The Reasoner

Volume 2, Number 8
August 2008

www.thereasoner.org
ISSN 1757-0522

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§1 Editorial

Some contradictions are true. This idea has been wandering around the logic, philosophy, and AI communities for a while now. Nonsense? Trivial? Nuts? Illuminating? Useful? If you haven't made up your mind yet, now's your chance!

The idea of having an issue on paraconsistent logic came to my mind some months ago. I was attending the conference Logique et realité in Namur (Belgium). Graham Priest gave the introductory lecture on dialetheism and the discussion that followed revealed the audience to be essentially divided in two groups: those who were trying to make sense of the idea that some contradictions are true, and those who, experienced paraconsistentists, debated about very specific points. Although vaguely familiar with the main tenets, I definitively belonged to the first group and couldn't resist asking 'live' questions to Graham about his views. What you also have to know about this conference is that another eminent paraconsistentist was around: the Ghentish Diderik Batens, also known as the father of 'adaptive logic'. A lively, entertaining, and captivating discussion took place between Graham and Diderik. I thought it was too nice a philosophical setting not to be shared with the reasoners.

I approached Graham and Diderik after the conference and arranged the deal. I would be patient until Spring (some people say that chasing latecomers is my favourite sport!) and they would prepare some Q&A focusing on agreements and disagreements between each other's positions. It took some time to get it ready, but here we go: a mutual interview between Graham and Diderik, a Key Terms entry on paraconsistent logic, and a piece on paraconsistent set theory (and, of course, much more in the features and news).

I'd also like to take up this opportunity to thank those who sent us reports on conferences and events, and to encourage those who haven't done so yet to share with *The Reasoner*'s community their ideas in the form of short pieces, letters, news. Finally, there is a last bunch of *Key Terms* entries available. Check out this page if you

wish to contribute.
Happy paraconsistent *Reasoner*!

Federica Russo
Philosophy, Louvain & Kent

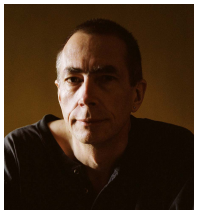
§2
Features

Graham Priest and Diderik Batens interview each other

Graham Priest is Boyce Gibson Professor of Philosophy at the University of Melbourne and Diderik Batens is Professor of Logic at the Centre for Logic and Philosophy of Science, University of Ghent. They have both produced an impressive amount of work in the area of paraconsistent logic. As their interviews show, Graham's and Diderik's disagreements on specific points or on foundational aspects become a fertile field for paraconsistency to develop further. I am very pleased to introduce Graham Priest and Diderik Batens.

Diderik Batens interviews Graham Priest

Diderik Batens: Most arguments you offered for dialetheism derive from conceptual considerations: language, arithmetic, set theory, and the like. Do you think that true contradictions are unavoidable because of properties of humans, rather than because of properties of nature in general?



Graham Priest (pictured): Any statement is part of a language; and language, with its meaning, is a human product. But statements describe reality; and, in general, if they are true, they are so in virtue of that reality as well. Hence, any truth is liable to be a product of both of these factors. Dialetheias are no different in this regard. Of course, the reality which a language describes may itself be a human product, but often it is not. Thus, natural objects, such as a planet, are not. If a natural object in motion generates dialetheias, as I hold, then the truth of these will be partly a function of a human product (language and its meanings), and partly a function of nature and its doings.

DB: Over the years, you have elaborated an impressive technical as well as philosophical underpinning for a monolithic and dialetheist conception of human knowledge. The construction will not be complete and the arguments will not be final until there is a paraconsistent set theory that allows for the formulation of a fully fledged and coherent metatheory. Are there hopes for this to be realized soon?

GP: I agree that a paraconsistent set theory, and a paraconsistent metatheory within this, are absolutely essential. Perhaps the most natural way of obtaining them is to have an axiomatic system based on the naive principles:

Comprehension $\exists x \forall y(y \in x \leftrightarrow \alpha)$ for every formula, α

Extensionality $\forall x \forall y(\forall z(z \in x \leftrightarrow z \in y) \rightarrow x = y)$

from which one can deduce, via the appropriate paraconsistent logic, standard results of set theory (including the paradoxes!) and also those of metatheory—e.g., appropriate soundness and completeness results. Such we do not have at the moment. To avoid triviality, the logic must not endorse various principles which are used in the orthodox proofs of these results (such as Contraction). The nearest we have come to this so far is in the work of my student, Zach Weber, who has shown how to prove most of the results of standard set theory without the problematic principles. A different way to go (described in detail in ch. 18 of the second edition of *In Contradiction*) is not axiomatic, but model-theoretic. The structure of the universe of sets is very rich: it contains the cumulative hierarchy as a (consistent) part, but also many other sets as well (non-well-founded, inconsistent, etc.) One can show that there are structures of this kind that are models not only of the appropriate naive set-theory but also of the theorems of Zermelo Fraenkel set theory. One may assume that the universe of sets is such a structure, in which case anything provable is ZF (including standard metatheoretic results) holds in the universe, and so is acceptable from a paraconsistent perspective too.

DB: In *Contradiction* you introduce denial as a propositional attitude. You also state that a dialetheist may commit himself to the falsehood of a statement A by stating that A *relevantly* implies everything (formally $A \rightarrow \perp$ *with* $\perp \rightarrow B$). Is there a difference between denying A and asserting $A \rightarrow \perp$?

GP: I take assertion and denial to be different speech acts. Essentially, to assert something is to show that you accept it; to deny something is to show that you reject it. The same syntactic string can be uttered with different illocutionary forces. (So an utterance of 'The door is open' could be an assertion, a question, a command.) The utterance of a string of the form $\neg A$ can be a denial of A: it often is. But sometimes it can simply be an assertion of $\neg A$. For example, if someone accepts A and $\neg A$—because they think it is a dialetheia, or for some other reason—an assertion of $\neg A$ can function in this way. If someone accepts A and $A \rightarrow \perp$ then they are committed to everything. An utterance of $A \rightarrow \perp$ will normally, therefore, function as a denial of A. But in the

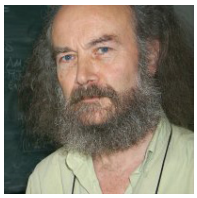
mouth of a trivialist (a person who accepts everything), it will simply be an assertion of $A \rightarrow \bot$.

