([Alchouron *et al.,* 1985]). Significant advances were also made by computer scientists and AI theorists. Some of the best-known of these developments include default logics ([Reiter, 1980]), theories of defeasible reasoning ([Rescher, 1976])[21], non-momotonic reasoning,([Schlecta, 2004]), logic programming,([Kowalski, 1979], [Pereira, 2002]) and various extensions and adaptations of them to the imperatives of time-sensitive, resource-based cognitive agency [Ginsberg, 1987]

A third source has been the informal logic movement, comprising three overlapping orientations. One is argumentation theory ([Johnson, 2000], [Johnson and Blair, 1994], [Johnson and Blair, 2002], [van Eemeren and Grootendorst, 1984], [Govier, 1986], [Freeman, 1991], and [Woods, 2003]), and fallacy theory, ([Hamblin, 1970], [Woods and Walton, 1989], [Walton, 1995] and [Woods, 2004]). Completing the trio is dialogue-logic ([Hamblin, 1970], [Barth and Krabbe, 1992], [Hintikka, 1981], [Mackenzie, 1990], [Walton and Krabbe, 1995], and [Gabbay and Woods, 2001a, 2001b])

We see in these various developments considerable encouragement of the idea that modernized systems might well be restored to logic's original purpose of investigating the structure(s) of real-life argumentative practice and reasoning as it actually occurs. It is an interesting rehabilitation, incorporating an unmistakable drift to the practical aspects of argument and inference.

This drift towards the practical is given further impetus by developments in cognitive psychology, especially those that take a mental models approach ([Johnson-Laird and Bryne, 1991]) or favour a bounded-rationality orientation ([Gigerenzer and Selten, 2001]) towards cognition.[22] Another stimulus is the practical logic of cognitive systems advanced in ([Gabbay and Woods 2003b], [Gabbay and Woods, 2004b] and [Gabbay and Woods, 2005a]).

These are important innovations both collectively and in their own right, and fully deserving of a name. We have proposed "the new logic" as a fitting baptism ([Gabbay and Woods, 2001a]). The net resultant of these transformations is that the alienation of a strictly mathematical and symbolic orientation from the give-and-take of legal thinking is substantially mitigated. The proof of the pudding is in the eating, needless to say. But the closure of the gap between mainstream logic and the law is sufficiently encouraging to take much of the sting out of the apples-and-oranges objection.

[20] See also [Bix, 2004, pp. 77—78].
[21] See also [Bix, 2004, p. 50].
[22] See also [Bix, 2004, 26—27].

Proposition 9 (Law and the new logic) *The apples-and-oranges objection is largely answered by the various adaptations of the* new logic *to the peculiarities of real-life reasoning.*

4.2 Inertia

If we are justified in accepting Proposition (9), an answer to the reciprocal inertia objection easily falls out. It is true that disciplines have a natural tendency to resist one another's advances, but as the example of analytic geometry, mathematical logic, biochemistry and cognitive science shows, when the conditions are right, such resistance can be overcome. Here, too, the very existence of the new logic justifies a certain optimism for a fruitful partnership between logic and the law. Still, as we say, the proof of the pudding is in the eating. We may take it that

Proposition 10 (Inertia) *Proposition (9) gives us reason to attempt the reconciliation, albeit, at this early state, without the re-assurance of guarantees.*

4.3 Tacitness

Logicians who investigate the structure of science have long recognized the tactiness in which the proclamations of science are systematically rooted. It is wholly typical of scientific laws that they hold *ceteris paribus*. The invocation of *ceteris paribus* clauses is a kind of hand-waving. It points to the importance of background knowledge which cannot, then and there,[23] be made fully explicit. The practical turn in logic engenders a wider recognition of tacit knowledge as factor in cognition as such. A dominant example is the phenomenon of common knowledge (so-called) in which propositions are advanced without their accompanying justifications.[24] A further instance is a class of practices made successful by the sufficiency of their comportment with the requisite rules, but in the absence of anything like a general articulate command of them. Memory, too, is highly selective in what it stores at high levels of articulability.

[Gabbay and Woods, 2004b] sets out the general structure of a resource-bound logic. A logic is conceived of as a model of the behaviour of real-life cognitive agents. In this approach, an agent is performing reasonably only in relation to at least three factors.

1. The cognitive target that he is aiming at.
2. The standard required (or sufficient) to hit that target.
3. The resources available for the task at hand.

It is clear that agents, whether individuals or institutions, routinely operate under conditions of cognitive-resource scantness. In the real world, agents must transact

[23] In some accounts, ever.
[24] In some accounts, without the possibility of recovering their justifications.

their cognitive agendas in the face of incomplete information, limited time and constraints on computability. Comparatively speaking, institutional agents (NASA, for example) do much better than the man in the street on all three scores. But relative to the loftiness of its cognitive targets and the strictness of the standards for meeting them, NASA, too, often knows the challenge of squeezed resources.[25] But, next to NASA, beings like us tend to aim lower and call upon less strict standards in following through. (We say more about this in the subsection to follow.)

Given the pervasiveness of resource constraints, agents of all types have a large stake in proceeding economically, that is, in ways that conserve scant resources. Accordingly, agents operate in *cognitive economies*. At their respective levels, both individual and institutional agents owe their rationality to how effectively they manage to transact their cognitive agendas "on the cheap." This bears directly on the factor of tacitness.

Proposition 11 (Economizing with the tacit) *Tacit knowledge and tacit understanding are attended by significant savings in the cognitive economy.*

One should not make more of Proposition (11) than is in it. We are a long way from suggesting that articulation is never possible or desirable. One of the central tasks of a *theory* of a given body of practice is to articulate the canons against which success is measured, notwithstanding that practitioners on the ground are not in the general case able to give full expression to them. Language is a case in point. Speaking is comparatively easy. Linguistics is terribly difficult. Given that the law admits of a distinction between legal practice and legal theory, there is occasion to still the present objection. A logic of the law is a theory. It seeks to articulate the structure of the practice of legal reasoning. It is no impediment to the theory's success that the fruits of its articulations are not always of direct edification to the legal reasoner in the buzz and boom of actual practice. Even so, given that a resource-bound logic is a theoretical model of the actual behaviour of cognitive systems, it must take pains to reflect the tacitness and inarticulacy of reasoning in the raw.

One of the attractions of classical variations of mathematical logic is the extent to which they are able to narrow the gap between articulate theories and tacit practice. In some instances, the theory's target properties are effectively recognizable by the reasoner on the ground. But this does not change the fact that even when recognition procedures are ready to hand, typically they are not invoked by real-life reasoners. What is more, the more a logic converges on the task of representating reasoning in the raw, the less it is able to make its target properties mechanically ascertainable.

4.4 Fallibilism

A procedure that makes a target property (e.g. validity) effectively recognizable is called a *decision procedure*. A decision procedure is one that executes mechanically,

[25] Something of an understatement, in the wake of the Columbia disaster.

finitely and infallibly. This helps us see that mainstream mathematical logic has an infallibilist orientation which, in some cases, is directly accessible by the agent in the field. It is important to observe that mainstream mathematical logic investigates cognitive processes for which infallibility is an attainable goal, at least in principle. Mainstream logic investigates the target of truth-preservation and, as a standard necessary for attaining it, validity. It discloses proof-rules and other devices for meeting this standard. The validity standard and infallibility fall into a wholly natural alliance. We could say that they were made for one another.

Still, the technically austere (and highly conservative) ideal of truth-preservation is at once too expensive and cognitively inappropriate given the actual interests of cognitive agents. It is no exaggeration to say that if we attempted to hold it to the validity standard, the criminal justice system would in short order be a paralyzed disgrace. Given our interests and our position in the world, most of what we seek to know is not deductively available to us. Reasoning, as such, is dominantly *ampliative*.[26] Legal reasoning is a paradigm of this.

Here, too, we must say that the extent to which a logic seeks to model the real-life behaviour of cognitive agents, it must (to say the least) displace the validity standard from the centre of its preoccupation. Given its purpose-built structure, mainline mathematical logic must fail in this regard. But the new logic is another thing entirely. Accordingly,

Proposition 12 (Fallibilism and the new logic) *Since the new logic strives to model the reasoning of actual agents, it has a stake in recognizing the fallibilist character of such reasoning.*

These are our answers to objections that a theoretical rapprochement of logic and law is an imperiled thing *in principle*. If our answers are adequate, we have reason to say that the logic and law project is not impossible. Welcome as it is, it is a rather weak result. In Part II we attempt a footfall on higher ground.

Part II Commonality of Concepts

5. Logically Salient Concepts of Law

Some of the general notions embedded in legal practice and theoretical jurisprudence are of little direct interest to the logician. For all their juridical importance, the concepts of copyright and easement, to take just two examples, have little in their makeup by which they could reasonably be called concepts of *logic*. However, perhaps it is not surprising that a large number of the notions that underwrite litigation have

[26] Reasoning is ampliative when its conclusions contain information not present in the premisses.

the dual significance of being at once concepts of law and concepts of logic. These are some of the major building blocks of the logical structure of the law. As we have said, the concepts that constitute the laws logical structure are these: *inference, evidence, probability, relevance, reasonableness, precedent, presumption, plausibility, explanation,* and *proof.*[27] We now give some brief indication of how each of these might be approached logically.

Evidence. The legal concept of evidence subdivides into three categories: *Physical, eyewitness,* and *expert.* Of the three, the latter two are of greatest logical interest. Eyewitness evidence is known to be unreliable when a witness's memory is stimulated by leading questions from a person in authority, or when the witnessed event was highly shocking or terrifying ([Loftus, 1980]). Expert evidence relies upon a judge's prior determination of qualifications and salience. Given that the judge is himself not an expert in the fields subject to these determinations, the judge is acting in those matters as an ordinary person reasoning in the way of ordinary persons.

The instability of eyewitness testimony also calls into question the role of eyewitness *corroboration.* ([Walton, 1997]; but see [Woods, 2004]. See also [Schlesinger, 1988], [Cohen, 1980, 1982, 1991]). The logician's role is to reconcile the probativity of such corroboration in face of the known instabilities of eyewitness recall.

A major task concerning the admissibility of expert testimony is determining the extent to which the judge (who sometimes takes expert advice on what to count as expert advice) is subject to the *ad verecundiam* fallacy, which, in its modern form is the fallacy of defective or unjustified reliance on the sayso of another ([Woods, Irvine and Walton, 2004]; but see [Woods, 2004]). A central task of a legal logic is to ascertain how determinations of the admissibility of expert testimony evades the charge of fallaciousness.

Evidence at trial is led by testimony. Testimony comes from witnesses by what lawyers call *examination.* Similarly, evidence is rebutted in two ways. One is by the direct testimony of contradicting witnesses. The other is by *cross-examination.* Examination and cross-examination are further aspects of trials that are subject to procedural constraints. These constraints, in turn, are grist for the mill of the standard of proof. Examination and cross-examination alike exemplify *interrogative models* of dialogue. What makes legal examination by question and answer distinctive is the distance of their regulatory canon from interrogations made at common sense levels and in scientific enquiry. The interrogative logics of examination and cross-examination

[27] Perhaps as further attestation to the law's fondness for the tacit, only one of these shared concepts (viz., "precedent"; see also the entry on "analogy") has an entry in Brian Bix's *A Dictionary of Legal Theory* ([Bix, 2004]). True, one of the aims of that little book is to help adjust its readers to theoretical concepts imported from disciplines other than the law. Even so, these are striking omissions in any work carrying such a title. We might observe in passing that whereas [Bix, 2004] contains an entry on "rationality" (to which "reasonableness" is merely cross-referenced), it has nothing to do with the legal notions of the reasonable man and of reasonable doubt.

are (in different ways) peculiar to legal practice, and this is something that the legal logician must give an account of. It is also clear that cross-examination has the structure of what Aristotle called *ad hominem* arguments ([Aristotle, 1984]), also so-called by John Locke ([Locke, 1975]). In Locke's characterization, one makes an *argumentum ad hominem* against an adversary when one "presses him with consequences of his own principles and concessions". In modern logic, *ad hominem* arguments are usually regarded as fallacious ([Woods, Irvine and Walton, 2004]). This is a puzzle for the logician. Either cross-examination is inherently fallacious (which seems absurd on its face) or somehow the modern logic of fallacies has yet to produce and adequate account of *ad hominem* reasoning ([Woods, 1993]).

A further feature of adversarial proceedings is the extent to which parties seek to discommode one another. Cross-examination, for example, pivots vitally on factors of non-cooperation. True, the requirement that witnesses give truthful and complete answers considerably constrains the extremes of non-cooperation (viz., refusal to answer[28] and perjury), but in actual practice considerable room is left for evasion and spin, depending on the skill of the parties. Non-cooperative dialogue logics study these factors in a systematic way, and accordingly are an indispensable tool for the legal logician. ([Gabbay and Woods, 2001a, 2001b])

Probability. Probability is a fundamental concept of reasoning in every system of jurisprudence since the *Talmud*. From antiquity to the Renaissance, probability has been the object of theoretical elaborations of considerable subtlety ([Franklin, 2001]). Probability is no less a part of common sense reasoning and scientific enquiry. As science entered its modern period in the 17^{th} century, probability was caught up in the general drift toward the mathematical. By the end of that century, Fermat (1601—1665), Pascal (1623—1662) and Huygens (1629—1695) had succeeded in mathematizing a conception of probability applicable to games of chance – or *aleatory* probability ([Cohen, 1989])[29]. This, the probability calculus, has been considerably refined in the ensuing centuries, and in its present form is without question the most successful and complete formal articulation of probability yet attained. One of the attractions of the probability calculus is the promise it offers of describing the logic of ampliative (i.e., other than strictly deductive) reasoning. "Bayesianism" is a term that names the most dominant of these contemporary theories of probabilistic reasoning ([Pearl, 1988]). In recent years a dispute has arisen between those who hold that Bayesianism[30] is the canonical theory of all conceptions of probability, includ-

[28] An American exception is the invocation of the fifth amendment, which releases persons from the necessity of answering questions in a way that may tend to incriminate them in the performance of an offence.

[29] "Aleatory" derives from the Greek word for game.

[30] Bayesianism is named after Thomas Bayes (1702—1761), discoverer of the famous probability theorem that bears his name. There exists some scholarly disagreement as to how much of a Bayesian Bayes himself actually was. This is a question that need not detain us here.

ing probability in the law ([Cohen, 1980 dissenting]), and those who see its range as limited to the peculiarities of games of chance. Anti-Bayesians tend to look with a certain wistfulness at the four thousand year history of learned commentary on probability. They tend to regard the probability calculus as a "Johnny-come-lately", too self-enamoured for its own good ([Franklin, 2001], [Cohen, 1980]). Right or wrong, there is ample necessity to test the mettle of Bayesianism in jurisprudential contexts. Such is a task for a *probability logic* ([Williamson, 2002]).

Relevance. On the standard legal definition, information is relevant to a proposition when it affects, positively or negatively, the probability that that proposition is true ([Cross and Wilkins, 1964]). In actual legal practice, it is clear that it is *ir*relevance, rather than relevance, that wears the trousers. The epistemic artifices that justice requires will often cause the exclusion of relevant evidence, but a judge will also make every effort always to exclude information that is irrelevant.

Aside from its formal definition, considerations of relevance also crop up in evidence-exclusion decisions that are not determined by whether the evidence in question would, if admitted, alter the probability of some or other salient claim. Here the exclusions are based on the finding that, if admitted, it would compromise the accused's right to a fair trial. Very often these decisions involve evidence of the accused's character ([Cross and Wilkins, 1964], [Murphy, 2000]). A common reason for exclusion is the judge's belief not that the evidence is probabilistically irrelevant but rather, even if probabilistically relevant, a jury would be enflamed by hearing it. It is here perhaps that we find the law at its epistemically most artificial. There are ranges of cases in which a judge will exclude testimony about an accused's character which, in common sense terms, well might increase the probability of some proposition of importance to the prosecution, but which he excludes on grounds of irrelevance.

This apparent contradiction is explained by observing that, in its actual employment in legal reasoning, the concept of relevance is ambiguous. In one sense, evidence is irrelevant because it doesn't affect the probability of some pertinent proposition. In the other sense, the same evidence is declared irrelevant precisely because it *does* enhance the probability of the proposition in question. It is therefore excluded not on grounds of probabilistic irrelevance but rather on grounds of what might be called "standard of proof" irrelevance, where, among other things, the standard requires that verdicts be reached dispassionately. We see from this that considerations of relevance in this second sense tie in with the proof standard in quite intimate ways. In plain words, the standard of proof is made strict not by the strictness of the target it aims at, but rather by constraints on what prosecutors are allowed to lead as evidence, even evidence that satisfies the probabilistic definition of relevance. It falls, then, to the legal logician to deploy the resources of an appropriate *logic of relevance* (see, e.g., [Gabbay and Woods, 2003] for the purpose of bringing these interconnections into tighter focus. In particular, the logician has the task of unpacking this notion of standard of proof-irrelevance. Part of that story will be one that takes due

note of the factor of *bias*.

