actions, and if, for example, the side-effects were not part of the intentions, then should something untoward happen and the agent need to revise his plan, the intentions could not perform the very guidance role for which they are required.

To be sure, such information must be in some way encoded and retained by the agent for possible use. But it seems to me that there is no reason why this information must be retained at the personal level at all; it may be hard-wired in, and be potentially accessible to the agent in certain circumstances. But if intentions are to be placed at the personal level, there is then no argument for over-inflating the size of intentions themselves to contain such information. The song says that Casey's mind was so loaded that it nearly exploded. Enç's account of action seems to me to have Casey's problem.

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Decisions, Uncertainty, and the Brain, by Paul W. Glimcher. Cambridge, MA: MIT Press, 2003, Pp. xx + 375. H/b £25.50.

This book aims to give a new framework for neuroscience by banishing the concept of the reflex and making an economic model central to explanations of the behaviour of organisms and their components. I very much doubt that it accomplishes these aims, but along the way some interesting issues are raised.

The first half of the book is a lively history of attempts to explain complex actions in simple terms, from Descartes to connectionism. I will not discuss this, as the material is familiar and no really new points are made. Glimcher sees psychology as having been saddled from the beginning with a contrast between simple actions, which are to be explained in terms of simple mechanical processes, culminating in Sherrington's description of the reflex, and complex psychological processes, which are to be explained in completely different ways which might be exempt from causal determination. He believes that the concept of a reflex is not simply of limited application but is in fact a bad idea, of explanatory value for no behaviour. The claim seems to be that there are no reflexes. To support this claim he describes a wealth of phenomena, in particular reafference phenomena, which require essentially more complex explanations, and then leaves the argument in suspension while he says what he takes to be really going on.

What is really going on is that individual components of the nervous sys-

tem, down to single cells, are computing expected utility. The essential point is that all aspects are probabilistic. What is important about the input to a neural module is the information it carries about objective probabilities which, combined with the aims of the module as part of the organism's attempt to achieve maximum reproductive fitness, lead it to produce the output which will maximize the expected value that the function of the module will be achieved. The assumption that organisms and their components do operate optimally, so that we can predict that the output will be the maximizing one, is defended with a number of examples, ignoring the numerous contrary cases. Glimcher cites studies from his own and other laboratories in which single cell recordings show that the firing of individual cells in the parietal cortex is proportional to the likelihood that that particular cell's activity will be conducive to a beneficial outcome, given the probabilities of possible states as given by recent inputs. I do not think Glimcher is really claiming that individual cells do the utility calculations, though he sometimes gives this impression. The claim must be that given a single cell we can always assume that its connections with others are such that somewhere in the system the calculation occurs and the cell's output is affected accordingly.

In one experiment the output is not optimal. Glimcher and colleagues induced single cells to behave in accord with Herrnstein's matching law, in which pigeons press either of two levers in a proportion that matches the rewardingness of that lever. However, in Glimcher's set-up, unlike Herrnstein's, this matching behaviour is not optimal. Glimcher promises an explanation of this deviation and then does not explicitly supply it. I take it that his explanation is bound up with the other major component of his theory, which is the strategicality of all behaviour. Glimcher points out that in many competitive or predator–prey situations it is important for animals not to be predictable. It is thus in their interest to produce the mixed strategies of game theory, in which what is chosen is not a single act but a probability distribution over acts. As a result, much animal behaviour will be deeply probabilistic: under the same circumstances a different action will sometimes be produced. Glimcher sees this aspect as permeating neural activity, so that outputs at all levels are probabilistic, with the probabilities those of mixed strategies for the game-theoretical situations the animal or neural module is in. In game theory, though, mixed strategies are optimal; Glimcher does not explain either why the output of organisms and cells is sometimes probabilistic when a certain outcome would have been optimal, nor what the analogues of strategic interaction for components of a nervous system are.

The rhetoric in the second half of the book is that the attempt to demarcate simple from complex behaviour should be replaced by explanations of neuropsychological phenomena in terms of 'economic theory'. By economic theory Glimcher means utility maximization and Bayes's theorem, plus a pinch of game theory. One conclusion he derives is that perception and decision-making are distinct processes, in which the former is subject to an allocation of

resources determined by the likelihood that a discrimination is going to be crucial, while the latter proceeds with strict optimality. No doubt there are many situations in which an organism has to allocate resources carefully in order to obtain the data it needs to choose actions, and then can make a straightforward choice. But there are also situations in which decision-making is costly, and an organism has to distribute resources between easy and approximate procedures and harder but more accurate procedures, in accordance with the importance of the decision. I would be surprised if principles of resource allocation did not permeate decision-making processes just as thoroughly as they do perceptual ones.

I am convinced by very little in this book. In fact no behaviour of any organism is ever absolutely optimal. Birds do not get mortgages to afford safer nests. An act is optimal relative to specific alternatives subject to constraints on what is possible for the organism. A very delicate business. This is not to say that searching for Bayesian updating and utility maximization in animal behaviour and nervous systems is a bad idea. On the contrary, it is a deep and powerful tool: but we are still waiting for the general framework that makes clear when it is appropriate and what kinds of explanations it gives. One thing it definitely does not do is to resolve issues about determinism, as Glimcher claims in his last chapter. Clockwork automata can produce mixed strategies. Nor does it banish the concept of the reflex, even if it deserves to be banished. Organisms with reflexes can maximize expected utility and update their probabilities.

I do not want to end on such a sour note. Glimcher may indeed have assembled some of the materials for a new neuroscientific paradigm. There are many very thought-provoking discussions of attention and decision at different levels of the nervous system. We may eventually see that Glimcher was leading us in the right direction. But should hesitate before saying what that direction is.

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Nature From Within: Gustav Theodor Fechner and His Psychophysical Worldview, by Michael Heidelberger, translated by Cynthia Klohr. Pittsburgh, PA: University of Pittsburgh Press, 2004. Pp. viii + 446. H/b $49.95.

An unscientific survey of American philosophers suggests that most have not heard of Gustav Theodor Fechner (1801–87), and those who have know him mainly as the crazy pantheist who founded the science of psychophysics.