DB: One of your central arguments may be paraphrased as follows. "If classical negation (or material implication) is sensible, there are true classical contradictions, and hence all statements are true. But this is not the case. So classical negation is not sensible." Suppose we restrict the formation rules of natural language: a statement is not well-formed if its well-formedness entails a classical contradiction. Why would such a restriction be less acceptable than declaring classical negation and material implication nonsensical?

GP: The grammatical (formation) rules of a natural language are what they are, and we have no control over them. We could, of course, change those rules, and so produce a new language. The test suggested will not, as it stands, deliver classical consistency. This is because A and B may each, on its own, pass the test, even though A and B together deliver classical inconsistency. But even assuming that some more holistic test could be devised, the strategy is still problematic. There would be no way to tell whether a sentence of the new language is grammatical (since there is no decision procedure for inconsistency). A language such that one cannot effectively tell whether a string is a grammatical cannot be used. And in any case, we are still faced with the problem of giving an account of the semantics of the original (our) language.

Graham Priest interviews Diderik Batens

Graham Priest: We are both known as paraconsistent logicians. I am a dialetheist (believing that some contradictions are actually true). You have always been hesitant about adopting the title, but I think that you are as much a dialetheist as I am (albeit of a somewhat different kind). Are you a dialetheist?



Diderik Batens (pictured): You described different kinds of true contradictions. In some papers, you argue that some languages, combined with a sensible understanding of truth, have true sentences of the form A-and-not-A. I cannot see how a competent person could deny this. I even argued for the following stronger position: the world may be thus that its best description in a humanly manageable language contains true contradictions.

This being said, I disagree with many of your arguments for dialetheism. You often presuppose an ontology that makes no sense to me. For example, you take the English language to form a system that is similar to a formal language.

Central to our differences is that I am a contextualist—see my answer to the next question. I am also convinced that one should try to replace inconsistent theories by consistent ones, even if this may be impossible for all of them. My reasons are that, if the replacement is possible without loss of empirical adequacy or conceptual clarity, we obtain a gain. Often, however, problems with the empirical adequacy or coherence or elegance of our knowledge may be more urgent than its consistency.

GP: I am a logical monist, and hold that there is essentially one correct deductive logic. You have always been a pluralist, holding that different logics are appropriate for different contexts. Your position could be thought of as some kind of logical instrumentalism: logics are just tools, and on any occasion one can use whichever one gives the best answer; there is no further consideration to which a logic must answer. Are you an instrumentalist?

DB: A deductive logic fixes the meaning of a fragment of a language. Languages are not God-given but are complex social constructions. We (try to) modify them in view of what we (think to) learn about the world. Such conceptual changes occur frequently in the languages of the sciences and, with some delay, in natural languages as well. Which languages are most adequate to handle certain aspects of the world cannot be settled a priori. Few will balk at this for 'referring terms' such as "phlogiston" or "mass". I claim it also holds for logical terms. The language of quantum mechanics offers a nice illustration. You yourself gave empirical arguments for dialetheism—whether I agree with them is not the point here. So my view is this: logicians develop logics just like one invents instruments, but nature (as knowable by us) determines which are the good instruments.

This qualifies your phrase "gives the best answer". Moreover, a logical instrumentalist has to *justify* that a specific language is used to tackle a specific problem. The Ghent group has contributed to the solution of this difficult but fascinating problem.

My reasons for this brand of instrumentalism derive from my view on knowledge. Now and presumably forever, our best knowledge will not form a monolithic set of statements. Our knowledge systems consist of chunks that are more or less internally coherent, but need not be and often cannot be mutually coherent. So a unique language cannot be used in all contexts, for languages involve presuppositions. A further argument regarding language derives from the way in which humans tackle problems. Let a context be a problem solving situation in the broadest sense of the term. In a context, we rely on the best relevant (unquestioned) *part of* our knowledge. The parts we rely on in different contexts need not to be coherent. In one context we may try to figure out the nature of heat. In a different context we assert statements that presuppose our present view on heat. So the meaning of the language elements varies

with the context. This is why I consider it sensible to use classical logic in one context and a paraconsistent logic in a different context. Your objections to classical logic typically presuppose a knowledge system and a language that are both universal and monolithic. For me these are just two fictions of Western philosophy.

GP: You are perhaps best known for your adaptive logics, an invention that I admire very much. Adaptive logics are just one kind of non-monotonic logic, however. Do you think that there is anything very special about adaptive logics within that general class?

DB: Many adaptive logics, including inconsistency-adaptive logics, are indeed non-monotonic, but others are monotonic. The aim of the enterprise was to characterize all forms of defeasible reasoning by an adaptive logic in standard format, which is a specific and strict structure. The standard format offers the proof theory and semantics as well as most of the metatheoretic properties, including soundness and completeness. The proof theory for defeasible logics is remarkable. It allows one to explicate human reasoning. Incidentally, defeasible logics do not concern deduction, but the formal characterization of *methods*. They are instruments according to everyone's view. And they are numerous, as desired.

Today, adaptive logics form the most elegant unifying frame that I know of (all known first order defeasible reasoning forms are characterized). If the future offers a better unifying frame, so be it.

Inconsistency deserves a separate comment. Inconsistency-adaptive logics are useful instruments for trying to restore consistency wherever possible. They locate the inconsistencies and interpret theories as consistently as possible; other adaptive logics guide one to remove inconsistencies. If one does not try to remove inconsistencies where possible, as is the case for you, one will still consider most classical reasoning as correct because *most* contradictions are false. You made this point: adaptive logics offer a way to systematically recapture most classical reasoning. So inconsistency-adaptive logics are useful instruments for everyone, from the classical logician to the hard dialetheist.

Paraconsistent set theory

The concept of a *set* is simple to state: A set is any collection of objects that is itself an object, and its identity is completely determined by its members. In first order logic this concept is captured in a pair of axioms, which look like the definitions of identity and predication, respectively:

$$x = y \leftrightarrow (\forall z)(z \in x \leftrightarrow z \in y),$$
$$\Phi(x) \leftrightarrow x \in \{z : \Phi(z)\}.$$

Frege stated the set concept in a single axiom,

$$\{z : \Phi\} = \{z : \Psi\} \leftrightarrow (\forall z)(\Phi(z) \leftrightarrow \Psi(z)).$$

Frege's axiom looks like a tautology: *The set of* Φ*s is identical to the set of* Ψ*s exactly when the* Φ*s are all and only the* Ψ*s*. That is obvious to the point of banality. Sets and concepts, or properties, or predicates-in-extension, are all much the same thing. Let us call this the *naive set concept*.