Bias lies at the heart of these exclusions. It is entirely possible that evidence exists which, if led, would wholly comply with the law's own definition of relevance. If a judge excludes it on the grounds of irrelevance, he excludes it for its *bias*. Again, he excludes it not because it doesn't increase the probability of the accused's guilt, but rather because it does increase the probability of his guilt and does so in ways that may induce the jury to give it excessive *weight*. The evidence is excluded because the judge thinks that the jury will make too much of it, with consequent risk to the requirements of a fair trial.

Precedent. Precedents are a "core aspect of common law reasoning ... [but in] most civil law systems, courts are not bound by prior decisions" ([Bix, 2004, p. 163]). Reasoning from precedents is the law's closest link to *analogical argument* ([Gabbay and Woods, 2005], [Bix, 2004, pp. 5—6]). In the logical literature, there are two entirely disjoint concepts of analogy, which answer to an ancient distinction. One is the notion of analogical *predication*[31] ([Woods and Hudak, 1992]). The other is the notion of analogical *argument* ([Woods and Hudak, 1990]).[32] The former concept pivots fundamentally on embedded ambiguities. The latter notion is a generalization of arguments from *logical form*. Precedential reasoning in legal contexts instantiates the second sense of analogy, and presents the logician with the task of exposing the structure of the logical forms on which they generalize.

Precedents are also extremely interesting for the further questions they raise about *ad verecundiam* thinking in the law. Precedents are created by judges both brilliant and stupid, scrupulous and foolish. They are binding irrespective of the qualities of the judges who created them. They derive their force not from a judge's virtues, and notwithstanding his vices; indeed they derive their authority from the judge's *office*. This raises the question of why a dubious decision by a stupid or careless judge should have any precedential standing.[33] On the face of it, this is a state of affairs tailor-made for the charge of *ad verecundiam* fallaciousness especially in the sense of the *Port Royal* logicians of the 17^{th} century ([Woods, 1999]).[34] It falls to the logician to examine the credentials of this accusation in the context of a suitably general logic of the fallacies. The anomaly noted above recurs. Either the doctrine of precedent is replete with fallacy, or the modern logic of fallacy has not taken adequate notice of the logical structure of criminal law.

[31] As with the statement that Philip Mountbatten is the First Lady of Great Britain.

[32] As with the claim made by some opponents of same-sex marriage that if the argument for same-sex marriage is sound, so too is an analogue of that argument on behalf of polygamy.

[33] In actual practice, courts are allowed "a great deal of freedom to 'distinguish' prior decisions as not being truly on point for an issue currently before the court." ([Bix, 2004, p. 163]).

[34] In the *Port Royal* approach, the fallacy in question is one of deferring not to the merits of the case but rather to the rank or social status of one of the parties. The principal authors of the Port Royal *Logique* were Antoine Arnauld (1612—1694) and Pierre Nicole (1625—1695), although some scholars conjecture that Pascal contributed the sections on probability.

Inference, presumption, plausibility. Like its logical counterpart, legal inference is a matter of drawing conclusions. But there are differences. Whereas in the precincts of mainstream formal logic inference has been understood deductively, legal inference rarely has that character. A greater commonality exists between legal inference and the approach to inference taken in the *new logic*. In both places, inferences are conclusions drawn in real time by psychological agents operating under various externalities. Inference here is dominantly non-deductive or ampliative; and a further feature is its largely presumptive character. In so saying, we are using the word "presumptive" in its logical meaning, in which a certain tentativeness is intended. What we intend to capture is that, in its employment of the notion of presumption, and of the allied concept of presumptive reasoning, legal reasoning most nearly takes on the character of *default logics*, ([Reiter, 1980]) and related forms of non-monotonic and defeasible reasoning ([Schlecta, 2004]).

This generates a question of central importance for a legal logic. Logically presumptive inferences are considerably influenced by considerations of plausibility. Plausible inferences are inferences made and accepted on sufferance. In the standard logics of such matters, presumptive reasoning and plausible inference fall well short of achieving standards that would justify the name of *proof* ([Rescher, 1976]). But it is precisely proof to which criminal procedure is fundamentally directed. The question, then, is whether procedures that are so imbued with aspects of the presumptive and the plausible can make any kind of logically justified claim on the notion of proof. In this there is a clear affinity to the doctrine of "the ordinary man" (or "reasonable person"), in particular, with the assumption that epistemically justified convictions can be entrusted to the untutored and the unlearned, when reasoning in the way of the ordinary man.

It is necessary to note legal uses of the word "presumption" that preserve neither the tie with default inference nor the connection with the notion of plausible reasoning. Cases in point are the presumption of innocence in criminal law, and the notion of *mandatory* presumption. In each case, the presumption is a matter not of inference but of juridical stipulation, and must be given a suitably different interpretation in a logic of the law. Lying somewhat closer to the logical idea of tentative inference is the further notion of discretionary presumption, in which it is juridically determined what a juror *may* conclude from a certain category of evidence.

Explanation. In a criminal proceedings, it is the duty of the prosecution to present to the jury (or where applicable to the judge) a *theory of the evidence*. A theory of the evidence is a hypothesis that best explains it. In the prosecution's hands, this hypothesis is always that the accused is guilty as charged. Although the accused need not enter a defence, it is usual in practice for counsel for the accused to do one or other (or both) of two things. One is to try to discredit the prosecution's claim that the accused's guilt best explains the evidence. The other is to launch an alternative theory of the evidence in which a hypothesis other than the accused's

guilt is proposed as better explaining the evidence. What lawyers call a theory of the evidence (or theory of the case) logicians call *abduction* or, more particularly, "inference to the best explanation" ([Harman, 1986], [Lipton, 1991]).[35]

Legal reasoning is thoroughly abductive ([Gabbay and Woods, 2005]). Some philosophers of science are of the view that a hypothesis' explanatory force is rarely, just as it stands, of probative value, i.e., that the satisfactoriness of an explanation of something is not a particularly reliable marker of its truth e.g. ([van Fraassen, 1980]). We ourselves share this view. This is problematic if true. If explanations don't confer truth, then, if the hypothesis that best explains the evidence is that the accused is guilty as charged, how can it be that this does anything at all to advance a juror in his basic duty, which is to determine whether the charge against the accused has been *proved*? It is a challenging issue for the legal logician, for whose solution he must develop the appropriate logic of abduction. (See Part IV below.)

Proof. The law's interest in proof centers around a distinction between the *burden* of proof and the *standard* of proof. The law is expressly clear about the former and not so clear about the latter. In either case, there is work for a logician to do. In the matter of burden,the criminal law is clear that proving the case rests solely with the prosecution and that an accused is subject neither to a duty to present a defence nor to a disadvantageous inference should he not do so. In actual practice, it is rare for this contrast to present itself so cleanly. This suggests that from the point of view of effective case-making, it is frequently if not typically the case that a defence is actually presented. On the face of it, the injunction not to draw inferences disadvantageous to an accused who chooses to stand mute is not heeded (or able to be heeded) by jurors. This needs to be accounted for in what dialogical logicians call the *logic of response to challenge* or – in one of its present-day meanings – *dialectic* ([Barth and Krabbe, 1982], [MacKenzie, 1990], [Walton and Krabbe, 1995], [Gabbay and Woods, 2001b, 2001c]).

The standard of proof is a pricklier issue. Among lay people it is widely believed that in criminal cases the standard is, as it should be, artificially strict. It is quite true that in the criminal law justice sometimes trumps truth, and that the law will tolerate epistemically wrongful *acquittals* as a cost of avoiding epistemically wrongful *convictions*. Accordingly, from the point of view of common sense there are epistemically compromising restrictions that courts will impose upon what a jury is allowed to hear. We see here the law's determination to acknowledge situations in which social goods override epistemic goods. This is indeed an artificial intervention, and it often has the cumulative effect of making counsel's evidential targets harder to hit than would be the case in non-legal settings. In that sense, too, there is an element of strictness. But it is not the *juror's* job to judge the admissibility of evidence. His

[35] As we show in [Gabbay and Woods, 2005], inference to the best explanation is just one form of Abductive reasoning, albeit it a common one. Even so, it seems the right form of it for reasoning to a verdict in criminal trials.

task is to assess the evidence as presented and to make of it, if he can, an assessment of the prosecution's theory of the case. These are his fundamental duties, and in performing them the juror is not required (or allowed) to engage in thinking that is either artificial or particularly strict. For he must determine the accused's guilt or innocence on the evidence he is allowed to hear as an ordinary person, reasoning in the way that ordinary reasoners reason.

This provides the logician with a central task. It is to specify the conditions under which reasoning is that of the ordinary person (hence the importance in our approach of the notion of practical agency). The logician must identify its characteristics, and he must offer an account of what it is about such reasoning that answers to the Crown's (and the public's) aversion to wrongful conviction. In a word, if the reasoning that leads to a conviction is distinguished by neither special expertise nor learnedness, how can it be believed that reasoning of this kind rarely leads to a bad result? No one would dream for a moment of leaving the results of neurobiology or topology to the ruminations of the untutored and the unlearned. Why should criminal procedure be an exception to this?

This brings us to the close of Part II. Our case so far has been that there is nothing in principle that rules out the logic and law project, and, by way of shared concepts, there is reason to think that the project might succeed. We said at the beginning that, while topical overlap may be encouraging, what really counts is whether the one discipline can make elucidations of the other's concepts that the other has not made, and perhaps could not make. A case in point is the proof standard in criminal trials. Our further purpose is to show how it attains a considerable degree of conceptual clarification in a branch of logic that deals with abduction. In the Part to follow, we lay out a schema for a logic of abduction. In the Part after it, we use the logic to probe the concept of reasonable doubt.

Part III: A Sketch of a Logic of Abduction

6. Ignorance Problems

We begin this section with the idea of an *ignorance problem (IP).*

Definition 1 (Ignorance problems) *An* IP *exists for a cognitive agent X if and only if X has a cognitive target T that cannot be attained from what he currently knows (or equivalently from K, his current knowledge-base).*

*IP*s present cognitive agents with two standard options. One is to acquire new information that will enable X to attain T. Accordingly, for an agent X,

IP-option # 1 (X overcomes his ignorance) X extends K to some successor

knowledge-base K^* such that K^* attains T. *Example*: Not remembering how to spell "accommodate", X checks his online dictionary. Now he knows.

Another response to an *IP* is to acknowledge that the pair $< K, T >$ constitute for X an insolubilium. Accordingly,

IP-option # 2 (X's ignorance overcomes him) Unable to succeed with option # 1, X capitulates. *Example*: Not remembering how to spell "accommodate" and lacking access to a dictionary, X decides to settle for a near synonym.

It is well to note the dynamic character of this pair of options. For example, X might try and fail to exercise option #1 at time t_1, and at time t_2 he might acquiesce to option #2. Yet at time t_3 he might recur to option #1 with good results.

Many people are of the viewthat, when an agent is confronted with an ignorance-problem, alternatives # 1 and # 2 exhaust his option space. In fact, there is a third option. *It is the founding datum of abduction.*

IP-option # 3 (Presumptive attainment) X finds an H which, if he did know it, would together with K solve his IP, and from that fact he conjectures that H. *Example*: Not knowing how to unify the laws of black body radiation, Max Planck postulated quanta and thereby presumptively achieved the unification (and revolutionized physics.)[36]

Option # 3 incorporates the element of conjecture in an essential way. This is obvious in the case of H itself, but what is often overlooked is that this does not solve the original problem. X's problem is that his T is attainable only on the basis of what he now knows (K) or can readily get to know (K^*). His situation *now* is that T cannot be attained either way. If he selects a H such that the truth of K revised by H *would* hit T, then *conjecturing* H does not produce K^*. In particular, K together with H (hereafter $K(H)$) is not a knowledge-base for X.So it does *not* solve X's ignorance problem.

This highlights the second irreducible element of conjecture that option # 3 embeds. $K(H)$ doesn't hit T, but we may say that it hits it *presumptively.* Accordingly, option # 3 offers X not a solution of his ignorance-problem, but rather attainment *faute de mieux* of a lesser target. Instead of a target that admits of only *epistemic* attainment, it proposes a conjectural variant of it that provides *presumptive* attainment. This is deeply consequential.

***Proposition 13* (*Ignorance-preservation*)** *Whereas deduction is truth-preserving and induction is probability-enhancing, abduction is* ignorance-preserving.

[36] Of course, over the decades quantum mechanics has acquired truly impressive levels of empirical confirmation. But at the time of its original conjecture there was nothing whatever in the physics of the day that lent it the slightest degree of confirmation. Here again we see the diachronic character of enquiry. What begins as an abduction may end up as a confirmed fact.

Proposition (13) sets forth what we will call the *ignorance condition.* For any account of abduction, it is a condition of adequacy that

AC1. *A theory of abduction must honour the ignorance-condition.*

Option # 3, as we see, is not a solution of an IP; it is a *transformation* of an *IP* into a problem that conjecture can solve. It is a response to an *IP* that requires X to lower his sights with regard to T. It turns on X's disposition to *satisfice* rather than *maximize.*

Here, too, it is prudent to emphasize the dynamic character of *IP*s and the responses that they induce. A cognitive agent might try and fail with option # 1, and then move to option # 3. If it also failed him, option # 2 might now recommend itself. If option # 3 succeeded, X might persist with it until, so to speak, he came to know better, in which case he might move to option # 1; and so on. Accordingly, we say that

Proposition 14 (IP-relativities) IPs *arise in relation to targets in play at a time and resources then available. Responses to* IPs *retain those targets and proceed in ways, permitted or otherwise, by subsequent resources.*

Peirce and others have emphasized that it is a condition on the scientific admissibility of an abductive conjecture H that it be *testable*, as indeed the quantum hypothesis turned out to be. By these lights, a solution to an abduction problem is also a step in a process that solves the originating ignorance problem. So, for the class of cases that Peirce has in mind,

Proposition 15 (Ignorance-mitigation) *Although a solution to an abduction problem preserves the ignorance that gave rise to it, it may also contribute to the solution of the originating problem by identifying* candidates *for the status of new knowledge.*

It is necessary to observe, however, that in certain cases abductive conjectures are *not* scientifically testable. For example, various forms of philosophical skepticism attract inference-to-the-best-explanation abductions. It may be that the best explanation of our external world experiences is that there is an external world that produces them. But to require that the external world hypothesis be testable is to beg the question against the skeptic, which in turn, ruins the anti-skeptic's rejoinder. Accordingly,

Proposition 16 (Testability) *Testability is not intrinsic to the making of successful abductive hypotheses.*

Corollary 16 (a) *Proposition (16) is of clear relevance to abductions in which the winning* hypothesis *is "guilty as charged."*

7. Abduction Problems

We now have the means to define abduction problems *(AP)*. With K and T set as before,

Definition 2 (Abduction problems) *X has an AP with respect to {K, T} if and only if he has an IP with respect to {K, T} in response to which he is disposed to exercise option # 3.*

Generalizing IPs. An *AP* is an *IP* to which X responds in a particular way. It substitutes conjecture for knowledge. It may be thought that all abduction problems are ignorance problems. This is a mistake. It is easy to see that the structure of abduction problems is wholly preserved if we substitute for K any cognitive state with regard to which presumption is epistemically junior to it (belief is the obvious example). Accordingly, given that an ignorance problem represents an *epistemic* shortfall,[37] a variant of it would represent a *doxastic* shortfall,[38] or in some cases a *plausibility* shortfall. In each case, the conjecture deployed by the abducer's solution would have to meet two strong conditions.

Proposition 17 (Epistemic juniority) *If H is a solution of an AP, H has a lesser epistemic status than the cognitive standard against which the original problem arose.*

Proposition 18 (Effective juniority) *If H is a solution of an AP, then although there is an epistemic disparity between it and the epistemic standard against which the AP arose, H's epistemic juniority must comport with the requirement that it produce a presumptive solution of AP.*

Proposition (17) generalizes on the ignorance-preserving character of abductive solutions to *IP*s. It provides that in its fully general form, abductive solutions are *cognitive deficit*-preserving. Proposition (18) offers the helpful admonition, that for all their cognitive limitations comparatively speaking, successful *H*s must have the wherewithal to produce rationally adequate, though cognitively subpar, solutions of their *AP*s. Proposition (17) gives us occasion to broaden adequacy condition *AC1*, which calls for theories of abduction to honour the ignorance-condition. As now we see, in its more general form, *AC1* would demand that abductive theories honour the *cognitive-deficit* condition. Henceforth we shall read the ignorance-condition in this more general way, in the absence of indications to the contrary.

8. Avoiding a Confusion

When a reasoning agent conjectures an H that bears the presumptive attainment relation to his cognitive target T, he is operating at an *epistemic* disadvantage. If he

[37] "Epistemic" derives from a Greek word for *knowledge*.
[38] "Doxastic" derives from a Greek word for *belief*.

cannot attain T on the basis K of what he now *knows*, he may conjecture a proposition H that he doesn't know but which, if it were true, would, in apposition to what he does know, attain T. Or, in a variation, if T cannot be attained on the basis of what a reasoner *strongly believes* or what he *takes to be highly probable*, his hypothesized H must be a proposition that he neither (that) strongly believes nor takes to be (that) highly probable. As we see, the epistemic juniority of H is relative to the epistemic standing of the Kin relation to which the ignorance-problem arose initially. So it bears repeating that the agent's recourse to H is from a position of *relative* epistemic juniority, and that this aspect of juniority is expressly recognized in the fact that in selecting it, the agent is proceeding conjecturally.

