Introduction

The essays gathered in this volume explore philosophical issues in logic, probability theory and the natural sciences. Though the volume explores diverse problems in several different fields of inquiry, a common thread running through the essays is that philosophical insight is brought about through the application of rigorous analytical methods to problems of interest. The essays printed here belong firmly in the broad tradition of analytic philosophy. The conceptual virtues they celebrate are exactitude and clarity.

The volume grew out of papers that were presented at the annual meeting of the Society for Exact Philosophy, held at East Tennessee State University in October 1996. The editors have also included three essays that were not presented at the conference, but which are embedded firmly in the tradition of exact philosophy. Our volume should not be viewed merely as the proceedings of a conference. The authors of the essays were given time to revise their papers in the light of discussions and analyzes of their work at the conference. These revised essays were then sent to commentators, whose comments are also published here, along with replies and reactions from authors of the essays.

The first two essays concern probabilistic logic and semantics. In *Canonical Models and Probabilistic Semantics*, Charles Morgan develops the concept of canonical probability distributions in probabilistic semantics by analogy with the concept of canonical models in modal logics. Morgan aims to prove that for (almost) every extension of classical sentence logic there is a characteristic probabilistic semantics with canonical probability distributions. In the course of his proof, Morgan challenges the usual assumption that probability functions are *a priori*, one-place functions. It is Morgan's contention that even in simple probabilistic contexts, background assumptions (concerning, for example, shapes of dice, colors of balls in an urn, and so on) play a fundamental role. To accommodate this feature of these examples, Morgan treats probability functions as two-place functions. As Morgan notes in his conclusion, his approach applies to a very general class of logics and he speculates that his characterization of default maximally consistent extensions may prove of value in the treatment of counterfactuals and general default logics.

In *A Many-Valued Probabilistic Conditional Logic*, François Lepage discusses some issues arising out of David Lewis' famous paper, "Probability of Conditionals and Conditional Probabilities." To evade some unintuitive consequences of Stalnaker's treatment of counterfactual conditionals, Lewis offered his System of Spheres Semantics (*SOS*). Here,

possible worlds are not linearly ordered, but weakly ordered, so many possible worlds may be the same distance from a given world. As Lepage puts it, "The best image is of embedded spheres of possible worlds centered on the world of evaluation. All worlds of a given layer are equidistant from the world of evaluation" (p. 37). But the imaging constraint, according to which, "the probability of any proposition A is the sum of the probability of the A-worlds" (p. 37), is not compatible with Lewis's SOS semantics.

Lepage explores the possibility that imaging can be introduced into SOS by changing the requirements on the truth conditions for conditional statements. Lepage considers the possibility that under certain circumstances conditionals can take fractional truth values. In the course of his essay, he goes on to present a non-extensional logic of conditionals in which (a) all instances of tautologies are valid, and (b) if all the sub-expressions of a proposition have classical truth values, then the proposition also has a classical truth value.

The next group of three essays are broadly concerned with issues arising out of decision theory, and Bayesian approaches to epistemology. In *The Exchange Paradox, Finite Additivity, and the Principle of Dominance*, Piers Rawling analyzes the exchange paradox, otherwise known as the two envelopes problem. The problem may be stated as follows: Ten dollars have been placed in an envelope, O, and a fair coin has been tossed. If it came up heads, twenty dollars was placed in a second envelope, T. If it came up tails then five dollars was placed in T. You are given one of the envelopes, and you are given the opportunity to trade the envelope you have for the other one. The puzzle is that the expected actuarial value of T is 1.25 times that of O. But the expected actuarial value of O is also 1.25 times that of T. Trading T for O is advantageous, as is trading O for T.

Rawling reviews previous results in the literature, providing some simpler demonstrations. It is Rawling's contention that the reasoning in the traditional version of the exchange paradox is fallacious. However, he proceeds to argue that there is a variant of this problem that raises much more troubling issues. In the course of his analysis, Rawling discusses connections between the St. Petersburg paradox. He notes, "Due to their common concern with infinite expected utilities, both the St. Petersburg paradox and the two envelopes 'trading paradox' (under countable additivity) can be undercut by evading infinitude" (p. 65). Rawling considers the rejection of countable additivity — what happens if probabilities are only finitely additive? Rawling concludes that, on the basis of the two envelopes problem, "If probability is merely finitely additive, it seems we must abandon decision theoretic reasoning with respect to infinite parti-

tions" (p. 69).

In *The Logical Status of Conditionalization and its Role in Confirmation*, Susan Vineberg considers the issue of the justification of the rule of conditionalization in Bayesian theories of confirmation and decision. The rule of conditionalization requires, "that an agent's new probability for A after learning E, and nothing more, should be equal to her old probability of A given E" (p. 77).

In the first part of her essay, Vineberg considers the role played by the Dutch strategy argument in the justification of the rule of conditionalization. A Dutch strategy is a betting strategy that secures a net loss for the bettor, and the Dutch strategy argument goes as follows: "If an agent's beliefs change, after learning E, by a rule other than conditionalization, then she is susceptible to a Dutch strategy, in that a bookie, who knows her degrees of confidence and her rule for updating, can devise a series of bets to be placed at different times, each of which would appear fair to the agent at the time offered, but which together guarantee her a net loss" (pp. 78–79).