As is well known, the set concept has inconsistent consequences. The inconsistency is not an accident, nor is it unimportant. These inconsistencies—paradoxes, since they are contradictions hiding inside of a tautology—all arise from a *diagonal* construction, the most famous of which is Russell's from 1902, arising in the concept of membership itself. Where $R = \{z : z \notin z\}$,

$$R \in R \leftrightarrow R \notin R.$$

Then by the law of excluded middle,

$$R \in R \wedge R \notin R,$$

a contradiction.

Diagonals have been and continue to be a very fertile source of information. One prominent attitude takes discoveries like Russell's to show that our intuitions are "bankrupt," because contradiction is the worst thing that can happen—worse, say, than abandoning hope of a precise theory of sets. *Paraconsistency* can be taken as the doctrine that a contradiction is not the worst thing that can happen. In fact, since contradiction does seem to be the sort of thing that happens, it is rather unhelpful to panic when they do. Any logic is paraconsistent when the inference from $\Phi, \neg\Phi$ to Ψ for arbitrary Ψ, called *explosion*, is invalid. In this way, paradoxes can be accommodated. For important philosophical concepts like sets, paraconsistent reasoning should be used.

To develop a paraconsistent set theory, some otherwise familiar inferences beyond explosion are not truth preserving and so cannot be used. The disjunctive syllogism is the most famous example; contraction is another, due to Curry's paradox. Depending on choices, there are others, just because the set concept is very powerful and cannot be used without care. The hard work for the naive set theorist is to prove core theorems by purely paraconsistent arguments, which in many cases cannot follow the proofs found in standard texts.

The hard work is worthwhile, though. More than just being accommodated by a paraconsistent theory, the diagonal paradoxes that arise naturally in our naive concepts can actually be shown to be very fecund. The details will depend on exactly which paraconsistent logic is being used; there are many such logics, e.g., da Costa's $C_1^=$ or Priest's *LP*, and these have been variously

employed. Here we will assume a background *intensional* logic in the tradition of Meyer, Routley, Brady, et al, which has strong negation principles like contraposition, $(\Phi \rightarrow \Psi) \rightarrow (\neg\Psi \rightarrow \neg Phi)$, and *counterexample*, $\Phi \wedge \neg\Psi \rightarrow \neg(\Phi \rightarrow \Psi)$, and a conditional supporting modus ponens. Given such a background logic, here is an informal sketch of how diagonals can be not merely coralled off but fruitfully studied.

The axiom of extensionality tells us that sets a, b are identical when they have the same members. Similarly, it is a part of the naive concept that two sets are distinct, $a \neq b$, when they have different members. Now, the most straightforward interpretation of Russell's paradox is as proof of a pair of theorems, $R \in R$ and also $R \notin R$. Then, because R differs from itself with respect to membership,

$$R \neq R.$$

(Of course, all objects are also self-identical, so $R = R$, too.) Non-self-identical sets are a novel and important feature of a paraconsistent theory; generally, that $a \neq a$ characterizes a as a paradoxical set.

Paradoxical sets have wide mathematical consequences. Consider the notion of a *inaccessible cardinal*, a transfinite number κ such that, for example, if λ is a number and $\lambda < \kappa$ then $2^\lambda < \kappa$, for any λ at all. Such large cardinals are important for understanding models of ZF set theory, but their existence is not provable from the stripped down axioms of ZF. Not so in the naive theory. Consider the set of all the cardinals, $\{x : x \text{ is a cardinal number}\}$. From the formalized set concept, this set exists, since it is a collection of objects. With a bit of work one can show that it has a cardinal number—evidently, *a cardinal number greater than any other*, call it $\mathfrak{C}$. By the ordering on $\mathfrak{C}$, it follows that $\mathfrak{C} \neq \mathfrak{C}$. This was in fact the object Russell was studying when he discovered his more famous paradox. Once $\mathfrak{C}$ is accepted as a genuine, paradoxical set, it becomes clear that for any cardinal λ such that $\lambda < \mathfrak{C}$, also $2^\lambda < \mathfrak{C}$. Therefore there are inaccessible cardinals. This technique provides ample fuel to prove many other theorems about the higher infinite.

Keeping the set concept, since it is a very clear and fertile, and I would say inalienable, notion, is a good thing to do. The arguments sketched above are only a beginning; the nuts-and-bolts of practicing set theory in weak logics is not easy, and the best days of such a set theory still lie ahead. But they are to be eagerly anticipated. There are very few certain, meaningful truths to be had in this world. It is only a good, decent respect for truth that we adapt our reasoning accordingly to do it justice.

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Philosophy, Melbourne

In a few words

Laureano Luna ('In at most one thousand words', *The Reasoner* 2(7)) considers the problem with Berry's Paradox in the form 'the least natural number not definable in English in at most one thousand words'. If this phrase has a referent, then, despite the description in the phrase, the referent would seem to be defined in less than a thousand words, which is paradoxical. But a first thought is maybe that what is definable in English is not clear cut. Luna shows, however, that the problem is independent of any fuzzyness there might be in English. For he constructs a language ΔL that cannot be fuzzy, and then demonstrates that a parallel referential paradox arises with 'the least natural number not ΔL-definable in at most one thousand words'. He draws the conclusion from this that there is no set of all ΔL-definitions of natural numbers in at most one thousand words, which he amplifies through a consideration of Shapiro and Wright's notion of 'indefinite extensibility'. Specifically he shows that 'ΔL-definition of a natural number in at most one thousand words' is extensible relative to the concept 'set ΔL-definable in at most n words', for the largest n small enough to render a ΔL-definition of the least natural number not in the set that is possible in at most one thousand words. He ends by saying "Since no set contains all ΔL-definitions of natural numbers in at most one thousand words, the signifier 'the least natural number defined by no ΔL-definition in at most one thousand words' defines variously along the hierarchy of extensions because the domain of its quantifier 'no' gets ever broader."

But there is a firmer result, obtainable immediately by logic, and independent of the notion of an indefinitely extensible concept. For if, say, 'the least number not definable in the present language in less than one thousand words' can have a variety of referents then the set of those numbers referrable to in the language in question, in less than one thousand words, likewise is variable. So there is no one such set, and therefore no one number that is the least number not in it. In different models, interpretations, or uses of the language there might be a determinate set, and so a determinate least number not in it, *in that model, interpretation or use*, but there can be no one set in general, without some such specification. So the given phrase has to be non-attributive, which is to say that, if the phrase is applied to something, that thing does not fit, exactly, the description in the phrase.