Note, however, that the content of the agent's conjecture of H is that H is *true*. This is as it should be, given that th conjecture of H turns on the fact (or what the abducer takes to be a fact) that if H *were* true, then H in apposition to K would attain the cognitive target T. Philosophers often characterize truth as an *alethic* property of propositions (or theories). Given that "alethic" derives from the Greek word for "true", the appellation has a certain redundancy about it, but not one that occasions any real harm. In fact, it is a baptism that affords us an essentially important distinction for the logic of abduction. Accordingly,

Proposition 19 (Epistemic v alethic factors) *While it is essential that a successfully abduced* H *possess the requisite* epistemic *juniority, it is neither necessary nor desirable that it be* alethically *subpar.*[39]

Corollary 19 (a) *If we put it that abducing a* H *is always a kind of guessing, it is easy to see that what the abducer hopes for is that his guess will* turn out to be true. *Abducers deliberately set their task as one of guessing, but they do* not *aspire to guess what is false.*

The same lesson applies to K-parameters of strong belief or propositions held as highly probable. In conjecturing H, one's epistemic hold on it must be of a lesser grade than that of strong belief or propositions held as highly probable. But nothing precludes the abduced hypothesis hitting the alethic standard of truth. On the contrary.

9. Abductive Schematics

Although ignorance abduction is but a case of epistemic-deficit abduction, we will here confine ourselves to the former as an expository convenience.

Let $T!$ express that T is a (contextually indicated) agent's target. K is the agent's knowledge-base, K^* a closely accessible successor of K, R the attainment relation for

[39] In classical approaches to truth, any proposition that is alethically subpar is false. In many-valued approaches, an alethically subpar proposition has a less truth-like value than the proposition to which it is subpar. In truth-approximation approaches, one proposition is alethically subpar to a second when the former is less approximately true than the latter.

T, R^{pres} the presumptive attainment relation, H in hypothesis, $K(H)$ the revision of K by $H, C(H)$ the conclusion that H is a justified conjecture and H^c the discharge of H. Then the schema for abduction can be sketched as follows.

1. T! [declaration of T]
2. $\neg(R(K, T)$ [fact]
3. $\neg(R(K^*, T)$ [fact]
4. H meets conditions $S_1, ..., S_n$.[fact]
5. R^{pres} *(K(H), T)* [fact]
6. Therefore, $C(H)$. [conclusion]
7. Therefore H^c [conclusion].

Where H is the hypothesis or conjecture that solves the *AP* for *{K, T}, C(H)* expresses that it is justified to conjecture that H. In the final line of the schema, H^c reflects two things. One is its release for premissory duty in further inferences in the *IP*'s subject domain. The other (denoted by 'c' in superscript position) reminds us of H's conjectural origins.

9.1 The Reach of Abduction

A contentious question is whether a sublogic for H exists, and, if so, how it would go. The H-factor presents the abduction theorist with at least two questions.

1. What are the conditions under which hypotheses are *thought up?*
2. What are the conditions under which hypotheses are *deployed*?

It is easy to see that part of the answer to (2) is that deployed Hs should honour the abductive schema. In some approaches (e.g. [Aliseda-Llera, 1997, [Kuipers, 1999]), H is required to be minimal, and neither to bear R to T nor to be inconsistent with K. In the present model, the conditions on H are less specific. The reason for this is that we are unsure about the proposed constraints. Let us take these in order. (This helps us specify certain of the conditions $S_1, ..., S_n$ mentioned in clause (4) of our abductive schema.)

(a) *K(H)'s minimality:* An ambiguity lurks. Does the condition require that H be the least modification of K that delivers the intended goods? Or, does it require that H modify the least class of K that delivers the goods? Or does it mean both? What we have here, in all three cases, is a contingency elevated to the status of a logically necessary condition. It is true that abduction problems don't require for their solution everything whatever the agent may know at the time. It is also true that winning hypotheses aren't wantonly redundant. In actual practice, abductive reasoning is from subsets of K augmented by not

overly redundant hypotheses. This is a fact for our schematic models to take note of. But minimization achieves this end over-aggressively.

(b) *H's independence*: The requirement in question is that it not be the case that H alone bear R^{pres} to T. Of course, one wants to avoid mischevious instantiations of H. If T is our target, we don't want H to be T. Other cases should give us pause. Causal inference is sometimes structured in such a way that T calls for a causal account of some phenomenon P and K fails to provide it. It may well be the case that although K itself doesn't yield the cause of P it does *indicate* that Hmight be a hypothesis worth considering. For this to be so, it is not at all required that H itself, if true, not be causally sufficient to P. So H could cause P even though the abducer rests his selection of P on the facts that $K(H)$ also causes P, and K (by itself) *suggests* that H be entertained.

(c) *H*'s *consistentcy with K:* There are cases in which the abducer is required to reason from databases that contain unresolved inconsistencies. Juries, for example, must determine the guilt or innocence of accused persons from evidence-bases that are routinely inconsistent. As we saw a theory of the evidence is an abduction that generates a verdict on the strength of what best explains the evidence, inconsistency and all.[40] Here, too, we find the constraint excessive.

9.2 The Cut-Down Problem

Perhaps the greatest problem posed by the thinking up of hypotheses is that, on any given occasion, a candidate for selection occupies an up to arbitrarily large *space of possibilities* or (*candidate space).* Whatever the details, it appears that abductive agents manage to solve what might be called a *cut down problem.* In the general case, it would appear that the hypotheses that an abducer actually entertains are relevant and plausible subsets of large candidate spaces. (We note in passing that the idea that the minimality condition seeks to honour is handled here non-quantitatively by relevance and plausibility *filters).* It is doubtful that the full story of the dynamics of cut down can be told in any logic, no matter how capacious; but part of it, certainly, requires the logician's touch. Accordingly,

Proposition 20 (Relevance and plausibility) *In giving an account of H an abductive logician should deploy the resources of the appropriate logics of* relevance *and* plausibility.[41]

[40] This may appear to generate a very bad problem for criminal jurisprudence. If the standard in criminal trials is *proof* beyond a reasonable doubt, how can it be envisaged that an abductive *conjecture,* however confidently made, could rise to it? See Part IV below.

[41] For relevance, see [Gabbay and Woods, 2003b]; for plausibility, see [Rescher, 1976] and [Gabbay and Woods, 2005].

It would seem that plausibility also bears in a central way on the question of hypothesis *selection.* It is implicated in a further step of the cut down process. It cuts down the set of *entertained* hypotheses to subsets (ideally a unit set) of the most plausible.

Abductive reasoning is shot through with considerations of plausibility and presumption. In our abductive it is explicit that presumption plays a role. It plays it in two connected ways. If we have a successful H, then $K(H)$ will hit the abducer's target presumptively. Correspondingly, it may plausibly be inferred that the conjecture of H is justified; that is to say, that the presumption of $H$is reasonable. Most of the work to date on the logic of presumption has been done by default logicians in the computer science and AI communities. As we have them now, such logics haven't adapted well to the particular requirements of abduction. There is work still to be done.

Proposition 21 (Presumption) *The logic of the conclusional operator "therefore" should subsume an appropriate logic of presumption.*

10. Grounds of Action

In a standard situation an ignorance-problem presents an agent with two choices. One is to acquire the knowledge that solves the problem and then to *act* on it in ways that may conduce to the agent's further interests. The other is (perhaps temporarily) to admit defeat and to postpone any action that would be suitably occasioned by a solution to the problem if it existed.

As we have seen, there is also a third option. Perhaps its principal attraction is that it is an alternative to the passivity of giving up on one's *IP*. It is, of course, a qualified alternative, since it does not solve the *IP* but rather solves it presumptively. Notwithstanding this essential qualification, an abductive solution bears on the question of *action* in two important ways. In the one case, the abducer's embrace of H^c constitutes the *cognitive act* of releasing H for generally unfettered inferential work in the domain of enquiry within which the abducer's *IP* arose in the first place. In the other case, it is open to the agent to take whatever *further actions* as may comport with his other interests, on the basis of conclusions in the descendent class of inferences dependent upon H. This is far from saying that H's conjectural origins are overlooked in such cases. It means only that the actions are taken so with requisite regard to the higher risk than that that would attach to actions occasioned by what the agent does really know. Accordingly, it is a deep fact about abduction that

Proposition 22 (Abduction as a spring of action) *Abduced hypotheses H give agents a basis for consideration of subsequent actions involving degrees of risk concomitant with the strength of H's conjecture.*

Briefly sketched though they are, we now have the resources to explore the role of abduction in criminal proceedings.

Part IV: The Criminal Proof Standard

11. Reasonable Doubt

The meaning of the reasonable doubt provision is not well-explained either in case law or in legal textbooks. As we saw, *McCormick on Evidence* takes a dim view of subjecting the idea to analysis:

> Reasonable doubt is a term in common use as familiar to jurors as to lawyers. As one judge has said it needs a skillful definer to make it plainer by multiplication of words ... [Strong:1999, p. 517].

It is sometimes supposed that it is the legal counterpart of the high standard of proof that one finds in science and mathematics, where in all three cases the standard is at the top of the epistemic scale. Whatever may be the case with science and mathematics, it cannot be so with convictions won on circumstantial evidence. The meaning of "beyond reasonable doubt" must preserve this fact. Cases in which a verdict of guilty is secured by circumstantial evidence are often those in which the link between evidence and verdict is understood probabilistically. There have been efforts of late to capture the structure of such reasoning in more or less stock models of Bayesian inference ([Tillers and Green:1988]). We ourselves are doubtful of the overall adequacy of this approach, even in civil cases in which the standard is "proven on a balance of probabilities". Inspection of the actual empirical record of such cases reveals the more dominant presence of abductive considerations.

On the face of it, however, this cannot be right. For if it were right, we would have it that when a conviction is won on circumstantial evidence, the verdict is mired in nothing stronger than a conjecture. But surely not even the most confident conjecture of guilt meets the standard of proof beyond a reasonable doubt.

Accordingly

Proposition 23 (The circumstantial conviction dilemma) *At first appearance, either circumstantial conviction cannot meet the required standard of proof, or it is not abductively grounded.*

We ourselves are minded to challenge the first horn of the dilemma, notwithstanding that great weight would appear to be placed against it by the doctrine of the reasonable person. In its most general sense, the doctrine requires that jurors perform as ordinary persons in the course of their reflections on the matters before them.

They are then required to use this ordinary thinking to reach a verdict. Verdicts are not only open to be produced by ordinary thinking, but are *required* to be so produced, except when juridically constrained in some or other particular way. If this is right, then in the context of realistically constructed cases based on circumstantial evidence, ordinary thinking is frequently, if not typically, abductive. Since abductive thinking is inherently conjectural, not only is it left open that a verdict of guilty might be conjecturally based, but it is inevitable that this frequently, if not typically, be so. What remains is to show *whether conjecturally structured theories of a case can manage to attain the required proof standard.*

The core idea embedded in the standard makes a twofold claim on reasonability. First, the theory of the case for conviction must be such as to draw the favour of a randomly selected reasonable person (where untutored reasonableness trumps expertise). Secondly, that self-same reasonable person must also be disposed to the view that the facts of the case do not answer to a rival theory of them that could reasonably be accepted. Interpreted abductively, this requires that an abductively secured conjecture of guilt must be strongly secured, and that there is no rival conjecture that is strongly enough secured. However, as the Indiana Court of Appeals has made clear in a case from 1978,

Convictions should not be overturned simply because this court determined that the circumstances do not exclude every reasonable hypothesis of evidence ([p. 69, Klotter, 1992]).

Accordingly,

Proposition 24 (Guilt and reasonable alternatives) *If a verdict of guilt is arrived at circumstantially it is not necessary that rival abductively reasonable theories of the evidence* not exist.

For the present suggestion to pass muster, the idea of abductive strength requires clarification. To do so, it is important to emphasize that typically a conviction based on circumstantial evidence is a conviction *faute de mieux*, epistemically speaking. The qualification "typically" is made necessary by the fact that the law allows that, on occasion circumstantial evidence may be as strong or stronger than direct evidence. Also significant is an American case from 1969,

> the trial court properly instructed the jury that 'the law makes no distinction between direct and circumstantial evidence but simply requires that the reasonable doubt, from all of the evidence in the case,' including 'such reasonable inferences as seem justified, in the light of your own experiences, [Klotter:1992, p. 68].

The betterness that circumstantially based verdicts fail to achieve is the grade of epistemic attainment, whatever that is in fine, that attends conviction by direct evidence.

Thus we assume as a matter of epistemology, rather than of juridical pronouncement, that unrebutted direct evidence possesses an epistemic strength not usually

possessed by circumstantial evidence in the face of competing and not unreasonable rival theories. In structural terms, let K be what the court knows of the matter before it by direct evidence. Since, by hypothesis, a conviction cannot be got from K, alone, it must be aimed for by some supplementation of K short of additional direct evidence. *This constitutes an abduction problem for the prosecution.* The prosecution must attempt to supplement K in ways that the contents of K itself make reasonable and without further direct evidence. The task of the juror is to determine whether the prosecutor's case is a strong enough abduction without strong enough rivals. To achieve this standard, he must overcome the epistemic disadvantage implicit in the fact that sufficiently strong abductions won't attain the *epistemic* standard hit by K.

Accordingly we shall say

Proposition 25 (Discounting epistemic disadvantage) *A successful abduction for conviction is one that is strong enough to off-set the epistemic disadvantage that inheres in abductive solutions. Correspondingly, a rival abduction is insufficiently strong when it does not off-set the inherent epistemic advantage to a sufficient degree.*

Corollary 25(a) *Implicit in the doctrine of the reasonable person is the principle that sometimes it would be unreasonable not to accept an abduction, or to accept it weakly, just because it failed to hit the epistemic standards reached by K.*

What we are here proposing is an epistemic commonplace. It is the idea that epistemic satisfaction is not only not typically achieved by epistemic optimization, but that, for large classes of cases, postponing epistemic satisfaction until greater strides toward optimization are achieved would be markedly unreasonable. In the absence of contrary indications, you know that you are your parents' child if you arrived during the child-bearing years of their union. In the absence of contrary indications or some contextually required standard of proof, resort to DNA testing would be quite mad. The criminal law requires that those of its obligations that fall to jurors be discharged by persons who operate as ordinary thinkers. The criminal law requires that the epistemic endeavours of jurors rise to the standards of the epistemically ordinary person. The requirement of determining whether, in its turn, the prosecution's theory of the case achieves the law's standard of proof is thus a requirement that a reasonable person can be expected to attain when operating as an ordinary thinker. What the criminal law clearly settles for is not optimization, but satisfization set against the requisite standards.

12. Hypothesis-Discharge

We must now deal with the question of whether hypothesis-discharge is possible within abductive contexts and, if so, what its structure would be. As we have it so far, hypothesis-discharge is achieved by an inference to a H^c. H^c reflects a readiness to

release H on sufferance for premissory work in future inferences. How does this hook up with what juries do?

The answer lies in what we have already discovered about the operation of the provisions of the beyond-reasonable-doubt standard for circumstantial criminal conviction. We summarize the main points of that determination.

- A verdict in a criminal trial is not usually thought of as a conjecture. It is a *finding* ; hence something that is forwarded assertively.
- Even so, especially in cases built upon circumstantial evidence, verdicts are reached abductively. They are solutions of abduction problems.
- This necessitates a distinction between how the verdict was *reached* and the manner in which it is *treated*.
- The standard of proof beyond a reasonable doubt in effect requires a jury to discharge its theory of the case, that is, to forward it non-conjecturally. This resembles what abducers in general achieve by forwarding H^c assertively.
- Since, in such cases, there is no independent means of demonstrating directly the truth of a jury's finding, the jury's discharge of the hypothesis cannot be seen as post-abductive.
- H^c denotes this twofold role. $H$was reached conjecturally but it is discharged assertively.
- Accordingly, in reaching its finding in such cases, hypothesis-discharge is part of the jury's solution of its abduction problem.

This allows us to say that

Proposition 26 (Discharge) *Conditions on abductive hypothesis-discharge approximate to those governing circumstantial conviction in a criminal trial.*

Accordingly, it may be said that when a jury reaches its verdict, they have done something like draw an inference to $C(H)$ and rendering a decision in the form H^c. "$C(H)$" expresses the jury's conviction that, although the evidence is only circumstantial, it may be taken with requisite confidence that the accused's guilt best explains it. In turn, H^c releases the verdict, "Jones is guilty", for work as a premiss in future inferences or decisions. For one thing "Jones is guilty" is a primary datum for subsequent decisions about sentencing. And thereafter, it states a legal fact. But here, too, it is a fact on sufferance, i.e. in the absence of an appeal that would eradicate it.

13. Proof Standards

As we begin to see, the criminal proof standard is subject to a considerable misconception. This is the idea that the standard is artificially high. In fact, it is not artificial, and it is not especially high — certainly it is no kin of mathematical proof or experimental confirmation of the sort required in drug trials. It is perfectly true that, in the name of justice, the law artificially constrains what evidence a jury may hear and, at times, the weight that a jury can give it; but this same artificiality is not intruded into the standard of proof itself. What shows this to be so is the commonplaceness of the constraints under which the standard is honoured in actual judicial practice. Key to a proper understanding of them is the idea of *satisfaction.* (See here [Woods:2005b]).