In the light of Vineberg's analysis of the Dutch strategy argument, the rule of conditionalization emerges not as a requirement of rationality, but as a rule of permission. As Vineberg puts it, "there is no rational requirement that the hypothesis H be updated by conditionalizing on E, when E is learned, as opposed to giving up the prior conditional probability of H given E" (p. 82).

In the second part of her essay, Vineberg considers the implications of this reading of the conditionalization rule for Bayesian confirmation theory. In the course of her discussion, Vineberg examines arguments to the effect that the conditionalization rule can resolve issues raised in the realist/anti-realist debate in the philosophy of science. Vineberg contends that the conditionalization rule, viewed as a rule of permission, cannot provide a resolution of the realist/anti-realist debate.

Further issues touching upon the philosophy of science are raised by Deborah Mayo in her essay *Science, Error Statistics, and Arguing from Error*. Mayo examines two divergent views of the task of a theory of statistics: the evidential relation view (exemplified by various versions of Bayesian confirmation theory); and the error-statistical view (exemplified by the Neyman-Pearson approach to statistics). Mayo contends that while experimental investigators tend to follow some version of an error-statistical approach, many philosophers insist on a Bayesian approach to scientific inference. Mayo's central thesis, contrary to the Bayesian orthodoxy, is that an error-statistical approach can provide a good foundation for a philosophy of experimental inference.

Central to Mayo's thesis is the concept of severe test. As Mayo puts

it: "Data e indicate the correctness of hypothesis H, to the extent that H passes a *severe test* with e . . . Hypothesis H passes a severe test with e if (a) e fits H and (b) the test procedure had a high probability of producing a result that accords less well with H than e does, if H were false or incorrect" (p. 99). In view of this, experimental inquiry is viewed as involving the construction and correction of models needed to systematically substantiate severe tests. In the end, and unlike the orthodox Bayesian approach to confirmation, the error statistical approach, "licenses claims about hypotheses that are and are not indicated by tests without assigning quantitative measures of support or probability to those hypotheses" (p. 105).

In *The Best is the Enemy of the Good*, Mark Lance offers some criticisms of the Bayesian approach to epistemology. Lance believes it is important to be able to answer questions about the rationality of belief revision, and contends that the Bayesian approach to epistemology prevents us from answering such questions. His argument centers on Bayesian idealizations of cognitive agents — the theory of rationality resulting from a consideration of such agents, "offers us . . . constraints compatible with obviously irrational attitudes" (p. 113).

In discussing the shortcomings of Bayesian epistemology, Lance examines the role played by Dutch Strategy arguments in the justification of the conditionalization rule. Lance takes issue with Vineberg's defense of Bayesianism. Recall that for Vineberg, the conditionalization rule is a rule of permission. So one can confront new evidence by conditionalizing, but one does not have to — one might revise instead one's prior probability assignments, especially since Bayesian epistemology allows crazy prior probability assignments. Lance wants to know what could motivate such a revision of prior assignments. As he remarks: "This is not to say that people shouldn't change crazy assignments of probabilities into non-crazy ones. One should, but the reason is that the assignment is crazy. The learning of new evidence does not give a Bayesian agent the reason to change" (p. 122). Drawing on his analysis of Bayesianism, Lance concludes his essay with a discussion of the role of idealization in philosophy.

The next group of three essays concern issues in, or arising out of, biological science, broadly construed. In *An Application of Bayes' Theorem to Population Genetics*, Robert Gardner and Michael Wooten attempt to elucidate practical applications of Bayes' Theorem in the context of an analysis of DNA fingerprint data. Gardner and Wooten attempt to use Bayes' Theorem to derive conditional probabilities — thereby avoiding the use of transition matrices — that can be used to resolve the problem of the determination of the degree of genetic relatedness between individ-

uals, based on their phenotypes.

Having presented their formal derivations of conditional probabilities, Gardner and Wooten apply their methods to re-analyze a British immigration case, in which the deportation of a child was at stake, depending on the degree of genetic relatedness. A mother-son relationship was being alleged, an aunt-nephew relationship was suspected. The methods actually used in settling the case (resulting in the determination of a mother-son relationship) are restricted and not suitable for general use. Gardner and Wooten show how to apply their general Bayesian approach to resolve the issue.

In *Another Look at Group Selection*, Peter Johnson explores some foundational questions in theoretical biology. Though biological orthodoxy rejects the possibility of group selection — the idea that natural selection works at the level of groups, not individual organisms or selfish genes — Johnson argues that the question needs to be re-examined. In the course of his analysis, Johnson raises some important questions concerning the nature of biological individuals. His approach, while controversial, is refreshingly anti-reductionistic in spirit. It is Johnson's contention that selection can operate — depending on context — at various levels in the biological hierarchy of organization. Johnson does not see individual level selection and group selection as opposing forces, rather he suggests that we should think in terms of a superposition of selection at various levels. In discussing the possibility of group selection, Johnson makes useful reference to the recent work of David Wilson and Elliott Sober.