But the length of the phrase shows that, in its application, it *must* be non-attributive. So we can reverse the last piece of reasoning, and immediately obtain the result that the phrase must have a variable referent, since non-attributive phrases must necessarily be given a semantically arbitrary (and so merely pragmatically provided) referent. The point holds also with regard to

the related paradox discovered by Keith Simmons, see Slater B.H. (2005: 'Choice and Logic' *Journal of Philosophical Logic* 34, 207-216).

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Attributing knowledge of the virtues of contextualism

Contextualism in epistemology claims two virtues: first, that it can explain the power of sceptical scenarios—such as the possibility that one is a brain-in-a-vat (BIV) with identical experiences to those in real life—to challenge knowledge claims; second, that despite the power of such sceptical scenarios, it can show why we do, in fact, know many things—such as that one has hands. The basic contextualist strategy is to show that there are (at least) two standards for knowledge: low (i.e., ordinary or non-sceptical) and high (i.e., sceptical) standards. A shift in the standards for knowledge occurs when sceptical possibilities are raised by an interlocutor, thus creating a high-standards epistemic context in which participants don't possess knowledge. Anthony Brueckner (2004: 'The Elusive Virtues of Contextualism', *Philosophical Studies*, 118, 401-405) aims to show that he cannot truthfully claim to know the virtues of contextualism, because the epistemic context in which he tries to state the virtues will have high standards established by the raising of sceptical possibilities necessary to explain contextualism. Thus, Brueckner constantly finds himself in a sceptical context which precludes him from knowing anything, including the virtues of contextualism. This implies that no one can know the virtues of contextualism.

Perhaps the virtues of contextualism are elusive to a solo epistemologist, as in Brueckner's situation. However, I will argue that there are possible conditions under which a friend—a possible attributer, to Brueckner, of knowledge—can truthfully attribute knowledge of the virtues of contextualism to Brueckner. According to contextualism, psychological features of the attributer determine the epistemic context for the truth-conditions of knowledge sentences. So, if the attributer is kept in a low-standards context, then the attributer can truthfully attribute knowledge of the virtues of contextualism to Brueckner. But how can the friend remain in a low-standards context if Brueckner must cite sceptical scenarios in explaining the virtues of contextualism?

I propose that the friend may be kept in a low-standards context provided two conditions are satisfied: (a) Brueckner does not raise specific sceptical possibilities, since this would cause his friend to consider those possibilities, thus shifting the epistemic context from low to high standards; and (b) the friend does not presuppose specific sceptical possibilities, which would activate high standards for knowledge, thus falsifying her judgment about Brueckner's epistemic state. How does this work? The framework for both conditions, I claim, is found in the contextualism of David Lewis (1996: 'Elusive Knowledge', *The Australian Journal of Philosophy*, 74, 549-567).

Concerning condition (a), I first invoke the Rule of Attention (Lewis 1996: 559): for any given possibility, "if in this context we are not properly ignoring it but attending to it, then for us now it is a relevant alternative," i.e., a possibility requiring ruling out in order to attain knowledge. No matter how far-fetched the possibility seems, if in this context we attend to it by raising the possibility, then it is relevant to the standards for knowledge within that context. But, what counts as a possibility? Lewis (1996: 552) says a possibility, P, needs to be specific enough such that anything we could say about P will apply to all sub-cases of P. Thus, if P has sub-cases such that what we say about P does not apply to the sub-cases of P, then P is not specific enough to count as an actual possibility. This implies that if Brueckner carefully suggests a general sceptical point-of-view or attitude, without invoking specific sceptical possibilities such as the BIV, evil demon, or dreaming scenarios, then he will not cause his friend to attend to those possibilities. In order to do this while expositing the virtues of contextualism, Brueckner might say, for example, 'according to the sceptic we might be mistaken about all we know', instead of raising specific possibilities. Thereby, the specter of scepticism is presented and subsumes several sub-cases without raising, and thus causing the friend to attend to, those sceptical sub-cases or possibilities. Thus, the friend would properly ignore those possibilities.

However, supposing momentarily that Brueckner needs to raise specific sceptical possibilities to exposit contextualism, I suggest that he could issue anti-sceptical prefatory comments in order to diminish the impact of scepticism on the epistemic context, to the effect that his friend needn't really attend to specific sceptical possibilities. By 'not really attend to' I mean that although the friend becomes aware of a possibility, she does not take it seriously so that it does not affect her reasoning about Brueckner's epistemic status. So, for example, Brueckner might say to his friend, 'I'm about to discuss the BIV scenario, but we should not take it seriously—it's just for the sake of explaining contextualism'. Then, the friend avoids attending to the sceptical possibility with serious intent, yet enough is said to explain the power of sceptical scenarios, and thus exposit the virtues of contextualism.

Concerning condition (b), according to the Rule of Conservatism (Lewis 1996: 559) if those around us "normally do ignore certain possibilities, and it is common knowledge that they do," we too can (defeasibly)

ignore those possibilities. For example, in some contexts of inquiry physicists ignore the possibility of friction in carrying out experiments. We can imagine that Brueckner's friend hails from a context of inquiry in which sceptical possibilities are consistently ignored. Thus, we can say that the friend starts off in a context of inquiry in which she does not presuppose sceptical possibilities.

Thus, if Brueckner's friend doesn't presuppose any specific sceptical scenarios—condition (b)—and she doesn't attend to any in virtue of what Brueckner says—condition (a)—then the friend will remain in a low-standards context. She can thereby truthfully judge that Brueckner knows the virtues of contextualism. In other words, although by himself Brueckner cannot know the virtues of contextualism, if he speaks generally enough and has the right kind of friend, that friend can truthfully attribute knowledge of the virtues of contextualism to Brueckner.

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§3 News

NA-CAP: The Limits of Computation, 10–12 July

Presentations at this year's North American-Computing and Philosophy explored various readings of the deliberately ambiguous conference theme, the limits of computation. Held at Indiana University-Bloomington, the conference brought together interdisciplinary and international research on:

- Theoretical and practical limitations on computability with respect to Turing Machine computability and complexity constraints;
- Theoretical and imposed limitations on robot agency, autonomy, and responsibility; and,
- The feasibility of providing computational accounts of special or uniquely human cognitive capacities, including human creativity.