What the law requires is that jurors attain a certain level of doxastic satisfaction. They must be satisfied that the picture that the evidence suggests to them is undisturbed by the fact that it is not an epistemically optimal theory of the case. The other is that the failure of a rival theory of the case to satisfy them is not something that counts against it in an epistemically optimal way. But this is the condition in which the epistemic satisficer finds himself quite routinely. It is the hallmark of the reasoning of an ordinary reasoner when reasoning in the way of ordinary reasoners about just about anything. What counts, both in the general case and in the case of proof beyond a reasonable doubt, is that these occasions of possible error do not disturb the reasoner's doxastic repose. (The language of the law is replete with the idioms satisfaction and repose. Judges tell juries that, to convict, they must be *satisfied* that such-and-such and so-and-so. When counsel have presented their case, they *rest.*) In this model of juridical determination, it is difficult to over-estimate the pivotal importance of satisfaction. Satisfaction is the dual of cognitive irritation, which is what occasions the need for abductive reasoning in the first place. Accordingly,

Proposition 27 (Doubt and satisfaction) *A jury's verdict meets the standard of proof beyond a reasonable doubt when its members are in a state of doxastic satisfaction achieved by the procedures of ordinary reasoning in abductive response to the evidence led at trial.*

Proposition 28 (Competence) *The present model of cognitive satisfaction presupposes the competence of individual jurors; in particular that the satisfaction required by the standard would not be achieved by a competent reasoner unless he were untroubled by the fact that his theory of the case did not attain standards of epistemic optimality and by the fact that his exclusion of rival theories did not attain them either.*

The key to hypothesis-discharge lies in the structure of the abducer's doxastic satisfaction. When a proposition is held conjecturally, what the reasoning agent is satisfied about is that it is a proposition that merits conjecture. When a proposition is

abductively discharged, what the reasoning agent is satisfied with is *it*. He is satisfied with its propositional content. A reasoner moves from $C(H)$ to H^c when he moves from the first kind of satisfaction to the second.

We have seen that jurisprudential contexts occasion significant distortions of most concepts of relevance and all standard conceptions of presumptiveness. This is a reflection of the epistemic compromise that justice negotiates with truth. It arises from the law's fundamental operating principle that epistemically wrongful convictions should be minimized even at the cost of epistemically wrongful acquittals. These, we say, are epistemologically significant distortions, but they are significantly redressed by the circumstance that in achieving even the high standard of proof required for a criminal conviction, the juror's reasoning, step by step, need not — and should not — aim at or attain a standard higher than the standard achieved by a reasonable person when reasoning as an ordinary being; i.e., including the drawing of "such inferences as seem justified, in the light of [his] own experience" ([Klotter:1992, p. 68]). This places the phenomena of circumstantial conviction in the spotlight, and gives us a point worth repeating. It gives us occasion to provide an interpretation of proof beyond a reasonable doubt according to which the juror is an abductive satisficer concerning the verdict he proposes, whose confidence in it is not shaken by his recognition that his own solution does not optimize to the level of K or higher, and for whom there is no rival abduction that could appeal to his obligations as a satisficer. We have it, then, that

Proposition 29 (Beyond reasonable doubt) *The judicial question of proof beyond a reasonable doubt has a solution in the logic of abduction.*

14. The Probativity Question

Pages ago we drew attention to a still unresolved contention among philosophers of science about the probativity of explanation. We pointed out that there is a considerable body of opinion – an opinion shared by the present authors – that the explanatory force of a proposition is not in the general case a satisfactory marker for its truth. At first sight, this is disastrous for the abductive theory of criminal conviction. For if the fact that the hypothesis of guilty as charged is indeed the best explanation of the evidence led at trial is a fact that is compatible with the *falsity* of that hypothesis, surely we are deluding ourselves in thinking that the common law offers to accused persons the safety of a fair trial, at least for the most part.

How shall we answer this objection? Perhaps this is the best place to drive home the point that the common law's criminal justice system does *not* offer accused persons epistemic guarantees. Another – and somewhat jolting – way of saying this is that the criminal justice system squarely faces accused persons with the prospect of outcomes

that are not *known* to be true.[42] (If this doesn't drive a stake, once for all, through the heart of the common belief that guilty verdicts attain an unusually high standard of proof, nothing will.) Accordingly,

Proposition 30 (The fundamental epistemic fact) *The fundamental epistemic fact about criminal convictions is that they constitute verdicts that need not be known to be true (and in general are not known to be true) in order to qualify as both just and cognitively scrupulous.*

Proposition (30) bears on the structure of abduction itself. Suppose, contrary to what the present authors believe, that best explanations are probative. That is, suppose that best explanations are truth-conferring. Then it is easy to see that an inference to the best explanation cannot be a case of abduction. Abductive inference is ignorance-preserving; but (on the present assumption) best-explanation inferences are truth-conferring. So best-explanation abductions don't preserve the ignorance condition on abduction. Accordingly,

Proposition 31 (Non-probativity). *If theories of the evidence are best-explanation abductions, explanations are not truth-conferring.*

Corollary 31(a) *By the fundamental epistemic fact (see Proposition (30)), best-explanation inferences are not truth-conferring in judicial settings.*

Part V: Concluding Remarks

As mathematical logicians will be aware, there is a celebrated paper in which W.H. Stone followed up on some work of Tarski's and sought to unify logic and topology. More strictly, he sought to unify Boolean algebra and topology [Stone, 1936]). Like Tarski, Stone gives an account in which conjunction, disjunction and negation correspond to set-theoretic multiplication, addition and complementation. The closed-open sets under these operations form a Boolean algebra. Stone also examines a class of topological spaces, known as Boolean spaces, that display some mathematically interesting features. They are totally disconnected, compact Hausdorff spaces. A particular case of these is the Cantor space which is got by according the pair (0, 1) the discrete topology and then assigning to the Cartesian product of countably many cases of it the product topology. The highlight of [Stone, 1936] is the Representation Theorem. It establishes a duality between any Boolean algebra and some or other Boolean space. The Stone Representation Theorem teaches us a useful lesson about interdisciplinarity at its most fruitful. The theorem is derivable in neither Boolean algebra nor topology. It carries the marks of the parent disciplines, but it does not owe

[42] This proceeds not only from the abductive character of verdicts but also from the admissibility of testimony.

its identity to them. The unification achieved by Stone is a good example of the offspring model of interdisciplinary amity. It produces results that are very much worth having and which neither parent is able to deliver.

What we have tried to establish in this paper is that the logic and the law admit of this same kind of creative advance. If we run the legal notion of proof beyond a reasonable doubt through a suitable logic of abduction, it is possible to learn something about the standard which is very much worth knowing and which would not have surfaced in either of the parent theories if simply left to their own devices. If we are not mistaken, we now have a better understanding of the epistemic structure of that standard, namely, that it is not an epistemic standard. It is a case in which logic has been able to elucidate the law. But we should also note that this has not been a one-way street. In response to the probes visited upon it by abduction logic, the law has kicked back in ways that help achieve an important clarification the structure of abduction itself.

In the minds of some logicians an abduction problem is solved at line (6) of the schema; that is to say, when the abducer concludes that H is a proposition that warrants conjecture ($C(H)$). However in the theory advocated in the *The Reach of Abduction: Insight and Trial* ([Gabbay and Woods, 2005]), it is argued instead that an abduction problem is not fully dealt with until the conjectured proposition H is also *discharged*. In the simplest possible terms, what this means is that, although conjecturally occasioned, H is (on sufferance) allowed to operate non-conjecturally. No one should think that in discharging H the abducer has put himself in a psychological state of denial. He is not trying to *forget* H's conjectural origins. Rather, he is not giving them a *structural role* in the further inferences that $H$is now free to drive forward. For its role in those inferences, H's conjectural origins are not forgotten, but they are inferentially suppressed. Another way of saying this is that at line (7) of the schema, the 'c' in H^c reminds us that H arose conjecturally; and beyond that it imposes no constraints on how H operates inferentially.

Why should we believe this account of hypothesis-discharge? The short answer is that we should believe it because the law requires us to believe it. We should believe it because a finding of guilt is an abduction that eventuates in a *verdict*. In a criminal trial, the proposition H that asserts the accused's guilt plays a twofold role. It *arises* as an conjecture, and thus as something in the form of the $C(H)$in our schema's line (9); and it is *treated* as a fact. No one thinks that real facts are ever made by mere *guess-work*. The decision to treat H as a fact does not require it to be one. Thus a jury's verdict has the structure of a H^c. It is well-knows that in matters of criminal conviction the law takes great pains that the legal fact of guilt coincide with the real fact of guilt, that is, that there be an equivalence between $H^c$and H. Alas, sometimes the equivalence fails. It is a dramatic way of telling us that the fact of guilt is a legal fact; it is a proposition that arises from conjecture, which is treated as if it didn't. We have it, then, that the structure of the law's guilt beyond a reasonable doubt gives

us reason to hold that abductions terminate not with judgements in the form $C(H)$, but rather with determinations in the form H^c. It is a welcome outcome. It discloses issues on which logic and law can be of assistance to *each other.* [43]

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LOGICAL LYRICS

In ΦNEWS 6, October 2004, a call was made to ΦNEWS-subscribers and ΦLOG-members for submitting favorite quote(s) on logic. The idea was to compile a collection of critical citations, funny aphorisms, and inquisitive quotations about logic similar to the recently released *Feisty Fragments: For Philosophy.*

As a result of the aforementioned call, many of quotes in *Logical Lyrics: From Philosophy to Poetics* have been suggested by you as working logicians reflecting on your own subject matter. *Logical Lyrics: From Philosophy to Poetics* may accordingly be seen as testimonial in the sense of ΦLOG's critical, funny and inquisitive field report about logic.

- *Logical Lyrics* contains almost 550 quotations on logic, logicians and logical matters (from a diverse fan of figures including Napoleon Bonaparte and Helena Christensen via Alfred Tarski, Stephen C. Kleene, A.N. Whitehead to Talking Heads and Supertramp) (about 210 individuals total).
- Approximately 80 of these citations have been suggested by ΦNEWS-subscribers and ΦLOG-members (from Brazil, Canada, Denmark, Finland, Iran, Italy, The Netherlands, Sweden, Ukraine, United Kingdom, USA).
- It took roughly 4 months to collect the 550 quotations and track the references; 3 months to obtain the 278 permissions required.
- Raymond Smullyan and Melvin Fitting kindly provided the blurbs for the back cover:

  I found this collection utterly absorbing from beginning to end. It combines some very sagacious ideas with some choice bits that are delightfully funny. —Raymond M. Smullyan, New York

  'If I were you, I would buy this book.' What does that mean? It means, 'buy this book.' Why does it mean that? Perhaps this book will help you understand. Or perhaps not, but it will certainly be entertaining reading in the meantime. — Melvin C. Fitting, City University of New York

- On the following pages please find some samples.

C.C. Chang & H. Jerome Keisler

For the amusement of all those who gave us help, we dedicate our book to all model theorists who have never dedicated a book to themselves.

Suggested by Stig Alstrup Rasmussen

Ralph Waldo Emerson

I hate quotations.

Suggested by David Makinson

Jon Barwise

As logicians, we do our subject a disservice by convincing others that logic is first-order, and then convincing them that almost none of the concepts of modern mathematics can really be captured in first-order logic.

Suggested by Joao Marcos

Yogi Berra

In theory there is no difference between theory and practice. In practice there is.

Suggested by Achille Varzi

Ambrose Bierce

LOGIC, n. The art of thinking and reasoning in strict accordance with the limitations and incapacities of the human misunderstanding.

Suggested by George Englebretsen

Alfred Hitchcock

Logic is boring.

Suggested by Ilpo Halonen

Stanislaw Lesniewski

Logic is a formal exposition of intuition.

Suggested by Jan Wolenski

Talking Heads

Stop Making Sense.

Suggested by Johan van Benthem

Alfred Lord Tennyson

For nothing worthy proving can be proven,
Nor yet disproven: Wherefore thou be wise.

Suggested by Paolo Di Gusta

Alfred North Whitehead

It should be noticed that logical proof starts from premises, and that premises are based upon evidence. Thus evidence is presupposed by logic; at least, it is presupposed by the assumption that logic has any importance.

Suggested by John Sowa

I would like to thank you all for participating in this endeavour and I hope you may enjoy the outcome of our joint venture.

Vincent F. Hendricks

Logical Lyrics: From Philosophy to Poetics. Vincent F. Hendricks. £9 / $15. King's College Publications, March 2005, ISBN 1904987044. *Logical Lyrics: From Philosophy to Poetics* is a collection of citations and aphorisms from all sorts of people – from Napoleon Bonaparte to Human League – expressing their embracing, critical and humorous views on logic and logical matters. *Logical Lyrics: From* is an independent follow-up to *Feisty Fragments: For Philosophy.*

ANNOUNCEMENTS

CONFERENCES

SouthEastern Logic Colloquium (SEALS), Gainesville, Florida, April 15–17, 2005. Invited speakers include: M. Dzamonja , D. Hirschfeldt, T. Jech, S. Lempp, J. Miller, V. Pestov, J. Remmel, E. Schimmerling, S. Solecki, J. Steprans, and G. Wu. The organizers are D. Cenzer and J. Zapletal. Limited travel support is available for graduate students and participants from the South. For further information, visit the website below.

`http://www.math.ufl.edu/~zapletal/seals/seals.htm`

International Conference on Rewriting Techniques and Applications (RTA 2005), Nara, Japan, April 19–21, 2005. This meeting is the major international conference on rewriting. Together with the International Conference on Typed Lambda Calculi and Applications (TLCA; see below) and several related workshops, it comprises the Federated Conference on Rewriting, Deduction, and Programming (RDP; see http://www.kurims.kyoto-u.ac.jp/rdp05/). For further information, visit the website below.

`http://www-i2.informatik.rwth-aachen.de/RTA05/`

Seventh International Conference on Typed Lambda Calculi and Applications (TLCA 05), Nara, Japan, April 21–25, 2005. This series of conferences serves as a forum for presenting original research results that are broadly relevant to the theory and applications of typed lambda calculi and related systems. The Chair of the Conference Steering Committee is S. Abramsky. For more information, visit the website below.

`http://www.kurims.kyoto-u.ac.jp/rdp05/tlca/`

Logical Aspects of Computational Linguistics (LACL 2005), Bordeaux, France, April 28–30, 2005. This is the fifth in a series of international conferences on logical and

formal methods in computational linguistics. It addresses in particular the use of proof theoretic and model theoretic methods for describing natural language syntax and semantics, as well as the implementation of natural language processing software relying on such models. The Co-chairs of the Program Committee are Ph. Blache and E. Stabler. The deadline for submission of papers is January 3, 2005. For further information, visit the website below.

`http://lacl.labri.fr/`

Workshop on Classification of Countable Structures, Notre Dame, Indiana, May 17–24, 2005. This event is intended to bring together researchers from model theory, descriptive set theory, and computability to discuss work growing out of Vaught's Conjecture. There will be tutorial-style lectures to help members of each group understand what members of the other groups have done and hope to do. The organizers include: S. Buechler, P. Cholak, J. Knight, G. Sacks, and S. Starchenko. For further information, contact J. Knight (email: knight.1@nd.edu.)

Philosophy, Logic, and Linguistics (SEP 2005), Toronto, Canada, May 19–22, 2005. This is the thirty-third annual meeting of the Society for Exact Philosophy. This organization is dedicated to providing sustained discussion among researchers who believe that rigorous methods have a place in philosophical investigations. Invited speakers include: E. Lepore, F.J. Pelletier, and J. Stanley. For further information, visit the website below.

`http://www.phil.ufl.edu/SEP/meeting`

Norms, Reasoning and Knowledge in Technology, Boxmeer, the Netherlands, June 3-4, 2005. Norms in Knowledge, NWO Project, Section of Philosophy and Ethics of Technology, Technical University of Eindhoven. As part of our continuing investigation in the epistemological features of normative claims and their role in technological setting, we present a conference on Norms, Reasoning and Knowledge in Technology. Invited speakers will discuss the relationship between various facets of technological knowledge and reasoning and related norms, with special emphasis on the relationship between practical reasoning and functional ascriptions. The conference features a diverse and distinguished panel of speakers interested in the normative aspects of technological knowledge and the relationship between practical reasoning and artifactual knowledge. Space is limited so we ask that you apply for attendance early. (Email: NiK-conf@tm.tue.nl) and please state your affiliations and interests in philosophy of technology. Please also indicate if you are willing to be a designated respondent during the conference.

Confirmed speakers

- Brown, Mark A., Syracuse University
- Hanson, Sven Ove, Royal Institute of Technology in Stockholm
- Horty, John F., University of Maryland
- Hughes, Jesse, Technical University of Eindhoven
- Koen, Billy V., University of Texas
- Pollock, John, University of Arizona
- Vaesen, Krist, Technical University of Eindhoven
- Vermaas, Pieter, Technical University of Delft
- Walton, Douglas, University of Winnipeg

For more information:

`http://www.tm.tue.nl/capaciteitsgroep/aw/philosophy/NiK-conf.html`

Computability in Europe 2005 (CiE 2005): New Computational Paradigms, Amsterdam, Netherlands, June 8–12, 2005. This meeting is being organized within the network "Computability in Europe" (CiE). A particular focus of the event is on aspects of 'New Computational Paradigms.' There will be tutorials on Quantum Computation (H. Buhrman) and Computability over the Reals (K. Weihrauch). Invited speakers include: S. Abramsky, J.D. Hamkins, U. Kohlenbach, J. van Leeuwen, Y. Matiyasevich, Y.N. Moschovakis, G. Paun, and U. Schoening. Special sessions on Biological Computation, Complexity, Epistemology and Methodology of Computing, Proofs and Computation, Real Computation, and Relative Computation also are planned. The organizers are: S. Bold, B. Cooper, S. de Jager, P. van Emde Boas, B. Lowe, and L. Torenvliet. For further information, visit the website below.