Johnson is also critical of attempts to reject group selection on the basis of Occam's razor. Complex biological systems, he contends, may require complex, messy explanations. His paper ends with a group-selectionist reappraisal of some human, sociobiological scenarios. If Johnson is right, these may be just as well explained as the result of co-adaptation within groups, as by the action of selfish genes.

In *Teleosemantics, Kripkenstein and Paradox*, Cory Juhl examines issues arising out of a biologically-inspired, naturalistic account of semantics, the teleological theory. According to the teleological theory, "just as our livers have proper functions (where these functions are determined by our evolutionary history), our brains or parts thereof have as their proper function to map onto states of affairs in particular ways" (p. 168).

Consider the word 'plus,' as in "Two plus two equals four." It is Juhl's contention that finite evolutionary histories, together with finite learning histories of individuals, is not sufficient, "to connect a given representing system with a unique infinitary object like the addition function . . ." (p. 169). The teleosemanticist is committed to the view that there are only finitely many past causal facts in the relevant history of an individual

member of a given species. But then, only finitely many quantities are definable from finitely many past facts.

Juhl considers the possibility that 'plus' doesn't mean something infinitary at all. Perhaps the addition rule only governs some finite set of possible applications. But as Juhl points out, this is a view that will manifest many of the problems associated with finitism in the philosophy of mathematics. In the end Juhl is sceptical of the attempt to account of semantic norms in terms of causal theory.

The next two essays are concerned with epistemological issues. In *Constitutive and Epistemic Principles*, Daniel Bonevac notes that we organize our thought with the aid of general principles. There appear to be two distinct types of principle. Constitutive principles assert that, "satisfaction of the subject term is responsible for satisfaction of the predicate term. Something's being a contract . . . makes it obligatory to honor it" (p. 183). In epistemic principles, "satisfaction of the subject term is a good indicator of satisfaction of the predicate. Fungal respiratory infections are good indicators of underlying illness . . . but are not responsible for it" (p. 183).

Bonevac notes that these principles are non-extensional and have no representations in standard logical systems. Moreover, while such principles are evidently more than accidental generalizations, they are not universal, for they admit of exceptions. Bonevac's central task is to provide a logical theory for these principles, a theory which will offer an account of their mutual relationships.

In *Empiricism, Mathematical Truth and Mathematical Knowledge*, Otávio Bueno discusses a problem originally raised by Benacerraf concerning current interpretations of mathematical truth and mathematical knowledge. An adequate characterization of the former implies an inadequate characterization of the latter, and *vice versa*. Bueno attempts to outline an empiricist interpretation of mathematics in which mathematical truth and mathematical knowledge can be simultaneously and adequately characterized. His main strategy, building on the earlier work of da Costa and French, is to work with a weaker notion of truth than is usual — quasi-truth, and a more general concept of structure — partial structure.

Bueno hopes to construct a constructive empiricist philosophy of mathematics by analogy with van Fraassen's constructive empiricist philosophy of science. The principle benefit of an empiricist interpretation of mathematics is a view of mathematics that is not committed to an ontology of abstract objects, such as sets or functions. The result of Bueno's labors is a view according to which, "Mathematical knowledge based on quasi-true theories is the result of the construction of certain partial structures and the study of their extension to full ones" (p. 231).

The final two essays in the volume are concerned with ontological questions raised by modern physics. In *Coins and Electrons: A Unified Understanding of Probabilistic Objects*, Chuang Liu points out that while quantum theory is essential for an understanding of the physics of the microcosm, it provides no clear characterization of the nature of the denizens of the microcosm, for example, electrons — especially in view of the murkiness and confusion that surrounds the doctrine of wave-particle duality.

As Chuang Liu notes, electrons would not be puzzling if they could be construed as billiard balls writ small, albeit one's that are irreducibly probabilistic. "The balls in a game of bagatelle . . . are objects of this kind, and so are fair coins and dice. But the kind of probabilistic laws the electrons obey are fundamentally different from those obeyed by the classical objects . . ." (p. 244). Chuang Liu wishes to characterize this difference, but in such a way that quantum objects do not end up as being fundamentally different from classical objects — i.e., as belonging to distinct ontological categories.

Finally, Anna Maidens, in *Are Electrons Vague Objects?*, discusses the claim that vagueness resides only in language, and cannot be part of the world. The essay concerns the controversy as to whether there can be vague objects, "in the sense that identity statements involving singular terms referring to these objects might be indeterminate in truth value" (p. 261). A counterexample in the literature concerns that case of an electron captured by an atom to form an ion which then subsequently emits an electron. It has been claimed that it is ontologically indeterminate as to whether the electron captured is one and the same electron as the one emitted.

Maidens points out that we should not insist that objects are just those things for which we have definite criteria for their identity over time — as is shown by the case of the Ship of Theseus. "Similarly, because of the way electrons enter into and then emerge from entangled states there is a vagueness in the relation relating their temporal parts" (p. 272). In view of this vagueness, Maidens concludes that identity statements about these objects are similarly vague.

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