IACAP President and recently elected Gauss Professor Luciano Floridi (Hertfordshire and Oxford) opened the conference on a much broader theme by arguing that we are in the midst of an information revolution. Discovering the fundamentally informational nature of the universe such that matter itself is just another kind of interface, we learn that we are informational organisms, or inforgs, inhabiting the infosphere.

Giving the Douglas C. Engelbart keynote address, Ronald Arkin (Georgia Tech) made the case that the behavior of live-fire autonomous battlefield robots can and ought morally be limited by the reasonably well-defined rules of warfare and more specific rules of engagement. Arkin closed his provocative talk by outlining current research intended to achieve this end which introduces the notion of an ethical governor in robot control. Throughout the talk, Arkin stressed the importance of maintaining clear lines of responsibility to human agents in light of the strong motivation for deploying live-fire autonomous robots.

Paul Thagard (Waterloo) argued during his Herbert A. Simon keynote address that, suitably cast in terms of changes wrought by manipulation, computers can understand causality. Since the title of Thagard's talk, "Can Computers Understand Causality?", invites such responses as "how could they since humans don't?" and "how could they since they don't understand anything, full-stop?", the discussion following the talk was predictably vigorous. NA-CAP President Selmer Bringsjord (Rensselaer Polytechnic) and James Fetzer (Minnesota-Duluth) responded that the epistemic notion of causality in terms of manipulability is a poor substitute for the difficult metaphysical debates over regularist and necessitarian conceptions of causation.

During a special session on Automatic Programming and Human Creativity, Bringsjord argued that the problem of writing programs that write programs is hard, much harder than the halting problem, which helps explain why there has been so little progress in the field over the last thirty years. Martin Frick (Arizona) suggested in discussion that interpreters, compilers, and Mathematica are programs that write programs according to high-level specification and, despite the difficulty of the problem, succeed admirably.

Other conference highlights included Anthony Chemero (Franklin and Marshall) and Michael Turvey's (Connecticut and Haskins Lab) use of hyperset theory to argue against Robert Rosen's claim that living (metabolism-repair) systems are not computable; Drew McDermott's (Yale) argument that special features of ethical reasoning make it an extremely difficult, if not intractable, problem for implementation in machine ethics; Darren Abramson's (Dalhousie) intriguing use of computational functionalism in an argument for phenomenal externalism; Fetzer's argument that digital computers, insofar as they cannot use signs, are fundamentally algorithmic, and can at most simulate affective states, cannot have thoughts; Matteo Turilli's (Oxford) approach to embedding ethics in the design of software for autonomous machines; and Chih-Chun Chen's (University College London) Goldberg Award winning presentation on agent-based simulations of emergent phenomena. Conferees universally applauded host Colin Allen (Indiana) and chair Anthony Beavers'

(Evansville) outstanding efforts to ensure high-quality, engaging presentations for lively discussion. Please see http://www.ia-cap.org/na-cap08/ for additional details about the conference.

Don Berkich
Philosophy, Texas A&M University-Corpus Christi

Fourth World Congress on Paraconsistency, 13–18 July

This Melbourne congress opened with a talk by Mark Colyvan, who argued that, far from being an isolated phenomenon, inconsistency is widespread in science. Thus, in addition to inconsistent foundational constructions such as set theory and basic calculus, the use of idealisations abounds in highly successful areas like fluid mechanics and celestial mechanics, and idealisations are typically inconsistent. One might hope in the fullness of time to resolve these consistently, but for practical use, their inconsistency must be recognised and contained.

The theme of consistentisation covered many different approaches. Thus Bryson Brown and Graham Priest developed their methodology of 'Chunk and Permeate'. Essentially this cuts the premises up into separate consistent chunks, and lets limited consequences pass between the chunks. In an earlier paper they had applied it to the use of infinitesimals in calculations of the derivative of a function, such as Newton did. Here they applied it to the old quantum theory (Bohr's theory of the atom). This is an improvement, it seems to this writer, since it applies to empirical argument which can be backed up by abductive appeal to the best explanation. Another methodology to exploit reasoning with consistent subsets is forcing, associated with Canadian logicians, including Jennings and Schotch. Yet another variant is Rescher-Manor reasoning with maximal consistent subsets. Yet another is the approach of adaptive logic, associated with Batens and his Belgian collaborators, who formed one of the largest national groups present. Here the idea is that inconsistency is presupposed false and only consistent conclusions are deduced *pro tem*. In the opinion of this (opinionated) writer, consistentising strategies are useful for the context of discovery, but fail to do justice to *a priori* reasoning from inconsistent premises, where one should be acknowledging the full role of all the premises without dodging the inconsistencies in them.

Another theme in the above is infinitesimals, which is a significant application of inconsistency to mathematics.The problem for inconsistent theories of infinitesimals, indeed inconsistent theories of hyperreal numbers (including reals), is that by well-known arguments it can be shown without appeal to *ex contradictione quodlibet* (ECQ) that every hyperreal number equals every other hyperreal number. Too many paraconsistentists have failed to see that contradictions can be spread by other means than ECQ; so that giving up ECQ is necessary, but hardly sufficient, for containing contradictions. Several speakers (Coniglio, Carnielli, Mortensen, Sweeney) addressed the issue of inconsistent infinitesimals. Inconsistent mathematics came up in other ways, too, for example in a formal explication of the informal Gödel paradox by Berto. This paradox derives a contradiction from the informal Gödel sentence (G) "This sentence is unprovable" in the metalanguage of mathematics: either G is unprovable or it is provable. Either way it is true, so we have proved it true, but if it is true then it is unprovable. This writer believes that this paradox should be taken very seriously as a particularly good example of a dialethia. One more novelty was the construction of impossible images, which several authors addressed, and which enrich the corpus of examples which incline toward inconsistent interpretations of data.

It is impossible to do more than skim the surface of the rich variety of offerings at the conference. The descriptions above doubtless distort the positions they attempt to survey. The epistemological/informational approach to inconsistency was much in evidence, as was the ontological/dialethic approach. In mentioning national groupings above, it should not be thought that paraconsistent research takes place in a misplaced attitude of nationalism: interest was shown on all sides for all points of view. A notable feature of the conference was also the large number of young logicians, graduate students and even undergraduates. The fourth world congress on paraconsistency demonstrated with a vengeance that the paraconsistency program, after many decades, continues to be highly progressive.