`http://www.illc.uva.nl/CiE/CiE2005.html`

Ninth Workshop on the Semantics and Pragmatics of Dialogue (DIALOR'05), Nancy, France, June 9–11, 2005. This is the ninth in a series of workshops that aims to bring together researchers working on the semantics and pragmatics of dialogues in fields such as artificial intelligence, formal semantics and pragmatics, computational linguistics, philosophy, and psychology. The Chair of the Program Committee is C.

Gardent. The deadline for submission of abstracts is March 1, 2005. For further information, visit the website below.

`http://cswww.essex.ac.uk/semdial/`

2005 Computational Complexity Conference, San Jose California, June 12–15, 2005. This annual event deals with computational complexity broadly defined. Topics include: structure of complexity classes, proof complexity, interactive proof systems, Kolmogorov complexity, complexity and logic, and quantum computation. The deadline for submission of papers is November 18, 2004. For additional information, visit the website beow.

`http://computationalcomplexity.org`

ACM Special Interest Group on Management of Data and Principles of Database Systems Conference (SIGMOD/PODS 2005), Baltimore, Maryland, June 13–16, 2005. This joint event is a leading international forum for database researchers, practitioners, developers, and users to explore cutting-edge ideas and results, and to exchange techniques, tools, and experiences. The General Chair for SIGMOD is Y. Yesha and for PODS is G. Gottlob. The deadline for submission to SIGMOD of papers is November 17, 2004. The deadline for submission to PODS of paper abstracts is December 1, 2004 and for full papers is December 8, 2004. For further information, visit the website below.

`http://cimic.rutgers.edu/sigmodpods05/`

Algebraic and Topological Methods in Non-Classical Logics II, Barcelona, June 15–18, 2005. This meeting shares the goals of the Tbilisi conference with the same title, held in July 2003, as well as those of the Patras conference on many-valued logics and residuated structures, held in June 2004. In recent years the interest in non-classical logics has been growing. Motivations from computer science, natural language reasoning and linguistics have played a significant role in this development. The semantic study of non-classical logics is a field where no single overarching paradigm has been established, and where a variety of techniques are currently being explored. An important goal of this meeting is to promote the cross-fertilization of the fundamental ideas connected with these approaches. Thus, we aim to bring together researchers from various fields of non-classical logics and applications, as well as from lattice

theory, universal algebra, category theory and general topology, in order to foster collaboration and further research. The scientific programme of the congress will include a few invited lectures and will provide ample time for contributed papers and interaction between participants. Researchers whose interests fit the general aims of the conference are encouraged to participate. The featured areas include, but are not limited to, the following (in alphabetical order): Algebraic logic / Coalgebraic semantics / Categorical semantics in general / Dynamic logic and dynamic algebras / Fuzzy and many-valued logics / Lattices with operators / Modal logics / Ordered topological spaces / Ordered algebraic structures / Residuated structures / Substructural logics / Topological semantics of modal logic.

INVITED SPEAKERS: Guram Bezhanishvili, New Mexico State University, Las Cruces (USA) / Robert Goldblatt, Victoria University, Wellington (New Zealand) / Ian Hodkinson, King's College London (UK) / Peter Jipsen, Chapman University, Orange (USA) / Franco Montagna, Università di Siena (Italy) / Hilary Priestley, St. Anne's College, University of Oxford (UK) / James Raftery, University of Natal, Durban (South Africa).

PROGRAMME COMMITTEE: Leo Esakia, Georgian Academy of Sciences / Mai Gehrke, New Mexico State University / Petr Hájek, Academy of Sciences of the Czech Republic / Ramon Jansana, Universitat de Barcelona / Hiroakira Ono, Japan Advanced Institute for Science and Technology (chair) / Constantine Tsinakis, Vanderbilt University / Yde Venema, Universiteit van Amsterdam / Michael Zacharyaschev, King's College London.

ORGANIZING COMMITTEE: Josep Maria Font, Universitat de Barcelona (chair) / Àngel Gil, Universitat Pompeu Fabra (Barcelona) / José Gil, Universitat de Barcelona / Joan Gispert, Universitat de Barcelona / Carles Noguera, Institut d'Investigació en Intel·ligència Artificial (Bellaterra) / Antoni Torrens, Universitat de Barcelona / Ventura Verdú, Universitat de Barcelona.

CONTRIBUTED PAPERS: Participants who wish to present a talk should submit an abstract through the Atlas service (http://atlas-conferences.com/) before 31 March 2005. The abstract should be written in TeX (or in plain, non-formatted text without formulas) and be at most 2 pages long. Authors will be notified before 30 April 2005 whether their submission has been accepted for presentation. Participants needing early acceptance are advised to submit as soon as possible and inform the organizers of their situation.

TRAVEL GRANTS: We hope to provide some funding to partially cover travel expenses of students and recent Ph.D.'s without grant support, as well as of active

researchers from countries with developing economies. The number and amount of these grants will depend on the available funding, and will be paid in cash during the meeting. Applications should be sent to (mathlog@ub.edu) before 31 March 2005. To apply send a message with your personal data, a short CV, a description of your research area and its relation with the topics of the meeting. Students and recent Ph.D.'s should also ask their supervisor to send a letter of support to the same address.

REGISTRATION: Registration is necessary to attend the meeting. There is a registration fee of Euro 30 (approx. $38 as of February 1st), to be paid upon arrival. Registration includes conference materials, coffee breaks and snacks, and a special price for Saturday's dinner. Abstracts of accepted contributed papers by registered participants will be included in the congress' booklet.

MORE INFORMATION: Further details about registration, hotels, schedule, etc., will be posted at the congress' web page

`http://www.mat.ub.edu/~logica/meeting2005/`

Seventh International Workshop on Logic and Computational Complexity (LCC'05), Chicago, Illinois, June 24–25, 2005. The LCC workshop concerns topics that connect the complexity theoretic and logic-based sides of computer science theory and practice. Confirmed invited speakers include A. Blass and C. Koch. The Program Chairs are S. Abramsky and L. Libkin. The deadline for submission of extended abstracts is April 17, 2005. For further information, visit the website below.

`http://www.cis.syr.edu/~royer/lcc/LCC05/`

Eighth European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU-2005), Barcelona, Spain, July 6–9, 2005. This biannual event is a major forum for advances in the theory and practice of reasoning under uncertainty. Contributors are expected to come both from researchers interested in advancing the technology and from practitioners who are using uncertainty techniques in applications. The Conference Chair is L. Godo. The deadline for submission of papers is December 20, 2004. For further information, visit the website below.

`http://www.ecsqaru.org/ECSQARU2005`

Twentieth Summer Conference on Topology and its Applications, Granville, Ohio, USA, July 10–13, 2005. Several topics at this meeting should be of interest to logicians. The deadline for receipt of abstracts is May 31, 2005. For further information, visit the website below.

`http://www.denison.edu/mathsci/sumtopo2005`

Model Theory, Algebraic and Analytic Geometry, Cambridge, England, July 11–15, 2005. This Euro Conference is supported by the European Commission in association with the Newton Institute program entitled Model Theory and Applications to Algebra and Analysis. Confirmed invited speakers include: M. Aschenbrenner, F. Cano, J. Denef, L. van den Dries, A. Gabrielov, J. Gordon, E. Hrushovski, E. Jaligot, P. Koiran, J.-M. Lion, L. Lipshitz, R. Moosa, R. Moussu, M. Otero, R. Pink, B. Poonen, F. Pop, Z. Robinson, J.-P. Rolin, T. Scanlon, S. Starchenko, K. Tent, N. Vorobjov, and F. Wagner. The organizers are: A. Macintyre, D. Marker, A. Wilkie (Chair), and C. Wood. Application forms for financial support may be found at the website below; the deadline for receipt of applications is January 31, 2005. For further information, visit

`http://www.newton.cam.ac.uk/programmes/MAA/maaw03.html`

Twentieth International Conference on Automated Deduction (CADE-20), Tallinn, Estonia, July 22–27, 2005. This event is the major forum for the presentation of research in all aspects of automated deduction. Invited speakers include: R. Bryant, G. Dowek, and F. Wolter. The Program Chair is R. Nieuwenhuis and the Organizing Chair is T. Tammet. The deadline for submission of titles and abstracts is February 25, 2005, and for papers it is March 4, 2005. For further information, visit the website below.

`http://sise.ttu.ee/it/cade`

Logic in Hungary, 2005, Budapest, Hungary, August 5–11, 2005. This event, organized by the Janos Bolyai Mathematical Society, celebrates the centenary of the birth of two great Hungarian logicians, L. Kalmar and R. Peter. The main topics of the conference are algebraic logic, foundations of space-time, and set theory. Confirmed invited speakers include: N. Belnap, J. Earman, M. Foreman, H. Friedman, S. Friedman, M. Gitik, I. Hodkinson, M. Hogarth, T. Jech, P. Koepke, M. Makkai, D. Monk, V. Pambuccian, N. Sauer, P. Suppes, S. Todorcevic, B. Velickovic, and C. Wutrich.

The members of the organizing committee include: A. Hajnal and J. Suranyi (Honorary Chairs); H. Andreka, I. Juhasz, P. Komjath, and I. Nemeti (Co-chairs); and L. Csirmaz, M. Ferenczi, M. Redei, G. Sagi, I. Sain, and L. Soukup. For further information, visit the website below.

`http://www.renyi.hu/lh05`

Seventeenth International Conference on Computer Aided Verification (CAV 2005), Edinburgh, Scotland, July 6–10, 2005. This is the seventeenth in a series dedicated to the advancement of the theory and practice of computer-assisted formal analysis methods for software and hardware systems. The conference covers the spectrum from theoretical results to concrete applications, with an emphasis on practical verification tools and the algorithms and techniques that are needed for their implementation. Invited speakers include: B. Bentley, B. Mishra, and G. Necula. Tutorials on automated abstraction refinement and the theory and practice of decision procedures for combinations of (first-order) theories will be presented. The Co-chairs of the Program Committee are K. Etessami and S. Rajamani. The deadline for submission of papers is January 21, 2005. For further information, visit the website below.

`http://www.cav2005.inf.ed.ac.uk/`

ILP 15th International Conference on 2005 Inductive Logic Programming, Bonn, Germany, August 10 -13, 2005.

`http://ilp2005.in.tum.de/`

Ninth Asian Logic Conference, Novosibirsk, Russia, August 16–19, 2005. The invited speakers tentatively include: P. Alaev, L. Beklemishev, Yu. Ershov, S. Gao, S. Jain, V. Kanovei, A. Mantsivoda, J. Miller, H. Ono, V. Rybakov, M. Sato, M. Vardi, A. Voronkov, and X. Zhao. The Chair of the Program Committee is S. Goncharov and the Chair of the Organizing Committee is S. Odintsov. For further information, visit

`http://www.sbras.ru/ws/ALC-9/index.en.html`

Computer Science Logic (CSL) is the annual conference of the European Association for Computer Science Logic (EACSL). The conference series started as a programme of International Workshops on Computer Science Logic, and then in its sixth meeting

became the Annual Conference of the EACSL. The 14th Annual Conference (and 19th International Workshop), CSL2005, will take place in the week 22 - 25 August 2005; it will be organised by the Computing Laboratory at the University of Oxford.

The conference is intended for computer scientists whose research activities involve logic, as well as for logicians working on issues significant for computer science. Suggested topics of interest include: automated deduction and interactive theorem proving / constructive mathematics and type theory / equational logic and term rewriting / modal and temporal logic / model checking / logical aspects of computational complexity / finite model theory / computational proof theory / logic programming and constraints / lambda calculus and combinatory logic / categorical logic and topological semantics / domain theory / database theory / specification, extraction and transformation of programs / logical foundations of programming paradigms / linear logic / higher-order logic.

The invited speakers for CSL05 are:

- Matthias Baaz (U. of Technology, Vienna)
- Ulrich Berger (U. of Wales Swansea)
- Maarten Marx (U. of Amsterdam)
- Anatol Slissenko (Université Paris 12)

`http://web.comlab.ox.ac.uk/oucl/conferences/CSL05/is.html`

Methods for Modalities 2005, Berlin, Germany, September 29–30, 2005. Call for papers: M4M-4. The workshop "Methods for Modalities" (M4M) aims to bring together researchers interested in developing algorithms, verification methods and tools based on modal logics. Here the term "modal logics" is conceived broadly, including description logic, guarded fragments, conditional logic, temporal and hybrid logic, etc. To stimulate interaction and transfer of expertise, M4M will feature a number of invited talks by leading scientists, research presentations aimed at highlighting new developments, and submissions of system demonstrations. We strongly encourage young researchers and students to submit papers and posters, especially for experimental and prototypical software tools which are related to modal logics. Regular papers should not exceed the length of 12 pages; short papers are up to six pages of length, and posters and tools can be presented on two pages of text. Proceedings will appear online and as a Humboldt university report. Depending on the submissions, papers

may be selected to appear in a special issue of an appropriate journal. The workshop will take place in Berlin - Adlershof, Germany, which is one of the worlds largest science and technology areas, comprising twelve research institutes, six faculties of the Humboldt University of Berlin, and more than 370 high tech companies. It is hosted by FIRST, the Fraunhofer Institute of Computer Architecture and Software Technology, in collaboration with the computer science institute of Humboldt University.For more information and registration information, see the M4M homepage at

`http://staff.science.uva.nl/~m4m/`

- Deadline for submissions: July 1st, 2005
- Notification of acceptance: August 15, 2005
- Camera ready versions due: September 8, 2005
- Workshop days: September 29-30, 2005

The program committee for M4M consists of

- Holger Schlingloff, Humboldt University / FIRST (local organizations);
- Carlos Areces, INRIA Lorraine;
- Patrick Blackburn, INRIA Lorraine;
- Torben Bräuner, Roskilde University;
- Stephane Demri, ENS de Cachan;
- Enrico Franconi, Free University of Bolzano;
- Rajeev Gore, University of Canberra;
- Ian Horrocks, University of Manchester;
- Joost-Pieter Katoen, University of Twente;
- Maarten de Rijke, University of Amsterdam;
- Renate Schmidt, University of Manchester; and
- Frank Wolter, University of Liverpool.

NEW PUBLICATIONS

Grounded Consequence for Defeasible Logic by Aldo Antonelli; Cambridge University Press (May 31, 2005); $55.00; ISBN: 0521842050.

The Philosophy of Jaakko Hintikka (Library of Living Philosophers Series) by Randall E. Auxier, Lewis Hahn; Open Court Publishing Company (February 28, 2005); $29.21; ISBN: 0812695496. Born in Finland in 1932, Dr. Jaakko Hintikka originator of game-theory semantics is a leading figure on the international philosophical scene. He is currently professor of philosophy at Boston University. This book includes an intellectual biography of Hintikka, 29 previously unpublished critical and descriptive essays by famous scholars, a reply to each essay by Hintikka himself, and a complete bibliography of Hintikkas published works.

Frege's Lectures on Logic: Carnap's Student Notes, 1910-1914 (Full Circle) by Steve Awodey, Erich Rech, Gottfried Gabriel; Open Court Publishing Company (October 30, 2004); $19.77; ISBN: 0812695534. When Bertrand Russell discovered an unresolvable contradiction in Gottlob Freges (1848-1925) logical system, the effect was calamitous, embittering Frege and overshadowing his important work in analytical philosophy. Freges student, Rudolf Carnap, took detailed notes of his lectures that show how Frege tried to address the contradiction and how he integrated his later doctrine of sense and reference into his exposition of logic. Reproduced in the original German with facing translations, these rare documents are published here for the first time.

The Birth of Model Theory: Lowenheim's Theorem in the Frame of the Theory of Relatives by Calixto Badesa; Princeton University Press (January 5, 2004); $43.43; ISBN: 0691058539. Löwenheim's theorem reflects a critical point in the history of mathematical logic, for it marks the birth of model theory–that is, the part of logic that concerns the relationship between formal theories and their models. However, while the original proofs of other, comparably significant theorems are well understood, this is not the case with Löwenheim's theorem. For example, the very result that scholars attribute to Löwenheim today is not the one that Skolem–a logician raised in the algebraic tradition, like Löwenheim–appears to have attributed to him. In The Birth of Model Theory, Calixto Badesa provides both the first sustained, book-length analysis of Löwenheim's proof and a detailed description of the theoretical framework–and, in particular, of the algebraic tradition–that made the theorem possible.

Badesa's three main conclusions amount to a completely new interpretation of the proof, one that sharply contradicts the core of modern scholarship on the topic. First, Löwenheim did not use an infinitary language to prove his theorem; second, the functional interpretation of Löwenheim's normal form is anachronistic, and inappropriate

for reconstructing the proof; and third, Löwenheim did not aim to prove the theorem's weakest version but the stronger version Skolem attributed to him. This book will be of considerable interest to historians of logic, logicians, philosophers of logic, and philosophers of mathematics.

Studies in the Philosophy of Logic and Knowledge by Thomas Baldwin, Timothy Smiley; Oxford University Press (February 28, 2005); $55.00; ISBN: 0197262910.

Vicious Circles (Center for the Study of Language and Information. Lecture Notes) by Jon Barwise, Lawrence S. Moss; Center for the Study of Language and Information (August 4, 2004); $25.95; ISBN: 1575860082. Circular analyses of philosophical, linguistic, or computational phenomena have been attacked on the assumption that they conflict with mathematical rigour. Barwise and Moss have undertaken to prove this assumption false. This volume is concerned with extending the modelling capabilities of set theory to provide a uniform treatment of circular phenomena. As a means of guiding the reader through the concrete examples of the theory, the authors have included many exercises and solutions: these exercises range in difficulty and ultimately stimulate the reader to come up with new results. Vicious Circles is intended for use by researchers who want to use hypersets; although some experience in mathematics is necessary, the book is accessible to people with widely differing backgrounds and interests.

Liars and Heaps: New Essays on Paradox by J. C. Beall; Oxford University Press (March 1, 2004); $29.95; ISBN: 0199264813.

Set Theory (Oxford Logic Guides) by John L. Bell; Clarendon Press; 3rd Ed edition (July, 2005); ISBN: 0198568525.

Explanatory Nonmonotonic Reasoning (Advances in Logic) by Alexander Bochman; World Scientific Publishing Company (January 30, 2005); $68.00; ISBN: 9812561013.

Universal Logic (Center for the Study of Language and Information. Lecture Notes) by Ross Brady; Center for the Study of Language and Information (January 15, 2005); $35.00; ISBN: 1575862565. The classical logic of Frege and Russell has dominated formal logic in the 20th century. But a new type of weak relevant logic may prove itself to be better equipped to present new solutions to persisting paradoxes.

Universal Logic conceptualizes a new weak quantified relevant logic where the main inference connective is understood as 'meaning containment.' This logic is intended to analyze naive set/class theories. The volume begins with an overview of classical logic and relevant logic, and discusses the limitations of both types of logic in analyzing certain paradoxes. A summary on the history of logic segues into the author's

introduction of his new logic modeled on the properties of set-theoretic containment. This book is the first to demonstrate how the main set-theoretic and semantic paradoxes can be solved in a systematic way, which is conceptualized independently of the paradoxes themselves.

Truth, Thought, Reason: Essays On Frege by Tyler Burge; Oxford University Press (March 30, 2005); $24.95; ISBN: 0199278547. Tyler Burge presents a collection of his seminal essays on Gottlob Frege (1848-1925), who has a strong claim to be seen as the founder of modern analytic philosophy, and whose work remains at the centre of philosophical debate today. Truth, Thought, Reason gathers some of Burge's most influential work from the last twenty-five years, and also features important new material, including a substantial introduction and postscripts to four of the ten papers. It will be an essential resource for any historian of modern philosophy, and for anyone working on philosophy of language, epistemology, or philosophical logic.

Handbook Of Mathematical Cognition by Jamie I. D. Campbell; Psychology Press (UK) (November 30, 2004); $120.00; ISBN: 1841694118.

The Collected Works of Alonzo Church by Alonzo Church, Tyler Burge, Herbert Enderton, Michael Zeleny; MIT Press (April 30, 2005); $125.00; ISBN: 0262025647.

The Logic System of Concept Graphs With Negation: And Its Relationship to Predicate Logic (Lecture Notes in Computer Science) by Frithjof Dau; Springer-Verlag (January 1, 2004); $47.00; ISBN: 3540206078.

Truth and Predication by Donald Davidson; Belknap Press (May 31, 2005); $29.95; ISBN: 0674015258. The two philosophers who did the most to persuade us not to take the Cartesian caricature of the human situation seriously were the brilliant and eccentric Ludwig Wittgenstein and Donald Davidson. Davidson's and Wittgenstein's writings are not easy for the nonspecialist to grasp. Neither are those of Kant and Hegel. But the work of original and imaginative philosophers such as these, in the course of generations, gradually comes to have an influence on the entire culture. Their criticisms of our intellectual heritage change our sense of what is important to think about. A couple of centuries from now, historians of philosophy will be writing about the changes in the human self-image that Donald Davidson's writings helped bring about.

The Undecidable: Basic Papers on Undecidable Propositions, Unsolvable Problems and Computable Functions by Martin Davis; Dover Publications (February 18, 2004); $16.47; ISBN: 0486432289. In this corrected reprint of the work originally published by Raven Press Books, Ltd., Hewlett, New York, in 1965, Davis (emeritus, mathematical sciences, New York U.) collects classic papers and authors' supplementary

notes tackling undecidability and unsolvability. This anthology of fundamental papers dealing with undecidability and unsolvability begins with Gödel's epoch-making paper of 1931. This paper demonstrated for the first time that systems of logic–no matter how powerful–could never admit proofs of all true assertions of arithmetic. Included in this outstanding volume are the basic papers of del, Church, Turing, and Post in which the class of recursive functions was singled out and seen to be just the class of functions that can be computed by finite algorithms. Also presented is the work of Church, Turing, and Post in which problems from the theory of abstract computing machines, from mathematical logic, and finally from algebra are shown to be unsolvable in the sense that there is no finite algorithm for dealing with them. Finally, the book presents the work of Kleene and of Post initiating the classification theory of unsolvable problems. Already the standard reference work on the subject, The Undecidable is also ideally suited as a text or supplementary text for courses in logic, philosophy, and foundations of mathematics.

Understanding Agent Systems (Springer Series, Agent Technology) by Mark D'Inverno, Michael Luck; Springer-Verlag; 2nd Rev&Ex edition (January 1, 2004); $44.95; ISBN: 3540407006. This book presents a formal approach to dealing with agents and agent systems. The Z specification language is used to establish an accessible and unified formal account of agent systems and inter-agent relationships. In particular, the framework provides precise and unambiguous meanings for common concepts and terms for agent systems, allows for the description of alternative agent models and architectures, and serves as a foundation for subsequent development of increasingly refined agent concepts. The practicability of this approach is verified by applying the formal framework to three detailed case studies. The methodology presented takes a very significant step towards organising and structuring the diverse and disparate landscape of agent-based systems by applying formal methods to develop a defining and encompassing agent framework. The book will appeal equally to researchers, students, and professionals in industry.

Games of Strategy (Second Edition) by Avinash Dixit, Susan Skeath; W. W. Norton & Company; 2 edition (April, 2004); $89.06; ISBN: 0393924998. Now available in a Second Edition, Games of Strategy remains the most accessible principles-level text for courses in game theory, addressing a remarkably broad range of concepts in a narrative that is both clear and compelling. Using resonant real-world examples, the authors simplify difficult theoretic ideas, helping students see the value of strategic thinking in a variety of situations. The text has been carefully updated for this Second Edition, including thorough revisions of the sections on sequential- and simultaneous-move games and those on voting and auctioning.

This is an inviting introduction to game theory, offering students an engaging, comprehensive view of the discipline without assuming a prior knowledge of economics or complex mathematics (uses only high school algebra).

Alfred Tarski: Life and Logic by Anita Burdman Feferman, Solomon Feferman; Cambridge University Press (October 4, 2004); $23.09; ISBN: 0521802407. Alfred Tarski, one of the greatest logicians of all time, is widely thought of as "the man who defined truth." His mathematical work on the concepts of truth and logical consequence are cornerstones of modern logic, influencing developments in philosophy, linguistics and computer science. Tarski was a charismatic teacher and zealous promoter of his view of logic as the foundation of all rational thought, as well as a bon-vivant and a womanizer, who played the "great man" to the hilt. Born in Warsaw in 1901 to Jewish parents, he changed his name and converted to Catholicism, but was never able to obtain a professorship in his home country. A fortuitous trip to the United States at the outbreak of World War 1 saved his life and turned his career around, even though it separated him from his family for years. By the war's end, Tarski was established as a professor of mathematics at the University of California, Berkeley, where he started a department in logic and methodology that attracted students and distinguished researchers from all over the world. From the cafes of Warsaw and Vienna to the mountains and deserts of California, this first full- length biography places Tarski in the social, intellectual and historical context of his times. It presents a vivid picture of a personally and professionally passionate man, interlaced with an account of his major scientific achievements. Anita Burdman Feferman is an author and biographer who has written on noted figures such as Jean van Heijenoort and Georg Kreisel. Solomon Feferman is a professor of Mathematics and Philosophy at Stanford University. Both authors were closely acquainted with Tarski and in a unique position to write about his life.

Modality and Tense by Kit Fine; Clarendon Press (July, 2005); ISBN: 0199278717.

Handbook of Temporal Reasoning in Artificial Intelligence by Michael Fisher, Michael David Fisher, Dov Gabbay, Lluis Vila; Elsevier Science (March 15, 2005); $182.00; ISBN: 0444514937.

This collection represents the primary reference work for researchers and students in the area of Temporal Reasoning in Artificial Intelligence. Temporal reasoning has a vital role to play in many areas, particularly Artificial Intelligence. Yet, until now, there has been no single volume collecting together the breadth of work in this area. This collection brings together the leading researchers in a range of relevant areas and provides an coherent description of the breadth of activity concerning temporal reasoning in the filed of Artificial Intelligence.

- Broad range: foundations; techniques and applications
- Leading researchers around the world have written the chapters
- Covers many vital applications

- Source book for Artificial Intelligence, temporal reasoning
- Approaches provide foundation for many future software systems

Greek, Indian and Arabic Logic (Handbook of the History of Logic Series) by Dov M. Gabbay, John Woods; North Holland (February 6, 2004); $145.00. Greek, Indian and Arabic Logic marks the initial appearance of the multi-volume Handbook of the History of Logic. Additional volumes will be published when ready, rather than in strict chronological order. Soon to appear are The Rise of Modern Logic: From Leibniz to Frege. Also in preparation are Logic From Russell to Gödel, The Emergence of Classical Logic, Logic and the Modalities in the Twentieth Century, and The Many-Valued and Non-Monotonic Turn in Logic. Further volumes will follow, including Mediaeval and Renaissance Logic and Logic: A History of its Central.

In designing the Handbook of the History of Logic, the Editors have taken the view that the history of logic holds more than an antiquarian interest, and that a knowledge of logic's rich and sophisticated development is, in various respects, relevant to the research programmes of the present day. Ancient logic is no exception. The present volume attests to the distant origins of some of modern logic's most important features, such as can be found in the claim by the authors of the chapter on Aristotle's early logic that, from its infancy, the theory of the syllogism is an example of an intuitionistic, non-monotonic, relevantly paraconsistent logic. Similarly, in addition to its comparative earliness, what is striking about the best of the Megarian and Stoic traditions is their sophistication and originality.

Logic is an indispensably important pivot of the Western intellectual tradition. But, as the chapters on Indian and Arabic logic make clear, logic's parentage extends more widely than any direct line from the Greek city states. It is hardly surprising, therefore, that for centuries logic has been an unfetteredly international enterprise, whose research programmes reach to every corner of the learned world.

Like its companion volumes, Greek, Indian and Arabic Logic is the result of a design that gives to its distinguished authors as much space as would be needed to produce highly authoritative chapters, rich in detail and interpretative reach. The aim of the Editors is to have placed before the relevant intellectual communities a research tool of indispensable value.

Together with the other volumes, Greek, Indian and Arabic Logic, will be essential reading for everyone with a curiosity about logic's long development, especially researchers, graduate and senior undergraduate students in logic in all its forms, argumentation theory, AI and computer science, cognitive psychology and neuroscience, linguistics, forensics, philosophy and the history of philosophy, and the history of ideas.

The Rise of Modern Logic: from Leibniz to Frege (Handbook of the History of Logic Vol 3) by Dov. M. Gabbay, John Woods; North Holland (March 8, 2004); $170.00; ISBN: 0444516115.

Interpolation and Definability in Modal Logics (Oxford Logic Guides) by Dov M. Gabbay, Larisa Maksimova; Clarendon Press (June, 2005); ISBN: 0198511744.

A Philosophical Introduction to Probability (CSLI Lecture Notes) by Maria Carla Galavotti; Paperback; Center for the Study of Language and Inf (October 15, 2004); $25.00; ISBN: 1575864908. Not limited to merely mathematics, probability has a rich and controversial philosophical aspect. A Philosophical Introduction to Probability showcases lesser-known philosophical notions of probability and explores the debate over their interpretations. Galavotti traces the history of probability and its mathematical properties and then discusses various philosophical positions on probability, from the Pierre Simon de Laplace's classical interpretation of probability to the logical interpretation proposed by John Maynard Keynes. This book is a valuable resource for students in philosophy and mathematics and all readers interested in notions of probability.

Basic Concepts of Mathematics and Logic (Addison-Wesley Series in Introductory Mathematics) by Michael C. Gemignani; Dover Publications (April 22, 2004); $10.85; ISBN: 0486435067. Conceived as an introductory text to college-level mathematics, this 1968 work seeks to demonstrate and build the thought processes essential to mathematics. The text provides a foundation in the mathematical concepts of set theory, logic, counting, numbers, functions, ordering, probabilities, and elementary geometry

The Search for Certainty: A Philosophical Account of Foundations of Mathematics by Marcus Giaquinto; Oxford University Press (July 1, 2004); $27.50; ISBN: 0198752458.

Introduction to Mathematical Thinking: Algebra and Number Systems by Will J. Gilbert, Scott A. Vanstone; Prentice Hall (July 22, 2004); $58.00; ISBN: 0131848682. Besides giving readers the techniques for solving polynomial equations and congruences, An Introduction to Mathematical Thinking provides preparation for understanding more advanced topics in Linear and Modern Algebra, as well as Calculus. This book introduces proofs and mathematical thinking while teaching basic algebraic skills involving number systems, including the integers and complex numbers. Ample questions at the end of each chapter provide opportunities for learning and practice; the Exercises are routine applications of the material in the chapter, while the Problems require more ingenuity, ranging from easy to nearly impossible. Topics covered in this comprehensive introduction range from logic and proofs, integers and

diophantine equations, congruences, induction and binomial theorem, rational and real numbers, and functions and bijections to cryptography, complex numbers, and polynomial equations. With its comprehensive appendices, this book is an excellent desk reference for mathematicians and those involved in computer science.

A First Course In Logic: An Introduction To Model Theory, Proof Theory, Computability, And Complexity (Oxford Texts in Logic S.) by Shawn Hedman; Oxford University Press (September 4, 2004); $155; ISBN: 0198529813. The ability to reason and think in a logical manner forms the basis of learning for most mathematics, computer science, philosophy and logic students. Based on the author's teaching notes at the University of Maryland and aimed at a broad audience, this text covers the fundamental topics in classical logic in an extremely clear, thorough and accurate style that is accessible to all the above. Covering propositional logic, first-order logic, and second-order logic, as well as proof theory, computability theory, and model theory, the text also contains numerous carefully graded exercises and is ideal for a first or refresher course.

Logic in Computer Science: Modelling and Reasoning about Systems by Michael Huth, Mark Ryan; Cambridge University Press; 2 edition (August 26, 2004); $56.15; ISBN: 052154310X. The second edition of this successful textbook continues to provide a clear introduction to formal reasoning relevant to the needs of modern computer science and sufficiently exacting for practical applications. Improvements have been made throughout with many new and expanded text sections. The coverage of model-checking has been substantially updated and additional exercises are included. Internet support includes worked solutions for teacher exercises and model solutions to some student exercises.

Subjective Probability: The Real Thing by Richard Jeffrey; Cambridge University Press (April 12, 2004); $21.99; ISBN: 0521536685. This book offers a concise survey of basic probability theory from a thoroughly subjective point of view whereby probability theory is a mode of judgement. Written by one of the greatest figures in the field of probability theory, the book is both a summation and a synthesis of a lifetime of wrestling with such problems and issues.

Formal Logic: Its Scope And Limits by Richard Jeffrey; Hackett Publishing Company; 3rd Rep edition (November 30, 2004); $28.95; ISBN: 0872207498. This brief paperback is designed for symbolic/formal logic courses. It features the tree method proof system developed by Jeffrey. The new edition contains many more examples and exercises and is reorganized for greater accessibility.

Nonstandard Analysis, Axiomatically (Springer Monographs) by Vladimir Kanovei, Michael Reeken, V. G. Kanovei; Springer Verlag (October 16, 2004); $109.00; ISBN:

354022243X. The book is devoted to nonstandard set theories that serve as foundational basis for nonstandard mathematics. Several popular and some less known nonstandard theories are considered, including internal set theory IST, Hrbacek set theory HST, and others. The book presents the basic structure of the set universe of these theories and methods to effectively develop "applied" nonstandard analysis, metamathematical properties and interrelations of these nonstandard theories between each other and with ZFC and some variants of ZFC, foundational problems of the theories, including the problem of external sets and the Power Set problem, and methods of their solution. The book is oriented towards a reader having some experience in foundations (set theory, model theory) and in nonstandard analysis.