Chris Mortensen
Philosophy, The University of Adelaide

Formal Epistemology Research Group at the University of Konstanz, Germany

The Emmy Noether junior research group *Formal Epistemology*, took up our work in January 2008. The members are Franz Huber (director), Peter Brössel (Doctoral Research Fellow), and Alexandra Zinke (Graduate Research Fellow). Additionally, Anna-Maria Eder (Catholic University of Leuven, Belgium) takes part as a Visiting Research Fellow.

We deal with philosophical questions in theoretical philosophy by applying formal tools. Our project consists of the following sub-projects:

Knowledge and Justification The classic conception of knowledge as justified true belief is accompa-

nied by the following problems: (i) we have to specify under what conditions an agent is justified in believing a proposition, and (ii) we have to give an answer to the question why knowledge is more valuable than mere true belief.

Gettier's refutation of the tripartite conception of knowledge suggests that it be supplemented by a fourth condition. In this case we also have to answer the question why knowledge is more valuable than justified true belief that falls short of knowledge.

The sub-project 'Knowledge and Justification' deals with the mentioned three problems of the theory of knowledge.

Belief and Its Revision The traditional epistemology of belief takes belief to be a yes-or-no affair. A person's beliefs simply correspond to a set of propositions. What does this set look like if we revise it by new information in form of a proposition? If the new information is compatible with the totality of the old beliefs, we might simply add it. If it is incompatible, the question arises how to consistently combine the old and new beliefs. This question is addressed by AGM belief revision theory (Alchourrón, Gärdenfors, Makinson 1985: 'On the Logic of Theory Change: Partial Meet Contraction and Revision Functions', *Journal of Symbolic Logic*, 50: 510-530; Rott 2001: *Change, Choice, and Inference: A Study of Belief Revision and Nonmonotonic Reasoning*, Oxford: Clarendon Press). The basic idea is that the new belief set should contain the new information and as many of the old beliefs as is allowed for by the requirement that the new belief set be consistent.

The project 'Belief and Its Revision' deals with the problem whether it is degrees of belief or categorical beliefs that drive belief revision. A further goal is to get rid of the idealizing assumption that we revise our belief system only if there is a logical contradiction between our old beliefs and the new information.

Degrees of Belief and Belief The Lockean thesis says that to categorically believe is to believe to a sufficiently high degree. Hardly any formal theory of degrees of belief provides a reasonable account of categorical belief satisfying the Lockean thesis. Spohn's (1988: 'Ordinal Conditional Functions: A Dynamic Theory of Epistemic States', in Harper & Skyrms (eds.), *Causation in Decision, Belief Change, and Statistics II*, Dordrecht: Kluwer, 105-134) ranking theory is an exception. However, ranking theory induces a structure on our beliefs that is too coarse-grained for decision making, which is one of the central fields of application for theories of degrees of belief.

The major task of the sub-project 'Degrees of Belief and Belief' is to investigate the relation between degrees of belief and categorical belief and to formulate a unifying model that connects both concepts in a natural way satisfying the Lockean thesis.

Theories of Degrees of Belief Which theory is the best theory of degrees of belief? The plausibility-informativeness theory of theory evaluation (Huber 2008: 'Assessing Theories, Bayes Style', *Synthese*, 161: 89-118) tells us that a theory should maximize plausibility and informativeness.

Some theories of degrees of belief are special cases of others. Probability functions can be considered instances of Dempster-Shafer belief functions and of interval-valued probability functions. Pointwise ranking functions on the natural numbers are a special case of general belief measures (Weydert 1994: 'General Belief Measures', in Lopez de Mantaras & Poole (eds.), *Proceedings of Uncertainty in Artificial Intelligence* 1994, San Mateo, CA: Morgan Kaufmann, 575-582) as well as of ranking functions in the sense of Huber (2006: 'Ranking Functions and Rankings on Languages', *Artificial Intelligence* 170: 462-471). Dempster-Shafer belief functions and interval-valued probability functions can be considered as special convex sets of probability functions. Hence comparisons between these theories are similar to comparisons between logically stronger, more informative and logically weaker, more plausible theories.

The aim of the sub-project 'Theories of Degrees of Belief' is to answer the question which of the above theories achieves the best trade-off between plausibility and informativeness.

Degrees of Belief and Justification There are several competing theories of degrees of belief. The traditional arguments for the probabilistic model are the Dutch Book Argument, Cox's theorem (Cox 1946: 'Probability, Frequency, and Reasonable Expectation', *American Journal of Physics* 14: 1-13), and the representation theorems of measurement theory. None of these is wholly convincing. Against this background Joyce's (1998: A Non-Pragmatic Vindication of Probabilism, *Philosophy of Science* 65: 575-603) attempt to justify the theory of subjective probabilities in purely epistemic terms is extremely important. Given some assumptions on how to measure the inaccuracy of degrees of belief, Joyce shows that an agent's degrees of belief avoid unnecessary inaccuracy just in case they satisfy the probability calculus.

Huber (2007: 'The Consistency Argument for Ranking Functions', *Studia Logica* 86: 299-329) gives an argument for the thesis that degrees of belief should obey ranking theory. If and only if they do so, the resulting set of categorically believed propositions is and will always be consistent and deductively closed.

The main purpose of the sub-project 'Degrees of Belief and Justification' is to pursue various justifications of theories of degrees of belief.

Degrees of Rational Acceptability To accept or reject a scientific theory is to make a decision. Traditionally, a decision is rational if and only if it maximizes

expected utility. According to Hempel, Hintikka, and Levi the utility of a theory is determined by its informativeness. The difficult question is how to measure the informativeness of a theory. Furthermore, it is not clear whether further values—such as simplicity, coherence, unification, and explanatory power—contribute to the utility of a theory. The question arises whether some of them can or should be reduced to others or whether some further others. Another question is whether the utility of a theory can—at least partly—be evaluated independently of the evidence.

The sub-project 'Degrees of Rational Acceptability' aims to offer a quantitative Bayesian account of the rational acceptability of scientific theories answering the above mentioned questions.

More information at: www.uni-konstanz.de/philosophie/fe.

Peter Brössel, Anna-Maria Eder, Franz Huber, Alexandra Zinke
Formal Epistemology Research Group, Konstanz

Professor Douglas Walton, Distinguished Research Fellow

The Centre for Research in Reasoning, Argumentation and Rhetoric (CRRAR) at the University of Windsor is pleased to announce the appointment, of Professor Douglas Walton as Distinguished Research Fellow, taking effect 1 August 2008. Dr. Walton also becomes Assumption University Chair in Argumentation Studies, and Adjunct Professor of Philosophy at the University of Windsor.