Socratic Logic by Peter Kreeft; St. Augustine's Press; 2nd edition (May 1, 2005); $40.00; ISBN: 1587318008. There are hundreds of logic tests in print, but none like this one. (1) This is the only complete system of classical Aristotelian logic in print. The "old logic" is still the natural logic of the four language arts (reading, writing, speaking, and listening). Symbolic, or "mathematical," logic may be superior to classical "ordinary-language" Aristotelian logic for the sciences, but not for the humanities, and is more sophisticated theoretically but not more useful practically. (How often have you heard non-philosophers argue in symbolic logic?) (2) This book is simple and user-friendly. It is highly interactive, with a plethora of exercises and a light, engaging style. Most beginners need a "back to basics" logic text rather than the latest overpriced one with state-of-the-art "bells and whistles" that they will never use outside class. (3) It is practical. It is designed for do-it-yourselfers as well as classrooms. It emphasizes topics in proportion to probable student use: e.g., interpreting ordinary language, not only analyzing but also constructing effective arguments, smoking out hidden assumptions, making "argument maps," and using Socratic method in various circumstances. It is divided into eighty-eight mini-chapters for maximum mix-and-match flexibility. (4) It is also philosophical. Its exercises expose students to many classical quotations, and additional chapters introduce philosophical issues in a Socratic manner and from a common-sense, realistic point of view. It prepares students for reading Great Books rather than Dick and Jane, and models Socrates as the beginner's ideal teacher and philosopher.

Temporal Logic And State Systems (Texts in Theoretical Computer Science. An Eatcs Series) by Fred Kroger, Stefan Merz; Springer-Verlag (February 28, 2005); $69.95; ISBN: 3540674012. Temporal Logic has been developed during the last 25 years to a basic and powerful formal setting for the specification and verification of state based systems. This book, based on manifold university lectures given by the authors, gives a comprehensive description of this field. It presents concisely and uniformly the up to date material of the theory and applications of linear and branching time Temporal Logic, Temporal Logic of Actions, automata theoretical connections, model checking and others.

All theoretical details as well as the numerous application examples are elaborated carefully and with all formal rigor, so intended to serve as a basic source and reference for active lectures and researchers.

Elements of Finite Model Theory (Texts in Theoretical Computer Science An Eatcs Series) by Leonid Libkin; Springer-Verlag (September 15, 2004); Price $47.63; ISBN: 3540212027. This book is an introduction to finite model theory which stresses the computer science origins of the area. In addition to presenting the main techniques for analyzing logics over finite models, the book deals extensively with applications in databases, complexity theory, and formal languages, as well as other branches of computer science. It covers Ehrenfeucht-Fraïssé games, locality-based techniques, complexity analysis of logics, including the basics of descriptive complexity, second-order logic and its fragments, connections with finite automata, fixed point logics, finite variable logics, zero-one laws, and embedded finite models, and gives a brief tour of recently discovered applications of finite model theory.

This book can be used both as an introduction to the subject, suitable for a one- or two-semester graduate course, or as reference for researchers who apply techniques from logic in computer science.

Wittgenstein, Austrian Economics, and the Logic of Action by Roderick T. Long; Routledge (February 1, 2005); $96.95; ISBN: 0415329485.

Frege's Logic by Danielle Macbeth; Harvard University Press (April 30, 2005); $45.00; ISBN: 0674017072. For many philosophers, modern philosophy begins in 1879 with the publication of Gottlob Frege's Begriffsschrift, in which Frege presents the first truly modern logic in his symbolic language, Begriffsschrift, or concept-script. Danielle Macbeth's book, the first full-length study of this language, offers a highly original new reading of Frege's logic based directly on Frege's own two-dimensional notation and his various writings about logic.

Setting out to explain the nature of Frege's logical notation, Macbeth brings clarity not only to Frege's symbolism and its motivation, but also to many other topics central to his philosophy. She develops a uniquely compelling account of Frege's Sinn/Bedeutung distinction, a distinction central to an adequate logical language; and she articulates a novel understanding of concepts, both of what they are and of how their contents are expressed in properly logical language. In her reading, Frege's Begriffsschrift emerges as a powerful and deeply illuminating alternative to the quantificational logic it would later inspire.

The most enlightening examination to date of the developments of Frege's thinking about his logic, this book introduces a new kind of logical language, one that promises surprising insight into a range of issues in metaphysics and epistemology, as well as in the philosophy of logic.

Bridges from Classical to Nonmonotonic Logic (Texts in Computing, vol 5) by David Makinson; Paperback; London: King's College Publications (February 2005); Price £10/$19.50; ISBN 1-904987-00-1. From the outside, nonmonotonic logic is often seen as a rather mysterious affair. Even from the inside, it can appear to lack unity, with multiple systems proposed by as many authors going in different directions. The few available textbooks tend to perpetuate this impression.

The main purpose of this book is to take some of the mystery out of the subject and show that it is not as unfamiliar as may at first sight seem. In fact, it is easily accessible to anybody with the minimal background that we have described in classical propositional logic and basic mathematical tools — provided certain misunderstandings and a tenacious habit, both signalled in the first chapter, are put aside.

The author shows that there are logics that act as natural bridges between classical consequence and the principal kinds of nonmonotonic logic to be found in the literature. These logics, which he calls paraclassical, are very simple to define and easy to study. They provide three main ways of getting more out of your premises than is allowed by strict deduction, that is, by good old classical consequence. In other words, they are principled ways of creeping, crawling or jumping to conclusions. Like classical logic, they are perfectly monotonic, but they already display some of the distinctive features of the nonmonotonic systems that they prefigure, as well as providing easy conceptual passage to them. They give us, in effect, three main paths from the classical homeland to nonmonotonic shores.

The book examines the three one by one. It begins with the simplest among them, whose moving idea is to use additional background assumptions along with current premises. Then it considers ways of getting the same result by excluding certain classical valuations. And finally it sets out a third means to the same end, by adding rules alongside the premises.

The author then examines the subtle relations between classical logic, probabilistic inference, and nonmonotonic reasoning. The last chapter of the book discusses the links and residual differences between nonmonotonic inference on the one hand and other well-known kinds of 'belief management': belief revision, update, counterfactual conditionals, and conditional directives

The text is written for the student in a classroom, the instructor teaching a course, without forgetting for the solitary reader. It provides recapitulations at the end of each chapter, exercises and problems, selected solutions, suggested projects, and guides to further reading.

Being Logical: A Guide to Good Thinking by D.Q. McInerny; Random House (August 3, 2004); $13.57; ISBN: 1400061717. "Major Premise: Sixty men can do a piece of work sixty times as quickly as one man. Minor Premise: One man can dig a posthole in sixty seconds; therefore-Conclusion: Sixty men can dig a post-hole in one second."

Ambrose Bierce's satire on the syllogism belongs to one of many species of specious reasoning that college professor McInerny takes to task in this precis on logic. Remarking that logic is rarely taught "as such" in American education, he presents this makeup course consciously modeled on Strunk and White's Elements of Style (1959). In concise language, McInerny's guide distributes the elements of logic among short, admonitory headings, such as "Avoid Vague and Ambiguous Language." McInerny also provides definitions of the tools of logic and their application in arriving at truth. Inculcating this noble and, in principle, attainable aim, McInerny's explanatory outline of sound thinking will be eminently beneficial to expository writers, debaters, and public speakers

Epistemic Logic for AI and Computer Science (Cambridge Tracts in Theoretical Computer Science) by John-Jules Ch. Meyer, Wiebe van der Hoek, C. J. van Rijsbergen; Cambridge University Press; New Ed edition (March 25, 2004); $39.49; ISBN: 0521602807. Epistemic logic has grown from its philosophical beginnings to find diverse applications in computer science as a means of reasoning about the knowledge and belief of agents. This book, based on courses taught at universities and summer schools, provides a broad introduction to the subject; many exercises are included together with their solutions. The authors begin by presenting the necessary apparatus from mathematics and logic, including Kripke semantics and the well-known modal logics K, T, S4 and S5. Then they turn to applications in the contexts of distributed systems and artificial intelligence: topics that are addressed include the notions of common knowledge, distributed knowledge, explicit and implicit belief, the interplays between knowledge and time, and knowledge and action, as well as a graded (or numerical) variant of the epistemic operators. The problem of logical omniscience is also discussed extensively. Halpern and Moses' theory of honest formulae is covered, and a digression is made into the realm of non-monotonic reasoning and preferential entailment. Moore's autoepistemic logic is discussed, together with Levesque's related logic of 'all I know'. Furthermore, it is shown how one can base default and counterfactual reasoning on epistemic logic.

Abel's Proof: An Essay on the Sources and Meaning of Mathematical Unsolvability by Peter Pesic; The MIT Press (April 1, 2004); $10.17; ISBN: 0262661829. In 1824 a young Norwegian named Niels Henrik Abel proved conclusively that algebraic equations of the fifth order are not solvable in radicals. In this book Peter Pesic shows what an important event this was in the history of thought. He also presents it as a remarkable human story. Abel was twenty-one when he self-published his proof, and he died five years later, poor and depressed, just before the proof started to receive wide acclaim. Abel's attempts to reach out to the mathematical elite of the day had been spurned, and he was unable to find a position that would allow him to work in peace and marry his fiance.

But Pesic's story begins long before Abel and continues to the present day, for Abel's proof changed how we think about mathematics and its relation to the "real" world. Starting with the Greeks, who invented the idea of mathematical proof, Pesic shows how mathematics found its sources in the real world (the shapes of things, the accounting needs of merchants) and then reached beyond those sources toward something more universal. The Pythagoreans' attempts to deal with irrational numbers foreshadowed the slow emergence of abstract mathematics. Pesic focuses on the contested development of algebra – which even Newton resisted – and the gradual acceptance of the usefulness and perhaps even beauty of abstractions that seem to invoke realities with dimensions outside human experience. Pesic tells this story as a history of ideas, with mathematical details incorporated in boxes. The book also includes a new annotated translation of Abel's original proof.

Set Theory and Its Philosophy: A Critical Introduction by Michael Potter; Oxford University Press (March 1, 2004); $29.95; ISBN: 0199270414.

Towards Non-being: The Logic And Metaphysics of Intentionality by Graham Priest; Oxford University Press (July 1, 2005); $49.95; ISBN: 0199262543.

The Law of Non-Contradiction: New Philosophical Essays by Graham Priest, J. C. Beall, Bradley Armour-Garb; Oxford University Press (November 30, 2004); $85.00; ISBN: 0199265178. The Law of Non-Contradiction – that no contradiction can be true – has been a seemingly unassailable dogma since the work of Aristotle, in Book G of the Metaphysics. It is an assumption challenged from a variety of angles in this collection of original papers. Twenty-three of the world's leading experts investigate the "law," considering arguments for and against it and discussing methodological issues that arise whenever we question the legitimacy of logical principles. The result is a balanced inquiry into a venerable principle of logic, one that raises questions at the very center of logic itself. The aim of this volume is to present a comprehensive debate about the Law of Non-Contradiction, from discussions as to how the law is to be understood, to reasons for accepting or re-thinking the law, and to issues that raise challenges to the law, such as the Liar Paradox, and a "dialetheic" resolution of that paradox. The editors contribute an introduction which surveys the issues and serves to frame the debate, and a useful bibliography offering a guide to further reading. This volume will be of interest to anyone working on philosophical logic, and to anyone who has ever wondered about the status of logical laws and about how one might proceed to mount arguments for or against them.

Epistemic Logic: A Survey of The Logic of Knowledge by Nicholas Rescher; University of Pittsburgh Press (February 28, 2005); $25.95; ISBN: 0822942461.

The Oxford Handbook of Philosophy of Math and Logic (Oxford Handbooks in Philosophy) by Stewart Shapiro; Oxford University Press (April 30, 2005); $85.00; ISBN:

0195148770. Mathematics and logic have been central topics of concern since the dawn of philosophy. Since logic is the study of correct reasoning, it is a fundamental branch of epistemology and a priority in any philosophical system. Philosophers have focused on mathematics as a case study for general philosophical issues and for its role in overall knowledge- gathering. Today, philosophy of mathematics and logic remain central disciplines in contemporary philosophy, as evidenced by the regular appearance of articles on these topics in the best mainstream philosophical journals; in fact, the last decade has seen an explosion of scholarly work in these areas. This volume covers these disciplines in a comprehensive and accessible manner, giving the reader an overview of the major problems, positions, and battle lines. The 26 contributed chapters are by established experts in the field, and their articles contain both exposition and criticism as well as substantial development of their own positions. The essays, which are substantially self-contained, serve both to introduce the reader to the subject and to engage in it at its frontiers. Certain major positions are represented by two chapters–one supportive and one critical. The Oxford Handbook of Philosophy of Math and Logic is a ground-breaking reference like no other in its field. It is a central resource to those wishing to learn about the philosophy of mathematics and the philosophy of logic, or some aspect thereof, and to those who actively engage in the discipline, from advanced undergraduates to professional philosophers, mathematicians, and historians.

A Brief History of The Paradox: Philosophy And The Labyrinths of The Mind by Roy Sorensen; Oxford University Press; New Ed edition (January 31, 2005); $10.85; ISBN: 0195179862. Can God create a stone too heavy for him to lift? Can time have a beginning? Which came first, the chicken or the egg? Riddles, paradoxes, conundrums–for millennia the human mind has found such knotty logical problems both perplexing and irresistible. Now Roy Sorensen offers the first narrative history of paradoxes, a fascinating and eye-opening account that extends from the ancient Greeks, through the Middle Ages, the Enlightenment, and into the twentieth century. When Augustine asked what God was doing before He made the world, he was told: "Preparing hell for people who ask questions like that." A Brief History of the Paradox takes a close look at "questions like that" and the philosophers who have asked them, beginning with the folk riddles that inspired Anaximander to erect the first metaphysical system and ending with such thinkers as Lewis Carroll, Ludwig Wittgenstein, and W.V. Quine. Organized chronologically, the book is divided into twenty-four chapters, each of which pairs a philosopher with a major paradox, allowing for extended consideration and putting a human face on the strategies that have been taken toward these puzzles. Readers get to follow the minds of Zeno, Socrates, Aquinas, Ockham, Pascal, Kant, Hegel, and many other major philosophers deep inside the tangles of paradox, looking for, and sometimes finding, a way out. Filled with illuminating anecdotes and vividly written, A Brief History of the Paradox will

appeal to anyone who finds trying to answer unanswerable questions a paradoxically pleasant endeavor.

The Russellian Origins Of Analytical Philosophy: Bertrand Russell And The Unity Of The Proposition (Routledge Studies in Twentieth Century Philosophy) by Graham Stevens; Not Avail (July 1, 2005); $115.00; ISBN: 0415360447.

Finite Model Theory and Its Applications by M. Y. Vardi; Hardcover: 300 pages; Springer-Verlag (March 30, 2005); $59.95. This book gives a comprehensive overview of central themes of finite model theory – expressive power, descriptive complexity, and zero-one laws – together with selected applications relating to database theory and artificial intelligence, especially constraint databases and constraint satisfaction problems. The final chapter provides a concise modern introduction to modal logic, emphasizing the continuity in spirit and technique with finite model theory. This underlying spirit involves the use of various fragments of and hierarchies within first-order, second-order, fixed-point, and infinitary logics to gain insight into phenomena in complexity theory and combinatorics.

The book emphasizes the use of combinatorial games, such as extensions and refinements of the Ehrenfeucht-Fraisse pebble game, as a powerful way to analyze the expressive power of such logics, and illustrates how deep notions from model theory and combinatorics, such as o-minimality and treewidth, arise naturally in the application of finite model theory to database theory and AI.

Students of logic and computer science will find here the tools necessary to embark on research into finite model theory, and all readers will experience the excitement of a vibrant area of the application of logic to computer science.

Abductive Reasoning by Douglas N. Walton; University of Alabama Press (March 30, 2005); $40.00; ISBN: 0817314415.

Frege Explained (Ideas Explained) by Joan Weiner; Open Court (September 9, 2004); $13.27; ISBN: 0812694600. What is the number one? Does 2 plus 2 always equal 4? These seemingly simple questions have perplexed philosophers for eons, but the ideas of German philosopher Gottlob Frege (1848-1925) transformed the discussion. Frege believed that the truths of arithmetic and of all mathematics are derived from self-evident logical truths. His new way of looking at logic and mathematics was influential and his convictions revolutionized logic and laid the foundation for modern analytic philosophy. Joan Weiner presents an accurate, accessible explanation of Frege's ideas, tracing the development of his thought and making the essential concepts understandable.

Legal Reason: The Use of Analogy in Legal Argument by Lloyd L. Weinreb; Cambridge University Press (February 28, 2005); $18.99; ISBN: 0521614902. Legal Reason

describes and explains the process of analogical reasoning, which is the distinctive feature of legal argument. It challenges the prevailing view, urged by Edward Levi, Cass Sunstein, Richard Posner and others, which regards analogical reasoning as logically flawed or as a defective form of deductive reasoning. Lloyd Weinreb reveals that it is the same as the reasoning used routinely everyday–derived from the innate human capacity to recognize the general in the particular, on which thought itself depends. Moreover, the use of analogical reasoning is dictated by the nature of law, which requires the application of rules to particular facts.

Realistic Decision Theory: Rules for Nonideal Agents in Nonideal Circumstances by Paul Weirich; Oxford University Press (September 1, 2004); $46.74; ISBN: 019517125X.

Bayesian Nets And Causality: Philosophical And Computational Foundations by Jon Williamson; Oxford University Press (April 30, 2005); $74.50; ISBN: 019853079X. Bayesian nets are widely used in artificial intelligence as a calculus for casual reasoning, enabling machines to make predictions, perform diagnoses, take decisions and even to discover casual relationships. But many philosophers have criticized and ultimately rejected the central assumption on which such work is based-the causal Markov Condition. So should Bayesian nets be abandoned? What explains their success in artificial intelligence? This book argues that the Causal Markov Condition holds as a default rule: it often holds but may need to be repealed in the face of counter examples. Thus, Bayesian nets are the right tool to use by default but naively applying them can lead to problems. The book develops a systematic account of causal reasoning and shows how Bayesian nets can be coherently employed to automate the reasoning processes of an artificial agent. The resulting framework for causal reasoning involves not only new algorithms, but also new conceptual foundations. Probability and causality are treated as mental notions - part of an agent's belief state. Yet probability and causality are also objective - different agents with the same background knowledge ought to adopt the same or similar probabilistic and causal beliefs. This book, aimed at researchers and graduate students in computer science, mathematics and philosophy, provides a general introduction to these philosophical views as well as exposition of the computational techniques that they motivate.

NEW JOURNAL

LOGICAL METHODS IN COMPUTER SCIENCE (LMCS).

Logical Methods in Computer Science is a fully refereed, open access, free electronic journal. The editors welcome papers on all topics of theoretical and practical areas in computer science involving logical methods, taken in a broad sense. The home page of the journal is:

`http://www.lmcs-online.org`

Logical Methods in Computer Science is published under the auspices of the International Federation for Computational Logic (IFCoLog). Technically it is an overlay of The Computing Research Repository (CoRR), which is part of arXiv.

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AiML – ADVANCES IN MODAL LOGIC

AiML—*Advances in Modal Logic* is the main international forum at which research on all aspects of modal logic is presented. The Advances in Modal Logic Initiative was founded in 1995 and the first AiML Conference was held in 1996 in Berlin, Germany. Since then the AiML Conference has been organised on a bi-annual basis with previous meetings being held in 1998 in Uppsala, Sweden, in 2000 in Leipzig, Germany (jointly with ICTL-2000), in 2002 in Toulouse, France, and in 2004 in Manchester, UK.

The next conference, the sixth of the series, the will take place in Queensland, Australia, in the second half of 2006. For further information visit the web site of the conference at

`http://www.itee.uq.edu.au/~aiml06`

or contact the organiser, Guido Governatori, at guido@itee.uq.edu.au.

ASL – ASSOCIATION FOR SYMBOLIC LOGIC

Computational Prospects of Infinity, Singapore, Republic of Singapore, June 20–July 16, 2005 and July 18–August 15, 2005. This two-month program, supported by the Institute of Mathematical Sciences at the National University of Singapore, will focus on recent developments in set theory and recursion theory. The program will include two workshops. The first, on set theory, will be held June 20–July 16, 2005; tutorials will be offered by J. Steel and H. Woodin. The second workshop, on recursion theory/computability theory, will take place on July 18–August 15, 2005, with tutorials given by R. Downey and T. Slaman. There will be invited lectures and regular talks arranged throughout the duration of the program. The organizers are: C. Chong, Q. Feng, T. Slaman, H. Woodin, and Y. Yang. Limited funds to cover travel and living expenses are available for young scientists. For further information, visit the website below. (ASL Sponsored Meeting.)

`http://www.ims.nus.edu.sg/Programs/infinity/index.htm`

Twentieth IEEE Symposium on Logic In Computer Science (LICS 2005), Chicago, Illinois, June 26–29, 2005. The LICS Symposium is an annual international forum on theoretical and practical topics in computer science that relate to logic broadly construed. The LICS General Chair is P. Kolaitis (email: kolaitis@cs.ucsc.edu); the LICS 2005 Program Chair is P. Panangaden (email: prakash@cs.mcgill.ca). Workshops are planned for June 25, June 30, and July 1. The deadline for submission of abstracts for papers is January 5, 2005. For further information, visit the website below. (ASL Sponsored Meeting.)

`http://www.lfcs.informatics.ed.ac.uk/lics/`

Twelfth Workshop on Logic, Language, Information and Computation (WoLLIC'2005), Florianópolis (Santa Catarina), Brazil, July 19–22, 2005. This is the twelfth in a series of workshops intended to foster interdisciplinary research in pure and applied logic. The Program Committee includes: E. Allender, S. Basu, P. Clote, J. Flum, D. Galmiche, A. Herzig, J.-B. Joinet, M. Kanazawa, Y. Kohayakawa, A. Macintyre, L.C. Pereira, H. Rott, R. Thomason, Y. Venema, A. Voronkov and M. Zaionc. The

Co-Chairs of the Organizing Committee are G. Bittencourt and R. de Queiroz. The deadline for submission of papers is March 1, 2005. Graduate students and recent Ph.D.'s in logic may apply for modest grants to attend the workshop; the deadline for applications is March 1, 2005. For further information, visit the website below. (ASL Sponsored Meeting.)

`http://www.cin.ufpe.br/~wollic/wollic2005/`

2005 ASL European Summer Meeting (Logic Colloquium '05), Athens, Greece, July 28–August 3, 2005. Invited speakers include: J. Bergstra, S. Goncharov, D. Haskell, E. Jaligot, J. Moore, A. Nies, C. Parsons, H. Schwichtenberg, M. Sheard, S. Tupailo, K. Weihrauch, and J. Zapletal. The following short courses will be offered (with speakers in parentheses): computer science logic (P. Kolaitis), model theory (I. Ben-Yaacov), philosophy of logic (G. Restall), and proof theory and constructivity (P. Aczel). The members of the Program Committee are: C.T. Chong, C. Dimitracopoulos, H. Field, G. Jaeger, G. Metakides, L. Newelski, D. Normann, R. Parikh, J. Steel, S. Todorcevic, J. Tucker, F. Wagner, and S. Wainer (Chair). The Local Organizing Committee includes: D. Anapolitanos, C. Dimitracopoulos (Chair), L. Kirousis, G. Koletsos, M. Mytilinaios, S. Papastavridis, Th. Pheidas, P. Rondogiannis, G. Stavrinos, A. Synachopoulos, and A. Tzouvaras. Abstracts of contributed talks submitted by ASL members will be published in The Bulletin of Symbolic Logic if they satisfy the Rules for Abstracts (see below). Abstracts—hard copy or email—should be received before the deadline of April 15, 2005 at the official meeting address: LC2005, Department of Mathematics, University of Athens, GR-157 84 Zografou, Greece; email: lc2005@math.uoa.gr. For further information visit the website below.

`http://eudoxos.math.uoa.gr/~lc2005/`

2005 Australasian Association for Logic Meeting, Perth, Western Australia, September 24–25, 2005. The principal organizer of this conference is Hartley Slater (email: slaterbh@cyllene.uwa.edu.au), who is currently President of the Association. Papers on all aspects of logic are welcome, with the deadline for their submission being June 24, 2005. The meeting will be held immediately prior to the annual meeting of the Australasian Mathematics Society on September 26-30, 2005, which also will take place in Perth (http://www.maths.uwa.edu.au/%7Eaustms05/index.html). There will be a special plenary session during the A.M.S. conference, featuring a sponsored 'Association for Symbolic Logic Lecture.' Further information may be found at the website below. (ASL Sponsored Meeting.)

http://www.philosophy.uwa.edu.au/aal_conference_2005

2005-06 ASL Winter Meeting (with APA), New York, New York, December 2005. The members of the Program Committee are M. Fitting, H. Gaifman (Chair), and A. Urquhart.

2006 ASL Annual Meeting, Montreal, Canada, May 17–21, 2006. The members of the Program Committee are: S. Feferman, S. Kuhlmann, D.A. Martin, P. Panangaden, S. Simpson, and M. Valeriote (Chair). The members of the Local Organizing Committee include: L. Bélair, F. Lepage, M. Marion (Chair), and P. Panangaden.

FoLLI – FOUNDATION OF LOGIC, LANGUAGE AND INFORMATION

FoLLI—The Foundation of Logic, Language and Information was founded in 1991 to advance the practising of research and education on the interfaces between logic, linguistics, computer science and cognitive science and related disciplines in Europe. Each year FoLLI organizes the European Summer School on Logic, Language and Information (ESSLLI). FoLLI has its own journal, the *Journal of Logic, Language and Information* (JoLLI), and book series, the *Studies in Logic, Language and Information* (SiLLI).

`http://www.folli.org`

Seventeenth European Summer School in Logic, Language and Information (ESSLLI-2005), Edinburgh, United Kingdom, August 8–19, 2005. The main focus of the European Summer Schools in Logic, Language and Information is on the interface between linguistics, logic and computation. Foundational, introductory and advanced courses together with workshops cover a wide variety of topics within the three areas of interest: Language and Computation, Language and Logic, and Logic and Computation. For further information, see the website below.

`http://www.folli.org`

TARK - THEORETICAL ASPECTS OF REASONING ABOUT KNOWLEDGE

Tenth conference on Theoretical Aspects of Rationality and Knowledge TARK X, Singapore, National University of Singapore, June 10-12, 2005. The mission of the TARK conferences is to bring together researchers from a wide ariety of fields, including Artificial Intelligence, Cryptography, Distributed Computing, Economics and Game Theory, Linguistics, Philosophy, and Psychology, in order to further our understanding of interdisciplinary issues involving reasoning about rationality and knowledge. Topics of interest include, but are not limited to, semantic models for knowledge, belief, and uncertainty, bounded rationality and resource-bounded reasoning, commonsense epistemic reasoning, epistemic logic, knowledge and action, applications of reasoning about knowledge and other mental states, belief revision, and foundations of multi-agent systems. TARK X will occur as part of an 8-week program "Uncertainty and Information in Economics", organized by the Institute for Mathematical Sciences (IMS), National University of Singapore in the period of 9 May - 3 July 2005. TARK X will take place in conjunction with a workshop in the program, which is to be held on 6-10 June 2005 (see http://www.ims.nus.edu.sg/Programs/uie/index.htm). The registration fee for the conference will be low, with an additional reduction for students. The participants will be offered a room in a 4* hotel at a special price not exceeding 90 US$ per day.

INVITED SPEAKERS: Sergiu Hart, Hebrew University of Jerusalem, Israel / Tom Henzinger, Ecole Polytechnique Federale de Lausanne, Switzerland / Isaac Levi, Columbia University, New York, USA / Rohit Parikh, CUNY, New York, USA.

PROGRAM COMMITTEE: Pierpaolo Battigalli, Bocconi University (Economics) / Larry Blume, Cornell University (Economics) / Adam Brandenburger, New York University (Economics) / Valentin Goranko, Rand Afrikaans University (Mathematics) / Vincent F. Hendricks, Roskilde University (Philosophy) / John Horty, University of Maryland (Philosophy) / Gerhard Lakemeyer, Aachen University of Technology (Computer Science) / Bart Lipman, Boston University (Economics) / David Makinson, Kings College London (Philosophy) / Ron van der Meyden (Chair), UNSW & NICTA (Computer Science) / Yoram Moses, The Technion (Computer Science) / Ramaswamy Ramanujam, Institute for Math Sciences, Chennai (Computer Science) / Robert van Rooy, University of Amsterdam (Linguistics) / Tuomas Sandholm, Carnegie Mellon University (Computer Science) / Wolfgang Spohn, University of Konstanz (Philosophy)

`http://www.comp.nus.edu.sg/~tark05/.`

FUNNY FRAGMENTS

Douglas Adams

There is a theory which states that if ever anyone discovers exactly what the Universe is for and why it is here, it will instantly disappear and be replaced by something even more bizarre and inexplicable. There is another theory which states that this has already happened.

John Berger

The human imagination ... has great difficulty in living strictly within the confines of a materialist practice or philosophy. It dreams, like a dog in its basket, of hares in the open.

Arthur C. Clarke

When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong.

Daniel C. Dennett

To him it was obvious that Professor Dennett was just inventing another of his wild science-fiction fantasies, yet another intuition pump to bamboozle the gullible.

Hugh Elliot

Science therefore, alone can furnish the data of philosophy. If there is any knowledge attainable that can truly be called philosophic, it is such knowledge only as is yielded by a study of the various sciences. Consequently, the first thing to be done in any search after philosophic principles is to travel over the special sciences with a view to extracting from them such information as is relevant to our purpose.

Anthony Flew

In the ordinary, everyday understandings of the words involved, to say that someone survived death is to contradict yourself; while to assert that all of us live forever is to assert a manifest falsehood, the flat contrary of a universally known truth: namely, the truth that all human beings are mortal. For when, after some disaster, the 'dead' and the 'survivors' have both been listed, what logical space remains for a third category?

Oliver Goldsmith

This same philosophy is a good horse in the stable, but an arrant jade on a jouney.

William Randolph Hearst

If you make a product good enough ... the public will make a path to your door, says the philosopher. But if you want the public in sufficient numbers, you would better construct a highway. Advertising is that highway.

Emmanuel Levinas

If philosophizing consists in assuring oneself of an absolute origin, the philosopher will have to efface the trace of his own footsteps and unendingly efface the traces of the effacing of the traces, in an interminable movement staying where it is.

Michael Oakeshott

Anyone who has had a glimpse of the range and subtlety of the thought of Plato or of Hegel will long ago have despaired of becoming a philosopher.

From *Feisty Fragments: For Philosophy.* Vincent F. Hendricks. £13.00 / $24. King's College Publications, September 2004, ISBN 190498701X. *Feisty Fragments* is a collection of more than 550 quotations from people from all the walks of life expressing their rather critical and often quite humorous takes on both philosophy and philosophers.

ONLINE LECTURE NOTES

Philosophy 240: Introduction to Logic
News, Lecture Notes, and Resources
http://phil240.tamu.edu/

Stefan Bilaniuk (Trent University, Canada)
http://euclid.trentu.ca/math/sb/pcml/pcml-16.pdf

Thomas Ferguson (UCLA)
Game Theory
http://www.math.ucla.edu/~tom/Game_Theory/Contents.html

Johan van Benthem (Amsterdam)
Logic in Games
http://turing.wins.uva.nl/~johan/Phil.298.html

Sidney Morris (Ballarat University, Australia)
Topology without Tears
http://uob-community.ballarat.edu.au/~smorris/topology.htm

Oleg Viro et al. (Uppsala University, Sweden)
Elementary Topology
http://www.math.uu.se/~oleg/topoman.html

John Nachbar (WUSTL)
Basic Non-Cooperative Game Theory
http://economics.wustl.edu/~e504s02/GameTheoryNC17.pdf

Jim Ratliff (prev. Arizona)
http://www.virtualperfection.com/gametheory/

Max Stinchcombe (Texas)
Notes for a Course in Game Theory
http://www.eco.utexas.edu/~maxwell/gtnotesF02.pdf

Lecture Notes Online.
http://www.econphd.net/notes.htm#Mathematics

Stanford: CS157: Computational Logic
http://logic.stanford.edu/classes/cs157/cs157.html

Thorsten Altenkirch:
Mathematics for Computer Scientists (G51MCS) – Autumn 2004
http://www.cs.nott.ac.uk/~txa/g51mcs/

Electronically Available Books and Lecture Notes (mainly Category Theory)
http://www.mcs.le.ac.uk/~akurz/ct.html

Online Resources for Students in Philosophy
http://people.brandeis.edu/~teuber/studres.html

George Mason University
School of Information Technology and Engineering
Department of Computer Science
CS 580 Introduction to Artificial Intelligence
http://lalab.gmu.edu/cs580-fa04/cs580-tecuci-g.htm

Ratna's Mathematics
http://ratnu.tripod.com/maths.html

The Reasoning Page
http://pegasus.cc.ucf.edu/~janzb/reasoning/

Enrico Franconi
Faculty of Computer Science
Free University of Bozen-Bolzano, Italy
http://www.inf.unibz.it/~franconi/dl/course/

LI Zheng
A Collection of Resources on Logic in Computer Science
and Theories of Programming Languages
http://www.pps.jussieu.fr/~li/g2tpl/g2tpl.html

Logic and Philosophy of Logic
http://www.epistemelinks.com/Main/Classroom.aspx?TopiCode=Logi

On-line books, lecture notes, etc
http://rsise.anu.edu.au/~jeremy/books.html

The Free Newsletter for Philosophical Logic and Its Applications

ΦNEWS is the freely distributed newsletter associated with ΦLOG and has much the same aims:

- To consolidate philosophical logic as an interdisciplinary activity
- To report on, and hopefully aid the coordination of, the research activities, conference activities and publications in philosophical logic, its applications and neighboring disciplines
- To shape and sharpen the general interest in philosophical logic and communicate important results and break-throughs in the field to a less specialized audience

ΦNEWS is edited by Vincent F. Hendricks, Stig Andur Pedersen and Dov M. Gabbay. The newsletter is published by ΦLOG and Kluwer Academic Publishers.

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ΦNEWS publishes contributions in terms of

- Extensive expositional papers
- Announcements
- New initiatives

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