J. Anthony Blair
Centre for Reasoning, Argumentation and Rhetoric (CRRAR) & Philosophy, Windsor (Canada)

Calls for Papers

Probabilistic Graphical Models in Computer Vision: Special issue of IEEE Transactions on Pattern Analysis and Machine Intelligence, deadline 16 August.

Conditionals and Ranking Functions: Special issue of Erkenntnis, franz.huber@uni-konstanz.de, deadline 31 August.

Psychology and Experimental Philosophy: Special issue of the European Review of Philosophy, deadline 1 September.

Dependence Issues in Knowledge-Based Systems: Special Issue of International Journal of Approximate Reasoning, deadline 15 September.

Sir Karl Popper Essay Prize: British Society for the Philosophy of Science, deadline 31 December.

§4 Introducing ...

In this section we introduce a selection of key terms, texts and authors connected with reasoning. Entries will be collected in a volume *Key Terms in Logic*, to be published by Continuum. If you would like to contribute, please click here for more information. If you have feedback concerning any of the items printed here, please email thereasoner@kent.ac.uk with your comments.

Argument

An argument is a connected series of propositions, of which exactly one is the conclusion and the rest are premises, or steps on the way from premises to the conclusion. There are two major categories of arguments. In deductive arguments, the premises are intended to force the truth of the conclusion. In inductive arguments, the premises are intended to raise the likelihood, or probability, of the conclusion. In evaluating arguments, we may examine both the truth of the premises and (this is the focus of logicians) the ways in which the premises work together to establish the truth (or likelihood) of the conclusion.

Andrew P. Mills
Otterbein College

Paraconsistent logic

In classical logic, every sentence is entailed by a contradiction: 'ϕ' and '$\neg\phi$' together entail 'ψ', for any sentences 'ϕ' and 'ψ' whatsoever. This principle is often known as 'ex contradictione sequitur quodlibet' (from a contradiction, everything follows), or the principle of explosion. In paraconsistent logic, by contrast, this principle does not hold (and so paraconsistent logics are contradiction tolerant). Although there are different approaches to paraconsistent logic, one of the most popular makes use of a valuation *relation* V between sentences and truth-values, rather than the usual valuation *function*. V can relate each sentence to either **true**, or to **false**, or to both (an alternative is to introduce a third truth-value, **both true and false**). V evaluates logically complex sentences as follows:

$$
\begin{array}{lll}
V(\neg\phi, \textbf{true}) & \text{iff} & V(\phi, \textbf{false}) \\
V(\neg\phi, \textbf{false}) & \text{iff} & V(\phi, \textbf{true}) \\
V(\phi \wedge \psi, \textbf{true}) & \text{iff} & V(\phi, \textbf{true}) \text{ and } V(\psi, \textbf{true}) \\
V(\phi \wedge \psi, \textbf{false}) & \text{iff} & V(\phi, \textbf{false}) \text{ or } V(\psi, \textbf{false})
\end{array}
$$

and so on for the other connectives. This approach gives Asenjo's Logic of Paradox, **LP**. Surprisingly, the validi-

ties of **LP** (true under every such V) are exactly the classical tautologies. But modus ponens is not valid in **LP**, for both 'ϕ' and '$\phi \rightarrow \psi$' can be true whilst 'ψ' is not true.

There are both practical and philosophical motivations for paraconsistent logic. A practical application is reasoning with inconsistent information, e.g., automated reasoning in large databases. Using paraconsistent logic does not force one to admit that contradictions could be true, but only that we sometimes need to draw sensible conclusions from inconsistent data. Some philosophers, including Richard Sylvan and Graham Priest, believe that there are true contradictions and so are known as 'dialethists'. They cite the liar sentence, 'this sentence is not true' which, if true, is false and, if false, is true and so looks to be a true contradiction. As dialethists do not want to say that a true contradiction entails everything, they adopt a paraconsistent logic.

Mark Jago
Philosophy, Nottingham & Macquarie

§5 Events

August

Language, Communication and Cognition: University of Brighton, 4–7 August.

ESSLLI: European Summer School in Logic, Language and Information, Freie und Hansestadt Hamburg, Germany, 5–15 August.

BLAST: Boolean Algebra, Lattice Theory, Algebra, Set Theory and Topology, Denver, 6–10 August.

IJCAR: The 4th International Joint Conference on Automated Reasoning, Sydney, 10–15 August.

DEMA: Designed Experiments: Recent Advances in Methods and Applications, Isaac Newton Institute, Cambridge, 11–15 August.

ICT: The Sixth International Conference on Thinking, San Servolo, Venice, 21–23 August.

MMIS: The 2nd KDD workshop on on Mining Multiple Information Sources, 24 August.

Compstat: International Conference on Computational Statistics, Porto, Portugal, 24–29 August.

FSKD: The 5th International Conference on Fuzzy Systems and Knowledge Discovery, Jinan, China, 25–27 August.

LSFA: Third Workshop on Logical and Semantic Frameworks, with Applications, Salvador, Bahia, Brazil, 26 August.

Logical Pluralism: University of Tartu, Estonia, 27–31 August.

Normativity: Graduate Philosophy Conference on Normativity, Amsterdam, 29–30 August.

September

IVA: The Eighth International Conference on Intelligent Virtual Agents, Tokyo, 1–3 September.

Grandeur of Reason: Rome, 1–4 September.

ECCBR: 9th European Conference on Case-Based Reasoning, Trier Germany, 1–4 September.

10th Asian Logic Conference: Kobe University, Japan, 1–6 September.

COMSOC: 2nd International Workshop on Computational Social Choice, Liverpool, 3–5 September.

KES: 12th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems, Zagreb, 3–5 September.

Phlox Workshop: Launch workshop on current issues in metaphysics and the philosophy of language, 3–5 September.

ICANN: 18th International Conference on Artificial Neural Networks, Prague, 3–6 September.

BLC: British Logic Colloquium, Nottingham, 4–6 September.

Naturalism: Kazimierz Naturalism Workshop, Kazimierz Dolny, Poland, 6–10 September.

SMPS: Soft Methods for Probability and Statistics, 4th International Conference, Toulouse, 8–10 September.

AiML: Advances in Modal Logic, LORIA, Nancy, France, 9–12 September.

Causality and Probability in the Sciences
University of Kent, Canterbury UK, 10–12 September

Colloquium Logicum: The biennial meeting of the German Society for Mathematical Logic, Technische Universitaet Darmstadt, 10–12 September.

Logic of Change, Change of Logic: Prague, 10–14 September.

MAS&BIO: MultiAgent Systems & Bioinformatics 2008, Cagliari, Italy, 13 September.

NMR: Twelfth International Workshop on Non-Monotonic Reasoning, Special Session on Foundations of NMR and Uncertainty, Sydney, 13–15 September.

ICAPS: International Conference on Automated Planning and Scheduling, Sydney, 14–18 September.

ECML PKDD: The European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases, Antwerp, Belgium, 15–19 September.

Spatial Cognition: Schloss Reinach, Freiburg, 15–19 September.

CSL: 17th Annual Conference of the European Association for Computer Science Logic, Bertinoro, Italy, 15–20 September.

PGM: The fourth European Workshop on Probabilistic Graphical Models, Aalborg, Denmark, 16–19 September.

KRAMAS: Workshop on Knowledge Representation for Agents and Multi-Agent Systems, Sydney, 16–19 September.

HAIS: 3rd International Workshop on Hybrid Artificial Intelligence Systems, Burgos, Spain, 24–26 September.

Ontology, mind and language: VIII SIFA National conference, Bergamo, Italy, 25–27 September.

CLIMA-IX: 9th International Workshop on Computational Logic in Multi-Agent Systems, Dresden, Germany, 29–30 September.

October

SUM: Second International Conference on Scalable Uncertainty Management, Naples, 1–3 October.

SETN: 5th Hellenic Conference on Artificial Intelligence, Syros, Greece, 2–4 October.

Reason, Activism, and Change: University of Windsor, 3–5 October.

Formal Modeling in Social Epistemology: Tilburg Center for Logic and Philosophy of Science, 9–10 October.

ICAI: The 1st International Conference on Advanced Intelligence, Beijing, 19–22 October.

FotFS VII: Bringing together Philosophy and Sociology of Science, Foundations of the Formal Sciences VII, Vrije Universiteit Brussel, 21–24 October.

MICAI: 7th Mexican International Conference on Artificial Intelligence, Mexico City, 27–31 October.

MDAI: Modeling Decisions for Artificial Intelligence, Barcelona, 30–31 October.

November

Automated Scientific Discovery: AAAI Fall Symposium, Arlington, Virginia, 7–9 November.

WPE: Workshop on Philosophy and Engineering, The Royal Academy of Engineering, Carlton House Terrace, London, 10–12 November.

Propositions: Ontology, Semantics, and Pragmatics: Venice, Italy, 17–19 November.

Game Theory: 5th Pan-Pacific Conference in Game Theory, Auckland, 19–21 November.

December

Inference, Consequence, and Meaning: Sofia, 3–4 December.

ICLP: 24th International Conference on Logic Programming, Udine, Italy, 9–13 December.

CIMCA: International Conference on Computational Intelligence for Modelling, Control and Automation, Vienna, Austria, 10–12 December.

Trends in Logic VI: Logic and the foundations of physics: space, time and quanta, Brussels, Belgium, 11–12 December.

ICDM: 8th IEEE International Conference on Data Mining, Pisa, 15–19 December.

PRICAI: Tenth Pacific Rim International Conference on Artificial Intelligence, Hanoi, Vietnam, 15–19 December.

January 2009

SODA: ACM-SIAM Symposium on Discrete Algorithms, New York Marriott Downtown, 4–6 January.

Biomolecular Networks: from analysis to synthesis, Pacific Symposium on Biocomputing, Fairmont Orchid, The Big Island of Hawaii, 5–9 January.

3rd Indian Conference on Logic and its Application: The Institute of Mathematical Sciences, Chennai, India, 7–11 January.

February

ACM International Conference on Intelligent User Interfaces: Sanibel Island, Florida, USA, 8–11 February.

March

Models and Simulations 3: Charlottesville, Virginia, 3–5 March.

April

EuroGP: 12th European Conference on Genetic Programming, Tübingen, Germany, 15–17 April.

May

The XIXth edition of the Inter-University Workshop on Philosophy and Cognitive Science: Zaragoza, Spain, 18–19 May.

June

Argument Cultures: Ontario Society for the Study of Argumentation, Windsor, Canada, 3–6 June.

§6
Jobs

Newton International Fellowships: Fellowships will be run by the British Academy, the Royal Academy of Engineering and the Royal Society to cover natural and

social sciences, engineering and the humanities, deadline 4 August.

2 Postdocs: Evolution, Co-operation and Rationality, Department of Philosophy, University of Bristol, deadline 4 August.

Post-doc Position: Bayesian Minimum Message Length (MML) and/or Kolmogorov complexity, deadline 5 August.

Lecturer in Computer Science: University of Nottingham, deadline 15 August.

Residential Fellowships in Naturalism: Center for Inquiry, Amherst NY, 15 August.

Post-doc position: Computational social choice, Institute for Logic, Language and Computation (ILLC), University of Amsterdam, late August.

Junior Teaching Position: Department of Logic, History and Philosophy of Science at UNED (Madrid), August.

§7
Courses and Studentships

Courses

MSc in Mathematical Logic and the Theory of Computation: Mathematics, University of Manchester.

MA in Reasoning

An interdisciplinary programme at the University of Kent, Canterbury, UK. Core modules on logical, causal, probabilistic, scientific and mathematical reasoning and further modules from Philosophy, Psychology, Computing, Statistics and Law.

MSc in Cognitive & Decision Sciences: Psychology, University College London.

ESSLLI: European Summer School in Logic, Language and Information, Hamburg, 4–15 August.

Mathematics, Algorithms, and Proofs: Summer School, Abdus Salam International Centre for Theoretical Physics, Trieste, 11–29 August.

Causality Study Fortnight

University of Kent, Canterbury UK, 8–19 September

Mind as Machine: Department for Continuing Education, University of Oxford, 1–2 November.

Summer Institute on Argumentation: University of Windsor, Canada, contact H.V. Hansen or C.W. Tindale, 25 May – 6 June, 2009.

Studentships

37 interdisciplinary PhD positions: Neuroengineering, Navigation and Robotics and Computing in Structural and Cell Biology Supervision, Graduate School, University of Lübeck (Germany), deadline August.

Graduate Study Opportunities: Sydney Centre for the Foundations of Science, deadline August.

PhD Studentship: AHRC-funded Research Project 'Evolution, Co-operation and Rationality', Department of Philosophy, University of Bristol, deadline August.

PhD Position: Formal Epistemology Research Group, University of Konstanz, deadline 30 September.